SUSTAINABLE FOREST MANAGEMENT

Proceedings of an International Seminar

31 August – 2 September 1998

Pokhara, Nepal

Editors: Prakash Mathema, Ishwar C. Dutta, Mohan K. Balla, and Shailendra N. Adhikary

Institute of Forestry/International Tropical Timber Organization

Training and Manpower Development in Community Forestry Management Project

PD 103/90 Rev. 1(F)

Sustainable Forest Management

Proceedings of an International Seminar

31 August – 2 September 1998
Institute of Forestry, Tribhuvan University
Pokhara, Nepal

Editors: Prakash Mathema, Ishwar C. Dutta, Mohan K. Balla,
and Shailendra N. Adhikary

May 1999

10/7/99

TO INTERNATIONAL TROPICAL TIMBER ORGANIZATION

YOKOHAMA, JAPAN

With the best compliments of

RECEIVED
-2. AUG. 1999
ITTO

Abhoy Kumar Das
Dean
Institute of Forestry
Pokhara, Nepal

Prakash Mathema, Ishwar C. Dutta, Mohan K. Balla, and Shailendra N. Adhikary, (eds.). 1999. *Sustainable Forest Management* (Proceedings of an International Seminar, Pokhara, Nepal, 31 August to 2 September 1998). Institute of Forestry, Pokhara, Nepal.

Please direct inquiries and comments to:

Institute of Forestry, Tribhuvan University
P. O. Box 43
Pokhara, Nepal

Design, page-layout and production management:

Dilip Manandhar
Multi – Link Pvt. Ltd., P. O. Box 10829
Dilli Bazar, Kathmandu, Nepal

Cover photograph: A community forest in Charikot, Dolakha District, Nepal
Courtesy of Prakash Mathema

Table of Contents

PART 3: WATERSHED MANAGEMENT AND ENVIRONMENTAL CONSERVATION

PART 4: WILDLIFE AND BUFFER ZONE MANAGEMENT

Foreword

The Institute of Forestry (IOF), Tribhuvan University is the only educational institution of Nepal which produces skilled forestry professionals. As such, it is recognised as a key organisation contributing to the forestry development of Nepal. In collaboration with the International Tropical Timber Organization (ITTO), IOF is implementing the Training and Manpower Development in Community Forestry Management Project. I commend the project for contributing to the overall development of IOF and for strengthening the teaching and research capabilities of IOF faculty members. Under the auspices of this project, the International Seminar on Sustainable Forest Management was organised by IOF in Pokhara, Nepal from 31 August to 2 September 1998.

The main objective of the Seminar was to provide an opportunity to the faculty members and Visiting Scholars of IOF to present their work in an international forum. The Seminar brought together more than 100 participants from ten countries. Experiences on various aspects of sustainable forest management were shared among the participants. The participation of a diverse mix of professionals highlighted the interdisciplinary nature of forest management.

The papers included in this publication contain a wealth of information on various aspects of sustainable forest management. I hope that this publication will be useful to the practitioners, academicians, students and other people interested in sustainable natural resource management.

I am grateful to the Training and Manpower Development in Community Forestry Management Project for funding the Seminar. I am particularly thankful to Dr. I. C. Dutta, Ex–Dean of IOF and Co-ordinator of the Seminar, for the successful organisation of the Seminar. Other members of the Seminar Organising Committee were M. H. Khan, M. K. Balla, C. P. Upadhyaya, S. M. Mishra, R. K. Pokharel and S. N. Adhikary. I acknowledge their untiring efforts for making the Seminar a grand success. I am also thankful to the Visiting Scholars, their counterparts and other staff of IOF who directly or indirectly contributed to the Seminar. My thanks also go to all the guests and participants of the Seminar. I am also grateful to J. B. Raintree for preparing the overview of the workshop.

My sincere appreciation goes to P. Mathema, I. C. Dutta, M. K. Balla and S. N. Adhikary for compiling and editing the proceedings of the Seminar. To Multi – Link Pvt. Ltd. and particularly to Dilip Manandhar, I am grateful for their hard work in preparing the camera-ready copy of the proceedings.

Abhoy Kumar Das
Dean
Institute of Forestry

Introduction

At the United Nations Conference on Environment and Development held in Rio de Janeiro, Brazil in 1992, the world leaders adopted a global policy on sustainable forest management known as the "Forest Principles". Since then the term "Sustainable Forest Management (SFM)" has been widely used despite the fact that it has no universally agreed definition. The International Tropical Timber Organization (ITTO), which is an inter-governmental organisation including all major producers and consumers of tropical timber, has defined SFM as "the process of managing forest to achieve one or more clearly specified objectives of management with regard to the production of a continuous flow of desired forest products and services without undue reduction of its inherent values and future productivity and without undue undesirable effects on the physical and social environment" (*Criteria and Indicators for Sustainable Forest Management of Natural Tropical Forests*).

To explain further, SFM maintains the ecological functions, processes and structure of the forest in healthy condition in perpetuity. SFM does not degrade soil or water quality and does not cause losses to biodiversity. It applies to the entire forest as an integrated whole rather than to any single component or product or service of the forest. As such, SFM can produce a wide range of environmental, social and economic benefits to society. SFM is an essential component of sustainable development to which most countries are now committed.

In recent years, interest in SFM has increased rapidly due to the increased awareness on degradation of forest resources, the negative consequences that go with it, and the urgent need to maintain the forest resource base in perpetuity. More and more people are now convinced that SFM is of great significance for the long-term prosperity and survival of human civilisation.

In this context, the International Seminar on Sustainable Forest Management was organised by the ITTO funded Training and Manpower Development in Community Forestry Management Project of the Institute of Forestry (IOF), Tribhuvan University. The Project has been in operation since 1993 and aims to upgrade the capability of the IOF to become a centre of excellence in community forestry education. The most important objective of the project is to strengthen the teaching and research capability of the faculty of IOF, through a Visiting Scholar Programme. More than eight person years of internationally renowned Visiting Scholars with expertise in Wildlife Management, Watershed Management/Environmental Science, Tropical Forest Management, Community Forestry, Agroforestry/Silviculture, and Non-Timber Forest Products (NTFPs), were recruited during the project. In addition to other outputs, the organisation of this International Seminar is a major achievement of the Training and Manpower Development in Community Forestry Management Project. The Seminar provided an opportunity to the Visiting Scholars, their faculty counterparts and other faculty members of IOF to present their work in an international forum.

The Visiting Scholars and their respective faculty counterparts had completed researches in various fields of forest sciences such as: Community/Participatory Forestry, Forest Management, Watershed Management, Wildlife/Buffer Zone Management, Agroforestry and NTFPs. Papers were invited in all of these areas because forest management has a broad scope and covers all of these aspects. This Seminar has contributed towards building up the confidence of the IOF faculty members through intellectual and professional interaction with the international scientific community. It has also helped in establishing linkage between the scientists working in various aspects of natural resource management and the IOF faculty members.

The theme chosen for the Seminar was "Sustainable Forest Management" for conservation and development. The General Objective of the Seminar was to learn about the state-of-the-art approaches and methods in:

- Community/Participatory Forest Management
- Participatory Watershed Management and Environmental Conservation
- People's Participation in Wildlife/Buffer Zone Management
- Agroforestry and Use of NTFPs in Rural Development.

Sharing of experiences on a wide range of topics related to tropical forest management was the specific aim of the Seminar. The Seminar was divided into three parts: Inaugural Session, Technical Session and Closing Session.

Inaugural Session

Dr. Kamal K. Joshi, Vice Chancellor of Tribhuvan University, chaired the Session. Mr. Ananda P. Dhungana, Honourable Minister of Forests and Soil Conservation, His Majesty's Government of Nepal, inaugurated the Seminar. Assistant Minister Mr. Mohammad Aftab Aalam and Secretary Mr. Narayan R. Tiwari, of the Ministry of Forests and Soil Conservation also spoke on the occasion. Mr. Abhoy K. Das, Dean of IOF, welcomed the participants of the Seminar. Dr. P. K. R. Nair, Professor of Agroforestry at the University of Florida, presented the keynote paper. Dr. Winston R. Rudder, Country Representative of FAO/Nepal, also gave his remarks. Dr. I. C. Dutta, Co-ordinator of the Seminar gave an introduction to the Seminar and the IOF/ITTO Project Manager, Mr. Shailendra N. Adhikary gave the vote of thanks. Dr. Kamal K. Joshi closed the session with his remarks.

Technical Session

There were altogether 11 sessions during the three days of the Seminar. Fifty papers were presented by participants of ten countries including Nepal. The participants represented a wide range of organisations: the government, NGOs, INGOs, universities and other research and development organisations. The papers selected for presentation fell in four major areas: Forest Management; Agroforestry and NTFPs; Watershed Management and Environmental Conservation; and Wildlife and Buffer Zone Management. Most papers focused on the participatory approach to the management of forests, watersheds and wildlife resources. Several papers also highlighted the importance of NTFPs in rural development. A large number of papers recognised the importance of the participation of local communities for achieving the overall goal of sustainable forest management.

Closing Session

Mr. M. Kashio, Programme Officer of the Asia-Pacific Regional Office of FAO, chaired the closing session. Chairpersons from each of the four areas presented the summary of the respective technical sessions. The points discussed were noted and summarised. The summaries of the four subject areas were consolidated into one summary, which is included in this publication as the Overview of the Seminar. The Plenary Session also decided that the organisers should publish the proceedings of the Seminar. Mr. Kashio gave some concluding remarks and Mr. Abhoy K. Das gave the vote of thanks.

The papers presented at the Seminar are compiled in this publication. Some of the papers included here were accepted but could not be presented at the Seminar. Unfortunately, some papers that were presented at the Seminar could not be included here because the authors did not send the full paper in time. The publication is divided into four parts. In Part 1 all the papers falling under the theme of Forest Management are included. The papers addressing Agroforestry and NTFPs are included in Part 2. Part 3 includes the papers on Watershed Management and Environmental Conservation. The papers on Wildlife and Buffer Zone Management are included in Part 4. The papers have been edited for style and space without impairing their focus and essence.

The International Seminar provided an excellent opportunity to the participants for discussing a wide range of issues on forest management. The participants expressed that the papers were very interesting and informative to update their knowledge on recent developments in SFM. The papers presented at the Seminar are very relevant and useful not only to Nepal but also to other countries with similar problems. The organisers believe that the Seminar will contribute to the sustainable forestry development efforts in Nepal and elsewhere.

Overview of the Seminar

The papers presented in this seminar speak for themselves. However, in order to reach a higher level of integration, the session chairpersons prepared brief summaries of each session. Subsequently, the session summaries were combined into theme summaries to produce the following overview. In the interest of preserving the original meaning, the subsequent editing of these contributions has not tried to impose a uniform style on the contributions. The reader should be aware that these outputs are not "recommendations" in the sense of formal workshop outputs. The gathering was a high level seminar rather than a workshop and the outputs are in the nature of summaries rather than recommendations.

1. Forest Management

In view of the impact of population pressure and continuously depleting forest resources, sustainable forest management is the main goal for the future. Conventional forest management practices have mainly aimed at timber production. There is a need to expand the scope of forest management to cover a much wider range of forest resource utilisation and conservation issues. The aim should be to achieve appropriate development of resources in order to fulfil the multiple needs of people, environmental protection and national forest production. Such appropriate development is the key to Sustainable Forest Management (SFM).

Many papers were presented under this theme, the largest section of the Seminar. Instead of summarising each paper, the main observations, considerations and suggestions emerging from the papers and discussion sessions are presented below:

- Enhancement of people's participation is the key issue of SFM, under the provision of a policy framework which supports the long-term development process.

- There is a need to understand the role of community forestry in rural and community development. Meanwhile, efforts to strengthen community forestry should focus on: income generation activities, increasing job opportunities, ensuring people's rights to forest resources, improved benefit sharing, equitable gender participation, better understanding and application of indigenous knowledge, and updating of technical skills in a wider range of management practices relevant to community forestry. Community forestry should also be strengthened through development of improved marketing structures.

- The need to make better use of the potential to produce wood and other forest products outside designated forestland and/or to extend forest cover to non-forest areas was also highlighted.

- The use of simple forest inventories to assess the value of both timber and non-timber forest products was recommended. The need is to develop an appropriate set of technologies to optimise the productivity of these products on a sustainable basis.

- The revision of forest management and working plans was also emphasised, including master plans and resource management strategies. Plans should take into consideration technical, socio-economic, cultural, environmental and policy issues. While holistic watershed and ecosystems approaches are important, flexibility at the local level is also crucial to take into account the site-specific conditions. Moreover, there is a need to develop feedback mechanisms at all levels of planning and management.

- Leasehold forestry and forage development approaches may be pursued as one promising option for degraded area rehabilitation as well as rural development.
- Integrated forestry extension and forestry education projects should be developed for capacity building among village and medium level resource managers. These should emphasise the integration of traditional knowledge with modern forestry practices and with the utilisation of other natural resources. Better co-ordination is required among grassroot-level organisations and with top-level organisation through improved communication and feedback mechanisms.
- Development of international co-operation in technology transfer, funding, trade, criteria and indicators, certification, marketing, legislation, etc. is also needed. Local indicators, viz., ecological, social, technical, cultural and economic factors need to be identified in order to monitor and assess the forest resource situation.
- Improvement in harvesting techniques should be encouraged.
- There is also a need for Human Resource Development to create capacities for implementation of integrated resource utilisation strategies.
- There is a need of a full-fledged development of forest management systems and marketing mechanisms. This needs to be supported through local credit systems and co-operatives to promote the development of cottage industries.
- An integrated approach with other sectors is recommended for sustainable forest management under which the living standard of the local people can be improved.
- Direct exchange of experience between the communities in developing countries should also be encouraged.

The gathering considered it realistic to aim for sustainable development that is socially acceptable, economically workable and environmentally sound. It was agreed that forestry practices should avoid exploiting the resource base beyond its carrying capacity. In fact, this is the essence of SFM.

2. Agroforestry and Non-Timber Forest Products (NTFPs)

The combination of agroforestry and NTFPs in the same session reflects the growing perception of a close but still largely undeveloped relationship between the two. Agroforestry has tended to focus on scientific research leading towards as yet unrealised technological improvements. By contrast, community forestry has advanced the social agenda but people are beginning to ask, "Where is the technology?" This convergence on appropriate technological applications is brought into focus by NTFPs, another neglected area of forest management. For agroforesters, many NTFPs are simply understory agroforestry crops. Agroforestry has an important role to play in community forestry. NTFPs provide the means—the efficient technological focus—for bringing agroforestry into community forestry.

The first paper by **Nair** presented an overview of the history of agroforestry. In the early days of agroforestry, the focus was on conceptual development and institutionalisation. Agroforestry is now well-established as a field of scientific research and is generating a sustained "harvest" of empirical information. In future the challenge to agroforestry will be to bring the growing body of empirical knowledge to fruition and to generate useful technological applications that can contribute to rural development, especially through attention to indigenous technology and the "agro" part of agroforestry.

The difficulty of further "horizontal expansion" of agroforestry was also the background to a paper from Nepal on integration of NTFPs into agroforestry systems. The paper by **Amatya** examined a number of models and proposed criteria for the sustainability of various combinations of trees and medicinal/aromatic plants in multi-strata agroforestry systems.

The paper by **Chakravarti** carried the focus to nitrogen fixing plants and elaborated on the criteria for their inclusion in agroforestry systems. **Singh *et al.*** presented the findings of a study done in India on some aromatic plants cultivated under agroforestry practices. The paper by **Gupta *et al.*** discussed the findings of the socio-economic study done on a part of Henwal watershed of Tehri Garhwal district, India. It revealed that agroforestry activities were influenced by the size of land holding, the size of households and the total number of livestock kept by a household.

S. R. Baral's case study from the Humla region of north-western Nepal documented the kind of NTFPs that are collected in alpine and sub-alpine environments in the Himalayas. Over seven tonnes of some 15 species were collected in 1995–96, but sustainability of harvesting is threatened due to the decline of traditional management practices caused by growing rural poverty.

Panchaule (*Dactylorhiza hatagirea)* is a very high value NTFP in the Annarpurna Conservation Area of Nepal and there is trade in this product even though its harvest is illegal. A recent study indicated that approximately 100 kg/yr of air dried root could be harvested on a sustainable basis. The paper by **Parajuli *et al.*** recommended changes in legislation to allow sustainable harvesting of this NTFP as a source of income for the local people.

Mushrooms are also NTFPs but their development as a component of community agroforests and farming systems has been neglected. Recent years have seen rapid increase in both the global consumption of mushrooms and the availability of techniques for small-scale cultivation. A systematic approach to the integration of mushrooms into farms and agroforests is needed in order to realise their full potential for poverty alleviation and sustainable forest management. The paper by **Raintree** discusses this at length.

Kayastha *et al.* discussed the dynamics of fodder trees in the middle hills region of Nepal. They have identified five most preferred fodder tree species for each Development Region of Nepal and suggested that more intensive research on these species is needed. The paper by **Yadav** discussed the *Leucaena*-based silvipastoral system in India and the one by **Dahal and Brouwer** explored the ecological aspects of establishing *Faidherbia albida* for agroforestry in the Sahel. **Rai *et al.*** presented the findings of their study on the growth of sissoo (*Dalbergia sissoo*) under agroforestry in the Terai region of Nepal.

In general, greater awareness about all aspects of NTFPs is needed among the people and beneficiaries. In particular, there is a great need for more information on technological aspects of NTFPs, such as propagation, cultivation, sustainable harvesting practices, processing and marketing, both domestically and internationally. There is also a need for training and education for everyone concerned with the various aspects of NTFPs promotion and development (collectors, Forest User Groups, foresters, farmers, traders, and entrepreneurs).

The operational plans of Forest User Groups should include the management of NTFPs and should consider the sustainability of collection and value addition in order to avoid overexploitation and degradation of environment.

Research and Development of NTFPs should focus on both conventional and non-conventional commodities (e.g. mushroom). Methodology of NTFP inventory is also an area that deserves urgent attention. Furthermore, review of policy, legislation, royalties and taxation related to NTFPs is also urgently needed.

3. Watershed Management and Environmental Conservation

This session dealt with a variety of subjects, the common elements were: how to evaluate and predict environmental changes, in climate, vegetation, sedimentation loads, watershed ecosystems, and crop production. The theme of "people's participation" in community forestry was also carried forward into watershed management. The papers by **Wagley; Ohler; Acharya and Shrestha;** and **P. N. Sharma** discuss various aspects related to participatory watershed management.

The session began with a paper by **Siddiqui** based on the results of computer simulation modelling on the effects of climate change on the spatial distribution and productivity of forest biomass in the mountains of northern Pakistan over the period 1990–2080. Strategies to cope with the very significant changes predicted by the model were advanced.

The paper by **Achet** examined a wide range of conceptual approaches, strategies and factors that can and should be taken into account at different levels of watershed management planning with special reference to Nepal. The sedimentation problem of Phewa lake in Pokhara, Nepal was the focus of another paper (**Sthapit and Balla**). Methods and results of sedimentation measurements were presented, followed by a discussion of sources and possible causes of the sedimentation, and predictions for the life of the lake. It was concluded that sedimentation cannot be completely halted, and some measures were proposed to cope with the problem.

Another paper from Nepal (**S. M. Mishra**) dealt with the role of bamboo plantations in environmental conservation, based on a study carried out in 1995 which assessed the effects of relatively intensive bamboo planting from 1980 onwards in farmland, private land and gullies. The correlation between farm size, ethnicity, and numbers of bamboo clumps was analysed. The effects of bamboo planting were both direct (erosion control, number of bamboo clumps, etc.) and indirect (regeneration of the natural forest).

The paper by **P. P. Sharma *et al.*** focused on monitoring instrumentation and data acquisition techniques for paired watershed studies. Evaluation of data shows that the set-up could be useful for both temperate and tropical sites. Citing the example of traditional water conservation techniques in Rajasthan, India, the paper by **A. Mishra** asserted that the local people are capable of solving their own problems. Another paper from India (**Kukreti *et al.***) discussed the work of the project on Himalayan Eco-rehabilitation in Garhwal Himalayas.

4. Wildlife and Buffer Zone Management

A total of five papers were contributed in this session. Two papers focused on threatened species, blackbuck in Nepal and musk deer in India, two on participation of people in conservation through ecotourism and other consumptive and non-consumptive direct benefits from the conservation areas in Nepal, and one on the possibility of participatory protected area management with reference to Indian conditions. The salient features of these papers are given below:

A case study of blackbuck in Khairapur, Nepal highlighted the declining blackbuck habitat conditions and dwindling population, which deserves to be protected by giving the area legal status as sanctuary (**Tamang and Shrestha**). The demographic structure of the population in the area indicates nearly optimal situation at present, but this is under pressure due to poaching, habitat degradation, and farmer's irritation about crop damage caused by blackbuck.

The paper on musk deer in India (**Tiwari and Singh**) called attention to the critical situation of this species, which is subject to heavy poaching due to the high commercial value of musk. It is listed in Schedule 1 of Wildlife (Protection) Act 1972, and Appendix 1 of CITES indicating highest conservation status and legal protection by complete ban on commerce. The paper reviews the biology of the species and proposes captive breeding as a solution to very low population levels and habitat degradation, based on examples of successful musk deer farming operations in Himachal Pradesh and Uttar Pradesh. In one of these farms a technique has been developed for extraction of musk from the deer without killing it.

The need to provide direct non-consumptive benefits to the people to elicit their co-operation in conservation was the central theme of the paper by **Shrestha and Adhikary.** They asserted that the income from ecotourism could reduce exploitation pressure on the conservation area and improve the quality of life. The paper by **Thapa** discussed the importance of managing the buffer zones around the protected areas of Nepal.

The paper by **Kotwal** discussed the possibilities for participatory protected area management in India. Highlighting the nature of conflicts between the wild animals and people living inside or close to protected areas, the paper noted that it is difficult for human beings and wild animals to live in the same area. Problems of local people in meeting their bonafide needs were also highlighted. Possibilities for participation by the people in protected area management, through protection, and ecotourism were discussed.

It is noteworthy that all of the papers in this session strongly recommended participation of local people in conservation of wild animals and protected areas.

Forestry in the Future: Think Globally, Act Locally

Keynote Paper by P. K. R. Nair

1. Introduction

Today, as we approach the new millennium, forestry is truly at a challenging crossroad, especially in the developing countries. Both the forests and the forestry profession are under severe stress. Forests are under threat as a consequence of the phenomenal increase in human and domestic-animal populations in the developing world, resulting in escalating demand for forest products, unprecedented rates of forest destruction, and mounting environmental problems. The forestry profession, although being "liberated" from the administrative servitude of being a handmaiden of agriculture for a long time, is facing tremendous pressures from the society at large and the increasingly powerful lobbies of all sorts. The profession has to maintain a delicate balance between efforts to produce timber and other forest products in a sustainable manner on the one hand and measure up to the society's constantly evolving definitions of environmental demands, ethics, and aesthetics on the other. Testing times, indeed !

What can we do to face this situation? No matter what the larger issues are, forestry is basically a site-specific activity. Collectively, the effects may add up. But, decisions are taken and implemented locally. Although we are primarily focused on and governed by the local issues, problems, and regulations, forest as a biological or ecological entity cuts across political and administrative boundaries. Actions (or inactions) in forest operations and management at one place or region will have influences over other places as well. Therefore, in our preoccupations with local issues, we cannot be oblivious of the problems at large. The unifying concept of *unasylva* (one world, one forest) is more current today than ever before. Thus, the phrase "think globally, act locally" is most appropriate to today's forestry. From that perspective, I will briefly review some of the current global forestry issues that can and need to be addressed by actions at the local level.

2. Global forest resources

Efforts to compile global forest statistics usually begin with disclaimers, caveats, and apologies: data are incomplete, inconsistent, and inconclusive. So, it is not unusual that different sets of data are published on the same aspects by different organisations. A case in point is the variation in data on tropical deforestation rates published by such organisations as the FAO of the United Nations and the World Resources Institute. Some of the data become authenticated more by repeated references to them than by their accuracy, and by the "reputation" of the agency that is credited as the source. The enormity of the tasks associated with collecting accurate data on such a complex and ill-defined ecosystem as forests is the root cause of this problem. We cannot therefore undermine the importance of commendable efforts that have gone into the comprehensive surveys and assessments of forest resources in the early part of the 20th century such as Zon (1910) and Zon and Sparhawk (1923), and all others thereafter. Beginning in 1953, FAO began publishing regular assessment of world resources. A plethora of such FAO databases are available, and with the advent of large-scale use of the electronic media (the world wide web) in the 1990s, these data sources, especially the SOFO (State of the World Forests) reports are easily accessible, admittedly to those who have those facilities. Additionally, several comprehensive studies and statistics on global forest resource conditions have been published in the past decade; examples include Mather (1990), Laarman and Sedjo (1992), Sharma (1992), and the World Resources Institute's annual publications.

In spite of the likely inaccuracy of these reported statistics, it is now generally accepted that:

- Forests occupy about 4 billion ha or 30% of global land area;
- Most of these conversions have been to accommodate agricultural expansion; and
- Today most of the forest destruction is happening in the developing countries.

Suffice it to say that forests in developing countries are under very serious threats. This can easily be illustrated by the recent data on world forest area, population, and economic development presented in Tables 1 and 2. Deforestation (defined as disturbance, conversion, or destruction of forests) is recognised as the number one problem in tropical forestry today. Figure 1 shows some trends in tropical deforestation in the decade 1980 to 1990.

Table 1. Global forest and land area

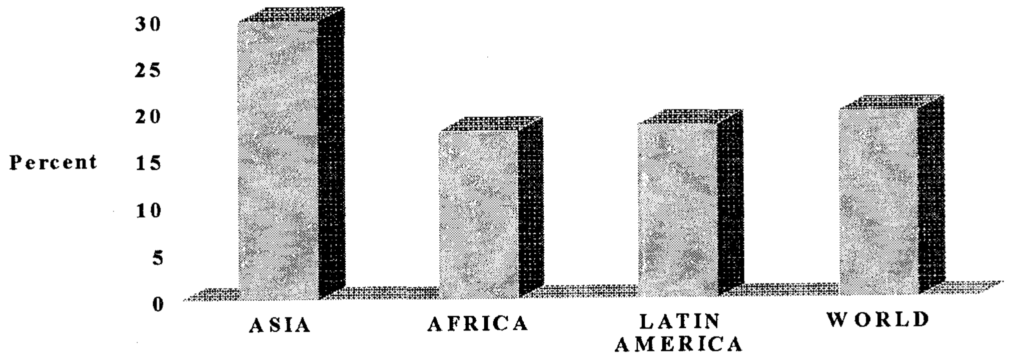
Region	Land (mill ha)	Forest (mill ha)	Forest (ha/cap)	Other Woodland (mill ha)	Forest & Woodland	
					(mill ha)	(% of land)
Europe	550	149	0.26	46	195	7
Former USSR	2139	755	2.15	187	941	44
North America	1835	457	1.65	293	749	40
Pacific (Developed)	818	71	0.51	106	178	21
Asia & Pacific	2613	497	0.17	163	660	25
Africa	2964	545	0.85	591	1137	42
Latin America & Caribbean	2016	967	2.16	292	1250	62
Total Developing	5342	1432	1.07	631	2064	38
Total Developed	7594	2009	0.50	1047	3056	40
World	**12936**	**3442**	**0.64**	**1678**	**5120**	**40**

Source: FAO (1995).

Table 2. Changes in population and forest area (1980–1990)

Region	Population		Forest Area	
	1990 (mill)	Annual Growth Rate (%)	(mill. ha, 1990)	Annual Change (%)
Asia	3071.6	2.0	484.5	-1.2
Latin America	448.3	2.0	919.4	-0.9
Africa	467.5	3.0	604.3	-0.8
North America	275.7	1.0	751.4	0
USA	248.7	0.8	298.1	-0.1
Nordic	17.8	0.1	61.0	0
Europe	547.1	0.2	134.0	0.1
CIS	287.7	0.7	941.5	0.2
Australia & New Zealand	20.4	0.2	153.1	N/A
World	**5316.1**	**1.7**	**4047.1**	**-0.4**

Source: World Resources Institute (1992).



Source: Bryant *et al.* (1997).

Figure 1. Percentage of tropical forests cleared in different regions and the world, 1960 – 1990.

4. Tropical forestry: issues, initiatives, and paradigms

Let us now briefly examine what we have been doing in tropical forestry and perhaps understand how or why we came to where we are today. Figure 2 presents a schematic overview of the major issues in tropical forestry and the initiatives taken during the past five decades. About 50 years ago, tropical forest "management" amounted mostly to unbridled exploitation. While making this statement, the reference is to the so-called post-colonial era in most parts of tropics. It is certainly not intended to ignore or belittle the importance of the magnificent work of some early foresters, as for example, on the silviculture and management of selected trees in the Indian subcontinent. Similarly, such significant developments as the establishment of hardwood plantations mostly through the *taungya* system supposed to have been started by Dietrich Brandis in the mid-1850s in Burma (today's Myanmar), then a part of British colonial India, should not go unnoticed in this context. But in many places, forests were considered as an unending resource that was difficult to manage and even to exploit, and often times were considered as a formidable impediment to what was considered as "development" in those days. Perhaps an old poetic metaphor in my native language Malayalam of Kerala, India, that describes the woods of the forest as **unending as the waves of the ocean and the aspirations of the human mind** describes the scenario aptly.

The first large-scale example of the application of scientific knowledge for the development of forestry resulted in the establishment of plantations. Described as a forest crop or stand raised artificially, including total new planting and enrichment planting or regeneration, plantations cover more than 100 million ha world-wide and account for about 50% of the world's wood supply. About 40% of these are in the developing countries of the tropics and sub-tropics (Evans, 1992; Nambiar and Brown, 1997; World Resources Institute, 1998). The area under plantations has increased significantly in all three developing continents, more than 80% of them in the developing world being in Asia. Although extensive areas under plantations exist in large countries such as Brazil, China, and India, plantation establishment has become an important forestry activity in most countries, large or small. For example, during the period from 1980 to 1990, the area under forest plantations has increased by 14% in Nepal (Figure 3).

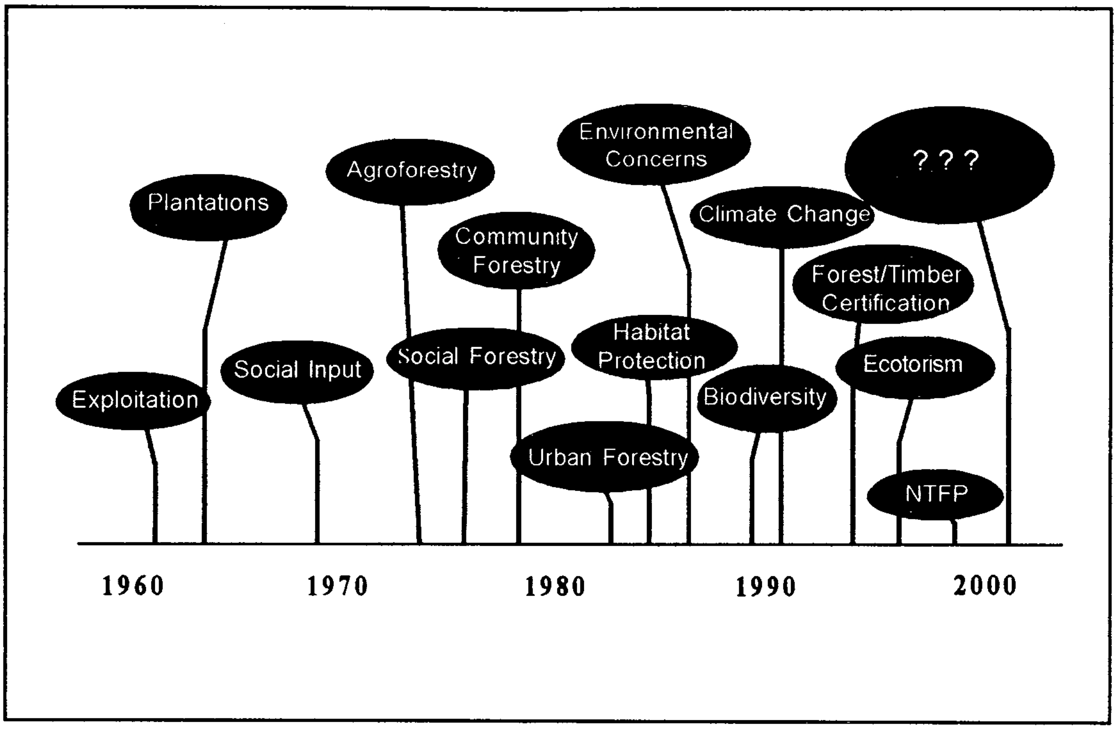
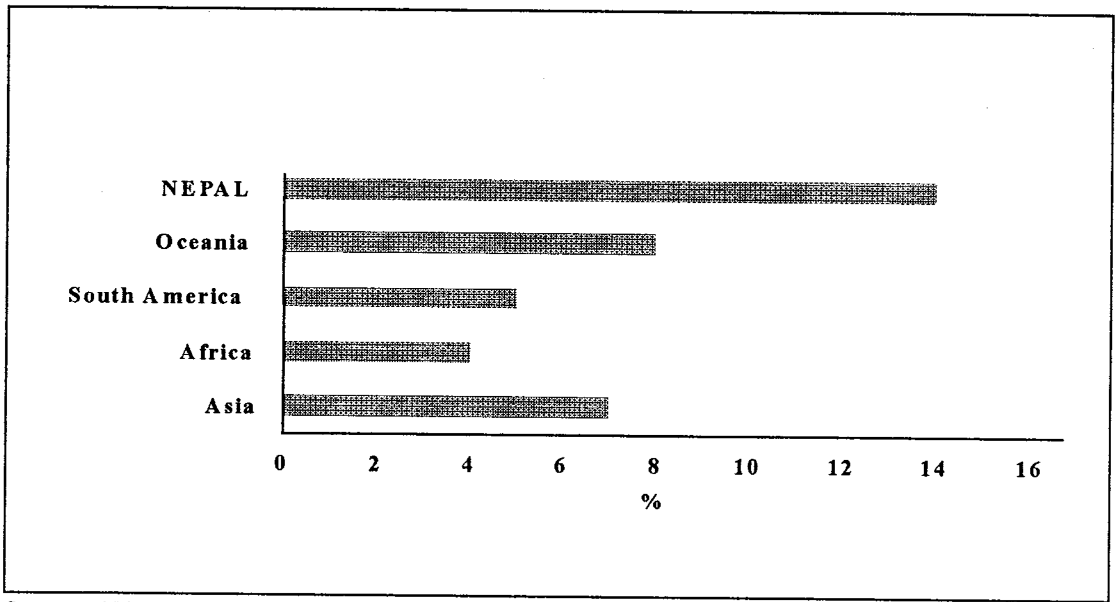


Figure 2. Major initiatives, issues, and programmes in tropical forestry during the second half of 20th century.



Source: World Resources Institute (1997).

Figure 3. Annual percentage change in area under forest plantations, 1980 to 1990.

In the history of 20th century forestry, the 1970s and 1980s saw revolutionary changes as a result of increasing interest of the society at large in forests and the awareness about the role of forests in addressing mounting environmental problems. Some puritans of forestry used to—and still do—view these as the onslaught on forestry by non-foresters. It was during this period that considerable initiatives were made to bring inputs from other disciplines especially social sciences into the art of forest management, which led to the emergence of a plethora of terms such as agroforestry, community forestry, farm forestry, and social forestry. Note that all of these "new" terms have forestry endings but other qualifiers. The concepts and activities encompassed by them represented the integration of a myriad of other land use activities with forestry, with explicit expectations from forests and forestry about a wide variety of products other than wood, and services other than the conventional ones that had until then been recognised as forestry-related. Thus the broad and varied social value of forest was recognised with a new perception and outlook. Forestry ceased to be the prerogative of traditional foresters alone. That the concept of agroforestry, social forestry, and such other activities had to be invented in order to emphasise the societal and social value of forest was even considered as an indictment of the narrow-value focus of "traditional" forestry and its close association with wood production and market prices.

Thus, the period (the 1970s and 1980s) witnessed a dramatic increase in forest-related activities that truly reflected the "think globally act locally" paradigm. Several programmes were launched, many of them at global levels with corresponding links to the local and regional activities. Unfortunately, some of the programmes misfired in spite of the elaborate euphoria that had been associated with their launching. A notable example is the Tropical Forestry Action Plan (TFAP). Initiated in the mid-1980s by the World Resources Institute and forest-related UN agencies (FAO, UNDP), the Plan was projected as capable of offering the best and most elaborate solution to problems of tropical forestry and saving the tropical forests on a truly global scale (FAO, 1985). But it fizzled out without much impact, and is today described as an excellent example of a failed attempt that encompasses the aspirations and frustrations in tropical forestry.

The levels of enthusiasm and expectations this agenda of integrating societal and social interest with professional forestry had generated were so enormous that quite a lot of bystanders, opportunistic groups, and "instant experts" boarded the forestry bandwagon. Many of them soon realised that there were no magical and "quick-fix" solutions to age-old and complex problems surrounding forestry. That was the time when the environment lobby was gathering unprecedented levels of momentum. Several of the self-styled and powerful "experts" of forestry, who were disillusioned with the progress and opportunities in the field of their new-found "expertise," switched from the "narrow" forestry wagon to the more "prestigious" and broader platform of environment. Thus, the late 1980s and the 1990s saw the emergence of a multitude of terms and activities linking forestry with such fascinating concepts and terms as environment and sustainable development, natural resources, biodiversity, habitat protection, climate change, ecotourism, and so on. I believe we will be hearing lots of discussions on several of these issues during this seminar.

To summarise this broad-brush treatment of forestry development scenario of the past five decades, we have seen a large number of initiatives and action plans as depicted in Figure 2. The judgement on the extent to which each of these has been successful depends partly on the criteria used for assessing success. But it is fair to say that most programmes have gone through a pattern of getting launched with much fanfare and unrealistic claims about their potentials, followed by disappointment stemming from the failure to reach those expectations. Nevertheless, without venturing to present any supportive statistics or long list of arguments, I would say that, on a global scale, two types of tropical tree-planting programmes have accomplished tangible results: plantation forestry and tree planting outside forests described by agroforestry and related variants such as social and community forestry. Basically these two programmes represent two approaches: the former relies on the time-tested biophysical side of things (genetic engineering, silvicultural techniques, technological inputs, and so on), the latter represents an evolution of social and community participation in forest management. Furthermore, while most of the tropical forest plantations are in public forestland, trees outside forests are mostly in private landholding. Lately we have seen various forestry development programmes and schemes designed or proposed for producing timber and or non-timber products (examples: joint forest management, village forestry scheme, fuelwood programmes, or whatever) and for exploiting forests and trees for their "service" functions (examples: carbon sequestration, environmental amelioration, aesthetics, and so on). From the ecological perspective of land management, they all involve the two tree-management approaches: growing trees in pure stands or mixed stands.

5. Emerging issues

As Brooks (1993) observed, the striking differences in forest resource use between or among regions, economic groups, and ecological zones emphasise the importance of distinguishing global forestry issues and forestry issues of individual countries and regions. In developed countries, per-capita timber consumption rates are high. The average consumption of wood and wood products is estimated to be 0.7 m^3 for the entire world; the corresponding figures for the developing and developed countries are 0.5 and 1.2; and, the US has the highest rate, 2.4 (World Resources Institute, 1998). Moreover, in the developed countries, the timber consumed is predominantly from coniferous species; the forests are managed intensively for fibre production; non-commodity services of forests are increasingly demanded; and there is a long tradition of an active role of the public sector as a steward for forest resources and supplier of timber to local and national markets. On the other hand, for developing countries, forestry issues are inseparable from the fundamental challenges of development and the environmental consequences of population growth and economic conditions. Although several of the tropical forestry issues such as the role of forest in climate change, carbon sequestration, and the preservation of biodiversity are presented as "global" issues and are given prominence in international agenda, a closer examination reveals that they have originated mostly as concerns of the developed nations and are viewed differently by developing nations. The call for promoting some of the "brand new" initiatives and regulatory mechanisms such as forest/timber certification as a means of ensuring sustainable management of tropical forests (Johnson and Cabarle, 1993) is also being criticised as a cover for providing easy access to tropical forests by outside agents. Thus, the developing nations face a great dilemma in trying to balance concerns and international pressures for environmental conditions with critical short-term, economic needs; a schematic representation of this dilemma is depicted in Figure 4.

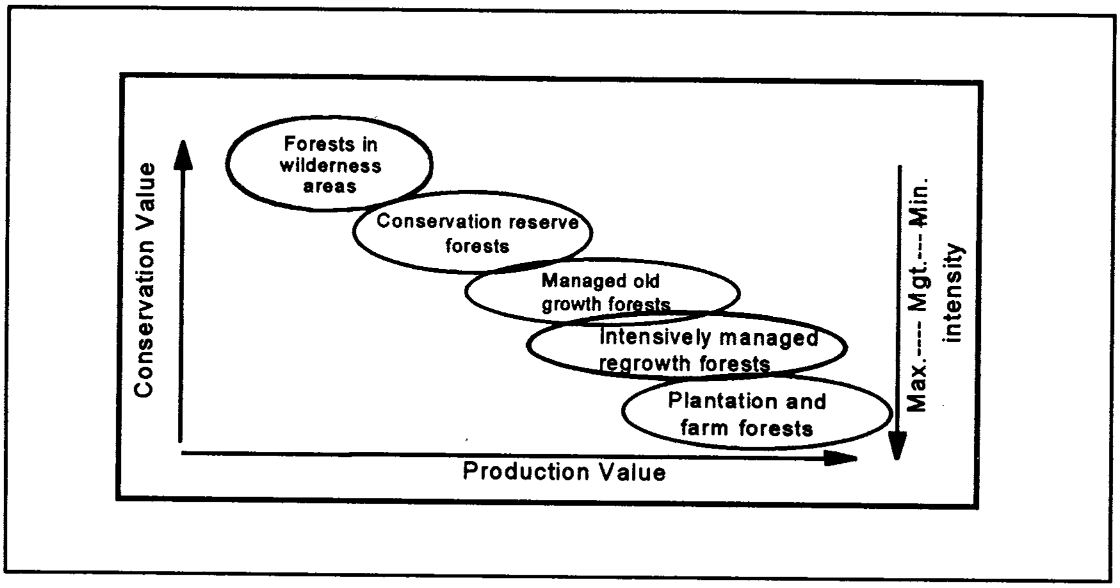


Figure 4. The conservation/production dilemma of tropical forestry.

So, what does the future hold for tropical forests? It is clear that in the next half-a-century, forestry issues are likely to be significantly different from what they have been in the previous one. Changes in regional and global objectives of forests, forest environments, and patterns of forest production and consumption of timber products are all going to be substantially different. Decreasing forest cover in almost all developing countries is a

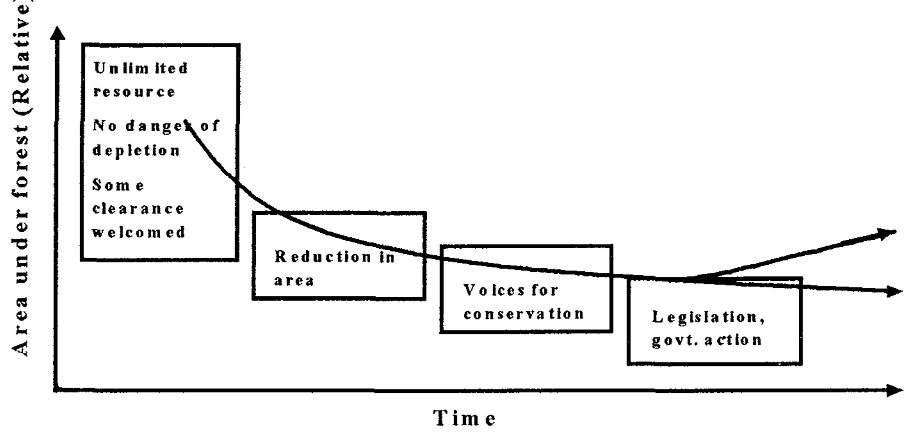


Figure 5. A generalised global pattern of change in area under forest with time.

matter of primary concern to developing and developed nations alike. Looking at the changes in conditions of US forests over the past century, it is tempting and perhaps natural to consider offering the US experience as a model for developing countries. The US model is indeed a striking example of how concerted policy and government actions can cause a significant turn around in pattern of forest utilisation. Following the agricultural expansion of the 1800s, forest area declined drastically in the US, and by the end of the 19th century, concerns were raised about an impending timber famine and need to make drastic measures to prevent the situation. Following that, the first forestry act was enacted and the concept of sustained yield forestry, which seeks to ensure that harvest matches re-growth, was strictly enforced. This resulted in a dramatic turn-around in the area under forest, and the downward trend took a sharp turn and changed direction to an upward one. Globally too, forest utilisation has followed a general pattern that has some similarities with the US model (Figure 5). The time scale within which the drastic changes occurred are different in various places; also, the extent of failure to implement sound policies to effect a turn-around from decline to increase in forest area may be different in different places. For example, the history of Mediterranean forests is no different. About 2000 years ago, the area was well-forested; but uncontrolled forest exploitation supported by inept policies and corrupt officials resulted in the creation of the present irreversible condition whereby the rich forests were reduced to mere scrublands, and the area under forests declined to a mere 5% of the original forest area. Many fear that a similar situation could happen in the case of tropical forests also unless drastic measures are taken, as was done in the US in this century, to avoid such a catastrophe. But, can we do that and if so how? Forestry in developed countries went from pre-industrial to industrial forestry and is now going into post-industrial stage, and in doing so, is experiencing stiff resistance from some professional foresters. Some argue that tropical forestry may not have to go through similar paths; the industrial stage could even be skipped as depicted in Figure 6.

Whatever be the scenario and pathway we adopt, one thing is clear: investment in research is essential. Although management of temperate forest ecosystems may be inherently easier than the management of tropical ecosystems, the successes of temperate zone forest management are built on considerable experience, and a considerable, continuing investment in research and support of institutions for

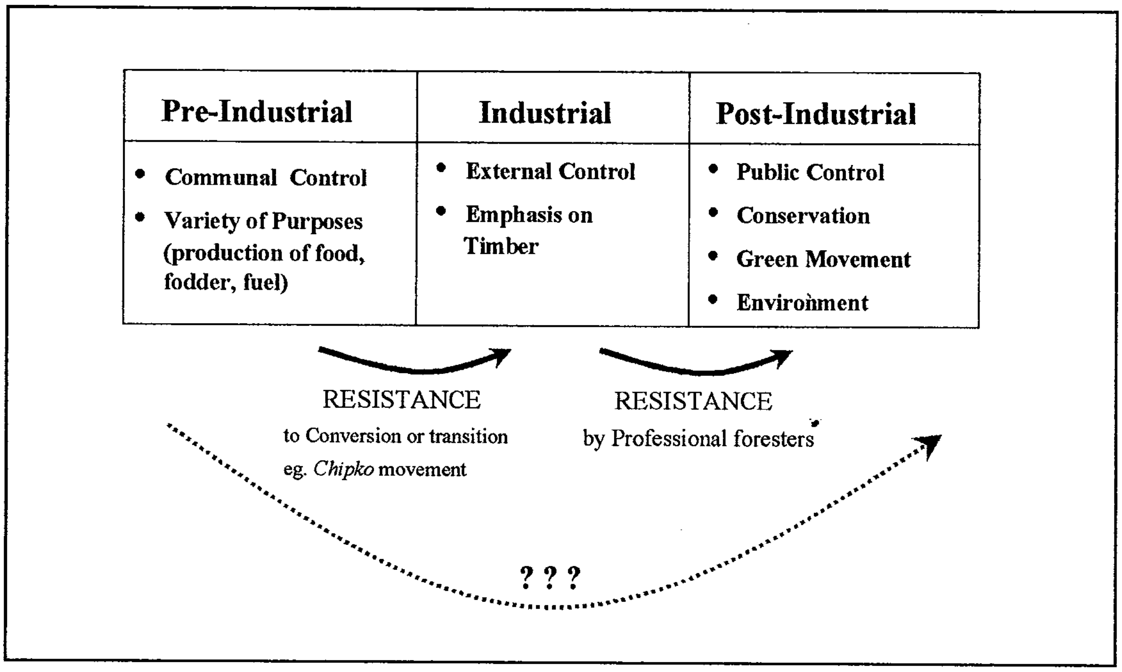


Figure 6. Forestry in transition

management. It is unreasonable to expect comparable success in the management of tropical forest systems without research and institutional support of a comparable magnitude. Indeed, if some of the initiatives in tropical forestry described in Figure 2 have not produced expected results, the reason could well be that the programmes were put together rather hurriedly without the benefit of required research background or back-up. In the parlance of some development agencies, research has, unfortunately, become a "dirty" word. We do not have to go too far back in history to realise that only programmes that were built up with solid scientific foundation and research support have succeeded. The two successful programmes in the tropical forestry scene identified earlier, plantation forestry and agroforestry, are the only ones to have been benefited by research of at least some extent; little wonder that the other mushrooming programmes have been rather ephemeral.

Another important lesson we can learn from the experience of temperate forestry is the importance of public sector in forestry development activities. Although European and North American forest management has a long tradition of an active role of the public sector as a steward of forest resources, most of those countries rely, to a greater or lesser extent, on private ownership and management of forest resources to satisfy commodity and non-commodity objectives. Tropical forests and forestry are, on the other hand, mostly State-controlled and/or owned. The importance of stable social and political institutions governing the uses of forestland is a lesson that we need to examine carefully for likely adaptation from the developed countries.

In concluding these reflections, as I mentioned in the beginning, forestry is at a challenging crossroads. As in almost any other profession, forestry of the future will drastically be different from what it has been in the past few decades. While exploring new frontiers in traditional forestry disciplines such as silviculture and forest productivity, we also need to heed the society's demands on forests and integrate social and cultural values into forest management strategies. Programmes dealing with issues such as non-timber forest products, ecotourism, biodiversity conservation, agroforestry, community forestry and other systems of tree growing outside the forests will form an increasing part of forest management strategies at all levels.

Forests are a global treasure. We need to manage them in perpetuity. Our actions in forest management have to be, admittedly, local. But, collectively these actions have global ramifications too. The important thing is that we must do our part locally in this global project. I hope this seminar provides the conviction and impetus for the move in that direction.

References

Brooks, D. J. 1993. US Forests in a Global Context. *USDA Forest Service General Technical Report RM-228.* Pacific Northwest Research Station, Portland, Oregon, USA.

Bryant , D., Nielsen, D., and Tangley, L. 1997. *The Last Frontier Forests: Ecosystems and Economies on the Edge*. World Resources Institute, Washington, DC, USA.

Evans, J, 1992. *Plantation Forestry in the Tropics*, 2nd Edition. Clarendon Press, Oxford, UK.

FAO. 1995. *FAO Production Yearbook, 1995.* FAO, Rome, Italy.

Johnson, N. and Cabarle, B. 1993. *Surviving the Cut: Natural Forest Management in the Humid Tropics.* World Resources Institute, Washington, DC, USA.

Laarman, J. C. and Sedjo, R. A. 1992. *Global Forests: Issues for Six Billion People*. Mc Graw Hill, New York, USA.

Mather, A. S. 1990. *Global Forest Resources*. Timber Press, Portland, Oregon, USA.

Nambiar, E. K. S. and Brown, A. G. (eds.). 1997. Management of Soil, Nutrients, and Water in Tropical Plantation Forests. Australian Centre for International Agriculture Research, Canberra, Australia.

Sharma, N. (ed.). 1992. *Managing the World's Forests.* Kendall/Hunt Publishers, Dubuque, Iowa, for the World Bank, Washington, DC, USA.

World Resources Institute. 1998 (and other years on an annual basis). *World Resources,* 1995–96. Oxford University Press, Oxford, UK.

Zon, R. 1910. Forest Resources of the World. Bulletin 83. USDA Forest Service, Washington, DC, USA.

Zon, R. and Sparhawk, W. W. 1923. *Forest Resources of the World.* Mc Graw Hill, New York, USA.

PART 1:
FOREST MANAGEMENT

Mathema, P., Dutta, I. C., Balla, M. K. and Adhikary, S. N. (eds.). 1999. *Sustainable Forest Management.* Proceedings of an International Seminar, 31 August – 2 September 1998, Pokhara, Nepal.

Integrating Community Forestry into Community Development: An Experience from Sindhupalchowk, Nepal

N. R. Baral

Abstract: Based on the current practices of community forest management in Sindhupalchowk, various opportunities for integrating community forestry into rural development are explored. It has been argued that community forests, if managed properly, not only meets the basic requirement of forest products of the rural people but also provide employment opportunities and income to the rural people. To justify the argument, various aspects of forest management and resource utilisation have been discussed. Suggestions for integrating community forestry into community development are also suggested.

1. Introduction

Community forestry (CF) was initially defined by FAO, as "any situation which intimately involves local people in a forestry activity" (FAO, 1978). It is a community-oriented forest management system where local users of forests control, manage and utilise forest resources for their own benefits. The ultimate objective of CF is to raise the standard of living of local community (FAO, 1992). Thus, the concept of CF underpins the notion that the State and the local community can jointly manage forest resources to the benefit of both parties (Anderson, 1995).

Nepal is a developing country where most of the population are subsistence farmers and live in rural areas. As the rural livelihood depends on agriculture, which in turn is closely linked with forests and other natural resources, the development of forests is highly associated with the development of rural livelihood. Due to the lack of raw materials, poor economy and landlocked situation, rapid industrialisation is not possible or feasible in Nepal at least for the coming few decades. Therefore, Nepal has to depend on its natural resources in order to eradicate poverty.

Therefore, sustainability of CF in Nepal is not only related to conserving forest ecosystem and meeting the basic needs of forest products of the community but also closely related to the well-being of the people. The challenge is to create opportunities for community development so that all benefits from forest use—tangible and intangible—can be optimised, while conserving the integrity of the forest ecosystem. This paper attempts to identify opportunities and constraints to integrate CF into community development. The main argument of the paper is that community forests, if managed properly, not only meets the basic requirement of forest products of the rural people but also provide employment opportunities and income to the rural people.

2. Methodology

Socio-economic and ecological issues of various Forest User Groups (FUGs) from Sindhupalchowk district have been considered for discussion and analysis. Operation plans of other FUGs within and outside the district were also consulted to verify the findings. Secondary data and published information related to the subject matter were also consulted.

3. Community forest management in Nepal

Community forestry evolved out of the realisation that conventional forest management in developing countries is incapable of and inefficient for active people's participation in forest conservation. It is based on the economic principle that forest policies based on the maximisation of revenue at the cost of social welfare have resulted in deforestation (Repetto, 1988).

The main characteristics of CF are that it: recognises the intimate relationship of people and forests; recognises indigenous forest management systems; aims to meet the basic needs of forest products of the users; focuses on increasing the benefits from forests for rural people, especially women and disadvantaged groups; and involves local people in project identification, design, implementation, monitoring and evaluation (FAO, 1989).

In Nepal, CF was launched about two decades ago. It is in the mainstream of forestry sector programme of the Ministry of Forests and Soil Conservation (MFSC). At present, more than 7,000 FUGs have been formed and more than 400,000 ha of forests have been handed over to them. Arguably, this is the most successful programme of the country. In fact, Nepal is an acknowledged leader in policy and implementation of CF, and its experiences are sought after by many developing countries in the world (Hobley *et al.*, 1994).

3.1. Main characteristics of CF in Nepal

- Phased handing over of all accessible hill forests to the communities (user groups) to the extent that they are able and willing to manage them.
- Government plays a catalytic role, providing technical advice and playing a supervisory role in the management of the forest.
- With help of forestry staff, the user groups identify, negotiate and prioritise their needs and aspirations among each other and the government.
- FUFs prepare operational plans (a set of rules and regulations and technical prescriptions including detailed plan of action, description of the forest and the beneficiaries and distribution systems, and after approval from the District Forest Officer it becomes the legal document of the user group).
- District Forest Office hands over the forest to the FUGs to protect, manage and get total benefit from the forest as per the plans.
- The Forest Act 1993 and Regulation 1995 govern the whole process of handing over CF.
- The user group is recognised as an autonomous and corporate body.

3.2. Shifting approaches to CF management

CF in Nepal began with the concept of fulfilling basic needs of forest products to local community and conserving the forest ecosystem. The improving situation in CFs shows that curbing poverty, improving the quality of life, and conserving the forest must be mutually supportive for a developing country like Nepal. CF in Nepal has already passed its infant stage of development and now has entered into its young stage of development. To carry forward the success of CF for its sustainable management it has to be redefined or linked with other sectors of community development. CF should not be confined within the boundary of forest or simply involving people in forest management to meet their basic needs of fuel, fodder and timber. It should be defined as a resource tenure system in which local people/community has ample opportunities and incentives to organise together and mobilise their resources (natural and human capital) to meet their own basic needs and improve their well-being. Therefore, it requires an integrated approach of community development in which CF plays the principal role.

Moreover, entirely new ways of addressing people's relation with forests are needed. It is not wise enough simply to recognise CF programme as one of the top priority programmes of Department of Forest. The challenge goes far beyond that. Social and economic consideration must be integrated into CF management and development thinking. The challenge is to create opportunities for community development so that all benefits from forest use can be optimised while conserving the integrity of the forest ecosystem.

3.3. Opportunities of integrating CF into community development

The subsistence livelihood of the rural people is primarily based on agriculture and livestock husbandry which in turn is intricately linked with forestry. It is well understood that without forest the life in the rural areas is impossible. Therefore, there are tremendous opportunities of integrating CF into community development. Some of the main opportunities are listed below.

- FUGs have been institutionalised by laws.
- There are well-defined forest policy, and rules and regulations on CF.
- Forests of Nepal are rich in biodiversity. Existence of various kinds of forest types and multi-purpose species having great commercial values mean that forests, if managed properly, can produce surplus supply of forest products, while conserving the integrity of forest ecosystems.
- Rural people are becoming more conscious and aware of their rights and duties and participation of women and other disadvantaged groups in CF is encouraging.
- CF is one of the most successful programmes in Nepal, and there is a huge demand for CF.
- Forests of Nepal are simply managed for fuelwood, fodder and timber. Non-timber forest products have not been fully utilised and FUGs have not benefited much from it. Establishment of non-timber forest product based industries (co-operatives) can generate considerable income as well as minimise the problem of rural unemployment.
- Community forests comprise many sites of extreme natural beauty and tourists attraction. Moreover, wildlife population is also increasing in community forests. All these factors indicate that there is a great potential of developing community based ecotourism in CF.
- Ecotourism not only creates market for these untapped natural resources but it also generates income and employment opportunities to the rural people.
- Many FUGs have collected a considerable amount of money from various sources such as sale of forest products, grants and others. But due to the lack of appropriate knowledge on resource (income) mobilisation most of the income from community forests has been under-utilised if not misused.

Many community forests can produce considerable amount of income even if a simple silvicultural operation such as thinning is carried out. It has been observed in many areas that most of the FUGs can now be described as cash poor but resource rich.

4. Community forestry in Sindhupalchowk

The district is famous for its pioneering work in community forestry. This is the first district in the country from where community forestry was started in 1978/79. In the early years, forest management was focussed on developing strategies for nursery and plantation. In the successive years, priorities were also given to develop the concept of FUGs as the focal point for the sustainable management of local natural resources including forests.

At present, with Australian aid, emphasis has been given to developing capabilities of FUGs, fostering income generation through sale of forest resources in excess of community needs and the use of income from CF for community development. Major forestry programmes carried out for CF management in the districts are, identification of FUGs and forest hand over, establishment of FUG nurseries, seedling production and plantation, establishment of forest management demonstration plots, literacy classes, and various training programmes to strengthen the capabilities of FUGs and transfer technical skills to them.

The total potential area for CF in the district is estimated to be 70,861 ha of which degraded forest consists of 63,705 ha and the rest is barren land. About 18,000ha of forest has been handed over to 336 FUGs till July 1998, and it has benefited more than 35,000 households. However, the distribution of FUGs is not uniform. Of the total 79 Village Development Committees in the district only 72 have been involved in CF management and development. Moreover, there are various social, economic and biological issues which have not been addressed properly.

Economic growth is an essential enabling force for development. Growth is needed to generate the resources which allow people to enjoy a reasonable standard of living and access to various other basic community services such as education and health. It also generates the funds needed for environmental conservation (AIDAB, 1994). However, economic growth *per se* does not necessarily lead to improvement in people's lives, nor does it ensure sustainable management of natural resources. What is needed is growth which is not only ecologically sustainable but also brings improvement in various aspects of rural development such as education, health and others. In this paper an attempt has been made to illustrate how to promote economic growth in CF so that it can be integrated into rural development, while managing the forest in a sustainable way.

4.1. Forest management practices

It has been observed that most of the existing community forests are over stocked. In most cases, the average number of trees per ha excluding regeneration is more than 1100. Natural forests are very young and have a few big trees while plantation forests are uniform. But average stocking (trees) in plantation forest is slightly lower than those of natural forests, while total volume per ha in plantation forest is always greater than those of natural forests. They need immediate thinning if their productivity is to be improved. There is shortage of fuelwood in the rural areas and people are meeting most of their fuelwood demand from trees on their own private land (Baral, 1998). Immature trees are frequently sacrificed for fuelwood while there is huge quantity of fuelwood untapped in their own community forests.

Study of several FUGs has shown that timber is not as scarce as fuelwood and fodder in rural areas. Therefore there will be surplus of timber in most of the FUGs. It has been observed that a plantation forest of an average age of 15 years can provide about 168 cft of timber worth to Rs. 25,000 from simple thinning. There are about 12,000 ha plantation forests in the district and most of them have been handed over to FUG. The average forestland per FUG is about 42 ha. Assuming 50 percent FUGs have plantation forests and estimating 110 cft timber per ha from thinning, each FUG can generate a revenue of about Rs. 16,500 from the sale of timber.

However, the present trend of forest management does not meet the above objective. Management of community forests is primarily based on operation plans. Operational plans define objectives of forest management but they are almost silent to various questions such as: How to meet the objectives? What are the potential options of forest management? When will the forest be ready for final harvest? Moreover, the traditional protection oriented attitude of FUGs also restricts them to various silvicultural operations such as thinning, removal of mature trees and others. FUGs lack knowledge on forest management and the commercial values of timber and therefore, are not confident in harvesting timber and generate income from it.

Moreover, benefits from CF can also be maximised through various timber processing industries such as small saw mill and furniture industry. CF if managed properly can produce more than enough timber to meet the needs of FUGs. FUGs often sell surplus timber in the local market without processing. But if FUGs establish a small saw mill or wood processing industries or a furniture industry they will get higher price for their products. Wastes from these industries such as sawdust, and bark can also be used as a substitute for fuelwood and making huts for cattle. In addition to this, processing of timber and manufacturing furniture also provide job opportunities.

Study of a small saw-mill in Banepa has shown that an investment of Rs. 200,000 can generate a net profit of Rs. 120,00 per year. Also, the community saw-mill in Chaubas of Kavre Palanchowk is the best example of maximising benefits from CF.

4.2. Management of Non-Timber Forest Products (NTFPs)

In most of the FUGs management of NTFPs is often neglected and their role in community development is poorly defined. Actually, NTFPs can generate a lot of income and employment. Here an attempt is made to illustrate how a small amount of money invested in establishing a simple lapsi (*Choerospondias axillaris*) industry can generate income as well as local employment.

Farmers of Pipaldanda and Shayale sell more than 403 *muri* (1 *muri* = 50 kg approx.) of lapsi worth Rs. 300,000 every year. They sell lapsi to the local middleman who later on sells it to the business man from Kathmandu and Kavre. Rate of lapsi varies from month to month. In a good cropping season price of lapsi goes down otherwise it remains almost constant. Similarly, farmers who sell lapsi in the early season or before ripening especially in Bhadra and early Ashwin receive less money than those who sell in late season or when ripe.

The amount of income from lapsi can be doubled if a small intergroup is formed to manufacture '*madha*' (semi-dried pulp of lapsi) is established in the area. *Madha* is a value-added product and has a huge market in Kathmandu valley. Demands for *madha* is increasing every year and its market has been extended to Terai and overseas. *Madha* is used for making candies and pickles. Manufacturing *madha* from lapsi is simple. The first operation is extraction of pulp. For this lapsi fruits are boiled in water mixed with common salt. After proper boiling seeds are separated and kept in containers. It has been learned from the local businessmen that 4 *pathis* (about 12 kg) of lapsi can produce 7.5 kg of *madha*. Market price of *madha* in Kathmandu is Rs 130–145 per *dharni* (1 *dharni* = 2.5 kg). The total cost for manufacturing *madha* is about Rs 45/*dharni* including lapsi. Farmers sell lapsi for Rs 15/*dharni*. Thus, the net benefit of selling *madha* is = Rs. 95/*dharni*.

Thus if the funds of FUGs are utilised for establishing such a processing or manufacturing unit, local people can generate large amounts of money. Also, there are a lot of other NTFPs such as lokta (*Daphne bholua*) for paper manufacturing, nettle and nigalo. The other most interesting product is sal leaves. Sal leaves are highly demanded in Kathmandu. A market survey of sal leaves shows that the price for a bundle of 60 sal leaves is Rs. 2.50 in Bhaktapur. The cost of collection of sal leaves is estimated about Rs. 0.50 per bundle in the rural areas. Benefits form sal leaves can also be maximised if they are sold in the form of *tapari* (sal leaves plate). In rural areas, most of the people are unemployed. If such unemployed people are used in preparing *tapari* they can earn some income to improve their livelihood.

4.3 Networking: maximisation of community resources

FUGs having similar objectives, attitude and natural resources can be organised into an association, or a network. Networking helps FUGs to start many forest-based industries and conduct community development. For this, they need fund for establishment. Table 1 shows the income and expenditure of 16 FUGs during Fiscal Year 2053/54 (1996/97). The income of FUGs varies from Rs. 227 (Ampghari) to more than Rs. 100,000 (Nadung Liping). But the average figure is about Rs. 18,689 per FUG. Thus if five FUGs are united to form a network, they can easily run an industry that requires an initial investment of Rs. 100,000. Moreover, income from CF is more or less constant. In fact, it will go on increasing every year rather than decreasing. Study of Karkitar FUG account has shown that average income from the forest till 2053/54 was about Rs. 1,200 per year. Last year the income increased drastically to Rs. 55,000 and the same level of income is foreseen for this year too.

Table 1. Income and expenditure of FUGs during Fiscal Year 2053/54

Range post	Name of the FUG	Income (Rs.)	Expenditure (Rs.)
Jalbire	Sisne Dhansar Mankha-6	7,891	4,954
	Ambaghari	35,298	25,246
Sikute	Pandherakhola	5,313	449
	Karkitar, Sathimure	13,332	12,603
Dandhapakhar	Bhanjyang, Attarpur -8	8,615	2,485
	Vesipa, Thulopakhar - 6	165	–
Barhabise	Nadung Liping, Tatopani	1,26,593*	77,817
	Sunkoshi, Barhabise	22,523	8,271
Chautara	Kamala Mai, Sanusirubari	3925	2,616
	Jalpa, Sanusirubari	24,855	11,515
Banskharkha	Tite, Dubachaur – 9	11,380	1,514
	Nurbuling, Kiul -9	23,421	11,921
Bansbari	Ampghari, Bansbari –5& 6	227	227
	Dahpokhari, Hebaung - 9	3,420	3,085
Nawalpur	Bismure, Sipapokhari – 2	8,608	335
	Nigre Panighat, Nawalpur-2,3	3,455	1,450
Total	16	2,99,023	1,60,711
Average		18,689	10,044

* Nadung Liping FUG has estimated about Rs. 11,039,500 income for the Fiscal Year 2055/56 (1998/99)

Various products, particularly NTFPs are available in community forests but in small quantity so FUGs often cannot bring them to the market or run a small processing unit. There is no active marketing on their part, NTFPs are sold only when a buyer approaches them. FUGs are ignorant of market prices and sell at the buyers' price which is way below the market rate.

Examples from some FUGs on mobilising local resources and CF's income are encouraging. Seven FUGs in the Danadhapakhar Range Post have already initiated to form an association (network) to maximise the benefits from medicinal plants in their CFs.

Many FUGs have already formed sub-groups within themselves to maximise benefits from local resource mobilisation. From the income of CF, they have conducted many community development programmes such as literacy classes, road maintenance, drinking water project, irrigation, etc. For these activities they have mobilised both internal and external resources (human, material and financial).

However, there are several bottlenecks for effective networking. At the most basic level, FUGs are unable to identify which forest product or plants have potential economic importance, where they can be sold and their prices. Moreover, political motive of the local élite, ethnicity and cultural values also sometimes hamper the process of networking. Therefore, care should be taken to form a network of FUGs having similar needs and socio-cultural setting.

5. Conclusions and recommendations

From the above analysis of the situation in Sindhupalchwok, the following inferences can be drawn:

- Significant amount of money can be generated through intensive forest management. Various community development activities can be conducted if FUGs increased their income through forest-based industries.
- Concept of networking is emerging to maximise the local resources by using the income of FUGs.
- Existing forest management plans are primarily focussed on producing large sized timber.
- Forest management is protection-oriented rather than production-oriented.
- FUGs operational plans are not focussed on forest management and also do not contain a holistic approach of community development.

CF is understood as an umbrella term denoting a wide range of activities which link rural livelihood with forests and trees, and the products and benefits to be derived from them. Objectives of CF should not be focussed on only one component – forest management. Depending on the range and diversity of these linkages, and the span of different disciplines involved in various aspects of CF, it requires focussing on different dimensions of rural livelihood. CF is therefore not a separate discipline, or even programme, but one dimension of forestry, agriculture, rural energy and other components of rural development.

In a community where the majority of people are worried about their next meal, financial resources often become the barriers of development. Studies have shown that FUGs have collected considerable amount of money from the sale of forest products and others. At present this resource is not used properly. They have no proper vision of mobilising this fund for optimising benefits. FUGs are not confident whether investment in various activities such as establishment of small forest-based industries will provide them benefits or not. Moreover, there are many other local natural resources, which if managed properly can also generate income to the local community. Therefore, the problem is not simply the lack of financial resource but the lack of confidence and knowledge on resource mobilisation and management.

However, it is unrealistic to expect CF programmes to achieve social and institutional changes at a pace faster than is taking place within society as a whole. The process of learning about and improving the application of CF is a continuous one and one in which we are at a relatively early stage on the learning curve. Nevertheless, it is clear that we are now at a point where the knowledge and experience that has accumulated over the past decade or more is being usefully consolidated.

Moreover, impediment to integrate CF into community development has to be removed. For this the following recommendations are made:

- Revise the existing CF operational guidelines and include the concept of holistic community development;
- Strengthen human and institutional capability, particularly in natural resource planning and management;
- Develop and operationalise practical, and easily learnt forest management systems suitable to local conditions :
- Change policy to incorporate wildlife management and ecotourism as one of the components of forest management/community development

References

AIDAB. 1994. *Towards a Sustainable Future,* BPD Graphic Associate, Australia.

Anderson, K. E. 1995. Institutional Flaws of Collective Forest Management, *Ambio* 24(6): 349–53.

Baral, N. R. 1998. Fuelwood Trade in Sindhupalchowk: A Paper Presented at the National Workshop on Wood Fuel Trade in Nepal, 18–21 August 1998, Dhulikhel, Nepal.

FAO. 1978. *Forestry for Local Community*, FAO, Rome, Italy.

FAO. 1989. *Women in Community Forestry: A Field Guideline for Project Design and Implementation*, FAO, Rome, Italy.

FAO. 1992. *Community Forestry Ten Years in Review*, FAO, Rome, Italy.

Hobley, M., Campbell, J. Y., and Bhatia, A. 1994. Community Forestry in India and Nepal Learning from Each Other, *The Nepal Journal of Forestry* 8(3): 27–47.

Repetto, R. 1988. *The Forest for the Trees? Government Policies and Misuse of Forest Resources,* World Resources Institute, Washington DC, USA.

Mathema, P., Dutta, I. C., Balla, M. K. and Adhikary, S. N. (eds.). 1999. *Sustainable Forest Management.* Proceedings of an International Seminar, 31 August – 2 September 1998, Pokhara, Nepal.

Social Dimension of Sustainable Forest Management in Tribal Areas of India

D. Debnath

Abstract: The natural forests and the indigenous people of India have symbiotic and mutually re-enforcing relationship. Due to the introduction of the forest management system that did not consider the livelihood of the indigenous people, forest degradation occurred. At present major emphasis has been given to learning from the local people, and the foresters and NGO workers are thinking about the indigenous people's input in forest management. This paper presents two case studies on new approaches to ecological security for economic and sustainable development.

1. Introduction

The United Nation's World Commission on Environment and Development (WCED) defined sustainable development based on "human needs and sustaining livelihoods" but more technical definitions of sustainability was given by the International Tropical Timber Organization (ITTO) in terms of a ecosystem's continued production of goods or services and maintenance of biodiversity. Sustainability is best secured by decentralising the management of resources upon which local communities depend and giving these communities an effective say over the use of the resources. It requires community initiative, people's empowerment, and strengthening of local democracy. Sustainable Forest Management (SFM) recognises that forests must be managed as complete ecosystems to supply a wide array of goods and services for current and future generations. "While the concept of SFM continues to evolve, some elements are common to most definitions. First is the forests should be managed in ways that meet the social, economic, and ecological needs of current and future generations. These needs include non-timber goods and ecological service" (Abramovitz, 1998).

Forest management should maintain and enhance forest quality, and look beyond the stand to encompass the much larger landscape so that biodiversity and ecological processes are maintained. When trees are cut, the rotation period should follow the longer natural cycle of forest rather than a shorter financial cycle. SFM seeks to mirror the conditions in natural forests that are heterogeneous. The social dimension is the most challenging one. Because people who live in or near the forest and those who are distant from it, are demanding to participate in decisions on how forests are managed. Instead of managing for the people we now manage it with the people.

2. Distribution of the Indian tribals

According to 1991 census, there are 596 communities which are listed as Scheduled Tribes numbering 67.76 million individuals constituting nearly 7.96% of the total Indian population. These tribals are geographically distributed in seven regions (Sharma, 1989):

- Central-Southern tribal regions: comprise Bastar and surrounding tribal areas in southern Madhya Pradesh, southern belt of Orissa, eastern tribal belt of Maharastra and northern tribal belt of Andhra Pradesh.
- Central-Northern Tribal belt: comprises the Chotanagpur belt of Bihar, eastern tribal belt of Madhya Pradesh, northern tribal belt of Orissa and western tribal belt of West Bengal.

- Western tribal belt: comprises the southern tribal belt of Rajasthan, eastern tribal belt of Gujarat, western tribal belt of Madhya Pradesh and northern tribal belt of Maharastra as well as Dadra, Nagar Haveli and Daman.
- North-Eastern tribal region: comprises (a) hilly areas in Assam, Meghalaya, Nagaland, Arunachal Pradesh, Mizoram, Manipur, Sikkim and northern West Bengal and (b) the plain areas in Assam and Tripura.
- North-Western Tribal belt: comprises the tribal belt in the hills of western Uttar Pradesh (UP) and northern Himachal Pradesh (HP).
- Southern Tribal pocket: comprises the tribal areas on the trijunction of Tamilnadu, Kerala and Karnataka.
- The Oceanic groups: comprise the tribal communities in Andaman and Nicobar Islands and Lakshadive.

The tribals are distributed in all the States of Indian Union except Punjab, Haryana and the Union Territories like Chandigarh and Delhi. About 93.8% of the total tribal population are living in rural areas and the rest (6.2%) are living in urban areas. About 60% of tribal population are living in the vicinity of forests and 65% of the tribal areas are located within forests. The Himalayan region which consists of Assam, Meghalaya, Arunachal Pradesh, Nagaland, Manipur, Mizoram, Tripura, hilly part of UP and HP have 12.3% tribal population. Middle Indian region which consists of Bihar, Orissa and Madhya Pradesh have 55% of the total tribal population. Western India which consists of Rajasthan, Maharastra, Gujarat, Goa, Dadra and Nagar Haveli have 26% of the total tribal population. South Indian region which consists of Karnataka, Andhra Pradesh, Tamil Nadu and Kerala have 6.4% of the tribal population. Andaman and Nicobar and Lakshadweep have 0.13% of the total tribal population.

3. Forest policy and tribals

The tribals treat the forests as their home and consider themselves as the Lords of forests. Based on the relationship of the forests, the Indian tribals are recognised as *Vanyajati*, *Vanaputra* and *Vanabasi* and can be broadly categorised into: (a) Primitive tribes or Primitive Tribal Groups (PTG) and (b) Shifting hill-cultivators.

The tribals formed the bedrock of Indian civilisation which was described by Rabindranath Tagore as *tapovana sanskriti* (ecological civilisation). From the hoary past, homogeneous social groups of tribals controlled a certain land area as common property resources in an organised manner. Sometimes the land area was marked under the names of clan, lineage or smaller social groups. The flow of materials was largely restricted within the territory, though there was some trade on honey and ivory. They had a real stake in the security of the resource base of their territory and evolved a number of cultural traditions to ensure its sustenance. They had some way of selective retention of some species like mahul and mango, at the time of felling during slash and burn. Furthermore, certain areas of terrestrial as well as aquatic ecosystems were set apart as sacred and immune to all human interference. There were a number of restrictions enforced by the community as to how harvests from common property resources such as community woodlot were to be made. Apart from sacred groves, there were some sacred trees like banyan (*Ficus bengalensis*) and pipal (*Ficus religiosa*).

The British turned this social utilisation into State management which was oriented towards the production-cum-commercial forestry. The Forest Department came into being in 1864 but the tribals were living in the forest areas for centuries. Prior to the establishment of Forest Department there was obviously no restriction on the use of forests for meeting their daily needs. After the survey of the forest area, they declared forest areas as reserved forests and protected forests so that the tribals were alienated from their own birthplaces. The traditional rights of the tribes were changed into merely privileges in respect of fuelwood, timber, grazing and were confined only to villages in and around the periphery of forest areas. The curtailment of tribal rights over forest resources under the 1894 National Forest Policy was a major blow to the rights of forest dwellers, initiating a process of alienation. For more than a century, tribals have been squeezed between the alienation of their land to money lenders and high caste Hindus and the loss of their forest resources to contractors and State agencies. This had led to animosity and deep-seated antagonism between tribals and foresters and was not improved by the general attitudes of government agency or staff towards forest communities (Poffenberger, 1995). This was further modified and various earlier facilities were further curtailed by regulations passed in 1927 and 1935. In this way the British raj gradually tried to bring the forest areas under their control for timber extraction and revenue earnings.

After independence, the first National Forest Policy was declared in 1952 giving importance to national interest and transferred the reserved forest into "National Forest". The rights of the tribals were reluctantly converted into some concessions. It created a chaotic situation when all the forests came under State control resulting in slack discipline in the management of forest together with the intensification of demand on forest resources. Government policy to control encroachment in forestlands encouraged more and more people to cut forest. The tribal resentment has been due to the complete denial of ownership status of forestland to the tribals which has been under their virtual control over generations. There has been a strained relationship between the tribals and forest officials with the latter implicating the former in any damage to the forest which is often done by the outsider's control. In 1961 Dhebar Commission reported the importance of forests in tribal life and impact of such forest policy in tribal life and economy. In 1976 National Commission on Agriculture (NCA) recommended drastic reduction of people's rights on forests. In 1982, the report submitted to the Ministry of Home Affairs, under the chairmanship of eminent anthropologist Professor B. K. Roy Burman, urged to integrate the forest policy and tribal sub-plans for the benefit of tribal economy, regional economy and consequently national economy to balance the ecology through conservation of soil, moisture and plantation programme. In the context of forest management Professor Roy Burman commented:

> "The tribal communities are not only forest dwellers but also for centuries they have evolved a way of life which, on the one hand, is woven round the forest ecology and forest resources and on the other, ensures that the forest is protected against degradation by men and nature" (Roy Burman, 1982).

This paper discusses the tribal's decision-making process and institutional mechanism in forest management.

4. Forest protection

Forest has been a common property resource since time immemorial. At present it is owned by the State. But by norms, customs, and conventions, it is a common pool natural resource. The State has taken sole responsibility to protect the property with its trained forest officials but the Forest Department has been unable to protect the forest from the various biotic and anthropomorphic factors. Hence the good forest area has receded to 10–14% of the total land area. At present forestry does not mean protecting the demarcated area by forest officials but developing the forest with the help of people. Since 1990s many case reports have showed that thousands of community protection groups have regenerated an estimated 40,000 ha of forests of Orissa, Bihar, Gujarat, Rajasthan, Karnataka, Madhya Pradesh and Andhra Pradesh (SPWD, 1993). These village groups have started protecting forest patches adjoining their villages in response to resource scarcity. The forest protection movement is very strong in Orissa and especially in the districts of Puri, Dhenkenal, Angul, Mayurbhanj, Sambalpur, Keonjhar and Bolangir. At several places even local federations have been formed. In Sarangi range in Dhenkanal the first community started forest protection as early as 1950. By mid 1990s almost all of 20,000 ha of the forestlands in the territory fell under the protection of individual hamlets. In a personal communication to Mark Poffenberger, Madhu Sarin—a freelancer in Society for the Promotion of Wastelands Development (SPWD)—commented that during that time indigenous people protected 600,000 ha of forestland whereas the government became successful in planting trees in only 5,000 ha of revenue land under social forestry project (Poffenberger, 1995).

In the tribal belt of south Bihar many village groups have been protecting forests since 1970s and 1980s in spite of meagre resources and strained relationships with Forest Department. Such groups can be seen in Hazaribagh, Ranchi, Singhbhum and Dumka districts. Most communities wanted some recognition of efforts that they have put in to protect and regenerate forests by contributing grains, money and voluntary labour.

In Gujarat forest protection efforts in tribal areas are well documented in Panchmahal district. Over 60 village groups have been protecting and regenerating degraded teak forests for many years. In Madhya Pradesh some information has come from Chhatishgarh area that some self-initiated forest protection groups have been originated. But the cases have not been documented so far.

5. Case studies

To show the social dimension of sustainable forest management and people's participation in forest protection, two case studies have been developed from tribal areas of Bihar and Madhya Pradesh.

Case I: Community organisation in protection and management of forest

This is a case of community mobilisation by a charismatic village leader. It emerged as an example of self-initiated forest protection by local communities when large scale felling and coupe selling to the contractors by the Forest Department was at its peak. The large-scale resource scarcity occurred due to individual felling or extraction by the Forest Department. Under these circumstances in early 1970s, Simon Oraon, the leader in the Parha panchayat of the Oraon community organised several meetings involving adjacent villages to protect its nearby forests from the contractors and the government.

This case study was done in the village Khaksitoli, a hamlet of Haripur-jamtoli, located 4 km away from Ranchi-Gumla-Bomaby highway and about 35 km south-east of Ranchi. One can clearly differentiate Khaksitoli from other villages by the well-grown surrounding forests. The approach road of the village is well maintained. Anyone can be taken by surprise while looking at the massive road-side fruit trees plantation which was initiated more than 30 years back. The village has an impressive forest, with sal *(Shorea robusta)* covering an area of about 73 ha. On entering the forest one can find a huge plantation of fruit trees like mango *(Mangifera indica)*, jamun *(Syzigium cumini)*, mahua *(Madhuca latifolia)* and jackfruit *(Artocarpus heterophyllus)*.

At the beginning, the villagers were inspired and guided by Simon to protect the forest. But work did not progress well. Later the total forest area was distributed to three forest protection committees viz. Jamtoli, Khaksitoli and Bertoli. The same village was assigned the task of guarding the forest without affecting their normal agricultural activities. The women also participated in this venture.

There were some incidents of conflicts between the contractors and the villagers. One was in 1978 when the forest was sold to a contractor by the Forest Department. The local people were determined to save the forest by defending with bow and arrows. When the contractor failed to work in Khaksitoli, another contractor played a clever game. Instead of trying to purchase the trees of that forest, he secured a license to collect stones from that forest. When he installed a stone crushing machine, close to the Khaksitoli forest the villagers thought that the scattered stones would be collected for crushing, hence they did not object. To their utter surprise, the labourers were digging out stones surrounding the roots of the standing trees. As a result, a few standing trees fell down and the labourers took the log to the contractor. When they understood the trick, the villagers seized all the equipment of the contractor.

Till 1991 the self-initiated committees were functioning as informal bodies. But after the notification of Joint Forest Management, a formal Village Forest Protection Committee (VFPC) was formed under the name *Gram Van Prabardhan aur Samrakshan Samity*. They drew up many rules and regulations to institutionalise their innovations. There are 18 general members of which seven are executive members. The function of the committee was also to protect forests and distribute the forest products.

The indigenous system of management that they imposed is more protection-oriented rather than use-oriented. The community has specific use rights. All households have equal rights in the community. Villagers are usually allowed to collect dry woods for fuel. On genuine requirement of woods such as burning of the dead body, the request is made to the executive committee or in an emergency to the village headman. To some extent fodder is available as fodder trees are planted near every house with community efforts. Free grazing is strictly prohibited. There is a common local understanding that villagers should never let their cattle into the forest as they have a separate grazing land. The villagers have equal rights to collect non-wood forest products for consumption and sale. The Khaksitoli committee once did multiple shoots cutting in the year 1991. All the villagers got equal share from selling of small woods. It has been in practice for the last 25 years to contribute voluntary labour once a week for village development. The labours finally paved the way for many development activities such as construction of road, dam, building, digging ponds, plantation along roadside, nursery work, helping other villagers in agricultural works or in emergency, and controlling forest fires. By their own effort, the villagers developed an excellent orchard within the forest and maintained it like a commercial farm. They have sown many mango seeds after eating the mangoes. They have prohibited anyone from collecting green mango from forest. In the last 30 years only locally available plant species have been planted and the survival rate has been very high.

Previously tribal people used to perform an annual *Bishnu shikar* (Hunting ceremony). A lot of damage was done to the forest. So they stopped the festival by a unanimous decision in a meeting. The forest had some sacred groves (*sarna*) on the hilltop. The villagers had great faith and respect for them. All the *sarnas* were covered with sacred trees and vegetation of large number of plant species. When there is violation of the norms and rules, fine and social boycotting are imposed.

During the field study villagers could easily identify as many as 35 forest species which are used in their day to day life as food, fuel, rope, fodder, oilseeds, medicine, manure, house construction and many other needs. Mango, fuelwood, sal seed, lac and mahua flower are sold in the market. Local children reported that there were a number of fruits available in their forest like pithor *(Zyziphus mauritiana)*, kend *(Diospyros melanoxylon)*, mango, mahua, jamun and aonla *(Emblica officianalis)*. In September–November people collected varieties of medicinal herbs from forest to use round the year. Local people still used many plants like kusum *(Schleichera oleosa)*, sal, vhilwa *(Semicarpus anacardium)*, dhawrd *(Anogeissus latifolia)*, kalihari *(Gloriosa superba)* and twigs or leaves for different occasions.

Case II: Social fencing and community banking

In the wake of such community initiative mentioned above progressive foresters also motivated the local people in protecting and managing the forest in tribal areas. Arabari is such an experiment in West Bengal. In response to the success of some experiments, the Government of India provided impetus to people's involvement in forest management by issuing a circular on 1 June 1990 (N.6.21/89-FP) in pursuance to the National Forest Policy, 1988 which envisages in its objectives the active involvement of local people in the protection and development of forest resources. Various State Governments have taken follow-up action to constitute Village Forest Protection/Development Committees in States to involve the people in managing forest resources and sharing of benefits. Till date, 20 States have passed resolutions on Joint Forest Management (JFM). In Madhya Pradesh the first Joint Forest Management order no. F-4-10-2-91 of 10 December 1991 and the next order no. F-16-4-10-2-91 of 4 January 1995 were issued. Forest Protection Committees were formed in different parts of the State, particularly in Harda, Hoshangabad, Dewas, Umaria, Burhanpur, Jhabua divisions. This case study was done in the Harda division.

The Harda division lies in Hoshangabad district of Madhya Pradesh. It has a total forest area of 1,41,749 ha. There were degraded forests of teak and miscellaneous species subject to pressures of overgrazing and fuelwood removal, but still possessing remnant rootstock. After introduction of JFM, 136 Forest Protection Committees (FPC) and 50 Village Forest Committees (VFC) were formed. Over 75% of that forest area came under the protection of these committees. This case study was done in Amakatara village, a forest village under Temagaon range of South Harda sub-division where a FPC was formed. The total forest area under it was 1333.3 ha and the agricultural land was 75,000 ha. There are 27 households with a total population of 189. Two tribal groups, Korku and Gond inhabit the village.

Before 1991 the villagers were not very happy, as they were very poor. They survived on the kodokutki (a less nutritious local food grains). They depended on outsiders who gave them money for grazing livestock in the common pastureland of the village. The Forest Department sued various cases against the villagers for illegal utilisation of the forest without permission. They did not take interest in controlling forest fire and in wise use of the forest areas. The villagers started selling charcoal and fuelwood. In this way there was much pressure on the forest.

In 1991 B. M. S. Rathore, the Divisional Forest Officer of the Harda division came in the village for coupe felling and met with the villagers. They were discussing the situations of the village. He assured that if they protected the forest for one year, the Forest Department would provide them with benefits. Realising the futility of policing the forests, the forestry staff took the people as their partner in forest management.

After that the people were convinced and a Forest Protection Committee was formed. The Committee has one representative from each family as member. The executive body consists of nine members. The forester in this beat acted as the member secretary. They took the headman of the tribal village as nominated member. The general body meeting was held every month. Sometimes the DFO also attended the meeting. They closed some compartments of the forestland covering about 559 ha and kept open for the grazing.

The DFO also utilised the World Food Programme which provided essential commodities at half of the market price against the wage. So the people stopped all illegal exploitation inside the forest. This also encouraged the villagers in forest protection and management. Each family deputed one or two members for patrolling and protecting the forest from tree girdling, fire and grazing. The villagers adopted rotational grazing and harvesting of forest produce. Social fines were imposed for forest offences and violations of grazing restrictions. They set up some social norms in connection with fuelwood collection, grazing, and protection of the trees.

The Forest Department organised several training programmes for capacity building and welfare activities. In this division there is an eco-development centre at Rahatgaon, 17 km from the village. This is a training centre for income generating activities viz. handloom, bee-keeping, sericulture, medicinal plants collection and herbal medicines production, nursery raising, horticulture, mushroom cultivation, cottage industry for making small bags and agroforestry. Due to social fencing, bumper production of the grass have taken place and these are being sold through Forest Department to the military dairy in Lucknow. So each family now earns nearly Rs.3,000 per year by selling grass. The Forest Department also provides job to the villagers in digging of staggered trenches. The allocation of the works is done through the executive committees of the FPC to ensure people's participation and economic upliftment of the poorer section.

Female self-help groups have also been formed. Each group has 10 members. Each member deposits Rs.10 per month in the account. The bank has given loan to this self-help group to purchase a sewing machine. Now they also produce cash crops like soyabean and wheat. The voluntary efforts of the farmers to undertake soil and water conservation in the village have led to an increase in productivity. This has been possible due to the supply of seed and application of fertiliser with the help of social banking and lift irrigation constructed by the World Bank assisted Natural Regeneration Project. Other forestry activities are the cut-back operation, singling of multiple shoots and lantana eradication.

Another most positive innovation of the FPC is the concept of community banking. A common account on behalf of the committee has been opened in a bank where the members deposit a certain amount from their earnings. The account now has Rs.116,000 (as of 30 September, 1996). From the social banking they are running a primary school. There is report of social conflict between the villagers of Temagaon and that of Amakatara. The villagers of Temagaon has the practice of grazing in the forest between two villages. But the FPC of Amakatara does not allow this.

6. Discussion

The similarities and differences between the two case studies are shown in Table1. From the two cases, we find that improved access, strengthened community organisation, improved forest management technology, institutional transformation, and new ways of learning have been instrumental in forest protection, management and use.

Table 1. Similarities and differences in the two types of protection

Characters	Khaksitoli case	Harda case
Initiative	Self-initiated protection	Govt.-initiated protection
Leadership	Traditional leader	External (DFO)
Sensitisation	By the villagers themselves	By the DFO
Motivation	By the village leader	By the Forest Dept. staff
Institution	Revived social norms, rules and conventions	Prescribed social norms and rules
Voluntarism	More	Less
Innovation	Women's involvement, abolition of traditional festival, multiple shoot cutting, planting of fodder trees and mango, conservation of indigenous species.	Revival of old practices, capacity building, skill development, installation of bio-gas plant and smokeless stoves
Management system	Protection-oriented	Process and use-oriented
Operational plan	Through process of discussion	Micro-planning
Implementation	Participatory	Mobilisation and participatory

Sustainable forest management requires leadership first to empower the villagers either from inside or outside. It combines both ancient traditions and emerging strategies. It is rooted in the concerns and initiatives of India's villagers. Sometimes this natural regeneration is taking without government projects and sometimes within government schemes. The old system of common property resource management regime is getting revived either by the people or the government. Sustainable forest management in tribal areas in India is providing valuable examples of collective community forest management where homogeneity, leadership, voluntarism, indigenous knowledge, organisational innovation and institutional activities play an important role in decentralised programme of rural development.

References

Abramovitz, J. N. 1998. Sustainable Forest Management. *Wastelands News* May–July, 1998, pp 75–78.

Poffenberger, M. 1995. India's Forest Keepers. *Wastelands News* Aug–Oct. 1995, pp 65–79.

Roy Burman, B. K. 1982. Report of the Committee on Forest and Tribals, Ministry of Home Affairs, Government of India, New Delhi, India.

Sharma, B. D. 1989. Planning for Tribal Development, New Delhi, India.

SPWD. 1993. Joint Forest Management: Concepts and Opportunities, Proceedings of the National Workshop, August 1992.New Delhi, India.

Mathema, P., Dutta, I. C., Balla, M. K. and Adhikary, S. N. (eds.). 1999. *Sustainable Forest Management.*
Proceedings of an International Seminar, 31 August – 2 September 1998, Pokhara, Nepal.

Changing Face of Nepal's Tropical Forests

M. S. Haque

Abstract: Nepal was known as an exporter of tropical timber until 1950s but this scenario has been changed and the country has become a net importer due to lack of proper management of forests. Since 1950s more than 60% of the forests has been deforested and half of the remaining forest is badly degraded. Sustainable development of the resource is essential if the country is to uplift the quality of life of its present and future generations. This paper focuses on the root causes of forest degradation and deforestation in order to improve development planning and to ensure sustainable development of forests.

1. Introduction

The Terai is a narrow plain extending from east to west and bordered by Siwalik range to the north and India to the south. The climate is sub-tropical humid monsoon with seven months dry season from October to May. The average annual precipitation is about 2000 mm and 95% of this rainfall falls in the monsoon season, i.e. June to September (Hawkins, 1986). Major forest types of the region are sal forest *(Shorea robusta)*, Tropical Deciduous Riverbank (TDR) forest, and *Dalbergia sissoo/Acacia catechu* (DS/AC) forest. The total area of the later two forest types is smaller than the total area of sal forests. Sal forests occupy the plain areas and the slopes of Siwalik hills up to an elevation of 800 m. The DS/AC forest is found growing on alluvium whereas TDR forest occupies the upper banks of the stream channels and gullies.

Soils of the Terai can be divided into two distinct groups: the fertile clay loams and Bhabar soils. The clay loams are found south of most of the remaining sal forest and agriculture is the predominant land use. The Bhabar soil is a complex of alluvial sediments of sand and gravel that overlay the clay loams found further south. Average depths range from 20 to 50 m depending on the site (Hawkins, 1986; Howell, 1987).

Sal forests are the primary source of timber and fuelwood for the country. About 6 million tons of fuelwood is extracted annually to meet the national demand. Increasing number of landless people with high birth rate, minimal literacy rate and unemployment combined with mass migration of hills people have increased the demand for more forest produce as well as for forestlands for subsistence farming. Consequently, the forests are being denuded faster than they can be replaced and faster than they can replace themselves (Wunder, 1987).

Out of over 300,000 ha of the forest, 100,000 ha are badly degraded (Wunder, 1987). Most degraded forestland is located near settlements along transportation corridors and agricultural land. A thin overstorey canopy with virtually no regeneration, severe erosion and low organic matter content characterise these degraded forests. Encroachment and overexploitation are principal agents in the degradation of the forests in Nepal Terai (Barraclough and Ghimire, 1990).

Brewbaker (1983) has predicted that the sal forest ecosystem in the region will not be able to contain the rising pressure and may not even exist by year 2010. Faced with the continuing degradation and potential loss of an important forest resource base and a critical habitat for diverse and unique flora and fauna, development of sustainable alternative for the remaining sal forest is crucial (Bhattarai *et al.*, 1985). This paper addresses the major issues in order to improve development planning and ensure appropriate and sustainable development activities.

2. Methodology

This paper is a part of the research conducted by the author for the "Rehabilitation of Degraded Forest Lands in the Terai, South of Siwalik Hills, Nepal", a project funded by FORSPA/FAO in 1995.

Out of 20 districts of the Terai region, two districts Bara and Rautahat were selected for detailed survey. Village Development Committees (VDCs) within the forests or adjoining the forests of the districts were identified. Two VDCs (Nijagadh and Haraiya) from Bara and one (Rangapur) from Rautahat were selected randomly. A sample of 5% households (hhs) from each VDC was randomly selected through equal allocation method.

Semi-structured interviewing was done to collect information on the communities and forest relationship; forest management issues; forest produce use pattern; government policy and their impact on the forest. Structured questionnaires were used to collect socio-economic data for the sampled hhs. In addition, Key Informant Survey (KIS) was used to collect information, which relate to the forest degradation history of the region. The key respondents were older villagers, teachers, social leaders, and working officials. Fifteen to twenty respondents were interviewed in each VDC under this survey.

To know the impact of settlements on surrounding forests in walking distance (approximately 2 km radius from settlement), forest inventory was conducted. To assess the forest status, recent aerial photographs (1989–90) of 1:25,000 scale were used. Circular areas of about 2 km radius around each settlement were delineated on the photos. Then the delineated areas were stratified according to crown cover density. Each stratum was interpreted to know the forest status e.g. stocking class, stand size, and forest type. Detailed field survey was conducted to crosscheck the result, as well as to assess the regeneration status.

3. Results and discussion

The results are based on reconnaissance and integration/analysis of socio-economic and biophysical data, review of past/present government policies and their impact on the forest resource of the region. The study revealed that the following are the main causes of the tropical forest degradation of Nepal.

The major deforestation of the forest occurred due to development works and resettlement schemes. Settlements of migrant population within and around the forest areas are a major cause of forest degradation. The migrants depend heavily on the forest for their survival. The people of the region also expressed that *sukumbasi* (landless) problem seems to be a never-ending problem. Hills people who are not even landless have been in business of getting the forestlands free and eventually selling them. During the study, we also found that more than three hundred people got forestland in the name of *sukumbasi* under resettlement scheme in the Haraiya VDC but they never settled there and sold some of the land to local people and some lands are still for sale. Hundreds of hectares of forest were clear-cut in the Haraiya VDC alone for this purpose. The study reveals that 10% population of the region (about one million) is landless. The problem cannot be solved on an equitable basis even after allotting the total available forestland of the region under the present resettlement scheme of the government.

The region is also facing an acute problem due to the activities of shifting cultivators. Shifting cultivators come down to the region from hills/mountains. First, they encroach forestland and build their houses, and gradually clear some forestlands for agriculture. After a couple years, the new comers from hills/mountains come and buy the lands/houses from illegal owners. The illegal owners then move to another spot and repeat the process. The officials cannot do anything to prevent them from encroaching and depleting the resource. The local people expressed that the officials have been encouraging the people to encroach more forestlands rather than discouraging them.

As the distance increases from the forest, people are found less dependent on the forest resource and have developed their own resources to fulfil their requirements. It was also found that most of the local villagers have very little awareness of government forest policy. A majority of people interviewed expressed that deforestation and degradation of the Terai forest is particularly due to the government policy of settlement schemes within the forest area. The concerned agencies are least interested to develop the resource on sustainable and equitable basis. They say, the concerned authorities have not been paying any attention to helping the local people meet their basic needs for forest produce. Even the Timber Corporation of Nepal (TCN) has not been fulfilling the needs of local people.

Poverty, landlessness, illiteracy, and unemployment are serious issues in the region. Agriculture, animal husbandry, and labour migration are the basic economic pursuits of the rural people. Some people practise small-scale entrepreneurship, e.g. roofing tile industries, brick industries and pond fisheries. While majority of the population (90%) in all three VDCs engages in farming, many are so poor that they are unable to meet the minimum annual family food requirements. The study found that no more than 30% of the households in the VDCs produce enough food to last year around. The poor people who have no alternative, engage in overexploitation of nearby forest for subsistence living. The survey found that more than 20% of population of Nijagadh and Rangpur VDCs and 10% of Haraiya are landless. It is quite clear that no matter how fertile the Terai lands are, and no matter how intensely the land is being farmed, many people are facing food deficit. Tenancy is a large and problematic issue in the region.

Different types of land tenure were found in the VDCs, e.g. *mohi*[1] land, purchased land, inherited land, *bataiya*[2] land, and leasehold[3] land. *Mohi* land tillers got tenure right of the lands they previously tilled as tenant under ceiling act of 1960s. Almost 50% of agricultural land in Rangpur VDC are held by 10% population whereas in Nijagadh and Haraiya 30% of the land is held by 10% population. Half of the population in Rangpur VDC holds 7.8% of cultivated land area whereas in Nijagadh and Haraiya VDCs, 50% of population holds 13.7% and 18.5% of the land area. A great deal of disparities in agricultural land distribution was found in the region. However, cropping pattern and crop yield of the three VDCs was almost same.

Livestock number was maximum (10 /hh) in Nijagadh VDC, followed by Haraiya (5/hh) and Rangpur (4/hh). Currently all household of Nijagadh rely mainly on grazing on forestland whereas 52% of Rangpur and 25% of Haraiya rely on grazing on forestland.

Income assessment of the three VDCs indicates that agriculture contributes 70% of total income in Rangpur, 65% in Haraiya and 51% in Nijagadh. In Nijagadh service sector contributes 25% of total income followed by Haraiya (17.7%) and Rangpur (2.5%). Per capita income of Haraiya and Nijagadh is Rs. 4,585 (US$92). For Rangpur it is

[1] The system in which tenant has ownership right over half of the land.
[2] The system in which tenant and owner share the product of land.
[3] The system in which tenant has to pay an agreed amount to the landowner.

Rs. 3,223 (US$ 66). People of the VDCs are poor, and 50% of total population is near landless[1]. Having limited or no option for alternate income source, the poorer have little choice for practising agroforestry. Therefore, the nearby forest, even in degraded state, is put under pressure to satisfy their need.

The forest of Nijagadh, Haraiya, and Rangpur VDCs suffer from poor management and overexploitation due to an increasing population, lack of options, illegal and illicit forest produce extraction and smuggling. Encroachment by new comers has become routine. Many poor people have taken to selling fuelwood as an occupation to earn their living. Many young people, almost 10–15 km away from the forest border, have been involved in selling fuelwood. Different modes of transport, e.g. head-load, back-load, shoulder-load, bicycle-load, cart, tractor, truck, and even bus are used. As a result the forests suffer continuing degradation and deforestation.

The study also indicated that location and ethnicity also dictate the use pattern of the resource. Field survey clearly indicates that hills people are more dependent on forest produce than the Terai people. Maximum consumption of fuelwood was found in Nijagadh (35 kg/hh/day). There are more than a dozen tile industry and seven brick industries in the VDC. Though the brick industries have licensed to use only coal but truth is that they use coal during daytime and fuelwood during night. Besides, there are hotels and numerous teashops which have been consuming much of the fuelwood of the VDC. Fuelwood from the VDC are also taken to Kathmandu, Birganj, Janakpur, etc. Therefore, Nijagadh forest is relatively the most degraded forest among the three VDCs.

Terai people of the study areas seldom collect tree fodder; they usually collect grasses from nearby fields. In contrast, hill people always collect tree fodder. Hill's people prefer different species for fuelwood, fodder, and building material than the Terai people. Livestock of Terai people are usually stall–fed except goat and buffalo where as hill people seldom practice stall-feeding.

Distant villages (about 10 km from the forest) have been using mostly crop residues as fuel. Where as those who have been living close to forest, mostly depend upon forest produce. However, Terai people traditionally use crop residues and rely less on forest produce but the hill migrants mostly use tree fodder collected from the nearby forest areas. Reckless use of forest produce and forestland by the migrants was found to be traditional and attitudinal problem, and not due to necessity. This is causing unrepairable damage on forest.

Forests around the VDCs are badly degraded and some of the areas have even been totally deforested. Some areas have hardly 10% crown coverage. Regeneration was almost none within 2 km radius from villages. Pole size sal can be hardly seen in the areas. In the absence of scientific management of the resources and continued official extraction of forest produce, illegal felling and smuggling of timber have put a heavy toll on the dwindling forest resource. As a result, the forest area has been reduced by about 65% since 1950 and half of the remaining forest depleted of trees. In turn, it has been becoming difficult even for people close to the forest to meet their basic needs for forest products. The situation is especially acute in Haraiya VDC. Pressure on the remaining forest areas is intense and is becoming more intense with time.

3. Conclusion

The tropical forests of Nepal have been degrading from periphery towards centre. Due to new settlement on the southern border of the forest, depletion of the resource has been surging northwards and from Siwalik range to the south. The agencies responsible

[1] The household with less than 8 katha (0.264 ha) of land

for protection and sustainable management of the resource are helpless. To check the continued depletion of the resource requires strong political will as well as scientific management and long-term planning of the resource. The survey results show that lack of a coherent resource policy, failure to eject the Terai economy from the cycle of extreme underdevelopment, and inability of the concerned agencies to implement a comprehensive strategy are the main causes of forest depletion in the region.

References

Barraclough, S. and Ghimire, K. 1990. The Social Dynamics of Deforestation in Developing Countries: Principal Issues and Research Priorities. *Discussion Paper 16*. United Nations Research Institute for Social Development, Geneva, Switzerland.

Bhattarai, K., Carpenter-Adkins, R. V. and Lawrence, J. H. 1985. Population Growth: A Challenge for Sound Land Use. *The Rising Nepal* May 6, 1985.

Brewbaker, J. 1983. Fodder and Fuelwood: Nitrogen Fixing Trees for Nepal. Consultants Report. Integrated Cereal Project. Department of Agriculture/Ministry of Food and Agriculture, Kathmandu, Nepal.

Hawkins, T. 1986. Adabhar Trial Site: Research Results (1980–1986). Nepal-UK Forestry Research Project. Forest Survey and Research Office, Kathmandu, Nepal. (Mimeo).

Howell, J. H. 1987. Soil Survey of an Agroforestry Plantation Area of the Terai Community Forestry Project in Bara District. Interim Report. Nepal-UK Forestry Research Project, Kathmandu, Nepal.

Wunder, W. G. 1987. Interim Progress Report: Terai Forestry Project. Technical Assistance to the Terai Forestry Project (UTF/NEP/038/NEP), Kathmandu, Nepal.

Sal Forest Management and Silvicultural Operations

T. Hartz

Abstract: Many hectares of community forests, national forest lands, and land available for private leasehold forests are comprised of stands of mixed sal, *Shorea robusta* (Roxb. ex Gaertn.). This valuable, abundant natural resource requires diligent attention for successful forest management. At Yogikuti, Rupandehi, of the 165 ha private leasehold forestry land managed by Butwal Plywood Factory Forestry Programme, 92 ha are in young sal coppice forest. The company has completed one full inventory on the stands of sal. Also on approximately 59 ha of sal stands, the Programme has conducted thinnings during the last four years. During a 1996 inventory of 74 ha of sal forest, the company discovered a high infestation rate of borers and unidentified, incipient heart and root rots. Three of the pathogens have been tentatively identified from their fruiting bodies. Herein are presented some of the experiences of the company in sal forest management and silviculture. Recommendations are made for conducting simple forest inventories and forest disease and insect surveys. The information from these surveys are then used to formulate stand thinning guidelines to optimise yields and incomes while maintaining long-term ecosystem sustainability.

1. Introduction

In 1985/1986, Butwal Plywood Factory (BPF) Forestry Programme (BPFFP) initiated an agroforestry research project on 131 ha of government land designated for private leasehold forestry at Yogikuti, Rupandehi district of Nepal. The company planted approximately 60 ha of trial plantations of *Eucalyptus camuldalensis, Bombax malabaricum, Acrocarpus fraxinifolius, Leucaena leucocephala, L. diversifolia, Ailanthus excelsa and Populus deltoides*. The company fenced off the 131 ha land and protected it from grazing and wildfire. The Forest Department then indicated the company would best manage an additional 34 ha of adjacent land lying to the east of the then occupied site.

The Programme then began site preparation activities on the sites designated for plantation forestry. Much of the site preparation was simple and successful. A thorough burning of the site had been done where some one to two-year-old sal (*Shorea robusta*) regeneration was growing. In 1988, shortly after site preparation activities were abandoned, dense sal natural regeneration sprouted from the roots and dormant seeds laying in the soil. Although due to prior uncontrolled grazing and wildlife, the site was in a barren degraded condition at the time of fencing in 1986, there were a few scattered residual sal trees. The company then made the decision to manage the 92 ha of sal regeneration as a part of its research and operational forestry activity.

2. Inventories and assessments

Inventories for stand density and site quality, and stand mapping were conducted in December 1994, January 1995 and December 1995. During thinning operations in February 1995, it was seen that a number of sal stems had borer and heart rot damage. Therefore, in the December 1995 inventory, the company included assessments for disease and insect infestation levels.

2.1. Inventory procedures

Inventory sampling intensities for the different surveys were only 1%. Plot size was 0.005 ha (radius = 3.99 m). Plot spacing was 50 m by 100 m. Although large sample sizes were not taken, plot distribution (spacing) and the circular plot sizes were designed to be close enough and large enough to sample stand density, differences, species composition, site quality changes, determination of the extent of insect and disease damage and future crop tree selection. BPFFP defines crop trees as those dominant and co-dominant trees on which management activities will focus attention for harvest at rotation length. All others may be removed during subsequent thinnings during the full rotation of the stand. The company rotation length for the sal forest is only 40 years.

At each circular plot, the following data were recorded:

- Total trees were counted.
- Two to three dominant and co-dominant crop trees were then selected for measurement of height and diameter. Each individual plot tree was not measured due to their small sizes. No volume equation could be expected to give accurate measures of stand volume based on such tree samples.

After inventory, the stands were then stratified by stand density. Post Thinning Stand Assessments were conducted just behind work crews during thinning operations in stands. Since 1997 operations, a Stand Compartment List was included in the Yogikuti Operational Management Plan Stand Register (Hartz, 1997) for the sal forest.

The thinning effect on current stand densities is shown in Table 1. Although no stands were stratified according to site quality, notes were made in plots and stands where site quality was noticeably less. Site quality seems to be reflected in the lower stand densities and the slower mean annual increment of height growth.

Table 1. Pre- and Post-thinning stand densities for sal stands at Yogikuti, Rupandehi

Compartment no.	Area ha	Year assessed	Year thinned	Area thinned ha	Pre thin density stems/ha	Post thin density stems/ha	Average removals stems/ha
C1*	10.1	1995	1995	10.1	NA	4540	NA
C2	15.0	1995	1995	5.4	8800	4500	4300
C2*		1995	1996	5.0	6382	3880	2502
C3	16.6	1995			4256		
C4	18.3	1995			3957		
C5*	16.4	1997	1997	15.7	6152	3900	2252
C6*	16.0	1998	1996	2.2	5966	3900	2066
C6*		1995	1998	9.1	6714	3900	2814

*These compartments were assessed in inventories, however, these more recent tree counts are from the post thinning stand density assessments.

2.2. Disease and insect survey procedures

In the December 1995 inventory, at each circular plot the following procedures were implemented:

- All trees in the plot were counted and at least two dominant or co-dominant trees measured for total height and diameter at breast height (dbh).
- Based on the full count of all trees in the plot, 10% of the total trees were selected for felling and examination.
- Based on the measurement of the two dominant and co-dominant trees, similar dominants and co-dominants were selected since the focus of the survey was to determine the health condition of future crop trees.

- The selected trees were then felled and the stump was examined for borer damage and disease presence.
- All other trees in the plot that exhibited obvious signs of disease, i.e., heart rot or root rot sporophores, knots, butt scarring, foliage and crown decline, bore holes in the stem, mushrooms growing from the stem were then selected to be included for disease or insect infestation tally.
- Trees that demonstrated obvious root rot were pushed over and roots were examined. Samples of root damage and the tree stump were collected and sent to a forest pathologist for proper identification. Sporophores and heart rot stem samples were sent for identification to the Centre for Agriculture and Biosciences (CAB), United Kingdom.
- Trees that demonstrated heart rot sporophores or punk knots were felled. The sporophores and a cross section of the rot in the stem were sent to a forest pathologist.
- Trees that demonstrated insect (borer) damage were felled only. These trees all demonstrated a blue stain around the margin of the borer holes inside the stem. Live borers were found in only a few trees.

Several difficulties existed in conducting this survey. These are:

- Although several different types of heart rot fruiting bodies were found, none could be immediately identified. The pathologist report came eight months after the survey. Some samples were confused during the shipping process.
- Due to a lack of prior training, forestry field staff often confused borer damage with incipient heart rot infection.
- Root rot-infected trees were easily pushed over. These may have also contained a heart rot infection, which was never identified.
- Several times incipient root rot and heart rot fruiting bodies were found just outside of sample plots. Those trees were not included in the data. However, the information was recorded in the stand notes for future reference.

The December 1995 insect and disease survey showed that out of the total 306 trees sampled, 161 had infestation i.e. 52%. Out of 143 plots, 73% contained infested trees.

The two assessments gave the following stand condition insights:

- High stand densities on slightly moister sites showed less infection from disease and less borer damage.
- Trees, which forked from the stump or stool (below dbh) had higher frequencies of borer damage.
- High stand densities demonstrated less butt scarring from fire damage because they had less understorey growth (grasses, weeds and young short sal regeneration).
- Diameter distribution before and after thinning was often quite broad in range. Although there are many "dominants and co-dominants" per hectare, because of their distribution on the site, it is necessary to leave a broad range of diameters to keep good stocking. Therefore, silviculture (thinning) prescriptions could not fix a leave-tree diameter class range. Some trees from all classes must be cut and uncut.

Although the damage extent is not great at this time, damage frequency and distribution is high. Borer holes in stems with accompanying blue stain were the most frequently observed damages. Only two diseases that could be identified by the pathologist were (CAB, 1996):

- Heart rots: *Lentinus polychrous* Lev. det Dr. R. Treu. Normally a saprophyte causing a white rot on sapwood and heartwood of *Shorea* sp. This was found on a living sal tree.
- Root rots: *Phellinus* sp., probably *P. robustus* (Karst.) Bourd & Gatz. causes white rot decay of living trees, mostly of dead heartwood. Root rot field observations: Crowns were stag-headed, some portion of the branches contained no foliage, and they were dying. Tree foliage may be very green however, the tree is somewhat easily "pushed over" by one or two people. Roots when examined have canoe shaped pits.

Fomes fastuosus, heart rot was tentatively identified from photography found in Bakshi (1976). Sporophores of these species were found on several young sal trees during the inventory.

3. Silvicultural prescriptions and their implementations

Based on the aforementioned inventories' information, prescriptions for thinning were set as follows:

1. Stand target post thinning densities for first entry thinnings were set at 4,000 to 4,500 trees per ha.
2. Order of selection for removal trees:
    a. Trees with obvious mushroom shaped fruiting bodies were first selected for removal, without regard for dbh and height size.
    b. Trees with obvious butt scars, pock - mark holes, or stem scars were then to be removed.
    c. Trees with weak or dying crowns, poor foliage development, poor branching habits and unbalanced crowns were then selected.
    d. Leave trees were to have a circular spacing of 1.5 to 1.6 m around them. Thinning supervisors were issued 3.99 m plot cords (0.01 ha) to do check plots behind the cutters. These check plots would then be used as references for controlling leave tree stand density.
3. Next to stand gaps, where tree density may be very low, fewer trees were cut to maintain sufficient density for future thinning yields.
4. The first 4 years of thinning operations have been done with pruning hooks and axes. Future thinnings will have to be done with saws.
5. Desirable dominant and co-dominant trees were indicated to the cutting crews. The desired frequency of leave–trees were then demonstrated within a plot circle for them to understand what could be left and what could be removed.
6. No *Bombax malabaricum, Dalbergia latifolia, Albizia* sp., *Terminalia arjuna,* nor *Pterocarpus marsupium* should be cut during thinning operations.

The Programme uses dbh size targets to monitor stand growth and yield in its plantations and natural stands. For the Yogikuti sal forest, the stand target average dbh of 28 cm at rotation was selected. Current crop tree, average dbh mean annual increment (MAI) is 1.3 cm per year. The target diameter was set after consideration of the sal growth and yield tables produced by Rautianen (1995). Accordingly, the operational management plan (Hartz, 1997) specifies that average crop tree dbh mean annual increment should be approximately 1 cm per year on crop trees. If stand crop tree average dbh MAI drops below that minimum MAI, then the following silvicultural treatments may be implemented to increase diameter growth:

1. Stand densities may be reduced via heavier thinning rates to increase diameter growth. Consequently, thinning entries then may be less frequent as well.
2. Stands may be fertilised with urea.
3. A combination of 1 and 2.

4. Thinning yields and incomes

In the first thinning operations, fuelwood was sold on a quintal (100 kg) weight basis. Five of the quintal basis trolley loads were scaled. These had an average weight of 52.32 quintal and average volume of approximately 1 chatta. These two figures are used to convert quintal loads to chatta and cubic foot estimates. Subsequent operations sold wood on chatta basis. These yields are recorded in Table 2. BPFFP estimates that most chatta yield approximately 300 cubic feet of solid wood. These estimates are based on felled, scaled trees from stands of *Acrocarpus fraxinifolius, Leucaena* sp. and *Eucalyptus* sp. Total thinning cubic foot yields are obtained by multiplying 300 cft times the total number of chatta harvested. (1 chatta = 20' x 5' x 5' stacked round wood).

Estimates of growing stock ($V_{growing\ stock}$) are calculated as:

$$V_{growing\ stock} = V_{removals}/\text{Trees per ha}_{removed} * \text{Trees per ha}_{growing\ stock}$$

In the absence of accurate volume equations for trees that range in dbh from 5 to 12 cm and height from 5 to 10 m, this method may be applied to develop growing stock and removal volume estimates from thinnings in young sal coppice forests.

Table 3 shows the thinning yields and residual growing stock per ha based on tree densities before and after thinning.

Table 2. Yields of thinning operations in the Yogikuti leasehold sal forest

Year Thinned	Yield (Quintals)	Yield (Chatta) ch	Estimated yield (cft)	Thinning costs (Rs.)	Thinning Income (Rs.)	Net Income (Rs.)	Net Income per cft (Rs./cft)
1995	1302.85	24.90	7470	27587	106903	79316	10.62
1996		29.85	8955	29486	168063	138577	15.47
1997		32.64	9792	57222	189970	132748	13.56
1998		12.64	3792	37900	75840	37940	10.01

Table 3. Per hectare thinning yields and estimated residual growing stock based on stand densities before and after thinning

Year	Area Thinned (ha)	Average removals (stems/ha)	Thinning Yields (cft)	Thinning Yields (cft/ha)	Average Yield per tree (cft)	Leave trees per ha (stems/ha)	Estimated Growing Stock per hectare (cft/ha)
1995	15.5	4300	7470	482	0.11	4526	507
1996	7.7	2368	8955	1163	0.49	6231	3060
1997	15.7	2252	9792	624	0.28	3900	1080
1998	9.1	2814	3792	417	0.15	3900	578

5. Discussion

Although the implemented disease and insect survey procedures are commonly used in other countries, the lack of clear scientific identification information with photography limits their utilisation. Such supporting information in the form of a manual if correlated with the results from scientific studies on silviculture treatments, would be very useful in planning silvicultural activities in sal coppice forests. Presently, the sal forest at Yogikuti is demonstrating advancement in the frequency of root rot in several stands. Also, in some of the same stands, several clusters of two to four dead trees can be found randomly distributed. Though the root rot frequency and cluster mortality distribution is not high at present, there is a concern that it will increase.

At least one researcher (Bakshi, 1976) has proposed that because of a potentially high frequency of heartrots, sal coppice forests may not be a reliable source of timber, instead they may be rather good for fuelwood. The Programme chose a rotation length of 40 years for the sal forest due to the present frequency and distribution of heart rot and root rot in the sal forest.

The purpose of these surveys is to provide feedback information about the effect of silviculture treatments on forest health conditions. Many root diseases spread from thinnings, i.e., *Fomes annosus, Phellinus weirrii* and *Armillaria* sp. (Bakhsi, 1976; Finck *et al.*, 1992). Some forest fertilisation routines are thought to adversely affect the nitrogen-phosphorus ratio, thereby increasing the infection levels of certain root diseases or other pathogenic fungi on some site conditions (Pritchett and Fisher, 1987). Therefore, the Programme does inventories and surveys every three years on all stands to monitor growth and yield, forest health and to update silvicultural prescriptions. As a secondary assessment, the company conducts post-treatment assessments after operations like thinning and fertilisation. Presently, Rautiainen's (1995) growth and yield models for uniform sal forests are being used. As trees mature, stands are thinned and diameter distributions become less broad in range and more normal in distribution, growing stock, yields, costs and incomes will be monitored.

Butwal Plywood Factory is committed to growing natural sal coppice forests as an absolutely necessary management activity. Such forests are valuable reserves for biodiversity, wildlife habitat and sources of natural scenic beauty for Nepal. These forests are also valuable sources of raw material and income for local economies. Good management information is essential so that activities may be sustainable in the long term. Implementation of these inventory and insect and disease survey procedures by others may provide better support to silvicultural prescriptions and long run sustainable yields of Nepal's valuable sal forests.

References

Bakshi, B. K. 1976. *Forest Pathology, Principles and Practices in Forestry.* FRI Press, Dehradun, India.

Centre for Agriculture and Biosciences. 1996. Simple Laboratory Report of Disease Assessments.

Finck, K. E., Humphreys, P. and Hawkins, G. V. 1992. Field Guide to Pests of Managed Forests in British Columbia. *Joint Publication No. 16.* Ministry of Forests, British Columbia, Canada.

Hartz, T. M. 1997. Operational Forest Management Plan for the Designated Yogikuti Rupandehi Private Leasehold Site for Butwal Plywood Factory Pvt. Ltd. *Unpublished Company Document.* Butwal Plywood Factory, Butwal, Nepal.

Pritchett, W. L. and Fisher, R. F. 1987. *Properties and Management of Forest Soils.* 2nd Edition. John Wiley and Sons, New York, USA.

Rautiainen, O. 1995. Growth and Yield Models for Uniform Sal *(Shorea robusta)* Forests in the Bhabar-Terai in Nepal. *FMUDP Tech. Rep. No. 17.* HMGN/Finnida, Kathmandu, Nepal.

Mathema, P., Dutta, I. C., Balla, M. K. and Adhikary, S. N. (eds.). 1999. *Sustainable Forest Management.* Proceedings of an International Seminar, 31 August – 2 September 1998, Pokhara, Nepal.

Participatory Approach in Nepal's Forestry Sector: A Policy Evaluation

A. L. Joshi and K. P. Pokharel

Abstract: The evolution of participatory approach adopted in Nepal's forestry sector is discussed in this paper. The experience to date demonstrates that people's participation in community forestry, soil conservation and biodiversity conservation has shown positive results. However, some gaps still remain in the policy, legislation and programmes which need to be addressed in order to make people's participation more beneficial to the people as well as the resource base.

1. Introduction

In traditional forest policy local people were considered as enemy of the forests. These policies gave more emphasis on forest protection by barbed wire fences and forest guards. The main duty of the guards was to stop and prosecute local people entering the forest for fuelwood and fodder. Classical forest legislation concentrates more in demarcating the forest from the local people. Removal of any forest produce without the permit of District Forest Officer (DFO) was considered as a serious forest offence. Classical forest legislation of any country contains very elaborated procedure of forest demarcation from the other lands to separate local users from the forests.

In Nepal people's participation was thought necessary only in 1976 as outlined in the National Forest Policy. In that policy, it is mentioned that people's participation will be sought for protecting forests from fire, theft and abuse. This was the first official publication in Nepal which envisaged people's participation in forest development. Two years after the publication of the National Forest Policy, Forest Act 1961 was amended. This amendment allowed the government to hand over parts of national forest as community forest (then called *Panchayat* Forest and *Panchayat* Protected Forests) to local people for producing their subsistence needs of firewood, timber, fodder and other forest products. This amendment was followed by enactment of Community Forest Rules 1978 (then called *Panchayat* Forest Rules 1978 and *Panchayat* Protected Forest Rules 1978) which gave authority to the Conservator of Forests to hand over pieces of government forest to local *Panchayat*, the smallest elected political unit in villages. Similarly, in 1979 and 1989 Forest Act, 1961 was further amended.

2. Community forestry: Translating participatory principles into practice

With the formulation of rules in 1978, community forestry (CF) was implemented throughout Nepal. In 29 hill districts, the programme was implemented with the loan assistance of the World Bank. In other hill districts, grant assistance was provided by different donors which include USAID, ODA, AusAid, etc. Moreover, the Master Plan for Forestry Sector (MPFS) was adopted in 1989 with a major shift in forest policy. The main features of the Master Plan with regard to CF are:

- First priority is to meet people's basic needs while managing forest.
- Accessible forests will be managed by empowering the local community.
- The primary task of the forestry field staff will be to assist and facilitate communities in their efforts to manage and utilise the forest on a sustained yield basis.

- Forest resources will be managed on a long-term basis, according to their ecological capacity to conserve soil, water, flora, fauna and scenic beauty.
- Community forestry will have priority over other forest management strategies.
- Decentralisation will be applied to forest management.
- Women, the main forest users, will be involved in forest management.
- Emphasis will be given to multiple use strategies of land.

Because community forestry was a new approach, there was absolutely no experience with the Department of Forest. In the beginning most of the foresters were sceptical and even scared of losing their authority. In the initial years, only poor sites such as steep slopes and degraded forests were handed over to the local people. However, as time passed, foresters as well as local people started realising that community forestry is the only way to save the forests in the hills of Nepal as well as fulfil the needs of local people. While implementing this programme, a big deficiency in forestry staff was identified, as the needs of community forestry were different from traditional approach of forest protection. Similarly, it was found that local users were weak on social and technical aspects of community forestry. To reduce these gaps massive training programmes have been implemented in all community forestry projects.

In the last 17 years many technical, social, institutional and legal problems were experienced. Technical and social problems were mostly solved through training. Institutional problems were solved by institutional capacity building such as converting community forestry assistants into regular rangers of District Forest Office. To solve the legal problems, Forest Act was enacted in 1993 and Forest Regulations in 1995. The evolution of community forest legislation is summarised in Table 1.

Table 1. Evolution of Community Forest legislation in Nepal

Subject	**1978 Rules**	**1979 Amendment**	**1987 Amendment**	**Forest Act 1993 & Regulation 1995**
CF area	not more than 125 ha (PF) 250 ha (PPF)	125 ha 500 ha	no limit no limit	no limit no limit
benefit share % to community	40%	75%	100%	100%
To be spent from the benefit	50% (for forestry)	50% (for forestry)	100% (for forestry)	Surplus fund for any community development
Pricing of products	not less than royalty	not less than royalty	not less than royalty	as per FUG's decision
Plan Preparation	by DFO	by DFO	by community	by community
Plan approved by	Conservator	Conservator	Regional Director	DFO
Boundary	Political	Political	Political	Use practices
Management units	*Panchayat* (political unit)	*Panchayat*	User committee under *Panchayat*	User Groups (assembly)
Chair person	Elected village leader	Elected village leader	selected by political body	Selected by the users' assembly by consensus

3. Main features of present community forestry legislation

- Any part of accessible forests can be handed over to the communities who are traditional users of the forests, if they are interested to manage the forests.

- Any amount of National Forest can be handed over to Forest User Groups (FUGs) if they indicate that they are capable of managing the forests.
- Conversion of national forests to community forest has priority over conversion to any other forest use such as leasehold, protected and production forests.
- CF boundaries are fixed by traditional use practices rather than administrative boundaries.
- DFOs are authorised to recognise FUGs and hand over forests to FUGs. This authority was vested with higher officials or the centre in the past.
- FUGs have to manage the CF as per their Constitution and Operational Plan (OP) which are approved by DFO.
- FUGs are autonomous and corporate bodies with perpetual succession rights.
- FUGs can plant long term cash crops, such as medicinal herbs, without disturbing the main forestry crops.
- FUGs can fix prices of forestry products irrespective of the government royalty.
- FUGs can transport forest products simply by informing the DFO.
- FUGs can establish forest-based industries.
- FUGs can use surplus funds in any kind of community development work.
- FUGs can amend their OPs simply by informing the DFO
- Any government and non-government agency can help user groups to be organised and to manage CF.
- FUGs can punish any members who break the rules of their Constitution or OP.
- DFOs can take community forests back from FUGs if they go against the OP. However, the DFO must give the forest back to newly reformed FUG as soon as possible once the problem is resolved.

4. Achievement of the community forestry programme

Although community forestry programme in Nepal started in 1978, initial progress was very slow. It took speed only after the reinstallation of democracy in 1990. Status of the community forestry programme until May 1996 is given in Table 2.

Table 2. Status of community forestry programme as of May 1996

Year	No. of FUGs formed	CF area (ha)	Household (no.)
1987/88	3	79.8	398
1988/89	34	518.84	2732
1989/90	29	1916.48	5356
1990/91	54	1949.99	5189
1991/92	354	1991.89	37506
1992/93	634	3592.14	73303
1993/94	950	63308.43	99249
1994/95	1390	98530.91	141159
1995/(May 1996)	325	26983.28	39255
Date not mentioned	1583	116446.99	181531
Total	**5,356**	**362,551.5**	**585,658**

FUGs are managing 3.6 million ha of community forests and 586,000 households are involved. A World Bank study has indicated that from community forestry programme additional benefit of Rs. 660 per ha per year is obtained. Even if the recognised community forest area is little, there is wider impact on the areas around those community forests. From the management of community forests, local people get firewood, fodder and timber, and are generating income also. The money earned has been spent for community development activities like building schools, running schools, constructing drinking water canals, etc. So, community forest could act as a vehicle for community development.

5. Participatory approach in soil conservation

There is widespread soil erosion problem in Nepal. However, intensity of the problem varies from place to place. Because the soil erosion problem is scattered everywhere it is not possible to tackle this problem by the government alone. Without people's participation, soil conservation problem cannot be tackled. With the successful experience of community forestry in the hills of Nepal, watershed management projects were also designed to involve the local people. Begnas Tal and Rupa Tal Watershed Management Project supported by CARE/ Nepal was the first project to involve local people as main actors in soil conservation. In this project soil conservation activities were carried out through local conservation committees. Participatory soil conservation programmes were very successful in Begnas Tal Rupa Tal Watershed Management Project. When the project was over in 1995, there were more than 100 conservation committees in the project area of six Village Development Committees. These committees also formed FUGs who have been managing community forest in the project area.

This experience has been used widely in the soil conservation programme elsewhere in the country. All the projects implemented under Department of Soil Conservation and Watershed Management like European Union supported Bagmati Watershed Project, Danida funded Nepal-Denmark Watershed Management Project, as well as USAID and AusAid funded soil conservation projects follow the approach of involving local people. In these projects, financial and technical support is given to conservation committees and the committees spend the money according to the plan made by them.

6. Participatory approach in biodiversity conservation

In classical model of biodiversity conservation, people were considered as problem. After declaration of national parks, local people lost all their traditional use practice. Because wild animals damaged agricultural crops, the local people were against biodiversity conservation. Conflict between the park and people was quite common in almost all national parks.

In co-operation with the Department of National Parks and Wildlife Conservation, the International Centre for Integrated Mountain Development (ICIMOD) and King Mahendra Trust for Nature Conservation (KMTNC) organised a seminar in May 1985, when the possibility of biodiversity conservation with participation of local people was discussed. As a result, Annapurna Conservation Area Project came into implementation in 1986 where local people participate in the conservation of local biological resources.

With the success of community forestry programme, biodiversity sector was encouraged to initiate conservation activities with the participation of local people. The idea was to help and use the potential of local communities by implementing some community development works while protecting wildlife. The principle of involving local people was later on followed in Makalu Barun Conservation Area Project in 1992 and in Parks and People Project in 1994.

To implement participatory biodiversity conservation nation-wide, buffer zone management concept was introduced in National Parks and Wildlife Conservation Act through the amendment of 1993. Later on Buffer Zone Management Rules was enacted in 1996. Main features of the Buffer Zone Management Rules include:

- Government can declare areas around the protected areas as buffer zone.
- The Warden has to prepare overall management plan for buffer zone development.
- User Committees will be formed for implementing development activities.
- The Operational Plan will be approved by the Warden.
- User Committees can manage buffer zone community forests to fulfil their needs of forest products.
- Thirty to fifty percent of the government revenue received from the national park will be spent for the community development in the buffer zone area.

Buffer zone management rules created ample opportunities to empower local people residing near protected areas for community development. Now, local communities can protect wildlife and at the same time fulfil their needs of forest products.

7. Existing policy gaps

In community forestry

- *Involvement of women and the poor:* Although it is in the policy, present legislation has not fixed any quota for the representation of women and the poor section of the community in FUG committee.
- *Authority to penalise non-FUG offender:* Present legislation does not clearly specify the authority of FUG to prosecute if some one outside FUG commit forest offence in CF. In some places this is done by DFO, in some places by FUGs themselves and in some places FUGs have even gone to District Court.
- *Size of household in FUGs:* It will not be practically possible to handle large number of households in FUGs. This is a special problem in the Terai where the forests are claimed by thousands of households. Existing legislation does not specify the maximum number of households in FUGs.
- *Standard pattern of Operational Plan:* Existing legislation does not prescribe standard pattern of Operational Plans. In the absence of a standard pattern, Operational Plans differ greatly in terms of content, quality and quantity. Some Operational Plans do not posses the required information necessary to implement the plan such as benefit sharing mechanism among the users.
- *Dissolution of FUGs:* Due to various reasons, if some FUGs decide not to continue with CF programme, the present legislation does not have any provision for dissolution of FUGs.

In soil conservation

There is a clear policy to involve local people in soil conservation, however, this provision is not incorporated in the existing Soil and Watershed Conservation Act and Rules. As a result, Conservation Committees are registered in District Offices as NGOs. District Soil Conservation Officer has no control over the process and the registration is often time-consuming.

In biodiversity conservation

As the buffer zone legislation is new, no serious gap is experienced.

8. Conclusion

The revolutionary change in forest resource management approach has proved that the local people can take responsibilities not only to manage forests which directly benefit them but also the endangered wild animals which has no direct benefit to them. People's participation in soil conservation activities has also been quite encouraging. However, to get successful participation from the people there should be enough flexibility in the system as experienced in the amendments of community forest rules. If such needs are incorporated in the policy, legislation and programme, then local people can conserve not only forests but also biodiversity.

Mathema, P., Dutta, I. C., Balla, M. K. and Adhikary, S. N. (eds.). 1999. *Sustainable Forest Management.* Proceedings of an International Seminar, 31 August – 2 September 1998, Pokhara, Nepal.

Towards Sustainable Management of Forests: Learning from the Experiences of Community Forestry in Nepal

I. S. Karki and S. Tiwari

Abstract: Nepal's community forestry (CF) policy is based on the premise that forest resources can only be conserved by those whose very survival depends on the existence of the forest itself. Appropriate policy, institutional and operational frameworks have been designed for the effective implementation of CF as a priority programme. Since its inception in late 1970s, CF has evolved over time as per the concerns and aspirations of local communities. It is widely believed that CF has shown promising results in ecological, economic and social fronts, and is leading towards desired outcomes. Recent studies, however, indicate that Forest Users Groups (FUGs) with the growing level of awareness and increasing number of handed over community forests, seem to have been left on their own to manage their forests. Some burning issues such as post-formation support, income generation activities and promoting CF in Terai remain to be addressed adequately. This paper attempts to review the present status of CF in the context of existing policy and practice, and presents an analysis of some issues together with what needs to be done.

1. Introduction

Forestry sector plays a central role in economic and social life of the Nepalese people. Subsequently, there are very few forests that are not under severe pressure from the nearby population, especially in the Middle Mountains and the Terai where the population density is relatively high. This situation is further exacerbated by the fact that forests are often scattered, in patches and with only 33% of the biomass accessible for exploitation due to physical and geographical isolation. Studies have shown that the sustainability of the subsistence farming system, in the face of growing human and livestock population, and the deteriorating forest, is severely threatened (Ives and Messerli, 1989; Banskota, 1992).

Land resources have always remained a major concern of the state in the past and the policy interventions over time without a long-term vision, has acted to the detriment of forest resources in Nepal until recently. Community forestry (CF) was formally embraced in the Nepalese forest policy in late 1970s with the realisation that sustainable management of forest resources is neither possible nor practical through the government efforts alone, it requires the collective effort of all the people in the country (HMG/N, 1976). In the last two decades, CF has evolved significantly but a lot remains to be achieved. In this paper, the evolution of CF is discussed and an analysis of some burning issues associated with the effective implementation of CF in Nepal is presented in the context of policy and practice.

2. Community forestry: learning from experiences

CF is a policy innovation that aims to provide productive assets for the benefit of the poor by bringing about social changes and establishing efficient property institutions at the local level (Sanwal, 1988). In Nepal, CF can be thought of as an attempt to establish and/or revive the community level institutions capable of managing and making efficient use of their forests.

In early stages of its inception, CF was directed towards creating plantations on wastelands and degraded hill slopes. Degraded forests and plantations were handed over to the *Panchayats*[1] for management. It took almost a decade to realise that the management control and the use rights needed to be handed over to the actual users of forests, and not to the *Panchayats*. Hence, the process of CF was amended to focus on handing over the forest to their traditional users and providing them with all the support required for managing those forests. The forestry sector policy document (HMG/N, 1989) endorsed CF as a priority programme and ensured its effective implementation through:

- encouraging social aspects of land use,
- supporting decentralisation in resource allocation and decision-making, and
- putting priority on resource-scarce, poor and socially marginalised in forest management.

In response to the slow progress in handing over due to the limited know-how of CF process in the part of forestry field staff, an operational guideline first issued in 1990 was further revised in 1992 based on experiences gained. Forestry staff are being continually trained since 1989 to build up their CF related performance standards with the growing level of knowledge-base. With the promulgation of Forest Act, 1993 and the Forest Regulations, 1995, FUGs have legally become self-governed and autonomous corporate bodies authorised to manage their property. They can raise funds through grants, donations, sale of forest products, fines, penalties etc., and use these funds in forestry and/or other development activities.

As per the data available until July 1998, 6,317 FUGs have been organised and have taken over the management control of 419,262 ha of forests in 64 districts, and 672,211 households are participating in CF throughout Nepal. Often the swelling bank accounts of many FUGs in recent years show that in general, there is a gradual shift of FUGs from subsistence towards monetised market economy (Singh, 1998). It is however, yet to be studied whether this shift is occurring after the sustainable security of subsistence or is just an impact of the rapidly developing market and urbanisation. Whatever the reason, this shift imposes risks on the sustainability of CF itself as market pressures increase the opportunity cost to the individuals to co-operate, the temptation for the élite to free ride, and chances of overexploitation by the whole group (Richards, 1997) resulting in inequality in income and divergence in other dimensions of common property systems (Quiggin, 1992).

3. Status of institutional arrangements in CF

In general, institutional (or decision-making) arrangements have to do with authority relationships that determine who decides what in relation to whom. Within FUG, institutional arrangement takes place in the formulation of their constitution (*Vidhan*), preparation of operational plans and their implementation. However, such institutional arrangements are intrinsically effected by the internal as well as the external stakeholders of CF. District Forest Office (DFO) being formally entitled to facilitate, assist and mediate within and between the interest groups, and hand over the community forest, often influence the FUG's institutional arrangements in many different ways. Furthermore, projects, non-governmental organisations (NGOs) and local governments also have significant say in FUG's decision-making structures.

[1] *Panachayat* is a territorially based politico-administrative unit established under the *Panchayat* political system.

Above all however, the most detrimental effect over the FUG's institutional arrangements comes from local, socially and economically well off and often politically motivated élite of the community.

Decision-making in most communities is skewed in favour of men, and normally women are culturally restricted or they are often not allowed to get involved in decision-making by their male dominated families. Similarly, poor, disadvantaged and socially marginalised groups are very often ignored and excluded from participating in decision-making (Baral, 1993). Existing patterns of decision-making in CF lacks required level of transparency and equity. This view is further supported by a number of recently surfacing conflicts within, between and outside the FUGs. Within the boundaries of CF policy, appropriate social and cultural changes can help to improve the institutional arrangement status of FUGs. In absence of such changes, there does not seem enough room for the required level of reciprocity, efficiency and equity in benefit sharing, all of which acting together may not allow sustainable community forest management.

4. Burning issues in CF

Undoubtedly CF in Nepal to date has been substantially successful in organising and empowering rural communities for efficient use and management of forest resources. The progress was slow in the early years due to the lengthy handing over procedures and the little know-how in the part of forestry staff. Nevertheless, it gained remarkable momentum once the appropriate legislation and the operational guidelines for CF were in place together with the continual and well-functioning staff training system.

Many issues have arisen over time with the growing popularity of CF as a viable forest management system. Most of such issues are noted to have come up due to the conflicting interests of stakeholders in local, district and regional level. They have also been sorted out over time by learning through experiences and continual mediation. Yet there remain some crucial issues that are not addressed adequately at the operational level and need immediate and sincere response from the policy level. Some such issues are briefly discussed here.

4.1. Post-formation support to FUGs

Efforts of agencies working for CF have so far concentrated in activities leading to handing over of community forests. Very little, however, has been done towards providing support and assistance to FUGs at the stage where they have to really transform their operational plans (OPs) into practice. Post-hand over is the most crucial stage in CF where FUGs need not only the social, technical and physical, but also moral support from outside (Joshi, 1997). This is the stage when the individuals within the FUG act and interact amongst themselves to formulate collective action for efficient use of their community forest. Hence, FUG as an institution seeks to attain robustness at this stage which might not be possible without a well-functioning and efficient support system from outside. Presently, the post-formation support is reported to have suffered due to:

- inadequate number of forestry field staff in DFO. The number of posts available in DFOs has been found to be unable to cope with the growing number of FUGs functioning at operational level
- lack of appropriate organisation and efficient management of the available manpower for the implementation and proper monitoring of CF

- little physical facilities and incentives for the staff in the field to make the best use of their existing motivation, commitment and effort in CF
- little know-how regarding type and kind of post-formation support to be provided to FUGs
- absence of NGOs in the local/district level to provide post-formation support.

Little is known about the types and forms of support required in the post-formation stage. Pokharel *et al.* (1993) have identified social development, physical support and technical advice as the main types of support to be provided. Further studies are required to identify and categorise different types of support needed.

4.2. Income generating activities (IGAs) in CF

IGAs in CF draws importance in the light of rapidly changing forest products market in rural areas. With the growth of transport system and communication links, remote areas are gradually transforming into small domestic markets and supply centres. Off-farm income and employment opportunities are gradually getting preference in rural household economy. FUGs having observed such market changes are eager to respond through improved forest management and economic strategies. Forest-based IGAs can play key role in rural economy, which however, is little studied.

Rural people collect seeds, fruits, nuts, roots, shoots, barks, leaves and many more forest products for household use and market. They also prepare household implements such as *doko*, *namlo*, *damlo*, *dori*, *theki*, *dhungro*, *dhiki*, *mudha*, *kucho, halo, juwa bhakari*, *mandro* and other items traditionally used in farming households. Market for new products is reported to have opened up in response to recent socio-economic changes in rural and semi-urban areas. Often the potentiality for many such IGAs remain constrained due to the lack of technical and financial assistance. IGA in CF could include activities as different as increased income from improved silviculture, appropriate processing of wood as well as non-wood products, tourism promotion and marketing of water resources. The policy encourages cultivation of non-wood forest products (NWFP) and other long-term tree crops that can generate cash in community forests. The problem however, is that field staff themselves have little technical know-how of NWFPs. The diversified nature and scope of IGAs require a well co-ordinated effort of professionals from different sectors to support FUGs through action research, technical and other assistance. Nothing much seems possible from DFO's level to promote IGAs. However, recently started Natural Resource Management Sector Assistance Programme (NARMSAP) is taking initiatives to study the feasibility of IGAs in CF in order to provide the required assistance. Policy has indeed given impetus in promoting IGAs, but a co-ordinated working modality efficient enough to transform the policy into action is lacking.

4.3. Implementing CF in Terai

CF in Terai was initiated in 1984 with the launching of Terai Community Forestry Project. The project did create some awareness towards tree planting, but did not succeed much in organising user groups and preparing OPs for community plantations. It is evident that most of the Terai DFOs started CF in its real sense after the enforcement of Forest Regulations,1995. As per the available records, by July 1998, 10 eastern Terai DFOs handed over 9,592 ha of community forests to 220 FUGs and Kailali DFO handed over 4,000 ha to a single FUG with about 2,200 households.

Despite these achievements the progress is slow in Terai. This is attributed to numerous complex and multidimensional problems. Recently, many NGOs and pressure groups are coming up for awareness building in Terai communities and assisting them to take over the community forests. It has however, often been reported that the driving force has been to make money out of the commercially viable Terai forests rather than to build a common ground for the community management of forests.

Experiences of CF in Terai to date have clearly revealed that the working modality adopted in the hills is not equally applicable in Terai. Terai has relatively new settlements with ethnic diversity particularly near the forest areas. Land and forest both have a high rent gradient due to strong market forces. Accessibility in Terai is rarely restricted, and it can not be defined in the way it is done in the hills. Identifying users in Terai itself has many different problems. Traditional users of forest have long been pushed away from the forests and the people who claim as users often potentially happen to be the encroachers of the past. The society is heterogeneous with big gaps between rich and poor and the rural economy is controlled by off-farm income and market forces. All these factors acting together tend to make little room for consensus based community management of forests. This is not to argue that CF is not feasible in Terai. Rather it is just to emphasise that a working modality must be developed considering the forestry situation of Terai, which allows the field staff enough flexibility to assist the communities in the process of CF.

As the government is well aware of what went wrong in the Terai forest in the past, it must review the policy on CF so that the policy can be transformed into action without any complications in future. Undoubtedly the CF policy is quite clear, but its implementation in Terai is not easy for DFOs. Hence,

- CF policy needs a thorough review to make it operational in Terai. Questions such as who should be the users, up to what distance the accessibility should apply, what should be the limit to users' willingness and ability and how to judge that the community forest is being demanded due to genuine local forestry concerns and not due to the tendency to make money out of forests.

- A working modality is urgently needed to promote CF in Terai. It must also clearly mention which type of land, forest and community should be given priority to initiate the process of CF.

Terai forests also need to be viewed on a national perspective owing to their commercial productivity. It must not be forgotten that though the government so far has failed to manage them in the national interest, it must manage a good part of Terai forests for the welfare of the people throughout the country. A guideline therefore must be developed for Terai to identify national as well as community and other types of forestry to be practised in the long run.

5. Conclusion

CF in Nepal has evolved in an attempt to establish a sustainable management of forests at local level. Rural communities have had significant achievements in meeting their forestry needs, generating and utilising funds for community welfare, and conserving the forests as well. However, the sustainability of the CF will be at risk if:

- The existing institutional arrangements within FUGs are not improved to ensure the say of women, poor and socially marginalised groups of the society.
- FUGs do not strive to attain a sustainable security for subsistence before they enter into monetised market economy.

Hence CF policy must be reviewed to incorporate the mechanism to overcome the aforementioned situations. Post-formation support should also be carefully designed.

The CF related issues in Terai are typically different from those of the hills. Additionally, relatively high rent gradient of the land and the forest resources impose many risks. This situation could further get complicated if the social processes involved in CF do not get steered towards attaining equity in decision-making right from the beginning. Therefore, it is crucial that the strategy to promote CF in Terai should incorporate these sensitive aspects. A comprehensive operational guideline for implementing CF in Terai should be developed based on the unique problems and prospects of Terai.

References

Banskota, K. 1992. Agriculture and Sustainable Development in Nepal. In: De Ville, J. G. (ed.). *Economic Policies for Sustainable Development*, ADB, Manila, The Philippines and ICIMOD, Kathmandu, Nepal.

Baral, N. R. 1993. Where is our Community Forestry? *Banko Janakari* 4(1): 12–15.

HMG/N. 1976. *The National Forestry Plan*, Ministry of Forest and Soil Conservation, Kathmandu, Nepal.

HMG/N. 1989. Forestry Sector Policy, Ministry of Forests and Soil Conservation, Kathmandu, Nepal.

Ives, J. D. and Messerli, B. 1989. *The Himalayan Dilemma–Reconciling Development with Conservation*. The UN University and Routlege, London, UK and New York, USA.

Joshi, A. L. 1997. Empowering Local Users in Forest Management of Nepal, *Banko Janakari* 7(2): 32–38.

Pokharel, B. K., Gayfer, J. R., Epstein, D. M., Kafle, G. and Tumbahamphe, N. 1993. Post-Formation Support for Forest User Groups, *Banko Janakari* 4(1): 80–84.

Quiggin, J. 1992. Common Property, Equality and Development, *World Development* 21(7): 1123–1138.

Richards, M. 1997. Tragedy of the Commons for Community-based Forest Management in Latin America, Natural Resources Perspective, ODI, London, UK.

Sanwal, M. 1988. Community Forestry: Policy Issues, Institutional Arrangements and Bureaucratic Reorientation, *Ambio* 17(5): 342–346.

Singh, B. K. 1998. Community Forestry in Nepal: Gradual Move from Subsistence to Monetised Sector of Economy, *Banko Janakari* 8(1): 46–49.

Mathema, P., Dutta, I. C., Balla, M. K. and Adhikary, S. N. (eds.). 1999. *Sustainable Forest Management.* Proceedings of an International Seminar, 31 August – 2 September 1998, Pokhara, Nepal.

The Potential of Teak Forest for Energy Production in the Dry Tropics

S. B. Karmacharya

Abstract: This study was conducted in different age series of teak plantations (4, 14 and 30 years old) in a dry tropical region of Varanasi Forest Division. An analysis of standing crop biomass and dry matter production was quantified through non-destructive methods. Allometric regressions were made relating girth to weights of bole wood, bole bark, branch, leaf and inflorescence through annual increments of the girth. The above ground biomass ranged from 25.7 to 76. 9 t/ha in the different age series. On the contrary, the share of leaf biomass decreased from 34% of the total at 4 years to 7% at 30 years. The net dry matter production was 25.6 t/ha/yr at 4 years, 14 t/ha/yr at 14 years and 12.9 t/ha/yr at 30 years. Seasonal calorific value calculation of above ground components showed that the net energy gain in woody parts occurred during the rainy season thereafter the net energy loss occurred. The annual cycle calculation of net biomass production and energy fixation in above ground components showed the lower ages to be more efficient.

1. Introduction

Teak (*Tectona grandis* L.f.) is a deciduous tree species having a leafless period of 2–3 months. It bears more or less rounded crown and tall cylindrical trunk. Inflorescences are protruded out from the mature twig after 12–18 leaves are formed. It is indigenous throughout greater part of Myanmar, the Philippines, Indonesia and the Indian peninsula (Bhatia, 1956). Teak forests are distributed over 8.9 million ha of land (Seth and Kaul, 1978) in Indian dry tropical region, of which about one half is located in Madhya Pradesh only (Anon., 1961). This species is widely dominant in the moist as well as dry tropical deciduous forests (Champion and Seth, 1968).

Teak survives and grows under a wide range of climatic and edaphic conditions. Best growth has been found in a region with annual rainfall ranging between 600 and 4,000 mm, the average maximum temperature between 39°–43° C and average minimum temperature between 13°–17° C. The optimum pH for its growth ranges between 6.5–7.5 (Seth and Kaul, 1978).

Teak has also been planted in many areas of dry tropical Vindhyan region in north India. Large teak plantations have been raised by the State Forest Department, both in clear-felled areas and in degraded open forests, and intensively tried along with *Shorea robusta* in Gorakhpur Forest Division (Forugi, 1972). Comparatively, considerable attention has been paid in India to teak regeneration (Mathur, 1973), but a much smaller database exists on aspects related to biomass and energy production in dry tropics (Singh and Misra, 1979).

Green plants are responsible for transforming radiant energy to chemical energy through the process of photosynthesis. Part of the total energy converted into organic compound is used in respiration and the remainder accounts for the net productivity in various components of the system upon which the rest of the trophic level organisms depend for their sustenance. The quantities of starch and soluble carbohydrates in the leaves and other components are the result of balance between the rate of carbon assimilation and the rate of carbon transformed to a short or long distance, under the influence of various sinks (Drossopoulos and Niavis, 1988).

The main objective of this paper is to quantify the standing crop biomass, dry matter production and net annual energy fixation in different age series of teak forest.

2. Materials and methods

2.1. Site description

Different teak stands of 4,14 and 30 years located in Chakia Range (Block Sherpur, Compartment 1) of Varanasi Forest Division, India, were studied. All the sites were at an altitude of 91 m above mean sea level and the distance between stands varied from 0.5. to 2.0 km. The soil was well-drained sandy loam of residual origin and similar at all sites. The climate is of monsoon type showing three distinct seasons: a hot dry summer (March to June), a warm humid rainy season (July to October), and a cool dry winter (November to February). Average annual rainfall is 762 mm. Of the average number of 55 rainy days every year, 48 occur in the rainy season. A much smaller spell of rain occurs in winter (January to February) and during the hot dry summer.

2.2. Bole biomass estimation

Bole is constituted partly of wood and bark. Wood and bark biomass in the tree bole was measured through a non-destructive volume estimation method. Monthly girth measurements in a limited number of trees showed the maximum girth increase in October. Therefore, sufficient number of trees (24, 24 and 20 in 4-, 14- and 30-year stands, respectively), distributed in all girth classes, were successively measured for seasonal girth increments (in April and October 1985, January and April 1986). These measures were used to estimate periodical standing crop through the following girth (cm): biomass (kg) regressions (Karmacharya and Singh, 1992a):

Log wood weight (kg) = – 2.56 + 2.63 log GBH (cm)
($r = 0.99$, d.f. = 32, $p < 0.001$)

Log bark weight (kg) = – 2.34 + 2.13 log GBH (cm)
($r = 0.99$, d.f. = 32, $p < 0.001$)

Log branch weight (kg) = – 2.58 + 2.56 log GBH (cm)
($r = 0.94$, d.f. = 21, $p < 0.001$)

Note: GBH = Girth at Breast Height

2.3. Leaf biomass and their size

Leaf biomass was estimated as the product of leaf number and individual leaf weight. Total leaf count was made in 22 trees of different sizes in 4-year stand in September and the leaf number was regressed against GBH. Direct leaf counts being difficult, leaves of all first order branches were counted in 20 trees in the 14-year stand and 12 trees in 30-year stand. After the determination of leaves per tree, the leaf number (LN) was regressed against GBH (cm) (Karmacharya and Singh, 1992 a):

Log LN = 1.40 + 0.054 GBH, in 4 years old trees
($r = 0.95$, d.f. = 20, $p < 0.001$)

LN = – 96.29 + 36.64 GBH, in 14 and 30 years old trees
($r = 0.99$, d.f. = 30, $p < 0.001$)

Six twigs each in different parts of crown of 8 trees in each stand were marked in May and every month the length of twig, number of leaves, and length and breadth of all leaves were recorded. The mean leaf area was calculated applying the Kemp's Constant Value (0.6115) derived separately. All leaves emerging in different months on these twigs were marked with glass marker, so that the emergence and shedding of leaves were continuously monitored.

2.4. Reproductive biomass

Reproductive biomass (flower weight and peduncle weight) during peak period in October was calculated by the regression models derived by Karmacharya and Singh (1992 b) as follows:

$$\text{Log flower (g)} = 1.35 + 0.0274 \text{ GBH (cm)}$$
$$(r = 0.95, \text{d.f.} = 58, p < 0.001)$$

$$\text{Log peduncle (g)} = 1.39 + 0.0274 \text{ GBH (cm)}$$
$$(r = 0.95, \text{d.f.} = 58, p < 0.001)$$

Similarly, fruit biomass was estimated as the product of total fruit number and the mean fruit weight during January (Karmacharya and Singh, 1992 b).

2.5. Estimation of calorific value

In the present investigation, samples (bole wood, bole bark, branch, bud, various categories of leaves from 4-year stand, additional flower and fruits from 14 and 30-year stands) were collected in three distinct seasons (September, January and April to represent rainy, winter and summer seasons, respectively). The samples were dried in an oven at 80° C for more than 24 hours, until the weight of samples was constant. The dried plant materials were powdered and stored in plastic bags. About 0.6 g of finely powdered plant material was pressed to make a pellet. The pellet was again dried at 80° C for 10–15 minutes, cooled and weighed. These materials were then, ignited in bomb calorimeter following the method described in Parr Instrument Co. Manual 130, (1968). The gross heat of combustion (Hg) or the calorific value per gram of the dry plant material was computed as follows:

$$Hg = W \times t\,(e_1 + e_2 + e_3) / G$$

Where W = water value of the calorimeter (cal), t = rise in temperature (° C), e_1 = fuse wire correction (cal), $e_2 + e_3$ = acids ($HNO_3 + H_2SO_4$) correction (cal), and G = wt. of the pellet (g).

2.6. Estimation of seasonal calorific content

Seasonal calorific content of above ground perennial woody components was calculated as the product of estimated seasonal standing crop biomass and corresponding calorific value. Similarly, the net energy fixation was calculated as the net production. The net gain in calorific content of all the components in above ground parts of the stands was added to give net annual energy fixation. By summing up positive and negative components the calorific content changes in different seasons, the annual net gain were derived.

3. Results

3.1. Above ground biomass

Mean tree size reflected by girth, height and crown diameter increased with age. Total above ground biomass increased from 25 t/ha at 4 years to 77 t/ha at 30 years. The biomass increase was about five times in the case of wood, two and half times in bark, and three times in branch. Leaf biomass, however, decreased with age.

The 30-year stand contained proportionately 42% less leaf biomass than the 4-year stand. The floral parts increased by over four and half times in 30-year stand compared to 14-year stand. Details are shown in Table 1.

Table 1. Comparative accounts of standing crop biomass, above ground net production and production efficiencies in teak of three ages

Measurements	Age (yr)		
	4	14	30
Standing crop biomass (kg/ha)			
Bole wood	9216 (37)	21215 (53)	49519 (64)
Bole bark	4122 (16)	6326 (16)	10783 (14)
Branch	3334 (13)	5682 (14)	10510 (14)
Leaf	8600 (34)	6450 (16)	5020 (7)
Reproductive parts	0	245 (0.6)	1122 (1.5)
Total above ground	25272 (100)	39918 (100)	76954 (100)
Net production (kg/ha/yr)			
Bole wood	10412 (41)	4770 (34)	4733 (37)
Bole bark	3436 (13)	1167 (8)	858 (7)
Branch	3020 (12)	1109 (8)	880 (7)
Leaf	8720 (35)	6720 (48)	5340 (41)
Reproductive parts	0	245 (2)	1122 (9)
Total above ground	25588 (100)	14011 (100)	12933 (100)
Production efficiency based on leaf weight (kg leaf/yr)	2.96	2.12	2.50
Based on leaf area (kg/m² leaf/yr)	0.36	0.22	0.25

In the 4-year stand, bole wood and leaf accounted for 37% and 34%, respectively, of the above ground biomass. With increase in age, greater allocation of biomass occurred in the bole wood (53–64%), and the share of leaf decreased consistently (7% at 30 years). The estimated biomass values of bole bark and branch were very close.

3.2. Above ground net production

High above ground net production was recorded in the 4-year stand (25 t/ha/yr); the net production, however, decreased considerably at greater ages, to almost one half in 30-year stand. Amongst different components, the net production was distributed as 35–48% in leaf, 34–41% in bole wood, 7–13% in bole bark, 7–12% in branch and 2–9% in floral parts. The highest percentage of net production was occupied by bole wood in the 4-year stand. In the 14- and 30-year stands, leaf contributed the main bulk of net production. Reproductive parts shared 2–9% of the total above ground production (Table 1).

The production efficiency or leaf efficiency on the basis of leaf weight was 3 t/tleaf/yr in 4-year stand, 2.1 t/tleaf/yr in 14-year stand and 2.5 t/tleaf/yr in 30-year stand. The efficiency on the basis of foliage area for the same ranged from 0.36 to 0.25 kg/m^2/yr (Table 1).

Teak trees showed measurable and varying girth increments. Mean annual increment varied with girth class, being maximum (6.7 cm/yr) in the 15–20 cm girth class and minimum (1.7 cm/yr) in the greater than 70 cm girth class (Table 2). Girth increment as high as 7.4 cm/yr was recorded in a few 4-year trees within the 15–20 cm girth class.

Table 2. Distribution of trees in various girth classes and their annual GBH increments in teak stands

Age	Girth class (cm)	Density (No./ha)	Trees sampled		
			No.	Mean GBH (cm)	Annual girth increment (cm/tree)
4 yr	10.0-12.5	727	5	12.1	2.9
	12.5-15.0	2030	14	13.1	3.9
	15.0-20.0	727	5	16.0	6.7
	Total	3490	24	13.5*	4.3*
14 yr	20-25	260	6	20.8	3.0
	25-30	624	14	28.9	2.4
	>30	156	4	40.2	2.1
	Total	1040	24	28.6*	2.5*
30 yr	30-40	89	4	33.2	2.5
	40-50	74	4	42.8	2.2
	50-60	89	4	52.1	2.1
	60-70	163	4	61.2	2.0
	>70	59	4	72.3	1.7
	Total	474	20	52.7*	2.1*

* Density weighted mean

3.3. Calorific content and net energy fixation

The calorific value of above ground components increased with ageing of the stands. In the 30 years old stand the total calorific content in above ground parts increased to over three times that of the 4 years old stand; the increase in bole wood was, however, about six times, and that of bole bark and branch two and half times each (Table 3). The bole calorific content as such comprised 53%, 69% and 78% of the total content in 4-, 14- and 30-year stands, respectively. But the calorific content of leaf distinctly decreased with age from 32% of total in 4-year stand to 6% of total in 30-year stand. Reproductive parts constituted a small fraction (<2%) of the total calorific content.

Table 3. Distribution of calorific content in various above ground components and net energy fixation in Teak stands

Measurements	Age (yr)		
	4	14	30
Calorific content in standing crop (10^6 Kcal/ ha)			
Bole wood	36.6 (36)	89.0 (54)	221.8 (66)
Bole bark	16.9 (17)	24.4 (15)	41.3 (12)
Branch	15.6 (15)	23.9 (14)	43.7 (13)
Leaf	32.0 (32)	25.7 (16)	2.4 (6)
Reproductive parts	0	1.4 (1)	7.0 (2)
Total	101.1 (100)	164.4 (100)	334.2 (100)
Net energy fixation* (10^6 Kcal/ha/yr)			
Bole wood	41.3 (40)	20.0 (35)	21.2 (37)
Bole bark	14.1 (14)	4.5 (8)	3.3 (6)
Branch	14.2 (14)	4.7 (8)	3.7 (7)
Leaf	32.5 (32)	26.8 (47)	21.7 (38)
Reproductive parts	0	1.4 (2)	7.0 (12)
Total	102.1 (100)	57.4 (100)	56.9 (100)
** Energy conserving efficiency (%)	1.53	0.86	0.85

* In net production

** based on 43% usable solar radiation (6677 x 10^6 Kcal/ha/yr) of total solar radiation (15528 x10^6 Kcal/ha/yr).

Values in parentheses denotes the percentage of total

Total net energy fixation decreased from 102 x 10^6 Kcal/ha/yr in 4-year stand to about 57 x 10^6 Kcal/ha/yr in 14- and 30-year stands. In absolute terms, the energy fixation reflected in wood production was twice as great in 4-year stand than at higher ages. Amongst the above ground components, at 4 years, largest fraction of energy captured annually was diverted to bole wood production (40%) (together with bark (54%), and about one-third for the formation of leaf. At greater ages, this distribution pattern changed slightly, towards much greater allocation for leaf production (38–47%), somewhat less allocation for bole wood production (35–37%), and distinctly less allocation for bole bark (6–8%). There was a distinct increase in energy fixed reflected in reproductive parts, from 2% of the total at 14 years to 12% at 30 years. Evidently, 68%, 51% and 50% of total energy fixed annually in above ground components in 4,14 and 30-year stands, respectively, were reflected in the corresponding perennial parts. Energy conserving efficiency decrease rapidly when the age progressed beyond 4 years, but at 14 and 30 years, it remained almost constant (0.85–0.86%).

3.4. Seasonal variation in energy allocation

The seasonal variations in calorific values and biomass of perennial components (wood, bark and branch) permitted an approximation of energy allocations and conservation compared to the summer base, the calculated increase in biomass during the rainy season indicated that energy equalling 51.4 x 10^6, 58.6 x 10^6 and 93.7 x 10^6 Kcal/ha/season was fixed in the bole wood of 4, 14 and 30-year stands respectively (Table 4). Correspondingly, 19.6 x 10^6, 8.5 x 10^6 and 11.1 x 10^6 Kcal/ha/season energy was fixed in bole bark. While the bole wood energy allocation increased at greater age that of bark declined.

Table 4. Seasonal variation in the allocation of energy fixed (x10^6 Kcal/ha/season) in different woody components of teak stands.

Age	Component	Net energy gain/loss (10^6 Kcal/ha/season)			Annual net energy gain/loss (10^6 Kcal/ha/yr)
		Rainy	Winter	Summer	
4	Bole wood	+51.4 (100)	-1.5 (-3)	-8.2 (-16)	+41.7 (81)
	Bole bark	+19.6 (100)	-7.7 (-39)	+2.3 (+12)	+14.2 (73)
	Branch	+11.4 (100)	-0.4 (-4)	+3.1 (+27)	+14.1 (123)
	Total	+82.4 (100)	-9.6 (-12)	-2.8 (-3)	+70.0 (85)
14	Bole wood	+58.6 (100)	-23.1 (-39)	-15.4 (-26)	+20.1 (35)
	Bole bark	+8.5 (100)	-5.2 (-61)	+1.2 (+14)	+4.5 (53)
	Branch	+9.5 (100)	-5.1 (-54)	+0.9 (+10)	+5.3 (57)
	Total	+76.6 (100)	-33.4 (-44)	13.3 (-17)	+29.9 (+39)
30	Bole wood	+93.7 (100)	-41.5 (-44)	30.9 (-33)	+21.2 (23)
	Bole bark	+11.1 (100)	11.1 (-100)	+3.2 (+29)	+3.2 (29)
	Branch	+5.1 (100)	-5.2 (-102)	+3.7 (+73)	+3.6 (71)
	Total	+109.9 (100)	-57.8 (-53)	-23.0 (-22)	+28.0 (+25)

Values in the parentheses denote the energy variation in percent relative to the net energy fixation in rainy season.

Relative to the amount of energy allocated in the different components in rainy season, a net decrease in energy allocation in all components was indicated during winter. This decrease was most marked in the bole bark at all ages and also in the branch at 14- and 30- years. In 30 years old plantation, for instance, the net energy decrease in the bole bark and branch, during winter equalled the net gain in energy during the rainy season. Further computation indicated that net loss increased with age and net gain in summer in the bole bark and branch components was noted in summer. In the bole bark the energy gain tended to increase at greater age.

4. Discussion

4.1. Above ground biomass and net production

Amongst the above ground components, the maximum biomass at 30 years was reflected in the bole (78%); this is in contrast to the pattern in most trees in the natural dry deciduous forest in the same region, whose allocation to branches is greater (Singh and Misra, 1979). At this stage, the bark constituted 18% by weight of the bole, which is close to the estimates of Seth and Kaul (1978) for teak in India (17%) and of Nwoboshi (1980) in Nigeria (13%). As expected, at younger ages the proportion of bark relative to wood was quite high (31% at 4 years). As the tree matures, the proportion of bark in the trunk decreases as in the case of *Podocarpus archboldii* and *Sloanea pulliniana*. Interestingly, the weight of bole bark closely matches the weight of branches in all the ages sampled in teak. Leaves, notably, accounted for about 7% biomass even at 30 years, again contrasting with 3–5% share of leaves in most local trees.

Murphy and Lugo (1986) reported that stem-wood biomass production ranged between 4 and 18 t/ha/year in tropical dry regions compared with 10–30 t/ha/yr in tropical moist and wet regions. At 14 and 30 years the bole production (5–6 t/ha/yr) in teak at Chakia was towards the lower end of the dry tropical forest range, but at 4 years under high-density conditions, for a short time, twice as high production of bole occurred. In several young plantations of fuelwood trees *(Prosopis, Eucalyptus Leucaena, Cassia, Casuarina* and *Albizia)* in dry tropics, the total biomass yields may exceed 20 t/ha/yr, but it is not clear if these yields can be sustained through many rotations (Murphy and Lugo 1986).

4.2. Energy fixation in woody components

Golley (1969) reported that on the average calorific values were greater for stems and fruits in four types of tropical forests (tropical moist, pre-montane, gallery, and mangrove). These values for the same components were: tropical moist forest 4185–4310 cal/g, pre-montane 4167–4073 cal/g, gallery 4248–3845 cal/g, mangrove 4337–4360 cal/g and combined 4220–4102 cal/g. Comparatively, teak has high calorific value components: flowers (6725–6818 cal/g), green leaf (4045–4947 cal/g) in different seasons and at greater ages the bole wood (3904–5474 cal/g).

An approximation of energy gain and loss in woody components in different seasons suggested that net accumulation occurred mainly in rainy season in bole wood. At this time the leaf produced surplus photosynthetic to support flowering as well as bole growth. Within limited time (i.e. 4–5 months of rainy season), teak extracted sufficient amount of photosynthate and other resources to sustain its maintenance throughout the stressed condition. The allocation in reproductive parts of teak was as high as 12% of the total net energy fixation. Computation suggested that during winter, both wood and bark of bole lost significant fractions of the rainy seasons energy accumulation.

It is suggested that such major loss occurred on two accounts. First, the energy must have been used up in the maintenance of the large woody biomass. Second, the developing fruits serve as active sinks for energy use. During the peak growing season (October), the relative strengths of the various sinks are as follows: fruits and seeds > young leaves and stem tips > mature leaves > roots > storage (Kramer and Kozlowski, 1979). Around October and beyond, progressive leaf senescence (e.g. < 55% of green leaf in crown in November, Karmacharya, 1989), is likely to reduce the photosynthetic gain to such a low level that it may barely meet the cost of leaf maintenance, and possibly some part of energy required during fruit development (Karmarcharya and Singh, 1994). Seasonal transfer (deposition and depletion) of carbohydrates and other organic compounds especially from xylem and bark has been reported by Drossopoulos and Niavis (1988) particularly at the time of high metabolic activities and environmental stress. Interestingly, the bole bark and branches showed another minor energy accumulation during summer; at least a part of which might be due to resorption from the rapidly senescing leaves.

4.3. Implications of findings

Teak trees coppiced for fuel or any other purpose on a rotational basis will provide substantial amount of wood. Besides, the next generation coppice will take only 12 years to reach a 20 cm diameter compared to 15 years for the first (Sujarwo 1998), i.e. 20% less time.

Due to higher production in younger stages, teak plantations can be strongly recommended for dry and moist tropical regions of Nepal such as Panchkhal valley, Chitwan valley, Dang valley and the Terai for fuelwood as well timber production.

References

Anon. 1961. *Hundred years of Indian Forestry*, 1861-1961. Vol. II. Govt. of India, FRI, Dehradun, India.

Bhatia, K. K. 1956. Contributions to the Ecology of Teak (*Tectona grandis*) Linn. f.) in Madhya Pradesh. *J. Ind. Bot. Soc.* 35(3): 3657–364.

Champion, H. G. and Seth. S. K. 1968. *A Revised Survey of the Forest Types of India.* Manager of Publications, New Delhi, India.

Drossopoulos, J. B. and Niavis, C. A. 1988. Seasonal Changes of the Metabolites in the Leaves, Bark and Xylem Tissue of Olive Tree (*Olea europaea* L.) II. Carbohydrates. *Annals of Botany* 62: 321–327.

Forugi, Q. 1972. Organic and Mineral Structure and Productivity of Plantations of Sal (*Shorea robusta* Gaertn.) and Teak (*Tectona grandis* Linn.). *Ph.D. Thesis*, Banaras Hindu University, Banaras, India.

Golley, F. B. 1969. Calorific Value of Wet Tropical Forest Vegetation. *Ecology* 50(3): 517–519.

Karmacharya, S. B. 1989. Ecological Studies on Phenology and Resource Allocation in Teak Plantations in a Dry Tropical Region. *Ph.D. Thesis,* Banaras Hindu University, Banaras, India.

Karmacharya, S. B. and Singh, K. P. 1992a. Biomass and Net Production of Teak Plantations in a Dry Tropical Region in India. *Forest Ecology and Management* 55: 233–247.

Karmarcharya, S. B. and Singh. K. P. 1992b. Production and Nutrient Dynamics of Reproductive Components of Teak Trees in the Dry Tropics. *Tree Physiology* 11: 357–368.

Karmacharya, S. B. and Singh, K. P. 1994. Quantitative Analysis of Energy Allocation Pattern in Above Ground Components of Teak Plantations. *Ecoprint* 1(1): 31–39.

Kramer, P. J. and Kozlowski. T. T. 1979. *Physiology of Woody Plants.* Academic Press, New York, USA.

Mathur, K. B. L. 1973. *Teak Bibliography* FRI, Dehradun, India.

Murphy, P. G. and Lugo. A. E. 1986. Ecology of Tropical Dry Forest. *Annu. Rev. Ecol. Syst.* 17: 67–88.

Nwoboshi, L. C. 1980. Nitrogen Cycling in a Teak Plantation Ecosystem in Nigeria. In: Rosswal, T. (ed.). *Nitrogen Cycling in West African Ecosystems* SCOPE/UNEP International Unit, Royal Swedish Academy of Sciences, Stockholm, Sweden. pp. 353–361.

Parr Instrument Company. 1978. *Oxygen Bomb Calorimetry and Combustion Methods. Manual No. 130.*

Seth, S. K. and Kaul, O. N. 1978. Tropical Forest Ecosystems of India: the Teak Forests (A Case Study of Silviculture and Management). In: *Tropical Forest Ecosystems*, UNESCO, Paris, France. pp.628–640.

Singh, K. P. and Misra, R. 1979 Structure and Functioning of Natural, Modified and Silvicultural Ecosystem of Eastern Uttar Pradesh. *Final Technical Report. Indian MAB Project*, Banaras Hindu University, Banaras, India.

Sujarwo, E. 1998. Teak trees in Indonesia. *Wood Energy News* 13 (1): 6.

Mathema, P., Dutta, I. C., Balla, M. K. and Adhikary, S. N. (eds.). 1999. *Sustainable Forest Management.* Proceedings of an International Seminar, 31 August – 2 September 1998, Pokhara, Nepal.

Some Movements towards Sustainable Forest Management in Asia and the Pacific

M. Kashio

Abstract: This paper discusses some key factors to be considered for successful sustainable forest management (SFM). Further, FAO's initiatives being taken for SFM are also introduced, such as a movement to review and improve timber harvesting codes in both the national and regional levels under the working group created by the 16th Asia-Pacific Forestry Commission in 1995. Some interesting facts found by the Asia-Pacific Forestry Sector Outlook Study, including a high potential to produce wood outside the forestlands, are also discussed from the viewpoint of SFM.

1. Introduction

Since the "sustainable development" concept was elaborated by the World Commission on Environment and Development in 1987, and endorsed by the United Nations Conference on Environment and Development (UNCED) in June 1992, it has become the most important issue in the development aspirations of the 1990s. In the forestry sector, this concept has triggered a review of the traditional forest management systems, under which the tropical natural forests have been continuously degraded and deforested. The annual deforestation rate in the Asia-Pacific region increased from 2.0 million ha during 1976–80 to 3.9 million ha during 1980–90 (FAO, 1993a).

Most deforestation in the region's tropical countries is attributable to the expansion of agriculture through shifting cultivation, grazing, cultivation of cash crops, colonisation, and transmigration programmes. Other direct cause of deforestation is infrastructure development. This means that in the course of social and economic development in developing countries, the demands and expectations from the forests became much broader and intensive, except for the case of war. Behind this deforestation phenomenon, there is a wide spread degradation process. It is not easy to analyse this process quantitatively, because many degradation indicators are more or less qualitative, such as a gradual change of species composition, or a gradual reduction of productive capacity and biodiversity. Continued degradation of forest resources ultimately results in deforestation. Although the extent of degraded forestlands and the level of degradation are difficult to quantify, available information indicate that degradation is even more widespread than deforestation.

In this paper, traditional forest management systems are critically reviewed, and some recent movements towards the achievement of sustainable forest management mostly under the FAO's programmes are introduced.

2. A review of forest management in tropical Asia and the Pacific Region

The roots of "sustainable forest management" can be traced to the classical concept of sustained yield forestry. Its main principle is of "balancing the volume (of timber) harvested against the growth predicted from regeneration and planting" (FAO, 1993b). Specialists agree that "the sustainable management of forests *for the* *production of wood* is based on a deceptively simple principle. All that needs to be done is to harvest the wood at an average annual rate no greater than the forest in question can grow it." (FAO, 1993b). Some, however, question the overall sustainability of this approach. Sustainable forest management is now widely acknowledged to mean much more than simply the sustained production of wood.

Modern forest management systems in tropical regions were, in many cases, introduced by the colonial powers of Europe and the United States of America during the middle of the 19th century and the early part of the 20th. The targeted forests were mainly located in plains and low hill areas. Economically valuable trees, such as teak (*Tectona grandis*) and sal (*Shorea robusta*), were first targeted. Except for sal, the dipterocarps—a major component of tropical rain forests in Asia—were not at first recognised as valuable. Most dipterocarp trees were too big to easily harvest and transport. They were also not initially recognised as suitable for furniture and construction, except for some species, such as chengal (*Balanocarpus heimii*), "Malaya's best-known heavy hardwood" (Wyatt-Smith, 1963).

Modern forestry in **India** and **Myanmar** began under the British colonial administration. The teak forests of India, Myanmar, and Thailand received special attention from the British due to their high strategic value for shipbuilding, as well as for their economic value for furniture making and decorative interior material. The colonial government applied the latest forest management theories, developed in Germany during the 1820s to 1830s, and established a selection system for teak in Myanmar in 1856 and sal in India in 1864. Dr. Dietrich Brandis, the first Director General of the Forest Department of Myanmar, then known as Burma and a part of Imperial India, developed a selection system for teak forests. His system, later to become known as the (Burma) Myanmar Selection System (MSS), was applied to the teak forest of India as well. This MSS has been in operation since 1856, marking the longest and the most successful record for a single forest management system in the entire region. India's selection system for teak did not function well, mainly due to the lack of regeneration. The selection system was modified into a uniform system, and in many places was replaced with an artificial plantation system.

Thailand established its Royal Forest Department (RFD) in 1896, and imported the MSS. The first Director General of RFD, H. A. Slade, a British forester, was invited from Myanmar since Thailand at that time had no experience in scientific forest management. They applied the same prescription of the MSS to the Thai teak forests and later expanded the system to include other non-teak tropical hardwoods (Kashio, 1995). In a serious contradiction between the forestry laws and the custom laws, however, forestlands of the country have been encroached by landless farmers for slash-and-burn agriculture. The custom laws allowed farmers to open forests when they faced a shortage of farming lands. The forest village system was introduced in 1968 to re-settle encroachers (Samapuddhi, 1974/75), but the promotion of cash crops guided by the agriculture sector policies, for example sugarcane, rubber, maize, cassava, pineapple, and vegetables, has led to the country's deforestation. The logging ban imposed in January 1989 and still enforced has resulted in abandoning the conventional forest management in natural forests. The RFD drafted the Community Forest Act in 1991 and submitted it to the Cabinet. This draft is still being discussed with farmers and NGOs. How much authority should be given to local communities or individuals for the management of national forest lands is the main argument.

Forest management in **Peninsular Malaysia** started with the production of "gutta percha" (latex from *Palaquium gutta*) during 1900–1910. Selective logging also began during this period for chengal. In response to an increasing demand for fuelwood, poles for mining, and sawnwood, Malaysia evolved several forest management systems up to the beginning of World War II. After the war, in 1948 the Malaysian Uniform System (MUS), well known among foresters in the region, was formulated to convert the virgin lowland tropical rain forest, dominated by dipterocarps, to more even-aged forest formations with commercially valuable timber species (FAO, 1989). Lowland dipterocarp forests were, however, converted to agricultural plantations, mainly rubber and oil palm, and MUS lost most of its importance. When applied to the hill dipterocarp forests, the MUS was found unsuitable and was improved to the Modified Malaysian Uniform System (MMUS). Later, this was replaced with the Selective Management System, which gives more flexibility in forest management practices, particularly in logged-over hill forests. They are now conducting field studies on how to achieve sustainable forest management by accepting the ITTO's guidelines for criteria and indicators. In **Sabah**, the MMUS was introduced after experiences of several logging and management practices. Refining this system gradually according to the local conditions, it has been in operation in logged-over hill forests. In **Sarawak**, after evaluating three silvicultural treatments, a modified MUS is now practised in the mixed swamp forest as an after-logging treatment, and liberation thinnings in the logged-over mixed dipterocarp forest (FAO, 1989).

In **Indonesia,** teak forest in Java was put under a management plan in 1891 by foresters of the Dutch colonial government. Now, about 900,000 ha of teak forests (mostly in plantations) is managed by the Clear Felling and Artificial Regeneration System. By the time of the breakout of World War II in 1941, logging by concessionaires had expanded to the outer island territories, such as Sumatra and Kalimantan. Large-scale commercial logging, however, started during 1969–70 after the Foreign Investment Law was enacted in 1967. An initial forest management system was based on the experiences gained through a concession system tested in East Kalimantan during the 1960s. A need was felt to develop a more sophisticated management system, and this led to the birth of the Indonesian Selective Felling System (ISFM), which was well blended with components from the MUS and the Philippines' Selection System. Since its modification to the Indonesian Selective Felling and Planting System in 1988, this system has been widely applied to the country's dipterocarp forests. Indonesia has now begun to develop criteria and indicators for seeking sustainable forest management in different forest types.

The **Philippines** founded its scientific forest management systems under the influence of the United States of America at the beginning of this century. With the emergence of the export-oriented forest industries in the early 1950s, a need was felt to develop a selective logging system for its dipterocarp forests (Agaloos, 1983). There was, however, a time gap between the development of an appropriate management system and its application in the field, and logging accelerated in response to the ever-growing demand. Also, the Philippine Selection System was largely ignored because of a weak administration and an unstable political situation. As a result, the country's forest resources were heavily exploited, mainly for plywood logs, during the 1960s and 1970s (Basa and Dalangin, 1991). A large number of landless farmers found refuge in logged-over forest areas and encroached on the remaining forests for their survival. The Philippines-German Timber Stand Improvement (TSI) Project implemented at the beginning of the 1980s was a belated attempt to rehabilitate damaged logged-over forests.

Cambodia, **Lao PDR**, and **Vietnam** were all under the colonial administration of France from 1870 until World War II. All three countries developed a type of selection system. Unfortunately, details are limited, mainly because of the destruction of historical documents and the loss of institutional records during the prolonged wars. When the troops of the Pathet Lao and Khmer Rouge took power in Laos and Cambodia in 1975, the revolutionary soldiers destroyed all forestry documents (Kashio, 1998). Continued war did not allow the governments to allocate enough budget and manpower for any significant forestry work. The weakness of such foundations in these three countries became the major constraints to establishing sound forestry and management systems.

Although **Cambodia** once had a relatively effective national forestry administration, this system was destroyed in 1970. Since then, forest management has been in disarray. During some periods, the Army, not the Forestry Department has had the authority to issue logging licenses. The Khmer Rouge, which controlled parts of western Cambodia, illegally sold forest resources to Thailand for years. In **Lao PDR**, its forestlands have suffered serious degradation caused by extensive shifting cultivation. The total area affected by shifting cultivation was estimated at 8.9 million ha in 1989. Logging is carried out by clear cutting in planned dam reservoir areas. Since 1996, a land allocation programme supported by community forestry and agroforestry approaches has been launched to reduce the pressure on forests. In October 1995, **Vietnam** shifted responsibility for forest management to provincial governments and local communities. There is as yet no clear picture as to the efficiency of community-based forest management. In December 1997, the government launched the 5 million ha tree-planting plan to rehabilitate degraded forests.

In **Fiji**, the United Kingdom introduced mahogany plantations. These plantations are planted in open grasslands or in logged-over areas, and trees are allowed to grow together with other species. When they reach harvestable size, 25–30 years after planting, stands look like natural forests. Large areas of lowland forests were converted to sugarcane fields. Timber was logged mainly for domestic use, not export. Large volumes of wood are consumed as fuel in sugar refining factories. Extensive plantations of Caribbean pine have been established in western Fiji.

In the **Solomon Islands** and **Vanuatu**, modern forest management only began in recent years under the technical support of Australia. A major constraint to co-ordinated forest management is the traditional land tenure system. Local tribal communities control forestlands and the central government can do little to control their practices. The government also faces great difficulty in stopping the destructive forest operations practised by foreign companies as concessions are granted directly by local tribes. As **Samoa** is prone to typhoons, its forest management system must be well prepared for such destructive storms. Generally, South Pacific island countries suffer from a scarcity of clean, fresh water. Forests in the watershed areas are thus extremely important for safeguarding precious water supplies. In this regard, the FAO/UNDP watershed management project in Samoa played a significant role to demonstrate a participatory approach in the forest and land resources management.

3. Limitations of conventional forest management systems

The forest management systems in the region differ by countries, but share some common characteristics. The first is that their forest management systems were designed and developed with timber production in mind. Very little attention was given to the welfare of local people. Forest policies and laws were also designed primarily to produce timber. Local people's rights to land were mostly neglected. Locals were not counted as partners in forest management. Another neglected point has been concern for ecology and the environment. The conservation of biological diversity, wildlife protection, and the water and soil retention functions of forests were all recognised in theory, but not considered in actual management plans and operations. It was assumed that if a forest were managed as prescribed, such functions would naturally be fulfilled. This assumption did not work as the management system lacked effective remedial solutions.

From the silvicultural point of view, the conventional forest management systems (either selection or uniform systems) require vigorous regeneration in a gap with the same species after the removal of mother trees. In most tropical forests, however, a gap is quickly occupied by light demanding pioneer species (woody, herbaceous or bamboo species), and this interrupts the growth of expected timber species. This problem becomes more serious in a bigger gap with less seedlings inside and mother trees around.

Another problem of the conventional forest management systems in natural tropical forests is the degradation of forest resources due mainly to unsustainably high harvesting levels carried out either in the absence of sound forest management plans or through failure to enforce management rules and regulations. It is widely recognised that logging operations cause considerable damage to forests. Although selective logging usually removes only one to ten trees per hectare, it is not unusual for 30–40 percent of the residual younger trees to be destroyed through indiscriminate logging. Logging roads provide access to forest areas and therefore contribute to accelerated deforestation, when logged-over areas are affected by other human activities. Fires set by shifting cultivators and clearing by farmers, cause deforestation. The most conventional forest management systems did not have effective measures to prevent this process.

The conventional forest management systems assumed the existence of a uniform forest in a wider range to design compartments or working circles under an entire harvesting cycle. This requirement is no longer satisfied in the current situation because natural forests in most countries have been seriously fragmented and degraded.

The conventional forest management systems neglected the management and utilisation of less-valuable or unvalued timber species. Until the recent modifications of forest management systems, they were largely wasted in forests. It can be observed in the management and utilisation of non-wood forest products (NWFPs). For example, rattan had been harvested from natural forests mainly by tribal people in Malaysia and Indonesia. It is said that ever-increasing demand for rattan lead to the overharvesting and depletion of its resources in the 1980s. This depletion was, however, not only caused by the overharvesting alone but also by a improper linkage between timber-oriented forest management systems and rattan harvesting systems. Rattan resources were unnecessarily destroyed and wasted during logging operations.

Forestry authorities in these countries made efforts to overcome these weaknesses through reviewing their forestry sectors during the late 1970s and 80s. The community or social forestry approaches derived from the Eighth World Forest Conference in Jakarta in 1978 triggered this movement. The Tropical Forestry Action Plan (TFAP) launched in 1985, now renamed as the National Forestry Action Programme (NFAP), offered another occasion. These reviews proposed forestry policy reform, peoples' participation in forest management, and more environmental concerns. The Integrated Social Forestry Programme in the Philippines, and the Nepal Forestry Sector Master Plan are two examples. India's new forest policy of 1988 recorded a historical change in the forestry sector. The initiatives of ITTO set up the first criteria and indicators in 1991 for the establishment of sustainable forest management at both the national and forest management unit levels.

4. Conditions for sustainable forest management

Diversification of forest management systems

In the course of social and economic development in developing countries, most forestry authorities failed to respond to changing situations and efforts to protect forests by force were not successful. While natural forests have been severely degraded and deforested, a large amount of agricultural land derived from forests has been also degraded, and in many cases abandoned as mere "wasteland." Extensive shifting cultivation has also degraded the forests. Consequently, the original tropical forests have been replaced with a wide variety of vegetation, including logged-over forests (usually under a certain forest management system based on natural regeneration), secondary forests without any silvicultural treatments, and artificially created tree plantations, many of them comprised of exotic species, such as *Eucalyptus* and *Acacia*. Also, the forests have been badly fragmented. These two trends—diversification and fragmentation in forest lands—have led to the simple reality that a uniform application of one forest management system has become unworkable.

Even to formulate a management system for timber production from natural forests based on sustained yield, prescriptions must differ from one forest type to another. Management systems for protected areas or man-made plantations are totally different from those of natural forests for timber production. There is an urgent need to prepare specific management plans for each forest type by determining its expected products and sustainable harvest level, and exactly who should take care of the forest and who is to receive its benefits. This process requires scientific and socio-economic studies, and local participation in the decision-making process.

Some forestry authorities are now attempting to work out prescriptions suitable for each vegetation type. To be successful in this attempt, it is essential to have a sufficient amount of reliable information and comprehensive understanding of the ecological phenomenon of the concerned forest type, local socio-economic conditions and requirements, trends in the market, and national policies on land use, development, environment, etc.

Land use plans and zoning

Every country has some kind of a framework for nation-wide land use planning, even if it only exists in its land use policy statements or guidelines. In the forestry sector, there is a tendency to separate forestlands from other land uses by zoning, which provides one practical framework. Forest lands are classified into broad functional categories, such as protection forests, production forests, national parks, wildlife sanctuaries, and so on. A classification of forestland from other land uses by the steepness of slopes is another zoning example as seen in the Philippines. Introduction of 'criteria and indicators' provides another framework, not only to help guide the formulation of sustainable forest management systems, but also to monitor and evaluate their workability.

Involvement of local people in forest management practices

The number of foresters is extremely small relative to the number of local people in most forest areas. Laws and regulations are ineffectual unless local people stand with, rather than against, foresters. In practice, foresters do not control forests, the local people do. Foresters must drastically change their attitudes and approaches. They should regard themselves as technical advisors dealing with forest management. Their real job is to provide local people with useful information and suggestions. This is the only way to earn local people's trust and respect, and to form a sound partnership to minimise conflicts.

Community/social forestry, agroforestry, and the use of non-wood forest products

The beneficial results of this approach can now be seen in many countries, and should be further enhanced. Remaining targets include the enhancement of economic returns to local communities through improving market access for community forestry products, technical and market information services, effective and workable rural credit systems, the creation of co-operatives, and the upgrading of education systems, particularly in environmental concerns.

Trees planted under community or social forestry programmes are usually well selected by the local people for their needs. Such a woody plot is relatively small in size and often mixed with other plants, but its total extent becomes huge. These products and planted areas are seldom covered in official forestry statistics, because trees are located outside the officially recognised forestlands. However, several studies indicate that they supply a large amount of wood and other products. In response to the request of the Asia-Pacific Forestry Sector Outlook Study (APFSOS), the Regional Wood Energy Development Programme in Asia reported that "a major part, often over 50% of woodfuel is derived from non-forest areas" (APFSOS, 1997). These facts must be well considered in national forest management programmes.

Extensive possibilities exist for developing forest resource management focused on non-wood forest products. There is a need, however, for foresters to develop new skills in the processing and marketing of these products. Many forestry experts believe that rural development is a prerequisite for saving the forests. It is obvious that the forestry sector alone cannot accomplish all the work needed. Accordingly, government services in different sectors of the economy must be better co-ordinated and integrated. Another need is to create a mechanism at the local level for co-ordinating government services and deciding how best to use them. When such mechanisms are firmly in place, people's participation will follow of its own accord.

Land tenure systems

Until recently, forestlands were owned and controlled by national governments. Forestry authorities held all legal powers over the forests, ranging from issuing concessions to taxing, logging, processing, and marketing of forest products. Though some recognition was given to the traditional rights of local communities to use the forests, ownership was still claimed by the government. This created conflicts with local users of forestlands, as customarily forests were perceived as belonging to local communities. Where these customs persist, they should be properly respected. It is imperative, however, that forestry departments provide technical packages for appropriate land use including agroforestry, and natural resources utilisation including NWFPs, in close collaboration with other social and economic service departments.

Protection of wilderness and biological diversity

Tropical forests have lost a large part of their former wilderness character. It is, however, still possible to identify original or near original forests, especially in protected areas. Many useful things can be learned from the wilderness and the value of biologically rich flora and fauna, and ecological knowledge should not be underestimated. New medicines and genetic materials for agriculture and forestry may well save our future. New silvicultural principles may also be developed based on better understanding of undisturbed original forests. The conservation and use of such forests, therefore, need priority attention.

New type of forester

Forestry education and training systems must be reshaped to meet the demands of forestry in the future. Since training programmes always suffer a time lag between inception and reality, urgent action is needed now. In general, the new type of forester should have an adequate knowledge of related sectors, such as agriculture, livestock, fisheries, and rural development, a good understanding of the ecological principles of forest ecosystems, a capacity for communication, and the ability to apply such modern technology like information systems, GIS, etc.

5. FAO's initiatives in promoting sustainable forest management

Working Group on Sustainable Forest Management

According to the recommendation made by the FAO/ITTO Regional Expert Consultation on the Implementation of Sustainable Forest Management held in Bangkok in December 1995, the 16th Session of Asia-Pacific Forestry Commission (APFC) held in Myanmar in January 1996 established an *ad hoc* Working Group on Sustainable Forest Management. Reviewing the existing codes of practice for forest harvesting, the Working Group submitted a draft regional Code of Practice for Forest Harvesting to the 17th APFC Session in February 1998. In a complementary arrangement with the ITTO's Criteria and Indicators, this Code aims to provide a component that will contribute to an integrated system designed to achieve sustainable forest management. The main subject is focused on timber harvesting from the region's natural forests, but also covers NWFPs. This Code is strongly expected to guide the improvement or development of a national code for forest harvesting.

The Asia-Pacific Forestry Sector Outlook Study

At the 16th APFC Session, an important programme called "The Asia-Pacific Forestry Sector Outlook Study (APFSOS)" was endorsed. Since then, FAO has been systematically conducting a series of studies on the scenarios of the region's forestry sector in the year 2010, including SFM related subjects. One interesting finding is that a large amount of timber and other produce has been produced from various non-forest lands, and consumed by the local people in their daily life. Thus, SFM cannot focus only on the timber or NWFP production from natural forests. Another interesting finding is that the remaining natural forests are more and more being assigned to protected status for biodiversity conservation and other environmental functions than to produce timber.

Information services

The collection, analysis and delivery of information on agriculture, forestry, fisheries, nutrition, and rural development are one of FAO's most important mandates. A major media for information dissemination has been publications, but now electronic media such as computer diskettes or CD-ROMs, are becoming more popular. FAO's statistics are also available through the Internet.

Neutral forums for organising meetings

Using its position as a UN agency, FAO organises meetings to offer neutral forums on various forestry subjects. It is certain that sustainable forest management contains political issues such as criteria and indicators' application and issuance of forest product certificates or ecolabels. As many forestry matters have not yet been settled to the satisfaction of all interest groups, FAO's ability to arrange neutral forums remains of high importance.

Technical support

FAO provides technical support to its member states through its regular programmes, field projects, professional staff, and consultants. The project approach also provides funding either by other sources or by FAO itself. By using the advantages of its accumulated experiences in great many countries, FAO provides policy recommendations at the highest levels.

Initiatives to formulate new concepts, approaches and movements

When necessary, FAO initiates new concepts, approaches and movements through various councils, committees or advisory bodies. Initiatives that FAO has already taken in community forestry and people's participation, are just two examples. In sustainable agriculture and rural development, FAO has always been the key UN agency. Promotion of the National Forestry Action Programme is another clear example.

In the absence of any universal agreement on the definition of sustainable forest management and seeking what it should be, FAO has been promoting movements towards sustainable forest management through all the functions mentioned in the previous section. As the components of sustainable forest management are deeply linked with global and local environmental issues, ranging from global climate change to the securing of clean water supplies, and helping with the prevention of floods and landslides—all these are included in FAO's work.

References

Agaloos, B. C. 1983. *Silvicultural and Logging Systems in the Philippines.* Proceedings of the First ASEAN Forestry Congress, Book II, October 10–15, 1983, Manila, The Philippines.

Basa, V. F. and Dalangin, N. B. 1991. Inventory of the Philippine Forests. Paper Presented at the Workshop on Methodology of Deforestation Assessment, May 6–17, 1991, Bangkok, Thailand.

FAO. 1989. Review of Forest Management Systems of Tropical Asia. *FAO Forestry Paper 89*, FAO, Rome, Italy.

FAO. 1993a. Forestry Resource Assessment 1990: Tropical Countries. *FAO Forestry Paper 112*, FAO, Rome, Italy.

FAO. 1993b. *The Challenge of Sustainable Forest Management.* FAO, Rome, Italy.

APFSOS. 1997. *Regional Study on Wood Energy Today and Tomorrow in Asia.* Working Paper No. APFSOS/WP/34.

Kashio, M. 1995. *Forestry in Thailand.* Country Study Series. Association for the International Co-operation of Agriculture and Forestry (In Japanese).

Kashio, M. 1998. *Forests in Southeast Asia.* Zest Publishing Co., Tokyo, Japan (In Japanese).

Samapuddhi, K. 1974/75. Thailand's Forest Villages. *Unasylva* 27(107): 20–23.

Wyatt-Smith, J. 1963. Manual of Malayan Silviculture for Inland Forests. Part III - Natural Regeneration. *Malayan Forest Rec. No. 23*, Kuala Lumpur, Malaysia.

Mathema, P., Dutta, I. C., Balla, M. K. and Adhikary, S. N. (eds.). 1999. *Sustainable Forest Management.* Proceedings of an International Seminar, 31 August – 2 September 1998, Pokhara, Nepal.

Effect of "Roots"—an Organic Biostimulant—on Seedling Physiology and Growth of *Alnus nepalensis*

M. H. Khan

Abstract: The experiment conducted on effects of "Roots"—an organic biostimulant—on seedling physiology and growth of *Alnus nepalensis* in greenhouse revealed significant differences (at 95% level) in fresh root weight, fresh and dry leaf weight, and whole plant leaf area. Although, there was no significant difference in mean of root length, stem length, collar diameter, root dry weight, and stem fresh and dry weight, the mean difference in these variables compared between treatments were inconsistent. Biostimulant increased nodulation and all nodulated seedlings had greater leaf area and chlorophyll content and probably more net photosynthesis.

1. Introduction

Alnus nepalensis is a common actinorrhizal and efficient nitrogen fixing tree in both natural and managed ecosystems in the central and the eastern Himalayas. It is a successful pioneer in freshly exposed soil in landslide affected areas, rocky and eroded slope. *Alnus nepalensis* plantations not only make significant contribution to soil nitrogen but also improves soil quality and protect the vulnerable slopes against erosion with luxuriant undergrowth (Sherma *et al.,* 1985).

Seedling production, establishing favourable rhizosphere association beneficial to seedling physiology and growth has received increasing attention in recent years. Planting for forest regeneration, land reclamation and stabilisation, or biomass production entail placement of tree seedlings in nutrient deficient and often poorly prepared soil. In such situations, where the early stages of seedling establishment are crucial for ultimate productivity, physiologically sound seedlings with microbial-root association are more likely to survive in the field (Berry and Torry, 1985).

Russo and Berlyn (1989 and 1990) reported that the organic biostimulant "Roots" greatly increased the growth and biomass of seedlings in nursery, while decreasing the fertiliser requirements up to 50% in a number of species (coffee, pines, Douglas fir, *Gliricidia* sp. and *Alnus acuminata).* Increase in nodulation by application of "Roots" had been demonstrated in *Alnus acuminata* (Russo and Berlyn, 1989) and increase of nodulation had been reported by phosphate application in *Alnus nepalensis* (Jha *et al.,* 1992). There is no published report on the role of biostimulant "Roots" on seedling physiology and growth of *Alnus nepalensis.* This paper deals with the effect of "Roots" or/and *Frankia* inoculation on seedling physiology and growth of *Alnus nepalensis.*

2. Materials and methods

The seeds of *Alnus nepalensis* were collected from India and stored at low temperature in a refrigerator. The seeds were washed thoroughly and soaked in water with gentle stirring and kept in growth chamber under low light and temperature for 48 hours for scarification. The seeds were germinated in trays containing vermiculite. Most of the seeds germinated in two weeks. Since the growth of seedlings on vermiculite was very slow, seedlings were fertilised once with one litre solution of Miracle Grow (15:30:15) 1 g/lit after one month of germination.

Seven-week old seedlings were transplanted in 200 cc plastic pots containing Promix, with one seedling in each pot. The pots were placed in groups of ten for the following treatments. Each treatment was replicated four times and placed under similar environmental conditions in a Randomised Block Design. The seedlings were irrigated every two days to maintain soil moisture status at 90–100%. The experiment was conducted in the greenhouse of Greely Memorial Lab., Yale University, New Haven, USA.

Treatments (Groups)

T1 = Promix + biostimulant ("Roots").
T2 = Promix + *Frankia* (*Myrica* and *Casuarina* rhizosphere soil).
T3 = Promix + biostimulant + *Frankia* (*Myrica* & *Casuarina* rhizosphere soil).
T4 = Promix only (Control).

The biostimulant was applied once immediately after transplanting (1:100 water) and all plants were fertilised with Miracle Grow (15:30:15) @ 1 mg/lit. Each plant was given 50 ml solution of biostimulant and fertiliser in T1 and T3 or only fertiliser in T2 and T4. The biostimulant was applied three times after six weeks' intervals.

Two weeks after transplanting, one teaspoonful of rhizosphere soil from *Myrica* and *Casuarina* grown separately in pots in the greenhouse, were added in the pots in T2 and T3 for natural *Frankia* inoculation. About five weeks after transplanting and first treatment, all plants were treated with insecticidal soap @ 18.8 ml/lit of water using one lit of solution twice after one week interval due to heavy infestation of black flies.

Data collection and analysis

The experiment was terminated after 25 weeks of sowing and the variables were measured after about 18 weeks of transplanting. The variables measured were root length; stem length; collar diameter; fresh and dry weights of roots, stem, and leaves; leaf area of whole plant; longest leaf length; relative chlorophyll content; and nodulation. Analysis of variance was carried out for the comparison of variables between treatments at 95% level.

3. Results and discussion

There was significant difference in mean fresh root weight between treatments. The highest mean fresh root weight value was found in T1 followed by T2, T4, and T3 in a decreasing order. Although, no significant difference in mean dry root weight between treatments was observed, there was least dry root weight gain in T1 and highest root weight gain in T2. Both the lowest dry root weight gain and highest fresh root weight gain in T1 indicated the positive role of biostimulant in water absorption and increasing the drought tolerance capacity of seedlings. The highest dry root weight gain in T2 may be due to the role of *Frankia* inoculum in increasing net photosynthesis due to increased mean leaf area and possibly more photosynthate allocation to root.

Significant differences were observed in both leaf mean fresh weight and leaf mean dry weight. Both leaf mean fresh weight and mean dry weight gain was highest in T2 and lowest in T1 but T3 showed greater fresh and dry weight gain than T4. This may be due to increased leaf area in T2 and T3 and increased net photosynthesis. Both the lowest leaf fresh and dry mean weight in T1 may be correlated with lowest mean leaf area and possibly increased rate of translocation of food and more allocation of photosynthate to stem.

There was significant difference in whole plant leaf area between treatments. The mean leaf area was greatest in T2 and lowest in T1 but the leaf area of T3 was greater than T4. This indicated the positive role of *Frankia* inoculum on leaf growth by providing more nitrogen to the plant through biological nitrogen fixation in both T2 and T3, since, nitrogen is the most important constituent of chlorophyll and most essential element for chlorophyll synthesis and leaf growth. The lowest mean leaf area in T1 may be due to more allocation of photosynthate to stem. The lowest mean leaf area in T1 also indicates the role of biostimulant in decreasing leaf area which can be correlated with increasing drought tolerance capacity and phenotypic plasticity of seedlings.

The average longest leaf length was highest in T2 and lowest in T1 which again suggests the positive role of *Frankia* in leaf growth and may be negative effect of biostimulant on leaf growth or more allocation to stem.

Although, nodulation was very poor which may be due to poor *Frankia* inoculum in rhizosphere soil of both *Casuarina* and *Myrica* grown in pots in the greenhouse, nodulation was best in T3 followed by T2, T1, and T4 in a decreasing order. Best nodulation in T3 than all treatments and more nodulation in T1 than T4 suggests positive role of biostimulant in nodulation. Nodulation in T1 and T4 without *Frankia* inoculum was unusual but it suggests the possibility of air born contamination with spores of *Frankia*. All nodulated seedlings had greater leaf area, relatively more chlorophyll content and vigorous growth due to more photosynthetic area and probably more net photosynthesis.

Statistically no significant difference was observed in stem height, root length, and collar diameter between treatments. The best stem height performance and greater collar diameter was in T2 whereas the poor performance was in T3, T4 and T1 in a decreasing order. This can be directly correlated with leaf area. Greater root length was observed in T1 followed by T2, T3, and T4 in a decreasing order. This indicated positive effect of biostimulant, *Frankia* alone and *Frankia* and biostimulant combined on root growth.

There was no significant difference in stem fresh and dry weight. However, stem fresh weight was greatest in T2 and stem dry weight was greatest in T1. Both stem fresh and dry weight observed lowest in T3. The greatest stem dry weight in T1 showed positive influence on dry matter production and more allocation to stem in comparison to other treatments.

4. Conclusion

The present study showed positive role of *Frankia* inoculation alone or in combination with organic biostimulant "Roots" on seedling physiology and growth of *Alnus nepalensis*. Comparison of variables measured between treatments using analysis of variance at 95% level indicated significant differences in mean values of fresh root, leaf fresh and dry weight, and whole plant leaf area. The effect of biostimulant alone in decreasing leaf area can be attributed to increasing drought tolerance capacity and phenotypic plasticity of the seedlings.

Although there was statistically no significant difference in other variables between the treatments, the seedlings in treatments with biostimulant or *Frankia* or a combination of both indicated better response in growth. Application of "Roots" also stimulated nodulation. The nodulated seedlings were healthier because they had greater mean leaf area and higher relative chlorophyll content due to more nitrogen availability, hence more photosynthetic area and probably more net photosynthesis. Thus beside *Frankia* inoculation, application of "Roots" in combination with *Frankia* inoculum in seedling production of *Alnus nepalensis* can improve afforestation and reforestation efforts in the Himalayas.

References

Berry, A. and Torry, J. 1985. Seed Germination, Seedling Inoculation and Establishment of *Alnus* sp. in Containers in Greenhouse Trials. *Plant and Soil* 87: 161–173.

Jha, D. K., Sherma, G. D., Mishra, R. R. 1992. Mineral Nutrition in the Tripartite Interaction between *Frankia, Glomus* and *Alnus* at Different Soil Phosphorus Regimes.

Russo, R. O. and Berlyn, G. P. 1990. The Use of Organic Biostimulants to Help Low Input Sustainable Agriculture. *Journal of Sustainable Agriculture* 1(2): 19–42.

Russo, R. O. and Berlyn, G. P. 1989. The Effect of a New Biostimulant on Acetylene Reduction in Nodulated Seedlings of *Alnus acuminata. Abstracts of Nitrogen Fixing Meeting*, August 1989. Ames, Iowa, USA.

Sherma, E., Ambasht, R. S. and Singh, M. P. 1985. Chemical Soil Properties under Five Age Series of *Alnus nepalensis* Plantations in the Eastern Himalayas. *Plant and Soil* 84: 105–113.

Mathema, P., Dutta, I. C., Balla, M. K. and Adhikary, S. N. (eds.). 1999. *Sustainable Forest Management.*
Proceedings of an International Seminar, 31 August – 2 September 1998, Pokhara, Nepal.

Sustainable Forest Management in Myanmar

A. K. Myint

Abstract: Myanmar is blessed with rich and diverse forest resources. Forestry in Myanmar produces as much revenue as the agriculture sector. This paper discusses the past and present efforts in sustainable forest management in Myanmar. The paper asserts that natural forest management needs to be supplemented with intensive plantations to meet the ever-increasing demands for forest products.

1. Introduction

Myanmar, with an area of 676,577 km^2 is situated within 9^0 53' N and 28^0 25' N latitudes and 92^0 10' E and 101^0 10' E longitudes. Approximately 75 % of the country lies within the tropics. Apart from its wide latitudinal range, it also has an altitudinal range from sea level to snow capped peak of over 5,727 m. Consequently, it has a wide range of temperatures. The rainfall, which is distributed over five months of the year also, ranges from 762 mm to over 5,080 mm. All these contribute towards a wide variety of environmental conditions and diversity in the types of forests that exist within the country. General types of Myanmar forest are (Myint, 1981):

- **Evergreen forest**
  - Tropical wet evergreen forest
  - Tropical semi-evergreen forest
- **Mixed deciduous forest**
  - Moist upper mixed deciduous forest
  - Dry upper mixed deciduous forest
  - Lower mixed deciduous forest
- **Deciduous dipterocarp forest**
- **Dry forest**
- **Hill and temperate evergreen forest**
  - Hill evergreen forest
  - Dry Hill forest
  - Alpine forest
- **Tidal, beach and dune and swamp forest**

The total forest cover of Myanmar is 53.5% of the total land area. Myanmar forests are of great economic value to the country. The economic importance of the forest resources has become so significant today that the revenue earned from forest resources is equal to that earned from the agricultural sector. The forest resources which are of vital importance to the country need to be systematically managed for sustained production. It must be acknowledged that the sustained yields, which are being harvested today, are due to good forest management in the past. However, with the increase in population and greater pressure on forested land for conversion to agricultural land, the management system needs to be modified so as to suit the present situation. Forest resources, being replenishable, can be managed so as to be in line with this situation. Natural regeneration and cultural operations are being carried out in natural forests in order to introduce regeneration or to encourage the existing natural regeneration. At the same time extensive areas of plantation are also being established in order to supplement the production of the natural forests.

2. Development of forest management

Management

Forest management in Myanmar can be said to have been started since the last dynasties of the Burmese kings. Teak (*Tectona grandis*) trees were, since then, declared as royal property and royalties were levied for their extraction (Brandis, 1896). However, scientific forest management started only in 1856 when Dr. Dietrich Brandis was given charge of the Bago forests (Blanford, 1956; Forest Department Myanmar, 1989). Early in 1857, new rules were published, bringing the Bago forests under regular conservancy and controlling the removal of teak trees. Soon after this, Brandis drew up the first working plans for Bago teak forests. The plans were based on ring counting and observation of trees of known age. He calculated that it took 24 years for trees of 45 cm – 60 cm dbh class to reach more than 60 cm dbh class. Accordingly, he prescribed that 1/24th of the number of yield trees (60 cm dbh and above) should be cut annually. Brandis estimated the number of yield trees for Bago forests from linear valuation surveys. This silvicultural system which form the basis for the present management method was known as the Brandis Selection System and was maintained for many years.

As a step in systematic management of Myanmar forests, a policy was laid down in 1894, according to which the forests were administered. Four main classes of forests were classified to be managed: **Protection Forests**, based on climatic and physical ground; **Commercial Forests** which afforded a supply of valuable timber for commercial purposes; **Local Supply Forests** to provide local people with day-to-day needs with respect to timber, fuelwood, charcoal, bamboos, thatch, etc.; and **Nature Reserves, Game Sanctuaries** and **National Parks** (Anon., 1986; Rao, 1961).

Brandis also instituted departmental extraction with sales in Yangon. This was to start the work on sound lines as the previous uncontrolled extraction by private agencies in the Tanintharyi forests was a disaster (Blandford, 1956). This system of departmental extraction had continued as Myitmaka Extraction Division up till 1948 when it was handed over to the State Timber Board (Hoe, 1956).

Geographical ground survey of reserved forests was initiated in 1882–83 on a 4" = 1 mile scale. This enabled the Forest Department to draw up more detailed working plans. In 1883, a detailed working plan for Thayarwady was drawn based on the division of the forests into compartments and 25% enumeration of the growing stock in each compartment. By 1920, the scale of map was changed to 2" = 1 mile and working plans sanctioned covered 28,964 km^2 with majority of these plans prescribing the Myanmar Selection System with Improvement Felling (IF). The IF was classified as O (old) and Y (young) fellings according to the age of growth to be especially assisted.

Recording of teak trees over 40 cm dbh (4'0" gbh) left standing at the time of girdling in each compartment was initiated in 1922. This provided a reliable basis for calculating the future yield and was decided that future working plans should be based on these records. By 1940, 75,249 km^2 of reserved forests were under sanctioned working plans.

With the outbreak of the Second World War in 1939 and the evacuation of all European and most of the Anglo-Indian staff to India in 1942, progress in forestry was checked until 1946. Reorganisation of forest management was seriously impeded. This was mainly due to the loss of records of teak trees left ungirdled and maps showing detailed boundaries of compartments.

Reservation

The first forest legislation applied to Myanmar was the Indian Forest Act VII of 1863 which was replaced by the Myanmar Forest Act XIX in 1881. Rules under this Act laid down the procedure for reservation of forests. By 1880, 5,284 km^2 had been reserved. This was increased to a total of 77,373 sq. km. or 11.8 % of the total area of Myanmar in 1920 and to 95,490 km^2 or 13.04 % of the total area of Myanmar during the period 1920-30. At present, a total of 103,090 km^2 or 15.2 % of the total area of Myanmar has been reserved.

Regeneration

The first *taungya* teak plantation was made in 1856. It was formed by U Panhee in the Thonze forests as a personal present to Dr. Brandis. Brandis foresaw this as the most efficient mode of planting teak if the people could ever be brought to do it. After Brandis left Myanmar in 1862, there were differences in opinion on whether to stress on forest reservation or formation of plantations. However, progress in reservation continued steadily. The area of plantation in 1875–76 was 1,371 ha, mostly of teak.

Up to 1906, teak and cutch *(Acacia catechu)* plantations had been scattered over wide areas to a total of 24,280 ha. In that year, the government resolved to close down all plantation works except in a few specified cases and concentrate more on IF. In the first Myanmar Forest Conference in 1910, it was proposed for working teak forests by a system of concentrated regeneration which would result in the formation of even-aged crops. It was decided that while continuing with the Myanmar Selection System with IF, a trial should be carried out with the proposed system in Thayarwady Forest Division. In 1911, a first attempt at concentrated regeneration (Uniform System) under the working plan was made in a very good teak forest in Bilumyo and Mohnyin Reserves in Katha Forest Division. Here it was found that although teak could be naturally regenerated by clear felling and burning, equal, if not better results could be obtained much more economically by planting with *taungya* method. In the latter case, the presence of abundant teak seed-bearers is also not necessary. Thus, after the war in 1918, the method of concentrated regeneration by planting with *taungya* method was adopted in Thayarwady Forest Division. This success of regeneration with *taungya* plantation in Thayarwady led to a wave of enthusiasm for this method during the period 1920-30. However, regeneration with *taungya* method was carried out only in areas where it was accessible to extract timber other than teak and where the site was suitable. Myanmar Selection System was applied in the less accessible forests. In 1920, a total of 32,375 ha were already planted with teak, cutch, pyinkado *(Xylia dolabriformis)* and some other species. By 1930, the plantation area had increased to 48,562 ha.

At the depth of the slump during 1932–33, there was great controversy on plantations. Zoologists and the Forest Economists had shown that the danger from beehole borer was three times more serious in plantations than in natural forests. The Chief Conservator of Forest thus put forward proposals for the complete cessation of teak plantations. The Government in part accepted the proposal and at the same time directed to increase attention to natural regeneration and fully approving planting mainly of teak and pyinkado for local demand. However, in 1937–38, the Government again revised the policy to increase plantation to 607 ha per annum. This was increased to 674 ha per annum during 1938–39. The total area of plantations in 1940 was 56,125 ha and that of concentrated natural regeneration was 28,145 ha.

Majority of these plantations was badly damaged during the Second World War and insurrection period. Plantation establishment operation gathered momentum again only in 1963. With the implementation of East Bago Yoma plantation project in 1979, there was a marked increase in plantation area from 714 ha in 1963 to 13,495 ha in 1980. A maximum of over 32,375 ha was reached in 1985. With the exception of slight decreases in some years, this peak was and will be maintained.

3. Working plans

Management plans were based on growing stock and growth rate obtained from valuation surveys in the form of working plans (Forest Department Myanmar, 1961). As teak was the only commercial species at that time, management was designed to favour teak, though in later years management of other commercially important species was also considered. The earliest plans were formed for individual forests but from 1920 onwards these plans were combined to cater to the whole forest division which consists of a group of forest reserves.

The forests are managed under working plans which generally cover four working circles:

- Teak Selection Working Circle (TSWC)
- Hardwood (Commercial) Supply Working Circle (HSWC)
- Local Supply Working Circle (LSWC)
- Special Working Circle (SWC)

The working circles are formed on the basis of accessibility and also on the nature and form of the forest product available. The working circles consist of a group of reserves, which are further divided into felling series for the convenience of working according to the drainage and geographical situation. Again they are sub-divided into compartments on maps as well as on the ground which are the basic management units. As for local supply reserves, annual coupes were the basic management units. They are similar to compartments, except that they are marked only on the maps and are not permanently demarcated on the ground.

4. System of management

The forests of Myanmar, being tropical in nature, consist of a large number of species of which comparatively few are utilised at present. Forest management during the early periods was solely based on teak, as teak was without doubt the most intensively studied timber species at that time. The original Brandis Selection System, modified into the Myanmar Selection System in 1920, is still in use up to the present time. This system is merely a selection-cum-improvement system with the main features being to carefully protect the immature stock and assist it to attain maturity (Blanford, 1956). These improvement fellings consist of thinning in immature teak, removal of certain proportion of silviculturally undesirable mature trees, opening up of patches of established advance growth, climber cuttings, removal of inferior trees suppressing teak and its valuable associates, and cutting of dead and moribund trees (Kermode, 1957).

In the Myanmar Selection System, the forest area is divided into 30 blocks of equal yield capacity. Each year, selection fellings are carried out in one of these blocks and the whole forest is therefore worked over a felling cycle of 30 years. Under this system when felling becomes due, all marketable trees, which have attained a fixed exploitable girth size, are selected for cutting. The fixed exploitable girth size varies with the type of forest. In good (moist) teak forest the girth limit at breast height 1.3 m (4'6") is 75 cm dbh (7'6" gbh) and in poor (dry) forest 65 cm dbh (6'6" gbh).

Unhealthy trees that have not attained these sizes, but are marketable, are also selected for cutting if they are unlikely to survive through the subsequent felling cycle. If seed-bearers are scarce a few high quality stems are retained as seed trees.

The same system of management is applied for hardwoods, with the exception that the fixed girth limit, depends upon tree species. For the Local Supply Working Circle, coppice with standard or clear felling system is applied.

5. Forest inventories

Traditionally, management plans are drawn from the data obtained from girdling operations which had some limitations. It is obviously very expensive and requires a long period of time to get a picture of whole series with a felling cycle of 30 years. Complete enumeration of teak is carried out down to 40 cm dbh (4'0" gbh) and data beyond this limit is not recorded.

A complete enumeration of marketable hardwood species within only one-foot girth class below the fixed girth limit is available in the HSWC. These enumeration data gathered in both TSWC and HSWC are considered inadequate for more intensive management planning due to lack of coverage of smaller size classes in the growing stock.

To overcome this situation, various inventory surveys based on statistical inventory designs were conducted in Myanmar from 1964 to 1975. Estimates from such surveys were used in calculating annual cuts from natural teak forests in 1969.

These surveys do provide reliable estimates for efficient management planning. However, as they were not on a continuous basis, they do not provide enough information on growth of the forest and also the mortality rate which is essential for long-term management planning. As growth estimation using stem analysis method is impossible for most timber species which do not have defined annual rings like teak, it will be necessary to carry out sampling on a continuous basis. Starting from 1981, a nation-wide inventory on a continuous basis has been conducted with the assistance of UNDP/FAO (Sum *et al.*, 1990). Here, the technique of sampling with partial replacement is being used.

The data obtained from such inventory surveys will form the basis of yield calculation, control and management of Myanmar forest in the future. Volume functions were also developed (Leech *et al.*, 1990). Yield calculations are carried out based on both tree number and volume (Brasnett, 1953).

6. Plantations

With the present population of 44.7 million and the increasing demand for forest produce, it is quite rational to supplement the natural stock of teak and other valuable species, by plantations. Then only sustained production can be assured and depletion of the natural forest resource and subsequent environmental degradation can be prevented.

During the pre-war period, plantations were formed on a modest scale and in a compensatory nature. No more than a few thousand acres had been established until late 1960's (Gyi, 1972). Starting from 1972 extensive forest plantations in large blocks were formed under four categories namely, Commercial plantations, Village supply plantations, Industrial plantations and Catchment protection plantations. Plantations established since 1896 are summarised in Table 1.

Table 1. Plantations established between 1896 to 1995

Year	Type of plantation				Total (ha)
	Commercial	Village supply	Industrial	Watershed	
1896–1941	386,260	8,907	0	0	47,167
1948–1962	1,230	692	0	0	1,922
1963–1972	16,973	9,522	322	0	26,817
1973–1982	47,186	24,631	1,420	5,884	79,121
1983–1992	173,779	66,819	33,977	27,412	301,987
1993	13,405	11,198	3,244	3,163	31,010
1994	6,515	12,780	890	2,641	22,826
1995	11,736	13,800	2,853	4,049	32,438
Total	309,084	148,349	42,706	43,149	543,288

Source: Myanmar Forest Department, 1996.

Commercial plantations are mainly of teak and pyinkado while industrial plantations are generally of *Eucalyptus* species and tropical pines to some extent on trial basis. The current planting rate has reached a maximum of about 32,300 ha annually. As can be seen from Figure 1, teak has always surpassed other species in terms of area planted.

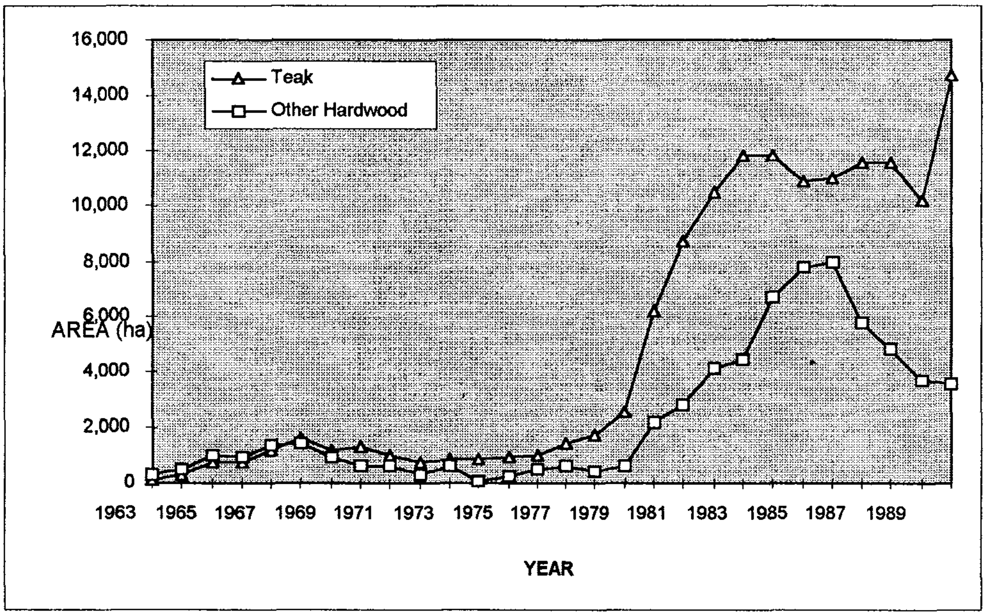


Figure 1. Plantations of teak and other hardwoods (based on data collected by th author form different sources)

7. Effect of forest management

7.1. Past production

Teak and some other valuable commercial hardwoods were harvested and utilised by the Myanmar kings and their subjects before the colonial days. After the annexation of Myanmar, European timber firms were allowed to continue and work in some of the accessible forests. However, extraction data up till 1918 are not available. Average annual production of teak and other hardwoods for a period of seven decades after 1918–19 is as shown in Table 2.

Table 2. Past production of timber

Period	Average annual production (hoppus tons)	
	Teak	Others
1918/19 to 1929/30	509,011	500,604
1930/31 to 1939/40	234,884	402,118
1940/41 to 1945/46	NA	NA
1946/47 to 1949/50	179,791	299,285
1950/51 to 1959/60	183,697	602,396
1960/61 to 1969/70	334,670	663,805
1970/71 to 1979/80	361,506	509,469
1980/81 to 1989/90	408,772	549,623
Average	**316,047**	**503,900**

Source: Gyi *et al.*, (1990); Myanmar Forest Department, (1996).
1 hoppus ton = 1.8024 m^3, NA = not available

Before World War II, teak productions ranged from 200,000 to 500,000 hoppus tons while those of non-teak hardwoods were from 400,000 to 500,000 hoppus tons. The extraction data during the war period were not available. After the war, timber productions increased to a maximum of 400,000 hoppus tons for teak and to 600,000 hoppus tons for other hardwoods. The average for teak is about 300,000 hoppus tons and that of other hardwoods about 500,000 hoppus tons.

Table 2 shows that the productions of both teak and other hardwoods did not drop during these seven decades (1918-19 to 1989-90). This reflects the effect of the forest management system that has been adopted for this country since 1857. The irregularities in production after World War II was chiefly due to the fact that roads and bridges were in a very bad condition and because the elephant power dropped to about 40% of its pre-war strength (Blanford, 1956).

7.2. Future yield

For teak the current yield of 400 thousand m^3 will be supplemented by the expected yield from plantations which will be available after approximately year 2003 (Myint, 1981; Tint *et al.*, 1993). It will be abruptly increased after two decades.

In the case of other species the yield from the natural forests will be substantial and the plantation yield will be less than the yield of natural forests. Here the point to be made is that the natural forests are situated in inaccessible areas and extraction is not possible or is expensive. Plantations are accessible and the final crop yields will be economically important.

Teak yield reduction in Myanmar is due to over exploitation especially in the accessible areas. This can be recovered by providing some rest period and through proper silvicultural operation. It is to be noted that plantation yields can be very high quantitatively and economically. More emphasis should be given to the plantations with higher investment.

References

Anon. 1986. *Notes on Forestry of Burma.* The Government of the Union of Burma, Ministry of Agriculture and Forests. Rangoon, Myanmar.

Blanford, H. R. 1956. Highlights of One Hundred Years of Forestry in Burma. *The Burmese Forester* Vol. VI, No.1.

Brandis, D. 1896. The Burma Teak Forest. *Garden and Forest* Vol. IX

Brasnett, N. V. 1953. *Planned Management of Forest.* Geroge Allen and Unwin Ltd., London, UK.

Forest Department, Myanmar 1996. *Forestry Fact Sheets.* Planning and Statistics Division, Forest Department, Ministry of Forestry.

Forest Department, Myanmar. 1961. *Working Plans Manual.* Superintendent Government Printing Press, Union of Burma, Rangoon.

Forest Department, Myanmar. 1989. *Forestry Situation in Myanmar.* Union of Myanmar, Ministry of Agriculture and Forests.

Gyi, K. K. 1972. An Investigation on Factors Relevant to Development of Teak Plantations in Southeast Asia with Particular Reference to Burma. (*M.Sc. Thesis*)

Gyi, K. K., Hla, T., Thein, P. and Win, S. 1990. *Forest Management in Myanmar.* A paper presented for ESCAP/ UNDP Regional Seminar cum Study Tour on Integrated Landuse and Sustainable Forest Management, 29 March to 6 April 1990, Yangon/ Yezin, Myanmar.

Hoe, T. C. 1956. One Hundred Years of Forestry in Burma. *The Burmese Forester* Vol. VI, No.1.

Kermode, C.W.D 1957. Teak, *Tropical Silviculture Vol. II*, FAO, Rome, pp. 108-178.

Leech, J. W., Myint, A. K., Kyaw, S. and Lynn, H. 1990. *Tree Volume Equations for Myanmar.* A paper presented for ESCAP/ UNDP Regional Seminar cum Study Tour on Integrated Landuse and Sustainable Forest Management, 29 March to 6 April 1990, Yangon/Yezin, Myanmar.

Myint, A. K. 1981. Management Planning for Teak Forests in Burma. *M. Sc. Thesis*, Australian National University, Canberra, Australia.

Rao, V. S. 1961. The Old Forest Policy. One Hundred Years of Indian Forestry. *Indian Forester Vol. II.* App. IV pp.337-342.

Sum, R. L., Tint, K., Kyaw, S., Bo, S. and Myint, A. K. 1990. *Forest Resources Assessment in Myanmar.* A paper presented for ESCAP/ UNDP Regional Seminar Cum Study Tour on Integrated Landuse and Sustainable Forest Management, 29 March to 6 April 1990, Yangon/ Yezin, Myanmar.

Tint, K., Kyaw, S., Bo, S., Myint, A. K. and Win, S. 1993 *Growth and Yield Tables for Plantation Teak in Myanmar.* Circulated by Forest Department, Ministry of Forestry, Yangon, Myanmar.

Mathema, P., Dutta, I. C., Balla, M. K. and Adhikary, S. N. (eds.). 1999. *Sustainable Forest Management*. Proceedings of an International Seminar, 31 August – 2 September 1998, Pokhara, Nepal.

Common Property Regimes: the Criteria to Assess their Effectiveness

B. K. Pokharel

Abstract: This paper provides an intellectual framework for understanding the theory of Common Property Regimes, which is an essential conceptual tool for the analysis of sustainable management of both people and resource. It demonstrates that communal forest management systems in Nepal are examples of common property regimes. "Successful" common property regimes, however, require specification of the criteria suitable for the institution and resource in question. Both institutional and ecological criteria must therefore be considered equally when evaluating the communal forest management systems as common property regimes. This paper also describes a criteria checklist which examines the effectiveness of common property regimes. The last part is devoted to the analysis of the Forest User Groups (FUGs), which are considered as common property resource institutions created by outside actors such as government and donor agencies. The paper concludes that the application of the theory of common property to analyse FUGs will be useful in understanding the internal structure and decision making arrangements, and also in identifying the gap between the ideal common property regimes and FUGs formed under the Community Forestry Programme in Nepal.

1. Defining common property regimes

Broadly speaking there are four types of property regimes: private property, State property, common property and open access or non-property (Feeny *et al.*, 1990; Bromley, 1992). The first three, in theory if not always in practice, are managed by "owners" or "users", whether they are private, public, or communal groups. The primary difference between these three property regimes is the decision-making process whereby rules of access and use are set. Ownership grants the right to set rules of exclusion and use, as well as a contingent duty of maintenance and restraint from "socially unacceptable uses." With non-property or open access resources, however, there is no owner group and thus no rights of use or duties of maintenance. Without defined ownership or a clearly delineated group of users, there can be no rights of exclusion; anyone may reap the benefits of open access resources.

Although theory differentiates four types of property regimes, in practice the lines of differentiation are not always clear. It is difficult to see these property regimes as separate and self-contained. Many resources are held in overlapping and sometimes conflicting combinations of these regimes. For example, the lines between State and non-property, and even between State and communal property are obscure. The status of Nepal's hill forests, for example, remains State property in law (i.e. *de jure* State property) but part of such forests are managed either under a *de facto* common property, an open access or sometimes private property regime. Furthermore, in a very real sense current property arrangement of such forest is based on co-management systems which are characterised by State regulation.

2. Criteria to assess the effectiveness of common property regimes

A serious constraint upon the common property resource literature is the complexity of the "ideal" common property institution. Questions of effectiveness or success require specification of the criteria suitable for the many actors involved. Success in the eyes of foresters, for example, differs from success in the eyes of local villagers. Environmentalists, policy makers and politicians have different agenda and criteria for success.

This paper argues that common property resource management is essentially about sustainable management of both people and resource. Both institutional and ecological criteria must therefore be considered equally when evaluating the outcome of resource management arrangements. A common property system which is not socially sustainable, will eventually break down and result in environmental degradation as has been illustrated by Arnold and Stewart (1989) in their study of common property resource management in India. Similarly, one of the main aims of resource management is the avoidance of resource degradation or, more specifically, resource collapse. In this sense, resource management goals should be a level of ecological sustainability "that gives future generations the option to continue such management or liquidate the resource" (Bromley, 1986). In other words, evaluation criteria of CPR management should be based on whether Common Property Regime Institutions (CPRIs) function actively over the medium to long term, and whether the resource does not suffer further degradation and is rehabilitated.

In addition, CPR management should also be evaluated on the basis of level of outside support (flow of technical, institutional and physical input) provided by outside agencies to make common property regimes self-reliant. Community forestry involves a partnership between the government and the community for a particular forest. Under this partnership both have to take some responsibilities and evaluation should be made of the sustainability of the partnership that has been established.

2.1. Institutional criteria

From the results of a study of a wide range of successful and long-lasting common property resource institutions, Ostrom (1990) highlighted the essential factors which helped account for their success. She tried to establish why it is that collective action groups in some common property systems create solutions and therefore resist the "tragedy of the commons" while others collapse. The key to long enduring common property systems she suggests, is the existence of internal rules and regulations; those communities which are able to set and enforce mutually acceptable rules will have a greater likelihood of instituting effective collective action in common property regimes. Ostrom (1990) describes eight "design principles" which she believes are the essential elements or conditions that help to account for the success of collective action. Such action occurs in institutions which function to sustain the common property resource and gain compliance (see Table 1). These design principles will affect incentives in such a way that "appropriators" (resource users) will be willing to commit themselves to following rules and monitoring one another.

Ostrom's design principles were derived from a set of long enduring CPR institutions that were self-organised and self-governed. Her focus was towards relatively indigenous, isolated and autonomous communities. However, deficiency in Ostrom's design principle is her assumption of "community" existing in isolation from government apparatus. Recently emerged CPR institutions are affected by external actors, the key actors being government and donor agencies. The community forestry approach which attempts to bring together the CPR institutions and government apparatus, aims at an institutional arrangement based on partnership. Hobley (1996) and Hobley and Shah (1996), who analysed the experience of externally sponsored Forest User Groups in India and Nepal have developed institutional criteria (see Box 1), which will be applied to analyse group's effectiveness in the later part of this paper.

Table 1. Ostrom's eight design principles

Clearly defined resource and user group boundaries	Individuals or households who have use rights must be clearly defined, as must the CPR itself.
Operational rules suited to local conditions	Operational rules governing time, place, technology and/or quality of resource used and cost in terms of labour, materials, and/or money needed to make it appropriate to local conditions.
Collective choice arrangements	Individuals affected by the operational rules can participate in modifying the operational rules.
Monitoring	Monitors who actively audit CPR conditions and user behaviour, are the users, or are accountable to them.
Gradual sanctions	Users who violate operational rules are subject to sanctions dependent on the seriousness and the context of the offence.
Conflict resolution mechanisms	Users and their officials have rapid access to low-cost local arenas to resolve conflicts among users, or between users and officials.
Recognition of rights to organise	The right of users to devise their own institutions is acknowledged and therefore not challenged by external governmental authorities.
Multiple layers of nested enterprise	Institutional mechanisms of CPRs are organised in multiple layers of nested enterprise.

Source: Ostrom (1990)

Box 1. Institutional criteria to assess groups' effectiveness

- Size of the group
- Boundaries for the resource and user households
- The relative power of sub-groups
- Existing arrangements for discussion of common problems
- The extent to which users are bound by mutual obligations
- Punishment against rule breaking
- Consensus on users' rights
- The distribution of rights
- Location of the resource and residence of users
- Users' demands
- Resource capacity
- Users' knowledge
- Investment in the resource
- Congruence between appropriation, provision rules and local conditions
- Detection and graduated sanctions.
- Collective choice arrangements
- Monitoring of the resource condition and the behaviour of users
- The relationship between User Groups and the State
- Conflict resolution mechanisms
- Multiple layer of nested enterprises

Source: Hobley and Shah (1996)

2.2. Ecological criteria

Institutional criteria discussed earlier do not provide a sufficient assessment of group robustness unless these are supplemented by ecological criteria (see Box 2). The later should be based on various silvicultural arrangements made in working plan in order to produce various kinds of forest products in a sustained basis. Bartlett *et al.* (1992) using rapid appraisal techniques, propose that protection system, afforestation programme and utilisation of various forest products give an indication of ecological sustainability. The way that users manage the resource will determine the nature of the benefits and also the future of the forests. Only active management can ensure that the users' needs will be met over time, and prevent their "institution" from collapse. The ecological criteria are developed to assess groups' effectiveness in terms of extent of effective forest management, derived mainly from field study along with the work of DFO (1994), Branney (1996), Campbell and Rathore (1996), and FRSC (1996).

Box 2. Ecological criteria to assess group's effectiveness

- Presence of written Forest Working Plan and record of forest inventory
- Resource capacity for sustainable production and the ratio of multiple products availability over time
- Extent of natural regeneration and enrichment plantings
- Forest protection and control systems
- Scale of application of silvicultural and harvesting operations
- The extent and magnitude of flow of timber and non-timber forest products and their management
- Adoption of soil conservation activities
- Scale of income and employment generation activities and agroforestry practice.

Source: Field survey (1995)

2.3. Outside support

Apart from social and ecological criteria described above, it is necessary that CPR managed under co-management arrangements should also be evaluated on the basis of the criteria of level of outside support. Generally, the negative effect of government involvement pointed out in various common property literature (for example Peluso, 1992) cannot be disputed. However, government involvement in co-management systems has had mixed results (Pokharel, 1998). The Department of Forest in Nepal, for example, supports the Forest User Groups in technical, financial, legal, and institutional matters (Pokharel *et al.*, 1993). This "support" has both positive and negative impacts in terms of the groups' effectiveness and sustainability. Poor resource condition has meant that the groups were unable to afforest and manage their forestland without government support. However, government organisations have been unable to respond to groups' specific needs (Pokharel, 1998).

Ostrom (1990) suggests that national governments can play an important role in community-based management systems, this role includes:

- enforcing a community's right to forest resources against outside interests
- guarding the interests of the State against short-term profit takers
- conducting research on silviculture, forest regeneration, and other topics of interest to community-based management and
- providing technical support to local communities in the development of community forest industries.

It is difficult to predict in which situation individuals in the community will be able to solve a common problem through self-organisation, and in which situations outside intervention is necessary to support common property institutions. The formulation of design principles is necessary to understand the collective behaviour of individuals, however, these design principles do not answer the initial question of why some communities are able to organise themselves to solve collective action problems while others are unable (Singleton and Taylor, 1992). Study of recently emerged community forestry paradigm which combines government bureaucracy and CPRIs may provide some answers. In particular, an investigation of interface between community and outside intervention gives some insights about potential partnership in community-based forest resource management systems (Pokharel, 1998).

3. Analysing forest user group as a CPR

The following paragraphs examine the effectiveness of Ramche Forest User Group, one of the FUGs formed by the District Forest Office (DFO) under community forestry programme financially supported by Department of International Development (DFID), UK.

Analysis of the FUG provides a partial test of the relevance of CPR theories to government sponsored FUGs. Ramche FUG was created in 1991 to manage about 35 ha communal forests. The major species are patle katus *(Castanopsis hystrix)*, okhar *(Juglans regia)*, utis *(Alnus nepalensis)*, chilaune *(Schima wallichii)* and lokta *(Daphne bholua)*. There are 137 households in the group. The majority of users are *Magar* and *Chhetri*. Economically the group is heterogeneous owing to great variations in land holding size, private trees, number of livestock, and level of education. There is a high correlation between caste and wealth, for example, the majority of *Brahmin/Chhetris* who are wealthy, have an average land holding of 2.7 ha and dominate the group and committee. All other castes were without exception poor having less than 0.25 ha land (none of it *khet*). These poor families provide different forms of domestic and on-farm services to wealthier households as payment in kind for vital supplementary foodstuff and other basic needs. For these poor household families it is also a long standing practice for members of the household to move to urban areas and even to India as seasonal wage labourers for supplementary source of cash income.

Ramche FUG is analysed on the basis of institutional and ecological criteria described earlier. The comparison of criteria for success and the situation pertaining in Ramche is in Table 2.

Table 2. The effectiveness of the Ramche FUG (institutional aspect)

Criteria for success	Fully met	Partly met	Not met
1a. Size		√	
1b. Boundaries	√		
1c. Power of sub-group	√		
1d. Culture of collective action		√	
1e. Mutual obligation	√		
1f. Enforceable rules	√		
1g. Consensus	√		
1h. Distribution of rights			√
2a. Forest-users location	√		
2b. Users' demands	√		
2c. Resource capacity	√		
2d. Users' knowledge	√		
3. Investment in the resources		√	
4. Flexibility of rules		√	
5. Enforceable sanctions	√		
6. Collective choice			√
7. Monitoring		√	
8. The State-group relationships		√	
9. Conflict resolution	√		
10. Nested enterprises	√		
Number of criteria met/partly met/not met	12	6	2

Source: Field survey (1995)

Despite its usefulness for the assessment of groups' effectiveness in terms of institutional functioning, the criteria presented in Table 2 do not provide adequate room for the two critical elements such as *equity* and *effective forest resource* *management*. The former is mainly related to social justice such as *equity in product distribution, participation and decision making,* and *allocation and share of group funds* (Chhetri and Nurse, 1992). The later is related to the technical aspect of *resource management* to optimise the production capacity of the resource in order to produce both timber and non-timber forest products (NTFPs). In Ramche, although the provisions for the distribution of forest products is kept as "equally to all" basis, this type of apparent equity of access to forest products does not necessarily seem to lead to true equity because users have unequal socio-economic background leading to an unequal needs. In both cases the poor members get far less benefits than what they actually require.

Similarly, there is very little participation of women and 'lower caste' people in the meetings and assemblies, and their voice is hardly considered in decision making process. Most of the respondent users, except a few committee members, perceive that the community forest still belongs to the Department of Forest and right to make decisions rest with forestry officials and committee members.

The poor members have not received a fair share of FUG funds. It can be said that Ramche FUG fails to provide an equitable share of the products to the majority of users from their forests. There is no equity in decision making and allocation of funds (See Table 3).

Table 3. Effectiveness of the Ramche FUG (equity aspect)

Criteria of success	Fully met	Partly met	Not met
1. Distribution of forest products		√	
2. Participation and decision making			√
3. Allocation and share of group funds			√
Number of criteria met/partly met/not met	0	1	2

Source: Field survey (1995)

Data show that the FUG is "protecting" the trees rather than "managing" the forest. Little attention has been given to silvicultural and management aspect of the resources (see Table 4) leading to the situation that there is minimum flow of forest products to user members.

Table 4. The effectiveness of the Ramche FUG (resource aspect)

Criteria for success	Fully met	Partly met	Not met
1. Working plan	√		
2. Resource capability			√
3. Natural regeneration		√	
4. Forest protection	√		
5. Silvicultural operations		√	
6. Management of timber and NTFPs			√
7. Soil conservation			√
8. Income generation			√
Criteria met/partly met and/not met	2	2	4

Source: Field survey (1995)

Strengthening ownership of community forest in favour of the poor and disadvantaged group of people, and effective management of the resource is a real challenge in Ramche. Failing to address these two important elements of *equity* and *effective resource management* may ultimately cause the collapse of the FUG itself. Apart from institutional, ecological and equity criteria shown earlier, FUGs should also be evaluated on the basis of level of *outside support* such as flow of technical, institutional and physical input provided by outside agencies, particularly by the forest bureaucracy to make the groups self-reliant.

4. Conclusion

The Ramche FUG is analysed in common property framework focusing more on internal factors, which do not necessarily give the whole picture of collaborative communal management, particularly the effect of external catalysts such as government/donor agencies to the group's collective action. Therefore it has become necessary to move beyond the common property framework to look at FUG action in terms of donor presence. It is important to remember that almost all hill districts receive community forestry development budget from foreign donors. This raises two important questions: How sustainable is community forestry programme? What happens to hill districts once donor agencies withdraw their financial support to community forestry programme?

This paper demonstrates that CPR literature provide a framework to asses the effectiveness of CPR institutions. However, the relevance of CPR criteria to many government/donor sponsored local institutions should be tested in a variety of situations and geographical areas, in which these criteria can be expanded to make them more relevant. These expanded criteria then can be used to suggest ways in which external agencies can assist more effectively in the development of durable CPR institutions.

Ramche FUG represents an example of both success and failure story of community management of forest resources in the hills. It meets some institutional and ecological criteria, but fails to meet the criteria of equity and efficiency.

References

Arnold, J. E. M. and Steward, W. C. 1989. *Common Property Resource Management in India.* Report to the India Agriculture Division of the World Bank. The World Bank, Washington DC, USA.

Bartlett, A. G., Nurse, M. C., Chhetri, R. B. and Kharel, S. 1992. Towards Effective Community Forestry through Forest User Groups. NACFP, Kathmandu, Nepal.

Bromley, D. W. 1986. Closing Comments at the Conference on Common Property Resource Management: In: *Proceedings of the Conference on Common Property Resource Management,* April 21–26, 1985. National Academy Press Washington DC, USA.

Bromley, D. W. (ed.) 1992. *Masking the Commons Work: Theory, Practice and Policy.* ICS Press, San Francisco, California, USA.

Branney, P. 1996. The New Silviculture: India and Nepal In: Hobley, M. *Participatory Forestry: The Process of Change in India and Nepal.* ODI, London, UK.

Campbell, J. and Rathore, B. M. S. 1996. The New Silviculture: India and Nepal. In: Hobley, M. *Participatory Forestry: The Process of Change in India and Nepal.* ODI, London, UK.

Chhetri, R. B. and Nurse, M. C. 1992. Equity in User Group Forestry: Implementation of Community Forestry in Central Nepal. Nepal Australia Community Forestry Project, Kathmandu, Nepal.

DFO. 1994. Dhankuta District Forest Office: An Introduction. DFO, Dhankuta, Nepal.

Feeny, D. F. Berkes, McCay, B. J. and Acheson, J. M. 1990. The Tragedy of the Commons: Twenty-two Years Later, *Human Ecology* 18(1): 1–19.

FRSC. 1996. Operational Forest Management Plan for Jhapa District, 1996/97-2000/01. Prepared for the Department of Forest. FRSC, Kathmandu, Nepal.

Hobley, M. 1996. *Participatory Forestry: the Process of Change in India and Nepal.* ODI, London, UK.

Hobley, M. and Shah, K. 1996. What Makes a Local Organisation Robust? Evidence from India and Nepal. *Natural Resource Perspectives Number 11.* ODI, London, UK.

Ostrom, E. 1990 *Governing the Commons: The Evolution of Institutions for Collective Action.* Cambridge University Press. Cambridge, UK.

Peluso, N. L. 1992. Tradition of Forest Control in Java: Implication for Social Forestry and Sustainability. *Natural Resource Journal* 32(4): 883–898.

Pokharel, B. K. 1998. Forests and Villagers in Contention and Compact: The Case of Community Forestry in Nepal. *Unpublished Ph.D. Thesis*, School of Development Studies, University of East Anglia, Norwich, UK.

Pokharel,B. K., Gayfer, J., Epstein, D. and Tumbahamphe, N. 1993. Post Formation Support for Forest User Groups, *Banko Janakari* 4(1): 80–84.

Singleton, S. and Tayler, M. 1992. Common Property, Collective Action and Community, *Journal of Theoretical Politics* 4(3): 309–324.

Mathema, P., Dutta, I. C., Balla, M. K. and Adhikary, S. N. (eds.). 1999. *Sustainable Forest Management.* Proceedings of an International Seminar, 31 August – 2 September 1998, Pokhara, Nepal.

User Group Forestry: An Option for Managing the Terai Forests in Nepal

R. K. Pokharel, S. N. Adhikary and Y. B. Thapa

Abstract: Sankarnagar Forest User Group (FUG) was found to be an effective FUG in Rupandehi district of Terai region. The FUG has been managing the forest for the last nine years and seems to be successful in managing forest, particularly minimising illegal felling, controlling encroachment, developing greenery, and making forest products available to the users. Income generating activity and employment opportunities are the major factors for attracting users towards User Group Forestry. Proper utilisation of available funds, establishing forest products distribution depot, and dedication of the leaders are the main reasons for the effective management of community forest resources.

1. Introduction

Nepal's Master Plan for Forestry Sector (MPFS) has identified six primary and six supportive programmes to implement the forestry sector policy. The most important among the primary programmes is the community and private forestry programme (MPFS, 1988). After the endorsement of the plan by the government, a lot of efforts have been made in community forestry. Such efforts have been seen mostly in the hills. Joshi (1997) reported that community forestry is very successful in the hills but could not get momentum in the Terai. Similarly, Subedi *et al.* (1991) indicated that forest products smuggling across the border with India and population pressure leading to large-scale encroachment on government forestlands are the major problems in the Terai. Such problems have slowed down the process of implementation of community forestry programme in the region and/or made it less effective. Despite the problems, some of the community forests in the Terai districts are managed quite well by the users.

Sankarnagar is one such successful Forest User Group (FUG). The functioning mechanism of the FUG is considered to be one of the successful ones in Rupandehi district. In this context, it is important to gather information and document such functioning mechanism. It is also significant to assess various factors responsible for sustaining the system. This paper assesses the existing situation of Sankarnagar FUG and tries to focus on the factors that are responsible for the success of the system.

2. Methodology

Semi-structured interview, direct observation, group discussions and informal discussions with key informants and forestry professionals were the major tools employed for data collection. The principle of "triangulation" was also used while collecting data by verifying collected information from several angles.

3. Findings

3.1. Background of Sankarnagar Forest User Group (FUG)

Sankarnagar FUG is the first FUG in Rupandehi district that took responsibility from the District Forest Office for managing forest resources. The forest area was handed over to the FUG in 1989. The FUG is situated in Sankarnagar Village Development

Committee (VDC) of Rupandehi district in Western Development region and is about 5 km south-east from Butwal bazaar.

The FUG includes 1,889 households of Sankarnagar VDC as users. The total population of users is 8,472 of which about 50% (4,072) are female. *Brahmins* form half of the total population, followed by *Gurung/Magar*, *Chhetri/Thakuri*, and others. Among them, about 50% are ex-army servicemen. The majority of users (70%) are dependent on agriculture. The landholding of the users varies from 1 *katha* to 6 *bigha* (per comm. Office-secretary Sankarnagar FUG, 1998). The FUG is quite large and the group is ethnically and economically heterogeneous. The average forest size is 0.29 ha per HH (one *bigha* = 20 *katha* = 0.68 ha).

3.2. Handing over process

The forest was handed over as community forest after long efforts of the community. Although the individuals of Sankarnagar VDC requested the District Forest Office (DFO) several times to hand over the forest as community forest, the District Forest Officer was reluctant to do so. The forest was only handed over under the King's directive during his special visit to the Western Development Region. When the King visited Sankarnagar VDC the people had an opportunity to meet the King and express their views regarding forest management. They told the King about their willingness to manage the forest since it was not managed properly by the government. The King acknowledged the request and gave special directive to the Western Regional Forest Office to act as per the rules for handing over the forest. After the King's directive, 153 ha and 350 ha of forest was handed over as PF and PPF, respectively. In 1998 the committee acquired an additional 46 ha forest.

3.3. Forest User Committee (FUC)

There are 17 members in the Forest User Committee (FUC) including two women. There is also representation from nine wards of the VDC since inhabitants of each ward are considered as users. The users have followed the following procedures for forming the FUC:

- Key posts (Chairman, Vice-chairman and Treasurer) are either selected or elected among the users, depending on the situation
- Nine members: one representative from each ward (ward Chairman become a member in the committee automatically)
- Five members are nominated by the Chairman among the users.

Besides, the Chairman also nominates three persons as advisors in the committee. Generally, Chairman and Vice-Chairman of the VDC and Ex-Chairman of the FUC are nominated as advisors. The users have delegated their authority to the Chairman for making him influential and powerful.

3.4. Sub-committees

There are three sub-committees under the main committee. The sub-committees were formed to look after a particular activity directed by the main committee. The sub-committees are:

- *Bhaban nirman samiti* (building construction sub-committee),
- *Briksharopan tarbar nirman samiti* (reforestation and fencing construction sub-committee, and
- *Lekha samiti* (accounting sub-committee).

A sub-committee consists of three members selected from among the users except executive members. The committee nominates the members. In fact, a sub-committee was formed to carry out a job easily and also to ensure transparency. The *Lekha samiti* is authorised to carry out auditing and monitoring the activities of the FUC. Such authorisation to the sub-committees has ensured transparency and credibility which obviously has supported the system.

3.5. Management system

Protection and harvesting

Protection of forest refers to some control over forest resources. In Sankarnagar FUG, the FUC employs forest watchers to look after the forest. The committee identifies the number of watchers to be appointed on the basis of forest area. Generally, the main responsibilities of the watchers are to protect the forest from: felling of trees for firewood, poles and timber; encroachment; grazing in newly planted area; grass collection; unauthorised entrance; hunting wildlife and forest fire.

The four watchers patrol the forest area and discourage the people from illegal works. Despite the efforts, there is still pressure on the forest because of easy market access and the presence of landless people around the forest area. However, it is believed that the forest is being managed better than before. The technical aspect of the management is not yet known. After the FUG management the forest condition has improved, encroachment in the forest area has been controlled, and illegal felling and forest fire have been minimised.

Harvesting of forest products is a regular and significant activity in the FUG. They harvest the products, especially timber, pole and firewood once a year by hiring labourers. A number of people (about 10–15) are hired as labourers during the harvesting time and the work is monitored by the committee members as well as the DFO staff. A forest technician from the DFO, usually a Ranger is invited during the period for monitoring the activities. The technician receives Rs. 80/day in lieu of his/her service.

Transporting the products from the forest is also done by the labourers. After harvesting, the products are collected at the depot. The rate of the labour varies depending on the nature of the works. Often, the labourers are hired @ Rs. 60/day for harvesting and Rs. 20/person for loading and unloading the products. Similarly, transporting cost from the forest area to the depot is Rs. 300/tractor. Usually, the priority for hiring labourers is given to the inhabitants of Sankarnagar VDC.

Depot establishment

A depot was established in Sankarnagar FUG for distributing the products in 1989. The depot is located in Purbi Sankarnagar village, which lies in the middle of the VDC. The products are distributed as per the rules established by the users. Generally, the depot is open once a week every Saturday. During the open days, the committee invites DFO staff for monitoring the sale of the products. Usually, three persons i.e., Office-secretary and representative from the committee and DFO are asked to monitor the sale. They are also asked to sign in the bill, which is issued by the office. The signed bill is required for taking out any product from the depot. The DFO staff receives Rs. 60 per day as allowance. Similarly, the same amount is also provided to the committee member.

3.6. Employment opportunity and benefit sharing

Besides labourers, an Office-secretary, Nursery Head and Forest Watchers are hired as full time employees. The salaries of the Office-secretary, Nursery Head and Forest Watcher are Rs. 2,600, Rs. 2,000 and Rs. 1,800 per month respectively.

The Chairman, Mr. Prem B. Bhandari does not receive any honorarium. In fact, the executive members have requested him to accept some amount as honorarium for serving as Chairman of the FUG. However, he has been denying such request continuously..He has accepted a FUG procured bicycle and Rs. 500 as maintenance cost of bicycle per year. Besides the Chairman, similar facilities are also provided to Nursery Head and Forest Watchers. Recently, the committee has decided to provide Rs. 300/month to the Treasurer as honorarium.

Firewood, poles and timber are made available to the users from the depot. The committee is responsible for managing the depot. Each household is given 3 quintals/week either firewood @ Rs. 80/quintal or poles @ Rs. 100/quintal. Similarly, 50 cft of timber @ Rs. 400/cft for sal (*Shorea robusta*) and Rs. 250/cft for other species is also given to each household for building new house or repairing the house on the recommendation of the FUC members from the respective wards.

There is an arrangement to provide firewood for those users who cannot buy it from the depot. Under this arrangement, the committee issues the ticket to the users charging one rupee per household as entry fee to the forest for collecting firewood. The users are allowed to cut only the dead, dying and diseased trees under the supervision of the committee members. With this ticket, the users can collect a maximum of 25 *bhari* (1 *bhari* = 30–40 kg, depending on the species) firewood from the forest. Generally, the forest is open during late December–early March for such activity.

There is a provision in the operational plan for providing 50 cft of timber for maintaining or repairing the school, temple and other organisations within the VDC free of cost. There is also a provision for a discount up to 50% of the price of the firewood if it is for religious, wedding and funeral purposes.

3.7. Source of income

The committee has been generating income from various activities such as nursery management, issuing identity cards to the users, penalty, entry fee and sale of forest products. The income collected for the last three years from different activities is listed in Table 1. It shows that the major source of income (67.8%) is from timber, poles and firewood. The table also shows that the income from such products have been increasing every year. Similarly, there is a decreasing trend in violating rules and regulations. So far, the committee has generated 1.1% of the total income from penalty.

Table 1. Source of income of Sankarnagar FUG for three years

Source	051/52 (1994/95)	052/53 (1995/96)	053/54 (1996/97)	Total (Rs.)	Percentage
Timber, pole and fuelwood	163,235	238,693	338,621	740,549	67.8
Grass	2,951	-	2,700	5,651	0.5
Seedlings	6,522	4,770	12,472	23,764	2.2
Entry fee	475	2,000	2,600	5,075	0.5
Penalty	8,845	2,195	1,250	12,290	1.1
Membership fee	4,200	15	125	4,340	0.4
Miscellaneous (bank balance, donation, etc.)	95,182	70,603	134,191	299,976	27.5
Total	281,410	318,276	491,959	1,091,645	100

Entry fee is also one of the sources of income of the FUG. Generally, the committee charges Rs. 200/group from outside as entry fee. Many groups come to the forest to learn how they have been managing their forest. The committee often receives the groups from Nepal as well as abroad.

The committee is also generating income from nursery which can produce 50,000 seedlings. The committee has not been able to produce seedlings in full capacity, but it still has contributed 2.2% of the total income. Grasses are also sold to the users by dividing into plots and auctioning the plots to the highest bidder. So far, 0.5% of the total income has been collected from grass sale.

Table 2 presents the regular expenditure of the FUG for the last three years. A total amount of Rs. 784,506 was used for different activities. The table also shows that 41.6% of the expenses was for administrative purposes i.e., salary, per diem, etc. Similarly, 21.1% of the expenses was used for hiring labourers during harvesting period. The committee has invested 24.4% of the total expenses in rural development works such as road construction and improving educational sector by providing grant as well as timber to the existing government schools within the VDC. The FUG office building is under construction with an estimated budget of Rs. 700,000.00.

Table 2. Expenditure for three years in Sankarnagar FUG

Particulars	2051/52 (1994/95)	2052/53 (1995/96)	2053/54 (1996/97)	Total (Rs.)	Percentage
Administrative (salary, per diem etc.)	98,158	113,054	115,538	326,750	41.6
Labour cost for harvesting & transporting forest products	36,122	53,211	76,115	165,448	21.1
Furniture, tools etc.	61,237	-	4,800	66,037	8.4
Office maintenance	15,263	9,312	10,549	35,124	4.5
Miscellaneous (development works, prize, donation etc.)	30,127	24,140	136,880	191,147	24.4
Total	240,907	199,717	343,882	784,506	100

The committee has decided to provide Rs. 1,000 as an incentive to those users who wish to install biogas plant in their houses. This was done to reduce the pressure on the forest. So far, Rs. 55,000 has been provided as grant to the users in lieu of installing biogas plants that is 55 households have installed biogas plants. Similarly, the committee has made announcement to give Rs. 2,500 per family as reward once the family adopts permanent family planning device after the birth of either one or two daughters.

4. Discussion

Sankarnagar FUG has confined its use right within Sankarnagar VDC which means the users are recognised as per the political boundary. This may be a reason why there is still pressure on forest. Despite the pressure, the progress in managing the forest is encouraging. The DFO staffs are happy with the progress made by the FUG, especially in controlling encroachment, minimising illegal felling and forest fire, and improving the forest condition. Such observations are also made by Pokharel *et al.* (1998). Almost half of the users are retired army people who are disciplined and sincere in obeying the rules agreed by all.

There is a good representation in the FUC in terms of area. The system for appointing VDC Chairman and Vice-chairman and also Ex-chairman of the FUG as advisors seems to be admirable which promotes co-operation between VDC officials and FUC. It also minimises conflicts and improves the management system through sharing of the past experience. The formation of sub-committees has developed transparency in the works of Sankarnagar FUG, in other words it has ensured credibility of the users, particularly in financial matters. This obviously has helped in sustaining the system. The representation of women in the committee is not enough. More representation of women in the committee is necessary since they are the primary users of the forest.

The users have authorised the committee for making the management system effective. Such delegation of the power has made the committee members more responsible. The committee makes most decisions and plan of action in developing and managing forest resources. FUC hires labourers to carry out harvesting rather than involving users in the works. Sakurai *et al.* (1998) have distinguished two different management systems in community forestry: centralised and collective. In the centralised management system, the FUC has a strong authority to make management decisions including employment of labourers for forest management operations whereas the FUC is more restricted in the collective management system.

The centralised system in the FUG was introduced due to the problems repeatedly encountered by the committee. The main problem was sending a child to work in the forest by a majority of the users during collective works. This indicated that the users were not really interested to participate in forest development work but still want to be a user of the forest by meeting the formality. Similarly, the committee also had difficulty in monitoring the involvement of unskilled users in forest operations, particularly thinning. Such problems gradually forced the committee to introduce the centralised system of management. The committee felt that the labour system is easier for supervising and monitoring. The systematic distribution of the products through the depot has saved the users' time. The system for signing the bills by three persons has discouraged illegal sale and manipulation by the influential people.

Incentives for installing biogas plant have reduced the dependency on forest for fuelwood. As a result, greenery has increased and illegal felling for firewood has been minimised. The people in the committee are very conscious about population growth. They have planned to minimise population in the VDC by encouraging people to adopt permanent family planning method. This scheme can reduce population growth in the VDC, which ultimately reduces the pressure on the forest.

In Sankarnagar FUG, the increasing trend in the FUG income from the forest has encouraged the committee members to devote more time to forest management. They have job satisfaction when they see many development works in the area such as office building, road construction, improvement in educational facilities, etc. Regular presentation of the financial statement in the FUG assembly removes the users' doubt about fund misuse.

Further, the Chairman of the FUC is very dedicated and sincere. He is less involved in other activities and very committed to do something for the society. He feels that the time devoted to the FUG is worthwhile. He seems to be a dynamic person and has enough food for his family. Such people with enough to feed their family can give more time to social work. The dedication of the chairman is one of the reasons why Sankarnagar FUG has been able to implement an effective management system.

5. Conclusion

The management system of Sankarnagar FUG seems to be effective due to the dynamic leadership of the committee and the Chairman. The well functioning mechanism developed by the committee, particularly in benefit sharing and product selling pattern is transparent and practicable. Such mechanism has minimised conflicts in the FUG, which is indicated by the decreasing tendency in the offences of the forest-related activities. The control of illegal activities in the forest, particularly forest encroachment, the progress made in forest conservation and the increasing trend in the income, have further encouraged the committee members to get actively involved in managing their forest resources. Formation of sub-committees, especially *Lekha samiti* to look after the financial matter has ensured transparency in financial activities which has gained credibility of the users.

The FUG seems to be very effective in controlling encroachment of forestlands by squatters, which is a major problem in the Terai. In this context, the FUG appears to be an effective option for controlling encroachment in the region. Technical aspects like biodiversity and productivity of the forest have not been studied. There is a need of assessing the forest and harvestable yield in order to avoid over exploitation of the resources.

References

Joshi, A. L. 1997. Community Forestry Programme in the Terai. Paper Presented at the National Workshop on Community Participatory Forestry Development: Experience in the Terai Region of Nepal, 8–10 November 1997, IOF, Pokhara, Nepal.

MPFS. 1988. Master Plan for Forestry Sector Nepal. Ministry of Forests and Soil Conservation, Kathmandu, Nepal.

Pokharel, R. K., Thapa, Y. B. and Adhikari, S. N. 1998. A Field Report on Participatory Forestry Development and Management Activities in Rupandehi District, A Report Submitted to IOF/ITTO Project, Pokhara, Nepal.

Subedi, B., Das, C. L. and Messerschmidt, D. 1991. Tree and Land Tanure in the Eastern Nepal Terai: A Case Study by Rapid Appraisal, A Research Report Prepared for the Forests, Trees and People Programme, Institute of Forestry, Pokhara, Nepal.

Sakurai, T., Rayamajhi, S., Pokharel, R. and Otsuka, K. 1998. Private, Collective and Centralised Community Management: A Comparative Study of Timber Forest and Plantation Management in Inner Terai of Nepal. A Paper Presented at the International Workshop on Land Tenure and the Management of Land and Trees: Community and Household Case Study from Asia and Africa, 1–3 July 1998, Tokyo, Japan.

Mathema, P., Dutta, I. C., Balla, M. K. and Adhikary, S. N. (eds.). 1999. *Sustainable Forest Management.* Proceedings of an International Seminar, 31 August – 2 September 1998, Pokhara, Nepal.

Community Forestry in the Philippines: Approaches and Emerging Lessons for Sustainable Forest Management

J. M. Pulhin

Abstract: Over the last two decades, community forestry has been increasingly recognised as a promising approach to achieve sustainable forest management in the Philippines. The country has developed extremely innovative and bold tenure instruments under its community forestry programmes that recognise indigenous peoples' rights and allow the community members to control and benefit from forestlands. It has also incorporated various livelihood strategies in the different projects to promote peoples' participation and help alleviate poverty. A combination of "soft" (social) and "hard" (technical) technologies are also continuously being developed and employed to ensure forest sustainability. Moreover, various modes of institutional arrangements are continually explored to encourage active participation of key stakeholders, particularly the People's Organisations, Non-Government Organisations and Local Government Units.

Despite innovative approaches, however, sustainable forest management is still far from being realised. Two decades of experience in community forestry points to some emerging lessons which are central to the achievement of sustainable forest management. These include: the exigency of resolving the concept of "community", the need to broaden the approach to sustainable forestry, "conscienticised" employment of tenure instruments, achieving a sustained flow and equitable sharing of benefits, going beyond bounded participation, and responsive institutional arrangement and support.

1. Introduction

The inability of the state-cum-corporate forestry approach to benefit the rural poor or address the increasing rate of deforestation in the tropics contributed to a major shift in the direction of forest management in favour of a *people-oriented* approach. Generally termed *community forestry*[1], this approach has lately been regarded as a new forestry paradigm (Gilmour and Fisher, 1991). The Food and Agriculture Organisation (FAO) of the United Nations earlier defined community forestry "as any situation which intimately involves local people in forestry activities" (FAO, 1978). It has been claimed to influence the nature of forestry activities more profoundly than any other development in the forestry profession (Arnold, 1991).

Community forestry, as currently practised in most developing countries, has been shaped by international development fashion and by the specific political and historical contexts in these areas. It has incorporated many of the ideas from mainstream development thinking; the most recent of which is the concept of sustainable development (Pulhin, 1996). In the Philippines, community-based forest management or CBFM, has been recently adopted as "the national strategy to achieve sustainable forestry and social justice" (E. O. 263: Section 1). CBFM has the avowed core objectives of democratising forest resource access; improving socio-economic welfare of upland communities, and promoting the sustainability of the forest resources. These core objectives closely parallel the political, economic, and

[1] Other related terms found in the literature include social forestry, people-oriented forestry and forestry for local community development. In this paper, the term community forestry and community-based forest management or CBFM is used interchangeably.

resource sustainability intentions inherent in the concept of Ecologically Sustainable Development (ESD).

This paper examines CBFM as the Philippine Government's national strategy for advancing sustainable forestry. It argues that the radical shift in policy orientation from a highly inequitable private corporate type of forest management to a more socially oriented CBFM—matched with recent innovative approaches—provides some opportunities for a more sustainable forest management in the country. However, achieving the goal of sustainable forestry is a long and tedious process. There is a need to distil emerging lessons from more than two decades of community forestry experience and judiciously apply them to achieve the goal of sustainable forestry.

2. Historical development

The first forest policy on community forestry in the Philippines was formulated in 1916 through the promulgation of Act 2557, otherwise known as the Administrative Code (Kirchhoff, 1993). It provided, among others, for the establishment of communal forests to insure that the people having rights therein will get continued supply of forest products for their domestic use. However, until recently, policies on the commercial utilisation of the country's timber resources consistently favoured the wealthy and politically more influential concessionaires under the so-called Timber License Agreements (TLAs). Such policies contributed to the socio-economic and political marginalisation of the rural population, but also to the continuous onslaught of the country's forest resources.

Sustained efforts to incorporate the concept of community forestry in the country's forest policy occurred in the last three decades as expressed in the various government programmes and projects initiated during this period. Following Rebugio and Chiong-Javier's classification (1995), the evolution of community forestry during this time can be loosely divided into three categories (Table 1). First is the *pioneering period* from 1971 to 1980. This term saw the adoption of three major people-oriented forestry programmes, namely, the Forest Occupancy Management (FOM), Family Approach to Reforestation (FAR), and the Communal Tree Farming (CTF). In general, these programmes centred on the involvement of the local people in reforestation activities. People were seen more as labour-provider rather than partners in forest conservation and development. Considering the volatile political situation during this time, community forestry was also seen as a form of counterinsurgency measure to maintain political stability and order in the countryside. However, it was during this period that the forestry sector started to realise that the problem of deforestation is not merely technical but also socio-political in nature.

The second era is the *integration and consolidation* from 1981 to 1989. This period marked the adoption of two main people-oriented forestry programmes, namely, the Integrated Social Forestry Programme (ISFP) and the Community Forestry Programme (CFP). ISFP consolidated the three earlier programmes, while recognising the vested rights of the forest occupants through the provision of a 25-year tenurial security. On the other hand, CFP extended the coverage of community forestry to natural forests allowing participating upland communities to commercially utilise forest resources subject to appropriate social and technical preparation. From merely labourers in reforestation activities, local people were increasingly recognised as the *de facto* resource managers, hence, partners in forest development and conservation.

Table 1. Brief history of community-based forest management (CBFM) in the Philippines

Period/Dates	Program/Projects	Policy Instruments
Pioneering Period (1971–1980)		
1971	Forest Occupancy Management (FOM)	FAO No. 62, BFD Circular No. 11; PD 389, 19874; PD 705, 1975; PD 1152, 1977
1976	Forest Protection and Forest Occupancy Management for Timber Licensees and Permittees	BFD Circular No. 12
1979	Communal Tree Farming	MAO No. 11; MAO No. 2
Integration or Consolidation Period (1981–1989)		
1981	Policy Directions for 80s Included Forestry for Rural Development	BFD Director Memorandum
1982	Integrated Social Forestry Program (ISFP) National Forestation Program (NFP) Launching	Presidential Letter of Instruction 1260; DAO 5, S. 1993
1988	ISFP Upland Development Project (ISFP-UDP)	
1989	Community Forestry Program (CFP)	DAO 39; Memorandum Circular 11
Institutionalisation and Expansion (1990–present)		
1990	Contract Reforestation (CREF) with Forest Land Management Agreement (FLMA)	DAO 71, S. 1990; DAO 31. S. 1991; DAO 23, S. 1995
	ADB Forestry Sector Project I Community-based Forestry Project (ADB/FSP-CFP I) Low Income Upland Community Project (ADB-LIUCP)	
1992	Institutionalisation of the Forestry Master Plan within DENR	Memorandum Circular 23, S. 1992
1992	USAID/NRMP Community Forestry Project (USAID-NRMP-CFP) Community-based Management of Logged-over Areas (CMLOA) Integrated Rainforest Management Forest (IRMP) ENR-SECAL Regional Resource Management Program (ENR-SECAL/RRMP)	
1993	ADB Forestry Sector Project II Community-based Forestry Project II (ADB-FSP-CFP II)	DAO 15, S. 1993
	Ancestral Land and Domain Program	DAO 2, S. 1993
1994	Community-based Upland Productivity Project (CUPP)	
1995	USAID-NRMP II Community Forestry Program (USAID-NRMP II-CFP)	

Source: Rebugio and Chiong-Javier (1995)

There are indications that the counterinsurgency intent of community forestry may have been sustained until the end of the second period (Pulhin, 1996). Despite this, the period saw the growing recognition that upland poverty alleviation, social justice and equity in resource distribution, and forest sustainability, can be simultaneously achieved through community forestry. During this time, the Ford Foundation-funded Upland Development Programme was also established following the framework of people-centred, learning process approach, and participatory project implementation. Increasing concern to promote participatory approach to development has also led to the development of various appraisal and planning methodologies and techniques such as Community Profiling Techniques, Rapid Rural Appraisal (RRA), Socio-economic Development Planning, Community Resource Management and Development Planning and others. These techniques are continuously being refined even at the present period.

The third period from 1990 to the present is the *expansion and institutionalisation* period. This term is characterised by the growth of community forestry to include various land use types not originally included in the first two periods. In particular, community forestry coverage included degraded watershed areas and practically all types of forests where there are Indigenous Cultural Communities. The era is also marked by increasing support from the international funding agencies such as the Asian Development Bank, World Bank, GTZ and the governments of Sweden and Italy. Efforts to provide tenurial security during this period led to the evolution of varied types of tenure instruments. Moreover, attempts to alleviate upland poverty while ensuring the sustainability of forest resources induced the development of diverse types of income generating technologies for the uplands.

Various forms of institutional arrangements also continue to evolve in the present period. From purely government-implemented projects in the 1970s, the practice of community forestry has increasingly involved upland communities in forest management (often through People's Organisations) with the assistance of other sectors such as the Non Government Organisations (NGOs), Local Government Units (LGUs), the academe, and other organisations.

The different CBFM programmes and projects that emerged in the last two periods were recently "integrated and unified" into one umbrella program, otherwise known as the *Community-Based Forest Management Programme* (CBFMP) through Executive Order (E.O.) No. 263 issued on July 1995 and its Implementing Rules and Regulations. Department of Environment and Natural Resources (DENR) Administrative Order No. 96-29 issued on October 1996. E.O. 263 adopted CBFM as the "national strategy for sustainable forestry and social equity" thereby institutionalising the practice of community forestry in the country.

3. Innovative approaches to sustainable forestry

Over the last two decades, the Philippines has developed innovative approaches under its various community forestry programmes and projects to promote sustainable forest management. Some of these approaches include: 1) the use of innovative and bold tenure instruments to provide access rights and some degree of control over forest resources including the Indigenous Peoples (IPs); 2) inclusion of various livelihood schemes in different projects; 3) increasing participation of upland communities in the management of local forest resources; 4) development and employment of appropriate "soft" and "hard" technologies; and 5) various institutional arrangements for collaboration and support.

3.1. Democratising forest access

Until recently, access to and benefits from the Philippines' forest resources have always been monopolised by the monetised, politically influential, or military-supported TLA holders. Forest occupants, including the IPs, were treated as "squatters" or "encroachers" in forestlands even if they may have occupied these areas since time immemorial. TLAs' control of the country's forest resources was heightened during the martial law period from 1972 to 1982. During this time, the then President Marcos centralised control over economic resources in the hands of the fraction of the traditional élite most closely aligned with him and his family. The period recorded the greatest number of licences issued in the history of Philippine forestry reaching to more than one-third of the country's total land area (10.5 M ha) and the largest area made available for exploitation. It also recorded the greatest decline in the country's forest cover and the highest rate of forest destruction, which ranged from 136,000 to 298,000 ha per year.

With the shift in the government's forest management approach in favour of CBFM starting in the 1980s, TLA areas gradually declined to the present 1.4 million ha through the cancellation of erring licensees and non-renewal of the expired ones. The institutionalisation of CBFM is seen as the main government strategy towards restructuring of the once TLA-controlled timber industry. Under the DENR Strategic Action Plan for CBFM, 9 M ha of forestlands have been earmarked for community management by the year 2008. This constitutes around 58 percent of the country's total forestland area of 15.8 M ha On the other hand, only 0.5 million ha are expected to be allocated for private corporations particularly the industrial tree plantations and related purposes.

In order to achieve the strategic plan, the government has developed innovative and bold tenure instruments under its various community forestry programmes and projects. Since 1982, six different types of tenure instruments have been developed. Such instruments recognise the vested rights of forest occupants, both migrants and IPs, and allow them to have some degree of control and enjoy the benefits from these areas. Under the recent CBFMP, the different tenure instruments were rationalised by providing only four types instead of the original six. The objective was to minimise confusion among the participating communities and facilitate the administrative efficiency in the part of the DENR—the sole government agency responsible for their issuance.

3.2. Alleviating upland poverty

Various livelihood schemes have been incorporated in the different CBFM projects to help alleviate poverty among participants. A common approach is the contracting of different site development activities such as reforestation, agroforestry, assisted natural regeneration and timber stand improvement to People's Organisation (PO). Part of the proceeds from these activities is set aside for some livelihood projects, which are jointly identified with the communities concerned. Depending on the resources found in the area and the skills available to local communities, livelihood activities may include any or a combination of the following:

- Paper making from hemp or *cogon* (*Imperata cylindrica*)
- Fibre production from coconut, *salago*, and *buri*
- *Sawali* weaving from African oil palm and bamboo
- Harvesting and marketing of non-wood products such as vines, orchids, etc.
- Rattan plantation development and furniture making
- Commercial bamboo and furniture making
- Tiger grass farming and broom making
- Mushroom culture
- Collection and processing of indigenous tree seeds
- Wood carving
- Coconut wine making
- Bee keeping
- Livestock production
- Wild fruit processing
- Construction of upland fishpond.

In support of the above livelihood activities, credit and/or marketing co-operatives are also organised in some communities through the project's Community Organiser.

Co-operative members are trained on various livelihood activities including simple bookkeeping and financial management for more effective functioning of the organisation.

Other than project fund, sources of capital for livelihood activities may come from limited utilisation of forest products such as timber, rattan, and other forest products. This particularly applies to those projects, which have been given the resource use permit to utilise forest products to augment participants' income. The scheme is based on the principle of "borrowing from nature to finance community and forest development". The idea is to plough back part of the sales income from legally harvested products from natural forests or existing plantations to finance livelihood projects, reforestation and related forestry activities to ensure forest sustainability.

3.3. Participatory forest management

The last two decades saw the increasing participation of upland communities in the management of the country's forest resources. As indicated above, the earlier CBFM projects particularly those initiated from 1971 to 1980 treated the upland communities as merely labour-provider in government-initiated reforestation projects instead of partners in conservation and development. By the later part of 1980s, however, various participatory techniques such as Rapid Rural Appraisal, Socio-economic Development Planning and more recently, Community Resource Management Planning and Community Profiling and Mapping have been developed. These techniques allowed for the participation of the communities not only during project implementation but also as early as the site assessment and planning stage.

Participatory monitoring and evaluation is also being undertaken in some CBFM projects with the guidance from Community Organisers. In some cases, the different stakeholders involved in project implementation—PO, DENR personnel, NGO, and LGU—jointly monitor project accomplishments to address emerging problems and issues and improve project implementation.

Community participation in CBFM goes beyond the project cycle. Provisions of the different tenure instruments are discussed by the government officials and community members to ensure that they are acceptable to both. Specifically, duties and responsibilities of both parties are agreed upon before they are formally translated into administrative orders for implementation.

3.4. Development and employment of appropriate technologies

A combination of "soft" (social) and "hard" (technical) technologies are continuously being developed and employed to ensure forest sustainability. Community Organising has been institutionalised by the government as the major social technology to prepare the communities managerially, organisationally, and technically to responsibly manage local forest resources on a sustainable basis. Various forest and non-forest-based livelihood activities such as those enumerated above have likewise been developed. Similarly, technologies on plantation/forest establishment and management are continuously being modified to suit the socio-economic and biophysical conditions in the area. Among the common technologies employed for site rehabilitation are the different nursery and plantation establishment techniques, timber stand improvement, assisted natural regeneration and agroforestry. Moreover, small-scale timber harvesting using two-man saw and hauling through the use of water buffalo locally termed as "carabao logging" is being employed in selected areas.

3.5. Institutional arrangements and support

Increasing emphasis on decentralisation and local governance in forest management have led to various modes of institutional arrangements that encouraged active involvement of key stakeholders in forest management. Aside from DENR, LGUs from the provincial down the *Barangay* level have started to occupy a central role in forest management. This supports the 1991 Local Government Code that recognises the role of LGUs in the management and protection of the country's natural resources. Under the CBFM implementing rules and regulations for instance, LGUs are involved as early as the project site identification through their actual participation in the site selection process. Moreover, selected project areas have to be endorsed by the Legislative Councils of the concerned LGUs for CBFM Programme

Initial experience on the involvement of LGUs shows some promising results. In Region 2 for instance, LGUs have demonstrated commitment to assist the POs by jointly financing CBFM activities. In 1996, the total counterpart funding provided by LGUs in this Region amounted to P625, 000.00. This increased to P1, 907,000.00 in 1997 and to P2, 000,000.00 in 1998.

Like the LGUs, the involvement of NGOs in CBFM projects has been institutionalised. There is hardly any CBFM project of DENR that does not include the participation of NGOs. This initiative supports the 1987 Philippine Constitution, which stipulates that "the state shall encourage non-government organisations that promote the welfare of the nation". The main task of NGOs in CBFM is facilitative in nature. Through community organising and training activities, NGOs ensure the social and technical preparation of the concerned communities towards a responsible and sustainable community-based forest management. In addition, they help the communities to establish linkages with different government, non-government, and private institutions, which may be of assistance to the communities. At the national level, some NGOs play an advocacy role in the area of forest policy. Others provide legal assistance to the upland communities particularly the Indigenous Peoples. In general, CBFM has promoted a healthy collaboration among the participating POs, DENR, NGOs and LGUs.

4. Overview of accomplishments

DAO No. 96-29, integrates and unifies a total of ten people-oriented forestry programmes and projects of the government under a general umbrella programme known as the Community-Based Forest Management Programme or CBFMP. These are: the Integrated Social Forestry Programme (ISFP), Upland Development Programme (UDP), Forest Land Management Programme (FLMP), Community Forestry Programme (CFP), Low Income Upland Communities Project (LIUCP), Regional Resources Management Project (RRMP), Integrated Rainforest Management Project (IRMP), Forest Sector Project (FSP), Coastal Environment Programme (CEP), and Recognition of Ancestral Domains/Claims.

As of June 1998, there are 1,017 projects covering a total area of 3.8 M ha distributed in the 15 administrative regions of the country. A total of 204,782 households are involved in the implementation of these projects. In terms of geographic distribution, Region 6 has the most number of projects (288 projects) while Region 2 has the biggest share of the area (705,538 ha). On the other hand, the Autonomous Region of Muslim Mindanao (ARMM) has the least number of projects (6 projects) and the smallest area coverage (3,254 ha). Region 6 has the highest number of household beneficiaries (66,839) while it can be subsumed that ARMM has the lowest.

Considering the significant shift from the TLA mode to the CBFM approach, it is defensible to argue that the evolution of community forestry in the Philippines especially over the last decade can be considered as both radical and progressive. Byron (1996) regarded these policies as something to be acknowledged or learned from, if not emulated by other countries of similar situation. Whether such policy initiatives, including the above innovative approaches, will be sustained and eventually lead to successful outcomes, remains to be seen in the coming years.

However, current CBFM accomplishment is still limited, compared to its overall target of handing over the management of 9 M ha to the local communities. Because CBFM as a development intervention activity is a slow process, there is doubt whether the target can indeed be accomplished in ten years. Exacerbating the problems is the huge number of population that depends on the forest for survival. Government statistics indicate that around 14 M of the country's total population of 70 M are directly or indirectly dependent on the forest and other upland resources for livelihood. At an average family size of six, this means that, only about 11% of this population has so far been reached by the CBFM projects.

The sad state of the country's forest resources also posed a great challenge to CBFM. Presently, the Philippines is barely left with 5.4 M ha of forest cover compared to 17 M ha in 1934. Of these, only 0.8 M ha are old growth forest while 2.8 M ha are second growth. If a 40% forest cover (12 M ha) is to be pursued and maintained to ensure environmental protection, the goal of sustainable forest management is still far from being realised.

5. Emerging lessons for sustainable forest management

Despite the Herculean task that beset CBFM, there are reasons to be optimistic about its future. This is considering the current responsive forest policy environment and the innovative CBFM approaches that have evolved through time. Initial experience from CBFM implementation points to some emerging lessons that have important bearing to sustainable forest management. As can be gleaned from the foregoing discussion, the lessons are distilled not only from the best CBFM practice, but also from problems that have emerged in the process of actual implementation. Some of these emerging lessons are as follows:

5.1. Exigency of resolving the concept of "community"

The word *community* is a basic concept in CBFM, yet it is used very loosely if not misunderstood. DENR Administrative Order No. 96-29 defined community as:

> a group of people who may or may not share common interests, needs, visions, goals and beliefs, occupying a particular territory which extends from the ecosystem, geographical, political/administrative and cultural boundaries and any resources that is with it (Article 1, Section 4).

This definition recognises the multiplicity of interests and by implication, the heterogeneity of people in a given geographic and political boundary defined as "community". Thus, a community may include the wealthy and the poor, the landed and the landless, the educated and the uneducated, the opportunists and the fooled, etc. Lumping these people together and calling them "community", that is, the target beneficiaries of the CBFMP, may spell disaster to the programme in terms of achieving its objectives on the promotion of social justice and equitable access to forest benefits. Cernea's (1992) observation is worth elaborating:

> Entrusting a social forestry program (and development programs in general) to the wrong social actor will lead to the failure of the program, as in fact has happened repeatedly. The loosely defined concept of community forestry used by some national or international development agencies in the recent past has reflected just such a vague and mistaken definition of the social actors. Some statements or articles are repeating the term *community forestry* from title to end hundreds of times, as mantra, without once bothering to discuss what specific social groups, strata, or classes compose this mythical "community"... it is necessary to desegregate the broad term *people* and identify precisely which unit of social organisation can do aforestation, and which social units and definable groups can act as sustaining and enduring social structures for long-term production activities.

Analysing various experiences from other countries, Cernea (1992) also cautioned:

> The initial assumption—that communities (villages) would be effective agents for implementing community forestry—was not confirmed. This assumption was sociologically naive and exhibited a lack of understanding of the structure and social stratification of village communities.

An analysis on the implementation of some CBFM projects in the Philippines shows that both the DENR field personnel and some NGOs often regard the community as *homogeneous* grouping with similar interest. There is little if any conscious effort exerted on the identification of different interest groups, including those whose source of livélihood are mainly dependent on the local forest resources. This has contributed to the perpetuation and reproduction of inequity in terms of access to forest benefits in favour of the local élite. Not unless the forest dependent communities are identified and prioritised as the primary target beneficiaries, effort to sustainable community-based forest management will always fall short of expectation.

5.2. Broadening the approach to sustainable forestry

Sustainability of the forest resources is the very essence of forest management. A central concept in forestry science, sustained-yield forestry, deals with the management of forest resources in perpetuity. The concept of sustained-yield forestry was originally developed to maintain stable timber supply. It was later broadened to include other outputs from the forests (Clawson and Sedjo, 1984). In practice, however, the application of the concept has been confined to commercial timber (Colchester, 1993), particularly in developing countries like the Philippines.

The rapidly changing forest management conditions in the Philippines over the last decade, calls for a broader approach to sustainability. Three major changes at the national level directly relate to CBFM. First is the changing role of local people in forest management and the necessity of satisfying their diverse forest-related needs. In the rural context, local people have varying degrees of dependence on the different forest resources other than commercial timber (Colchester, 1994). There is diversity of community interests in the forest in similar manner as there is diversity of potential product yields (Holdgate, 1993). What forest products to be sustained, why they are to be sustained, and for whom should they be sustained need serious consideration in implementing CBFM projects.

Second is the changing nature of forest resources to be managed, that is, from old growth forests to second growth and plantation forests including other non-wood forest products. Currently, the only sources of commercial timber in the Philippines are the second growth forests. The different conditions of these forests (e.g., good, fair, poor and marginal) may require highly specialised silvicultural treatments to promote sustainability. Moreover, other forest products not formally managed in the past but are valuable to the local people, may now need some form of management to prevent extinction and increase productivity (WCED, 1991). Whether technical knowledge is readily available and whether it can be effectively transferred to and implemented by the local people, will largely influence the future of these resources. Equally important is the re-discovery and/or harnessing of relevant indigenous knowledge for possible incorporation in the present forest management practices (Sajise and Ganapin, 1990; Wiersum, n. d.).

Third are the rapid demographic and economic changes in upland areas. High upland population growth and the relentless penetration of market economy in these areas contribute to mounting pressure to exploit the remaining forest resources. Thus, "augmentation of the natural capital" (Brookfield and Byron, 1993) becomes of central importance especially if the forest related needs of the future generations are to be met. However, forest rehabilitation or renewal, the most common approach of augmenting the forest, is very costly.[2] Protection of the remaining natural forests, on the other hand, is less expensive (D'Silva *et al.*, 1994), hence, a promising approach to support forest rehabilitation efforts. Whether the government can effectively win the support of local people for forest protection in perpetuity and under what conditions, are also crucial issues in promoting sustainable forestry. In summary, the *how* of sustainability is equally crucial as that of the *what*, *why*, and *for whom*.

Obviously, community forestry requires a broader approach to sustainability than currently provided under the forester's concept of sustained-yield forestry. "Until wide agreement has been reached on what constitutes sustainable forest management, (and how it should be pursued via CBFM), pledges to achieve it will need to be taken with a grain of salt" (Poffenberger and Stone, 1996; statement in parenthesis added).

5.3. "Conscienticised" employment of tenure instruments

At the centrepiece of CBFM is the recognition of vested rights over specific forest lands of both the indigenous and migrant communities who are willing to take the responsibility of sustainable forest management. This is to be achieved through the issuance of three types of land tenure instruments: 1) Certificate of Ancestral Domain Claim (CADC) or Certificate of Ancestral Land Claim (CALC) for recognised Indigenous Peoples (IPs); 2) Community Based Forest Management Agreement (CBFMA) for migrant communities and IPs who opt for this scheme; and 3) Certificate of Stewardship for individually-claimed lands in the case of individual families. With the best of intention, these instruments are meant to provide the participants tenure security and use-rights over a given forest land and the resources therein. However, it should be understood that they are not-value neutral. They draw their main legitimacy from the government (through the DENR) which institutes them rather than from the community. In reality, the paramount allocator and enforcer of rights to forest resources remains the government.

Case studies conducted on two community forestry projects using two types of tenurial instruments revealed that contrary to the claim that the issuance of these instruments assists the "returning of the forests to the people", they tend to reinforce the government's territorial jurisdiction over these areas through a form of regulated freedom (Pulhin, 1996). The reinforced government control has in turn resulted in

[2] The present reforestation cost in the Philippines is around P20,000 per ha. If the targeted 2.5 million ha of plantation forests under the Forestry Master Plan are to be pursued, the country needs around P50 billion over the next 20 years to finance the operation.

unforeseen negative socio-economic and environmental consequences. There is therefore the need to fully understand the nature of these instruments to allow for their more "concienticised" application, thus avoid their negative outcomes.

A concienticised application of these instruments includes three things: skills in application; ethics in application; and politics in application (Pulhin, 1996). Skills in application take care of the practical aspects, that is, that appropriate information is available in terms of the area to be covered by the instruments and the legitimate claimants of these areas. It also implies that conflicting claims should be properly resolved before the actual issuance takes place. On the other hand, ethics in application concerns the issuance of the different instruments with the right spirit: that they should primarily serve the interest of the concerned community before that of the project or outsiders. This necessarily requires that the concerned communities/individuals are aware and amenable to the different provisions of the instruments particularly their rights and responsibilities and are clear about the positive and negative implications of their issuance. Finally, politics of application is the enabling aspect. This means imparting to the local people the confidence and skills to negotiate their rights and responsibilities in forest resource management.

The concienticised application of the different tenure instruments points to a need for "catalysts" to facilitate the cosncientisation process. In the Philippine experience, this task is better performed by developmental NGOs which are more sensitive to the needs of the local communities.

5.4. Achieving a sustained flow and equitable sharing of benefits

Local communities will continue to participate in CBFM projects only for as long as they receive a steady stream of social, economic, and ecological benefits at levels that exceed the value of their inputs (Vergara, 1997). As Byron (1996) argued, "There were some naiveté in the expectation that communities would take collective action for managing forests, retaining existing remnants, or in reforesting through plantations or assisted natural regeneration, with little prospect of benefit for themselves." At present, however, the experience in the early versions of CBFM are not long enough and have little to show in terms of clear trends that a stream flow of benefits can be assured from participating in these projects. In some CBFM projects, delayed budget releases or at worst, unpaid reforestation wages, have rendered the participating communities economically worse off. Inability to provide sustainable livelihood to participating communities, through a combination of forest and non forest-based activities, remains to be one of the greatest challenges to sustainable community-based forest management.

It should be added, however, that a sustained flow of socio-economic, environmental and other benefits from community forestry is not a guarantee for the welfare of the participants. As experienced elsewhere, benefits from community forestry (and other rural development initiatives in general) are usually captured by the élite sector of the population. Unless benefits are shared equitably, community forestry will only contribute to the reproduction of rural poverty and lead to division and disharmony among those affected.

5.5. Going beyond bounded participation

The use of participatory techniques such as those for appraisal and planning, support the general ideals to empower the local people and build their capability for self-determination. It is an improvement on the traditional top-down and purely technocratic planning strategy of earlier forestry projects which has, in the past, resulted in the ejection or resettlement of upland communities residing within reforestation sites. In reality, however, these techniques have to be employed against the backdrop of a pre-defined project component. With such components intact and officially agreed to, one could only hope that these components would fit the needs of the local people.

As experienced in the Philippines, the use of participatory techniques can promote a type of "bounded participation" that locked the local people into an agenda that have been pre-determined by the government and the donor agencies. These techniques have led the local people, with the assistance from NGOs, to prepare their own development plans within the boundaries of pre-defined project components. In essence, the technique legitimises the communities' acceptance of the project earlier prepared by the consultants that often conflict with the real needs and priorities of the local people which in turn produce undesirable effects. This demands that CBFM projects should shift from the programmatic, target-driven mode of implementation to a more flexible learning process approach that treats participation not only as means but also an end product of community empowerment.

5.6. Forging a responsive institutional support system

Two decades of experience in the Philippines have shown that CBFM as a form of development intervention can only flourish if responsive institutional support system is available. This requires the creation of an enabling environment for collaboration and teamwork among various institutions concerned with CBFM. Experience in CBFM projects has established that different institutions would have varying interests and motivations for their involvement. Such interests and motivations may be contradictory or conflicting that sometimes breed misunderstanding and disharmony among these actors. For instance, conflict in development approach and operational procedures between DENR and some NGOs on the ADB-funded Low Income Upland Development Projects resulted to the untimely disengagement of the latter from their involvement in the project. In the same manner, some LGUs complain that the DENR retains the full control in local forest management and what was decentralised to them are all responsibilities.

On the other hand, some NGOs have apprehension on the big hand given to LGUs under the CBFM Programme (UNAC, 1997). DAO 96-29 involves LGUs as early as site selection to eliminate potential opposition and ensure funding support. Specifically, it requires the CBFM applicants to submit, among other documents, individual or joint endorsement of the concerned legislative councils of the *Barangay*, Municipal, and Provincial LGUs, depending on the jurisdiction and coverage of the area. However, there is apprehension among some NGOs that if the areas are not populated by organised POs able to penetrate the LGUs, the system of site identification described in DAO 29 leaves the programme vulnerable to political intervention by local officials with vested interests. Evidently, an appropriate mechanism that would allow dialogue, negotiation, and conflict resolution, and more importantly, partnership among various interest groups for the common good of the communities, have to be developed.

In addition to collaborative undertakings, key institutions, particularly the DENR, have to undergo bureaucratic transformation to further the goal of sustainable community-based forest management. The CBFM approach demands for a paradigm shift within the DENR organisation from its traditional, regulatory-oriented forest land management strategy towards a developmental, people- and service-oriented one. Such a shift should be appreciated and internalised by the whole DENR constituency from the central down the field level in order to effectively perform their role of promoting social justice/equity, socio-economic improvement of upland communities and the sustainability of the country's forest resources. Field observations demonstrate that where DENR personnel have appreciated and internalised the CBFM approach they are able to establish better working relationships among different actors, able to play a more facilitating role, and hence, produce better results.

In addition, DENR have to create an enabling policy environment where grassroots community forestry initiatives will flourish. It has to support more such local initiatives other than what it has previously emphasised, that is, the interventionist and highly programmatic type of community forestry. Similarly, policies will have to focus more on harnessing indigenous knowledge and the role of local institutions (both formal and informal) in forest management. An enabling policy environment that will facilitate the taking over of forest management by the local community instead of reinforcing government territorial jurisdiction and control may indeed serve as the pathway to forest sustainability. This would mean improvement in the policy formulation process by providing opportunities and mechanisms for dialogue, negotiations, and conflict resolutions among various interest groups involved in CBFM. Mechanisms for the distillation of experiences and lessons particularly from field implementation should also be instituted and serve as basis for formulating responsive CBFM policies.

Finally, there is a need to improve the effectiveness of development agency support for better CBFM outcomes. This can be achieved through: 1) greater participant review and integration of field lessons; 2) greater collective attention to be given to project design experiences, indicators, evaluation and other lessons; 3) viewing their forestry sector work as part of a broader change process rather solely a time-bound, target-driven project; and 4) holding of national and regional fora to co-ordinate the activities of different development agencies and relate these initiatives to emerging national policies and international environmental strategies (Poffenberger *et al.*, 1997). How to facilitate the adoption of these strategies among development agencies is a challenge confronting CBFM.

6. Conclusion

The last 25 years saw the incorporation of the concept of community forestry from the periphery to the central policy agenda of the Philippine government. Considering the radical shift in policy orientation from a highly inequitable private corporate type of forest management to community-based approach, as well as the innovative approaches that have evolved in more than two decades of its implementation, there is reason to be optimistic about CBFM's future. This optimism, however, should be balanced with a caution: there is a need to build on and apply the emerging lessons in CBFM if the goal of sustainable community forest management is to be achieved. It is hoped that these emerging lessons will also find their application in other tropical countries as well.

References

Arnold, M. 1991. Community Forestry: Ten Years in Review. *Community Forestry Note 7.* Food and Agriculture Organisation of the United Nations, Rome, Italy.

Byron, N. 1996. Research Needs for Community Forestry. In: *Community Forestry as a Strategy For Sustainable Forest Management.* Proceedings of the International Conference. May 24–26 1996, Manila, The Philippines,

Brookfield, H. and Byron Y. (eds.), 1993. *South-east Asia's Environmental Future: A Search for Sustainability.* United Nations University Press, Tokyo, Japan.

Cernea, M. M. 1992. A Sociological Framework: Policy, Environment, and the Social Actors for the Tree planting. In: Sharma. N. P. (ed.). *Managing the World's Forests: Looking for Balance Between Conservation and Development*, Kendall/Hun Publishing Co, Iowa. pp. 301–335.

Clawson, M. and Sedjo, R., 1984. History of Sustained-yield Concept and its Implications to Developing Countries. History of Sustained-yield Forestry: a Symposium. Portland Oregon: Forestry History Society, Inc. pp. 3–15.

Colchester, M. 1993. The International Tropical Timber Organisation: Kill or Cure for the Rainforests? In: Rietbergen, S. (ed.). *The Earthscan Reader in Tropical Forestry.* Earthscan Publication Limited, London, UK. pp. 185–207.

D'Silva, E. *et al.* 1994. Sustainable Forest Management in Developing Countries. Experiences from Asia. *Natural Resources Forum* 18(4): 251–262.

FAO. 1978. Forestry for Local Community Development. *FAO Forestry Paper No. 7.* Food and Agricultural Organisation of the United Nations, Rome, Italy.

Gilmour, D. A. and R. J. Fisher 1991. *Villagers, Forests and Foresters: The Philosophy, Process and Practice of Community Forestry in Nepal.* Sahayogi Press, Kathmandu, Nepal.

Holdgate, M. 1993. Sustainability in the Forest. *Commonwealth Forestry Review* 72 (4): 217–225.

Kirchhoff, J. F. 1993. Community Participation in Forest Management. Paper Presented at the Conference on Natural Resource Policies in the Philippines: Bottlenecks and Solutions to Implementation. Asian Institute of Management. Makati, The Philippines, December 9, 1993.

Poffenberger, M. and Stone, R. D. 1996. Hidden Faces in the Forest: a Twenty-first Century Challenge for Tropical Asia. *SAIS Review.* Winter-Spring Issue.

Pulhin, J. M. 1996. Community Forestry: Paradoxes and Perspectives in Development Practice. *Ph D. Dissertation.* The Australian National University, Canberra, Australia.

Rebugio, L. L. and Chiong-Javier, M. E. 1995. Community Participation in Sustainable Forestry. In: Review of Policies and Programs Affecting Sustainable Forest Management and Development (SFMD). A Policy Report submitted to the Department of Environment and Natural Resources, pp. 2–1 to 2–27.

Sajise, P. and D. Ganapin 1990. An Overview of Upland Development in the Philippines. Technologies for Sustainable Agriculture on Marginal Uplands in Southeast Asia: Australian Centre for International Agricultural Research: pp. 31–44.

UNAC 1997. Issues Pertaining to the Guideline on Community-Based Forest Management Program (CBFMP), DAO 29 Series of 1996. Proceedings of the Roundtable Discussion on CBFMP, Center for Rural Development, 4 August 1997, Calauan, Laguna, The Philippines.

Vergara, N. T. 1997. Is Community Forestry Management Implementable and Sustainable? Paper presented at the 1997 National Convention and Workshop of the Society of Filipino Foresters, June 5–7 1997, Cavite, The Philippines.

WCED. 1991. *Our Common Future.* Oxford University Press, Melbourne, Australia.

Wiersum, K. n.d. Developing Strategies for Social Forestry: A Conceptual Approach. Working Paper. Environment and Policy Institute, East West Center, Honolulu, USA.

Mathema, P., Dutta, I. C., Balla, M. K. and Adhikary, S. N. (eds.). 1999. *Sustainable Forest Management*. Proceedings of an International Seminar, 31 August – 2 September 1998, Pokhara, Nepal.

Ecology and Growth of *Shorea robusta* in Central Nepal

S. N. Rai, I. C. Dutta, S. Haque, B. B. Khanal,
J. P. Chaurasia, and I. P. Indu

Abstract: Sal (*Shorea robusta*) is one of the most prized timber species in India and Nepal. In Nepal sal forests occur mainly in the Terai region. However, they also are distributed in the Mid-Mountain areas. With a view to study the ecology and growth of sal in Central Nepal, the nested quadrant approach was adopted for data collection covering the entire range of vegetation types. Proportion of sal among over-wood species is higher in the mid–mountain regions. Its main associates in the Terai are *Terminalia tomentosa, Lagerstroemia parviflora, Anogiessus latifolia*, and in the sub-tropical areas the main associates are *Schima wallichii, Castanopsis indica*, etc. *Clerodendron infortunatum* and *Pogostemon* sp. are the two commonest shrubs across the range in these forests.

The Basal Area in these forests ranged from 18.61 to 30.62 m^2 per ha. For the swampy conditions it was 22 m^2 per hectare. The DBH/Height relationship for 22 sites from these forests was considered. It was found that for the same diameter the best height growth was in inner-Terai. It is possible to apply a single regression equation to predict the height based on DBH.

1. Introduction

Sal (*Shorea robusta*) is one of the most important timber species of India and Nepal. It is one of the prized constructional timbers and in the past the wood was highly valued for railway sleepers. It has two main zones of distribution: the Gangetic plain (both in India and Nepal) and the hilly tracts of peninsular India and the Siwalik hill ranges (again both in India and Nepal). In the plains it occurs on deposited soils while in the hills it is on soils which have developed *in situ*.

In Nepal sal occurs in the extended Gangetic belt, the Siwaliks and also at the foothills of the Himalayas. Sal is a gregarious species and forms dominant composition usually greater in number than all the rest put together. Sal forests in Nepal cover over one million ha, representing more than 16% of the total forest of the country.

With a view to study its ecology in the Central part of Nepal, data collection was done in Rupandehi, Nawalparasi, Chitwan, Tanahun and Lamjung districts. The objective was to study number of stems per ha, tree in various DBH class, Basal Area per ha and also the DBH/Height relationship.

Unlike most of sal forests of India, natural regeneration of sal is not a problem in Nepal but its finally becoming the future crop is limited due to various external factors such as fire, grazing, lopping for fodder, hacking for woodfuel and other purposes. In Nepal, there is fairly good rain every year in the month of May before the seed fall and therefore recruitment and establishment is favourable. Sal seedlings exhibit die- back in which the young seedlings keep dying for several years and as a result, they develop a carrot like taproot. There is variation in this phenomenon, which is dependent on the site and locality factors. It is interesting to note that generally die- back is not seen in the seedlings that are grown under *taungya* system, indicating a positive role of inter-cultivation and soil working. The period of die-back in the natural forests varies considerably.

2. Sal forest vegetation

Sal forms extensive forests and is highly gregarious. Where other factors are favourable, the upper limit of sal is probably regulated to a great extent by frost. In excessively dry localities, such as on southern aspects, it gives way to more xerophytic species. While in localities with tendency to water logging, it is unable to compete with evergreen species. Within these limits sal occupies soils possessing widely differing characteristics which makes it possible to distinguish several different types of forest. Three main types are recognised, namely "Hill sal", "Bhabar sal" and "Terai sal".

Grasses appear in abundance in all types of sal forest where sufficient light reaches the ground. There is a continual struggle between grasses and trees or shrubs (such as *Mallotus* and *Callicarpa*) for the possession of the ground. In most sal forests of whatever type, sal comprises 80 to 90% of the dominant tree species and tends to form a dense canopy. That the virgin sal forests contained a much higher percentage of miscellaneous species than the present forests cannot be doubted. Certain species with limited coppicing powers such as *Buchanania latifolia* and *Lannea grandis* are heavily handicapped in the struggle for existence. Sal is itself semi-deciduous and all the commonest tree associates are deciduous with the exception of *Syzygium cumini* and *Mallotus philippinensis*. Amongst shrubs there is considerable variation though two of the commonest, *Clerodendron infortunatum* and *Colebrookia oppositifolia* are evergreen.

Terai, Bhabar, Dun valleys, and outer foothills at the present time comprise much the extensive forested areas of tropical and sub-tropical Nepal. The forests, which grow here, are composed predominantly of deciduous and semi-deciduous species. True tropical evergreen forest is very limited in extent, confined only to some shady gullys and damp places.

Forest in which sal predominates is the most extensive type of forest in all these flat places, and the composition of this forest varies remarkably little from east to west throughout Nepal. Sal does not grow on recently formed alluvium or on waterlogged soil. Close to the river edges, on newly formed gravels or on midstream islands there are often strips of forest composed of *Acacia catechu* and *Dalbergia sissoo*. It is only along streams or rivers where riverain types of forest occur or in gullys where tropical evergreen forest grows that the dominance of sal forest is broken. Grassland is also a feature of some parts of these flat areas. In the outer foothills there is a considerable difference between the types of forest found in eastern and western parts of the country.

Some of the sub-tropical types of forest penetrate up the big river valleys which cut deep into the Middle Mountains. Sal forest can be found here up to 1,200 m and sub-tropical deciduous hill forest up to 1,300 m.

The forests of western Middle Mountains resemble those of Kumaon, and the eastern forests those of Sikkim. The meeting of these different types of forest in the Central Himalayas is complicated somewhat by the fact that the Pokhara area is exceptionally wet. In most parts of the Central Himalayas the western forest types are usually present on the south faces and the eastern forest types on the north faces. Tropical and sub-tropical forests are not extensive in the Central Himalayas. Sal forest and sub-tropical deciduous hill forests grow in some of the lower valleys, and *Dalbergia sissoo* and *Acacia catechu* occur along the rivers in some places.

3. Material and methods

Selection of site was initially started after discussion with the local District Forest Officer (DFO). The Ranger of the areas accompanied in the field visit and in the exploratory phase. The objective was to study the variation from the ecological point of view and also the physiographic and management variations. The study aimed to cover the Hill, Bhabhar, Terai, Swamp, Riverain, Degraded and Regenerated areas.

On each site two replicates of 50 m x 50 m were laid with the help of nylon ropes. All trees above 10 cm DBH in the entire plot were measured for diameter with callipers (recording two DBH measurements at right angles to each other). Where the trees could not be measured with callipers, their girth was recorded. Inside these large plots a smaller plot of 10 m x 10 m was laid. In this plot all trees and saplings of below 10 cm DBH and above 1 m height (whose diameter could be measured) were measured for DBH). Further, inside the same plot another sub-plot of 5 m x 5 m was laid, in which all plants (including herbs) above 30 cm height and up to 1 m or more (including those whippy ones where DBH was not recorded) were counted species-wise. The three categories would broadly represent as "tree", "shrub" and "herb" layer. Lianas were considered as tree. Basal area of tree and shrub layer was computed and frequency distribution of the DBH classes and percentage contribution of the species were worked out. From each of the replicates 15 trees of sal were measured for DBH and height. The data of both the replicates were combined to give a representative DBH/Height relationship for the area.

4. Results

The collected data were processed in several ways. For each study site the trees were classified in diameter classes of 10–20, 20–30, 30–40, 40–50, 50–60 and 60 and above and their Basal Area was computed. Further details of number of trees for each district in DBH classes were worked out. Analysis of the data has given certain interesting results. The average number of trees in different DBH classes for the four physiographic zones are given in Table 1. It may be seen that the National Park area and the coppice regeneration areas, which are afforded better protection, have better representation of lower DBH classes, indicating better regeneration. Most of the natural forests lack young pole crop and this needs serious attention. Table 2 shows the details of important tree species and their percentage occurrence in the four physiographic zones. Sal forms a very high proportion in the Mid-Mountain regions as compared to Terai and Siwalik zones and it is the only species which is common in all the four zones. *Lagerstroemia parviflora, Semicarpus anacardium* and *Syzygium cumini* are the other species which have wider distribution. *Schima wallichii* and *Castanopsis* occur in the Mid-Mountains only. Table 3 gives details of shrub species. It is interesting to note the very distinct vegetation of the swampy area. These species have no representation elsewhere. Here again sal is the only species occurring in all the four zones and *Lagerstroemia* in three zones. The species composition of the forests is entirely different in the Terai and the Mid-mountains except for the dominance of sal.

Table 1. Number of stems per ha in different sal forests of four physiographic zones of Nepal

Districts	DBH Class (cm)											
	Phygio-graphic Zone	10-15	15-20	20-25	25-30	30-35	35-40	40-45	45-50	50-55	55-60	Over 60
Rupandehi (i) Natural Forest	Terai	100	40	44	22	176	177	169	166	4	4	8
(ii) Natural & Coppice Regeneration		1152	192	16	16	-	-	-	-	-	-	-
Chitwan (i) Natural Forest	Inner Terai	23	24	10	23	14	18	19	15	11	13	17
(ii) National Park		84	52	32	36	20	40	16	8	-	8	12
Tanahun	Mid-Mountain	341	175	65	36	13	13	8	7	-	-	-
Lamjung	High Himal	212	240	184	78	26	3	-	-	-	-	-

Table 2. Percentage occurrence of trees (above 10 cm DBH) of various species in sal bearing forest

Species	Districts			
	Rupandehi	Chitwan	Tanahun	Lamjung
Shorea robusta	51.2	66.2	90.0	97.1
Terminalia tomentosa	13.1	0.8	–	–
Lagerstroemia parviflora	5.4	3.8	0.6	–
Anogeissus latifolia	3.1	–	–	–
Dillenia pentagyna	3.5	5.3	–	–
Semicarpus anacardium	1.5	1.5	1.9	–
Lanea grandis	1.9	1.5	–	–
Madhuca latifolia	1.2	–	–	–
Schliechera oleosa	0.4	–	–	–
Mallotus philippinensis	5.8	1.5	–	–
Dalbergia latifolia	0.4	–	–	–
Pterocarpus marsopium	2.7	–	–	–
Litsea sp.	3.1	0.8	–	–
Syzygium operculatum	0.4	4.5	–	–
Syzygium cuminii	0.8	0.8	0.6	–
Terminalia belerica	0.8	0.8	–	–
Adina cordifolia	–	3.0	–	–
Ehretia leavies	–	2.3	–	–
Holorrhina antidysentrica	–	0.8	–	–
Schima wallichii	–	–	5.1	2.9
Castanopsis indica	–	–	1.1	–
Lianas	1.2	1.5	–	–
Others	3.1	6.0	0.8	–
Total	100	100	100	100

Table 3. Percentage occurrence of important species of shrub layer (below 10 cm DBH and up to 1 m height) in sal bearing forests

Species	Rupandehi	Chitwan		Tanahun	Lamjung
		Sal forest	Swamp		
Shorea robusta	57.8	33.6	–	67.4	24.4
Terminalia tomentosa	7.1	6.2	–	–	–
Lagerstroemia parviflora	3.6	7.1	–	4.4	–
Holorrhena antidysenterica	5.0	–	–	–	–
Casaerea sp.	4.3	8.8	–	–	–
Chuiya	4.3	–	–	–	–
Mallotus philipinensis	2.8	–	–	–	–
Madhuca latifolia	2.1	–	–	–	–
Khukuri	2.1	–	–	–	–
Syzygium operculata	–	8.0	–	–	–
Litsea sp.	–	5.3	–	–	–
Miliusa velutina	–	2.6	–	–	–
Murraya koenghi	–	–	63.0	–	–
Coolebrookia oppositifolia	–	–	18.5	–	–
Trewia nudiflora	–	–	7.4	–	–
Pogestemom sp.	–	–	3.7	–	–
Dhaturang	–	–	1.9	–	–
Arari Lati	–	–	1.9	–	–
Schima wallichii	–	–	–	14.8	22.2
Castanopsis indica	–	–	–	5.9	13.3
Engelharditia spicata	–	–	–	2.2	–
Melastoma sp.	–	–	–	–	13.3
Basante kanda	–	–	–	–	13.3
Pipari	–	–	–	–	4.4
Others	10.9	28.4	3.6	5.3	9.1

Table 4 gives species composition at the herb layer for the four zones. Sal and *Clerodendron* are the two species that are found in all the zones. Proportion of *Clerodendron* appears to be more in Mid-Mountain zones as compared to Terai and Siwalik. Sal appears to be regenerating better in the lower zones. Other than sal, *Clerodendron, Syzygium* and *Pogostemon,* there are clear sets of species at herb layer for the four zones and the swampy areas.

The representative basal area per ha in Rupandehi, Chitwan, Tanahun and Lamjung districts was 21.34, 22.98, 18.61 and 30.62 m^2/ha, respectively. For the swampy site, it was 22 m^2/ha. It is interesting to note the high basal area in Lamjung which is because of larger number of stems of smaller dimension present per unit area.

Table 4. Percentage occurrence of important species of herb layer (below 1 m and above 30 cm in height) in sal bearing forests

Species	Rupandehi	Chitwan		Tanahun	Lamjung
		Sal forest	Swamp		
Shorea robusta	33	55.6	–	45	9.8
Clerodendron infortunatum	30	8.6	16.6	26	19.6
Flemingia sp.	7.6	–	–	–	–
Teminalia tomentosa	5.4	–	–	–	–
Phoenix sp.	4.8	–	–	–	–
Holorrhena antidysenterica	3.8	–	–	–	–
Bayuri	3.1	–	–	–	–
Litsea sp.	2.9	–	–	–	–
Syzygium cumini	2.1	–	4.1	–	–
Dillenia pentagyna	1.7	1.4	–	–	–
Pogestemom sp.	–	6.3	11.1	–	5.3
Eupatorium sp.	–	3.7	–	–	–
Stereospermum sp.	–	2.3	–	–	–
Bantori	–	3.5	–	–	–
Mallotus philippinensis	–	1.6	–	10	–
Raina phool	–	1.4	–	–	–
Phuljor	–	–	41.6	–	–
Murrayya sp.	–	–	20.8	–	–
Trewia nudiflora	–	–	2.7	–	–
Coolebrookia oppositifolia	–	–	1.4	–	–
Arari lati	–	–	1.4	–	–
Melastoma sp.	–	–	–	4.2	–
Castanopsis indica	–	–	–	2.3	2.7
Lagerstroemia parviflora	–	–	–	2	–
Syzygium operculata	–	–	–	1.5	–
Climber	–	–	–	2	–
Climbing fern	–	–	–	1.5	–
Fern	–	–	–	1.5	5.4
Indigofera sp.	–	–	–	–	24.5
Hypericum sp.	–	–	–		6.3
Paite	–	–	–	–	5
Basante kanda	–	–	–	–	3.1
Others	5.6	15.6	0.3	4.0	18.3

DBH/height relationship of sal trees in central Nepal

With a view to establish Diameter Breast Height (DBH) and height relationship of sal trees, data was collected from 22 locations in Rupandehi, Nawalparasi, Chitwan, Tanahun and Lamjung districts in the central part of Nepal.

The data was plotted on graph paper and it apparently showed an asymptotic trend. The non-linear (asymptotic) model **y = a + b * R ** x** was fitted in most cases. In some cases, linear model of the form **y = a + bx** was also fitted. The details of all the equations are given below.

In case of Rupandehi district the non–linear equation was:

$$\textbf{Height} = 40.87 - 39.59\,(0.9761)^{DBH} \quad (n = 138;\ F = 594.61;\ r = 0.947)$$

For Chitwan and Nawalparasi districts the data was combined. There was only one site in Nawalparasi and 7 in Chitwan. There were 3 sites in Chitwan which were low lying almost like swampy areas. Data of these areas has been considered separately. For the remaining representative sites, the equation was:

$$\textbf{Height} = 46.27 - 46.51\,(0.97998)^{DBH} \quad (n = 88;\ F = 445.72;\ r = 0.955)$$

Data for Tanahun district was mostly from the coppice crop with few older trees. The upper range of DBH was also low. The equation was:

$$\textbf{Height} = 45.3 - 41.1\,(0.9853)^{DBH} \quad (n = 45;\ F = 90.23;\ r = 0.896)$$

For this data set a linear model of the form: **y = a + bx**, was also fitted and the equation was:

$$\textbf{Height} = 6.191 + 0.4032\ DBH \quad (n = 45;\ F = 176.59;\ r = 0.894)$$

The upper DBH in this case was 51.9 cm and hence the range of data was such that both asymptotic and linear equations gave practically identical fit (r–values being 0.896 and 0.894, respectively). However, as the known trend is asymptotic only that curve has been considered.

For Lamjung district again the data was collected from 3 sites. Here again the upper DBH limit was 36.6 cm. The equation obtained was:

$$\textbf{Height} = 28.75 - 28.27\,(0.9622)^{DBH} \quad (n = 83;\ F = 98.95;\ r = 0.840)$$

For the same data set a linear model was also fitted and the equation was:

$$\textbf{Height} = 5.68 + 0.4735\ DBH \quad (n = 83;\ F = 173.91;\ r = 0.823)$$

As in case of Tanahun both the asymptotic and linear models gave comparable results. However, the asymptotic model has been adopted.

Sites, which were low lying in Rupandehi and Chitwan generally, gave an indication that the DBH/height ratio in these sites was lower as compared to other areas. It meant that for the same DBH the heights in the low lying or swampy areas were lower as compared to other forests. Two models non–linear and linear were attempted and they were:

$$\textbf{Height} = 37.4 - 51.78\,(0.9767)^{DBH}$$
$$\textbf{Height} = 2.37 + 0.3735\ DBH$$

The number observations for these equations were 60. The value of r for the two equations was 0.68 and 0.67 respectively, which was considered not very good.

Overall relationship for the entire data (excluding that from swampy areas) was considered together. The non-linear regression was:

$$\textbf{Height} = 45.48 - 43.69\,(0.98115)^{DBH} \quad (n = 354;\ F = 1492.40;\ r = 0.946)$$

In order to have an overall picture of the relationship another regression, including the data from swampy areas was tried. The equation obtained was:

$$\textbf{Height} = 52.95 - 48.96\,(0.988)^{DBH} \quad (n = 414;\ F = 939.33;\ r = 0.906)$$

Comparision of the r-values obtained for the above two equations shows that the data of swampy and non-swampy areas do not combine well. Furthermore, in the water-logged areas there is inherent variation in the height growth and adequately good fit was not obtained.

In order to get a fit for comparable physiographic zones, data for Rupandehi, Chitwan and Nawalparasi was considered together. The equation obtained was:

$$\textbf{Height} = 43.16 - 42.23\,(0.978)^{DBH} \quad (n = 226;\ F = 1071.23;\ r = 0.951)$$

For the same reason, the data of Tanahun and Lamjung was also considered together. The equation obtained was:

$$\textbf{Height} = 33.12 - 30.94\,(0.97253)^{DBH} \quad (n = 128;\ F = 194.36;\ r = 0.868)$$

It may be seen that the data of Terai and inner Terai districts combines better than the data of Mid-Mountain districts.

For the data set of Tanahun and Lamjung district a linear model obtained was:

$$\textbf{Height} = 6.275 + 0.4283\ DBH$$

This indicates that up to about 40–45 cm DBH, there appears to be a linear relationship between DBH and height.

7. Comparative prediction

In the foregoing paragraphs, 13 equations (9 asymptotic and 4 linear) have been given for sal. The study areas covered swampy locales, Terai and inner Terai, Siwalik hills, Mid-Mountain and High Mountain districts (practically the upper limit of sal in Lamjung district). The best fit obtained (r = 0.955) was for the combined data of Chitwan and Nawalparasi district, followed by Chitwan, Nawalparasi and Rupandehi (r = 0.951), and Rupandehi (r = 0.947). These data sets did not consider the low–lying water logged (swampy) areas. The overall prediction for all the districts (excluding swampy locales) was also equally good (r = 0.946), however when combined with the data from swamy locales, it goes down (r = 0.906). In the data set of Tanahun and Lamjung as most of the crop is of coppice origin and large trees were absent, both asymptotic and linear models have given comparable prediction (r- values 0.896, 0.894 and 0.840, 0.823 for the two districts and two types of equations, respectively). In the entire process the poorest fit obtained was for the swampy areas. Although the data had a sample size of 60 yet the value of r was 0.68 and 0.67 for the asymptotic and the linear regression, respectively.

Table 5 gives the predicted values of heights based on these equations. Depending upon the values of Determination coefficients the predicted values for Chitwan and Nawalparasi; Chitwan, Nawalparasi and Rupandehi combined; and Rupandehi separately should be nearer to the real values and more acceptable.

Table 5. Diameter and Height (predicted values) from regression equations for various sal forest of central Nepal

DBH (cm)	Predicted values of Height (m)							
	Overall	Overall excluding swamp	Rupandehi, Chitwan, Nawalparasi	Rupa-ndehi	Chitwan & Nawal-parasi	Tanahun	Lamjung	Tanahun & Lamjung
10	9.74	9.36	9.35	9.78	8.28	9.86	9.52	9.70
20	14.65	15.62	16.10	16.45	15.23	14.74	15.67	15.40
30	19.01	20.79	21.49	21.69	20.92	18.94	19.85	19.70
40	22.87	25.07	25.81	25.81	25.56	22.57	22.70	22.97
50	26.29	28.61	29.27	29.04	29.35	25.70	24.63	25.43
60	29.32	31.53	32.04	31.58	32.45	28.40	25.95	27.30
80	34.39	35.95	36.04	35.14	37.05			
100	38.37	38.96	38.59	37.34	40.11			
120	41.50	41.03	40.23	38.69	42.16			

Based on the predicted height values it may be seen from Table 5 that as compared to Terai (Rupandehi) the height for the same diameter is more in the inner Terai (Chitwan and Nawalparasi). Further, for the range of observed data compared to Terai and inner Terai the height for the same DBH is lower in Middle Mountain (Tanahun) and High Mountain (Lamjung) district. Again between these two districts Tanahun has better height growth than Lamjung. It appears that the site conditions of the inner Terai districts are best suited for height growth of sal. On combining the data of the swampy areas very interesting prediction comes out—the height growth at the lower and upper ends of diameter range is more in the combined data as compared to the overall but swamp excluded data. This primarily is due to large variability in site conditions in the swamp type of locations. The main finding of this study is that the overall equation, which includes all the sites except the water logged ones, can be applied with reasonable accuracy for the entire forests of Central Nepal. Of course it will have to be tested further for eastern and western Nepal, and more work is needed for predictions in swampy areas. The trend of linear models, giving good fit in the coppice regrowth forests of Tanahun and Lamjung districts up to the diameter range of 45–50 cm, needs to be further studied and examined.

Mathema, P., Dutta, I. C., Balla, M. K. and Adhikary, S. N. (eds.). 1999. *Sustainable Forest Management*. Proceedings of an International Seminar, 31 August – 2 September 1998, Pokhara, Nepal.

Environment, Growth Rate, Effect of Inter-cultivation and Volume Production in *Dalbergia sissoo* and *Eucalyptus camaldulensis* Plantations at Sagarnath, Nepal

S. N. Rai, Y. Ansari, C. P. Upadhyaya, S. N. Adhikary,
B. Mahato, S. M. Mishra and S. Rayamajhi

Abstract: Sagarnath Forestry Development Project is the largest mechanised plantation initiative in Nepal. Of the 11,000 ha planted, around 55% is *Eucalyptus camaldulensis* and 40% is *Dalbergia sissoo* (sissoo). Twenty sites (8 planted with sissoo and 12 planted with *Eucalyptus*) were taken up for the study of diameter and height growth. Most of the plantations were inter-cultivated for periods varying from one to five years. The age of sissoo plantations ranged from 3 to 25 years while those of *Eucalyptus* was from 3 to 13 years. Regression equations for Age/Diameter and Diameter/Height were established for both the species under inter-cropped and not inter-cropped conditions. It was observed that inter-cropping initially gives good start to the seedlings. However, in the long run, growth is determined by site potential, and the impact of inter-cropping is nullified. It was seen that up to the age of 3 years, the diameter growth of both *Eucalyptus* and sissoo was equal while between 3 and 11 years, *Eucalyptus* had better growth than sissoo. Thereafter, sissoo has better diameter growth. Regarding over bark volume production in *Eucalyptus*, the average scenario (8–13 years old) from the data of *Eucalyptus* gave productivity of 15.86 m^3/ha/year while the best scenario (9 years of age) gave a figure of 31.01 m^3/ha/year and the worst scenario (13 years old plantation) gave a figure of 6.44 m^3/ha/year. In case of sissoo, the average volume production at 15 years was 11.17 m^3/ha/year and at 25 years it was 15.35 m^3/ha/year.

1. Introduction

Sagarnath Forestry Development Project is located in Bhaktipur village of Sarlahi district of Nepal. The Sagarnath forest was the only large block of forestland left in the Janakpur zone covering about 16,000 ha extending from the eastern boundary of Sarlahi district to the western boundary of Mahottari district with an average length and breadth of about 20 km and 8 km, respectively. Almost 99% of the project area lies on the Bhabar belt, and only 1% on the southern border is actually on Terai soil.

The project objectives were: (i) to replace depleted and degraded unproductive sal (*Shorea robusta)* forest by fast growing short rotation species to fulfil the imminent shortages of fuelwood in the eastern and central Terai, (ii) to provide employment to the landless and unskilled labourers and (iii) to prepare skilled manpower in the field of forestry operations. The project was for 12 years. The first phase was from 1979–1985 and the second phase was 1986–1990. Based on the past experimental results, it was decided to plant *Dalbergia sissoo* (sissoo) and *Tectona grandis* (teak) in larger proportion. In a further experiment 20 species were tried and of them *Euclayptus camaldulensis* Petford provenance was selected for large scale planting. Of the 11,000 ha planted around 55% is *Eucalyptus* and 40% is sissoo.

1.1. Past management

The natural forest was clearfelled one or two years prior to the planting. The clear-felling gave around 50 m^3/ha of timber and firewood. The site was usually ploughed, and planted with container grown seedlings. The most common spacing in planting was 4 m by 2 m (1,250 seedlings/ha).

Site preparation was completed before commencement of the monsoon. Sissoo, teak and *Eucalyptus* were planted at the break of monsoon at 2 m spacing between rows whereas *Acacia catechu* (khair) was pit-planted on a 20 m wide belt along streams to reduce soil erosion. The plantation area was fenced for protection. Replacement of casualties was carried out in the second year after plantation but no subsequent silvicultural operations such as pruning or thinning were recommended. Grazing in sissoo and *Eucalyptus* plantations was encouraged after the plantations were established. The plantation area was divided into square-shaped blocks of 100 ha. Each block was further divided into four sub-blocks of 25 ha. The sub-block was the smallest management unit: a sub-block was planted in the same year with the same species. Sometimes, however, two or more species have been planted in one sub-block. These sub-blocks are called "mixed" stands although they usually are not mixed but consist of sub-areas of pure stands. In the first and second year of inter-cropping, the most important summer crop was maize. Tobacco and mustard were grown as winter crops.

The most important management operations were weeding and fire protection. It was learned very soon that the original production target of 80,000–100,000 m^3 per annum from 10 years and older plantations would not be possible without very careful weed and fire control. The competition by *Imperata* grass and other weeds was so strong that it could impair the growth of the trees.

2. Study area

The altitude of the study area is around 100 m. It has an average rainfall of 1200–1500 mm/year and the temperature ranges from 10º– 40º C. The relative humidity is 42%–86%. The Sagarnath area is monsoonal in terms of rainfall and sub-tropical in terms of temperature. Rainfall mostly occurs in the summer months of May to October. In most years Sagarnath experiences soaking pre-monsoon rains in May; these are followed by a dry spell and again without fail by the monsoon one month later.

The vegetation is mainly sal and its associates mainly *Lagerstroemia parviflora, Anogeissus latifolia, Dillenia pentagyna, Schleichera oleosa,* etc. The area also has some khair. The shrub vegetation has *Mallotus philippinensis, Butea monosperma, Helicteres isora* and *Holorrhena antidysenterica.*

3. Materials and methods

In order to collect representative data from the plantation of *Eucalyptus* and sissoo at Sagarnath, two levels of randomisation were adopted. In the first place from among the available Block and Plot numbers planted in different years, two plots were randomly selected by drawing lots and by keeping the probability of selection constant. Each of these plots were 25 ha (500 m x 500 m). During field verification, some of the plots had to be replaced by others in order to get a representative sample. This was done as per the advice of the project field staff.

In each selected plot two replicates of 20 m x 25 m were taken in a representative manner and all the trees in the plot except those which were not considered representative were numbered. Out of these numbered trees, 15 or more were randomly selected by drawing lots and keeping the probability constant. Diameter at Breast Height (DBH) was measured twice with metal callipers. In case of exceptionally large trees, Girth at Breast Height (GBH) was recorded with a tape. Height of trees was measured with a clinometer. DBH of all trees was recorded and height measurement was done for every fifth sissoo tree and fourth *Eucalyptus*. This was done to reduce the fieldwork and also in view of the fact that fairly good regression equations and estimates of volume production were available from the past studies of these plantations.

Eucalyptus plantations of the years 1984, 1985, 1987, 1988, 1989, 1990, 1991 and 1994 in which inter-cropping was done and plantations of the years 1984, 1985 and 1987 in which inter-cropping was not done were taken for the study. Similarly, sissoo plantations of the years 1980, 1982, 1986, 1987, 1989, 1991 and 1994 in which inter-cropping was done and plantations of the years 1972, 1981, 1987 in which inter-croping was not done were considered.

4. Results and discussion

Eucalyptus and sissoo plantations of the entire age range were considered for data collection. Variations of inter-cultivated and not inter-cultivated plantations were also covered. After the plotting of the data it was felt that in both the cases DBH/Height data of smaller and larger trees were not available from the plantations. (The plantations of sissoo were from 3–25 years of age and those of *Eucalyptus* were 3–14). In order to have more representative data, *Eucalyptus* of smaller and larger dimensions were measured. Similarly, data on smaller trees of sissoo was also collected from the same locality (larger dimension sissoo trees do not exist in the locality). It turned out that the additional data collection was very useful in fitting regression equations. Certain details of parameters like age, average DBH, average height and the location of the study areas are given in Tables 1 and 2. It was attempted to fit both linear and curvilinear regressions for the data set. It was also attempted to fit regression equations for inter-cultivated and not inter-cultivated plantations separately.

Table 1. Age, present spacing, mean diameter and height of sissoo plantation in Sagarnath

Age	Population size	Sample size	Present Spacing (m)	Mean diameter ± S.D. (cm)	Mean height ± S.D. (m)	Inter-cropped
3	43	30	3.4 x 3.4	6.60 ± 1.68	5.90 ± 0.98	Yes
6	32	32	4.0 x 4.0	11.43 ± 4.14	10.33 ± 1.61	Yes
9	78	30	2.5 x 2.5	14.26 ± 4.56	13.83 ± 3.56	Yes
10	41	36	3.5 x 3.5	12.85 ± 2.48	12.56 ± 1.42	No
11	75	30	2.6 x 2.6	14.24 ± 4.63	14.13 ± 5.1	Yes
15	64	30	2.8 x 2.8	16.65 ± 4.89	16.02 ± 2.92	Yes
17	75	31	2.6 x 2.6	18.58 ± 6.06	17.98 ± 3.9	Yes
25	23	23	4.7 x 4.7	32.23 ± 8.29	25.55 ± 7.43	No

Table 2. Age, present spacing, mean diameter and height of *Eucalytpus* plantation in Sagarnath

Age	Population size	Sample size	Present Spacing (m)	Mean diameter ± S.D. (cm)	Mean height ± S.D. (m)	Inter-cropped
3	84	32	2.4 x 2.4	7.72 ± 1.68	10.15 ± 2.42	Yes
6	42	30	3.5 x 3.5	11.04 ± 3.82	14.93 ± 2.81	Yes
6	89	31	2.4 x 2.4	11.01 ± 2.96	15.94 ± 3.71	Yes
8	57	30	3.0 x 3.0	12.53 ± 3.62	15.59 ± 2.87	Yes
9	56	31	3.0 x 3.0	21.03 ± 6.07	18.10 ± 4.4	Yes
10	47*	6	3.3 x 3.3	19.54 ± 3.66	21.58 ± 2.64	No
10	97	32	2.2 x 2.2	12.95 ± 3.72	16.52 ± 3.01	No
10	78	30	2.5 x 2.5	15.89 ± 4.61	21.56 ± 4.13	Yes
12	55	31	3.0 x 3.0	15.95 ± 4.53	17.00 ± 3.47	Yes
13	35	15	3.8 x 3.8	14.96 ± 4.33	17.18 ± 4.79	Yes
13	29	29	4.2 x 4.2	16.59 ± 5.35	19.69 ± 5.65	No
14	80	31	2.5 x 2.5	12.76 ± 4.69	16.02 ± 3.73	Yes/No

*The other trees were of sissoo

In case of sissoo plantation of 10 years, the data at S. No. 4 of Table 1 gives an impression that although the spacing is more than the plantations of 9 and 11 years age (at S. No. 3 and 5), both the average diameter and height are lower. The site was considered to have had heavy soil and hence was not inter-cropped. The site is flat with heavy soil and grass cover. Therefore, the slow growth could be attributed to unfavourable site for sissoo, rather than to absence of inter-cropping.

In case of *Eucalyptus* (Table 2) there appears to be inconsistency in diameter growth with age even for the inter-cropped sites. This can only be due to variation in site conditions. So is the case with height growth. There is a fairly large variation in diameters also. The only data available for inter-cropped and not inter-cropped site is for 10 years plantation. The site at S. No. 6 is the same which has been described above for sissoo, where inter-cropping was not done due to the soil being too heavy. Here *Eucalyptus* was planted to fill up the gaps. The other two sites at S. No. 7 and 8 indicate some difference. In fact the site at S. No. 7 is better than 8 but the poor growth at 7 could be due to closer spacing and heavy undergrowth of *Eupatorium* and *Holorrhena*. The site at S. No. 8 is not well-drained and has heavy soil and grass cover, but it was inter-cultivated for 4–5 years. Better growth here could be due to less competition, both from ground cover and as a result of more spacing, and due to tillage effect of inter-cultivation.

Regression equations for sissoo

Altogether 56 trees were measured for height in the process of data collection of DBH. Thereafter, additional 40 smaller trees were measured for DBH and heights in the same locality. The linear and curvilinear regressions obtained are given below:

Linear:

Ht = 3.46 + 0.685 DBH ($n = 56$; $r = 0.916$)
Ht = 3.66 + 0.717 DBH ($n = 96$; $r = 0.94$)

Curvilinear:

1/Ht = 0.0096 + 0.924 x 1/DBH ($n = 56$; $r = 0.63$)
1/Ht = 0.029 + 0.721 x 1/DBH ($n = 96$; $r = 0.744$)

It looks that there is linear relationship between DBH and height up to these diameters. Although the relationship is supposed to be curvilinear, the same is not reflected in the available data set of the locality. It could also be said that the asymptotic relationship starts somewhere beyond this age or DBH. While considering the inter-cropped and not inter-cropped plantations for the same type of DBH/Height relationship, the best-fit equations again were linear. They are as follows:

Inter-cropped: **Ht = 2.658 + 0.72 DBH ($n = 43$; $r = 0.91$)**

Not inter-cropped: **Ht = 6.057 + 0.61 DBH ($n = 13$; $r = 0.92$)**

Age/DBH relationship of *Eucalyptus*

A non-linear asymptotic model was tried for Age/DBH relationship of *Eucalyptus* (overall i.e. both inter-cropped and not inter-cropped). The equation obtained was:

$$\mathrm{DBH} = 16.228 - 24.95\,(0.7174)^{\mathrm{Age}} \quad (n = 314;\ F = 76.19,\ r = 0.57)$$

A linear model gave $r = 0.64$ only. This indicates that there is no reliable predictable relationship between Age/DBH in *Eucalyptus* plantations of Sagamath.

Several of these plantations were inter-cropped for few years. However, some were not inter-cropped. The data for the inter-cropped plantations gave a non-linear relationship of the form:

$DBH = 17.99 - 23.16 (0.7805)^{Age}$ (n = 229; F = 81.85; r = 0.644)

The same data was also used to fit a linear regression which gave r = 0.61.The overall indication is that the diameter growth in *Eucalyptus*, did not show high correlation with Age under inter-cropped conditions at Sagarnath. However, Age/DBH relationship appears to be more asymptotic than linear. In case of the not inter-cropped data the regression for both non-linear and linear form did not give a satisfactory fit.

Age/DBH relationship in sissoo

Sissoo plantations also were inter-cropped and not inter-cropped. In case of combined data for cropped and non-cropped plantations, the non-linear model did not give the desired curve. Here the DBH appeared to be rising exponentially with age, which can not be the case. This model was therefore rejected. For the same observed range of data the linear model gave an equation of the form:

$DBH = 4.244 + 0.9860\ Age$ (n = 243; F = 253.91; r = 0.715)

In case of the inter-cropped plantations, both non-linear and linear models did not give appreciable correlation. However, for the not inter-cropped data the linear model gave the best fit.

$DBH = 2.20 + 1.2276\ Age$ (n = 90; F = 280.69; r = 0.871)

DBH/Height relationship in *Eucalyptus*

The data shows a clear asymptotic trend. The equation obtained was:

$Height = 41.39 - 39.94 (0.96886)^{DBH}$ (n = 155; F = 610.5; r = 0.942)

The same data was also plotted to give a sigmoid curve. The form of the equation obtained was:

$Height = -53.11 + 90.3/[1 + EXP\{-0.1211^*(DBH - (0 - 0.04999)\}]$
(n = 155; F = 405.04; r = 0.942)

Both the equations have the same determination coefficient. However, considering the F values and the Standard Error of the Mean (S. E.) of the Determination coefficient, the asymptotic equation is slightly better than sigmoid. But the most significant fact is that the data set although not fully representative of the whole range of life form of the species could give the sigmoid growth curve with a very high degree of correlation.

DBH/Height relationship in sissoo

The non-linear regression of asymptotic form was attempted for DBH/height data. The equation obtained was:

$Height = 36.11 - 39.16 (0.95212)^{DBH}$ (n = 92; F = 327.74; r = 0.937)

Similarly, linear relationship was tried for the same data set. The equation was:

$Height = 2.782 + 0.8575\ DBH$ (n = 92; F = 424.03; r = 0.907)

The asymptotic relationship gave better fit than the linear in this case.

Diameter/Height relationship in sissoo and *Eucalyptus*

The data collected during the study was used to fit DBH/Height curves. The values obtained from the equations are given in Table 3. In case of *Eucalyptus* the data set gave both exponential and sigmoid fit with practically comparable prediction. In fact sigmoid is the real growth curve, but it is not easily obtained in forestry data sets of trees because the measurements are often recorded above a certain range of parameters. In this case the equation gives a good result. The predicted height at the lower and the upper ends of the data range is higher as compared to that obtained from the asymptotic curve, while in the central part of the diameter range the predictions from both the equations are comparable.

Table 3. DBH (cm)/Height (m) relationship of sissoo and *Eucalyptus* for block plantations

DBH (cm)	Height (m)		
	Eucalyptus		
	Exponential	Sigmoid	Sissoo
5	7.29	7.44	5.47
10	12.28	12.22	12.14
20	20.18	20.23	21.44
30	25.93	26.12	27.13
40	30.12	30.18	30.61
50	33.18	32.85	31.81
55	34.38	33.80	

Table 3 also gives an interesting comparison between the two species. The height growth of sissoo up to 5 cm DBH is slower as compared to *Eucalyptus*, but it equals at the 10 cm DBH level and in fact between 10 cm and 40 cm DBH, the height growth of sissoo is better than that of *Eucalyptus*. This is an interesting feature of this study as in the past *Eucalyptus* was considered more favourably in comparison to sissoo.

Volume production

From the growth data shown in Table 1, the average volume (o.b.) production for sissoo at the age of 15 and 25 years was 11.17 and 15.35 m^3/ha/yr. In case of *Eucalyptus* for the age group 8–13 years the best, the average, the worst scenario of volume production (o.b.) was 31.01,15.86 and 6.44 m^3/ha/yr, respectively. The average data is for 8 to 13 years of age, while the best volume data is for 9 years of age and the lowest volume production data is for 13 years old plantation.

Long term impact of inter-cropping on growth of sissoo and *Eucalyptus* at Sagarnath

Eight sites (both inter-cropped and not inter-cropped) of sissoo were randomly selected covering the entire range of age gradation. In all 242 trees were measured for DBH. Similarly, 12 sites were randomly selected for *Eucalyptus* and 324 trees were measured for DBH. Analysis of data for studying the long-term effect of initial Inter-cropping was taken up with respect to age. For inter-cropped and not inter-cropped *Eucalyptus* the r-value obtained for the asymptotic curve was 0.570 which is a poor fit. The linear fit gave still lower r-value of 0.50. The curvi-linear equation has been used to predict the diameter and details are given in Table 4. For the inter-cropped data alone the curvi-linear equation gave a r-value of 0.644 (slightly better fit). Once again this has been used for prediction and details are given in Table 4. For the not inter-cropped data reasonable fit could not be obtained.

Table 4. Age (yr)/Diameter (cm) relationship for *Eucalyptus* and Sissoo in Sagarnath plantations

Age	Overall *	*Eucalyptus* Inter-cropped *	Overall **	Sissoo not inter-cropped	Block plantation
3	7.0	6.98	7.20	5.88	
5	11.44	11.28	9.17	8.34	9.25
7	13.79	13.91	11.15	10.79	
9	14.97	15.50	13.12	13.25	
11	15.58	16.47	15.09	15.70	
13	15.90	17.07	17.06	18.16	
15	16.06	17.43	19.03	20.61	
20	-	-	23.96		25.54
25	-	-	28.89		

Note: * Asymptotic curve; ** Linear curve
In case of *Eucalyptus* the not inter-cropped and in case of sissoo the inter-cropped data did not give acceptable fit.

For sissoo, the linear fit gave acceptable trend. The r-value was 0.715. This has been used to predict the diameters and details are given in Table 4. In case of inter-cropped sissoo the r-values obtained were very low and hence this has not been considered. However, for the inter-cropped data, linear model gave an r-value of 0.871 and the predictions from this are given in table 4. White (1986) had made out a case for *Eucalyptus* planting in Sagarnath by comparing the growth and productivity in the natural sal forests and also by concluding that sissoo which is a natural pioneer in the riverain areas had failed. Having established *Eucalyptus* as the species of choice, he also argued strongly in favour of disc ploughing and ripping the area to 25–30 cm and 50 cm, respectively as it favoured better growth and weed control. He also strongly recommended inter-cropping of the areas. However, he agrees that the growth was largely dependent upon site quality.

5. Conclusion

There appears to be considerable variation in site factors so inter-cropping or otherwise does not seem to indicate a definite trend. It is likely that the initial good start given by inter-cropping gets neutralised with the passage of time and eventually, it is the intrinsic site potential that determines tree growth. At best, only the overall predictions can be considered for these species. The linear models for sissoo, however, limits the utility of this prediction. The species has nearly linear diameter growth up to 30 years.

Comparing the overall rate of growth for *Eucalyptus* and sissoo, at 3 years of age both are equal, while between 3 and 11 years *Eucalyptus* has better growth than sissoo. Thereafter, sissoo shows a better diameter growth. This gives a clear picture on the relative growth of the species. This also indicates that if the aim is to produce wood biomass, then *Eucalyptus* is the choice and it should be harvested around 7–8 years of age. If timber volume is the objective, sissoo should be chosen with a rotation of 25–30 years.

Reference

White, K. J. 1985. Formulation of Second Phase of Sagarnath Project. A Report to the ADB Mission Leader, April 1985.

Mathema, P., Dutta, I. C., Balla, M. K. and Adhikary, S. N. (eds.). 1999. *Sustainable Forest Management.*
Proceedings of an International Seminar, 31 August – 2 September 1998, Pokhara, Nepal.

Leasehold Forestry and Forage Development for Poor: Conceptual Models and their Applications

B. K. Singh and J. K. Tamrakar

Abstract: Leasehold forestry and forage development has been applied in rehabilitation of degraded forestlands through participation of poor families and has made substantial achievements. The concept has been implemented in nine hill districts of Nepal. Four line-agencies (Department of Forest, Department of Livestock Services, Small Farmers Development Programme of the Agricultural Development Bank and Nepal Agriculture Research Council) are working together in an integrated manner for raising the income of the families living below the poverty line, and improving the ecological condition of the hills. Over a five-year period, a number of institutional, technical and social models have been developed. The paper discuses the process and application of these models in the renovation of degraded hills. Some of the interesting models are: stabilisation of shifting-farms, renovation of failed plantation areas, integration of forage and tree crops, forage seed co-operative, integration of community forestry and leasehold forestry.

1. Introduction

Leasehold forestry is a concept to assign forestland, on contractual basis, to any corporate body, industry, or community for a certain period of time (Forest Act, 1993). The forest laws intend that leasehold forestry can be developed for: (i) commercial purposes (industrial or commercial production or tourism); (ii) scientific research; and (iii) poverty alleviation. The discussion hereafter will focus on leasehold forestry for the poor, a new concept for the management of failed plantation areas, degraded hills, swidden farms, shrubland, overgrazed and overexploited natural regeneration forest. All these lands are unmanaged, environmentally sensitive and threatened. Their plight is rapidly worsening each year resulting in severe erosion and landslides. On the other hand, 45% of the population is compelled to live below the poverty line in Nepal. This percentage is even higher in hills and mountains.

The Hills Leasehold Forestry and Forage Development Project which started in 1993, now covers nine contiguous districts of Nepal's Central and Western Development Regions. Four districts (Kavre, Makwanpur, Sindhupalchok, and Ramechhap) were covered in the three-year exploratory phase, and two districts (Dhading and Dolakha) were added during the interim year. A further three districts (Sindhuli, Chitwan, and Tanahu) jointed the project in the first year of the development phase, in July 1996. The Government of the Netherlands, through Food and Agriculture Organisation of the United Nations, has granted technical assistance to the project for the methodological development. The implementation is funded through a loan from the International Fund for Agricultural Development (IFAD).

Four line-agencies are working together in the project: the Department of Forest (DOF), the Department of Livestock Services (DLS), the Agricultural Development Bank of Nepal (ADBN), and the Nepal Agricultural Research Council (NARC). DOF acts as the project's co-ordinating agency. A number of NGOs and the Agricultural Project Service Centre (APROSC) have also been involved at village and field level.

DOF is responsible for identifying blocks of degraded forestlands suitable for leasing. Furthermore, it facilitates the leasing process which includes identifying the customary users of each site, obtaining the community agreement, surveying and demarcating sites, providing legal notification, assisting in preparation of five-year operational plans for the sites, forwarding lease applications to the Ministry of Forest and Soil Conservation (MFSC) for final approval, and handing over the land after lease certificates are prepared. DOF, through the District Forest Office (DFO), provides training on nursery establishment, land development and installation of improved cooking stoves. DOF also provides leasehold groups with seed, seedlings and materials to establish nurseries. DLS is responsible for advising groups on forage development in their management plans; improving on-farm forage development, animal health, and animal production; providing seeds and technical support for forage development; and related training. ADBN, through its Small Farmers Development Programme (SFDP), is responsible for group formation, initiating group savings, providing credit and training related to group management, and income generation. NARC is responsible for an applied research programme on forage development and for providing inputs such as grass and legume seeds, inoculants, and planting material.

The project aims to improve the living conditions and raise the incomes of families living below the poverty line. It also endeavours to improve the ecological conditions in the mountains. The target beneficiaries of the project are the people with less than 0.5 ha of private arable land and an annual per capita income of less than Rs. 2,500 (about US$ 44). However, the project focuses on those with less than 0.1 ha of land and the landless or near landless. Most families are comprised of ethnic and tribal groups, such as Tamang, Majhi, Magar, Danuwar and Praja. The project focuses on degraded lands like unsuccessful plantations, overgrazed and naked forestlands, bush or shrubland, encroached or shifting cultivation areas and small patches of wastelands distributed throughout the communities. The soils of most leasehold sites are acidic and low in organic matter. Most of these lands fall between 400 m to 2000 m elevation.

Total target of the project is to form 2,038 groups covering 14,566 families and to lease them 13,025 ha forestland by the end of 2000. Till July 1997, 599 groups were formed including 4,114 poor families and 2,844 ha forestland was leased to them in four-year period. Forestland is leased to the groups of poor people (7 families on an average). The project assigns forestland equivalent to 1 ha per family but only in groups. For example, if there are seven families in a group then a maximum of 7 ha forestland is leased to them. The assumption is that a family can comfortably manage 1 ha of forestland to generate ample source of income for their livelihood.

In the five-year period, the project has learned a number of interesting lessons. This paper deals with some of the conceptual models and their practical applications for the rehabilitation of degraded forestlands and poverty alleviation.

2. Conceptual models and their applications

Degraded land improvement through poor families is a challenging task. A number of models were tested during the first three-year exploratory phase of the project. Some of these models have been adopted from the programmes of project line-agencies and modified according to the biophysical condition and aspiration of poor families. The successful models have been replicated in the development phase of the project.

Model 1. Leasing forestlands to the groups of poor families

In 1993 when the project started, there were forest laws but no developed methodology on how to lease forestland. The project successfully outlined stepwise strategies and methodologies for leasing forestlands to groups of poor families. It encompasses an assessment of degraded forestlands and their customary users;

social mobilisation; extension on the concept of leasehold forestry; conflict management if it arises; social agreement to assign forestland for the exclusive use of the poor families; identification of poor families; group formation of poor people; group registration, demarcation of forestland; operational plan preparation by the leasehold group with technical assistance from forestry, livestock, and SFDP field staff; official approval process of the lease, and ultimately handing over the forestlands to the leasehold groups. Some of these steps can be done concomitantly. To apply this model, the field staff (forestry, livestock, group organiser) should have skills and knowledge on social mobilisation, group organisation, planning processes, bureaucratic process and forestry laws. Following this teamwork technical assistance and social preparation, the forestlands were easily leased to poor families.

Model 2. Natural regeneration promotion through protection of the degraded lease sites from grazing and fire

For the rehabilitation of the leased degraded forestlands, the project beneficiaries have made substantial achievements in grazing control. The crucial point is that when people have secure ownership right, they can afford to take long-term view, and to protect, conserve and enhance resources (Chambers *et al.*, 1991). In Nepal the average livestock holding is 4.06 and in the leasehold areas it is 8 (Raut, 1997). Domestic animals freely graze in the forest and common lands. It is a challenging task to apply grazing control in the leaseland, but the project has successfully introduced grazing control in leasehold forestry. Over five years, not a single forest fire in any lease site of the 599 groups has been reported. Actually, it is a social process to bring changes in the behaviour of local people from open grazing to cut-and-carry system. The process is, at first, to get social agreement in the community to assign some forestland to the groups of poor families for their exclusive use with no interference from the rest of the community. In the second stage, strict protection measures are adopted by the leasehold members in the leaseland such as rotational guarding, live fencing and so on. In the initial stage, they face a lot of grazing pressure in the leaseland, which is not unusual. Gradually the people get accustomed to it, and grazing pressure slows down from the second year onward. In some cases, penalties and fines are imposed when repeated and intentional grazing occurs. A study among 599 groups has indicated that 429 (71%) of these groups have no grazing conflict at all. Of the groups with grazing conflict (170), about 43% of those groups have mild grazing conflict, which is very common in the first and second year. Only 12 groups have serious conflicts (Singh and Sterk, 1998).

Application of grazing control in the degraded leaselands allows seed germination and revival of root-suckers. It was learnt that protection of degraded lands from grazing and fire allows excellent natural regeneration. Positive impact was observed in all the lease sites from tropical to alpine, plain to hills and high mountains. Suttie (1997) has recommended that simple protection from grazing with or without tree planting should be done as a means of encouraging natural regeneration of vegetative cover.

Model 3. Management of shifting cultivation area in hills

Some of the shifting cultivation areas such as Korak, Kabilas and Darechok VDCs of Chitwan district have been brought under leasehold forestry. The forest areas, previously cultivated by the local people in a rotation of 4–10 years, now have been handed over as leasehold forests for 40 years. Actually, these forests were cultivated by an ethnic group (Praja) for long period without any land-title. Now they have lease certificates for 40 years. Under leasehold forestry, the sloping forestlands have been stabilised by sowing and planting perennial grasses and multipurpose tree species along contours, which give short-term, medium-term and long-term benefits. Shifting cultivation, which is a socio-economic, and environmental problem has not been addressed by any other programme. The project is trying to address social, economic and environmental problems of shifting cultivation in remote hilly areas.

The strategy is to stabilise steep hills with minimum tillage and grow perennial forage and multipurpose tree species that can provide a good source of income to the poor people. Stylo (*Stylosanthes* sp.) and molasses (*Milinis minutiflora*) are aggressive perennial grasses that grow very fast in degraded lands and cover the land within a year or two. Napier grass (*Pennisetum purpureum*) has also been widely planted on leaselands as well as on private lands. As per the demand of the local people, fruits like pineapple and banana are also grown to give income in short period. Broom grass (*Thysanolaena maxima*) is intensively propagated to get short-term benefits and fodder. In addition, multipurpose tree species such as lapsi (*Choerospondias axillaris*), chiuri (*Bassia butyracea*), and other suitable species have been planted along contours. Protection of leaseland from grazing and fire hazards allows the natural regeneration of local species. All these crops have not only stabilised the slopes but also provided a good source of income to the poor families from the second year onward. The land title for 40 years takes away the insecurity and an environment of trust was established between forestry staff and shifting cultivators who were previously antagonistic to each other. More than 100 ha forest land which was previously cultivated under shifting cultivation is now managed under the leasehold forestry programme in Chitwan district. In the hills, a lot of forest areas have been cultivated under shifting cultivation since long time. Thus, the project has developed a technically feasible, socio-culturally acceptable, economically viable and legally suitable model to address shifting cultivation in other areas as well.

Model 4. Encroachment control in forestlands and common lands

Small patches of common lands and forestlands are widely distributed in the hills of Nepal. These forest patches are gradually converted into agriculture land by the people whose lands are adjacent to them. This process of encroachment, albeit slow, is done in the rainy season when forestry staffs are unable to visit the area. Under the leasehold forestry programme, such small patches of common and forestlands are identified by the villagers and gradually leased to the groups of poor families by completing all the official procedures. The leasehold forestry programme has protected such lands – with official records and in social agreement – from being encroached. Progressive development of such lands into productive areas to fulfil the forestry and forage needs of local people is indeed a great achievement. Thulosirubari VDC of Sindhupalchok district is a good example where 43 leasehold groups have been formed covering about 120 ha of idle lands.

Model 5. Renovation of failed plantations

Till a decade ago, most of the plantations were done by donor-supported projects or government agency with or without barbed-wire fencing. In fact, there was a lot of investment in the plantation for fencing, pitting, planting, cost of seedlings, weeding, and paid-watcher expense. When the project was terminated and/or watchers were withdrawn from the plantation area, many such plantations failed chiefly due to heavy grazing. Such failed plantation areas were identified as potential sites for leasehold forestry and handed over to groups of poor families. With the technical support from the project line-agencies these unsuccessful plantation sites were planted with perennial forage, multipurpose trees and fruit species by the leasehold groups.

The basic difference between previous plantation and recent plantation are:

- There is a community agreement in assigning government lands to the groups of poor people;

- Organised and well-functioning leasehold groups are responsible for developing and protecting leaselands and sharing all the benefits;
- There is social fencing rather barbed-wire fencing;
- Government investment is done in skill development and awareness raising of rural people than in plantation;
- All the labour contribution in the establishment of plantation is provided by the leasehold members;
- The motive is to produce multiple products including forage, fruit, fuelwood and timber rather than only timber;
- Process approach has been applied in the leaseland development enabling the poor families rather than one-shot plantation.

Leasehold forestry has successfully developed a model for renovation of unsuccessful plantation areas. Leasehold sites of Padam Pokhari, Hatia, Harnamadi VDCs of Makwanpur district and Baramche VDC of Sindhupalchok district are good examples of renovation of such failed plantation sites.

Model 6. A silvi-forage production system not a silvi-pasture system

Forage development in the forestland integrating the Departments of Forest and Livestock Services has resulted in amazing outputs. Previously, each department had independent programmes. This is the first endeavour in which forestry-forage development programme has been successfully combined. Leaseland and leasehold groups are providing common grounds for the integration of forage and multipurpose tree species. Easy availability of forage has supported livestock development and farming systems as a whole. Stylo and molasses are two promising species in degraded leaselands up to 1700 m altitude. Further, broom grass is also widely planted in leaselands for forage and broom production. Likewise, Napier grass is planted on private lands. Intentional promotion of these species supplies abundant forage which directly supports livestock development – a good source of income to the rural poor. It has considerably reduced the forage collection time for the women and has stabilised the degraded slopes. *Considering the environmentally sensitive sites, grazing is completely prohibited in the Silvi-Forage Production System which is different from Silvi-Pasture System.* However, for the replication of this concept on a nation-wide scale, a policy should be formulated for intensive promotion of forage production in leasehold forestry as well as in community forestry.

On the basis of preliminary findings, it is recommended to adopt line sowing with minimum tillage practices on steep slopes. Additionally, it was recommended to inoculate and lime-pellet the seeds of legume for good establishment. An inventory has shown that stylo and molasses are by far the most important species, which cover 49% and 23% of the area covered by grass. Five major tree species: sissoo (*Dalbergia sissoo*), badahar (*Artocarpus lakoocha*), ipil-ipil (*Leucaena* sp.), bakaino (*Melia azederach*), and lankuri (*Fraxinus floribunda*), made up 75% of all species planted in the leaselands (Tiwari, 1997).

Model 7. Integration of community forestry and leasehold forestry

Two separate divisions of the Department of Forest implement community forestry and leasehold forestry. At district level, the District Forest Officer is a single authority responsible for the operation of both the programmes. In the initial stage, leasehold forestry and community forestry programmes were implemented through separate forest rangers. The study regarding conflicts in leasehold groups found that fewest conflicts were observed in the leasehold groups where there are Forest User Groups (FUG) of community forestry compared to implementation of leasehold forestry in isolation (Singh, 1998). Two pilot studies were done in Kavre and Makwanpur districts. The preliminary findings show that joint implementation of community forestry and leasehold forest by the same ranger has resulted in: reduced manpower requirement; removal of confusion between community forestry and leasehold forestry at grassroots level, thus there is less chance of conflict; less government cost; and smooth execution of both the programmes.

However, the forest ranger should have a clear concept of both the programmes and he/she should be given clear-cut responsibility by the District Forest Office for both the activities (Box and Singh, 1998). Community forestry is an extensive programme for the whole community whereas leasehold forestry focuses on landless and marginal families to uplift their socio-economic conditions by giving them a source of livelihood. Thus, leasehold forestry is intended to complement community forestry (Sterk, 1998).

Model 8. Leasehold forestry and forage development: a complete package for livestock development

It seems that leasehold forestry and forage development is nearly a complete package for livestock development in rural areas. It includes:

- Institutional strengthening of leasehold groups to work together for livestock development;
- Skill development of farmers through training, visits, and experience sharing for forage production, conservation and management;
- Forestland for deliberate production of forage and fodder;
- Inputs such as forage seeds and planting materials from the project;
- Forage species, suitable to degraded forestland are selected through on-site research with lease members by NARC;
- Adequate supply of forage for livestock from leaseland and/or private land;
- Primary livestock services through trained Village Animal Health Worker supported by the JT/JTA and Livestock Office;
- Additional livestock services to the leasehold group families from the District Livestock Office;
- Credit from ADBL for the purchase and marketing of livestock and its products, transportation subsidy for the purchase of animals if brought from other districts.

This is one of the successful forage and livestock development packages of the Department of Livestock Services.

Model 9. Training model for the empowerment of poor families and rehabilitation of degraded forestland

In theory, development of degraded forestland through poor families looks awkward but in practice, it is functioning well. The process is as follows:

- The field staff of three line-agencies are jointly trained following which joint programmes are set out and implemented;
- All the trainings for farmers are designed jointly.
- Poor families are organised into leasehold groups.
- Group members including women are empowered through training, cross visits and workshops.
- A number of trainings are organised for example: land development, nursery, improved stoves, forage development and management, livestock management, bee-keeping, animal health worker training, medicinal plant management, record keeping, etc.

- Likewise, study visits are organised within and outside districts.
- Furthermore, experiences are shared in ilaka and district level workshops among lease members.
- Besides, the leaseholders have been provided with forage and tree seeds and planting materials.

All these theoretical and practical training provides a good exposure to the poor families. These trainings have made the poor farmers capable to develop the degraded forestlands for their own benefit. Starting from zero, the project has developed appropriate training modules, handbooks, and training materials (HLFFDP, 1997) for the poor families that empower them to get out of the vicious circle of poverty.

Model 10. Concentration of leasehold groups in one VDC/locality or distributed in many localities

From 1993 to 1997, 599 groups have been formed in 83 VDCs of nine districts. Minimum and maximum size varies from 1 to 43 groups in a VDC. Average group in one VDC is 7.21. Minimum and maximum number of VDCs covered in a district is 2 in Dolakha and 19 in Makwanpur. Where there are more than 10 groups in a VDC, it is easy for the line-agencies to provide services and inputs, and easily monitor the group activities compared to scattered groups in many VDCs. Once a few groups are formed in a VDC, their demonstration effect attracts other people. Consequently, more groups are formed in the same VDC/locality with minimum efforts. From the administrative, service delivery, monitoring and other support point of view, the line-agencies have focused to form, more groups in one VDC/locality rather than disperse the groups in many VDCs.

Model 11. Nigalo management model

In Riyale VDC of Kavre district, nigalo forest is found in natural condition above 1700 m in moist and shady areas. Previously the nigalo forest was openly grazed with livestock. Harvesting of nigalo was very common for home use. Thus, the condition of nigalo forest was degrading each year. Under the leasehold forestry programme, part of the nigalo forest has been handed over to groups of poor families on 40 years lease. Simply through protection from grazing and unmanaged cutting, the condition of nigalo forest has considerably improved within three years. Some silvicultural treatments (such as removal of dead, dying and diseased trees and unwanted shrubs) have been done. Now the lease group members have a good source of nigalo of required size and quality. They convert nigalo into various kinds of furniture, local umbrellas, baskets (*doko*), thatching material, and so on. They need further training to make marketable goods from nigalo and access to markets to sell the products so that they can earn income from the utilisation of this local resource.

Model 12. Forage seed-co-operative model

Makwanpur is a pioneer district for producing substantial amount of forage seeds, especially stylo on leaseland. Farmers have managed to produce more than 500 kg good quality stylo seed per year and gradually the amount of seed production is increasing. Stylo is a leguminous species that grows very fast; increases soil fertility; conserves soil moisture and helps in soil conservation. Farmers say that it is one of the most preferred species because feeding it to milking buffaloes increases milk production with high fat content and ultimately increases the income of farmers. On the initiative of forage seed producers, two forage seed co-operatives were officially registered in the District Co-operative Office namely: (a) Padampokhari Forage and Forage Seed Development Co-operative, and (b) Harnamadi Forage and Forage

Seed Development Co-operative. In the past, seed producers as well as purchasers faced a number of problems in selling forage seed to government offices. Seed sale of more than Rs 5,000 requires at least three quotations which farmers cannot produce. It was also difficult for the purchaser to roam around each farmer and find the required amount of seed. In addition, quality of seed was not guaranteed. Now these problems have been solved and it has become easy for farmers to sell forage seeds through their co-operative; and for purchaser to buy quality seeds from the co-operatives at fixed prices. Stylo seeds sold at Rs. 400/kg gives a good income to the producers (poor families). With the facilitation of leasehold forestry programme, farmers have not only produced considerable amounts of forage seed but also managed to sell their products through co-operatives.

Model 13. Environmental conservation by poor families

Poor families were previously blamed and given many nicknames like *forest-destroyer, wood-cutter, firewood-seller, forest encroacher, shifting cultivator* and so on. Some of the leasehold families do not hesitate to acknowledge that their previous occupation was woodcutter and firewood-seller. Now these families have been given degraded forestlands on lease for 40 years with technology, training and a minimum of inputs. They have changed their way of life from wood-seller to conservationist of forest and environment. They have rehabilitated degraded forestlands and converted them into productive forestlands that give them a good source of forage, income, fuelwood and timber. There is no fire hazard, no erosion, and no grazing in the degraded lands. They are now gradually converted into good forest through plantation and natural regeneration. This is a typical model of environmental conservation by the poor families. The process is: to organise the poor into small functional groups; orient them on group approaches; lease them forestland as per forest laws for 40 years with lease certificate; orient them on degraded forestland management; encourage them to practice zero grazing in the lease site: monthly group meeting – a mechanism to solve problems and take group decisions; and train them on forage and tree species plantation and management methodologies.

Model 14. A practical co-ordination mechanism

Leasehold forestry is an integrated project and four tiers of co-ordination mechanism have been functional. Under the chairmanship of the Secretary of the Ministry of Forests and Soil Conservation, a Project Co-ordination Committee (PCC) is formed. Other members of the PCC are the Director Generals (DGs) of DOF, and DLS, the General Manager of ADBN, the Executive Director of NARC, representatives of the Ministry of Finance, National Planning Commission, the Chief Technical Adviser and the Project Co-ordinator. This high level co-ordination body discusses and decides on policy matters of the project. The PCC meeting is held twice a year.

Each of the four line agencies has assigned one co-ordinator namely: forestry or project co-ordinator, livestock co-ordinator, credit co-ordinator and research co-ordinator. Under the chairmanship of the DG of the Department of Forest, four co-ordinators, representatives of the Ministry of Finance and the National Planning Commission, and the Chief Technical Adviser form the Project Co-ordinators Working Group (PCWG). This body takes all the operational decisions at departmental level and provides operational guidelines and directions to the district level agencies. The meeting of PCWG is held three or four times a year.

At district level, a body called District Co-ordination Committee (DCC) is formed. The District Forest Officer is the co-ordinator of the body. Other members are the ADBN Branch Manager, the Veterinary Officer, the Livestock Officer, the Local Development Officer, the Women Development Officer, the Assistant Chief District

Officer and one member of the District Development Committee responsible for the forestry sector. Two leasehold members (one male and one female) are also members of this committee. This monitors the leasehold forestry activities. In addition to the DCC, there is another body called District Co-ordination Working Group (DCWG) of three line-agencies: the DFO, the ADBN Branch Manager, the Livestock Officer and/or the Veterinary Officer. Meeting of this body is held every two months to discuss joint operation of leasehold activities at district and field level.

At field level, the forest ranger, the livestock JT/JTA and the SFDP group organiser meet every month. This meeting is held at five or six places in each district where there is a SFDP or livestock service centre or forestry range post or Ilaka office. This body discusses integrated field implementation of the leasehold forestry activities through farmers.

For all the co-ordination mechanism, norms and guidelines have been developed. Meeting minutes are kept for every meeting. The co-ordination mechanism is functional at every level. However, some problems have been observed at field level co-ordination where field offices are distributed at three different locations.

3. Discussion and conclusion

Leasehold forestry is a new programme for the three line agencies thus it requires at least 3-6 months to understand its conceptual models for newly transferred staff in the field. Frequent transfer of project staff has seriously hampered smooth implementation. Despite many problems, the above-mentioned models are operating. Some of the indicators of the leasehold forestry that will led to the sustainable management of forestland and environment are:

- Institutional arrangement: small functional group operating according to the plan prepared by themselves and approved by the government.
- Security of land and its product.
- Tangible and direct benefits.
- Successful social intervention (social agreement, grazing control).
- On-site tested technical packages for the degraded land development with the involvement of lease members.

The project has three major challenges. These are: (i) to deal with people living below the poverty line and raise their income, (ii) rehabilitate degraded forest lands through poor families, and (iii) to create a functional integration between line-agencies and deliver services and inputs on time to the poor families.

Applications of the aforementioned models vary depending upon the biophysical condition of the leasehold sites and socio-cultural situation of the leasehold groups. Bottom-up approach and process approach are the foundation stones of this concept. Furthermore, active and functional leasehold groups are the basis on which all the models are dependent for their successful implementation. Another key factor of leasehold forestry has been the change from common forestland to leaseland for the exclusive use for 40 years. Moreover, social agreement, economic benefits (income to individual family), environmental factors (improvement of degraded lands for own benefits), and integrated delivery of services (inputs, loan, leaseland certificate, training) to the poor families are the four driving forces which are acting together in the successful implementation of the models. In totality leasehold forestry for poor is an interesting concept that has brought a positive difference within a short period of time. The lessons learned are time-tested over five years and can be applied with some modifications in other areas as well.

References

Box, A. and Singh, B. K. 1998. The Pilots: Integration of Community Forestry and Leasehold Forestry in Makwanpur and Kavre Districts. *Project Working Paper 44*. Hills Leasehold Forestry and Forage Development Project, Kathmandu, Nepal.

Chambers, Robert, 1983. *Rural Development: Putting the Last First.* John Wiley and Sons, Inc. New York, USA.

Chambers, R., Saxena, N. C. and Shah, T. 1991. *To The Hands of the Poor: Water and Trees*. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi, India.

Forest Act, 1993. Ministry of Forest and Soil Conservation, Kathmandu, Nepal.

HLFFDP, 1997. Tenth Progress Report of the Technical Assistance, Hills Leasehold Forestry and Forage Development Project, Kathmandu, Nepal.

Jodha, N. S. 1998. Poverty-Environmental Resource Degradation Links: Questioning the Basic Premises. *Issues in Mountain Development 98/1.* ICIMOD, Kathmandu, Nepal.

Raut, Y. 1997. Livestock Development Situation and its Constraints in Nepal: An Experience of the Leasehold Forestry. Seminar Proceedings: Leasehold Forestry and Forage Development for the Poor, 24–28 August 1997, Kathmandu, Nepal.

Singh, B. K. 1997. Second Report of the Social Forester in the Leasehold Forestry and Forage Development Project, Kathmandu, Nepal.

Singh, B. K. and Sterk, A. 1998. Conflict Management in the Leasehold Forestry for Poor. *Project Working Paper 39.* Hills Leasehold Forestry and Forage Development Project, Kathmandu, Nepal.

Sterk, A. 1998. Leasing Degraded Forest Land: An Innovative Way to Integrate Forest and Livestock Development in Nepal. *RAPA Publication: 1998/4.* FAO, RAPA, Bangkok, Thailand.

Suttie, J. 1997. Report on a Technical Support Mission to the Forage Component. *Project Working Paper 46.* Hills Leasehold Forestry and Forage Development Project, Kathmandu, Nepal.

Tiwari, B. N. 1997. Land Development Model for the Rehabilitation of Degraded Lands. Seminar Proceedings - Leasehold Forestry and Forage Development for Poor. 24–28 August 1987, Kathmandu, Nepal.

Mathema, P., Dutta, I. C., Balla, M. K. and Adhikary, S. N. (eds.). 1999. *Sustainable Forest Management.* Proceedings of an International Seminar, 31 August – 2 September 1998, Pokhara, Nepal.

A Holistic Strategy for Sustainable Management of Forest Resources

J. Singh

Abstract: India's National Forest Policy 1988 envisages sustainable management of forest resources through a holistic and professional strategy of forest management for achieving the objectives enunciated therein. The traditional forest management approach (Working Plan) provides silvicultural treatment on sustained yield basis which is far inadequate considering the present scenario of resource conditions and policy objectives. The proposed strategy envisions a holistic treatment of an ecosystem on watershed basis. It proposes an integral and site-specific treatment of forest resources and incorporates overall planning for Macro Unit – the entire landscape of a district as well as site-specific planning for a Micro Unit. It provides a systematic approach to extend the forest cover to non-forest areas and stresses involvement of field managers in the planning process. It proposes to provide natural management to the forest tracts in their natural settings and stresses integration of different streams and approaches in forest management through a Uniform Management Plan Code.

1. Inroduction

The history of scientific management of Indian forests is more than a century old. The strategy of management has been evolved in the form of Working Plans based on scientific and silvicultural principles. Most of the recorded forests of India are managed as per the prescriptions of Working Plans or Working Schemes. Over the years, comprehensive guidelines have been evolved in the form of Working Plan Code for writing up a Working Plan for a given tract of forest. The procedure and methodology for writing up a Working Plan is more or less same throughout the country. In the past, Working Plans were used to be written for a period of 30 years which was subsequently reduced to 20 years. At present, they are written for a period of 10 years.

Working Plan is considered "sacrosanct" for the scientific management of forests throughout the country. After independence, a new forest policy was framed in 1952 for managing the forest resources. Over the years, due to tremendous increase in human and cattle population, pressure on adjoining forest areas increased manifold. Moreover, deteriorating law and order situation, decadence of ethical norms of the society as well as increased awareness of people about their rights and privileges have created conditions inconducive for traditional forest management.

The National Forest Policy 1988 (MOEF, 1988) has categorically realised the disturbing trends and conditions prevailing in the forestry sector. The policy has not only re-prioritised the objectives of forest management but also has emphasised sustainable management by involving local communities in order to minimise conflicts and maximise harmonious relations. The strategy enunciated by the policy is innovative and requires new perceptions, approaches and methodologies to translate the objectives into reality. The protection and conservation of natural heritage and biodiversity through people's participation needs new ways and means. Moreover, it is becoming more and more difficult to manage forests in the traditional way. Considering the prevailing conditions in forestry sector, changed perceptions of the society, advance developments in the field of science and technology, needs and aspirations of people and above all the policy objectives, an innovative and holistic strategy of management of forest resources is the need of the time.

2. Traditional management approach

Traditionally, forests of the nation are managed through scientifically prepared Working Plans. The concept of sustained yield and silvicultural requirements of prominent species of a forest tract are the prime considerations. A Working Plan is written in accordance with the guidelines prescribed in the Working Plan Code. As per standard format, it is written in two parts. Part I deals with collection of requisite data, entitled, "Summary of facts on which proposals are based" while Part II, deals with "Future Management discussed and prescribed".

Information on the land use pattern and past treatment, required in Part I is collected through trained staff. Presently, a forest division is treated as a unit for writing up a Working Plan. In the past, a district or a compact forest ecosystem used to be the unit for writing up Working Plan. It normally takes 2½ to 3 years to complete a Working Plan. In order to prepare a Working Plan the entire forest tract is divided into more or less homogenous units on the basis of nature and composition of the crop and silvicultural requirements of the prominent species. The objectives of management and mode of regeneration are also given due consideration. These units of management, primarily, delineated for specific silvicultural treatments are termed Working Circles (WC).

For the purpose of execution and uniform distribution of operations, Working Circles are further divided into Felling Series (FS) and Annual Coupes. The area of an annual coupe is, normally, equivalent to the size of a compartment, which is the smaller unit for silvicultural treatment, having distinct boundaries, and more or less homogenous crop. The entire tract is organised into WCs, FSs and Annual Coupes. The compartments are arranged, in sequence, in Felling Series for treatment under respective Working Circles and a statement for year-wise schedule of work is prepared for each Working Circle.

3. Inadequacies in the traditional management approach

There is no doubt that the Working Plan Approach of managing forests is based on sound silvicultural principles and has stood the test of time for over a century. Over the years, however, it has not kept pace with the changing perceptions and conditions in the forestry sector to the extent desired. As a result, relevance of Working Plans is being questioned by an increasing number of forest managers. The prominent inadequacies which have seriously affected the relevance and effectiveness of the approach may be summed up as follows.

3.1. A conditioned rather than an open approach

The prime aim of National Forest Policy is to increase the forest cover to at least one-third of India's land area. The management approach remains confined to the traditional forest areas, giving little consideration for non-forest tracts. Some non-forest tracts were treated under social forestry and community development programmes but serious thought for extension of management planning to areas other than traditional forests was not given. As a result, instead of increase of forest cover, a serious degradation and depletion occurred.

To achieve the goal enshrined in the policy, a serious review of management strategy is required. The unit for management planning of forest resources needs reconsideration in the light of policy objectives. For holistic management and development of resources, entire landscape of a district may be taken as a unit of management planning for forest resources.

3.2. Forest-type specific approach

The present approach can best be termed as species-specific approach than an ecosystem approach of management. The approach provides treatment in accordance with the silvicultural requirements of a few principal species in the growing stock. The requirement of an ecosystem as a whole is not given due consideration in the management strategy. Moreover, large chunks of forest areas are treated under one silviculture treatment, ignoring the variations in crop composition and site quality.

3.3. A methodological than a process approach

The traditional approach of managing the forests is systematic as well as methodological. It provides detailed planning from alpha to omega. It doesn't seek the involvement of field managers while planning. Moreover, there is very little scope of incorporating changes during the progress of the plan. It does not seek the application of mind of the field managers but seeks rigorous follow up of the prescriptions. It is contrary to the process approach which assumes that management and development are ever-changing and ever-evolving processes. The change should be incorporated in the management process as and when the need arises. Any approach based on rigid prescriptions becomes irrelevant the very next moment. Therefore, management strategy should have inherent capability to evolve with time and situation.

3.4. No significant role for watershed management

The traditional strategy primarily, orients around the silvicultural requirements of the principal species of a given forest type. The management units, such as, Working Circles and Felling Series are purely artificial. It is not based on watershed boundaries.

Water is the life of all life forms on earth. Therefore, without *in situ* conservation of water integral development is not possible. Moreover, holistic treatment of an area is not possible without incorporating watershed management approach in the strategy. Thus, there is a need to review the approach and strategy so as to modify it in accordance with the watershed of the terrain.

3.5. People not involved

Forests have traditionally been managed for the welfare of the society. However, the involvement of people in forest management has been emphasised only recently (in National Forest Policy 1988). For involving the people in forest management a different approach, attitude and institutional arrangement is required. Some enthusiastic efforts have been taken in this direction, yet the Forest Department is not fully oriented and geared for the job at hand. The micro-planning approach evolved under Joint Forest Management needs incorporation and integration with overall management planning of the entire landscape.

3.6. Inadequate emphasis on biodiversity

It is ironical that wildlife protection and management is considered different from forest management. Separate management plans are written for Protected Areas for conservation and protection of wildlife and biodiversity. Wildlife management and conservation of biodiversity are the integral part of forest management. Wildlife cannot be segregated by artificial boundaries and plans. An appropriate strategy should give due consideration to protection, conservation and management of wildlife as well as conservation of biodiversity. Separate plans for Protected Areas mean fragmenting ecosystems with different management strategies which is contrary to sound management principles. In the traditional strategy due emphasis is not given to this aspect. Detailed prescriptions need to be incorporated in management plans instead of writing separate plans for such areas.

3.7. Inadequate emphasis on forest protection

Keeping in view the deteriorating conditions of the forest resources, protection aspect needs prime consideration. Due emphasis to protection is not given in the traditional management strategy. Effective measures against fire, grazing, encroachment and other deleterious factors need to be incorporated in the management plans. Institutional arrangements and mechanisms for involving people for forest protection and annual plans for grazing regulations, fire management as well as provision of disposal of offence cases need to be incorporated. Strengthening of protection machinery and infrastructure facilities also need emphasis.

3.8. Sustained yield concept shortfalls of sustainable management

The traditional management revolves around sustained yield concept. It gives little consideration to sustainable management of resources as well as conservation and management of biodiversity. The concept of sustained yield needs evolution to transform itself as sustainable management of a given forest area. The enumerable Non-Timber Forest Products (NTFP) may be meaningfully harvested to provide gainful employment to the local populace as well as to meet their bonafide demands and to realise fully the potential of a given forest area.

Besides the inadequacies explained above, managerial considerations were given a lower importance than silvicultural considerations. The principles, concepts and techniques of management have undergone tremendous evolution over the years. Forest management also requires the incorporation of advanced concepts and techniques for evolving a strategy appropriate to the resource conditions and the need of the time.

4. Objectives of National Forest Policy

The philosophy of Management by Objectives (MBO) is said to be the most widely accepted philosophy of management today. The essential features of MBO are:

- set objectives carefully
- review them periodically
- pursue them relentlessly.

The policy of the nation expresses the wishes of the people in the form of objectives of management. The objectives of management of forest resources of the country have been clearly spelt out in the National Forest Policy, 1988. The principal aim of forest policy must be to ensure environmental stability and maintenance of ecological balance which are vital for sustenance of all life forms. The derivation of direct economic benefit must be subordinated to this principal aim.

The policy is holistic in nature and realistic in approach. It envisages integral and professional management of forest resources of the entire country. It has also outlined the strategy to be followed for achieving the objectives. It has categorically recognised the involvement of local people in forest management, their rights and concessions as well as creation of symbiotic relations.

In order to achieve the objectives in a wholesome manner a dynamic, holistic and innovative management strategy is required. The present strategy needs to be radically transformed to suit the present requirements. The new concepts, innovative approaches and policy emphasis need to be suitably incorporated in the strategy to make it self-evolving and sustainable. Sustainable management is possible only through a strategy which may sustain itself in the long run.

5. The proposed strategy of forest management

5.1. Basic assumptions

The proposed strategy of forest management is based on the philosophy of MBO. The proposed strategy is primarily based on the following assumptions:

- The unit of forest management planning should, preferably, be co-terminus with the basic unit of overall planning and development.
- Integral and holistic management of forest resources on lines of ecosystem and watershed management is possible, only if, the watershed of a landscape forms the basic framework of the strategy.
- Site-specific and professional treatment of the Micro Unit is more relevant than the type-specific silvicultural treatment.
- Planning process cannot be completely divorced from execution. The strategy envisions overall planning of entire Macro Unit along-with site-specific planning of Micro Units at the time of treatment.
- Natural management of forest resources is an appropriate strategy for sustainable management than the sustained yield approach, as natural management sustains in the long run.
- National Forest Policy envisages an integral strategy of management for forest resources by incorporating different streams and approaches, such as Protected Areas Management, Biodiversity Conservation and Management, Joint Forest Management, Eco-development, etc.
- Management is an ever-evolving dynamic process.

5.2. Essentials of an appropriate (sustainable) strategy

The need of an appropriate strategy is imperative for achieving the given objectives and for managing the resources in a sustainable manner. The strategy should have the following essential features in order to qualify as an appropriate one.

- Match the organisational potential, capabilities, working environment and resource conditions.
- Based on the latest concepts, philosophies and approaches as well as capable of incorporating the latest innovations in the field of science, technology and management.

- Sensitive to the changing perceptions and environmental variations, and responsive to the genuine needs and hopes of the people.
- Dynamic in nature and intrinsically capable to evolve holistically with time and situation.

The proposed strategy is an earnest effort to evolve an appropriate strategy for sustainable management of forest resources. Moreover, to ensure continuity of management of forest resources the present strategy needs to be modified and transformed suitably to assume the form and nature of an appropriate strategy.

5.3. The salient features of proposed strategy

In order to achieve the policy objectives in a planned and systematic manner and for sustainable management of forest resources, a strategy has been outlined below. The strategy comprises following salient components:

Nomenclature

Keeping in view the emphasis of the National Policy on sustainable forest management and latest trends in the field of forestry there is a need to evolve an appropriate nomenclature for the strategy. The expression of "Management Plan" seems more agreeable than the "Working Plan" which is still in vogue. Moreover, the entire landscape of a district is proposed as Macro Unit for management planning. Considering the nature and scope of the strategy and the prevailing trends in the field of management planning the following expression is proposed as nomenclature of the strategy: "Forest Resources Management Plan of .... District"

Macro Unit—entire landscape of a district

The entire geographical area of the country has been delineated into semi-permanent and stable units of manageable size (districts) for the purpose of administration and planning. In order to streamline the management planning strategy of forest resources, the entire landscape of a district is proposed as Macro Unit of management planning. It will integrate the management planning of forestry sector with management planning of other sectors. It will bring the entire geographical area of a district within the scope of a Management Plan. It will also provide a systematic strategy to extend the forest cover to non-forest areas which is a cherished goal of National Forestry Policy.

Division of Macro Unit (landscape) into Ecosystems

The division of entire landscape into broad Ecosystems, having more or less defined boundaries is envisioned on the basis of: locality factors; composition and condition of the growing stock; and broad objectives of management. The proposed sub-divisions are: Forest Areas and Non-forest Areas

Superimposing Ecosystems on the landscape

Each Ecosystem is further proposed to be divided into Medium Watersheds for the purpose of convenience of management of resources holistically. It will provide advantage of convenience of working in a synergetic manner in the entire watershed. It will also provide naturally delineated units for management.

Division of Watersheds into Management Series

Each Medium Watershed is proposed to be further divided and arranged into number of Management Series of appropriate sizes for the purpose of distribution of management operations to the entire watershed.

Division of Management Series into Micro Units

Each Management Series is further divided and organised into Micro Units of suitable sizes. These Micro Units will serve as Annual Management Units (AMU). Considering, natural delineation and homogeneity of the crop, each compartment may be taken as a Micro Unit for forest management. The areas not delineated into compartments may be divided into Micro Units of manageable sizes in order to uniformly distribute operations of management over the entire area.

Proposed treatment

Amongst all the systems of silvicultural treatment, the Selection System is more akin to nature and may be termed as Natural System of Silvicultural Management. It is, therefore, proposed that the well-stocked forest areas should be managed in accordance with the requirements of the Selection System or its modified versions. The compartments in each Watershed are proposed to be organised into Management Series, preferably, comprising 20 Micro Units or in accordance with felling cycle, regeneration period and intensity of management.

The forest tracts as well as the areas devoid of forest cover are proposed to be rehabilitated on the basis of Recreation of Ecosystem (Singh, 1994) and Eco-development approach. Presuming such tracts will not be of extensive nature. Management Series is proposed to comprise Micro Units, conforming to the intensity of management.

The strategy envisages overall planning and broad guidelines for Macro Unit as well as for Micro Units. At macro level, it envisions overall planning and distribution of operations for the entire tract for a given period on the basis of ecosystem and watershed management approach. It provides broad guidelines and prescriptions for the fulfilment of general objectives enshrined in the policy. It will provide holistic and integral treatment for the entire tract. At micro level, it envisages site-specific professional planning on the basis of complete and holistic assessment of resources and locality factors of a particular site. The micro plans will be prepared by the field managers at the time of treatment, in accordance with the broad guidelines outlined in the overall planning.

The strategy incorporates differential management on the basis of Ecosystems (basic unit of Eco-management) and holistic treatment on the basis of watershed (natural unit of resource management). It also incorporates holistic management of Micro Units i.e. compartments. The strategy also seeks to integrate Protected Areas Management, Joint Forest Management and Eco-development being practised in traditional forest areas as well as Eco-development and site-specific treatment given to non-forest areas.

The approach of two-phase planning, at macro as well as the micro level, ensures the active involvement of field managers in the planning process. It also makes the planning strategy flexible and self-evolving. Moreover, it ensures the uniformity of treatment of entire landscape as well as professional and site-specific treatment of Micro Units, in consonance with, ecological requirements of the tract. The strategy envisions the development of each Micro Unit to its potential as well as conversion of its vegetal cover into normal form.

6. Revision of Working Plan Code

The proposed strategy of sustainable management necessitates drastic revision of Working Plan Code. In fact, it envisages a Uniform Management Plan Code for management of forest resources of the entire country. It is proposed that central government through Ministry of Environment and Forest may take initiative through legislative and administrative intervention for preparation of a "Uniform Management Plan Code".

Besides, additions and changes proposed in the Working Plan Code, various forms required to collect information such as compartment history form, enumeration form, control form, etc., need reformatting or revision. Moreover, there is a need to devise some new forms for collecting information on socio-economic conditions, wildlife protection; biodiversity conservation; extent of non-forest areas; existing management practices and institutional arrangements.

Keeping in view the extent of the landscape and the quantum of information to be collected, it is suggested that management plan shall be written in two volumes: Volume I - Prescriptions for the Management of Entire Landscape (Part I & Part II) Volume II - Appendices, Forms, Tables and Maps.

7. Relevance of the proposed strategy

The relevance of the proposed strategy may be ascertained by examining its nature, composition and suitability to the field conditions. The following aspects may help in ascertaining its relevance:

- It conforms to the objectives of the National Forest Policy.
- It proposes an integral approach of management of entire landscape and conforms to the strategy outlined in the policy document.
- It seeks involvement of people in forest management through JFM and Eco-development as well as aims at creating conducive conditions for sustainable management.
- It envisages increase in forest cover by extending the scope of strategy to non-forest areas.
- It is flexible and open-ended. It envisions overall planning of entire landscape as well as site-specific planning at the time of implementation by the field managers.

8. Conclusions

The proposed strategy of management planning is not only a holistic and professional approach but also an attempt to provide a lasting strategy for sustainable management of forest resources. It proposes re-organisation and re-arrangement of Micro Units into Management Series on watershed basis. The Management Series are proposed to be further re-organised into Ecosystems which in turn, forms the entire landscape of a Macro Unit. Once, these basic units are organised and aligned in the proposed pattern, it will provide a natural framework for sustainable management. Moreover, it is the natural management which sustains in the long run. The proposed strategy provides the structure and approach akin to natural management.

The proposed strategy necessitates drastic revision and modification in the present strategy. The innovative approach, visionary goal and objectives enunciated in the policy call for an innovative and dynamic strategy for sustainable forest management. The proposed approach may be considered as a step in this direction. The proposed strategy is also an effort to look into nature more closely and to find a suitable way to live with nature in harmony.

References

MOEF. 1988. *National Forest Policy 1988.* Resolution No. 3-1/86-FP, Ministry of Environment and Forest, New Delhi, India.

Singh, J. 1994. Biodiversity Afforestation Model–Approach. *The Indian Forester* 120: 860–867.

Mathema, P., Dutta, I. C., Balla, M. K. and Adhikary, S. N. (eds.). 1999. *Sustainable Forest Management.* Proceedings of an International Seminar, 31 August – 2 September 1998, Pokhara, Nepal.

Community Forest Management Aspects in the Terai Region of Nepal

G. Skarner

Abstract: Community forestry (CF) has been a successful programme in the hill districts of Nepal. Its success remains to be seen in the lowland Terai areas of southern Nepal where the conditions are different from the hills. There is about 90,000 ha of potential CF area in the twenty Terai districts. About 48,000 ha has already been handed over to Forest User Groups (FUGs) but active forest management is lagging behind as the FUGs are very conservative in their forest utilisation. Community forestry is needed in the Terai, and the FUGs should be given training and guidance to be able to manage the valuable forest resources growing in the area as the Terai villages have a weak tradition in forest management. Firstly there is a need to further adjust the CF concept to suit the Terai conditions. Criteria have to be developed and guidelines given. Here the already established projects in the Terai have an important role to play, and there is an urgent need of further investment in the CF concept in the area.

1. Community forestry in Nepal

Community forestry (CF) is the established model for participatory forestry in Nepal. The CF concept became developed during the 1970s, and legislation to promote CF was made in 1978. From the beginning the concept was developed primarily for the prevailing conditions in the hills and less concerned with the forests of the Terai. The current legal provisions of CF are spelt out in the Forest Act 2049 (1993) and in the Forest Regulations 2051 (1995). The Forest Act states that "the District Forest Officer (DFO) may hand over any part of a national forest to a forest user group (FUG) in the form of a CF". The Forest Regulations add that "the DFO shall have to take into account the distance between the forest and the village and the wishes as well as the management capacity of the local users who have to manage the forest, while handing over any part of a national forest to a FUG as a CF". The forest law identifies two main groups of forests, national and private. The national forests are classified into five sub-groups of forests of which CF is one. In the law CF has been given priority over leasehold forestry.

The special feature of the CF programme is the formation of FUGs. A FUG is defined as a group of people given rights by the DOF to manage, use and protect an area of land for growing trees. Subsequently a certificate signed by the DFO confirms these rights. The government has a policy to hand over all accessible forests to FUGs. The FUGs will get all the benefits from the products and income from the allocated forest. The Nepali concept of CF is described in some basic CPFD documents as CF Manual (Shrestha *et al.*, 1995), CF Operational Guidelines (CPFD, 1995) and a booklet on the CF programme (CPFD, 1997).

The number of FUGs established in Nepal as of June 1998 is 6,306 (CPFD, 1998), of which 283 (4.5%) were established in the four Inner Terai districts and 279 (4.4%) FUGs in the 20 Terai districts of which 159 in the Environment and Forest Enterprise Activity (EFEA) project covered Dang District. The remaining 5,744 (91%) were established in the 51 hill districts, of which 1,191 in the Nepal-UK Community Forestry Project (NUKCFP) area and 463 in the Nepal-Australia Community Resource Management Project (NACRMP) (previously Nepal-Australia Community Forestry Project, NACFP) area and 147 in the Nepal-Swiss Community Forestry Project (NSCFP). This shows the importance of the work done by the bilateral projects and the success of the programme in the hills. However, the area of each FUG is bigger in the Terai than in the hills.

2. Forests and forest management in the Terai

2.1. Forest area

The size of the forest area in the Terai has recently been studied by the Forest Survey Division of Forest Research and Survey Centre (FORESC), in co-operation with the Finnida supported Forest Resource Information System Project (FRISP). The total forest area in the 20 Terai districts was given as 1,405,600 ha (FORESC, 1993). Of this 238,300 ha (17%) has already been protected as wildlife reserves and national parks. Of the remaining unprotected forest area 545,900 ha (47%) are in the plains and the remaining 621,400 ha in hilly areas. All 20 Terai districts are bordering India. The four Inner Terai districts Surkhet, Makwanpur, Sindhuli and Udayapur have altogether 363,000 ha forest. The Inner Terai area consists of a wide valleys between the Churia Hills (Siwaliks) and Mahabharat Mountains.

2.2. Operational forest management plans

Operational forest management plans (OFMPs) for the Terai forests were prepared for an active forest management. So far 18 OFMPs have been prepared of which 14 have been approved. Fifteen of the plans have been made in Terai districts and only one in a hill district (Ilam). When only 15 Terai districts with OFMPs are counted, the forest area outside wildlife reserves and national parks is 0.85 million ha, which should be compared to 0.91 million ha found in the forest inventory 1990/91 for the same districts, a reduction of 6% during a period of about five years. The potential and handed over CF area in the 15 districts is 73,000 ha (9% of the forests in the districts) and 71,000 (27%) in the Inner Terai. With the same proportions in the remaining five Terai districts about 90,000 ha would be potential and handed over CF area in the 20 Terai districts in Nepal and about 390,000 ha production forest in government managed forests. Forest area already handed over to FUGs in the Terai is 47,700 ha, which is about half of the potential CF area.

None of the plans has so far been implemented. The following five major drawbacks for the implementation of the OFMPs in Nepal has been given (Skarner, 1995):

- diffused land use policy;
- the field organisation for both implementation and follow-up is not appropriate for DFO to carry out operational activities;
- financial constraints to carry out operations;
- the wood market is neither developed nor explored
- existing regulations that disturb rather than enhance the market progress;
- people's participation rights and responsibilities are unclear.

This shows that the development process to make the Terai forests productive needs time.

2.3. Deforestation

The forest area in the Terai is decreasing both in size and stocking, and the remaining forests are being destocked day by day. Deforestation in the Terai plains has been 1.3% per year or 8,300 ha annually during the 12 year period from 1978/79 to 1990/91 (FORESC, 1993). The areas are shrinking in favour of additional agriculture land, often through encroaching, but also for other national priority interests as roads, power and industrial use. Deforestation in the whole country has been estimated at 1.75% (Skarner *et al.*, 1998), which means that the deforestation is much more severe in the hills than in the Terai.

In addition to the alarming area deforestation in the Terai, Forest Management and Utilisation Development Project (FMUDP) alerted about the heavy on-going destruction in the remaining forests during its preparation of the OFMP in Rautahat District. The World Bank funded Terai Community Forestry Project (TCFP) carried out a forest inventory in 1989 in Rautahat (Bennett, 1989). Their result was compared with the figures from the new forest inventory made for the preparation of the OFMP. The destocking of the forests was shockingly high and more alarming than the area related deforestation. During the period 1989–1994 the average forest stocking in Rautahat District had decreased from 209 m^3/ha to 152 m^3/ha, which means a 25% destocking in 5 years or annually 11.5 m^3/ha. There is a problem of accuracy in this comparison, as the inventories were not carried out in exactly the same way. Nevertheless, the figures are very alarming. The best trees are cut leaving the genetically inferior trees which in the long run may have a negative influence on availability of quality trees. Political pressure is also used to cut trees in non-priority areas from the proper forest management point of view. Destocking in the upper slopes of the hills has further been alerted by NACFP (Tamrakar *et al.*, 1997).

2.4. Forest management practices

Forest management practices in Nepal have changed from exploitative, when major forest products were sold to India, to the protective form of management introduced in 1987. From then on, export of forest products was highly restricted and a ban on felling green trees was imposed. The ban unintentionally hampered the development of good forest management practices, and the exploitation and protection policies have resulted in a lack of experience in practical forest management. During the exploitative period, less attention was paid to regeneration, as the major purpose was to clear land for new settlements. Attention to silvicultural practices has slowly been given, but it has never become routine in national forests.

Already in 1956, with the First National Development Plan, importance was given to the management of forest resources. Illegal felling was denounced and domestic forest-based industries were encouraged as an alternative to exporting unprocessed logs. After the first national forest inventory was completed in 1973, the first national forestry plan was made in 1976 (2033 B. S.). This was followed by the Master Plan for the Forestry Sector in 1988, when CF was given a priority status (MPFS, 1988).

Forest management responsibilities lie with the DFOs. Harvesting and transportation is normally carried out by the Timber Corporation of Nepal (TCN), which operates under the Ministry of Supplies. This organisation has no graduate forester employed and is not able to take forest management responsibilities. Recently HMG has issued a circular which gives the TCN the sole right to carry out harvesting and transportation operations (Aryal and Gyawali, 1998).

Alternative models to TCN operations in government managed forests are available and have been partly tried in the frame of FMUDP. One model is to make the DFO responsible for the operations but further organisational changes are needed. Another alternative, which has been proposed but not tried, is a private joint-venture model. FMUDP proposed that it should be tried in a five-year programme for Bara District, but the proposal met with many obstacles and so far has not been tried. A third model is practised by the Forest Products Development Board (FPDB). The organisation is operating in plantation areas under separate rules in Sagarnath and Nepalgunj.

A fourth model is participatory forestry which in Nepalese concept means CF. As CF is new in the Terai this model has not been practised sufficiently long to be properly evaluated. The question remains: which alternative forest management and utilisation system would be the most appropriate for the Terai? Certainly a combination of different models will be the most suitable concept.

2.5. Participatory forestry practices in the Terai

Community forestry in the Terai started with TCFP. The Project did not succeed in establishing a model for CF which could suit the Terai conditions and the result of the project was discouraging. Partly the model from the CF in the hills was practised but the project was not successful in the establishment of FUGs. The project tried the participatory *taungya* forest management concept, which has been successfully practised in India for a long time. This agroforestry management system was tried in Bara District, but turned out to be unsuccessful in Nepal as practised in Bara. Instead of an innovative sustainable use of the forest land and introduction of a cheap forest management system, a new 350-people village with its own agriculture land area emerged in the midst of a big block of natural forest.

During the time of OFMP preparations a proposal for alternative model to the hill concept of the CF programme was looked at. The Indian Joint Forest Management (JFM) programme has some interesting aspects worth considering, especially the concept of profit sharing between the government and the local communities.

CF in Nepal has a great similarity to the JFM programme in India. Both concepts are using a highly participatory approach with a village organisation as a base for community action: FUG in Nepal and village committee in India. JFM emerged out of the experience gained in India's social forestry programme in the 1980s, and is a newer concept compared to CF in Nepal. The States in India show mixed experience and the JFM concept is still to be further developed in different State regulations. The CF programme is in a refined stage of process in the hills but needs more attention in the Terai.

The basic similarities of the two concepts are:

- Forest areas are defined and demarcated around rural villages to be protected and managed by the villagers in a participatory approach.
- Management plans/working schemes are drawn up and approved by the DFO.

The major differences between the two concepts are:

- Forest products are shared between the government and community in JFM but the local community gets all the benefits in CF.
- NGO involvement is needed in JFM but not in CF.
- DFO/NGO representatives in the village committee in JFM, not so in CF.
- A central reorientation training programme for district staff in CF but not done in JFM. However, the need for such a programme has been identified.

2.6. Forest management policy

There is no clear policy for either the central authorities or the local authorities and people how to use the forest resources in the Terai. The current policy practised by DOF is a non-active forest management and to allocate dead, decaying and fallen trees for removal by TCN. All concerned agree that this is not a wise policy as the forest resources are not taken care of. With a central policy to allocate forest areas to FUGs according to the CF programme, the demand from the local people grows stronger for handing over of forests. It is worrying that the question remains *ad hoc,* as the case is a source of conflict. At the same time as discussions are going on, the forest resources are dwindling. The country would need a clearer policy in the Terai and that all natural resource projects working in the Terai should contribute to this.

The major criticism against the CF programme performance in Nepal has been the speed of formation of new FUGs. The physical target was set high. It has been realised that it takes time to consolidate the already established FUGs. The CF programme performance differs greatly between districts and depends much on the enthusiasm and knowledge of the DFO and his staff.

3. Community forestry in the Terai

The CF concept has been successful in the hill region of Nepal in terms of number of established FUGs, but initial difficulties have come up in the Terai. This is partly because the CF programme started in the hills and only at a late stage reached the lowlands. Also, the donor supported CF projects have until recently been located in the hill region. TCFP was an exception and a forerunner for CF in the Terai. The project also had difficulties in running CF programme in that area. The problems of Terai should not be underestimated and a proper analysis is of utmost importance.

Most of the DFOs seem to be positive to the programme in the hills and have learnt how to work with the CF concept. The situation in the Terai is different, where the DFOs have great hesitation and doubts about how to implement CF. The guidelines issued are mainly written for use in the hills and does not give any indications how to deal with the special conditions in the Terai. The hesitation for a bigger scale CF programme in the Terai seems to mainly depend on the great difference from the conditions in the hills. The major general factors influencing the CF strategy and concept are:

- size and condition of forest areas
- village structure and demographic situation
- historical background.

Basically there are two reasons for the slow progress of CF programme in the Terai:

- The participatory forestry concept for the Terai is still unclear and the hill community forestry concept cannot be directly replicated in the Terai.
- The DFOs in the Terai are confused about how to go ahead.

The Terai forests are of higher value than the hill forests. In most cases it is not easy just to hand over and the DFOs prefer not to do so. Additionally, the centre has given informal directives for not handing over mature valuable forests to FUGs though this attitude goes against the general policy of handing over available forest areas to FUGs and a general confusion is prevailing.

The majority of the population of the Terai has migrated from the hills and elsewhere. For a long time malaria made the lowland plain areas inhabitable. With the eradication of malaria, much more land suddenly became available to the people in Nepal and a great number of people migrated from the hills to the Terai. This considerably changed the life of the Tharus, who had been living in the lowlands for generations.

In the hills it has been easier to hand over forests where the villages are spread and the forest scattered. In the Terai there are bigger patches of forest remaining. The latest settlers have occupied the areas nearest to the forest. According to the CF principles the people near the forest will be the main beneficiaries. In the Terai this sometimes creates an absurd situation, as the original settlers will be given only a smaller benefit from CF.

Additionally the value of mature forest in the Terai is very high and only a few will become rich because of the sheer value of the forest handed over. Certain harvesting restrictions are there and the value will not immediately be cashed. Again it means a low intensity forest management where the nation will be the loser as valuable national capital is idling. With a higher intensity of use of the renewable natural resource the total economy would be healthier. The experience from the hills has shown that the communities are very restrictive and practice a very low intensity forest management.

Conflicts on how to make the best use of available forestland have appeared. These conflicts are manifold, as there are many vested interests in land utilisation. Firstly between the original settlers and the newcomers, secondly between local people and national interests and thirdly a general issue of land use conflict between agriculture and forestry.

The mature natural forest in the Terai is a big asset for Nepal. Currently this is protected through law and only dead and fallen trees can be cut. The law is not efficient and actually a great destruction of the forests in the Terai is currently going on. Not to cut trees is not proper from professional forest management point of view. Certain areas have to be protected for the sake of environmental reasons. Such areas have to be very clearly defined and great effort made to enforce protection. The current general protection of all forest will not gain the objectives of conservation. Rather it is spreading a general confusion about how to use the resources.

The great value of a forest is not seen or understood until the value is realised in monetary terms and a resource not used will not be protected in the long run as is happening with the forests of the Terai. The protected forests are not protected and a change of the current policy for use of the forests is needed. It is here that an adjusted CF concept for the Terai comes into picture.

The size of the block forest areas in the Terai are practically too big to manage for user groups. A preliminary guideline for immediate planning could be, that the people's participation in the Terai should be concentrated on the forest areas still remaining outside the block forest areas and in the fringe zones of block forest areas. It is a delicate and difficult task to define how big areas of mature forest will and will not be proper for handing over to FUGs. Too little fact is currently available and the concept too loose. Once a forest is handed over, the local people will be given priority for the forest use, as is the intention in the forest law, but a big burden should not be laid on them for properly managing big blocks of forest areas. For those areas other alternatives have to be found, of which commercial forestry is one.

During the process of adjusting the CF concept for the Terai many questions appear such as:

- What is the maximum area of mature forest to be handed over to FUGs?
- What to do with the big areas of mature forest not planned to be handed over to FUGs?
- People living up to what distance from the forest will be the beneficiaries of that forest area?
- How will income from operations be used in a fair way?
- Should the nation get any benefit from harvesting in CF with mature valuable forests? Is the JFM concept a source of additional ideas?
- How should socio-economic studies be carried out to give the most realistic picture for a DFO to make decision about FUG areas?
- How to define existing forest users with regard to non-wood forest products?
- How to speed up the utilisation and protection efforts?

4. Opportunities

A brief study was recently carried out on the scope of CF in the Terai (GDI, 1997). The fieldwork was carried out in Banke and Dhanusha districts. The general conclusion was that CF is both a feasible and a desirable strategy of forest management in the

Terai region. The importance to involve the communities in forest management has been further accentuated in other studies (RDC, 1998).

It is of great importance that the land use conflict be solved. The CF issue should be settled so that leasehold forestry can take place in faster pace. OFMPs already made give a preliminary guideline but criteria for allocation of CF land has to be further worked out and basic principles agreed upon.

Guidance and training is further needed for the FUGs. To get proper guidance the DFO staff needs further training in Terai forest management practices. The DFOs will continue to be reluctant to hand over forest areas to the FUGs until the hand over criteria are specified and unless a clear land use policy is made.

Currently CF gives no significant contribution to HMG. It has to be reviewed how to adjust the CF concept in the Terai, so that HMG gets more benefit out of the forestland handed over to FUGs. This is important for the fair distribution of income from the natural resources to all the citizens. Currently mainly denuded and barren forestland is given to FUGs and the FUGs have difficulties in organising proper forest management. In some cases, valuable forests have been handed over which has resulted in other complications like certain people getting high value forests and thus becoming rich overnight.

Project input has given a very positive effect on the CF programme in the hills. The Churia Forest Development Project (ChFDP) and EFEA project have a good opportunity to take the lead in the programme development in the Terai. These projects have made a good start in concept development. CF as well as other forest management alternatives are needed in the Terai to save the valuable forest for the future and to properly use the resources for the benefit of the local people and the country as a whole.

References

Aryal, U. and Gyawali, D. 1998. Finnish Aid and Forestry: Context, Case Study and Lessons (Draft). University of Helsinki, Institute of Development Studies/Interdisciplinary Analysts, Kathmandu, Nepal.

Bennett, M. 1989. Rautahat Forest Management Plan. World Bank Forestry I Project, Hetauda, Nepal.

CPFD. 1995. Operational Guideline for Community Forestry Development Programme 2051. (Revised Issue). Community and Private Forest Division, Department of Forest, Kathmandu, Nepal.

CPFD. 1997. The Community and Private Forestry Programme in Nepal (Booklet). Community and Private Forest Division, Department of Forest, Kathmandu, Nepal.

CPFD. 1998. FUG Database Record Available in MIS. Community and Private Forest Division, Department of Forest, Kathmandu, Nepal.

FORESC. 1993. Forest Resources in the Terai Districts 1990/91. *Publication No 57*, Forest Research and Survey Centre/Forest Resource Information System Project, Kathmandu, Nepal.

GDI. 1997. Community Forestry in the Terai Region of Nepal. German Development Institute, Germany.

MPFS. 1988. Master Plan for the Forestry Sector Nepal. His Majesty's Government of Nepal, Ministry of Forests and Soil Conservation, Kathmandu, Nepal.

RDC. 1998. Participatory Consultative Process on Bara Forest Management. Rural Development Centre, Pokhara, Nepal.

Shrestha, M. L. *et. al.* 1995. Community Forestry Manual. Community and Private Forest Division, Department of Forest, Kathmandu, Nepal.

Skarner, G. A. 1995. Final Report of Forest Utilisation Expert. *Technical Report No 14*, Forest Management and Utilisation Development Project, Kathmandu, Nepal.

Skarner, G. A. *et. al.* 1998. Strategic Guidelines for Forest Utilisation. Forest Resource Utilisation Strategy Project, Kathmandu, Nepal.

Tamrakar, R. M. *et al.* 1997. A Comparative Land Use Study in Two Middle Hills Districts of Nepal. Nepal-Australia Community Resource Management Project, Kathmandu, Nepal.

Mathema, P., Dutta, I. C., Balla, M. K. and Adhikary, S. N. (eds.). 1999. *Sustainable Forest Management.* Proceedings of an International Seminar, 31 August – 2 September 1998, Pokhara, Nepal.

Economics of Social Forestry in Pakistan

K. M. Suleman and M. Ayaz

Abstract: There is an acute shortage of forestry goods and services in Pakistan which is mainly due to very low forest area under the control of government. Under this situation, the farmlands are a major source of fuelwood and timber supply in the country. But this potential of farmlands is not fully utilised. Farmers have shown good response by planting more trees under social and farm forestry programmes mainly for economic reasons. Moreover, the farmlands also produce other agricultural crops, and interests of social forestry and traditional agriculture are some times conflicting. A Benefit-Cost analysis has been carried out to determine the net-marketing margin of farm trees in comparison to traditional agricultural crops. The results show that by planting *Eucalyptus*, farmers can earn a higher profit than the agricultural crops.

1. Introduction

Pakistan is deficient in forest resources and 4.8% of the forest area under the control of Forest Department is badly failing in fulfilling its production and protection functions. The low forest area is the reason for an acute shortage of forest products and degradation of natural environment. To increase the production of fuelwood, timber and other forest products as well as for the improvement and protection of natural environments, it is urgently needed that forest area in the country be increased up to a desirable level of 25% for environmental stability and sustained economic growth. There are many options to increase the forest area for more production of forestry goods and services. So far the increase of forest area in public sector is very limited because the land available with the Forest Department is limited and not fit for raising trees. Farmlands in Pakistan are already supplementing the national needs of forest products to a great extent. It is estimated that farmlands provide about 90% of the fuelwood and more than 70% of timber supplies in the country (Amjad *et al.*, 1996). Moreover, farmlands also have a very high potential for further expansion of forest resource base in the form of social forestry and farm forestry. Desirability of social and farm forestry projects beside the production of traditional forestry goods and services lie in the improvement of socio-economic condition of the farmers through the sale of tree products like fuelwood and timber.

Farmers have already started planting of trees for commercial purposes to supplement their income (Shah and Bakhsh, 1992). Social forestry and farm forestry projects supplement the efforts of farmers mainly through motivation and incentives to plant more trees on their farmlands. Moreover, the irrigated farmlands are intensively cultivated to raise different crops. One major aspect in the popularity of the social and farm forestry projects is the net-economic return in comparison to the traditional agricultural crops. Generally, the fast growing tree species are planted under social and farm forestry programmes. These help to reduce the rotation age and guarantee early returns from tree planting on farmlands. It is an established fact that most of the farmers plant trees for economic return. Work of government agencies may be simpler if enough information is provided to farmers about the economic return from trees and agricultural crops. This must include net-marketing margin of tree products, existing and future markets, price trends and future demands of a particular wood species.

Common economic tools such as Benefit-Cost ratio and Internal Rate of Return (IRR) are used to evaluate the economic benefits of forest trees in comparison to agricultural crops. However, these tools can only quantify in monetary terms the material products; other tree and forestry benefits like environmental impacts and social services cannot be quantified in this way.

1.1. Importance of social forestry

At first glance social forestry seems to address land resource issues facing developing countries, such as food security, energy shortages and unemployment. It is a critical element in the resolution of food security because it can help to halt declining agricultural productivity associated with poor land use, deforestation, erosion, and diminishing water supplies. Social forestry also plays a crucial role in resolving energy crises in rural areas in particular and urban areas in general. Finally, social forestry can give rise to significant employment and income opportunities, both in forestry activities and related processing activities (Gregerson *et al.,* 1989).

In Pakistan about 70% of the population live in rural areas and directly or indirectly depend on agriculture to earn their living. In addition to the development of traditional agriculture, introduction of social and farm forestry programmes have the following benefits:

- Increased farm production; additional income for farmers; supply of forest based goods (like timber, fuelwood and fodder) and services (like environmental protection and development).
- Timber produced on farmlands besides meeting the constructional demands is a substantial source of raw material for wood-based industries in the country for the production of value added wood products.
- Waterlogging and salinity is a major threat to irrigated agriculture. Social and farm forestry can rehabilitate the waterlogged and saline areas/farmlands.
- Social forestry is a labour intensive activity which can provide on farm employment to the people of rural areas where the alternate means of jobs are very meagre.

1.2. Major species planted under social forestry programme

Under social forestry programmes different indigenous and exotic tree species are planted depending upon the site. Among the indigenous species: simal (*Bombax ceiba*), kikar (*Acacia nilotica*) and shisham (*Dalbergia sissoo*) are widely used. Fast growing exotics like: *Eucalyptus camaldulensis* and poplars (*Populus euro-americana* and *P. deltoides*) are the most common. *Eucalyptus* performs well on a wide variety of sites while poplars are ideal for the northern part of the country. Among the different tree species, *Eucalyptus* is the major species planted on farmlands and wastelands in all of the four provinces. Poplar is the most popular species among the farmers of North West Frontier Province. Similarly, kikar is the most preferred species in lower Panjab and Sindh.

2. Material and methods

For the Benefit-Cost analysis *Eucalyptus* is taken as an example of the fast growing farm tree species because it is extensively planted throughout the country under social forestry programme. The agricultural crops used in the Benefit-Cost analysis are wheat, maize and sugarcane. Secondary information was used for analysis in this paper. Benefit/Cost (B/C) ratio was calculated to determine the net-marketing margin in growing of *Eucalyptus* on farms and other agricultural crops like wheat, maize and sugarcane. Various costs were considered in this analysis like cost of plantation establishment, management, tree growth, yield and market prices.

3. Results and discussion

As given in Table 1, the estimated cost of establishment of one acre of *Eucalyptus* plantation is the highest followed by sugarcane, wheat and maize.

Table 1. The cost of establishment per acre

Function	Wheat	Maize	Sugarcane	*Eucalyptus*
Ploughing	175	150	250	150
Levelling	47	47	47	47
Sowing/planting charges	5	10	300	1,613
Planting stock	150	100	700	4,840
Manuring	400	500	600	-
Irrigation	150	150	1,500	150
Fertiliser	500	400	600	-
Pruning	-	-	-	10
Labour	277	277	277	277
Transport	100	100	100	750
Weedicides	250	250	250	-
Hoeing	-	-	100	-
Harvesting	300	250	-	-
Threshing	400	200	-	-
Total	2,754	1,979	5,649	7,832

Table 2 gives the results of Benefit-Cost ratio which has been calculated on the basis of 15 percent discount rate for a period of seven years. *Eucalyptus* plantation has the highest B/C ratio of 1.89, except for maize crop which has B/C ratio around 2.3. While the B/C ratio for sugarcane and wheat is 1.79 and 1.81, respectively. Siddiqui (1991) has reported lower Benefit-Cost ratio of *Eucalyptus* plantations raised in Khipro (Sindh). With the improvement of marketability of *Eucalyptus* wood, B/C ratio could be further increased.

Table 2. Discounted cost and benefits of different crops grown on one acre for 7 years (discounted @ 15%)

Crop	Total Discounted Cost (Rs.)	Total Discounted Revenue (Rs.)	B/C
Wheat[1]	11,467	20,828	1.81
Maize[2]	8,082	18,747	2.32
Sugarcane[3]	23,229	41,658	1.79
Eucalyptus[4]	8,826	16,731	1.89
Eucalyptus (Thailand)			1.60

[1] @ Rs. 200/40 kg
[2] @ Rs.150/40 kg
[3] @ Rs. 20/40 kg
[4] MAI 17 m^3/ha/year @ Rs. 40/40 kg

Net-marketing margin of *Eucalyptus* plantations in Pakistan has been compared with net-marketing margin of *Eucalyptus* plantations in Thailand as 1.6 for pure stand and 1.5 under agroforestry system, respectively (Table 3). Literature also indicates higher net-marketing margin for *Eucalyptus* grown for timber production.

Table 3. Income/cost ratio (annual basis)

Crop	Annual Cost (Rs.)	Annual Income (Rs.)	Net Benefit (Rs.)	I/C	N-B/C
Wheat	2,754	5,000	2,246	1.81	.81
Maize	1,979	4,500	2,521	2.27	1.27
Sugarcane	5,649	10,000	4,351	1.77	.77
Eucalyptus	1,261	2,390	1,129	1.89	.89
*Eucalyptus**	948	2,746	1,798	2.89	1.89

* USAID data

The net value of *Eucalyptus* wood has also been calculated which can be added if *Eucalyptus* trees of seven years are used for pulp production in the country. These results confirm that use of *Eucalyptus* as raw material in pulp industry is to add the highest value to the *Eucalyptus* wood. An amount of Rs.175,529/acre is added to the agriculture economy of the country if the crop of seven years is processed. Value added by manufacturing is important because it represents the contribution of a particular segment of manufacturing to GNP (Gregory, 1987). In order to achieve the maximum benefit from social forestry programme, market development should be an essential component because efficient markets allow for greater productivity and price, which in turn raise the socio-economic welfare of small-scale farmers (Pabuayon, 1990).

4. Conclusion

From this study it is clear that *Eucalyptus* plantation gives a higher marketing margins than the other agricultural crop considered in addition to other production and environmental benefits. Therefore, the forestry agencies should continue to promote social forestry programmes for the benefit of rural communities. Efforts should also be made to address the constraints in the marketing of wood produced on the farms.

References

Amjad, M., Shah, H. and Khan, N. 1996. *Forestry Statistics of Pakistan.* Pakistan Forest Institute, Peshawar, Pakistan.

Gregerson, H., Draper, S. and Elz, D. 1989. People and Trees. The Role of Social Forestry in Sustainable Development. *EDI Seminar Series.* The World Bank, Washington DC, USA.

Gregory, G. R. 1987. *Resource Economics for Foresters.* John Willey and Sons, New York, USA.

Pabuayon, I. M. 1990. Marketing Tree Products from Small Farms. In: *Proceedings of Multipurpose Tree Species.* Winrock International Institute for Agricultural Development. U.S.A. pp. 240–247.

Shah, H and Bakhsh, I. 1992. Tree Growth on the Farmland of the Punjab. *Pakistan J. For.* Vol. 42(1): 44–54.

Siddiqui, K. M. 1991. Financial Analysis of Different Types of Tree Plantations. *Pakistan J. For.* (4): 60–68.

PART 2:

AGROFORESTRY AND NON-TIMBER FOREST PRODUCTS

Mathema, P., Dutta, I. C., Balla, M. K. and Adhikary, S. N. (eds.). 1999. *Sustainable Forest Management.* Proceedings of an International Seminar, 31 August – 2 September 1998, Pokhara, Nepal.

Agroforestry for the Development of Non-Timber Forest Products in Nepal

S. M. Amatya

Abstract: In Nepal various traditional and modern agroforestry models are in operation. Agroforestry could also be applied in the development of Non-Timber Forest Products (NTFPs). This paper discusses a model of inter-cropping NTFPs with tree crops. Limitations of the model are also identified.

1. Introduction

Non-Timber Forest Products (NTFPs) are products other than timber, fuelwood and fodder. These could be obtained from trees, herbs, shrubs, climbers, etc. NTFPs have always been and continue to be an important element of the forest. It has been playing a traditional role in nutrition and health of rural people. Income from the sale of NTFPs is paying for the essential inputs to agriculture in the rural areas. Moreover, NTFPs could be domesticated for improving their quality and quantity so that they are attractive to farmers.

2. Scope of combining NTFPs in agroforestry

Agroforestry is a system where forestry practices are combined with agricultural and related activities. The main objective of an agroforestry system is to optimise production and economic return per unit area in a given period of time. In Nepal, there are various traditional and modern agroforestry models in operation (Amatya, 1994)

There is growing evidence that in some circumstances agroforestry is more profitable than forestry alone and may have a number of social advantages from both the farmer and nation's viewpoint. The principle of agroforestry could also be applied in the development of NTFPs. For example, early results of an inter-cropping trial conducted by Adkins (1988) showed that planting fuelwood tree species, such as *Eucalyptus camaldulensis*, with essential oil plants i.e. citronella grass (*Cymbopogon winterianus*), could emerge as a useful agroforestry system, especially in the Terai. Similarly, an experiment carried out for three years to find the effect of *Dalbergia sissoo* on the yield of an adjoining medicinal herb *Cymbopogon winterianus* showed that there was no difference in the yield of citronella oil, whether grown with or without trees (Amatya, 1996). These preliminary findings suggest that there is an ample scope of growing medicinal and aromatic plants (MAPs) along with tree crops.

There are more than 700 different species of MAPs in Nepal (FAO, 1982). They are distributed in all the physiographic regions of the country. The distribution has been found approximately to be 31% in tropical and sub-tropical zones, 55% in temperate zone, and 14% in alpine zone. All these areas possess immense potential for combining NTFPs with agroforestry.

3. Possible models of combining NTFPs in agroforestry

Of the various models, inter-cropping NTFPs with tree crops could be one of them. Experiment has shown that a simple alley cropping of citronella under sissoo trees is a viable model for the Terai. Inter-cropping sissoo with *Zanthoxylum* has also become an increasingly promising model in the Terai.

There could be other viable models suitable for different agroecological conditions of the country. One needs to develop, test and disseminate such models suitable for various agroecological conditions of the country.

4. Limitations

There are limitations in the development of NTFPs under trees. Of the various factors, shading is of crucial importance. Shading, however, could be modified through spacing as suggested by Amatya and Newman (1993).

Models might lead to domesticating and commercialising the NTFPs. It may affect household livelihood strategies. For example, labour input may be decisive in the production of NTFPs. But this input, other things remaining the same, might change the production of staples. It is envisioned that the greater the intensity of domestication, there will be less diverse productions and trade-off will have to be made regarding the intensity of domestication, ecological functioning and socio-economic equity (Figure 1). The optimal point varies depending on the species and local conditions. In this context, one has to be very careful in choosing a model for implementation.

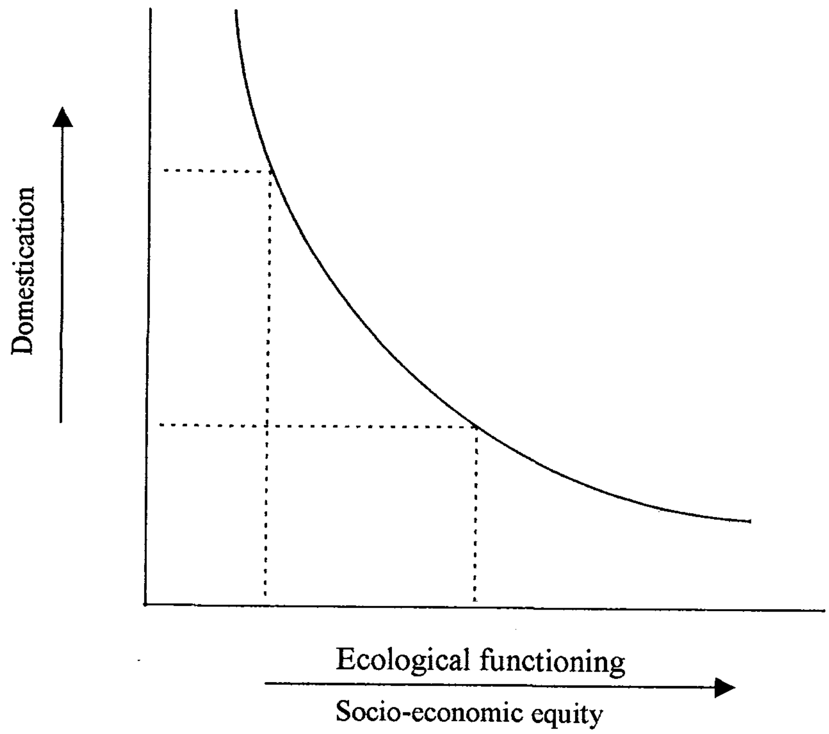


Figure 1. The relationship between domestication of NTFPs, ecological functioning and socio-economic equity

Whatever be the form of models that combine NTFPs with tree crops these should have three pre-requisites. These pre-requisites are that the combinations should be socially acceptable, economically viable and suitable to the given site. If the NTFPs that are unaccepted by the local communities because of social reasons even if they are economical and suitable to the site, will not get development priority. The case is true with the other two factors as well. If we denote these factors as three different and independent circles, then the best model would be the one, which gets maximum overlaps among them (Figure 2). In ideal conditions, it would be practicably different to attend a complete overlap. Therefore, the closer the circles, the more acceptable will be the model.

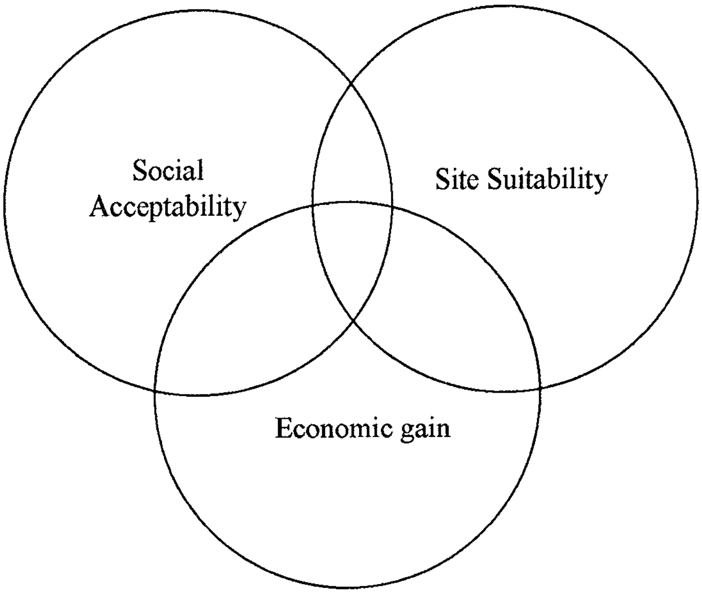


Figure 2. Sustainable NTFP model

References

Adkins R. Van C. 1988. Inter-cropping Firewood Trees with Essential Oil Plants. *Banko Janakari* 2(1): 52–55.

Amatya, S. M. and Newman, S. M. 1993. Agroforestry in Nepal: Research and Practices. *Agroforestry Systems* 21(3): 215–222.

Amatya S. M. 1994. *Agroforestry Systems and Practice in Nepal.* National Forest Division, Department of Forests, Kathmandu, Nepal.

Amatya S. M. 1996. Non-timber Forest Products and their Production Opportunities in Nepal. In: Leakey, R. R. B., Temu, A. B., Melnyk, M. and Vantomme, P. (eds.). *Domestication and Commercialisation of Non-Timber Forest Products in Agroforestry Systems. Proceedings of an International Conference*, Nairobi, Kenya.

FAO 1982. Medicinal Plants of Nepal. *RAPA Publication No. 64.* Regional Office for Asia and the Pacific, Bangkok, Thailand.

Mathema, P., Dutta, I. C., Balla, M. K. and Adhikary, S. N. (eds.). 1999. *Sustainable Forest Management.* Proceedings of an International Seminar, 31 August – 2 September 1998, Pokhara, Nepal.

Use of Non-Timber Forest Products in Nepal's Mid-Western Himalayan Region Adjoining Tibet (China)

S. R. Baral

Abstract: Humla district lies in the mid-western Himalayan region of Nepal adjoining Tibet. An investigation on the range of Non-Timber Forest Products (NTFPs), their use, trade and traditional management practices were carried out at different places of Humla. This paper lists over 50 species of NTFPs along with their local uses. Over 70 tonnes of NTFPs comprising of 13 species were exported from Humla in the fiscal year 1995/96 which increased to over 113 tonnes in 1996/97. It fetched a revenue of about Rs. 1.33 million in 95/96 and Rs. 1.42 million in 1996/97. The estimation of overall trade of all NTFPs was difficult because of the unavailability of their selling rate. The marketed species such as *Delphinium himalayens, Nardostachys grandiflora, Picrorhiza scrophulariiflora, Rhododendron anthopogon, Acer acuminata and Morchella esculenta* are the major source of local income. As a result of increasing access to market and competition for collection, the tendency to follow the indigenous management of NTFPs is declining.

1. Introduction

Humla district of Nepal is located between two distinct botanical regions of the western and eastern Himalayas. It therefore, harbours plants from both the regions. In Humla the sub-tropical vegetation and the arid vegetation (of the Tibetan plateau) are separated merely by about 25 km aerial distance. The variety of ecosystems present in the area (Baral and Poudel, 1996) provides an appropriate environment for the growth of a large number of plants of medicinal use. This makes the Humla region rich in biological resources and an important place for biodiversity research.

Every year about 10,000 to 15,000 tonnes of Non-Timber Forest Products (NTFPs) are harvested (and traded) from the natural sites of the mid-hills and high mountains of Nepal (Edward, 1996). This includes Humla also where most of the local people who are very poor, depend on subsistence agriculture. Except livestock farming and weaving of woollen items, few other income generation activities are available. The local people are compelled to collect forest products which have market potential, or work as seasonal labourers in neighbouring districts and/or nearby Indian towns. Because of the lack of transportation facilities, most of the local people of this region prefer to remain in their villages to collect and sell NTFPs.

This paper presents the results of a study done in Humla on various aspects of NTFPs. These include: types of NTFPs available and their uses, trade pattern and existing management practices. As no previous research on the NTFPs of this region has been carried out so far, except for the one by Sheldon *et al.* (1993) which is unpublished, the present work provides first hand information on the above mentioned points.

2. Methodology

This study was carried out at Lamtang, Chuakhola and Luruppya of Humla district. Key informants (leaders and elderly people) of each village were requested to join the discussions in order to collect the required information on existing NTFPs. Some people were also individually interviewed. Field visits to sub-alpine and alpine areas with a knowledgeable key informant fetched information on habitats of various species.

3. Results and discussion

Human settlements in the Humla region, as in other mountainous areas of Nepal, are highly scattered. Numerous patches of settlements, irrespective of the population number, are often given different names to represent a village. These villages are situated mostly in between the sub-tropical (ca. 1,300 m) and temperate (ca. 3,000 m) regions. At sub-alpine and alpine regions, highland pastures are located where commercial NTFPs grow. Therefore, ownership of such pastures is the most important issue for the Humli people. Traditionally they are owned either by a particular community or a group of people. In some cases, even individuals own such pastures. Conflicts for ownership do occur from time to time.

Based on the group discussions and individual interviews, it was found that the commercial collection of NTFPs from such pastures and the adjoining sub-alpine forests started about 50 years ago when the people from Jumla (an adjoining district south of Humla) collected medicinal herbs such as *Picrorhiza scrophulariiflora, Delphinium himalayens, Dactylorhiza hatagirea,* and *Morchella esculenta* (an edible mushroom). At that time the Humli people were unaware of the value of these plants and they allowed others to collect their resources either free or through barter with agricultural tools and grains. After the construction of an airport in Simikot, the district headquarters in 1985, access to Humla became easy for the traders from the Terai (the southern flat land adjoining India). Even Indian traders started making business trips to these places. As a result, the demand of *N. grandiflora, P. scrophulariiflora* and *Morchella* shot up. The extent of collection of these species could be imagined through the fact that an entire village stays in the highland pastures during June to September—the peak season for collecting these species. People of almost all age groups who can work (10–65 years) are involved in the collection. Also, competition for collection is such that most of the collectors erect temporary huts and prefer to stay on site for the entire collecting period, instead of travelling to and from their villages.

Over 70 tonnes of NTFPs comprising of 13 species were exported from Humla in the fiscal year 1995/96 which increased to 113 tonnes in 1996/97 (Table 1). The major species being collected are *P. scrophulariiflora* and *N. grandiflora.* The revenue was Rs. 1.33 million in 1995/96 which increased to Rs. 1.42 million in 1996/97. The rate per kg of each species could not be known therefore the total amount of money generated through NTFP trade could not be estimated. Nonetheless, some local traders estimated that it is over Rs. 10 million. Analysis of the Department of Forest's previous records (unpublished) on the export of NTFPs from Humla indicated that the demand for a particular species varies from year to year. The collection and trade of NTFPs increased in 1996/97 by almost 43 tonnes thereby increasing the revenue. But this increase is contributed mostly by two species only (*N. grandiflora* and *P. scrophulariiflora).* Their sustainability therefore needs proper attention.

The growth and distribution of these species seem to be controlled by microclimatic conditions. Field observation revealed that the distribution of *N. grandiflora* and *P. scrophulariiflora* is more or less clustered. In some places they are highly abundant but a few metres away they disappear abruptly. It may be due to variation in soil moisture or the symmetric/allopathic relation with other species growing at the same place. This is very interesting and calls for further research.

Table 1. Quantity of NTFPs (kg) exported from Humla in two fiscal years

Species	Local name	Fiscal year	
		1995/96	1996/97
Delphinium himalayens	atis	3341	4000
?		166	-
Picrorhiza scrophulariiflora	kutki	59627	71230
Artemesia siversiana		5	-
Nardostachys grandiflora	bhutle	2971	35546
Valariana wallichii	sungandhawal	904	738
Morchella esculenta	gurchi	1388	228
Juniperus sp.	dhupi	20	-
Paris polyphylla	satuwa	14	-
Rheum arstrale	padamchal	10	484
Rhododendron anthopogon	sunpati	110	-
?		648	-
Asphalt	silajit	1272	1368
Total quantity (kg) permitted to export		70476	113650
Total revenue (Rs.) collected		1.33 million	1.42 million

Source: Department of Forest, Official Records.

3.1. List of NTFPs and their local use

The NTFPs fall into two categories with regard to collection and trade. Collection of some species such as *Dactylorhiza hatagirea* and *Cordyceps sinensis* is banned even for individual use. However, the government authorities have no firm mechanism to monitor their collection and trade. Table 2 presents a long but not exhaustive list of NTFPs growing in the Humla region and their local use. In fact, not all of the mentioned NTFPs are being used by the local people. For example, fruits of different species of *Rosa* and *Berberis* are said to be edible but the local people do not seem to eat these fruits which are seen hanging on the plants as if they are of no use. The same holds good for many other species also. The NTFPs of Humla (and also of the whole Nepal) should, therefore be classified according to their marketing or commercial potential. If we do so then apart from *Delphinium, Picrorhiza, Nardostachys, Morchella,* silajit (natural asphalt) and honey no other species have commercial value at present.

Sheldon *et al.* (1993) prepared a list of NTFPs found in Humla area. They have also given a list of species which are being harvested in other districts of Nepal but not from Humla. All these indicate that in spite of being rich in NTFPs, Humla has not yet capitalised the resources fully. Understandably, this is because of the remoteness of the area and the lack of proper access to market.

3.2. Trade pattern

The local people are merely involved in collecting the NTFPs. There exist a number of steps of marketing from collectors to consumers [see also Edward (1996) p 41]. The collectors are exploited by the middlemen. The extent to which the collectors receive low price of the collected items, could be imagined through a big difference between the buying and selling price. Dried *Morchella esculenta* for example, is purchased locally by the middlemen at Rs. 1,000 to 1,500 (US$ 15 to 22 approx.) per kg whereas it is sold in India at a much higher price equivalent to US$ 100 to 200 per kg. However, it is extremely difficult to know the final selling price of the Humla NTFPs, as the middlemen would not like to share this information with anyone else. The example of *Morchella* may indicate the price difference of other traded NTFPs as well. As the collectors need to collect more NTFPs to make even a small amount of money (the bigger profit of which goes to other levels of traders), the NTFPs are being depleted.

Table 2. List of NTFPs and their common uses in Humla

Species	Habit	Use
Acer acuminata Wall	T	Wooden utensils
Acer cappadocicum Gled.	T	Wooden utensils
Aconitum spicatum Stafp.	H	Poison
Acorus calamus L.	H	Mouth freshener and relieves sore throat
Aesculus indica Hook.	S	?
Allium wallichii Kunth	H	Vegetable as common garlic
Amaranthus spinosus L.	H	Leafy vegetable
Arisaema utili Hook.	H	Rhizome edible
Arundinaria falcata Nees	S	Weaving mats and grain containers; high fodder value
Berberis aristata DC	S	Stems for yellow dye, fruits edible
B. asiatica DC	S	Same as above
Betula utilis D. Don	T	Papery barks used as under roofing material
Canabis sativa L.S	S	Seeds contain fatty oil, edible. Leaf used as narcotic and bark for making grain sacs and cloth
Chenopodium album L	H	Leafy vegetable
Cordyceps sinensis Sacc.	Saprophyte	Tonic
Dactylorhiza hatagirea D. Don	H	Rhizome edible, tonic
Dioscorea deltoidea Wall	Climber	Rhizome edible
Eulaliopsis binata Ritz	S	Fodder, thatching grass
Fritillaria cirrhosa D. Don.	H	Bulb powder are mixed with flour to make breads tasty
Girardiana diversifolia Link.	H	Fibbers for making cloth
Herculeum nepalens D. Don.		Seeds for spice
Hippophae rhamnoides L.	S	Seeds very sour, used for making pickles
Impatie balsmina L.	H	Seed oil applied in wooden utensils for glazing
Juglans regia L.	T	Kernel edible and used for extracting fatty oil; fruit bark for making dye.
Juniperus indica Betrol.	T	Dried leaves put on fire as incense
Malva verticillata L.	H	Tender leaves used as vegetable
Morchell esculenta L.	Mushroom	Highly priced edible mushroom
Morina polyphylla Wall.		Root powder as one of the ingredient for incense
Nardostachys grandiflora DC.	H	Same as above
Pentapenax leschenaultii DC.	H	Ripe fruits as blue dye
Picrorhiza scrophulariiflora Pennel	H	Root decoction for curing fever
Pinus wallichiana Jackson	T	Firewood and timber, heartwood burnt as torch
Pleurospermum angelicoides DC	H	Mature seeds edible
Pleurospermum dentatum DC	H	Roots aromatic, relieve abdominal pain
Podophyllum hexandrum Royle	H	Fruits edible
Polygonatum cirrhifolium Royle	H	Shoots used as vegetable
P. oppositifolium Royle	H	Same as above
P. verticillatum L.	H	Same as above
Prunus armenica L.	T	Fruits edible, kernel oil is used for cooking
Pyrus pashia D. Don	T	Ripe fruits edible
Rheum australe D. Don	H	Highly used vegetable dye
Rhododendron anthopogon D.Don	S	Leaves used as incense
Rosa macrophylla Lindl.	S	Fruits edible
Rosa sericea Lindl.	S	Fruits edible
Rubus ellipticus Smith	S	Fruits edible
Rumex nepalensis Spreng.	H	Rhizome as dye
Silene himalayensis Majumdar	H	Roots used as soap to wash especially wools
Solena heterophylla Lour.	H	Ripe fruits edible
Trillidium govainianum D. Don	H	Roots relieve abdominal pain
Usnea sp.	Lichen	Dye?
Valariana wallichii	H	Incense
Zanthoxylum armatum DC.	S	Pericarp used as spice (throughout Nepal)

Note: T = Tree; S = Shrub; H = Herb

3.3. Indigenous management practice

No management practice for the sustainable harvest of NTFPs could be seen in the study area. Even the territorial rights for highland pastures have no far-reaching effect on conservation. The pastures being common property, are considered as nobody's property. Instead of sustainable harvest, everybody seems to be interested to collect those items which have market value. Hard cash, irrespective of the amount, means much to Nepali villagers. They are always in need of cash for purchasing consumer goods other than agricultural products. In this context, the first instant reaction of the Humla people is to collect as much NTFPs as possible and sell them at whatever price they can get. In such a scenario, sustainable harvest is totally out of the question. The prevailing situation is that if one does not collect, others will.

It was found that in the past the collectors were not allowed to harvest roots/rhizomes of *N. grandiflora* and *P. scrophulariiflora* with metallic tools. They had to be collected only with hands and wooden tools. This was probably aimed at leaving behind some portions of roots/rhizomes so that regeneration could occur in the next rainy season. This practice does not exist anymore. Also, in those days the limited market automatically supported sustainability, as only a few NTFPs in smaller quantities were either used for local medicinal purpose or bartered for wool with traders from Tibet. It is not so now. And it seems that NTFPs will continue to be harvested as long as there is a market for them and as long as the competition for harvesting continues.

4. Recommendations

It is quite apparent that the sustainable harvest of the Humla NTFPs is an important issue. As sustainability is connected with many aspects, addressing them is the foremost requirement. If the government can clarify how much of a particular species can be collected per unit area per year followed by an efficient monitoring mechanism, there could be a tremendous contribution to the sustainability of NTFPs. Studies on sustainable harvest and management are, therefore necessary.

Value addition is another aspect of sustainability. There are two small distillation units established to distil oil from *N. grandiflora.* The quality of oil extracted as well as the impact these units might have on local environment should also be monitored regularly.

The Department of Forest's recording system on the export of NTFPs from a particular area does not seem appropriate either in terms of the actual quantity harvested, or the accurate botanical names of species, or both. The staff of District Forest Offices cannot identify the NTFP species and there is no herbarium of NTFPs at District Forest Office. Consequently, the same species has been listed under two different local names and perhaps have two revenue rates. All these need to be corrected.

References

Baral, S. R. and Poudel, S. S. 1996. Biological Baseline Information of Margor Region (Durpa and Radikot), Humla District. A Report Submitted to the Asia Network on Sustainable Agricultural Bioresources, Kathmandu, Nepal.

Edwards, D. M. 1996. Non-Timber Forest Products from Nepal: Aspects of the Trade in Medicinal and Aromatic Plants. Forest Research and Survey Centre, Kathmandu, Nepal.

Sheldon, J., Bhattarai, N. K. and Baral, S. R. 1993. Humla Ecozone Management Assessment: Biodiversity Component. A Report Submitted to the Asia Network on Sustainable Agricultural Bioresources, Kathmandu, Nepal.

Mathema, P., Dutta, I. C., Balla, M. K. and Adhikary, S. N. (eds.). 1999. *Sustainable Forest Management.* Proceedings of an International Seminar, 31 August – 2 September 1998, Pokhara, Nepal.

Role of Nitrogen Fixing Multipurpose Trees, Shrubs and Herbs in Agroforestry

V. Chakravarti

Abstract: Agroforestry is a sustainable land management practice that can produce a multiplicity of outputs. It will be more beneficial if appropriate multipurpose and nitrogen-fixing trees/shrubs/herbs are introduced. The role, usefulness and problems associated with many such species are hilighted in this paper.

1. Introduction

Agroforestry involves intimate and interacting association of agricultural and horticultural crops with woody perennials in the same land unit (Huxley, 1983). This form of land use has three main objectives: productivity involving a multiplicity of outputs; sustainability; and restitution of soil to broaden future land use option. This alternative sustainable land management may prove to be even more beneficial if nitrogen-fixing multipurpose trees and shrubs (MPTS) are introduced. These MPTS can yield both timber and non-wood products of immense economic value. In addition, they can provide regular supply of nitrogen into the field enriching soil fertility which unlike chemical fertilisers will not produce any health or environmental hazards. Considering these attributes, cultivation of nitrogen-fixing plants would definitely alleviate the socio-economic condition of the disadvantaged group of people. This paper discusses the role of nitrogen-fixing plants in agroforestry.

2. Characteristics of tree or shrub species in agroforestry

Selection of right species is the first step towards a successful agroforestry programme. The general considerations are based on (a) biological and (b) social criteria:

Biological criteria

- The species should adapt to the site and should be able to produce optimum outputs on a sustained basis.
- The leaf litter should decompose quickly thus adding organic matter to the soil.
- The species should enrich the soil by fixing nitrogen.
- The morphological characters of the tree may play a vital role e.g. wide crown may be preferred for fuelwood plantation although narrow crown is favourable to agricultural crop.
- The species should have deep rooting property.
- The species should generally be fast growing and harvestable at short rotation.
- Coppicing is an added advantage where agroforestry aims for social benefit.

Social criteria

- The species should be able to fulfil the needs of local people. Multipurpose trees or shrubs thus have a significant role in this context. The tree/shrubs, which have non-timber value in addition to their wood products, are suggested for this purpose.
- Local customs and traditions must not be overlooked.

- The plant products should have economic importance and be easily marketable.
- Favourable economic return is another point to be considered.
- The trees or shrubs which provide raw material for local Non-Timber Forest Products (NTFP) based industries have an added advantage.
- The choice of tree or shrub species should be done in such a way that the rejuvenation of the environment is possible by planting them.

3. The suitability of nitrogen fixing multipurpose tree species in agroforestry

Nitrogen constitutes 78–80% of the earth's atmosphere. Yet the plants cannot use it directly. Some of the tiny organisms (fungi/bacteria) are capable of absorbing and utilising this gaseous element. Plants can only absorb nitrogen through roots in the form of organic nitrogen, ammonium salt and nitrates.

Nitrogen is reduced in most of the farmland due to continuous land exploitation so chemical nitrogen fertiliser input is generally required for maximising crop yield. Soil organic nitrogen is continuously lost through removal by plants and also by other processes, e.g. leaching, denitrification and ammonia volatilisation. Intensive monocroping with no or inadequate crop rotation results in edapho-nitrogen imbalances. Biological Nitrogen Fixation (BNF) and chemical sources supply most of the soil nitrogen. BNF replenishes the soil nitrogen pool. Its role in enhancing soil fertility and maintaining the nitrogen balance in different agro-based cropping systems has been well established. Nitrogen is the nutrient that most frequently limits yields in both tropics and temperate zones. Woody leguminous trees that have the potential to fix significant quantities of nitrogen can have a posistive influence on yield in deficient soils. Trees can also help to control erosion and some arboreal legumes are found to be tolerant of even acid, alkaline and saline soils.

As nitrogen controls growth, chemical fertilisers are commonly used though it consumes large amount of money and energy; and has health and environmental hazards. Therefore, unavailability of nitrogen fertiliser is more severe in developing countries. Nitrogen fixed by the trees is not only disseminated to the soil but also is a source of green manure. Table 1 shows the estimated amount of nitrogen fixed by different species.

Table 1. Estimated nitrogen fixation by some trees

Species	Nitrogen fixed (kg/ha/yr)
Acacia mearnsii	200
Casuarina equisetifolia	40–60
Casuarina equisetifolia	12–50
Coriaria arborea	192
Gliricidia sepium	13
Leucaena latisiliqua	110
Leucaena leucocephala	224–274
Prosopis chilensis	30

A number of leguminous tree/shrub species can grow in short rotations. If the intent is to grow small trees on short rotation, woody legumes often prove to be the best. The leguminous shrubs and trees as well as herbs play an important role in nitrogen cycle. The roots of these leguminous species not only fix atmospheric nitrogen but also bind the soil to check soil erosion.

The rapid genetic advance is one of the major characteristics of woody legumes in comparison to other woody species as many have a very short seed to seed cycle of less than two years. Majority of the species is self-sterile, self-incompatible and genetically highly variable. Moreover, inter-specific hybridisation allows wide crossing and exploitation of hybrids.

Most of the tree/shrub legumes offer a number of other benefits in addition to timber/fuelwood. The details are shown in Table 2.

Table 2. List of some arboreal legumes with their economic uses

Species		**Usage**
Acacia albida	:	Forage (pods, foliage); shade.
Acacia auriculaeformis	:	Fuelwood; pulpwood.
Acacia confusa	:	Fuelwood; ornamental.
Acacia foeresiana	:	Fuelwood; forage; tannin; perfume; ornamental; black dye.
Acacia mangium	:	Timber; firewood.
Acacia mearnsii	:	Fuelwood; charcoal; tannins.
Acacia nilotica	:	Fuelwood; charcoal; fodder; tannin & gums.
Acacia saligna	:	Fodder; fuel; sand-dune fixation; tannin; erosion control; ornamental.
Acacia senegal	:	Fuelwod; charcoal; gum arabic; feed.
Acacia tortillis	:	Fuelwood; fodder.
Albizia faclcataria	:	Pulpwood; soft moldings; boxes, soil improvement.
Albizia lebbeck	:	Fuelwood; fodder (foliage); furniture.
Colliandra calothyrsus	:	Fuelwood; utility timber & forage.
Dalbergia sissoo	:	Lumber; fuelwood.
Erythrina bertoeroana	:	Live fence post; easily cloned.
Erythrina fusca	:	Shade of coffee & cocoa; live fence post; soft wood.
Gliricidia sepium	:	Fuelwood; timber; fodder; shade; live fence.
Leucaena diversifolia	:	Fuelwood; shade; forage.
Leucaena leucocephala	:	Fuelwood; nurser tree; forage; energy planations.
Mimisa scabrella	:	Fuelwood; pulpwood; shade for coffee; rapid growth.
Parkis javanica	:	Timber; ornamental; seed used in local medicine.
Parkia speciosa	:	Food (seed from large pods).
Parlomspoa aculata	:	Fuelwood; fodder; fences; local medicine.
Pithecellobium dulce	:	Fuelwood; forage; construction postwood; shade; food; some tannin & oil (seeds).
Pongamia pinnata	:	Fuelwood; fodder; oil (seeds); pest control; medicine.
Pongamia chilensis	:	Fuelwood; occassional use as timber; medicine.
Prosopis cineraria	:	Fuelwood; excellent charcoal; some timber; green manure.
Prosopis juliflora	:	Fuelwood; charcoal; fodder (pods); honey; wood.
Prosopis tamarguo	:	Fuelwood; forage (pods, leaves).
Pterocarpus indicus	:	Choice timber (narra); furniture; flooring.
Robinia pseudoacacia	:	Fuelwood (dense); erosion control; nurse tree; posts; forage.
Samanea saman	:	Shade; timber & craftwood; food; ornamental.
Sesbania gradiflora	:	Pulpwood; forage (leaves, pods); food (flower, leaves, young pods).
Inga vera	:	Timber, decking (highly resistant to rot); heavy vehicle bodies.

4. Protective roles

The protective roles as indicated by Nair *et al.* (1984) includes conservation and improvement to soil through nitrogen fixation, rapid nutrient cycling, addition of organic matter of soil and soil stabilisation by roots. About 20–25% of the total living vegetal biomass of the trees/shrubs is in their roots and there is constant addition of organic matter to the soil through dead and decaying roots. The major avenue for addition of organic matter to the soil ecosystem from the trees is through litter fall in addition to root decay. The gradual accumulation of mineral nutrients by arboreal legumes and incorporation of these into an enlarged plant litter-soil-nutrient cycle mechanism are responsible for soil fertility enrichment. The rhizobial association (symbiosis) is responsible for the nitrogen fixation in soil. The Rhizobia form nodules in the root where nitrogen is fixed and transferred to the host organism in the form of ammonia.

There are other families as well which can fix atmospheric nitrogen with the association of microbes. Even a particular variety of *Rhizobium* is responsible for nodulation in non-leguminous plants like *Parasponia*. Table 3 shows a list of nitrogen fixing bacteria and their host plants.

Table 3. Nitrogen fixing agents and their host plants

Nitrogen fixing agent	Host Plants
Frankia sp.	*Alnus* (Betulaceae), Casuarinaceae, *Coriaria* (Coriariaceae), Several members of Elaegnaceae, Rhamanceae, Rosaceae
Rhizobium sp.	Leguminosae, Ulmaceae
Cyanobacter (Azolla)	Water fern, *Anabena* (alga)
Klebsiella pneumoniae	*Deplachne fusca*

5. Productive role

Energy plantation

Many arboreal legumes have been successfully used for energy plantation. *Acacia, Albizia, Leucaena,* and *Prosopis* are important fuelwood genera. A list of fuelwood leguminous species with their approximate calorific value is given in Table 4.

Table 4. A list of arboreal legumes showing their calorific values

Species	Calorific value (Kcal/kg)
Acacia catechu	5200
Acacia leucocephala	4886–4889
Acacia mearnoli	3500–4000
Acacia nilotica	4800–4500
Acacia senegal	3200
Albizia amara	5049–5306
Albizia lebbeck	5163–5166
Albizia indica	4570–4865
Butea monosperma	4925
Cassia fistula	5164
Dalbergia sissoo	5180
Derris indica	4834
Leucaena leucocephala	3895–4675
Prosopis cineraria	5003

Afforestation of problematic soil area

A number of leguminous trees, shrubs and herbs can adapt themselves and grow well in acidic, alkaline and salt affected edaphic condition. *Acacia, Prosopis, Albizia, Leucaena, Dalbergia,* and *Parkinsonia* are ranked as moderately salt tolerant woody legumes while *Acacia oraria, A. stenophylla, A. amplicaps* are high salt tolerant species. A list of Nitrogen Fixing Trees (NFTs) tolerant of problem soils is given in Table 5.

Table 5. NFTs tolerant of problem soils

Species	General environmental requirements
NFTs tolerant of saline soils	
Acacia nilotica	arid, semi-arid, sub-humid
Acacia saligna	arid, semi-arid
Albizia lebbeck	semi-arid, sub-humid
Casuarina equisetifolia	humid, sub-humid
Prosopsis cineraria	arid, semi-arid
NFTs tolerant of acid soils	
Acaic auriculiformis	humid
Acacia saligna	arid, semi-arid
Albizia lebbeck	semi-arid, sub-humid
	semi-arid, sub-humid
NFTs tolerant of alkaline soils	
Acacia auriculiformis	humid
Acacia tortilis	arid
Casuarina equisetifolia	humid, sub-humid
Casuarina glauca	humid, sub-humid
Prosopis cineraria	arid, semi-arid
NFTs tolerant of poor drainage	
Acacia auriculiformis	humid
Acacia nilotica	humid, semi-arid, sub-humid
Acacia saligna	arid, semi-arid
Casuarina equisetifolia	humid, sub-humid
Dalbergia sissoo	semi-arid, sub-humid
Sesbania grandiflora	humid, sub-huid
Sesbania sesban	semi-arid, arid
NFTs tolerant of long dry season (>3–4 months)	
Acacia auriculiformis	humid, sub-humid
Albizia lebbeck	semi-arid, sub-humid
Albizia saman	humid, sub-humid
Dalbergia sissoo	humid, sub-humid
Gliricidia sepium	humid, sub-humid
Leucaena leucocephala	humid, sub-humid
NFTs tolerant of prolonged drought	
Acacia nilotica	arid, semi-arid
Acacia polycantha	arid, semi-arid, sub-humid
Acacia saligna	arid, semi-arid
Acacia senegal	arid, semi-arid
Prosopis cineraria	arid
Prosopis juliflora	arid, semi-arid

In addition to timber, the plants can provide a number of NTFPs of economic value. They may also be sources of food, fodder, gums, resins, fatty oil seeds, medicines, aromatic oils, tans, dyes, fodder and charcoal. Some of the plants provide shade to the companion crop which may be beneficial if the latter is shade loving.

6. Performance of different leguminous multi-purpose tree/shrub species in different agroforestry systems

Trees on farmland

Prosopis cineraria is often grown with millet *(Pennisetum americanum)* and pulses during kharif and wheat in winter. It may be lopped in systematic manner from mid-November to mid-January. It can withstand tract as well as alkalinity. In semi-arid to arid zones trees to be chosen are *Acacia nilotica, A. senegal, Albizia lebbeck* and *Prosopis juliflora. P. juliflora* is reported to ameliorate the soil sufficiently to grow annual crops for at least two years. P. *cineraria* has no adverse effect on crops as reported by Shankaranarayan *et al.* (1987) when associated with green gram/cluster bean from arid zone of Africa. *A. albida* has shallow/horizontally spreading root system and affects the yield of green gram adversely.

Most *Acacia* sp. are grown extensively in and around agricultural fields throughout India. In semi-arid to arid region under insufficient soil moisture regime, *A. nilotica* has adverse effect on companion crops such as wheat. Proper lopping or harvesting may be beneficial (Sinha, 1958). *A. nilotica* is also grown in paddy fields.

In the areas with erratic rainfall in Tamil Nadu, it has been reported that sorghum yields 20% more dry fodder when grown with *Leucaena leucocephala*. It is also associated sometimes with *Dolichos biflorus* (horse gram) and *Pennisetum glaucum* (Tejwani, 1994). Sorghum, pulses, groundnuts and chillies are grown among *Acacia planiforms* trees for four to five years until the tree canopy closes.

Trees like *Acacia catechu, A. modesta* and *Dalbergia sissoo* are preferred in Punjab and the foothills of Shivalik (Grewal, 1992).

Tamarindus indica occurs throughout Tamil Nadu. Reduction in agricultural crop yield caused by this tree is reported to be severe due to its shedding effect. However, in poorer sites this tree should be used.

Leucaena leucocephala has been paid maximum attention. Still not so much information is available about its interaction with companion crop. The tree yields more fodder under 1000–1500 mm annual rainfall range when inter-cropped with maize, black gram, cluster beans, etc. The pure crop paddy, wheat, maize, black gram, cluster bean etc., are much less economical than inter-cropping with *Leucaena*.

Alley cropping of *Leucaena leucocephala* and pearl millet is common in semi-arid tropics of India. It was observed that if the distance between the rows of *L. leucopephala* is increased, crop yield decreases. Alley cropping with groundnut, green gram and black gram also has beneficial effect as *Leucaena* trees yield fodder during drought years also when the crops fail.

Pongamia pinnata another multi-purpose tree has been found to be successfully grown in Andhra Pradesh. *Sesbania sesban* and *S. grandiflora* are two other trees which have immense agroforestry value.

Trees on farm boundaries

Leucaena leucocephala is reported to be one of the best performers. *Delonix elata* a small evergreen Caesalpineaceae member is grown in Tamil Nadu. *Prosopis juliflora* grown on farm boundaries is observed to adversely affect agricultural yield. *Dalbergia sissoo* serves as an effective windbreaker in the semi-arid areas of Haryana.

Trees with plantation crops

In tea plantation *Albizia stipulata* gives definite benefits. Different species of *Albizia* (*e.g. A. odoratissima, A. lebbeck, A. lucida*), *Acacia lenticularis, Derris robusta* and *Dalbergia sericea* are recommended to be grown in mixed stands as shade trees in

North East India. In South India, in addition to *Acacia* sp., *Albizia* sp., *Erythrina lithosperma* and *Indigofera* sp. are also used as shade trees (Dutta, 1997). For coffee plantation *Albizia stipulata, A. lebbeck, A. moluccana, A. sumatrana,* and *Dalbergia* are commonly used as shade trees.

Pastoral silvicultural practices

Acacia nilotica, A. planiformis, Tamarindus indica, Leucaena leucocephala, Dalbergia sissoo, etc. are among the common trees recommended for arid to semi-arid zones. Companion grasses grown successfully with arboreal legumes are *Schimia, Chrysopogon, Eremopogon,* etc. In addition to edapho-climatic factors and agro-ecological situation, the canopy structure of the trees are important considerations. *Prosopis cineraria* is compatible with grasses and facilitates good grass growth and yield.

Herbs in agroforestry

So far herbs have not been used in agroforestry and woody species by definition are the components of agroforestry. But the leguminous herbs of NTFP values can also be included in agroforestry though in depth research is needed. If used they can be involved as only companion crop in a mixed cropping system.

7. Problems

The problems associated with tree species for agroforestry are as follows:

- The tree crown spread which is more than what is needed reduces agricultural crop growth. In that case only growing shade loving crops will be more economical.
- It is always preferable to have deep-rooted tree species. For the above reason *Prosopis cineraria* is more suitable in agroforestry than different species of *Acacia* (Toky and Bisht, 1992). The former will have less competition for nutrients in the soil with the companion crop. It was found that nodules at different soil depths fix different amount of nitrogen. The efficiency of nitrogen fixation decreases with advancement of nodule age and size (Das and Chakravarti, 1992). *Acacia* sp. have comparatively shallow root system.
- The tree should be characterised by fast vertical growth with few branches. In this respect *Leucaena leucocephala* is always better than *Albizia lebbeck.* Singh and Bhargava (1996) rightly suggested a model tree architecture in agroforestry system: as vertical growth, small crown, few branches with narrower angle, loose canopy, straight and clear bole with aggressive apical dominance, deep roots and deciduous nature.

8. Conclusion

Afforestation through the right choice of multipurpose tree, shrub, or herb species considering the edapho-climatic situation and the agro-ecological conditions of a particular concerned region is probably the only way to rejuvenate degraded farmlands. Hence the cultural practices, method of propagation and harvesting of the concerned species should receive primary research priority.

References

Das, P. K. and Chakravarti, V. 1996. Nodulation and Nodule Activity in Different Tree Legumes at Diffent Soil Depth. *Ind. Biologist* 28(2): 72–74.

Dutta, I. C. 1997. Shade Trees, Green Crops and Cover Crop Plants in the Tea Estate of North East India. *Memorandum No. 30*, Tokai Experimentation Centre, Jorhat, India.

Grewal, S. S. 1992. Watereshed Management *Relmajra (Punjab) Annual Report*, CSWCRTI, pp. 142–143.

Huxley, P. A. 1983. The Role of Trees in Agroforestry: Some Comments. In: Huxley, P.A. (ed.). *Plant Research and Agrofoestry*, ICRAF, Nairobi, Kenya. pp. 257–270.

Nair, P. K. R., Fernandes, E. C. M. and Wambug, P. N. 1984. Multipurpose Leguminous Shrubs for Agroforestry. *Agroforestry Systems* 2: 145–163.

Shankarnarayan, K. A., Harsh, L. N. and Kathju, S. 1987. Agroforestry in the Arid Zones of India. *Agroforestry Systems* 5: 69–88.

Singh, V. P. and Bhargava, K. S. 1996. Model Tree Architecture for Agroforestry: a Conceptual Approach, *National J. Plant Improvement* 1: 22–36.

Sinha, R. L. 1958. Fodder Resources of U. P. *Southern Forest Rangers College Magazine* 34: 180–190.

Tejwani, K. J. 1994. *Agroforestry in India.* Oxford & IBH Publication Company, New Delhi, India.

Toky, O. P. and Bisht, R. P. 1992. Observations on the Rooting Pattern of Some Agroforestry Trees in an Arid Region of North Western India. *Agroforestry Systems* 18: 245.

Mathema, P., Dutta, I. C., Balla, M. K. and Adhikary, S. N. (eds.). 1999. *Sustainable Forest Management.* Proceedings of an International Seminar, 31 August – 2 September 1998, Pokhara, Nepal.

Ecological Aspects of Establishment of *Faidherbia albida* (Del.) A. Chev. in Agroforestry in the Sahel

K. R. Dahal and J. Brouwer

Abstract: *Faidherbia albida* (Del.) A. Chev., syn. *Acacia albida* forms the basis for sustainable agriculture through subsistent agropastoral system throughout much of the Sahel. This leguminous tree is unique in its curious habit of dropping its leaves at the start of rainy season, re-growing them at the start of dry season and bearing fruits in the driest part of the year. However, planting this tree in the farm is not a common practice as almost all farmers rely on its natural habitat. An experiment was conducted in International Crop Research Institute for Semi-arid Tropics Sahelian Centre (ISC), Niger in 1991 to study the establishment behaviour of the tree in its early stage on farmer's field. The experiment showed that little care in the planting time and afterwards might considerably increase the survival of the seedlings in initial years after plantation. It was also observed that the tree has site specificity and special preference regarding fertility gradients and nearness to termite mounds.

1. Introduction

Sahel refers to the region in West Africa bordering the Sahara desert from the south between 10^0-16^0 north latitude. This paper concerns only with the semi-arid part of the Sahel. Being not far from the equator, not having big mountains and water bodies and mostly being land-locked, the semi-arid Sahel region has a unique climate characterised by high degree of hotness and aridity. Because of the poor soil fertility and/or inadequate water, most of the lands in general, and the land in northern part in particular, are unsuitable for arable farming. However, people of this region have developed agrosilvipastoral (agroforestry) system to sustain farming in which trees and shrubs play a vital role in crop and animal production and thereby supporting their existence. Cultivation of annual crops (millet, sorghum, etc.) in association with trees leftover while clearing the bushes and/or naturally occurred, known as parklands, is being practised for centuries. The best example is the crop production in the *Faidherbia albida* parklands.

Faidherbia albida, a leguminous thorny tree, is an important component of parkland agroforestry systems in Sub-Saharan Africa and is a well-known and widespread agroforestry species of the semi-arid zone of West Africa. It is revered by the local people and is central to various popular myths and religious belief. The central point of its high appreciation by the people is its so called "albida effect", its beneficial effect on soil fertility and crop productivity under the tree. The albida effect is attributed to the specific characteristics of the tree, a periodicity in bud activity and dormancy, which is totally opposite to that of other general tree species in the Sahel. As a consequence, this tree has a unique and curious habit of dropping its leaves at the start of rainy season, re-growing them at the start of dry season and bearing fruits in the driest part of the year. In practical terms it means:

- By shedding its leaves at the beginning of the rainy season, precisely when cereal crops are sown *F. albida* provides a remarkable natural fertiliser.
- Animals can feed on the leaves through the dry season and on the fruits during the driest part of the year (Baumer, 1990).
- The presence of trees in the crop field reduces potential evapotranspiration and thus provides a better environment for crop growth (Sall, 1992).

Positive influence of *F. albida* tree on soil improvement and crop productivity has been reported by many authors (Charreau and Vidal, 1965; Jung, 1970; Poulain, 1984 as quoted by Sall, 1992). Litter drop combined with high microbial activity in the soil (especially during rainy season) apparently constitute the main soil improving effect of *F. albida* (Sall, 1992). As a result there are "islands of fertility" around mature *F. albida* trees which are characterised by increased levels of soil organic matter, cations and phosphorus. Crops can grow under the crown of the tree without any yield reduction due to shading and there is even report of increased sorghum yield by 60% under the canopy of the tree (Rocheleau *et al.*, 1988). In the same way the influence of the tree on millet yields is both quantitatively and qualitatively remarkable (Sall, 1992). Positive effects of *F. albida* has also been reported in the trials on maize and sorghum in Ethiopia (Poschan, 1986) and on wheat in Sudan (Blair, 1963 as cited by Wickens, 1969).

F. albida is reported to be associated with many environmental changes at the micro-environmental level that results in a more favourable agroecological environment and provides the opportunity for increased diversity of cropping with the traditional millet growing regions of Africa (Williams, 1992). The land under the tree can be cultivated intensively without fallow period hence sustaining the agricultural systems throughout much of the Sahel.

Despite the obvious benefits of the tree, its density is on decline in many places in the region (McGahuey, 1992). Dancette and Saar (1985) as quoted in McGahuey (1992) report the disappearance of many *F. albida* parks over the last 20 years and link the reduced productivity of these areas to this disappearance. Planting this tree in the farmer's fields is not common and farmers usually rely on its natural stand. Although there has been much effort in the past 20 years or more to introduce /or re-introduce the tree in the farmer's field, the success is limited. Torrekens *et al.* (1992) have reported the high mortality rate and slow growth of this tree which, among others, probably may have limited its successful plantation by the farmers.

Considering the importance of *F. albida* in sustaining the farming systems throughout much of the Sahel, an experiment was conducted in ICRISAT Sahelian Centre (ISC), Niger in 1991, to study the ecology of establishment of outplanted seedlings in the farmer's field. This paper presents the result of some of the parameters of the seedling growth studied at their early stage of growth.

2. Materials and methods

The experiment was conducted at International Crop Research Institute for Semi-arid Tropics Sahelian Centre (ISC), 45 km south of Niamey, Niger. The site receives an average of 562 mm of rainfall most of which falls during June–September. Aggregate potential evapotranspiration during the dry months of October–May is 1820 mm. The soil is a deep reddish sand with moderate acidity, poor water retention capacity and low nutrient status with a water table depth of about 30–40 m.

F. albida seedlings were planted in early August, 1991 in an experimental field with 13 columns each of which were divided into 9 rows, making a total of 117 plots of 10 m x 10 m size each. Seedlings in tubes made of 40 cm long black polythene bags, filled with local soil were planted at 2.5 m x 2.5 m spacing accommodating a total of 1,872 seedlings in the field.

Data on seedling height and diameter (at 10 cm above the soil surface), starting from October 1991 till April 1994, with an interval of three months, were taken. Seedling survival was recorded regularly. Due to the similar trend in the growth of seedling height and diameter, only the data on seedling height is presented in this paper. Data up to April 1993 were used to analyse the growth behaviour of the seedlings, except for the calculation of survival percentage where the data from the whole observation period were used. Survival status of the seedlings in the field, in percentage, during the time was calculated by counting the number of dead seedlings in the whole experimental basis (n = 1872) at each observation date. Calculation of maximum, minimum and mean (n = 1872), damaged seedlings were excluded from the calculation (wherever necessary) for seedling height and diameter were performed in whole experimental scale. Only the result of the dynamics of maximum and minimum in seedling height is considered to serve the purpose of this paper. Old termite mounds were located in the field and minimum distance from the plot to the termite mounds (MDT) was determined by the following steps:

- Locating the 5 termite mounds in the field and fixing their X and Y co-ordinates.
- Locating the co-ordinates of the plots distance to which was needed to know.
- Distance (D) in metre was calculated by using the formula:

$$D = \{(X_T - X_P)^2 + (Y_T - Y_P)2\}^{0.5}$$

Where, X_T and X_P are the X and Y co-ordinates while Y_T and Y_P are the Y co-ordinates of termite mounds and experimental plots, respectively. MDT from each plot to the termite mound was found by sorting those distances in ascending order. Regression analysis of seedling height with MDT was done. Seedling height taken in January, 1992 and July, 1993 were used in regression analysis as the former shows the point where recession in seedling growth starts and the latter is the point where growth starts progression.

3. Results and discussion

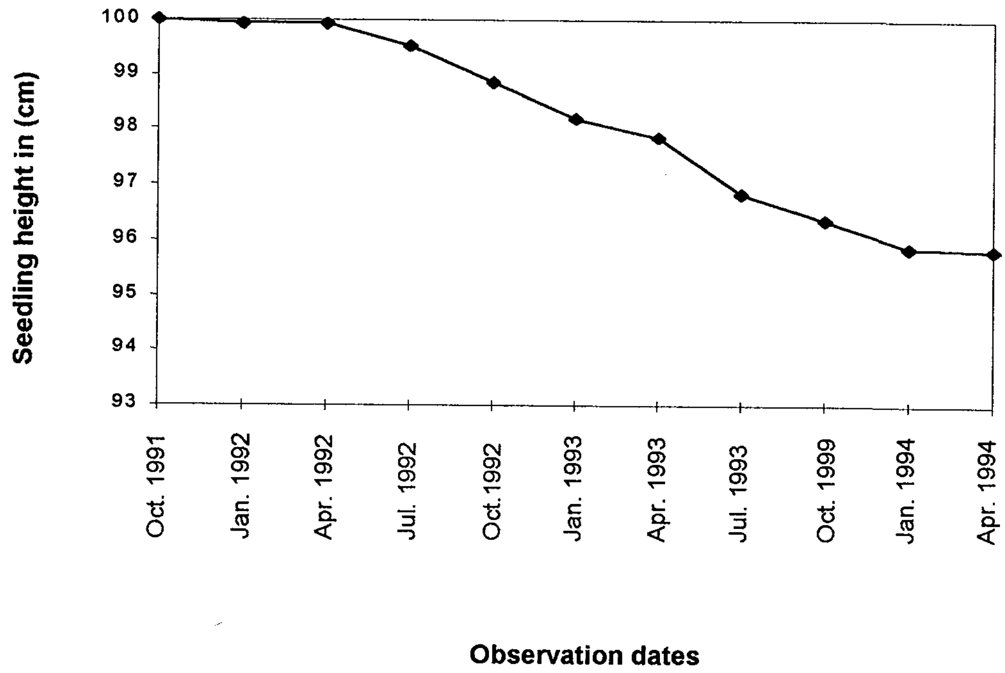
Survival status

The graph of seedling survival in the experimental field (Fig. 1) shows a good survival percentage, of about 96% up to 32 months after planting. High survival percentage found in this experiment contradicts with the low survival of the tree generally reported in the literature (Buccowich, 1990; Torrekens *et al.,* 1992). McGahuey (1992) reports high variation in the survival rate, which he relates with many factors such as seedling size, rainfall distribution, supervision and so on. The higher survival rate of the seedlings in our experiment is possibly, due to the watering of the pits at the time of planting and protection from livestock. However, the increasing mortality of seedlings with time suggests that long term study on this parameter is needed to better understand the establishment behaviour of outplanted seedlings in the field.

Maxima and minima

The data on seedling height shows a big gap between the maxima and minima. This may be due to the difference in response of seedlings to the spatial variation in the field. Brouwer *et al.,* (1992) reports that spatial variability in the growth rate of crop and trees over distances of only 5–20 m is widespread in the Sahelian zone of West Africa. This effect is largely due to pre-existing variability in soil physical and chemical properties (Scott-Wendt *et al.*, 1988; Manu *et al.*, 1990 cited by Brouwer *et al.,* 1992). Most probably, the seedling that happened to be planted in fertile microsite establishes itself quicker and continues to grow faster than the rest of the seedlings. It also indicates the large fertility variation in the field.

Figure 1. Dynamics of survival of *F. albida* seedlings in percentage



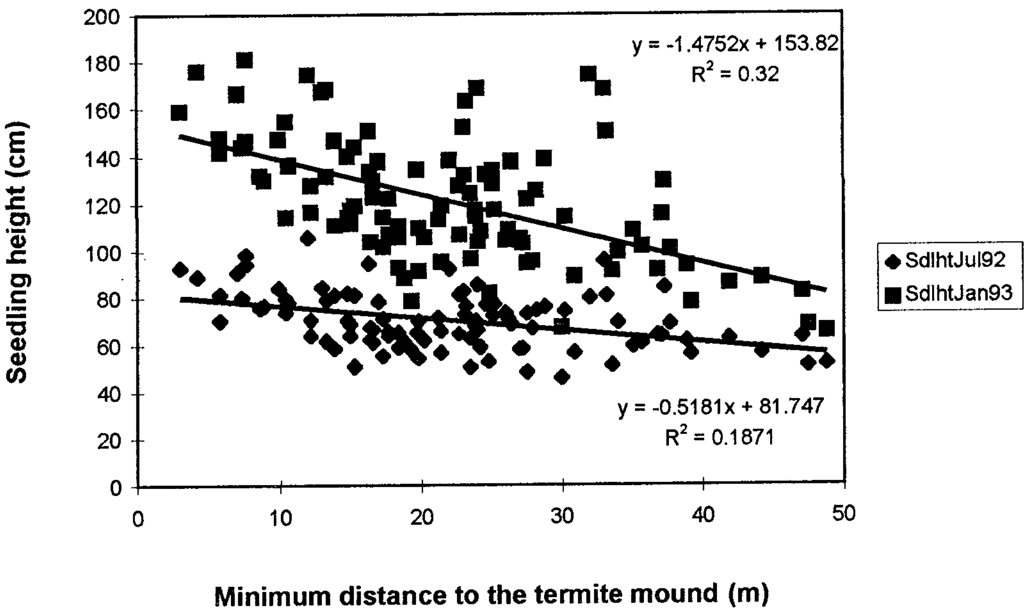
Plant height by column

The average seedling height by figures show a low response of seedling height to the spatial variation (in north-south direction of the field) in their early stage of growth. But when the seedlings grow further there is a trend of poor growth in the south. This growth pattern is, probably, due to the topographical variation and fertility gradient decreasing towards the south. Seedlings show better growth in 5th column from the beginning and in the 2nd and 8th column about 22 months after planting showing the effect of fertile microsite on seedling growth. Distinct higher growth in these pockets is associated with the presence of old termite mounds in these parts of the field. Better growth of *F. albida* around termite mounds has been reported by Brouwer *et al.* (1992).

Seedling height and termite mounds

The regression analysis of seedling height of the observation dates, July 1992 and January 1993 and minimum distance to the termite mounds (Fig. 2) shows a positive correlation: the more the distance from the termite mounds the less the seedling height. The older seedlings have strong correlation with the nearness to the mounds as they have higher demands for nutrients and other favourable soil factors. The positive effect of termite activities on the growth of *F. albida* has been reported by many authors involved in similar research (Brouwer and Bauma, 1997). An association between abandoned termite mounds and increased seedling growth could be attributed to: (1) water harvesting from the surface of the mound, where rain falling on the crusted surface runs off and is concentrated in the surrounding soil; and (2) increased fertility of the soils beneath the mound due to an enrichment in clay (Geiger *et al.*, 1992).

Figure 2. Relationship between average seedling height (in July 1992 and January 1993) and minimum distance to the termite mounds



4. Conclusion

Based on the analysis of the available data the following conclusions can be drawn:

- Watering the seedlings during plantation and protecting them from livestock can ensure good survival of seedling.
- There is a high difference between the maximum and minimum seedling heights suggesting the presence of fertile microsites in the field and special response of the seedling to those sites.
- There is spatial variation (fertility gradient along north-south direction) and old abandoned termite mounds (in 2nd, 5th and the 8th columns) in the field, which have profound effect on seedling height.
- There is strong influence of old (abandoned) termite mounds in the field on the growth of outplanted seedlings of this tree.
- Planting *F. albida* seedlings around abandoned termite mounds wherever possible, watering of the pit during planting and protection of seedlings from the livestock are recommended.

References

Baumer, M. 1990. *Agroforestry and Desertification.* Technical Centre for Agricultural and Rural Co-operation. ACP-Lome Convention, Wageningen, The Netherlands.

Brouwer, J. and Bauma, J. 1997. Soil and Crop Growth Variability in the Sahel: Highlights of Research (1990-95) at ICRISAT Sahelian Centre. *Information Bulletin No. 49,* ICRISAT, India and WAU, Wageningen, The Netherlands.

Brouwer, J., Geiger, S. C. and Vandenbeldt, R. J. 1992. Variability in the Growth of *Faidherbia albida*: a Termite Connection? In: Vandenbeldt, R. J. (ed.). *Faidherbia albida* in the West African Semi-Arid Tropics: Proceedings of a Workshop, 22–26 April 1991, Niamey, Niger. pp. 131–135.

Buccowich, M. 1990. *Faidherbia albida. Forestry* 504 pp. 71

Geiger, S. G., Vandenbeldt, R. J. and Manu, A. 1992. Preexisting Soil Fertility and the Variable Growth of *Faidherbia albida*. In: Vandenbeldt, R. J. (ed.). *Faidherbia albida* in the West African Semi-Arid Tropics: Proceedings of a Workshop, 22–26 April 1991, Niamey, Niger. pp. 131–135.

McGahuey, M. 1992. Extension of *Acacia albida*: Recapitalization of the Natural Resource Base. In: Vandenbeldt, R. J. (ed.). *Faidherbia albida* in the West African Semi-Arid Tropics: Proceedings of a Workshop, 22–26 April 1991, Niamey, Niger. pp. 159–164.

Poschan, P. 1986. An Evaluation of the *Acacia albida* Based Agroforestry Practices in the Hararghe Highlands of Eastern Ethiopia. *Agroforestry Systems* 4(2): 129–143.

Rocheleau, D., Weber, F. and Field-Juma, A. 1988. *Agroforestry in Dryland Africa.* ICRAF, Nairobi, Kenya.

Sall, P. N. 1992. Site Effects of *Acacia albida* Del. In: Vandenbeldt, R. J. (ed.). *Faidherbia albida* in the West African Semi-Arid Tropics: Proceedings of a Workshop, 22–26 April 1991, Niamey, Niger. pp. 103–105.

Scott-Wendt, J. W., Chase, R. G. and Hossner, L. R. 1988. Soil Chemical Variability in Sandy Ustlfs in Semi-Arid Niger, West Africa. *Soil Science* 145: 414–419.

Torrekens, P., Lemane, I. and Gambo, S. 1992. Trial on Nine *Acacia albida* Provenences in Dosso, Niger. *in Faidherbia albida.* In: Vandenbeldt, R. J. (ed.). the West African Semi-Arid Tropics: Proceedings of a Workshop, 22–26 April 1991, Niamey, Niger. pp. 77–78.

Wickens, G. E. 1969. A study of *Acacia albida* Del. (Mimosoideae). *Kew Royal Botanical Garden Kew Bull.* (23): 181–201.

Williams, J. H. 1992. The Agroecological Significance of *Faidherbia albida*. In: Vandenbeldt, R. J. (ed.). *Faidherbia albida* in the West African Semi-Arid Tropics: Proceedings of a Workshop, 22–26 April 1991, Niamey, Niger. pp. 127–129.

Mathema, P., Dutta, I. C., Balla, M. K. and Adhikary, S. N. (eds.). 1999. *Sustainable Forest Management.* Proceedings of an International Seminar, 31 August – 2 September 1998, Pokhara, Nepal.

Sustainable Management of Himalayan Ecosystem through Societal Approach

B. N. Gupta, R. M. Singhal and V. Kumar

Abstract: This paper discusses the socio-economic study done in a part of Henwal watershed of Tehri Garhwal district, India. The study revealed that agroforestry activities in the area were influenced by various factors. The extent of tree planting positively correlates with the size of farm holdings, the size of households and the total number of livestock kept. However, it negatively correlates with the age of the household head.

1. Introduction

Although significant attempts have been made during the past decade to find a way to work towards a people-oriented policy, there is yet to be a true people-oriented policy fulfilling local needs and conserving biodiversity in the real sense of the term. Sustainability requires local partnership in forest management coupled with improved technologies. A "community-based resource management" approach, in which local communities are actively involved in the planning, decision-making and implementation of resource management policies complemented with sustainable technologies is therefore, advocated by this paper. Sustainable technologies are advocated through this paper along with institutional issues and strategies to rehabilitate the degraded areas of Himalayas.

The justification for community-based resource management is based on three major premises: a) local people rely directly on local natural resources for their immediate survival, so they have strong incentives to manage these resources judiciously and sustainably; b) local people possess intimate indigenous ecological knowledge and have for many years, developed and employed effective traditional resource management practices; and c) since centralised approaches have had limited success in promoting sustainable resource management at a local level, alternative approaches based on participatory and decentralised management and decision-making.

Resource management involves: the physical resource base (land, water, flora, fauna, climate, etc.), the production system (including an array of knowledge systems, production activities and technologies), and the institutional arrangement including laws and policies, institutions, administrative approaches and procedures, incentives, education, training, extension and public participation. This paper discusses some of these elements and specifically, the institutional arrangements and prospects for community-based resource management for eco-rehabilitation in Himalayan watersheds.

2. Methodology

The approaches were based on expected utility model (EUM) and models based on safety-first or risk minimisation decision rules. The EUM was based on the assumption that farmers maximise expected utility (expressed as a function of profit/income, leisure, and adequacy of basic goods) subject to land and labour availability, credit, and other resource constraints. Profit or income is expressed as a function of crop and technology choices, prices of inputs and outputs, and the annualised costs of the technologies. Expected utility is determined as a function of the choice of a technology mix, including traditional practices and the set of available innovations (for example, agroforestry combinations, high-yielding varieties, and no tillage). Solving this optimisation problem each period determines the farmer's choice of technology and the allocation of land and inputs for crops. Information of actual yields, revenues, and profits are used to update the parameters the farmers use in making the decisions for the next period. A sample area was selected in the Henwal watershed of district Tehri Garhwal, between 30^0 15'–30^0 20' N latitude and 78^0 25'–78^0 30' E longitude (total area 461.7 ha, elevation 1600–2000 m). It consists of 15 micro watersheds. In one of the micro watersheds (No. 8) of the Henwal river, nine villages, viz. Bhandar Gaon, Jaul, Semalwari, Sudhra, Gwar, Syuta Bara, Syuta Chhota, Dikhol Gaon and Manjyur were selected for the socio-economic survey.

Household survey of the area was carried out using a structured and close-ended questionnaire. Data pertaining to demography, land use, occupation and employment, cast composition, literacy, residential house/cattleshed condition, family size, land holding, annual income, livestock population, fuelwood/fodder requirements, distance to travel for fuelwood/fodder collection, distance of grazing lands, etc. were collected on census basis (100% household survey). Baseline survey was carried out on 10% of household in each site selected at random, to prepare socio-economic and ecological profiles of areas damaged by shifting cultivation and mining. A structured questionnaire translated in local language was used for this purpose.

The information collected included demands for agroforestry goods and services; choices of species for food, fruit, wood, fodder, vegetable and grasses; desired extent of participation in conservation of forest resources as per the criteria established by the project; and socio-economic constraints faced by the villagers in adopting new land use systems. Data collected from the survey were analysed statistically by database and SPSS packages.

Setting of priority PRA methods were adopted to identify priorities of people in the Henwal watershed. The method used was matrix scoring and ranking. The methods of ranking and scoring revealed priorities and preferences and provided opportunities to rural people to physically rank some items or preference of some uses and explain the reason for a given ranking. For the identification of the priority, fixed matrix scoring method was used. The success of these methods is influenced by the facilitation of the villagers.

2.1. Data analysis

The information obtained from the survey was used in modelling some of the factors which are postulated to affect the tree and grass planting activity in these villages. A linear regression model was adopted for the purpose and the method of ordinary least square was used for calculating the regression equation.

Null hypothesis: HO: TTGP ... *f* (FS, HS, DWFOD, AGE, TANI, DFUEL)
(Implying that the regression coefficient $B_{1 \ldots 6} = 0$)

Alternate hypothesis: TTGP = *f* (FS, HS, DWFOD, AGE, TANI, DFUEL)

In developing the regression equation, coefficients were not zero and independent variables did not explain the dependent variables. The dependent and independent variables were defined as follows:

The dependent variable

TTGP = The total number of tree seedlings and grass cuttings planted by each household (in farmers plots). It was hypothesised that the impact of the factors that influenced agroforestry activity in the farmer's plot was reflected in the number of tree/grass cuttings that the household ultimately managed to plant.

The independent variables

FS (Farm Size) = The size of the farm owned by the household. Since planting was to take place in the farmer's plot, FS was considered a very important factor. It was hypothesised that all the things being equal, farmers with bigger farm size would plant more trees/grass species.

HS (Household size) = It was hypothesised that more labour would be available in the household for tree/grass planting, resulting in higher number of trees/grass planted by the household, other factors being constant. In defining this variable it was important to consider only those households who were "potential participants" in the planting activity at household level. Only household members in the age group of 13 to 70 years were considered for the purpose.

DWFOD (Number of days per week when household member collect fodder) = It was hypothesised that as DWFOD increased, less time would become available for the planting activity.

AGE (The age of household head) = In the study area, the household head has the final decision in almost every aspect. Age is normally a very important factor which influences decisions. The hypothesis here was that older household heads would tend to put less time in the planting activity because of old age problems. But AGE had positive impact because it is always prestigious for old man in the study area to die and leave behind valuable property such as well-established farm for their children to inherit.

TANI (Total number of animals kept in the household i.e. cattle, goats and sheep) = Poultry was excluded from the trial because they are not dependent on fodder. Since stall-feeding is a common practice in the study area, it was hypothesised that TANI could influence the planting activity in two ways. More TANI means labour shortage in the household resulting in less trees/grass planted by household. It could also motivate farmers to plant more trees and grass species due to fodder shortage.

DFUEL (Distance travelled in fuelwood collection by household members) = It was hypothesised that with longer distances, less time would be available at the household level for the planting activity, implying that fewer tree/grass would be planted. Longer distances also had a positive impact on people planting more trees to reduce their problems.

Test applied

A 't' test at 0.05 level of significance was applied. The null hypothesis (was rejected when calculated 'p' value was less than 0.05. However the independent variables were tested for multi-colinearity. This was achieved by making a correlation analysis among the independent variables. The correlation coefficients (r-values) were used to indicate the strength of inter-correlation among the variables by considering the corresponding r^2 values.

3. Results and Discussion

The people enlisted nine major priorities. The first priority was given to fodder. Villagers said that due to the shortage of green fodder they were not rearing improved breeds of cattle for milk production. The acute shortage of fodder is experienced in winter season. Second priority was given to fuelwood. The villagers argued that forests were shrinking day-by-day and there was a crisis of fuelwood in the villages. Third priority was given to water. Natural water sources were diminishing day-by-day. In summer season people experience acute shortage of water. People gave fourth priority to timber. The availability of timber for house construction is insufficient. The prices of timber in the market are unaffordable. The fifth priority was given to market. People said that due to unavailability of market, they were compelled to sell their produce in the community at lower prices. Distance of market was also more from these villages. Sixth priority was given to transportation facilities. All the nine villages are situated far from highway. There are no means of transportation except walking or mules. Villagers suggested that road construction should be done to improve transportation facilities. Animal health was given sixth priority along with transportation. There was no Animal Health Care Centre near these villages. Villagers wanted to rear improved breeds of cattle for more milk production but due to unavailability of bull and other health facilities, this was not practised. Land consolidation was given seventh priority. Lands were fragmented. More time is consumed to reach the fragmented lands. Management of such lands was expensive. People argued that land consolidation was essential.

3.1. Screening of species

Screening of the species suitable for fodder, fuelwood, timber and multipurpose uses and for plantation on private lands was done following the fixed matrix scoring methodology. In these villages forests have become degraded due to overexploitation. Efforts were made to select the species for domestic uses with the people's perception and opinion. In all the nine villages people sat together and discussed their priorities and enlisted the species found in the area. This group decided the criteria for the importance of the species and gave marks for each criterion. They determined the ranking of the species. This methodology was used to screen species suitable for fodder, fuelwood, timber and multiple purposes and for plantation on private lands.

Fodder species

Tree species: Screening of the fodder tree species in the villages was done by adopting the fixed matrix scoring method. Villagers were facilitated to enlist the fodder species. Availability, easy transportation, palatability, and animal preference were the criteria for the screening of fodder species found in the study area. Ten marks were allotted for each criterion.

Grewia optiva (bhimal) ranked first. Villagers argued that this species is available on the farm bunds. Main feature of bhimal is its availability in lean fodder period (in winter). Feeding the leaves of bhimal to the animals increases milk production. *Celtis australis* (kharik) ranked second, *Bauhinia* sp. (achnar) ranked third, while *Morus* sp. (kimbu) and *Toona ciliata* (toon) ranked fourth followed by *Melia azedarach* (daikan) and *Quercus leucotrichophora* (banj). The latter two, though important fodder species but not easily available, require long travel for collection. Serrated margin of the leaves of banj also makes it difficult for collection. *Alnus nepalensis* (utis) and *Prunus cerasoides* (padam) ranked seventh. *Aesculus indica* (panger) received the last priority. Thus the order of preference was *Grewia optiva* > *Celtis australis* > *Bauhinia* sp. > *Morus serrata* or *Toona ciliata* > *Melia azedarach* > *Quercus leucotrichophora* > *Alnus nepalensis* or *Prunus cerasoides* > *Aesculus indica*.

Fodder grasses: Screening of fodder grasses was done by using fixed Matrix Scoring Method. Four criteria, were followed for the purpose which included availability, ease in transportation, palatability and preference of animal. Each criterion was allotted ten marks. Villagers were facilitated to use the matrix and scoring method. The species of fodder grasses were ranked in the order, *Chrysopogon fulvus* (golda) > *Cynodon dactylon* (doob) > *Cenchrus ciliaris* (anjan) or *Heteropogon ontortus* (kumeria) > *Eragrostis uncoloides* (bansaria) or *Paspalus dilatatum* (dalis) > *Panicum miliare*. *Chrysopogon fulvus* was ranked first while *Panicum miliare* last (sixth). The perception and opinion of women were given priority while determining suitability. Village women argued that *Chrysopogon fulvus* is a long grass and easily available and easy to transport. Animals also prefer this grass.

Fuelwood species

Screening of fuelwood species available in the study area was done by the fixed matrix scoring method. Six criteria, i.e. smokelessness, inflammability of wood, ease in transportation, effect on the taste of food, ash and coal production were used for the purpose of screening. Each criterion was allotted ten marks. The species, which got maximum marks, ranked first and which got minimum marks ranked last. On the basis of people's perception and opinion the species suitable for fuelwood were ranked in the order *Quercus leucotrichophora* (banj) > *Grewia optiva* (bhimal) > *Pinus roxburghii* (chir) > *Toona ciliata* (toon), *Rhododendron arboreum* (gurans) or *Lyonia ovalifolia* (anyar) > *Myrica esculenta* (kafal) > *Alnus nepalensis* (utis).

Timber species

The screening of timber species was also done, following the fixed matrix scoring method. Efforts were made to choose the species really preferred by local people. Villagers used five criteria viz. soundness, resistance to insect and disease, clean bole, knot free and price for the ranking of timber species. Ten marks were allotted for each criterion. *Cedrus deodara* (deodar) ranked first and *Pyrus pashia* (mehal) ranked sixth. Villagers felt that *Cedrus deodara* was best suited for construction purposes but its higher price made it unaffordable. This species because of sound wood quality, resistant to decay, clean bole and knot free timber got first priority. The species suitable for timber and found in the study area were ranked in the order of *Cedrus deodara* > *Pinus roxburghii* (chir) > *Quercus leucotrichophora* (banj) > *Juglans regia* (akhrot) > *toona ciliata* (toon) > *Pyrus pashia* (mehal).

Multipurpose tree species

Screening of the multipurpose tree species available in the study area was also done by the methodology adopted in other cases. *Grewia optiva* ranked first, *Morus serrata* ranked second, *Toona ciliata* ranked third, *Juglans regia* and *Myrica esculenta* both ranked fourth. *Quercus leucohrictophora* ranked fifth, *Bauhinia* sp. ranked sixth, *Pinus roxburghii* ranked seventh, *Comus capitata* (bhamora) ranked eighth. *Cedrus deodara* ranked ninth. *Rhodendron arboreum* and *Alnus nepalensis* were the least preferred.

Species suitable for plantation on private lands

The order of ranking decided by the villagers for the species to be planted on private lands was *Grewia optiva* > *Quercus leucotrichophora* > *Morus serrata* (kimu) > *Celtis australis* or *Ficus* sp. (dudhila) > *Prunus cerasoides*. Villagers were aware of fast growing species *Populus ciliata* but they did not favour it because it shelters birds that damage crops and has no market for its timber.

3.2. Farmers participation in agroforestry activities

Population in the watershed area is dependent on forest for fodder, fuel and timber. Due to rapid increase in population, the forest resource is not enough to fulfil the requirements of population. Due to felling of trees, forests have become degraded. Screening of species suitable for planting on private land was therefore, done by people's perception and opinion. People gave their priorities for species like *Grewia optiva* and *Morus* sp. for the private lands. *Chrysopogon fulvus* was the grass species preferred by farmers for planting on unirrigated land. Seedlings were raised in nursery. *Grewia optiva, Morus* sp. and *Chrysopogon fulvus* were distributed freely to farmers. Seedlings were provided according to their requirements. A total of 978 seedlings were planted by farmers on their private lands. Analysis of the determinants affecting farmer's participation was done. Plantation was done in 1994 with participation of 80 farmers in the study area. A total of 80 households participated in plantation activities. After plantation a base line survey of all the households who participated in activities was done. A structured close-ended questionnaire was used. The questionnaire elicited among other things, household status, fuelwood, animal fodder situation and number of species planted.

3.3. Land distribution and household size

Results suggest that the problems of land scarcity and high population density per household are experienced in Henwal watershed. Only 4% of households have farmland of more than 1 ha but on an average, each household owns about 0.58 ha of land with average household size of 9.9 people (a standard deviation of 3.616). This indicates that population density of about 17 people per ha of arable land goes up by almost one person per household.

3.4. Animal husbandry and fodder availability

About 20% of the surveyed households do not have cattle. The reason for not having livestock is too small land holding to allow on-farm fodder production and non-inheritance of livestock from their parents or no capacity to buy. Mean livestock number per house from the surveyed households was 2.20, 2.30 and 1.60 with the standard deviation of 1.23, 1.49 and 1.32 for cattle, goats and sheep, respectively.

On the slopes, where animals are normally stall-fed, only a few animals are kept per household. Cattle and goats are preferred over sheep. On these slopes each household kept on an average 2.2 cattle, 2.3 goats and 1.6 sheep. But a substantial number of poor farmers keep less productive local breeds because they could not afford to buy improved breeds. Farmers collect animal fodder from forest, farms, open areas in villages, and other distant places. A decline in number of livestock per household over the last two censuses was only because of fodder shortage. These households who keep livestock have to spend on an average of 3.2 hrs per day for fodder collection.

3.5. Energy situation and fuelwood availability

All households use fuelwood and crop residues for fuel. Each spends 3.75 hrs everyday on fuelwood collection. About 72% households send women and children for fuelwood collection. One adult and one child from each household collect fuelwood every day. The average distance travelled for this purpose is 2.6 km. Tree pruning in the farms is quite common.

3.6. Agroforestry activities in farmer's fields

About 76% of the respondents planted seedlings in their farms. Of these, 85% planted along their farm boundaries and terraces and the remaining 15% with other crops. Among the species planted are *Grewia optiva, Morus* sp. and *Chrysopogon fulvus.* On an average, each household used 2 adult labour for at least

6 days and one child labour (mostly primary school drop out) for at least two days for planting trees.

3.7. Multicollinearity

The values in the correlation matrix (Table 1) are the correlation coefficients for each pair of independent variables tested. Results show that the situation of having perfectly uncorrelated independent variables is not attained. The variables which have the highest correlation are HS and TANI, but the "r" value (0.504) is considered reasonably low because its square value is 25% and quite far from 100%. Therefore, the variables have been accepted for the model.

Table 1. Correlation coefficients for independent variables

	AGE	TANI	DFUEL	HS	DWFOD	FS
AGE	1.00					
TANI	0.295	1.00				
DFUEL	0.370	0.153	1.00			
HS	0.386	0.504	-0.431	1.00		
DWFOD	-0.186	-0.018	-0.109	0.134	1.00	
FS	0.112	0.307	-0.074	0.158	-0.337	1.00

3.8. Linear regression equation

The linear regression equation developed is:

$$\mathbf{TTGP = 978 + 145\ FS + 13.0\ HS - 41.9\ DWFOD - 6.49\ AGE + 21.7\ TANI - 20.5\ DFUEL}$$
$$\mathbf{(R^2 = 76.2\%)}$$

Table 2 gives a summary of the significance tests. From the regression equation, the null hypothesis was rejected in favour of the alternative hypothesis.

Table 2. Significance tests for different variables in Henwal watershed

Predictor	Coefficient	t-value	p-value
Constant	978.4	3.71	0.001
FS	144.5	3.02	0.004*
HS	12.993	2.31	0.025*
DWFOD	-41.91	1.13	0.263
AGE	-6.495	4.67	0.000*
TANI	21.678	3.12	0.003*
DFUEL	-20.494	2.29	0.027*

* Significant at 5% level

This implies that these factors were important in explaining the total number of seedlings planted by the households in the study area.

4. Conclusion

The study revealed that the agroforestry activities in the Henwal watershed were influenced by various factors. Since the extent of planting activities were positively correlated with size of farm holdings, the size of households and total number of livestock stall-fed by the farmers. However, these values are negatively correlated with the age of the head of the household. It was found that younger generation was more receptive to experimentation with trees.

Mathema, P., Dutta, I. C., Balla, M. K. and Adhikary, S. N. (eds.). 1999. *Sustainable Forest Management.* Proceedings of an International Seminar, 31 August – 2 September 1998, Pokhara, Nepal.

Dynamics of Fodder Trees in the Middle Hills of Nepal

B. P. Kayastha, M. H. Khan, S. N. Adhikary,
R. A. Khan, K. R. Tiwari and K. M. Shrestha

Abstract: Traditionally farmers have been planting fodder trees on their farmland and around homesteads to fulfil the demand of green fodder for their livestock. Green fodder is essential particularly during dry season, when other sources are scarce. This paper presents and discusses the results of fodder tree survey done in five districts in the Middle Hills of Nepal. It was found that different types of fodder tree species are planted on private land. Variations in fodder trees according to regions and altitude are also examined. Five most preferred fodder tree species in each development region according to farmer's experience based on characteristics such as palatability, milk production, nutrition, availability, etc. are also identified. Different aspects of fodder tree management are also discussed.

1. Introduction

The Middle Hills of Nepal is composed mainly of ridges and valleys. The elevation ranges from 200 m to the highest point on the ridges about 3000 m (HMG, 1988). Long and intensive use of land is evidenced by the intricate, extensive terrace systems. It is also characterised by a large number of landslides, soil erosion and loss of forestland. There is a high concentration of population in the Middle Hills. The major land use consists of about 2.5 million ha of forestland including shrubland and grassland, and about 1.2 million ha of farmland (EPC, 1993).

The agricultural system in the Middle Hills is a combination of crop and livestock production in which the heavy dependence on trees and forestland is a significant feature. Crop production is largely practised on terraced slopes. On terraced land soil nutrient losses through topsoil erosion can be replaced by compost addition. The maintenance of fertility of farmland in the Middle Hills is dependent on the application of animal manure and the import of nutrients in the form of fodder, animal bedding and leaf litter from adjacent forest. The gradual decline in soil fertility and eventual loss of productive land through soil erosion together with population growth has resulted in greater utilisation of marginal land.

Livestock raising is a fundamental component of hill farming system. Livestock, together with man, provides virtually all the draught power required for crop production. Sale of livestock and their products are an important source of farm income. Almost every farm family maintains a range of animals, namely: cattle, buffaloes, sheep, goats, pigs and poultry. On a per capita basis Wyatt-Smith (1982) estimated one large animal per person or 5–6 large animals per family. On higher altitudes where animal husbandry is the main occupation the number may be more.

Of particular interest in the hill farming systems is the presence of a variety of multipurpose trees and shrubs on farmland. Farmers usually plant fodder species, fruit species and fuelwood species on their farmland. These farmland trees and shrubs play an important role not only in conserving soil but also provide much needed fodder, fertiliser, fuelwood, fibre and several other products. Forest products are of great significance in the hill economy. Farmer utilises these products free of cost. Although some of these products are available from farmland they are not in sufficient quantity to fulfil their needs.

1.1. Importance of fodder trees in rural economy in Middle Hills

Farmers in the Middle Hills of Nepal have long tradition of using fodder from trees to feed their animals. Farmers depend on their livestock for meat, milk, manure and draught power. Buffaloes, cattle, sheep and goats are the most common farm animals kept by farmers, but in terms of fodder use, buffaloes and cattle are the most important. Because of limited resources, animals suffer from malnutrition in this region. During the dry season farm animals often suffer weight loss and parasitic disease. It is in this period, that fodder trees play a key role in providing green fodder to animals. Although farmers know little about their chemical properties, they have considerable knowledge of their empirical nutritional quantities (Amatya, 1992).

According to Panday (1982) there are over 100 species of fodder trees in Nepal. Shah (1980) reported that over 35 species are used in Phewa Tal watershed area. Dutt (1977) stated that some 40 tree species are used for fodder in the hills of eastern Nepal. Although there may be several species used for fodder, the number of tree species planted on the farmland may be few. These tree species vary from one region to another. Most of the tree species are lopped only once a year. However, there are few species, which can be lopped twice a year. Farmers usually lop the trees in the forest from top to the bottom almost all the re-growth that has come up in one year. But they lop their own trees on the farmland with much care.

1.2. Fodder requirement in the Middle Hills

Estimating the consumption of fodder by animals is a difficult task. Different methods have been used by foresters and livestock scientists to estimate tree fodder productivity. While foresters are more interested in trees, livestock researchers are more interested in animals. Thus, foresters analyse yield in terms of leaf and branch biomass (Pradhan, 1982) while livestock researchers concentrate on utilisable fodder and leaves and are particularly interested in quality assessed by chemical analysis.

Various estimates of fodder use have been made (Shah, 1980; Panday 1982; Wormald, 1975). While this is useful background information, it is not very useful for comparing the potential information of different species because it ignores growth rate. Since there is a large variation in lopping practices of farmers, within and between trees, and between feeding habits of different animal types a very large sample of animals and farmers would be required to make any reasonable estimate. In addition to this, fodder includes crop residues and grazing of animals in the forest. Hence these estimates may only be rough. However, there is general agreement that consumption far exceeds supply. Panday (1982) has made some estimates on the present supply and demand of fodder with an annual demand of 2 tonnes Dry Matter per livestock unit (one buffalo = one livestock unit). At present the fodder deficit is about 1.3 million tonnes of Total Digestible Nutrients (TDN) or 17% of the demand. Even though there is variation in how important tree fodder is in feeding livestock in the Middle Hills, it is notable that there is considerable demand of tree fodder. Where there is sufficient tree fodder to satisfy the needs, its use is of more or less the same order as fuelwood use in terms of biomass.

There are several reports (FAO, 1974 and Integrated Hill Development Project, 1980) which demonstrate that there exists a tremendous livestock population pressure. ADBN (1982) has estimated that the density of livestock per hectare of cultivated land in the hills is 6.3 livestock units and it is the small farm sizes, which have the highest livestock population densities (Hopkins, 1983; Heuch, 1986). Thus, because of limited feed resources only milking animals, particularly buffaloes, are given better feed.

1.3. Distribution and ownership of fodder trees

There are two major sources of tree fodder for farmers: a) private owned tree and b) tree fodder from forest and shrubland.

a) *Privately owned trees*

Fodder trees are planted on cultivated land, normally on terrace risers. They are also planted along homesteads, pathways and roadsides. Farmers tend to plant these trees near their homes to save much labour that otherwise would be spent on long trips to the forest. Fodder trees are more common on non-irrigated than irrigated land. This is because farmers think that fodder trees cast shade and reduce yield of crop particularly on irrigated rice fields.

Privately owned trees come from a number of sources. Some are trees left on *kharkas* (grasslands) left as part of original forest before cultivation. Some trees might also grow through natural regeneration on such land. Trees cultivated on farmland are propagated by farmers through a number of methods. Some are transplanted from seedlings found growing on farmland or in the forest. Some fodder trees are propagated vegetatively often from large branch cuttings, which can yield fodder leaves in 2 or 3 years. However there are only few species, which can be raised vegetatively such as *Brassiopsis* species and *Garuga pinnata*. Some seedlings of fodder trees are collected from community forest nurseries or government nurseries in the nearby locality.

b) *Tree fodder from forest and shrubland*

Farmers have been collecting tree fodder from forests and shrubland as and when necessary. Apart from tree fodder collection they have been using grasses, herbaceous plants, shrubland, and climbers for fodder. There is still significant amount of shrubland in the Middle Hills of Nepal. Most of these shrublands were once forest but due to repeated coppicing for fodder and fuelwood they were reduced to shrubland. These shrublands can provide fodder and fuelwood on sustained basis if managed properly on sound silvicultural basis as shrubland.

In some cases, where forests still exist people have access to forests. In general cases communities have no forest left and they have no access to fodder from forest areas. In some cases some communities have to travel distances of 4 to 6 hours to collect fodder from the forest. In drier areas the only forest is of pine species (*Pinus roxburghii* and *Pinus wallichiana*) where no tree fodder is available. However for communities close to broad-leaved forest, there may be very few fodder trees around houses and cultivated areas.

During monsoon season when the grasses and weeds are available for fodder, farmers use less fodder tree while tree fodder from privately owned trees are used during dry season. Therefore the fodder used during the monsoon is likely to be from forest areas.

2. Objectives

The general objective of the study was to find out indigenous knowledge of farmers in identifying fodder tree species and their preferences of fodder trees on the basis of management and utilisation. More specifically the present study aims to ascertain:

- fodder tree species used by farmers in all the five regions in the Middle Hills;
- preferred fodder tree species in each of the five regions in the Middle Hills,
- management of fodder trees in the Middle Hills.

3. The study area

One district from each Development Region was selected for the study. These were Dhankuta in Eastern Development Region, Nuwakot in Central Development Region, Kaski in Western Development Region, Salyan in Mid-Western Development Region and Baitadi in Far-Western Development Region.

4. Methodology

In each of the five districts three sites were selected, one each at 1200 m, 1600 m and 2000 m. On each of the sites, 40 households were interviewed. Information was collected from secondary sources as well. The methods adopted in this research were (1) household survey and (2) participant observation.

Household survey involved the use of a formal survey questionnaire that measured socio-economic variables. The interviewees were briefed about the aims of the study. They were very inquisitive about the whole aspects of this process and their response was very encouraging. Households were chosen randomly. The household heads, generally elderly persons, irrespective of sex, were administered the questionnaire. The questionnaire was first discussed and then filled up by the field assistants. This proved to be a good technique for collecting reliable information.

In the participant observation method, field assistants, particularly forest rangers and their field staff who were familiar with local conditions, provided additional information. These people are generally aware of farmer's knowledge of fodder trees, their preferences and practices. They were particularly helpful in identifying local names of fodder trees. In some cases school teachers also assisted in giving valuable information regarding indigenous systems of management and utilisation of fodder trees.

5. Results and discussion

5.1. Indigenous fodder trees in the Middle Hills

The results of the present study suggested that farmers in the Middle Hills used a great variety of trees. In all, at least 75 tree species were recorded in the fodder survey, though the number used is probably greater. These fodder tree species are listed alphabetically in Table 1.

Table 1. Indigenous fodder trees in the Middle Hills

Scientific Name	Local Name
Acacia catechu	khair
Aesculus indica	panger
Albizzia julibrissin var. *mollis*	rato siris
Alnus nepalensis	utis
Artocarpus lakoocha	badahar
Arudanaria species	nigalo
Bambusa species	bans
Bauhinia variegata	koiralo
Bauhinia purpurea	tanki
Bassia butyraceae	chiuri
Boehmeria regulosa	dar
Bombax ceiba	bans
Betula alnoides	saur
Brassiopsis glomerulata	chuletro
Brassiopsis hainla	seto chuletro

Bridelia retusa	gayo
Buddleja asiatica	bhimsenpati
Butea monosperma	palans
Castanopsis hystrix	bada katus
Castanopsis indica	dhale katus
Castanopsis tribuloides	musure katus
Cedrela toona	tuni
Celtis australis	khari
Cornus oblonga	latikath
Engelhardtia spicata	mauwa
Ficus subincisa	gedulo, bedulo
Ficus hispida	thotne (khasreto)
Ficus auriculata	nimaro (timila)
Ficus retusa	jammu
Ficus glaberrima	pakhuri
Ficus lacor	kavro
Ficus religiosa	pipal
Ficus neriifolia va. *nemoralis*	dudhilo
Ficus semicordata	khanyu
Ficus semicordata var. *montana*	rai khanyu
Fraxinux floribunda	lankuri
Garuga pinnata	dabdabe
Grewia aptiva	bhimal (syal fusro)
Grewia tiliecfolia	fusro
Holoptelia integrifolia	papari
Lannia coromandelica	jhinger, jhingat
Litsea cubeba	siltimur
Litsea polyantha	kutmiro
Macaranga pustulata	mallato
Machilus odoratissima	aulo
Melia azederach	bakaino
Michelia champaca	champ
Morus alba	kimbu
Myrica esculenta	kafal
Myrsina semiserrata	kalikath
Ougeinia dalbergiodes	sandan
Pavetta indica	kaingyo
Phyllanthus emblica	amla
Populus ciliata	lahare pipal
Premna latifolia	gidari
Prunus cerosoides	painyu
Pyrus pashia	mayal
Quercus glauca	falant
Quercus lanata	ryanjh
Quercus leucotrichophora	banjh
Quercus semecarpifolia	khasru
Quercus spicata	arkhalo
Rhus javanica	bhakyamlo
Salix tetrasperma	bains
Sapindus mukorosi	ritha
Sarauria nepaulensis	gogan
Schima wallichii	chilaune
Sterculia villosa	andal
Shorea robusta	sal
Symplocos robusta	chamalyo
Symplocos pyrifolia	kholme
Terminalia alata	saj
Terminalia belerica	barro
Wendlandia exserta	tilko
Zanthoxylum armatum	timur

5.2. Regional variation in fodder tree types

The survey results suggested that the number of tree species differed from one region to another. The differences in species composition also varied from one region to another although there is a considerable overlap of tree species in different regions. However, the maximum number of fodder tree species was found to be used in Western Development Region and the minimum number of fodder tree species in Central Development Region (Table 2).

Table 2. Regionwise number of fodder tree species by development regions

Regions	Number
Eastern Development Region	40
Central Development Region	28
Western Development Region	54
Mid-Western Development Region	49
Far-Western Development Region	37

5.3. Fodder tree types according to altitude

Although farmers used a great variety of fodder trees, the species composition varied from low elevation to high elevation. Therefore, it is more appropriate to consider which tree species were considered valuable by farmers at 'low' and 'high' elevation, taking 1600 m as the dividing line in each of the regions.

Low altitude fodder trees

In Dhankuta district in Eastern Development Region low elevation households used several tree species. More commonly used fodder tree species were badahar, kimbu, dudhilo, tanki, nimaro and bamboos. In Nuwakot district in Central Development Region, several tree species were used. More commonly used species among them were dudhilo, khasreto, kutmiro, bedulo and khanyu.

In Kaski district, Western Development Region more commonly used species were badahar, painyu, chuletro, gindari, bedulo, dudhilo, nimaro, and khanyu.

In Salyan district in Mid-Western Development Region, the more commonly used species were bhimal, khari, and khanyu. Similarly, in Baitadi district in Far-Western Development Region, more commonly used tree species were bhimal, khari, nimaro, koiralo, and dudhilo.

High altitude fodder trees

Among the high altitude species, dudhilo was commonly harvested in all five regions. Gogan and nimaro were commonly used species in four regions except Far-Western Development Region. Gogan was commonly harvested in Eastern Development and Central Development Region. Among other species high altitude oaks particularly khasru was the considered an important fodder tree. Bhimal was most commonly harvested fodder tree in Mid-Western Development Region and Far-Western Development Region.

5.4. Five most preferred fodder tree species

The preference of fodder tree species was according to the farmer's experience regarding the performance of the species. Important criteria that farmers considered were: (a) palatability, (b) milk production, (c) nutritiveness, (d) digestibility and (e) availability.

Out of several fodder tree species recorded in a district in one region, five most preferred tree species were ranked on the basis of number of interviews in which the species was mentioned. In this way five most preferred tree species were rated for each of the five regions (Table 3).

Table 3. Five most preferred tree species according to region

Eastern Development Region

S. No	Tree Species	Ranking Percent
1.	*Ficus auriculata*	88.6
2.	*Morus alba*	77.6
3.	*Artocarpus lakoocha*	76.9
4.	*Bauhinia purpurea*	68.8
5.	*Ficus neriifolia* var. *nemorales*	60.0

Central Development Region

1.	*Ficus neriifolia*	87.1
2.	*Litsea monopetala*	63.6
3.	*Ficus hispida*	51.1
4.	*Sarauria nepalensis*	51.1
5.	*Ficus subincisa*	44.1

Western Development Region

1.	*Artocarpus lakoocha*	86.8
2.	*Ficus neriifolia*	80.3
3.	*Ficus auriculata*	70.6
4.	*Ficus semicordata*	67.5
5.	*Ficus subincisa*	67.2

Mid-Western Development Region

1.	*Grewia optiva*	81.6
2.	*Celtis australis*	66.7
3.	*Ficus neriifolia*	49.3
4.	*Litsea monopetala*	45.8
5.	*Ficus semicordata*	45.5

Far-Western Development Region

1.	*Grewia optiva*	96.7
2.	*Celtis australis*	47.5
3.	*Ficus neriifolia*	25.8
4.	*Ficus auriculata*	25.0
5.	*Quercus leucotrichophora*	20.5

5.5. Management of fodder trees

Management of fodder tree species is strongly influenced by (a) geographical difference and (b) socio-economic considerations. The number and type of fodder species differed according to region and also according to elevation. These have already been discussed in previous section. It was obvious that the maximum number of tree species were used in Western Development Region and the lowest in Central Development Region. In general, farmers in high altitude above 1600 m usually had less number of fodder trees on their farmland. The probable reason for this may be their dependence on existing forest and grazing ground. In some extreme case, farmers had to depend entirely on private fodder trees in which case they were highly interested in planting more fodder trees.

The amount and type of fodder required depend on the number and type of animals and also the manner in which they are kept i.e. whether they are stall-fed, grazed daily or moved seasonally from one altitude to another. Usually the number and type of livestock is correlated with economic status. This was reflected in amount of fodder collected, which declined with decreasing household wealth. Poor households have fewer large ruminants (cows and buffaloes) than the richer households hence their demand for fodder is less.

Although fodder supply situation varies from region to region, by and large fodder deficit is very substantial in various regions. However, the fodder supply situation was found to be better in Western Development Region in comparison to other regions. This may be due to the fact that farmers use more number of fodder trees than other regions.

Harvesting practices

Farmers deliberately manage trees that they cultivate according to products that they require. They harvest tree fodder by cutting off leaves and branches normally with a sickle. Species that are highly valued for fodder is not usually lopped until they are fully-grown. When such trees are lopped the whole crown is rarely lopped; farmers lop only old branches and leave small twigs for next season. They will not lop valued trees more than once a year. However, some species such as badahar, nimaro and dabdabe are completely lopped.

Most trees are lopped only once a year during the dry season, but some species in some areas are lopped more often. For example, bhimsenpati in Kaski district and kimbu in Dhankuta district are harvested two to three times a year. On the whole privately owned trees are lopped with more care.

Farmers practice of raising fodder trees

Fodder trees are planted mainly on marginal land such as kharbari (grass areas), terrace risers, bunds, border, gullies, etc. Farmers propagate fodder species by planting saplings brought from the forest. Some seedlings naturally grow on terrace risers, kharbari (grass areas) gullies, etc. that are protected by farmers. Only few farmers bring seedlings from forest nurseries and private nurseries. Some fodder species such as kimbu several *Ficus* species, dabdabe, kutmiro, etc. are propagated by cuttings.

Problems of fodder tree planting

Farmers reported several problems in planting fodder species. Important problems that farmers face are: availability of land because of small landholdings; shortage of seeds and seedlings; damage by man and animals; insect and pest attack and labour constraints.

6. Conclusion

Farmers in the Middle Hills have to depend on fodder trees for providing green fodder during the driest period of the year. Although more that 75 species are used as fodder, the number of fodder trees planted on individual landholdings are small. However, they are important source of fodder. Farmers in the Middle Hills have a fairly good knowledge of fodder trees but their efforts need to be backed up by technical and financial support. If such supports are made available, the farmers may be able to increase their fodder resources and thereby become self-sufficient.

7. Recommendations

The present study clearly reveals that farmers face several problems in planting and growing fodder trees:

- An integrated approach is necessary to address the problems faced by farmers by involving agencies such as forestry, livestock and agriculture.
- Public awareness should be geared up in planting good quality fodder trees and extension workers at grassroot level should provide technical know-how.
- Agriculture Development Bank should provide loans to farmers to grow more fodder trees on their land.
- Research support to develop better quality fodder tree species is essential. Because so many species are used for fodder, it is necessary that researchers concentrate on small number of preferred tree species and build up a useful bank of knowledge.

References

ADBN. 1982. *Agriculture Sector Strategy Study.* Agricultural Development Bank of Nepal, Kathmandu, Nepal.

Amatya, S. M. 1992. Indigenous Fodder Trees: Their Management and Utilisation in the Terai Belt of Nepal. *Ph.D. Thesis.* Tribhuvan University, Kathmandu, Nepal.

Dutt, P. 1977. Grazing Improvement and Fodder Development in the Middle Hills and High Hills of the Annapurna Region. Lumle Agriculture Centre, Kaski, Nepal.

Environmental Protection Council (EPC). 1993. Nepal Environmental Policy. A Compendium on the Environmental Statistics of Nepal. HMG, NPC Secretariat, Kathmandu, Nepal.

FAO. 1974. Working Paper on Livestock Production. Kathmandu, Nepal.

Heuch, J. H. R. 1986. Fodder for Forester. Lumle Agricultural Centre. *Technical Paper 86/3.* Lumle Agriculture Centre, Kaski, Nepal.

HMG. 1988. Master Plan for Forestry Sector, Nepal. Main Report. Ministry of Forests and Soil Conservation, Kathmandu, Nepal.

Hopkins, N. 1983. The Fodder Situation in the Hills of Eastern Nepal. *Occasional Papers 2.* APROSC, Kathmandu, Nepal.

Integrated Hill Development Project. 1980. Livestock Policy. Swiss Association for Technical Assistance, Kathmandu, Nepal.

Panday, K. K. 1982. *Fodder Trees and Tree Fodder in Nepal.* Swiss Development Co-operation, Berne, Switzerland.

Pradhan, P. R. 1982. Fodder Tree Productivity Study 1980/81 in the Local Target Panchayats. Pakhribas Agriculture Centre, Dhankuta, Nepal.

Shah, S. G. 1980. Phewa Watershed Animal Husbandry and Feed Resources Survey, Results and Recommendations. IWM, TC and LUD Project (NEP/74/020). *Field Document No. 16.* Kathmandu, Nepal.

Wormald, T. J. 1975. Village Forestry in the Hills of West-Central Nepal. Lumle Agriculture Centre, Kaski, Nepal.

Wyatt-Smith, J. 1982. The Agriculture System in the Hills of Nepal, the Ratio of Agriculture to Forest Land, the Problems of Animal Fodder. APROSC Occasional Paper, Kathmandu, Nepal.

Mathema, P., Dutta, I. C., Balla, M. K. and Adhikary, S. N. (eds.). 1999. *Sustainable Forest Management.* Proceedings of an International Seminar, 31 August – 2 September 1998, Pokhara, Nepal.

Agroforestry Research in Support of Rural Development in the Tropics: Experience of Two Decades of Efforts

P. K. R. Nair

Abstract: Reflections on the experience of two decades of agroforestry research show that although agroforestry has become a rigorous science, expectations about the role of research in solving the problems have largely been unfulfilled. The research agenda, so far, has given high priority to soil fertility and other biophysical interactions, less to anthropological and sociological aspects, and little to evaluating costs and returns, pests and diseases, and the non-timber forest (tree) products. Moreover, larger-spatial-scale issues, such as carbon sequestration, water quality, and biodiversity conservation, have been neglected due to an emphasis on field- and farm-scale studies. Agroforestry research has progressed from an inductive to a deductive mode and thus been transformed into a rigorous scientific activity. But the results of the research have been either inadequate to address the problems that they were supposed to resolve, or have not been adopted by the targeted clientele.

In order to overcome this, research should be refocused on the generation of appropriate, science-based technologies of wide applicability, especially under resource-poor conditions and in smallholder farming systems. Methods of transferring the technology to the intended users should be vastly improved. Applied research should build upon the findings of basic research to generate technologies for application at the farm, regional and global levels. Such research should place increased focus on previously neglected subjects, for example, the exploitation of indigenous fruit-producing trees, the agronomic components of agroforestry systems, and the global issues mentioned above. Furthermore, an appropriate methodology that embodies economic, social, and environmental costs and benefits needs to be developed to realistically assess the impacts of agroforestry, and an enabling policy environment that will facilitate agroforestry adoption needs to be made available.

1. Introduction

As an organised scientific discipline, agroforestry is believed to have started (or "born") in 1977, when an international initiative resulted in the establishment of ICRAF (International Council—renamed as Centre in 1991—for Research in Agroforestry). Thanks to the dedicated efforts of an increasing number of professionals, and to the motivation they receive from the millions of agroforestry practitioners world-wide, agroforestry is now a promising and challenging discipline. During this period, the image of agroforestry and the directions in agroforestry research have changed considerably. From a rather loosely defined and differently interpreted concept, it has emerged as an integrating discipline that cuts across the rather strict disciplinary boundaries of traditional land use disciplines such as agriculture and forestry. Today, agroforestry is a recognised interface between agriculture and forestry and a viable approach to land management particularly in resource-poor smallholdings of the developing countries, and an important part of ecosystem management and environmental protection in the industrialised nations. Yet, as a development tool, some of the early expectations that were raised about agroforestry have not been fulfilled. While this may be because of a myriad of reasons that contribute to the slow overall progress that is characteristic of most rural development efforts, there might be some development pitfalls that are specific to agroforestry. This paper reviews the accomplishments and frustrations of two decades of efforts, primarily in research, to make agroforestry a useful tool for rural development.

2. Agroforestry research

2.1. Early beginnings

It was in the wake of frustrations arising from the Green Revolution's failure to benefit poor farmer, and from escalating land management problems such as tropical deforestation, fuelwood shortage, and soil degradation that agroforestry emerged in the 1970s as a new concept of integrated land management. The development community embraced this "new" concept with unprecedented enthusiasm as a magical approach, with a perceived relevance to "difficult" or "fragile" environments and resource-poor conditions (Nair, 1993). The early initiatives were based on data and assumptions derived from past research in related areas such as agronomy, forestry, soil science, ecology, economics, and anthropology, and were supported by information, albeit of a largely descriptive nature, collected from successful, existing agroforestry systems (Nair, 1991). The main categories of agroforestry research during that period were: methodological, component and system descriptions, and empirical (Nair, 1993). Methodological research refers to research methods that were developed for the specific characteristics and attributes of agroforestry; a major example is the "Diagnosis and Design" methodology (Raintree, 1987). The other major category of agroforestry research during the early 1980s was system/component descriptions, which assembled a large body of knowledge on existing agroforestry systems in different agro-ecological and geographical regions of the topics (Nair, 1989). By the late 1980s, the relative importance of these two categories of research (methodological and system/component descriptions) declined and empirical (quantitative and experimental) research became more dominant. On the empirical side, a major share of the studies was related to soil improvement by trees and soil fertility management. Screening and evaluation of multipurpose trees and shrubs, and evaluation of prototypes of new technologies such as alley cropping were the main areas of applied research during that period. Many such studies evaluated improved agroforestry practices in comparison with the local land use systems, usually sole-crop agricultural stands, and were of relatively short duration of two to four years. The issue of research methods and sites—i.e., on research stations versus on farmers' fields—also became important; "on-station" and "on-farm" research were recognised as mutually complementary aspects of agroforestry field research (Nair, 1998).

The overall output during this early phase of agroforestry research can be summarised as the development of: (1) the concepts and principles of agroforestry, (2) databases, (3) methodologies, and (4) prototype technologies and their performance evaluations. These efforts provided the sound conceptual framework that was critically important to agroforestry during those early days. A number of concepts were identified and developed. These included the formation of systems by integrating crops and/or animals around the central component of trees; the increased diversity and complexity within these systems; the emphasis on exploitation of ecological and economic interactions among components in order to achieve optimum, rather than maximum, benefits; and the interplay of socio-cultural values in the manifestation of these benefits. All of these concepts are perhaps taken for granted today, but the efforts that went into their development, and their importance in providing a solid foundation upon which to build future research strategies, should not be underestimated. Equally important are the efforts of the

1980s in building up databases and developing research methodologies of a general nature. Examples of such databases include those on agroforestry systems (Nair, 1989), multipurpose trees and shrubs (von Carlowitz *et al.*, 1991), and nitrogen-fixing trees (MacDicken, 1994), whereas the most important among the methodologies is the Diagnosis and Design (Raintree, 1987).

Among the efforts to develop prototype technologies, the major focus has been on alley cropping (Kang *et al.,* 1990). The expectations that this technology aroused during the 1980s are somewhat comparable to those by the "miracle" varieties of cereal crops in the 1970s during the height of the Green Revolution. But the comparison between the two stops there because the success of alley cropping and the extent of alley cropping research pale when contrasted with those of the high-yielding varieties of food crops. So much so, alley cropping has become a subject of much criticism lately. To be fair, however, it must be noted that, from the very beginning, the potential role of alley cropping as a land management technology was exaggerated. The technology has been tested in numerous locations representing a wide range of physical (soil, rainfall, relief, and altitude) and socio-economic conditions, and using a large number of tree and crop species, and system management techniques (Rao *et al.*, 1998). In some of these situations, there was no logical chance for the technology to succeed, e.g., in areas with serious limitations of climate, relief (slope), and soil conditions (such as high acidity). Although cautions about the inapplicability of the technology in such situations had been expressed (for example, Nair, 1990; Tejwani and Lai, 1992), expectations always remained high, based on not reason but rote. Little wonder then that some results have been disappointing. Criticisms against alley cropping have continued unabated and have been exaggerated to the extent that the benefits of the technology—e.g., in soil conservation (Lal, 1989; Young, 1989; Kiepe and Rao, 1994) and in food-crop production (Kang, 1993; Kass, 1996)—have been vastly overshadowed by the extreme criticisms of a "pie-in-the-sky" (Ong, 1994) type of unfairness. In retrospect, it is clear that at least some of the criticisms could have been avoided had rational thinking preceded the enthusiastic promotion of this technology. Several lessons—procedural as well as scientific—can be learned from the experience with alley cropping during the past 10 to 15 years: (1) there is insatiable craving in the technology-starved field of agroforestry for any technology that appears new and promising; (2) realistic assessment of the potential role, and limitations of any new land use innovation should be carefully undertaken before it is promoted; and (3) technology generation and testing should be pursued based on rigorous scientific procedures, not on wishful speculations.

An unfortunate consequence of this obsessive preoccupation of the agroforestry research community with alley cropping was that other promising technologies—with the exception perhaps of shaded perennial systems (Beer *et al.*, 1998) and agroforestry for soil conservation (Young, 1989; 1997)—received relatively little attention during this period. The potential of agroforestry for other applications, such as tree fodder and silvipastoral systems, sequential systems for fallow improvement (ICRAF, 1997), and fuelwood production systems, remained largely underexploited.

2.2. The present

The "present" of agroforestry research represents the period since ICRAF became a research centre in 1991. During this period, empirical research and the science of agroforestry grew in importance, and the mostly descriptive information of earlier years gave way to a more robust and predictive understanding of the theoretical foundations of agroforestry.

Sanchez (1995) wrote an elaborate paper describing the steps involved in the process of this transformation, and reviewed developments in agroforestry research to explain how the new research direction was being implemented. He argued that the development of agroforestry as a science should be based on two principles: competition and complexity, and that they in turn determined two desirable properties: profitability and sustainability. Semantically, competition and complexity are not principles, but reflect the system's properties, which when managed could lead to the other listed properties (profitability and sustainability). According to Sanchez's (1995) argument, complex agroforestry systems could become economically more profitable and ecologically sustainable when interactions between (or among) components for growth resources are managed based on scientific principles; the author draws heavily from the literature to substantiate his arguments. Although some aspects of Sanchez's claims have been questioned (Kass, 1996), the paper provides an excellent account of the pangs of agroforestry research in the past and at present.

What significant changes have happened in agroforestry research since the early 1990s? Nair (1998) conducted an analysis of the topics of research publications in agroforestry during the period and found that:

- a vast number of publications (55%) dealt with biophysical aspects (plants and soils and their interactions);
- papers on animal-related and socio-economic aspects had been relatively few (4% and 10%, respectively); and,
- very little had been reported (researched) on issues such as pests and diseases, indigenous trees, and agronomic crops.

A significant development that has happened in agroforestry research during this period (i.e., in the 1990s) is the formulation of quantitative models to describe specific aspects of agroforestry research. Ong's tree-crop interactions equation (Sanchez, 1995), which has undergone several modifications (Kass, 1996; Sanchez, 1996; Cannell *et al.*, 1996), is an example. Others include Van Noordwijk and Purnomosidhi (1995), Lawson *et al.* (1995), Gregory (1996), and Ong *et al.* (1996). Also, several new quantitative models and concepts in computer-based modelling in agroforestry systems, mostly in temperate situations, were presented at an international workshop on modelling and fundamental research in agroforestry held at Montpellier, France, in June 1997. Selected papers from this workshop are being published as a separate special issue of *Agroforestry Systems* (Auclair and Dupraz, 1999).

The status of research on other areas of agroforestry is reflected in a recent publication on directions in tropical agroforestry research (Nair, 1998). Other recent research publications on specialised topics—e.g., tree-crop interactions (Ong and Huxley, 1996), plant litter quality and decomposition (Cadish and Giller, 1997) and soil conservation (Young, 1997)—reflect the advances in those specific areas. Efforts to address specific land management problems have resulted in some application-oriented agroforestry publications on subjects such as the management of imperata-infested grasslands in South-east Asia (Garrity, 1997), and improved fallow systems (Buresh and Cooper, in press). Collectively these efforts have helped to prove or disprove some notions and hypotheses about agroforestry, especially in the biophysical area.

Although there may not be a unanimity of views on the nature, pace, foci (geographical and thematic), and extent of accomplishments in agroforestry research, it is indisputable that today agroforestry is no longer a mysterious enigma that defies science and scientific principles, as it was perceived two decades ago. Today we do not just speculate on the advantages of trees and crop and/or animal associations, nor do we fantasise about their magical or imaginary virtues; we now have scientifically rigorous data to prove/disprove several of the assumptions and speculations that used to riddle discussions on agroforestry. Agroforestry is now on a firm scientific footing. Equally important, agroforestry is no longer simply a handmaiden of agriculture or forestry; it has a niche of its own. To reiterate Sanchez (1995), agroforestry is well on its way to becoming a specialised science at a level similar to those of crop science and forestry science.

2.3. The future

The gains and developments of two decades of agroforestry research are certainly impressive. The question, then, is what next? What direction should agroforestry research take? In order to answer this, we need to critically assess: (1) the extent to which the original research/ development expectations and goals—whether stated directly or implicitly two decades ago—have been fulfilled, and (2) the current and emerging problems and expectations.

The charter of ICRAF's 1977 mandate states that research in agroforestry would and should lead to alleviation of hunger and poverty, reversal of environmental degradation, reduction of deforestation, and enhancement of fuelwood and fodder supply. To what extent have these expectations been fulfilled? The scenarios of land use problems and trends in developing countries during the past 20 years could be good indicators, although these are certainly not related exclusively to the influence of agroforestry, and the relative impact of agroforestry practices on these indicators will vary considerably. Deforestation, shortage of fuelwood and fodder, and soil erosion are the land management indicators that are likely to be most influenced by agroforestry. The situation in respect of any of these is not fully satisfying by any standards. Data from the latest FAO statistics (FAO, 1999) show that while food production in Asia and Latin America has shown an upward trend, it has shown a disappointingly negative trend in Africa (Table 1), where agroforestry research has been most concentrated. Deforestation (which is, admittedly, influenced by a myriad of factors) has certainly not declined (Table 2); fuelwood shortage and other forms of problems continue unabated (Table 3). Soil erosion control and reclamation of degraded lands (such as the abandoned pastures of the acid lowlands of Latin America, imperata-infested grasslands of South-east Asia, and salt-affected soils of the Indian subcontinent) have lagged far behind expectations; the plight of the forest dwellers and others who traditionally have depended on non-timber forest products has not improved by any account; and so on. Most of these situations can be argued to be the consequences of unexpected population growth (Table 4); but that sort of argument is redundant. Agroforestry, by itself, cannot be "blamed" for this rather unsatisfactory scenario nor can agroforestry by itself solve the world's land use problems. Perhaps because improvement has been so slow or non-existent, ICRAF's main goals for agroforestry remain basically the same as they were 20 years ago when ICRAF (and agroforestry research) started: alleviation of poverty, increasing food and nutritional security, and enhancing environmental resilience (ICRAF, 1997). But given this scenario, it seems prudent to ask: should not agroforestry research be refocused to address some of these problems, and if yes, how?

It is not an exaggeration to say that scientists and development experts are somewhat frustrated about the results and progress of agroforestry research.

Scientists are unhappy that the science of agroforestry has not progressed to the extent desired and are, perhaps, also concerned that progress during the immediate future will be no brighter. Development experts are disillusioned with agroforestry because it has not lived up to their expectations even if some of those expectations were unrealistic. Perhaps these frustrations are also based on biased perceptions about research and science. A fundamental review of the concept of research is essential in this context.

Table 1. Net per capita index of food production in the three developing continents and the world during 1970–1998

Period	Africa	Asia	Latin America & Caribbean	World
1970–1974	109.1	98.9	86.9	89.5
1975–1979	103.5	99.8	93.0	92.8
1980–1984	96.3	101.6	96.7	95.5
1985–1989	97.8	103.3	99.4	98.8
1990–1994	99.4	99.2	100.8	100.4
1995–1998	80.4	102.6	107.6	104.1

Source: FAO (1999) base 1989–91=100

Table 2. Changes in forest cover in the three developing continents and the world during 1970–1994

Period	Forest cover (million ha)			
	Africa	Asia	Latin America & Caribbean	World
1970–1974	731.2	573.7	999.4	4316.1
1975–1979	729.1	561.4	979.8	4274.6
1980–1984	720.0	545.0	100.3	4281.9
1985–1989	715.1	533.3	1013.5	4233.3
1990–1994	714.5	548.0	1012.9	

Source: FAO (1999)

Table 3. Use of fuelwood and charcoal in the three developing continents and the world during 1970–1997

Period	Fuelwood and charcoal use (million t)			
	Africa	Asia	Latin America & Caribbean	World
1970–1974	258.2	585.5	194.0	1209.0
1975–1979	295.8	641.9	218.4	1334.5
1980–1984	345.5	701.3	248.2	1540.8
1985–1989	401.9	770.0	271.0	1693.1
1990–1994	461.4	842.6	257.6	1780.6
1995–1997	514.1	896.5	251.6	1844.6

Source: FAO (1999)

Table 4. Population growth in the three developing continents and the world during 1970–1998

Period	Population (million)			
	Africa	Asia	Latin America & Caribbean	World
1970–1974	364.1	2203.8	298.0	3853.8
1975–1979	413.9	2447.3	335.7	4227.0
1980–1984	475.7	2685.4	374.9	4603.8
1985–1989	547.7	2952.1	414.1	5021.3
1990–1994	629.4	3260.4	453.4	5445.9
1995–1998	719.5	3488.1	484.3	5767.9

Source: FAO (1999)

3. Research, science, and technology

Although the two words "research" and "science" are often used together, they are not synonymous. It is true that research is done according to scientific procedures, but research does not, and need not, always result in advancement of basic science. According to dictionary definitions, science is systematised knowledge derived from observation, study, and experimentation carried on in order to determine the nature or principle of what is being studied; it refers to the state of fact or knowledge, as opposed to intuition or belief. Research is careful, patient, systematic, diligent inquiry or examination in some field of knowledge, undertaken to establish facts or principles, and involves laborious or continued search for truth (Webster's Dictionary, 1997). Thus, while all research must be carried out scientifically, the objective of the research could be the advancement of knowledge (science) or the application of knowledge; the latter aspect, which involves the study of the practical or industrial application, is usually referred to as technology.

The distinction between science and technology is important in this discussion. While the goal of science is pursuit of knowledge and its emphasis is on "knowing," technology relies on application of knowledge and "doing." The motivation for science is curiosity, whereas technology is need-driven. Furthermore, although appropriate scientific methods are important in both science and technology, the latter involves more of a skilful synthesis and integration of techniques and procedures from a cross section of disciplines rather than following a specific set of methods of any specific discipline or its subset. If the objective of agroforestry research is to solve land management problems, it seems that our efforts should be aimed at generating appropriate technologies. However, because technologies cannot be generated without application of science, scientific understanding of the principles that can be applied is the essential first step in the process of technology generation. Without pushing this discussion too far, suffice it to say that a judicious balance between (fundamental) science and (application-oriented) technology should be the strategy for agroforestry research in the future (Nair, 1998).

3.1. Research to support the development of agroforestry technologies

If it is accepted that the main focus of agroforestry research should be technology generation for solving the land management problems that we set out to address 20 years ago, and that research should be a means rather than an end in itself in the era of dwindling research support, it is imperative to properly prioritise the research agenda of agroforestry for the 21st century. Long lists of research topics that appear in many publications need to be combined, co-ordinated, and prioritised according to a well-thought-out direction. Some general areas and topics, which ought to be considered while setting the agroforestry research agenda for technology generation in the future, are highlighted here.

3.2. Indigenous and underexploited trees

Traditionally, people throughout the tropics have depended on indigenous plants for a variety of their basic household needs, from food (mainly fruits) to medicines to fibres; these products have also generated the much-needed cash for purchased products. Examples of the use of a large number of such tree species in homegardens and other agroforestry associations can be found in almost all descriptions of traditional agroforestry systems (e.g., Nair, 1989). Exploitation of these indigenous trees through domestication and improvement was recognised as one of the most promising opportunities in agroforestry even during the early stages of organised agroforestry research (Nair, 1990). Systematic efforts in this direction, however, have not been undertaken until recently. Most tree selection and improvement efforts in agroforestry have been on the so-called multipurpose trees, and such efforts have often involved popularisation of "exotic" species (Turnbull, 1987; MacDicken, 1994). Many indigenous fruit trees and other woody species that provide medicinal products, ornamentals, or high-grade timber, have been largely overlooked in agroforestry research (Leakey and Simons, 1998; Leakey and Tomich, 1999). Domestication, improvement, and exploitation of indigenous trees should be a major focus of agroforestry research in the 21st century. Domestication of these tree crops could increase yields, provide higher quality products, enhance commercial potential, and above all, contribute to the food security of the local population. Several reports that list a vast variety of such trees under different situations are available (e.g., Okafor and Fernandes, 1987; Smith *et al.*, 1992; Leakey *et al.*, 1996) but organised initiatives in moving forward with the task of domestication and improvement are still lacking.

3.3. The "agro" part of agroforestry

In spite of any semantic shortcomings of the word agroforestry (Nair, 1993), it is obvious that it literally entails two parts: "agro" and "forestry". In most discussions, development efforts, and research initiatives, agroforestry is perceived more as a part of forestry than of agriculture. In reality, agroforestry is an aspect of neither agriculture nor forestry. Agroforestry has (or, should have) an identity of its own.

Putting aside semantic and "niche" problems, it is clear that in most cases, the agronomic component of agroforestry systems is equally as important as the forestry (tree) component. However, all discussions on component improvement or research tend to centre on trees—multipurpose trees, nitrogen-fixing trees, indigenous fruit trees, and so on—to the total exclusion of agronomic components. The reasons are several: trees are the "central" components of all agroforestry systems; the greatest opportunities and needs in agroforestry are, or were, in the area of trees; trees provide production and service functions; the emphasis in agroforestry is on exploiting the trees and their attributes for enhancing productivity and sustainability of farming systems, and so on. However, the "agro" components of agroforestry are important too, at least from the production point of view. Usually, in agroforestry experiments, the crop component is considered a "given". In most cases, the varieties used are improved genotypes that have been developed for high performance under conditions of optimum supply of light, nutrients and water, and freedom from pests and diseases. Paradoxically, one of the compelling reasons for the development of agroforestry is the lack of such optimum conditions in many cases; agroforestry is expected to do well under conditions that are far from optimal for the performance of agronomic crops (Nair, 1998). Suffice it to say crop varieties and cultivars that are adapted to less-than-optimal growth conditions are essential in agroforestry. Varieties of crop plants have been developed for some special conditions (water shortage, lower and higher pH ranges, and even nutrient deficiency), but breeding/selection of varieties adapted to low light conditions has perhaps never been attempted. There is a wide range of other issues related to crop selection and management in agroforestry systems. Agroforestry research in the 21st century should embrace agronomic components as enthusiastically as the tree components.

3.4. Research methodologies

In most agroforestry research, we are seriously constrained by the lack of methodologies that are appropriate, or are misguided by the use of methodologies that we consider appropriate but in reality are inappropriate, to the systems we are studying. A case in point is a recent assessment of research on homegardens and multi-strata systems (Nair, 1999). He argues that homegardens remain a mystery, both ecologically and economically. Most reported ecological studies on these systems have been descriptive, often containing long lists of plant names in various languages and descriptions of their characters and uses, and sometimes accompanied by schematic diagrams of system structure and configuration. Even the more quantitative studies dealing with soil fertility and plant nutrition have not contributed substantially to our understanding of the intricacies of these systems. These studies mostly follow a general pattern: start with the assumption that homegardens are ecologically stable and sustainable systems characterised by highly efficient nutrient cycling, and then create nutrient budgets with the "conventional" mass balance approach with estimates of inputs and outputs. Invariably all such estimates have led to high rates of nutrient outputs from the system implying that the systems in the long run will deplete the soil of its nutrient store and make the systems ecologically unsustainable. Yet, homegardens have flourished for a long time without any apparent symptoms of soil-nutrient-depletion. Homegardens are a puzzle to the economist too. Since the basic-needs approach of classical political economics (goods have value because people find them useful in satisfying needs for food, shelter, or clothing) has been replaced by the market superiority premises of neo-classical economics (it is only for the sake of profit that any man employs his capital in the support of an enterprise, and he will therefore endeavour to employ it in the support of value or to exchange for the greatest quantity of goods or money), economic efficiencies of farm enterprises are calculated based on their profit generation. Homegardens and other multi-strata systems that are primarily subsistence systems, which fulfil the basic needs of farm families (mostly food), rank very low in the value premises and theoretical assumptions that underline the neo-classical analysis (Current *et al.*, 1995). Yet, homegardens have flourished for a long time and, remained a mystery to the economists as well. So, Nair *et al.* (1999) argue that conventional nutrient cycling studies and economic analyses that have proven to be inappropriate for homegardens should give way to innovative and appropriate methods that have the scientific rigour as well as the required depth and breadth to truly handle the "real" situation. This argument is true for most other agroforestry systems as well.

3.5. Impact assessment

A related problem facing agroforestry research is the lack of a comprehensive, robust, and widely applicable methodology for realistically assessing the benefits and impacts of agroforestry practices. Traditional agroforestry systems have evolved under site-specific conditions for meeting the land users' basic needs. Our information about them is mostly experiential rather than experimental. In experimental systems, the objectives are specific, and the results are therefore quantifiable according to the accepted criteria for assessing those objectives. Notwithstanding the concern about appropriateness of such methods to agroforestry as discussed in the previous section, methodologies for some specific subsets of the intricate puzzle of agroforestry have been developed—or at least attempted—by some researchers. Examples include: experimental designs and statistical analyses of agronomic-type field experiments (Rao and Coe, 1992; Coe, 1994), measurement of competition for light and water (Ong *et al.*, 1996), and root interactions (Van Noordwijk *et al.*, 1996). Studies of this nature have been much less common in the socio-economic arena. Although some notable initiatives have been made—calculation of a whole farm efficiency index (Johnson, 1994), bio-economic modelling (Menz and Grist, 1996), and socio-economic impact assessment of some agroforestry interventions (Current *et al.*, 1995; Mercer and

Miller, 1998) are among the few such examples—these, unfortunately, have not been vigorously pursued.

These analyses of single (or a small cluster of) factors cannot be used for realistic assessment of the impact of agroforestry. Agroforestry systems have multiple objectives, products, and services; the success of a system is not judged by the performance of just one factor, but by the performance of a combination of several factors, products, and services, each of which is a complex issue in itself. For example, the extent of complexity involved in biophysical interactions is evident from the discussion on that topic in a recent comprehensive review on that subject (Rao *et al.*, 1998). Assessments that focus on only one or a few of the factors that affect agroforestry systems will be partial and inadequate. The problem is further compounded by the temporal (short- vs. long-term) nature of the benefits. We need a measure of the combined value of all products and services at various time scales. It is, indeed, a formidable task. It is essential that the development of appropriate methodologies that embody economic, social, and environmental costs and benefits of agroforestry should be a priority item in the agroforestry research agenda for the 21st century.

4. Policy environment

Development of appropriate biological technologies forms only one, perhaps the first step in the promotion of agroforestry; provision of public policies and institutions that support programme implementation is an equally important requirement. Analysis of the experience of several countries in Latin America has shown that rapid and dramatic expansion of agriculture and plantation forestry occurred when supportive public policy was put in place through appropriate subsidies, national investment, and adequate extension programmes (Southgate, 1992). The Green Revolution in Asia was similar: it too occurred in places where national policies supported and facilitated the availability and adoption of the technologies.

Policy here refers to the rules and regulations of government (as opposed to societal and cultural norms) that bind the whole citizenry of a political system. Passing land utilisation laws, collecting levies and other forms of commodity-specific taxes, providing (or denying) access to reserved forests, and regulating import or export of agricultural commodities are all examples of State policies or interventions that affect the lives of citizens (Blair, 1991), as well as affect land use patterns and sectoral development. The lack of institutional support for agroforestry is a major policy-related constraint to agroforestry development. A number of factors can be cited to explain this lack of support: the absence of multidisciplinary institutions capable of addressing integrated natural-resource and land use problems, little institutional recognition that small farmers must allocate their few resources toward the production of a variety of goods and services, a shortage of institutions with the mandate or capability of allocating resources across institutional boundaries, and institutional interest in minimising the influence of competing organisations (Follis and Nair, 1994). An enabling policy environment that favours smallholder rural development is an essential condition for the success of agroforestry. This issue, however, has not been addressed with deserving seriousness in agroforestry research.

5. Spatial issues: the need for larger-scale perspectives

Agroforestry field research has so far focused on smaller spatial scales or research plots in experiment stations or farmers' fields. Less than 5% of the publications in agroforestry are based on global, regional, or even watershed scales (Nair, 1998).

Publications that appear to take a broader perspective usually address the issues in a conceptual generalised manner, with little data from empirical investigations. As a consequence, the importance of agroforestry in issues that need to be assessed on a much larger scale than individual fields or plots—for example, carbon sequestration, water quality improvement, biological conservation and biodiversity, and extraction of non-timber forest products—has been neglected.

Carbon (C) sequestration in terrestrial ecosystems is a good example of such larger scale spatial issues. Agroforestry systems such as fuelwood plantations, shelterbelt/windbreak systems and woodlots may have the potential to sequester C, or offset fossil fuel emissions by substituting sustainably produced fuelwood and fodder (Brown *et al.*, 1993; Schroeder, 1993). Based on a preliminary assessment of national and global terrestrial C sinks, Dixon (1995) argues that there are two primary beneficial attributes of agroforestry systems in this regard: (1) direct near-term C storage (decades to centuries) in trees and soils and (2) potential to offset immediate greenhouse gas emissions associated with deforestation and subsequent shifting cultivation. Schroeder (1994) estimated that median C storage by agroforestry practices was 9, 21, and 50 Mg C/ha in semi–arid, sub-humid, and humid ecozones, respectively. Dixon (1995) estimated that within tropical latitudes, one hectare of sustainable agroforestry can provide goods and services with the potential to offset 5 to 20 ha of deforestation. The impact of agroforestry on terrestrial C budget is an area that needs to be researched.

Other environmental benefits such as water quality improvement through agroforestry have received no attention in agroforestry research in the tropics. Results from temperate zone agroforestry point to the beneficial effects of riparian buffer strips in reducing sedimentation load and nutrient pollution in agricultural landscapes (Schultz *et al.*, 1995). These may not be relevant to most of the tropics, at least for now. However, other potential benefits such as amelioration of salt-affected soils through agroforestry have been amply demonstrated (Tejwani, 1994) but not adequately promoted.

Conservation of biodiversity is another issue in which agroforestry may have a major role to play but which has received scant attention. It is obvious that agroforestry systems are far more diverse than crop or tree monocultures. It may not be prudent, however, to expect that having a high number of economically useful plants per hectare would lead to biodiversity conservation. Similarly, in commercial prospecting among natural sources for new products (such as the biodiversity prospecting, which is usually promoted not because of the realisation of the value of nature's diversity for ecological, aesthetic, or spiritual reasons, but by the lure for the discovery of the miracle plant or animal that contains the cure for such human diseases as cancer or AIDS), the value of biodiversity is not as high as some conservationists might suppose (Simpson, 1997). Apart from a few attempts of listing the number of economically useful plants that are found in some indigenous agroforestry systems (for example, Nair, 1989; Tejwani, 1994; De Jong, 1996; Lawrence, 1996), or isolated studies such as mammalian diversity in coffee agroforestry systems (Gallina *et al.*, 1996), agroforestry research has seldom attempted to establish the importance of agroforestry as a viable option for biodiversity conservation.

6. Conclusions

The past two decades of agroforestry research has contributed substantially to our understanding of the scientific basis of agroforestry and therefore the contribution it can make to rural development in the tropics. However, all expectation about the potential role of agroforestry may not have been fulfilled. This is perhaps nothing unique to agroforestry; it is the state of affairs of all developmental agendas. The frustrations arising from the apparent failure to fulfil the seemingly high levels of expectations should not, however, be allowed to undermine our enthusiasm. Agroforestry is in the threshold of a leap forward. Any slackening of efforts at this stage could scuttle the potential gains of two decades of efforts, and would thus be a serious blow. As we enter the new millennium, we should place greater emphasis on harnessing the science of agroforestry to develop technologies of wide applicability. The question should be how to blend science and technology in an optimum balance in order to develop science-based technologies that will address the problems. Future generations will judge the merits of our efforts based on our success in accomplishing this important task of balancing science and technology. It is satisfying to note that ICRAF, the world's premier tropical agroforestry research institution, envisions (ICRAF, 1997) that agroforestry research by the year 2020 will have accomplished the goals that were established when agroforestry research was initiated 20 years ago.

References

Auclair, D. and Dupraz, C. (eds). 1999. Agroforestry for Sustainable Land use—Fundamental Research and Modelling, with an Emphasis on Temperate and Mediterranean Applications. *Agroforestry Systems* 43 (Special Issue) (In Press).

Beer, J. W., Muschler, R. G., Kass, D. C. L., and Somarriba, E. J. 1998. Shade Management in Coffee and Cacao Plantations. *Agroforestry Systems* 38: 139–164.

Blair, H. W. 1991. The Uses of Political Science in Agroforestry. In: Burch, R. B. Jr. and Parker, J. K. (eds.), *Social Science Applications in Asian Agroforestry*, Winrock International, Arlington, VA, USA. pp. 85–109.

Brown, S., Hall, C. A. S., Knabe, W., Raich, J., Trexler, M. C., and Woomer, P. 1993. Tropical Forests: their Past, Present, and Potential Future Role in the Terrestrial Carbon Budget. *Water, Air, and Soil Pollution* 70: 71–94.

Buresh, R. J. and Cooper, P. (eds.). The Science and Practice of Short-term Improved Fallows. *Agroforestry Systems* (Special Issue) (In Press).

Cadish, G. and Giller, K. E. (eds). 1997. *Driven by Nature: Plant Litter Quality and Decomposition*. CAB International, Wallingford, UK.

Cannell, M. G. R., Van Noordwijk, M., and Ong, C. K. 1996. The Central Agroforestry Hypothesis: the Trees must Acquire Resources that the Crop would not Otherwise Acquire. *Agroforestry Systems* 34: 27–31.

Coe, R. 1994. Through the Looking Glass: 10 Common Problems in Alley-Cropping Research. *Agroforestry Today* 6: 9–11.

Current, D., Lutz, E., and Scherr, S. (eds.). 1995. *Costs, Benefits, and Farmer Adoption of Agroforestry*. The World Bank, Washington, DC, USA.

De Jong, W. 1996. Swidden-fallow Agroforestry in Amazonia: Diversity at Close Distance. *Agroforestry Systems* 34: 277–290.

Dixon, R. K. 1995. Agroforestry Systems: Sources or Sinks of Greenhouse Gases? *Agroforestry Systems* 31: 99–116.

FAO. 1999. FAO Statistics Database on the Web, March 12, 1999. http://www.faostat.fao.org; www.faostat.fao.org. Food and Agriculture Organisation of the United Nations, Rome, Italy.

Follis, M. B. and Nair, P. K. R. 1994. Policy and Institutional Support for Agroforestry: An Analysis of Two Ecuadorian Case Studies. *Agroforestry Systems* 27: 223–240.

Gallina, S., Mandujano, S., and Gonzales-Romero, A. 1996. Conservation of Mammalian Biodiversity in Coffee Plantations of Central Veracruz, Mexico. *Agroforestry Systems* 33: 13–27.

Garrity, D. P. (ed.). 1997. Agroforestry Innovations for Imperata Grassland Rehabilitation. *Agroforestry Systems* 36 (Special Issue): 1–284.

Gregory, P. J. 1996. Approaches to Modelling the Uptake of Water and Nutrients in Agroforestry Systems. *Agroforestry Systems* 34: 51–65.

ICRAF. 1997. ICRAF Medium-Term Plan, 1998–2000. International Centre for Research in Agroforestry, Nairobi, Kenya.

Johnson, T. R. 1994. Agroforestry Performance Evaluation. *MS Thesis*, University of Florida, Gainesville, FL., USA.

Kang, B. T. 1993. Alley Cropping: Past Achievements and Future Directions. *Agroforestry Systems* 23: 141–155.

Kang, B. T., Reynolds, L., and Atta-Krah, A. N. 1990. Alley Farming. *Advances in Agronomy* 43: 315–359.

Kass, D. C. L. 1996. Letter to the Editor, *Agroforestry Systems* 33: 101-106.

Kiepe, P. and Rao, M. R. 1994. Management of Agroforestry for the Conservation and Utilisation of Land and Water Resources. *Outlook on Agriculture* 23: 17–25.

Lal, R. 1989. Agroforestry Systems and Soil Surface Management of a Tropical Alfisol. Parts I–VI. *Agroforestry Systems* 8(1): 1–6, 7–29; 8(2): 97–111, 113–132; 8(3): 197–215, 217–238, 239–242.

Lawrence, D. C. 1996. Trade-offs between Rubber Production and Maintenance of Diversity: the Structure of Rubber Gardens in West Kalimantan, Indonesia. *Agroforestry Systems* 34: 83–100.

Lawson, G. T., Crout, N. M. J., Levy, P. E., Mobbs, D. C., Wallace, J. S., Cannell, M. G. R., and Bradley, G. R. 1995. The Tree-Crop Interface: Representation by Coupling of Forest and Crop Process Models. *Agroforestry Systems* 30: 199–221.

Leakey, R. R. B. and Simons, A. J. 1998. The Domestication and Commercialisation of Indigenous Trees in Agroforestry for the Alleviation of Poverty. *Agroforestry Systems* 38: 165–176.

Leakey, R. R. B., Temu, A. B., and Melnyk, M. (eds.). 1996. Domestication and Commercialisation of Non-Timber Forest Products for Agroforestry. FAO, Rome, Italy.

Leakey, R. R. B. and Tomich, T. P. 1999. Domestication of Tropical Trees: From Biology to Economics and Policy. In: Buck, L. E., Lassoie, J. P., and Fernandes, E. C. M. (eds.), Agroforestry in Sustainable Agricultural Systems, CRC Press, Boca Raton, FL, USA. pp. 319–338.

MacDicken, K. G. 1994. *Selection and Management of Nitrogen-Fixing Trees*. Winrock International, AK, USA.

Menz, K. M. and Grist, P. 1996. Increasing Rubber Planting Density to Shade Imperata: A Bio-Economic Modelling Approach. *Agroforestry Systems* 34: 291–303.

Mercer, D. E. and Miller, R. P. 1998. Socio-economic Research in Agroforestry: Progress, Prospects, Priorities. *Agroforestry Systems* 38: 177–193.

Nair, P. K. R. (ed.). 1989. *Agroforestry Systems in the Tropics*. Kluwer, Dordrecht, The Netherlands.

Nair, P. K. R. 1990. The Prospects for Agroforestry in the Tropics. *Technical Paper No. 131*, The World Bank, Washington, DC, USA.

Nair, P. K. R. 1991. State-of-the-art of Agroforestry Systems. In: Jarvis, P. G. (ed.). *Agroforestry: Principles and Practice*, Elsevier, Amsterdam, The Netherlands. pp. 5–29.

Nair, P. K. R. 1993. *An Introduction to Agroforestry*. Kluwer, Dordrecht, The Netherlands.

Nair, P. K. R. 1998. Directions in Tropical Agroforestry Research: Past, Present and Future. *Agroforestry Systems* 38: 223–236.

Nair, P. K. R. 1999. Do Tropical Homegardens Elude Science, or is it the Other Way Round? Keynote Presentation. In: Jimenez, F. and Beer, J. W. (compilers). Proceedings of the International Symposium on Multi-strata Systems, CATIE, Costa Rica. pp. 7–13.

Nair, P. K. R., Buresh, R. J., Mugendi, D. N. and Latt, C. R. 1999. Nutrient Cycling in Tropical Agroforestry Systems: Myths and Science. In: Buck, L. E., Lassoie, J. P., and Fernandes, E. C. M. (eds.), *Agroforestry in Sustainable Agricultural Systems*, CRC.Press, Boca Raton, FL, USA. pp. 1–31.

Okafor, J. C. and Fernandes, E. C. M. 1987. Compound Farms of South-eastern Nigeria: A Predominant Agroforestry Homegarden System with Crops and Livestock. *Agroforestry Systems* 5: 153–168.

Ong, C. K. 1994. Alley Cropping - Ecological Pie in the Sky? *Agroforestry Today* 6(3): 8–10.

Ong, C. K., Black, C. R., Marshall, F. M., and Corlett, J. E. 1996. Principles of Resource Capture and Utilisation of Light and Water. In: Ong, C.K. and Huxley, P.A. (eds.). *Tree-Crop Interactions: A Physiological Approach*, CAB International, Wallingford, UK. pp 73–158.

Ong, C.K. and Huxley, P.A. (eds). 1996. *Tree-Crop Interactions: A Physiological Approach*. CAB International, Wallingford, UK.

Raintree, J. B. 1987. The State-of-the-art of Agroforestry Diagnosis and Design. *Agroforestry Systems* 5: 219–250.

Rao, M. R. and Coe, R. 1992. Evaluating the Results of Agroforestry Research. *Agroforestry Today* 4(1): 4–9.

Rao, M. R., Nair, P. K. R. and Ong, C. K. 1998. Biophysical Interactions in Tropical Agroforestry Systems. *Agroforestry Systems* 38: 3–50.

Sanchez, P. A. 1995. Science in Agroforestry. *Agroforestry Systems* 30: 5–55.

Sanchez, P. A. 1996. Letter to the Editor. *Agroforestry Systems* 33: 106–108.

Schroeder, P. 1993. Agroforestry Systems: Integrated Land Use to Store and Conserve Carbon. *Climate Research* 3: 53–60.

Schroeder, P. 1994. Carbon Storage Benefits of Agroforestry Systems. *Agroforestry Systems* 27: 89–97.

Schultz, R. C., Colletti, J. P., Isenhart, T. M., Simpkins, W. W., Mize, C. W., and Thompson, M. L. 1995. Design and Placement of a Multi-Species Riparian Buffer Strip System. *Agroforestry Systems* 29: 201–226.

Simpson, R. D. 1997. Biodiversity Prospecting: Shopping the Wilds is not the Key to Conservation. *Resources for the Future* 126 (Winter 1997): 12–15.

Smith, N. J. H., Williams, J. T., Plucknett, D. L., and Talbot, J. P. 1992. *Tropical Forests and their Crops*. Cornell University Press, Ithaca, USA.

Southgate, D. 1992. Policies Contributing to Agricultural Colonisation of Latin America's Tropical Forests. In: Sharma, N. P. (ed.), *Managing the World's Forests; Looking for Balance Between Conservation and Development*. Kendall/Hunt Pub., Dubuque, Iowa for the World Bank, Washington,DC, USA. pp. 215–235.

Tejwani, K. G. 1994. *Agroforestry in India*. Oxford & IBH, New Delhi, India.

Tejwani, K. G. and Lai, C. K. 1992. Asia-Pacific Agroforestry Profiles. *APAN Field Doc. 1*. FAO Asia-Pacific Agroforestry Network, Bogor, Indonesia.

Turnbull, J. (ed). 1987. Australian Acacias in Developing Countries, *ACIAR Proceedings 16*. Austr. Cent. for Int. Agri. Res., Canberra, Australia.

Van Noordwijk, M., Lawson, G., Soumare, A., Groot, J. J. R. and Hairiah, K. 1996. Root Distribution of Trees and Crops: Competition and/or Complementarity. In: Ong, C. K. and Huxley, P. A. (eds.), *Tree-Crop Interactions: A Physiological Approach*, CAB International, Wallingford, UK. pp. 319-364.

Van Noordwijk, M. and Purnomosidhi, P. 1995. Root Architecture in Relation to Tree-Soil-Crop Interactions and Shoot Pruning in Agroforestry. *Agroforestry Systems* 30: 161–173.

Von Carlowitz, P. G., Wolf, G. V., and Kemperman R. E. M. 1991. Multipurpose Tree and Shrub Database: An Information and Decision Support System. ICRAF, Nairobi, Kenya and GTZ, Eschborn, Germany.

Webster's Dictionary. 1997. Merriam Webster Inc., Springfield, MA, USA.

WRI. 1996. World Resources 1996–1997. World Resources Institute, Washington, DC, USA.

Young, A. 1989. *Agroforestry for Soil Conservation*. CAB International, Wallingford, UK.

Young, A. 1997. *Agroforestry for Soil Management*. CAB International, Wallingford, UK.

Mathema, P., Dutta, I. C., Balla, M. K. and Adhikary, S. N. (eds.). 1999. *Sustainable Forest Management*. Proceedings of an International Seminar, 31 August – 2 September 1998, Pokhara, Nepal.

Dactylorhiza hatagirea: Resource Assessment and Issues for Sustainable Management in Annapurna Conservation Area of Lamjung District, Nepal

D. P. Parajuli, A. R. Gyanwali, S. D. Chaudhary,
B. M. Shrestha, N. K. Rasaily, R. C. Tribedi and R. C. Pandey

Abstract: Annapurna Conservation Area is very rich in high value medicinal herbs like panchaule (*Dactylorhiza hatagirea*). The existing policy and regulations do not allow harvest and export of this species on the ground that the species is threatened with extinction. The ban was imposed by the government without examining parameters like resource inventory, biophysical characteristics, appropriate harvesting regimes, economic contribution to rural communities, etc. The repercussions of such ban are noticed as continuation of illegal harvesting, underpayment to harvesters, deteriorating economic condition of the rural people and lack of incentives to conserve the resources.

A socio-economic study was carried out in four Village Development Committees of Lamjung district under Annapurna Conservation Area followed by biophysical and quantitative resource assessment of panchaule between 3000 m–5000 m. Information was also collected on existing market prices, marketing channels, etc. from primary and secondary sources. It was found that the study area could produce annually 106 kg of air dry tuber worth Rs. 10 million (US $ 1.5 million) in a sustainable manner. Recommendations are also made to amend the existing legislation of the government to allow the harvest of panchaule tubers in a sustainable way.

1. Introduction

Nepal is blessed with a great wealth of biodiversity with over 7,000 species. Almost 700 plant species of Nepal are known to possess medicinal properties (Singh, 1998). Most of these plants grow in the Himalayas and show high degree of polyploidy due to cold climate (Bhatta, 1976) and contain a larger amount of active ingredients as compared to plants growing in warmer regions. Most of these plants are being used by the Nepalese people, mostly from the rural areas, for their livelihood and well-being in the form of food, fibre, fruits, aromatic oils, medicines, dyes, gums, resins, etc. Herders are the main collectors of the whole or part of these plants for sale. All these biological materials coming from forest ecosystem are termed as Non-Timber Forest Products (NTFPs) contributing to almost 5% of the total revenue collected from the forestry sector (Edwards, 1996). In certain rural areas, NTFPs alone provide up to 50% of family income. This shows the importance of the sustainable use of NTFPs.

Dactylorhiza hatagirea (panchaule in Nepali), one of the highly valuable medicinal herbs, was prohibited to harvest and export in 1988 by the Government of Nepal on the ground that the species is threatened with extinction because young plants are being harvested before they disperse seeds for further propagation. This ban was imposed without conducting any scientific research on biophysical characteristics of the species and the socio-economic impacts on the people who have been using it since time immemorial. But the vigorous harvest from the wild and illegal trade of this species still continues.

2. The Study Area

The study area covers four Village Development Committees (VDCs) lying in Annapurna Conservation Area Project (ACAP) area in Lamjung district. They are Bhujung, Ghanpokhara, Khudi and Taghring. Most of the settlements are located at lower parts of the VDCs. The areas above the settlement consist of mountainous areas with slopes of more than 30 degrees and are predominantly covered by broad-leaved and coniferous forests, particularly fir. However, the forests between the altitudes of 3200 m–4500 m have been degraded to shrubland due to heavy livestock grazing. Only a limited area is regarded as ideal habitat for panchaule herbs.

The number of households in the study area is 2,041. Major ethnic groups in the area are Gurung, Tamang and Kami who have very low level of income. Less than 10% of the total land is available for agricultural crop production. As a result, almost 95% of the households do not have sufficient food for the whole year. Local employment opportunities are very limited so almost 16% of the male population between the age of 15–60 are working outside the villages to supplement their income (Trapp and Mool, 1996). Infrastructures like road, power supply and telecommunications are non-existent. Literacy rate is also very low as compared to other parts of the district.

3. Rationale

No initiation has been taken by the government for the research on panchaule with regard to its biophysical characteristics; quantitative resource assessments; appropriate harvesting regimes; proper season of harvesting; socio-economic study on the incentive package to motivate the local community for its conservation and cultivation; potential of processing for value addition and market information. This has led to the decline of panchaule through unsustainable harvest. At the same time, the harvesters are being exploited by the middlemen by paying very low price because it is an illegal product. However, the customers pay a high price thus benefiting only the middlemen. If such circumstances do not improve, the collectors would have no motivation to conserve the resource for its sustainable harvest. Ultimately the rural poor will lose their income as a result of resource depletion. Even the effective conservation and management measures undertaken jointly by the government and the community may not be productive because of the availability of its substitutes in the market. This situation will cause a great under-use or even complete waste of panchaule resource. This paper aims to assess the quantity of panchaule in the ACAP area and reviews the strengths and weakness of government's existing policy.

4. Biophysical characteristics

Panchaule is a herb (nearly 45 cm tall) growing in wet areas of open grassy meadows of central and western parts of Nepal between the altitude of 3050 m–3500 m. More information on its natural occurrence, description, best harvesting season, conservation status, royalty rate, market price, uses/ethnobotanical uses and active constituents are available in Parajuli *et al.* (1998). However, this species is also reported to occur at elevations up to 5000 m. This plant has underground root tuber with five digits and is of high economic value which is used throughout Nepal as tonic. It is also used against dysentery, cholera, diarrhoea and fever. Due to its aphrodisiac properties the demand of this species has remained very high not only in Nepal but also in India. It used to be exported even to Japan, Hong Kong, Switzerland, Germany and USA before the government banned its collection and export.

Panchaule can be cultivated at an altitude of 2500 m–5000 m. It favours acidic soil containing high amounts of organic matter (Shrestha, 1995). It is propagated by both seeds and vegetative methods. Seeds germinate after the snowmelt. In vegetative method the new underground shoots are collected and raised in the nursery bed for a few months and transplanted at a distance of 15 cm x 15 cm. Root tubers mature after two years in natural conditions and plantations. These tubers decay if they are not harvested within two growing seasons. The best time for collecting the tubers is September and October.

5. Materials and methods

PRA tools were used to collect general information on resource availability, distribution pattern, travelling distance from main settlements to panchaule growing areas, major harvesters, main seasons and ethnic groups involved in harvesting, primary trade routes, marketing system and prices, forest areas under community or government management, literacy status, and economic conditions. A wide range of respondents including government officials, local traders, exporters, and the farmers involved in the collection of NTFPs from ACAP area were also consulted during the first week of March, 1997.

Bhoje, Khudi and Pasgaun VDCs within ACAP area were randomly selected for the socio-economic study. A total of 15 households were purposively selected and information on main ethnic groups in the study area, family size, major occupations, land holding, on-farm and off-farm employment, major sources of income, cattle population, food sufficiency, NTFPs collection including panchaule, etc. were collected by using semi-structured questionnaires. In addition to socio-economic survey, information collection from other sources like the official records and publications of the District Forest Office, ACAP and ICIMOD were used for cross checking. The findings of the socio-ecomic survey are summarised in Table 1.

Table 1. Major socio-economic information in the ACAP area by VDCs

Name of VDC	Main ethnic group	Family size/ HH	Cattle pop^{n}.	Major occupation	Av. Land holding (ha)	Major source of income	Grazing on forests (months)	HH with food sufficiency for >12 months
Bhoje	Gurung (68.8)	5.75	10.50	Agriculture	1.36	Cattle, NTFPs	9	1.5%
Khudi	Gurung (42)	7.33	3.50	Agriculture	0.24	Off farm labour, NTFPs	11	6.0%
Pasgaun	Gurung (92)	5.71	6.83	Agriculture	0.98	Cattle, NTFPs	10	4.5%

Quantitative resource assessment of panchaule was carried out in the second week of August, 1997 in areas lying between the altitudes of 3000 m–5000 m within the four VDCs of ACAP areas identified as the potential panchaule growing areas (Table 2).

Table 2. Potential panchaule growing areas in Lamjung

Name of VDCs	Total area (ha)	Potential area covered (ha) between		Total potential area (ha)
		3000–4000 m	4000–5000 m	
Bhujung	6378.2	1347.60	351.00	1698.60
Ghan Pokhara	5894.2	1074.50	98.00	1172.00
Khudi	10105.1	1045.1	974.80	2019.90
Taghring	11130.1	2825.60	2050.70	4876.30
Total	33507.6	6292.80	3474.5	9767.30

Total potential panchaule growing areas to be studied between the altitudes of 3000 m–4000 m and 4000 m–5000 m were calculated by using grid system (counting dots), totalling to 9767.0 ha (29.1% of total area). This area was further stratified longitudinally (north to south) into three strata. One of the strata was again randomly selected for stratified systematic sampling to carry out quantitative resource assessment. A total of three sampling points were marked on the working map at equal distances in each altitudinal range thus totalling six sampling points. However, some field compromise was made at a few places to fix the points by shifting about 100 m up or down due to steep terrain, river system and continuous rainfall during study periods. Three circular sample plots of 17.8 m radius (1000 m^2) were marked on the ground at 200 m distance from each sampling point at 120 degrees angle to avoid any bias in sample plot selection. Thus a total of 18 sample plots were prepared for this study.

Altitude, aspect, slope, site condition, soil type, associated vegetation with panchaule, forest types, biotic impacts, presence of illegal harvesters, etc. were recorded for each sampling point and sample plot. Two key informants also accompanied the study team. The total number of panchaule plants was counted in each sample plot as juvenile, immature and mature based on the size of plant and their distended underground tubers. The population of other associated species was also recorded in all sample plots.

Air dry underground tuber biomass of panchaule was calculated by digging out three plants each of different sizes available inside and outside the sample plots. All the dug out materials were washed, air-dried and weighed for average air dry under ground biomass production per hectare.

6. Limitation and constraints of the study

Dense bushes and thickets of understorey plants with thorns and hooks together with rugged terrain were the main obstacles in the quantitative assessment of panchaule in the Conservation Area. Lack of tested tools and proper documentation on the quantitative assessment of panchaule tuber limited the development of an appropriate methodology of this study.

Panchaule near the trails and settlements were seen to be heavily extracted by the collectors but untouched in the difficult and inaccessible habitats. Thus, the sampling points fixed for this research may not be representative of the whole research area. Season of research (mid August) was another limiting factor to carry out this research in a very precise manner. Continuous rain throughout the study period may have substantially affected the quality of fieldwork.

Due to limited financial resources, time availability and rugged terrain, the sampling size taken seems to be very small (1.8 ha out of 9,767 ha). This might have over or under estimated the resources. Since the harvest and export of this species is illegal and the sampling areas fall under Conservation Area the perceptions of the local respondents may not reflect the field reality.

7. Results and discussion

The first panchaule plant was detected in juniper forest at 3150 m on south-west aspect with moist and black clay soil. The forest was under heavy biotic pressure of grazing and fire. Its population was observed in an increasing trend from 3800 m upwards, mostly on southern and south-east aspects with stunted vegetation of *Rhododendron* and *Berberis*. Above this altitude it was found mixed with other valuable medicinal plants like bikh (*Aconitum* sp.), jatamansi (*Nardostachys grandiflora*), kutki (*Picrorhiza scrophulariiflora*), nirmansi (*Delphium denudatum*), padamchal (*Rheum australe*) and pakhanbed (*Bergenia ciliata*) with different frequencies. It prefers open flat grassland with deep fertile soil, mostly close to seasonal sheds of sheep and cattle where this species receives regular manuring. In this study no panchaule plant was found beyond 4900 m. Altogether 31 plants of different stages were recorded from the sample plots. An average of 17 plants was recorded per hectare (Table 3). Other associated high value medicinal plants were also recorded.

Table 3. Number of panchaule plants of different stages found in the study area together with other associated medicinal plants

Species	Number of Plants for 18 plots			Total plants counted	Plants/ha.
	Juvenile	Immature	Mature		
panchaule	20	10	1	31	17
bikh	95	364	27	486	270
jatamansi	80	127	12	219	121
kutki	5	10	20	35	19
nirmasni	40	282	0	322	189
padamchal	0	2	0	2	1
pakhanbed	0	300	0	300	166

Table 3 shows that almost all mature panchaule plants had been already harvested illegally from the accessible areas leaving behind only juvenile and immature plants. Almost similar trend could be observed for other medicinal plants as well.

The average weight of air-dry tuber per plant was found to be 0.64 g (2.5 g fresh). On this basis, the production of air-dry tuber per hectare is calculated at 10.88 g, i.e. a total of 106.3 kg air-dry tuber for the whole study area. This figure could be doubled since the research team had observed many new illegally harvested areas. Attempt was made to calculate the illegal harvests from the study area. However, it became very difficult to assess the number of plants already dug out simply by counting the pits developed during harvesting or pulled out plants left at the sites.

The real market value of panchaule is not exactly known due to its ban on harvest and marketing. However, one could see its marketing (illegal) at the major trading centres like Kathmandu, Pokhara, Gorkha, etc. at different rates (Rs. 50–80/plant). Malla *et al.* (1993) had indicated Rs. 600.00/kg in Kathmandu market. However, this figure seems to be highly under priced as compared to recent market demand (though illegal). Even in the Forest Regulation (1995) the royalty rate for root tuber is fixed at Rs. 500.00/plant for court matters which seems to be very high compared with the previous study.

For the purpose of this study the average price for air-dry root tuber is fixed at Rs. 60/plant. On this basis, the study area (between 3000 m–5000 m altitude) could produce root tubers worth Rs. 10 million (US$ 1.5 million) per annum, which comes to around Rs.1000.00 per capita. Sustainable harvest of the other valuable medicinal plant resources also could provide substantial amounts to uplift the economic condition of the rural community.

A number of authors have provided different approaches to conserve and use the forest diversity. IUCN/UNEP/WWF (1991) states that the management of wild renewable resources would be possible only by involving the local communities through incentives. Jackson and Ingles (1994) stated that biodiversity is often lost when the forests are being used for income generation activities. Wilson (1988) believes that the loss of biodiversity is a natural process, however, human activities like deforestation and overgrazing will accelerate the rate of extinction. Such activities could pose a threat to the local occurrence of rare species. Global trends have shown that the species which are banned are not threatened at all whereas many which are showing exhaustion are still allowed to be collected without any restriction. This situation seems to be very true in Nepal also. Management of wild resources for sustainable use requires harvest rates sustainable for the species most vulnerable to exploitation. The harvest of a resource should not exceed its capacity to sustain exploitation. This could be done by regulating access or by setting collection quotas together with *in situ* and *ex situ* conservation. Yarsagumba (*Cordyceps sinensis*), an insect borne fungus used as aphrodisiac, for example, is banned to harvest and export by Nepal. China, on the other hand, is generating a lot of income in the country by allowing to harvest and market this species in a sustainable manner through *ex situ* conservation. This shows the possibility of conserving biodiversity through proper utilisation. This aspect is particularly very important to Nepal where the rural communities are heavily dependent on local resources for their livelihood. Available marginal farmlands in the hills do not provide enough food for their survival. The income, thus, generated from the marketing of the high value medicinal plants like panchaule could improve the food supply situation in the project area. This would ultimately help to motivate the local community in conserving their resources even if they are located in remote areas.

Awareness creation on local community regarding the importance of NTFPs on their livelihood is a prerequisite for the sustainable management of these resources. Local communities also presumed to have ample knowledge on proper season and appropriate method of harvesting of the resources. This study shows a big gap with respect to this matter. Hence there is an urgent need to bridge this gap through proper training either from the governmental or non-governmental organisations by developing simple tools on sustainable harvesting of NTFPs.

To assure its regular and profitable production, it is necessary to domesticate this species. The Department of Plant Resources is conducting research on its domestication at two altitudinal ranges namely Dhitachour (2100 m) and Narkesoda (2725 m) of Jumla district since the last three years. Since early results are very encouraging it is suggested to conduct further research and apply in the field for commercial purpose. Nevertheless, the outcome of Jumla research could be very useful to ACAP area for profitable and sustainable production of panchaule plants at the lower altitudes of the project areas.

A socio-economic study conducted at the Besisahar basin of Lamjung district (Parajuli *et al.*, 1997) has found that about 15 kg panchaule tubers were extracted in 1996 from the ACAP area although its extraction was illegal. Similarly, illegal harvest of about 100 kg of this species in 1989 was mentioned on the Forest Management Scheme of Lamjung district. Amatya *et al.* (1995) argue in their study that simply formulating law to ban the collection and marketing of panchaule tubers and not translating law into practice does not make any sense since its illegal collection is being continued unabated. Above studies and records give plenty of data to the resource managers that panchaule is regenerating (presence of juvenile plants) as per capacity of the site. Had there been environmentally aware people and efficient organisation in the remote areas to manage this resource, perhaps the loss due to harvesting of premature plants and due to biotic interference like forest fire, illegal harvesting, sheep and goat grazing could have been significantly minimised.

8. Conclusion

Forest resource in the study area is being used as an open access regime at least for cattle grazing, fuelwood and NTFPs collection. Open access regimes are often managed inefficiently leading to degradation of natural resources. Poverty and joblessness are forcing the Gurung and Tamang communities to harvest the medicinal plants unsustainably. People with empty stomachs certainly resort to any destructive activity irrespective of whether they have immediate or eventual impact on the community and environment. Economic needs are causing the local people to earn additional money from the sale of NTFPs including panchaule. Likewise, they are bound to graze their cattle in the forest areas by putting seasonal sheds to supplement their income from these cattle even at the cost of environmental degradation. Even if the laws are enforced effectively, the illegal collection of forest resources like panchaule may not be controlled without an active participation of the local people.

Biophysical characteristics of this species have suggested that it could be easily propagated by seeds. Field observation has also indicated that the study area is very conducive to panchaule growth. Since the panchaule growing areas are located at about two days' walk from the main settlements, there hardly exists any effective institutions like Community Forest User Groups, Panchaule Conservation Committees, forestry organisations, etc. to monitor the law enforcement.

Keeping in mind the biophysical characteristics of the species, potentiality of domestication, the present resource status in the study area, potential income likely to be generated from the sale (legal) of panchaule tubers, market availability and economic condition of the rural people at the study site, it is concluded that there is a need to harmonise between the social and biophysical parameters for long-term conservation of panchaule in the study area. There is an urgent need to lift the existing ban on its harvest and marketing.

9. Recommendations

- It is highly recommended that existing government policy on panchaule's sustainable harvest, marketing and present royalty rate be reviewed.

- Quantitative resource assessment for high value medicinal plants including panchaule should be carried out extensively for long-term planning and programming in developing enterprises within the district or country for value addition and employment generation.

- The government should prepare a technical manual on propagation, cultivation, domestication and harvesting techniques of the high value medicinal plants like panchaule and implement at once in the field for the perpetual supply of these products in the markets.

- Since most of the panchaule growing areas seem to be located at high altitudes and far from the permanent settlements there are hardly any Conservation Committees or Community Forest User Groups formed in the area. It is suggested to prepare a forestry operational plan of the particular area by involving all potential stakeholders like herders and local forestry institutions.

- ACAP should provide a regular market information to the harvesters on potential NTFPs so that they would not be exploited by the middlemen. This information will develop confidence in the harvesters to bargain with the middlemen for a reasonable price. This would ultimately encourage the communities for long-term resource conservation.

- Present scope and practices of research and development on domestication and cultivation of panchaule should be extended to different potential physiographic zones of the country.

- ACAP should develop and implement a training package (which includes identification, habitat, economic importance, ethnobotanical uses, cultivation and domestication, sustainable harvesting, processing, marketing channels, etc.) targeting the local communities so that each member of the community would have reasonable knowledge on resource conservation and wise use.

- It is recommended to develop an effective monitoring system by involving the local community and the forestry staff to control the present unscientific practices of NTFPs collection from the conservation area.

References

Amatya, K. R., Shakya, P. R., Bajracharya, P., Chitrakar, B. R. and Tuladhar, P. M. 1995. A Study Report on the Policy and Institutional Support for Sustainable Utilisation of Medicinal and Aromatic Plants in Nepal Himalaya. International Centre for Integrated Mountain Development (ICIMOD), Kathmandu, Nepal.

Bhatta, D. D. 1976. *Natural History and Economic Botany of Nepal.* Orient Longman Limited, New Delhi, India.

Edwards, D. M. 1996. Non-timber Forest Products from Nepal: Aspects of the Trade in Medicinal and Aromatic Plants, *FORESC Monograph No. 1/96*, Forest Research and Survey Centre, Ministry of Forests and Soil Conservation, Kathmandu, Nepal.

IUCN/UNEP/WWF. 1991. Caring for the Earth, A Strategy for Sustainable Living. IUCN, Gland, Switzerland.

Jackson, W. J. and Ingles, A. W. 1994. Developing Rural Communities and Conservation of Biodiversity of Nepal's Forest through Community Forestry. A paper presented at the Seminar on Community Development and Conservation of Forest Biodiversity through Community Forestry, 26–28 October 1994, Bangkok, Thailand.

Malla, S. B., Shakya, P. R., Rajbhandary, K. R., Bhattarai, N. K. and Subedi, M. N. 1993. Quantitative Assessment and Evaluation of Minor Forest Products in Rasuwa and Makwanpur Districts, Forestry Sector Institutional Strengthening Programme Component No. 2, Kathmandu, Nepal.

Parajuli, D. P., Gyanwali, A. R., Chaudhary, S. D., Shrestha, B. M., Rasaily, N. K., Trivedi, R. C., Pandey, R. C. 1997. A Report on Socio-economic Study at the Basisahar Basin of Lumjung District (*Unpublished Report*), IOF/ITTO Project, Pokhara, Nepal.

Parajuli, D. P., Gyanwali, A. R. and Shrestha, B. M. 1998. Manual of Important Non-Timber Forest Products in Nepal. IOF/ITTO Project, Pokhara, Nepal.

Shrestha, D. N. 1995. A Report on Training on Cultivation of Medicinal and Aromatic Plants and their Marketing Procedure (*Unpublished Report*), Pakhribas Agricultural Centre, Dhankuta, Nepal.

Singh, L. M. 1998. Medicinal Plants and Traditional Medical Practice in Gorkha District of Nepal, Paper presented at the National Training on NTFPs Marketing and Sustainable Management, 1–14 February, 1998, Institute of Forestry, Pokhara, Nepal.

Trapp, H. and Mool, P. 1996. Lamjung District Information System for Local Planning and Assessment of Natural Resources Using GIS and RS Technology. *MENRIS Case Study Series No. 4*, ICIMOD, Kathmandu, Nepal.

Wilson, E. O. (ed) 1988. *The Current State of Biological Diversity.* National Academic Press, Washington, DC, USA.

Mathema, P., Dutta, I. C., Balla, M. K. and Adhikary, S. N. (eds.). 1999. *Sustainable Forest Management.* Proceedings of an International Seminar, 31 August – 2 September 1998, Pokhara, Nepal.

Growth Studies on *Dalbergia sissoo* under Agroforestry in Dhanusa and Mahottari Districts, Nepal

S. N. Rai, Y. Ansari, C. P. Upadhyaya, S. N. Adhikary, B. Mahato, S. M. Mishra and S. Rayamajhi

Abstract: Along with some other tree species like *Ficus religiosa* and *Mangifera indica*, *Dalbergia sissoo* could be one of the earliest cultivated trees on farm lands. Its cultivation by farmers in Nepal is more than 100 years old. In order to study its growth under agroforestry conditions, data from 16 sites covering trees of 3 to over 70 years age was collected in parts of Dhanusha and Mahottari districts of Nepal. Analysis of soil samples from sites showed slight increase in organic matter and mineral contents of the soil around the trees. Regression equations for Age/Diameter, Age/Height and Diameter/Height were developed for trees on farm bunds, in block plantations, in different soil types and also for the combined data. There was a high degree of correlation between Age and Height, and Age and Diameter. The overall trend was curvi-linear. The growth was initially fast on lighter soils, however, eventually the heavier soils produced better height and diameter growth. Up to the age of 30 years the height growth is linear and thereafter it starts becoming a curve.

1. Introduction

The genus *Dalbergia* has around 300 species distributed in the tropics and sub-tropics of the world; most are trees. The best known members are called rosewoods. The well-known example in Nepal and India is *Dalbergia latifolia*. Its close cousin and not so highly priced yet more widely distributed, planted and used by the people, is *Dalbergia sissoo*. It is commonly called sissoo or shisham in the Indian sub-continent.

Sissoo is said to have been used for making charcoal in ancient times as evidenced by the findings of the excavations of the Mohanjodaro. It is distributed from Afghanistan to Assam, along the Indus, the Ganga, Brahmaputra and their tributaries. It is also found in the sub Himalayan region and ascends up to 1,500 m. Champion and Seth (1968) considered sissoo to be native of moist deciduous forests. It is a species of the riverain succession and a close associate of *Acacia catechu.* It occurs naturally in India, Nepal, Pakistan and Afghanistan, while elsewhere it has been planted. It can grow on slightly acidic to slightly sodic soils. It rarely regenerates under its own shade, however it can come up fairly widely from the seeds dispersed through wind and water. It is in full leaf during the hot summer months, a character not shared by its associates. It flowers in the early summer months and the fruits are ripe from November onwards.

In parts of Nepal farmers have been planting sissoo for at least 100 years now mainly by collecting wildlings. During the past 25 to 30 years nursery raised seedlings were planted and for the past 20 years stem cuttings have been used for propagation. Sissoo is a multipurpose tree, planted on farms for leaf fodder, fuelwood and timber. Sissoo yield ranges from 7 to 11 m^3 per ha per year in India and Pakistan. Sissoo is traditionally propagated from seed and is also amenable to vegetative propagation from stem or root cuttings, budding or grafting.

Terai Community Forestry Project was implemented in 16 districts in 1980s, over a total operational area of 20,000 km^2. The general goal was to increase fuelwood availability and provide employment. The components included free distribution of seedlings and block and strip plantings. Sissoo constituted 96% of all the species planted under the project. This paper discusses the results of a study on growth of sissoo under agroforestry conditions in Dhanusa and Mahottari districts of central

Terai in Nepal. In the Terai region of Nepal with its rapidly increasing population and decreasing forest resource base, agroforestry holds real potential for increasing the overall productivity of the limited land base.

2. Material and methods

In order to get an idea about the rate of diameter and height growth, both under bund and block plantations, measurements of Diameter at Breast Height (DBH) and height was recorded on a large number of trees. For this 16 sites were selected (12 bund plantations ranging from 3 to 75 years of age and 4 block plantations from 3 to 20 years of age). Measurement on 464 trees was recorded. From the available plantations trees were selected to represent all age classes. Out of the total population, generally 30 or more sample trees were selected by drawing random numbers. In case of block plantations, two plot replicates of 25 m x 20 m were selected to represent the plantations. All trees were numbered and 30 were randomly selected for measurement. For each tree DBH was measured twice with metal callipers, nearest to one tenth of an inch; and height was exactly measured with a clinometer. In case of trees larger than 24 inch in diameter, girth was measured with a tape. Later on where required, all the measurements were converted to metric system. The entire data was processed on computer using "Genstat" programme.

3. Results and discussion

Age/DBH relationship of sissoo on farm bunds

In case of agroforestry data of sissoo planted on field bunds in Dhanusa and Mahottari districts, non-linear regression of the form **y = A + B*R**X** and linear regression of the form **Y = A + BX** was fitted for Age and DBH. The non-linear regression values were:

$$DBH = 120.8 - 118.3*(0.9877)^{Age} \quad (n = 394, F = 569.57, r = 0.862).$$

The linear regression between age and DBH was of the form:

$$DBH = 6.288 + 1.0502\ Age \quad (n = 394, F = 1084.74, r = 0.856)$$

The non-linear relationship which is in form of an asymptote gives slightly better results than the linear equation.

Age/DBH relationship of sissoo in block plantation

In case of sissoo planted in blocks in Dhanusa district, the non-linear regression equation for Age/DBH was:

$$DBH = 42.6 - 41.7*(0.9563)^{Age} \quad (n = 108, F = 168.03, r = 0.87)$$

The linear equation in this case was:

$$DBH = 4.326 + 1.0582\ Age \quad (n = 108, F = 327.17, r = 0.868)$$

Overall Age/DBH relationship of sissoo

The overall Age/DBH relationship for sissoo in Dhanusa and Mahottari districts was:

$$DBH = 133.0 - 130.3\ (.98924)^{Age} \quad (n = 502, F = 790.61, r = 0.871)$$

The overall relationship in linear regression was:

$$DBH = 5.607 + 1.0658\ Age\ (n = 502, F = 1515.92, r = 0.867)$$

Age/DBH relationship in North Dhanusa

The data was also analysed for North and South Dhanusa categories. The soil of North Dhanusa is lighter and that of South Dhanusa is heavy. The non-linear relationship of Age/DBH for the data from North was:

$$DBH = 53.1 - 57.42 * (0.9528)^{Age}\ (n = 306, F = 376.41, r = 0.843)$$

The linear relationship for the same data set was:

$$DBH = 2.804 + 1.352\ Age\ (n = 306, F = 684.45, r = 0.831)$$

Age/DBH relationship in South Dhanusa and Mahottari districts

The data had one sample of ten trees of 70 years of age. When this data was included the DBH rose exponentially with respect to age. This cannot be the expected trend. Therefore this data was excluded and the remaining data up to only 40 years was considered. The asymptote curve for this data gave the equation:

$$DBH = 58.0 - 58.06 * (0.969)^{Age}\ (n = 186, F = 302.9, r = 0.875)$$

The linear regression for the above data (including the 70 years old trees) gave an equation:

$$DBH = 4.328 + 1.0204\ Age\ (n = 196, F = 1053.70, r = 0.919)$$

Age/Height relationship of sissoo in agroforestry

The overall relationship for Age/Height which had a single non-bund planting and some block plantations was used to fit non-linear regression. The overall equation was:

$$Height = 22.312 - 26.97\ (0.8763)^{Age}\ (n = 464, F = 531.0, r = 0.835)$$

The linear equation for this data set did not give a good fit. The data for northern part of Dhanusa district for Age/Height relationship gave a curve of the form:

$$Height = 24.074 - 28.32\ (0.8892)^{Age}\ (n = 281, F = 349.28, r = 0.844)$$

The data for South Dhanusa and Mahottari district was used to fit non-linear equation which was of the form:

$$Height = 21.517 - 22.74\ (0.896)^{Age}\ (n = 183, F = 228.63, r = 0.845)$$

In these cases also, linear regression gave a poor fit as compared to asymptote.

DBH/Height relationship of sissoo in agroforestry

The data was considered to fit regression between DBH/Height, as seen in northern part of Dhanusa district. The non-linear equation of the form given below gave the best fit:

$$Height = 26.72 - 26.806\ (0.9499)^{DBH}\ (n = 281, F = 452.69, r = 0.874)$$

Similarly, for South Dhanusa and Mahottari districts the non-linear regression excluding the data of 70-year-old trees was:

$$Height = 26.06 - 25.242\ (0.9513)^{DBH}\ (n = 183, F = 513.86, r = 0.921)$$

Similarly, an overall non-linear relationship for the entire data was tried and the equation was:

$$Height = 27.262 - 26.034\ (0.9513)^{DBH}\ (n = 464, F = 854.5, r = 0.887)$$

From the above analysis it may be seen that the DBH/Height relationship is better correlated for the data of North Dhanusa followed by that of South Dhanusa and Mahottari and when both are combined the value of R^2 becomes lower, indicating that the data of two areas do not combine well.

DBH/Height relationship in bund and block plantations

It was considered worthwhile to look at the DBH/Height relationship of sissoo trees in the study areas under farm bund planting and under block plantations separately. The non-linear relationship for bund plantation, excluding the data of the 70–year–old trees was:

$$Height = 28.25 - 26.939\ (0.9632)^{DBH}\ (n = 357, F = 812.59, r = 0.906)$$

Similarly, the data for the block plantations of sissoo in North Dhanusa district had a non-linear relationship of the form:

$$Height = 32.90 - 35.56\ (0.95143)^{DBH}\ (n = 107, F = 404.55, r = 0.94)$$

It is evident that there is better correlation between DBH and Height in block plantations as compared to those in bund planting. This is as expected. There is more uniform growing space and more competition for height in block plantations than in bund plantings.

DBH/Height relationship of sissoo in Dhanusa

The study sites were distributed in north and central Dhanusa and in southern part of both Dhanusa and Mahottari districts. The main focus was on bund or single row planting of sissoo. Therefore of the 16 study areas, 12 represent such trees whose age varies from 3 to 40 years with one exceptionally old planting where trees are said to be over 75 (in Parkauli village of Mahottari district). In addition, four block plantations of age 3 to 20 were considered.

DBH/Height data of 464 trees were collected, which can be grouped as block and bund plantation. Further, this data can also be considered as north, central and southern parts of the district. The areas in North Dhanusa had sandy soil and those in the south had loamy sand or sandy-loam. The data has been divided into north and south and is based on 281 and 183 trees respectively. The equations derived on DBH/Height relationship are given below. Combined equation for 12 bund-planting sites in Dhanusa and Mahottari districts was:

$$1/Height = 0.0215 + 0.8489 \times 1/DBH\ (n = 357, r = 0.917)$$

Similarly, combined equation for four block plantations in Dhanusa district (in northern part on lighter soils) was:

1/Height = 0.0209 + 0.6481 x 1/DBH (n = 107, r = 0.962)

Regression equations were also derived for North Dhanusa, South Dhanusa and South Mahottari and a combined one for the entire data. The equation for north Dhanusa was:

1/Height = 0.0211 + 0.7645 x 1/DBH (n = 281, r = 0.9105)

The equation for South Dhanusa and South Mahottari was:

1/Height = 0.0309 + 0.6697 x 1/DBH (n = 183, r = 0.9347)

The combined equation for the entire data of 464 trees for the sissoo in these two districts was:

1/Height = 0.0243 + 0.7389 x 1/DBH (n = 464, r = 0.9168)

Based on these relationships a DBH/height table has been constructed (Table 1).

Table 1. Diameter/Height relationship in sissoo under agroforestry in Dhanusa and Mahottari districts

DBH (cm)	Height (m)				
	Bund	Block	North	South	Combined
1	1.2	1.5	1.3	1.4	1.3
5	5.2	6.6	5.7	6.1	5.8
10	9.4	11.7	10.3	10.2	10.2
20	15.6	15.8	16.9	15.5	16.3
30	20.1	23.5	21.5	18.8	20.4
40	23.4	27.0	24.9	21.0	23.4
50	26.0	29.5	27.5	22.6	25.6
60	28.1	31.5	29.6	23.8	27.3
80	31.1	34.5	32.6	25.5	29.8

The values of determination coefficients for bund, block, North, South and combined data is 0.841, 0.925, 0.837, 0.874 and 0.841 respectively. This means, for the combined data, 84.1% variation in height is dependent upon diameter of the tree. This relationship is maximum in block plantations where it could be 92.5%. Based on the values of correlation coefficients (r) all the five equations are significant at 1% level of probability.

Age/Height relationship: From the 16 sites the average height data was available and was used for plotting. It clearly has a curvi-linear trend. Regression was fitted which is given below:

1/Height = 0.0271 + 0.474 x 1/Age (n = 16, r = 0.95)

This relationship is significant at 1% probability. The Current Annual Increment (CAI) and Mean Annual Increment (MAI) values of height are given in Table 2.

Age/DBH relationship: As in case of Age/Height curve, the average data available from the 16 sites was also plotted. Both linear and curvi-linear regressions were tried. In this case the linear model gave better fit. The equation **DBH = a + b Age** was found suitable.

Although the relationship is highly significant, this equation has some limitations. It shows that at age 0 DBH is 5.27 cm which is absurd but for the observed range of diameters the equation gives reliable values. The value of determination coefficient is 0.852, which shows that to the extent of 85.2% DBH is directly related to age of the tree. The data of the plantation of 18 years with an average DBH of 36.2 cm was not considered in the calculation. The resultant equation was:

y = 4.64 + 1.09 Age (n = 15, r = 0.96)

Table 2. Age/Height, Age/DBH relationship in sissoo in Dhanusa and Mahottari districts

Age (yr)	Height			DBH		
	Av. height (m)	CAI ($m^3 ha^{-1} yr^{-1}$)	MAI ($m^3 ha^{-1} yr^{-1}$)	Av. DBH (cm)	CAI ($m^3 ha^{-1} yr^{-1}$)	MAI ($m^3 ha^{-1} yr^{-1}$)
1	2.0	-	-	5.7	-	-
5	8.1	1.2	1.6	10.1	2.0	2.2
10	13.4	1.1	1.3	15.5	1.1	1.6
20	19.7	0.6	1.0	26.4	1.1	1.3
30	23.4	0.4	0.8	37.3	1.1	1.2
40	25.7	0.2	0.6	48.2	1.1	1.2
50	27.4	0.2	0.6	59.1	1.1	1.2

Predictions of rate of diameter and height growth under agroforestry in Dhanusa

Most data set was from farm bund plantations of age ranging from 3 to over 70 years. This has generally been called bund planting and the other category was block planting. The soils of northern and southern part of Dhanusa appeared different and hence the data set was considered as north and south.

Age/Diameter relationship: As expected, overall and bund planting predicted values of diameter against age are very comparable (Table 3). From 5 to 20 years of age the rate of diameter growth appears to be very fast, it still continues to be fast for the bund plantations up to 30 years, thereafter it slows down. As expected, the rate of growth in block plantations (studied up to 20 years of age) is appreciably slower than the bund plantings. When the North and South Dhanusa predicted values are compared, it is revealed that the rate of diameter growth in South Dhanusa is faster than in North Dhanusa. It is interesting to note that diameter growth in North Dhanusa is appreciably faster up to the age of 20. Around the age of 30 years both the areas are comparable, but thereafter the diameter growth in South Dhanusa is faster. The predictions have been restricted to the age of 40 only as most data set is up to this age.

Table 3. Age (yr)/Diameter (cm) relationship of sissoo under agroforestry in Dhanusa district

Age (yr)	DBH (cm)				
	Overall	Bund	Block	North Dhanusa	South Dhanusa
5	9.56	9.61	9.25	8.01	8.40
10	16.06	16.29	15.93	17.69	15.62
20	28.05	28.48	25.54	31.27	27.07
30	38.81	39.24		35.96	35.43
40	48.47	48.75		39.64	41.52
50	57.14	57.15			
60	64.92	64.57			
70	71.90	71.13			

Age/Height relationship: This has been considered for North and South Dhanusa and overall for the district. As revealed in Table 4, the height growth is faster in North Dhanusa as compared with South. However, the overall growth rate also is more than what is obtained in South. The interesting aspect is that height growth declines sharply at the age of 20 years and it appears to reach a plateau around 30 years. The height growth appears to be uniformly fast in all the categories up to 5 years of age when a maximum rate is seen. Thereafter it progressively slows down. At the age of 30 there is a difference of around 3 m in the height obtainable in North and South Dhanusa.

Table 4. DBH (cm)/Height (m) relationship of sissoo under agroforestry in Dhanusa district

DBH (cm)	Height (m)				
	North Dhanusa	South Dhanusa	Overall	Bund Plantation	Block Plantation
5	5.99	5.98	5.98	5.92	5.18
10	10.68	10.08	10.46	9.73	11.29
20	17.12	15.95	16.67	15.52	19.76
30	20.98	19.66	20.44	19.50	24.92
40	23.29	22.01	22.73	22.24	28.85
50	24.66	23.49	24.12	24.12	
60	25.49	24.44	24.96	25.41	
65				25.90	

DBH/Height relationship: When we compare the predicted values for North and South Dhanusa, they are same at 5 cm DBH. However, the differentiation starts appearing thereafter and North Dhanusa maintains the lead till 60 cm DBH. The block planting has an initial slow start up to 5 cm but thereafter it picks up and is appreciably higher at 40 cm DBH, as compared with the bund planting. Block plantations have more competition for light and space hence there is better height growth for the same DBH. The bund planting values reveal that near culmination of height growth occurs when the DBH is around 65 cm.

4. Conclusion

Sissoo is a popular species for agroforestry in the Terai. In the study area up to the age of 30 the height growth of sissoo is linear, thereafter it becomes curvi-linear. Trees of 50 years of age have average diameter 59.1 cm, height 27.4 m and over-bark volume of 3.01 m^3.

Reference

Champion. H. G., and Seth, S. K. 1968. *Forest Types of India* (A Revised Survey) Ministry of Publication, Government of India, New Delhi, India.

Mathema, P., Dutta, I. C., Balla, M. K. and Adhikary, S. N. (eds.). 1999. *Sustainable Forest Management*. Proceedings of an International Seminar, 31 August – 2 September 1998, Pokhara, Nepal.

Domestication of Edible and Medicinal Mushrooms: An Underdeveloped Side of NTFPs

J. B. Raintree

Abstract: The domestication and cultivation of overexploited non-timber forest products (NTFPs) is an area of forest management that is finally beginning to receive the attention it deserves. One aspect, which is yet to be addressed however, is the enormous potential for domestication of mushrooms and other fungi through mycological landscaping in community forest grades or more intensive methods in agroforestry based micro-enterprises. Although everyone agrees that mushrooms are NTFPs almost no one seems to know what to do about them.

This paper highlights some of the outstanding opportunities for mushroom cultivation and marketing in Nepal and seeks to raise awareness of the wealth of new techniques and resources that can now be brought to bear on this development. Following a preliminary analysis of prerequisites for success under Nepalese conditions and drawing on the ancient mushroom growing traditions of East and Southeast Asia, and the emergence of small scale mushroom enterprises both in America and Europe, a number of specific options and lines of development are identified.

1. Introduction

1.1. Why domesticate?

Historically, domestication has been one of the most common eventual solutions to problems of natural resource degradation though overexploitation. By bringing a species into cultivation, it then becomes a matter of conscientious routine – rather than chance that its continued propagation and survival is ensured. One of the things to come out of the study of the *jaributi* (medicinal plants) trade in Nepal was a favourable attitude toward domestication as a solution to problems of overexploitation; but as Edwards (1993) points out, it is not a panacea:

> Potential for common property management of HVHAs [high value products from high altitudes] is severely limited by the magnitude of the areas over which the products as collected by a single community. Cultivation may therefore offer the only widely applicable solution to overexploitation. However cultivation on private land is unlikely to benefit the majority of the current collectors, who do not have the necessary land, labour or capital. Collection to destruction in the wild may thus continue, regardless of domestication by a few.

The tenure issue is at the heart of any effort to improve community forests through improved technology and management. For community "agroforests" to develop and to reach their full potential, some form of more intensive management must replace unregulated collection, if villagers are to be encouraged to invest more labour and other resources in hope of eventual gain. Nepal is one place where precedents for successful management of community forest resources do exist (Fisher, 1994). If adequate common property management solutions can be implemented, domestication can become an important tool of management. Even if full investment in community agroforests is slow in coming, many mushroom-growing technologies can be applied on farms and in small household based production units, irrespective of community forest developments. In many different forms mushroom growing can help:

- Relieve pressure on overexploited biotic resources
- Address poverty alleviation issues by developing new livelihood options compatible with local needs and opportunities
- Ease work burdens by creating livelihood opportunities closer to where people live
- Provide additional short-term incentives for improved management of community forests.

1.2. Why mushrooms?

Among the many reasons mushrooms are attractive candidates for domestication in Nepal are:

- Rapidly expanding global and national markets for mushrooms – the "food and medicine of the future"
- It is possible to produce high-value, light-weight dried mushrooms that can help overcome the transport disadvantages of remote areas
- The wide altitude range found in Nepal provides opportunities or taking advantage of special climatic niches, making it possible for otherwise disadvantaged communities to enjoy a comparative advantage
- Mushrooms and other fungi play important, though still little understood, roles in the ecosystems and are thought to have a special potential for eco-remediation and development of more sustainable production systems (e.g. through the use of symbiotic mycorrhizal associations
- Recently, there has been a virtual explosion of innovation in small-scale mushroom production technology, which opens up possibilities of cultivation to a wider group of beneficiaries.

2. Gourmet and medicinal mushrooms in global perspective

2.1. Some statistics

The popularity of mushrooms as food and medicine is increasing globally. Mainland China is still the world's largest producer, accounting for about 50% of global production. During the past two decades total mushroom production world-wide has increased more than ten-fold, most of this occurring during the last ten years. Table 1 shows the total production of the main edible mushrooms in global commerce and a shift in the proportion of different mushrooms in the market. Twenty years ago, the button mushroom, *Agaricus bisporus*, accounted for over 70% of the world's supply. By 1991, although production of button mushroom had continued to increase, proportionately it had dropped to only 38% of world production, giving way to other, lesser-known mushrooms, such as *Lentinula, Flammulina, Pleurotus, Hypsizygus, Hericium, Morchella*, and *Grifola*. Based on these historical trends, the outlook is for continued growth of the global mushroom market, fuelled by improvements in technology that will allow consumer prices to decline (Royse, 1996).

In the past decade, a "global herbal renaissance" has developed as part of an emerging awareness of alternatives to western medicine. The medicinal mushrooms enjoy a special reputation within this movement for their efficacy in chronic viral and immune disorders in which western medicine has not been very effective. The traditional Asian herbalists have long recognised the special role of the medicinal fungi. Recent scientific research has tended to corroborate and extend our understanding of the underlying physiological mechanisms, although much is still not well understood. The medical effects of six of the most important of these fungi are summarised in Table 2.

Table 1. World production of the major edible mushrooms of commerce (tonnes)

Mushroom	1980/81	% of Total then	1990/01	% of Total now	% increase	Major Producers
Agaricus (button)	940	70%	1,446	38%	154%	China, France, Holland, USA, Ireland, UK, Italy, Spain, Indonesia
Shiitake	192	14%	402	11%	209%	Japan, Korea, Taiwan, China, France, USA
Straw	50	4%	207	5%	414%	China, Taiwan, Thailand, Indonesia
Oyster	32	2%	909	24%	2841%	Italy, Germany, France, Hungary, India, Taiwan, Thailand, Japan, Latin America, China
Wood Ear	46	3%	400	11%	870%	China, Taiwan, Thailand
Winter	60	4%	143	4%	238%	Taiwan, Japan
Silver Ear	7	1%	105	3%	1500%	Taiwan, Japan
Nameko	17	1%	53	1%	312%	Japan, Indonesia, Philippines
Others	2	0%	129	3%	6450%	SE Asia and China
Total	1,346	100%	3,794	100%	282%	

(Source: http://molbiol.soton.ac.uk/msdn/market3.html)

Table 2. An indicative list of medicinal mushrooms and their physiological effects

Mushroom Uses	*Cordyceps sinensis*	*Lentinula edodes*	*Ganoderma lucidum*	*Grifola frondosa*	*Tremella fuciformis*	*Wolfporia cocos*
Anti-Viral	+	+	+	-	-	+
Anti-Tumor	+	+	+	+	+	+
Immune Enchancer	+	+	+	+	+	+
Anti-inflammatory	-	-	+	-	+	-
Blood Pressure	+	+	+	+	+	-
Cardio-Vascular	+	+	+	-	+	-
Lower Cholesteroal	+	+	+	-	+	-
Increase Libido	+	+	-	-	-	-
Kidney Tonic	+	-	+	-	-	-
Asthma/Bronchial	+	-	+	-	+	-
Stress Reduction	+	-	+	-	-	-
Diabetes	-	-	-	+	+	-
Liver/Hepatitis	+	+	+	+	+	+
Chitin	+	+	+	+	+	+

(Source: GMHP Health Products website: http://health.pln.net/index.htm#SMX)

From Table 2 it would appear that each of them could be regarded as a "panacea". The reason each of these mushrooms has so *many* different effects is that their active chemical constituents (mainly polysaccharides and triterpenes) work to strengthen key homeostatic mechanisms and fundamental processes like phagocytosis, interferon production, hormonal regulation, etc., which are central to the body's health maintenance systems. Some of these mushrooms have been classified as "adaptogens," similar to *ginseng,* which neutralise stress, normalise bodily functions, and increase non-specific resistance.

Many of the medicinal mushrooms are polyphores, bracket fungi which usually grow out of the side of trees or on decomposing logs. Most of them are quite woody (e.g. reishi mushroom) and only suitable for tea or extracts, but some of them are actually very delicious - gourmet mushrooms in their own right! Chief among these is *Grifola frondoza* (maitake), also known as "hen-of-the-woods" in America. Dr. Andrew Weil, spokesman for a growing body of scientifically respectable alternative medicinal practitioners, regards maitake as one of his very favourite edible mushrooms. Says Weil (1995):

> I recommend supplements of maitake to people with cancer, AIDS, and other immune system problems as well as to those with chronic fatigue syndrome, chronic hepatitis, and environmental illnesses that may represent toxic overloads.

Sports medicine and other "performance" enhancing uses are another major area of application. In this connection, one of Nepal's own mushrooms, Yarsagumba (*Cordyceps sinensis*) is particularly interesting. Stamets (1996) sheds an interesting light on the relevant physiological effects of this high altitude mushroom.

> Hot water extracts of this fungus have compounds, which relax the bronchial passages, enhancing respiration. At a recent mycological conference, a group of Japanese researchers showed that water extracts of this mushroom dilated the right aorta by 40% under stress. The increase in blood flow would benefit muscles pushed to their maximum, and greatly add to endurance. A clinical study with sexually dysfunctional men found that 64% improved in performance from ingesting a gram per day.

Whatever it might be able to do for athletic performance, *Cordyceps* most certainly has been a help in coping with the energy demands and stresses of the high altitude environment. Until very recently, very few people in the outside world had ever heard of it. But this is changing rapidly. As Stamets (1996) comments:

> This mushroom has made sports headlines. At the Chinese national Games in 1993, a team of nine Chinese women runners shattered 9 world records, with the 10,000 metre run broken by an unprecedented 42 seconds. Recently a marathon "road-runner" called me to report that he was able to cut 25-minutes off the Boston Marathon in one month using this mushroom in a tea.
>
> I recommend ingesting medicinal mushrooms 3 times a week as a regimen. For endurance training, Reishi (*Ganoderma lucidum*) and Caterpillar Fungus (*Cordyceps sinensis*) are the best candidates and should be used for no more than 3 days in a row. For competition, I recommend preparing a tea made of these mushrooms and ingesting it one to two hours prior to the event. Presently, none of these mushrooms is listed as disqualifying performance-enhancing drugs, nor are they illegal.

2.2. What is it all worth?

Table 3 presents some representative price data in order to give some idea of the value of the income earning potential of mushrooms traded on the world market. These are – not rock bottom but – *well-settled luxury prices* in a well-supplied and efficient market. It is not unusual to sell at much higher mark-ups if one is operating in less efficient markets. Ideally, this should be supplemented by interviews with mushroom traders in Nepal in order to ascertain the prevailing prices within country.

Table 3. Indicative retail prices of gourmet and medicinal mushrooms

Mushroom type	Retail prices ($ per kilo)
Fresh gourmet mushrooms at the Moneterey Market in Berkeley, California (Source: http://danr.ucop.edu/ihrmp/oak34.htm)	
Shiitake	13-25
Oyster	9
Morel	29-33
Matsutake	42
Chantrelle	28-33
Boletus	33
Black truffles	297
Dried gourmet mushrooms on the internet http://www.seamertrunkmerchants.com/driedmushrooms htm (Note: dried mushrooms typically weigh 10-20% of their fresh weight)	
Porcini (*Boletus edulis*)	121
Chanterelle	136
Morels	165
Shiitake	84

Table 4 gives prices for mushroom extracts. In order to get an idea of the value-added price increment, the price "per kilo" of the dry weight whole mushroom equivalent of the bottled extract has been calculated, although one would never have to pay this price if one were buying the equivalent amount of dried mushrooms. Obviously, the processing and small-unit packaging costs add very significantly to the market value of the raw ingredients.

Table 4. Single mushrom mycelium extracts from GMHP Health Products

Mushroom	Retail price	
	Unit price $/bottle	Value of raw materials after processing $/kg (mushroom dry weight)
Ganoderma lucidum (Reishi, Ling chi)	22.00	786
Lentinus edodes (Shiitake)	22.00	786
Cordyceps sinensis (Yarsagumba)	27.00	964
Grifola frondosa (Maitake)	25.00	893
Tremella fuciformis (Jelly Fungus, Silver Ear)	22.00	786
Wolfiporia cocos (Poria cocos, Fu ling Hoelen)	22.00	786
Sold in 1 fl. oz bottles (20-30% alcohol by volume). The amount of dried mushroom in each bottle of extract was not revealed on this website, but if normal herbal tincture procedures were followed there will be about 1 oz of mushroom (dw) for each 1 fl. oz of solution. (This was the basis for calculating the price/kg of the mycelium used).		

(Source: http://health, pon.net/index.htm#SMX).

2.3. Value-added processing and marketing

As the above indicated increase in "per kilo" prices suggest, there is scope for considerable value-added processing. The reader is cautioned against jumping to the conclusion that the primary producers or collectors of the mushrooms are not getting their fair share of the final price. Each additional value-adding step in the chain of processing and marketing has costs and risks that have to be covered. In the mountains, even simply moving an NTFP raw material down to the roadhead and its subsequent transportation chain until it reaches the final consumer (see Table 5).

In terms of material processing, drying of mushrooms for portage from the mountains would be, in most cases, a necessity because it is difficult to transport down out of the mountains quickly enough to enter the fresh market, unless perhaps by helicopter. Mushrooms can be dried but this can greatly effect the price. The value of a product can also be increased by breaking it down into "convenience packages". This too has substantial material and labour costs. Beyond that, very considerable price multiples can be added by processing the raw material into a form that is preferred by the market (e.g. putting standard doses of biter medicinal extracts into germ-free capsules).

With medicinal mushrooms there is also the very real possibility of producing extracts and even packaging them for sale to resellers in specific niche markets or for direct sales to final consumers over the Internet. Producers can capture more of the final value by adopting a strategy of vertical integration, doing their own value-added processing - possibly on a workshop scale or as a cottage industry linked more directly (conceivably through a marketing co-operative) to export markets. The normal assumption that the cost of capital equipment to enter into this kind of business would be prohibitive, has not been borne out by my own experience with herbal product manufacturing in Bangkok. It is a question of scale and appropriate technology. The Asian tradition itself, best exemplified by China and India, never lost sight of the family farm, family business or shop-house scale of production, and is still the best source of "intermediate technology" for a decentralised herbaceutical cottage industry.

2.4. How much of the final price can the producer expect to capture?

Producer prices in most industries run at about 25% of the retail price to the ultimate consumer. Mushrooms are not an exception to this rule. Farmgate and roadhead price and subsequent margins along the chain can be expected to run more or less as shown in Table 5 from a survey of morel marketing in North West Frontier Province, Pakistan (Ali, n. d.).

Table 5. Increments in the price of morel mushrooms in the marketing chain from collector (c) to exporter (e) in North West Frontier Province, Pakistan (Rupees per kg)

Mushroom	Collector (c)	Local Trader	Non-local Trader	Exporter (e)	Price Increase (c to e)
M. conica	2000-2500 ($40-50)	2500-2800 ($50-56)	2900-3600 ($58-72)	4000-4800 ($80-96)	100%
M. rotunda	400-600 ($10-15)	600-800 ($12-16)	800-1000 ($16-20)	1300-1800 ($26-36)	300%

The observations of researchers on the *jaributi* trade in Nepal may help create a balanced perspective on the marketing functions performed by various "middlemen" and the advisability of trying to by-pass the existing marketing chain:

> The village traders play a decisive role in the trade as it is they who have direct contact with the collectors ... When calculating the income generated per beneficiary, the village trader appears to make only slightly more than a hard-working collector's household. The village trader's advantage may lie in his option to store the products, speculate on the price ... and sell at the opportune time.
>
> In theory there are prospects for collectors to by-pass the village traders and increase their incomes by direct sale to the roadhead. However, the

essential marketing functions played by village traders must not be overlooked, in particular the provision of credit and labour. The village trader network must not be jeopardised without first establishing alternative sources of marketing assistance for collectors. If this could be achieved, perhaps through co-operatives or forest user groups, the collectors should double their current income (Edwards, 1993).

3. Eco-friendly, small scale mushroom growing technologies

At no other time in history has such a wealth of resources been available to the would-be mushroom cultivator. Paralleling the rise of global interest in mushrooms as a commodity has been the growth of the home cultivation movement in North America, led by Paul Stamets (1983, 1993), Bob Harris (1986) and others. This combines with techniques from the older European tradition (Steineck, 1981; Singer and Harris, 1987; Oei, 1996), and an *amazing* variety of low-cost methods from the mushroom growing traditions of East and Southeast Asia (RAPA, 1983), to give us a toolkit of considerable scope.

The technique of growing *champignon*, the button mushrooms of commerce, on compost represents only a tiny fraction of the available techniques for growing mushrooms. In global perspective it is, in fact, a rather anomalous technique, with a greater dependence on human labour than natural process.

3.1. Options for domestication

The concept of domestication implies more than just the cultivation of mushrooms. Any sort of beneficial management of naturally occurring fungal resources can qualify as a kind of semi-domestication. Opportunities for involvement in the domestication process occur at many different intensities of domestication, e.g.,

- Sustainable harvesting from wild populations
- Enrichment planting (*in situ* inoculation or planting of inoculated seedlings)
- Natural cultivation (mycological landscaping, gardening with mushrooms)
- Indoor cultivation on artificial substrates
- Mycelial culture.

3.2. Major gourmet and medicinal species and their cultivation possibilities

A good overview of the range of possibilities can be garnered from a close reading of the following table.

Table 6. Major gourmet and medicinal mushroom species, associated cultivation techniques, and markets

Mushroom	Conditions for Fruiting		Natural Culture	Substrates	Market
	Temp. Range (^{0}C)	Humidity Range (%)			
Agarius bisporus (Button)	10-20			Pasteurised & fermented compost with casing	Gourmet Fresh, canned
Agaricus bitorquis (warm weather button)	25-26	85-92		Pasteurised & fermented compost with casing	Gourmet Fresh, canned, longer shelf life than *A. brunnescens*

Auricularia polytricha (Tree Ear)	21-30	85-90	Inoculated hardwood logs *a la* shiitake; other agroforestry mixtures (China)	Logs, supplemented (supp.) sawdust	Gourmet, medicinal Fresh, dried
Ganoderma lucidum (Ling Chi, Reishi)	21-27	90-95	Inoculated hardwood stumps & buried logs	Supp. hardwood sawdust blocks	Medicinal Dried, extract
Grifola frondosa (Maitake)	13-16	85-90	Inoculated hardwood & some conifer stumps & buried logs (incl. pine, larch, Douglas fir) (incl. non-virgin stumps)	Supp. hardwood sawdust blocks; strains for conifers under development	Gourmet Medicinal Fresh, dried, extract
Hericium erinaceus (Lion's Mane)	18-24 15-25? 20-28?	90-95	Inoculated hardwood logs a la shitake	Sterilised supp. sawdust?	Gourmet, medicinal Fresh, dried whole florets
Hypholoma sublateritium (Kuritake)	10-16	90-95	Inoculated stumps & buried logs	Supp. Sawdust blocks	Gourmet Japan Fresh, dried
Hypsizygus tessulatus (Buna Shimeji)	13-18	90-95	Inoculated hardwood stumps & buried logs, deep beds of woodchips	Supp. Sawdust blocks (willow, oak, cottonwood, beech, elm)	Gourmet Japan Fresh, dried, powdered
Lentinula edodes (Shiitake)	16-18 Stam 8-24 strain dep.	60-80	Inoculated hardwood logs	Serialised or pasteurised supp. hardwood sawdust blocks	Gourmet, medicinal Fresh, dried
Morchella augusticeps (Black Morel)	4-16	85-95	Inoculated patches of special sawdust/chips mix on burnt site	Peat moss, ash gypsum mix	Gourmet Fresh, dried
Pholiota nemeko (Nameko)	13-18	90-95	Inoculated hardwood logs a la shitake	Supp. Sawdust blocks (incl. pine & *Cryptomeria*) w/ good envir. Controls; bran supp. at 15% for conifer & 10% for broad-leaf sawdust	Gourmet Japan Fresh, canned
Pleurotus abalonus (Abalone)	25-30			Pasteurised, sterilised	
Pleurotus citriopileatus (Golden Oyster)	21-29	90-95	Inoculated hardwood stumps & buried logs	Supp. hardwood sawdust blocks, straw, other agric waste	Gourmet
Pleurotus ostreatus	10-21 5-25	85-90	Inoculated hardwood stumps & logs	Pasteurised, sterilised	Gourmet
Pleurotus pulmonarius (Indian Oyster)	18-24 13-20	85-95	Exceedingly easy to cultivate on inoculated hardwood stumps & logs, straw, other agric waste materials	Wide variety of substrates, esp. straw, agric waste	Gourmet

Pleurotus djamor (Pink Oyster)	20-30	85-90	Inoculated hardwood stumps & logs; straw mounds (aggressive coloniser)	Sawdust, straw, agric wastes of many kinds	Gourmet (best tasting oyster according to Stamets)
Polyporus umbellatus (Zhu ling)	10-16	85-95	Sclerotia from inoculated logs already colonised by e.g. *Armillaria*; spec. technique	Limited success with spent blocks of shiitake, maitake, reishi	Med-dried sclerotia (esp. lung cancer) Gourmet - fresh fruiting bodies
Stropharia rugoso-annulata (King Stropharia)	16-21 10-25 strain dep.	90-95	Inoculated woodchip beds (alder); wheat straw bales or mounds Mycelium easily transferred to new bed	Pasteurised straw or sterilised sawdust with casing	Gourmet (only young mushrooms)
Tremelia fuciformis (Jelly Fungus, Silver Ear)	20-27	85-90	Inoculated hardwood logs a la shiitake (no need to inoculate the helper mycelium if using logs)	Mixed culture with "helper" mycelium of *Hypoxyion archeri* on sawdust	
Vovariella volvacea (Paddy Straw)	27-32	85-90	Ideal for low-tech outdoor cultivation on straw in the tropics	Paddy straw or supplemented wheat straw; sawdust	Gourmet Fresh, canned, rarely dried

(Sources: Stamets, 1993; Hobbs, 1986; Oei, 1996)

3.3. Development of gourmet mycorrhizal fungi

It is a curious accident of nature that the choicest of the gourmet mushrooms are all mycorrhizal symbionts! The host-symbiont relationship, which forms between the fungal mycelium and the roots of the host tree, is a symbiotic relationship beneficial to both partners. This form of co-dependency is a good platform for sustainable cultivation. Foresters have paid a lot of attention to the role of mycorrhizal fungi in improving timber yield, but little attention has been given, outside of Europe, to the culinary dimensions of this practice. A system that helps the trees to grow better and provides the world's most expensive gourmet mushrooms as a by-product – surely this is how the gods practise agroforestry!

Table 8. Cultivation status of some gourmet mycorrhizal mushrooms and other unusual fungi

Mushroom	Cultivation Status	Comments
Mycorrhizal Symbionts		
Tuber melanosporum (Perigord truffle)	Mycorrhizal symbiont of oak and hazelnut has been semi-domesticated since the mid 1800s in France by transplanting seedling from under infected trees. In 1970s reliable nursery techniques for controlled cultivation were developed in France and Italy and it is now cultivated in the U.S. and New Zealand. Inoculated oak and hazelnut seedling are commercially available and can be produced in the lab.	There may be other kinds of truffles than just the Periogord truffle to consider. Several other Tuber species have entered into commerce in recent years and they still fetch a handsome price.

Boletus edulis *Boletus* sp. *Suilius* sp.	Fruiting bodies of *B. edulis* have never been produced in culture. Unlike the Perigord black truffle, its fruiting bodies have never been obtained from plantations established using inoculated plants. Commercialisation of this mushroom is dependent on collection from natural forests during late summer and autumn in Europe, N. America and parts of Asia. *B. edulis* is found throughout Europe, and in China from Hilongjiang Province to Yn-Gui and Tibet. In England *B. pinicola* is primarily found on *Betula palustris* (birch) and *Pinus syivestris* (Scots pine); true *B. edulis* on birch, *Quercus robur* and *Q. petraea* (English oak), and *Fagus sylvatica* (beech); and *B. aestivalis, B. reticulatus* and *B. aereus* in Southern England on birch. In China it grows under mixed forests of Pinaceae and Fagaceae, e.g. under mixed forests of *Pinus tabulaeformis* (Chinese pine) and *Quercus mongolica* (Mongolian oak), and under *Picea* and *Quercus*. It can be found growing around the bases of single trees although it is more likely to be found in woodland situations with no grazing. While it is often found on mature trees it can also be found in birch woodland of 10 years old. Fruiting occurs in late summer or autumn (Hall, 1993a)	Given the widespread distribution of the boletes it would be very surprising if members of this and related genera were not present in Nepal. The best way to proceed would be to work with locally well established mycorrhizal associations to culture the mycelium and then use it to inoculate seedlings of the same species for establishment of new mycorrhizal plantations in favourable locations.
Cantherellus cibarius (Chanterelle)	Normally first fruit is from 30 yr. old trees but recently fruited in the nursery pot of an inoculated seedling of a Swedish researcher in Oregon. Research continues toward commercial production of inoculated seedlings.	
Tricholoma matsutake	Fruiting bodies have never been produced from plantations with artificially infected trees. In nature the mycorrhizal symbiosis occurs with conifers. In Japan *T. matsutake* is found with *Pinus densifolia* (Japanese red pine) and also with *P. thunbergii, P. pumila, Tsuga sieboldii, T. diversifolia* and *Picea glehnii*. Elsewhere in Asia it can be found with *P. karaiensis, P. taiwanensis, Abies mariesii* and other coniferous trees. In North America *Tricholoma ponderosa* grows with *Tsuga plicata, T. heterophylla, Pseudotsuga menziesii* (Douglas Fir) and *Pinus contorta*. In Europe *Tricholoma caligatum* is found associated with *Cedrus libanotica* and other conifers. The various species can be found between 200 and 1,500 m on flat sites to sunny slopes of up to 30^{0}C and where there is an annual rainfall of 750-1,000 mm. Some sunlight should reach the forest floor to prevent it staying too wet. The litter layer should be about 30 mm deep and the shrub layer relatively sparse (Hall, 1993).	Matsutake production has fallen in Japan since the mid 1800s 12,000 tonnes were consumed per year. Now it is only 3,000 tonnes. Japan produces 1,000 tonnes in a good year & imports 2,000. Japanese Grade 1 retails for $1330/kg. Fully-opened, Grade 4 as low as $33/kg at peak season. Grades 4-7 are often frozen and used by manufacturing industries but preservation diminishes the flavour.
Fungi with other "Unusual" ecological associations		
Morchella sp.	Successful indoor commercial cultivation has been achieved by only one company. Some success has been achieved with outdoor cultivation in specially prepared beds of complex wood ash substrates. Old apple orchards and burnt over forest lands are traditionally recognised as primary sites for morel collection. Do-it-yourself morel cultivation kits in the U.S. offer sufficient reliability to satisfy mushroom hobbyists. Researchers in India have reported observing mycorrhizal associations between morel and certain herbaceous plants. If it is correct, this totally anomalous observation could explain why the mushroom has been so difficult to domesticate, since Morchella is not generally thought to be a mycorrhizal genus.	Morchella is known to occur in some abundance in Nepal. No published information was available on the trade, if any, in Nepalese morels.

Wolfiporia cocos (*Poria cocos*, fu ling, hoelen, tuckahoe)	*Wolfiporia cocos* grows underground on the roots of pine and other trees, hardwoods and conifers. Not yet domesticated.	Apart from its importance in traditional Chinese medicine, the sclerotium of this fungus has long been an important food known as "Indian bread", "Indian potato" or "tuckahoe". A single growth might weigh 7-15 kg and is a valuable emergency food.
Cordyceps sinensis (Yarsagumba)	This highly prized medicinal mushroom is native to the grasslands of the Tibetan Plateau and can be found, for example, in the Langtang valley in July before the yaks come up to their summer pastures and eat it up. It is called "summer grass winter worm" because the fruiting body looks like grass and emerges from the head of a certain caterpillar. The caterpillar stage of the life cycle of the fungus can be skipped by simply culturing the mycelium on a grain substrate. Researchers have found the medicinal properties of the mycelium to be the same as those of the fruiting body. As this is not mainly a culinary mushroom, there is no need for the fruiting body stage. The mycelium can be extracted or simply dried and ground for direct use in medicinal preparations.	The possibility of producing an acceptable high-value mycelial product on grain substrate opens up cultivation possibilities by making it virtually independent of location. The only serious requirements, apart from correct temperature, would be for a space that is clean enough for sterile culture and a manager with enough savvy to manage it. This could be something for remote high altitude areas above tree line where the air is notoriously clean and where a low tech approach to germ-free culture is a possibility.

4. A closer look at mushroom production potentials in Nepal

In general there appears to be very little published information on mushrooms in Nepal, either from a botanical or development point of view. There does not even appear to be a field guide to mushrooms of Nepal. Nevertheless, there is enough incidental information to piece together a reasonably good picture of mushroom production potentials in Nepal.

4.1. Earlier recommendations

Mushroom farming: a good bet in the Hindu Kush-Himalayan (HK-H) Region

In a review of forestry-farming linkages in the mountain areas in which ICIMOD is active, Mahat (1987) gave an enthusiastic endorsement of mushroom cultivation as a livelihood option that ought to be developed for both cash and subsistence purposes:

> There is a high demand for mushrooms in the urban areas and prices are going up. As in the case of other forest products, rapid depletion of the forest has, however, affected the supply of mushrooms ...
>
> Although detailed data are not available on mushroom growing it could be a paying cottage industry for the rural people in these mountains. Instead of depending solely on the forest for mushroom yields, increasing production through artificial methods seems to be desirable. There is a demonstrably high potential for cash income generation through mushroom growing in India, Nepal, Pakistan, Bhutan and the other countries of the HK-H Region.

The mushroom industry is highly suited for developing countries such as those of the HK-H Region because of its labour intensive nature. Mushrooms of high quality are exportable items and have the potential of earning foreign exchange. Rural people in the mountains can benefit directly from good quality mushroom collection. Most edible mushrooms are, however, highly perishable goods and marketing facilities are essential prerequisites for their development on a commercial scale.

Promoted by the Ministry of Industry

Another strong endorsement, specific to mushroom growing in Nepal, has come recently from the Foreign Investment Promotion Section of the Ministry of Industry in Nepal:

> Many varieties of edible mushrooms are found in a wild state in the Terai lowlands, the hills and mountains of Nepal. Two rare varieties similar to European types known as "Guchchi" and *Cordyceps* (Yarshagumba) are found in the hills and mountains under natural conditions. Among the cultivated varieties, *Agaricus bisporus*, *Pleorotus* sp. and *Volvariella* are important. The temperature and humidity conditions necessary for growing *Agaricus bisporus* (button mushroom) are very satisfactory in the hilly regions during some seasons. The *Pleorotus* sp. (oyster mushroom) and *Volvariella* (paddy straw mushroom) grow easily during most seasons. Kathmandu Valley has temperature, humidity and other biological factors suitable for the cultivation of these two varieties of mushrooms throughout the year... The potential for mushroom production on a commercial scale is good especially with a view to marketing overseas as fresh mushroom, dried mushroom and canned mushroom (Ministry of Industry, 1998).

4.2. Altitudinal gradients and environmental niches

Temperature and humidity are the main environmental parameters which define the windows of opportunity for mushroom cultivation. Since humidity can be more readily controlled, the main factor is temperature. Mountain microclimates are notoriously varied, depending not only on the temperature-altitude relationship, but also on aspect, and exposure to monsoon and continental weather influences. Site-specific microclimatic constraints and opportunities must be examined in detail.

The following tables present *preliminary* and *indicative results of a rough first approximation* of the kind of matching exercise that is needed to identify seasonal environmental niches for mushrooms based on temperature.

Table 9a. Preliminary indicative identification of temperature "niches" for mushrooms

a) Terai

Place	Bhairawa		
Alt (m)	110		
Temp (^{0}C)	Min	Max	
Jan	8	22	
Feb	10	25	*Auricularia polytricha, Pleurotus abalonus, P. djamor, Volvariella volvacea*
Mar	14	31	
Apr	20	36	
May	24	37	
Jun	25	35	
Jul	25	33	
Aug	25	33	
Sep	24	32	
Oct	21	33	
Nov	14	28	
Dec	9	24	

Table 9b. Kathmandu

Place	Kathmandu			
Alt (m)	1350			
Temp (^0C)	Min	Max		
Jan	2	17		
Feb	4	19		
Mar	7	24		
Apr	12	27		
May	16	28		
Jun	19	28	*Auricularia polytricha, Ganoderma lucidum, Pleurotus citriopeleatus, P. ostreatus, P. pulmonarius, P. djamor, Tremella fuciformis*	*Hericium erinaceus*
Jul	20	27		
Aug	20	27		
Sep	18	26		
Oct	13	25		
Nov	8	22		
Dec	3	18		

Table 9c. Jumla

Place	Jumla		
Alt (m)	2300		
Temp (^0C)	Min	Max	
Jan	-5	13	
Feb	-4	13	
Mar	0	17	
Apr	4	22	
May	7	24	
Jun	13	25	*Hericium erinaceus, Lentinula edodes, Pleurotus eryngii, P. ostreatus, P. pulminarius, Stropharia rugoso-annulata*
Jul	15	24	
Aug	15	24	
Sep	12	23	
Oct	4	21	
Nov	-2	18	
Dec	-5	15	

Table 9d. Jomsom

Place	Jomsom		
Alt (m)	2744		
Temp (^0C)	Min	Max	
Jan	-2	11	
Feb	1	12	
Mar	2	16	
Apr	5	18	
May	7	19	
Jun	11	21	*Agaricus bisporus, Grifola frondosa, Hypoloma sublateritium, Hypsizygus tessulatus,*
Jul	12	21	*Lentinula edodes, Morcella augusticeps, Pholiota nameko, Pleurotus ostreatus,*
Aug	12	21	*Pleurotus pulminarius, Pleurotus eryngii, Stropharia rugosa-annulata*
Sep	11	20	
Oct	6	18	
Nov	2	14	
Dec	-1	13	

Table 9e. Namche Bazar

Place	Namche Bazar		
Alt (m)	3450		
Temp (^0C)	Min	Max	
Jan	-8	7	
Feb	-5	7	
Mar	-3	10	
Apr	1	13	
May	4	14	
Jun	7	16	*Agaricus bisporus, Grifola frondosa, Hypoloma sublateritium,*
Jul	8	16	*Morcella augusticeps, Pholiota nameko, Pleurotus ostreatus,*
Aug	8	16	
Sep	7	15	
Oct	2	12	
Nov	-3	9	
Dec	-6	8	

4.3. Mushroom potentials by forest type

Another way of thinking about mushroom potentials is by forest type. Table 10 represents a preliminary look at this aspect, but really this exercise needs to be supported by much more systematic botanical survey of the fungi which naturally occur in each forest type and their ecological relationships with other flora and fauna.

Table 10. Mushroom potentials by forest type

General Forest Types	Specific Forest Types	Potential Worth Investigating: Mycorrhizal Fungi	Potential Worth Investigating: Lignicolous Mushrooms
Tropical & Sub-tropical Broadleaf Forests	Sal forest, *Dalbergia sissoo-Acacia catechu* forest, Tropical deciduous riverain forest, Tropical evergreen forest, *Terminalia* forest Subtropical evergreen forest Subtropical deciduous hill forest *Schima-Castanopsis* forest	*Boletus ?* *Sullius ?*	These kinds of trees are prime substrates for many lignicolous mushrooms. Forest thinnings could provide feedstock for mushroom growing. Chipper can turn even light thinnings into feedstock. Sawdust & other sawmill waste is major resource for mushroom growing in bags
Sub-tropical Conifer Forests	*Pinus roxburghii*	Matsutake?	
Temperature & Alpine Broadleaf Forests	*Quercus incana-Q. lanuginosa* forest *Quercus dilatata* forest *Quercus lamellosa* forest *Quercus semecarpifolia* forest Laurel forest *Aesculus-Juglans-Acer* forest Temperatre mixed broadleaf forest Rhododendron forest *Betula utilis* forest *Alnus nepalensis* forest	*Boletus?* *Sullius?* *Tuber?*	Same as for Tropical and Sub-tropical Broadleaf Forests.
Temperate & Alpine Conifer Forests	*Pinus wallichiana* forest *Cedrus deodara* forest *Picea smithiana* forest *Tsuga dumosa* forest *Cupressus torulosa* forest *Abies pindrow* forest *Larix griffithana* forest *Abies spectabilis* forest *Juniperus* forest	Matsutake?	*Pholotia nameko ?* *Pleurotus eryngii?* *Grifola frondosa*?
Alpine Scrub Forests	Humid alpine scrub Dry alpine scrub Barren alpine		Mycelial culture on grain in relatively germ-free high altitude environment?

(Source for forest types: Shrestha, 1989)

4.4. Socio-economic and culture niches

What mushroom resources do the hill folk collect? This question, really, should be the starting point for intensive field investigations into mushroom growing potentials, but for the present we will have to rely on literature. Unfortunately, the available literature does not evince much systematic knowledge of the fungal resources of Nepal, but the little bit that we do know from ethnobotanical studies has interesting implications. In a study of *Useful Plants of Manang District*, Perdita Pohle reports on a systematic inventory of the collection of wild plant resources in three villages at different altitudes in Manang District, in the northernmost reaches of the Annapurna area (see Table 11).

Table 11. Foraging and use of herbs and fungi by communities at different altitudes in Manang District

Community	Altitude	Vegetation	Population	Livelihood	Foraging & Fungi
Nar	4500 m drier than Nyeshang 300m	Much of it is above timberline with Tibetan Steppe vegetation : *Juniperus, Carangane, Berberis, Rosa*	*Narpas* (language similar to the Manangi's, also fluent & many also literate in Tibetan)	Tradational herding of yaks, sheep, goats with irrigated barley & potatoes, small scale trading at lower altitudes in winter	66 wild plants collected 3 of them fungi: *(Cordyceps, pansermo, sasermo)*
Nyeshang	3400 m 442 mm rainfall	Pines, firs & birch *Pinus wallichiana, Abies spectables, Betula utilisa*	*Manangi* (descendents of immigrants from Western Tibet who came to Manang centuries ago)	1/3 of population has migrated to Kathmandu to engage in international trade, remaining population farms buckwheat, wheat, barley & potatoes with help of hired workers from Gorkha & Lamjung	98 wild plants collected, incl. 5 fungi (*Cordyceps, lam bar, phortsema, priti, tsema, phortimo*) and 4 lichens
Gyasumdo	3000 m 908 mm rainfall	upper belt - conifers *Picea smithiana, Tsuga dumosa* Subtropical vegetation dominant lower belt – *oak & rhodendron*	*2/3 Gurung* (Tibeto-Burman) 1/3 *Gyasumdopas* (5^{th} gneration decendents of immigrants from Tibet)	Gurung farmers cultivate maize, barley & wheat, keep cows, sheep & goats, & do a little herb trading. Gyasumdopas (may not have land) are usually involved in trade with Tibet or herb trade with Kathmandu; some work as tenant farmers, others work in tourist industry or own hotels & restaurants	77 wild plants collected, incl. 1 fungus (*sinyape*) and 1 lichen

(Source: Pohle, 1990)

> What is striking is that the greatest number of wild plants used by the local people has not been recorded in the middle altitudes (around 2000 m) of Gyasumdo, where the flora has a greater variety, but in the region of Nyeshang, which lies higher up (above 3200 m) and where the climatic conditions are drier and more severe. This would seem to indicate that there is a greater dependence among the population upon natural resources in the higher and climatically less favourable regions than is the case in the lower ones, where there is overall a greater possibility of variation in the agricultural products (Pohle, 1990).

This leads to an important point to keep in mind when deliberating options for domestication, namely that:

> ... wild edible plants were predominantly recorded in the high-altitude regions of Nar and Nyeshang, whereas medicinal plants figured most prominently in Gyasumbo. *Apparently there is in fact more urgent need for nutritive sources in the climatically less favourable regions to supplement daily diet,* so that there more plants are collected which can be used as wild vegetables or salads (Pohle, 1990 - italics added).

Another very relevant consideration is the existence of cultural differences in the social distribution of knowledge about medicinal plants. As Pohle (1990) explains:

> For the Gurungs, for example, knowledge of medicinal plants is a folk tradition in a way that it is not for the Gyasumdopas and Narpas. Among the Gurungs, each person asked was able immediately to specify a number of plants with medicinal properties. Moreover, almost all of the persons questioned had a detailed and discriminating knowledge of both useful and harmful properties of the plants.
>
> The Gyasumdopas, by contrast, have rather a more comprehensive practical knowledge of the plants. They are acquainted more with other useful plants than with specifically medicinal ones ... The reason Gyasumdopas do not use medicinal plants for private consumption lies presumably in their Tibetan cultural tradition, in which knowledge concerning such plants and their effects and uses is the prerogative of specially trained "amjis" (doctors) or "lamas" (priests).
>
> Thus the inhabitants of Nar-to also had comparatively little grasp of folk medicine. There it is the abbot of the monastery who commands the special knowledge of traditional Tibetan medicine, its proper application and pharmacognosy. As fundamental significance is attached within Tibetan medicine to herbal treatments, he was also the person best informed on medicinal plants and their effects upon the human organism. Moreover, he was familiar with the very intricate rules of collection, which stipulate, among other things, when particular herbs may be collected, which plant parts must be removed and which preserved in order to insure the plant's survival. Since the local population had full confidence in the lama's medical knowledge and abilities, they knew only comparatively few medicinal herbs.

The most interesting fungus to come out of this survey was undoubtedly the famous *Cordyceps sinensis* (Nepali: Yarsagumba). The Tibetans call it, "Yertsagumbu" which means "Summer Grass Winter Worm":

> The name 'summer-grass winter-worm' not only very accurately describes the appearance of this medical herb but also betrays a level of biological knowledge based on exact observation. The plant in this case is a parasitic mushroom *(Cordyceps sinensis)*, which at the beginning of the monsoon period attacks a caterpillar (unidentified up to now) recently emerged from its cocoon. Whereas one can observe the caterpillar still alive in spring (winter-worm), it is no longer alive in autumn, at the time of picking. The part of the mushroom peeking out above the ground (ophilglossum) is at that time, in fact, hard to distinguish from the grass of the alpine pastures surrounding it (summer-grass)" (Pohle, 1990).

4.5. Lessons from the *jaributi* trade

Jaributi has been defined as those herbs, which comprise the component of the herb trade in Nepal that goes to India for use as raw materials in the Indian herbal industry. It has been the subject of considerable research in recent years. Although, little or no attention has been given specifically to mushrooms, the findings of this research are very relevant to our task of identifying realistic opportunities for mushroom domestication.

The *jaributi* researchers noticed that the herbs found on the market fall naturally into two groups: low-value herbs from low-altitude sources (LVLAs) and high-value herbs from high-altitude sources (HVHAs). This makes good sense, since only high value herbs are worth the cost of transportation to bring them down out of the high mountains.

Among the main conclusions of the *jaributi* studies relevant to our purposes here we may cite the following (Edwards 1993; Edwards and Bowen, 1993):

Every opportunity should be taken to improve production from the wild on a sustainable basis; add value within Nepal; and improve marketing at all levels.

Many of the species that have established markets have also the disadvantage that they can be grown throughout the subtropics. The emphasis might advantageously be switched to the high-altitude plants that are unique to the Himalayan region. Research should focus on the domestication of the most overexploited these. The fundamental goal must be the establishment of sustainable harvesting rates ... Sustainable harvesting may require social re-organisation, for example, by restricting access to the resource through common property management.

Collectors could benefit from adding value to the raw materials in Nepal, especially at the village level. Furthermore, such an approach would ensure a fairer distribution of profits within the marketing chain and perhaps discourage overharvesting for short-term economic gain. Opportunities should be examined for collectors' co-operatives to trade directly to the national and later the international markets (rather than via brokers in India).

The village trader network must not be jeopardised without first establishing alternative sources of marketing assistance for collectors. If this could be achieved, perhaps through co-operatives or forest user groups, the collectors should double their current income.

4.6. Preliminary identification of "best bet" alternatives

This paper cannot make any recommendations, because it is based entirely on desk work and the kind of systematic fieldwork that ought to be done to provide a solid foundation for recommendations is really still in the future. However, in order to indicate the kind of recommendations that could result from such a process, a brief and strictly provisional outline of the main mushroom domestication potentials is presented in Table 12. Certain species may be highlighted here but for a fuller appreciation of the range of species possibilities, Tables 9 and 10 should be consulted. Table 12 leaves out some species, presently unknown, that may already be prevalent in a particular area. Obviously, these native or naturalised species should be one of the main focal points for the domestication effort, apart from whatever else might be introduced.

5. Outline for a systematic approach to the development of these potentials

It is hoped that this review and analysis of mushroom domestication potentials will give a clear idea of the kind of potentials that may exist in the Nepalese situation. However, it must be emphasised once more that this deskwork exercise is just a precursor to the kind of systematic assessment needed to develop a viable programme. Obviously, such an exercise will be successful only if it involves full participation of the concerned households and communities in both the diagnostic assessment and the R & D process. Hopefully a project can be developed along these lines.

Table 12. Preliminary identification of "best bet" options for domestication in different environmental and socio-economic niches

	Preliminary Identification of "Best Bet" Alternatives			
Production Unit	**Terai**	**Kathmandu & Pokhara**	**Midhills**	**High Himalayas**
Community Forest User Groups			▪ Sustainable harvest of wild mushrooms ▪ Enrichment planting of mycorrhizal fungi with inoculated seedlings; ▪ inoculation of stumps and buried logs; ▪ log culture a la shiitake on forest thinnings; ▪ chip bed culture on thinnings; ▪ artificial substrate culture in shade	For communities below tree line: There may be possibilities in temperate & alpine coniferous forests for: ▪ sustainable harvesting & enrichment planting of gourmet mycorrhizal mushrooms (matsutake on conifers?) And in temperate & alpine broadleaf forests for: ▪ sustainable harvest & inoculation of thinnings & stumps with gourmet and medicinal mushrooms (e.g. *Pleurotus eryngii*, maitake, nameko, birch polyphore, etc.)
Farm households	Mushroom production on agricultural waste and artificial substrates for HH use & market ▪ gardening with mushrooms, other agroforestry & natural culture systems ▪ backyard mushroom houses ▪ feeding of livestock with spent substrates	Mushroom production on agricultural waste and artificial substrates for HH use & market ▪ gardening with mushrooms, other agroforestry & natural culture systems ▪ backyard mushroom houses ▪ feeding of livestock with spent substrates	Mushroom production on agricultural waste and artificial substrates for HH use & market ▪ gardening with mushrooms, other agroforestry & natural culture systems ▪ backyard mushroom houses ▪ feeding of livestock with spent substrates	Supplemental food from mushrooms cultivated on farm waste and compost in: ▪ small backyard mushroom houses to create sufficient humidity for cultivation (Is yak dung a good substrate?) ▪ feeding of livestock with spent substrates
Village or urban households living near agricultural & industrial waste resources	*Near sawmills* ▪ mushroom cultivation on sawdust for HH use and market; backyard mushroom houses as cottage industry	*Near urban industries* - cultivation on waste substrates (sawdust, textile, food industry, etc.) for HH & market; backyard mushroom houses as cottage industry;		
Village Co-operation Enterprises (or Village Scale Private Enterprises)	*For all communities* ▪ value-added processing of mushroom products ▪ co-operative marketing ?	*For all communities* ▪ value-added processing of mushroom products ▪ co-operative marketing ?	*For all communities* ▪ value-added processing of mushroom products ▪ co-operative marketing ?	*For communities above tree line:* germ-free mycelial culture, processing, packaging and marketing of *Cordyceps sinensis* (with co-operation of local lama)

A systematic approach to domestication of mushroom

1. Survey of naturally occurring fungal resources
2. Survey of existing marketing channels for mushrooms
3. Diagnostic survey of domestication potentials (constraints and opportunities)
   a) environmental - What is possible biologically?
      - climate
      - substrates
      - transport logistics

   b) market - What is feasible economically?
      - local consumption as dietary supplement
      - regional markets
      - national markets
      - international markets
      - locally produced specially products

   c) local community interest and potential - Which of these biologically and economically feasible potentials is most desirable and appropriate in particular communities?
4. Selection of "best bet" options for development and trial domestication in selected communities
5. Participatory Research and Development (PR&D) on domestication as crops
   - domestication trials in selected communities (with research station backstopping)
   - on-station R&D (in parallel with domestication trials) on: mushroom strain capture and tissue culture, spawn production, substrate development, growing systems, pest management, harvesting
6. PR&D on post-harvest processing and marketing of products
   - *in situ* village trials of appropriate processing technologies (e.g. solar dryers, hydro-powered grinding machines, low-cost but reliable extraction methods, etc.)
   - market survey and market development
   - linkages to private sector processing and marketing concerns (assistance may be needed n order to safeguard producers' equity)
7. Extension of proven technologies to appropriate communities
8. Central support facilities (spawn production, marketing assistance, etc.)

References

Ali, F. n.d. Mushroom Trade Survey in North West Frontier Province of Pakistan. http://molbiol.soton.ac.uk/msdn/survey.html.

Edwards, D. M. 1993. Research into the Collection and Trade of Jaributi from the Middle Hills of Nepal. In: Edwards, D. M. and Bowen, M. R. (eds.). 1993. Focus on *Jaributi*: Proceedings of the Non-Timber Forest Products. Seminar held in Kathmandu on 12 May 1993. *FRSC Occasional Paper 2/93*. Forestry Research and Survey Centre, Ministry of Forests and Soil Conservation. His Majesty's Government of Nepal. Kathmandu, Nepal.

Edwards, D. M. and Bowen, M. R. (eds.). 1993. *Focus on Jaributi*: Proceedings of the Non-Timber Forest Products Seminar held in Kathmandu on 12 May 1993. *FRSC Occasional Paper 2/93*. Forestry Research and Survey Centre, Ministry of Forests and Soil Conservation. His Majesty's Government of Nepal. Kathmandu, Nepal.

Fisher, B. 1994. Indigenous Forest Management in Nepal: why Common Property is not a Problem. In: Allan, M. (ed.). *Anthropology of Nepal: Peoples, Problems and Processes*. Mandala Book Point. Kathmandu, Nepal.

Hall, I. 1993a. *Boletus edulis* - Eating Mushroom. Crop and Food Research. Invermay Agricultural Centre. New Zealand. http://www.crop.cri.nz/broadshe/boletus.htm

Hall, I. 1993b. Matsutake. Crop and Food Research. Invermay Agricultural Centre. New Zealand. http://www.crop.cri.nz/broadshe/matsutak.htm

Harris, B. 1986. *Growing Shiitake Commercially: A Practical Manual for Production of Japanese Forest Mushrooms.* Science Tech Publishers. Madison, Wisconsin, USA.

Hobbs, C. 1986. *Medicinal Mushrooms.* Botanical Press. Santa Cruz, California, USA.

Mahat, T. B. S. 1987. Forestry-Farming Linkages in the Mountains. *ICIMOD Occasional Paper No.7.* Kathmandu, Nepal.

Ministry of Industry. 1998. Opportunities-Feasible Project Areas: Agroforestry and Forest based Industry, His Majesty's Government of Nepal, Ministry of Industry, Foreign Investment Promotion Section. http://www.info-nepal.com/members/flips/opportunities/feasible.html

Oei, P. 1996. *Mushroom Cultivation: With Special Emphasis on Appropriate Technologies for Developing Countries.* Tool Publications. Leiden, The Netherlands.

Pohle, P. 1990. *Useful Plants of Manang District: A Contribution to the Ethnobotany of the Nepal-Himalaya.* Franz Steiner Verlag. Stuttgart, Germany.

RAPA. 1983. *Growing Mushrooms: Oyster Mushroom, Jew's Ear Mushroom, Straw Mushroom.* Regional Office for Asia and the Pacific. FAO. Bangkok, Thailand.

Royse, D. J. 1996. Specially Mushrooms. In: J. Janick (ed.). *Progress in New Crops,* ASHS Press, Arlington, Virginia, USA.

Shrestha, B. P. 1989. *Forest Plants of Nepal.* Educational Enterprises. Laltipur, Nepal.

Singer, R. and Harris, B. 1987. *Mushrooms and Truffles.* Koeltz Scientific Books. Koenigstein, Germany.

Stamets, P. 1993. *Growing Gourmet and Medicinal Mushrooms.* Ten Speed Press. Berkeley, California, USA.

Stamets, P. 1996. Mushrooms, the Hwarang and the Martial Arts. http://www.csn.net/hwarang/Hwa.Mushrooms.html

Stamets, P. and Chilton, J. S.. 1983. *The Mushroom Cultivator. A Practical Guide to Growing Mushrooms at Home.* Agarikon Press. Olympia, Washington DC, USA.

Steineck, H. 1984. *Mushrooms in the Garden.* Mad River Press. Eureka, California, USA.

Weil, A. 1995. *Spontaneous Healing.* Knopf. New York, USA.

Mathema, P., Dutta, I. C., Balla, M. K. and Adhikary, S. N. (eds.). 1999. *Sustainable Forest Management.* Proceedings of an International Seminar, 31 August – 2 September 1998, Pokhara, Nepal.

Yield of Some Aromatic Plants in Agroforestry Practices in Tarai Region of Kumaon, India

R. P. Singh, F. Mohsin, A. Tewari, and J. Ram

Abstract: *Mentha* and *Cymbopogon* species were inter-cropped with poplar (*Populus deltoides*) and *Eucalyptus* hybrid trees of different ages. Inter-cropping *Mentha* and *Cymbopogon* species individually with *P. deltoides* and *Eucalyptus* hybrid indicated that the height and diameter of poplar remained lower in the sole crops in comparison to inter-cropped stands. The dbh and height of poplar trees were higher than *Eucalyptus* stands at the same age in both sole and inter-cropped stands.

Fresh herbage yield (q/ha) and oil yield (kg/ha) of various *Mentha* species under poplar showed higher average yield in all 4 stands (434.10 t/ha and 191.0 kg/ha) than under *E.* hybrid (338.5 t/ha and 168 kg/ha). Herbage and oil yield of *Cymbopogon* species was also marginally higher in inter-cropped poplar (average 297.10 t/ha and 138.52 kg/ha). However, the yield of herbage and oil in *Cymbopogon* species inter-cropped with *P. deltoides* was marginally higher in sole (346.10 t/ha and 186.6 kg/ha) than inter-cropped with *P. deltoides,* (294.65 t/ha and 134 kg/ha).

1. Introduction

Forests in India are under tremendous biotic pressure with low growing stock and poor productivity. Plantations outside forest area in vacant government land, marginal agricultural lands, community land and agroforestry will be vital for bridging the gap between demand and supply of various forms of wood. However, the major contribution to the national effort for achieving self-sufficiency in wood will be through agroforestry plantations. Tree farming is gaining ground in the country under various afforestation programmes. Growing trees in agricultural field bunds combined with cash crops for augmenting biomass production per unit area is now becoming popular among farmers.

Aromatic plants constitute the most viable alternative cash crop for growers, and are virtual "goldmines" for pharmaceutical and essential oil industries. As such, they could be a powerful supplement to economic emancipation of the rural masses, industrial growth and enhancing exports.

Under Tarai conditions large number of farmers have planted fast growing commercial trees like *Eucalyptus* and poplars. *Eucalyptus* is regarded as one of the most important tree species available for man's exploitation in spite of its controversial nature. Studies on poplar plantations coupled with non-conventional crops like aromatic plants (*Mentha* and *Cymbopogon* sp.), for three years have revealed no adverse effect on poplar growth in terms of height and diameter.

The genus *Mentha* (family: Labiateae), comprising of about 40 species, can be grown in the temperate as well as sub-tropical climatic conditions. Two varieties of *Cymbopogon martinii* viz. Motia and Sofia are suitable for commercial exploitation. On steam or water distillation, the sub-aerial parts of the variety Motia yields commercially important oil of palmarosa. *Cymbopogon winterianus* is cultivated for citronella oil whereas *Cymbopogon flexuouses* commonly known as lemon grass has given a citeral content of 75–85%.

These aromatic plants were tried along with short rotation plantations of *Eucalyptus* and poplar as they were expected to be the best crops under these plantations and a study was undertaken to assess the adverse or favourable effect of these crops on plantations of *Eucalyptus* and poplar and vice-versa.

2. Description of the study site

The study was undertaken in the Tarai region of Kumaon (U.P.) with an elevation of 250 m above mean sea level. The area is in the sub-tropical moist zone, with high rainfall and wide temperature variations. It has a dry season from early October to June and a wet season from mid July to early October. The average annual total rainfall is about 1350 mm. The weekly average daily maximum temperature remains high (approx. 35° C) during summer and low during winter (approx. 6° C) Geologically, Tarai is characterised by sedimentary deposits of tertiary age consisting of lower stone of old Tarai deposits. The sediments in this region are largely derived from gabbro, chlorite, schist, sand-stone, basalt, shales, slates, gneiss and granite washed from the Himalaya mountains (Valdiya, 1980). The soil of the experimental plot was clay loam, having bulk density of 1.35 g/cm^3 with an average pH of 7.1, 1.2% organic carbon, 345 kg. ha^{-1} N, 22 kg. ha^{-1} P and 183 kg. ha^{-1} K.

3. Material and methods

The field investigations were conducted for two years (1991 and 1992) in a randomised block design with three replications. Nine treatments comprising of five *Mentha* sp. (*M. arvensis, M. piperata, M. citrata, M. spicata, M. cardiaca*) and three *Cymbopogon* sp. (*C. flexuouses C. winterianus, C. martinii*) with *Populus deltoides* (G3) and *Eucalyptus* hybrid along with sole trees were conducted. Trees selected for the study were of early (two and three years) and advanced age (six and seven years) groups. Man-made monoculture forests were studied with inter-cropping of *Mentha* sp. and *Cymbopogon* sp. which have medicinal and other economical values. The spacing of the poplar and *Eucalyptus* were at 5 m x 4 m and 2.5 m x 2.5 m, respectively. The stand density of poplar and *Eucalyptus* was 500 and 1600 trees ha^{-1}.

Mentha species were planted during the month of January at a row spacing of 60 cm by suckers, runners or whole plant during both the years. *Cymbopogon* species were planted during the second fortnight of February at the spacing of 60 cm between the rows and 45 cm within the rows in 1991 and same crop continued till the final stage of observation.

A uniform fertiliser dose of 150 kg N, 26.2 kg P and 33.2 kg K ha^{-1} $year^{-1}$ was applied to these crops, except *Mentha piperata* in which it was 100, 21.8 and 33.2 kg $ha^{-1}yr^{-1}$, respectively. Whole quantity of P, K and 1/3 of N was applied at planting and the remaining 2/3 of N was top-dressed in two equal splits, in the later stage of growth.

Crops were irrigated immediately after planting and sufficient moisture level was maintained till the establishment of crops. Total number of irrigation applied to *Mentha* ranged between 11–15 days. In *Cymbopogon*, subsequent irrigation were given at an interval of 10 days during summer and 25 days in winter months. However, during rainy season the crops were irrigated as per need.

For *Mentha*, two weedings in first and one weeding in the second cut were done. In case of *Cymbopogon*, two weedings and two hoeings were done each year. The growth of trees of both the species under all the treatments was studied by taking observations on diameter at breast height (dbh) and height. Dbh was measured by callipers and height was measured from base of the tree to growing tip by Ravi multimeter.

First cut in *Mentha* was taken after 120 days of planting and second cut was done after 65-70 days after first cut. All the three *Cymbopogon* sp. were harvested twice (August and December) in the first year, and thrice (April, August and December) in the second year. The sum of the two cuts was taken as the total herbage yield.

A separate 100 g sample of each crop at each harvest was collected and oil content was measured with the help of Clevenger's apparatus. Oil yield was calculated by multiplying fresh herbage yield with oil content.

4. Results

Diameter and height

Observations obtained from inter-cropping *Mentha* and *Cymbopogon* sp. individually with *P. deltoides* and *E.* hybrid have indicated that the height and diameter of poplar and *Eucalyptus* remained lower in the sole crop in comparison to inter-cropped stands. Among the trees, poplar had larger diameter as compared to *Eucalyptus* at a particular age.

Diameter of *Poplar deltoides* at the age of two years was 6.5 cm in the sole, 7.2–7.9 cm in *Cymbopogon* and 8.0–8.6 cm in *Mentha* inter-cropped stands. In the three-year old poplar stand, the sole stand had a diameter of 11.4 cm. In *Cymbopogon* inter-cropped stand it ranged between 12.2–12.8 cm and in *Mentha* treated species stand it ranged between 13.2–13.9 cm. Dbh at the age of six years ranged between 22.6–22.8 cm in *Cymbopogon* inter-cropped, 23.0–23.5 cm in *Mentha* inter-cropped stands while in the untreated stand it remained 21.2 cm. At the age of seven years the untreated stands had diameter of 22.3 cm while in *Cymbopogon* and *Mentha* inter-cropped stands it ranged between 23.5–23.9 cm and 24.0–24.7 cm, respectively.

The diameter of *Eucalyptus* hybrid was found to be lower than that of *Populus deltoides* at each age group. At the age of two years it ranged between 3.2–3.5 cm in the *Cymbopogon* treated stand and 3.7–4.4 cm in the *Mentha* inter-cropped stands while in the untreated stands it measured 2.6 cm. At the age of three years the dbh ranged between 7.3–7.5 cm and 7.7–8.7 cm in the *Cymbopogon* and *Mentha* inter-cropped stands respectively, while in the untreated stands it remained at 6.8 cm.

Dbh at the age of six years old stand was in the range of 15.2–15.4 cm in *Cymbopogon* inter-cropped stands, which increased to the range of 15.6–17.8 cm in the *Mentha* inter-cropped stands. In the untreated stands it measured only 15.0 cm. The dbh of seven-year-old trees varied between 15.8–16.0 cm in *Cymbopogon* treated stands and 16.3–18.4 cm in the *Mentha* inter-cropped and 15.6 cm in the untreated stand.

While considering the height of the trees it was observed that at the age of two years the height of the poplar ranged between 10.0–11.2 m in the inter-cropped and 9.8 m. in the isolated stands, which increased significantly in the 3rd year and ranged between 11.3–12.5 m in the treated and 11.1 m in the sole stands.

The average height of the poplar trees at the age of six years was found to range between 19.9–21.1 m in the inter-cropped and 19.7 m in the untreated stands. At the age of seven years, the height remained at 21.2 cm and the diameter at 22.3 cm for the untreated stands. In *Cymbopogon* and *Mentha* inter-cropped stands, the diameter ranged between 23.5–23.9 cm and 24.0–24.7 cm, respectively. In *Eucalyptus* the height was found to range between 6.3 to 7.5 m and was always lower than *P. deltoides* stands in different age groups. The range of height was more or less similar for *Populus* and *Eucalyptus* in 7th year (20.0–21.8 m and 18.1–19.3 m).

Herbage and oil yield

Data on total herb (fresh weight) and oil yield of *Mentha* and *Cymbopogon* grown alone and with *Populus deltoides* and *Eucalyptus* hybrid indicated that the total fresh herbage yield of sole crops of *Mentha* ranged between 456.0 and 630.0 q ha^{-1}in year 1, whereas in year 2 it was 393.0–609.0 q ha^{-1}. In *Cymbopogon* the range was 207.6–254.6 q ha^{-1} in year 1 and 247.60–600.50 q ha^{-1} in year 2. The highest total fresh herbage, however, was produced by *M. citrata* in both years when grown along with *P. deltoides* of two and three years, the values being 604.0 and 578.0 q ha^{-1}. Even with *Eucalyptus, M. citrata* had the highest herbage yield in two and three year old plantations (538.0 and 525.5 q ha^{-1}). Only *Cymbopogon martinii* showed significantly high yield in two-and seven-year old stands of *P. deltoides* (600.50 and 520.20 q ha^{-1}) and *E.* hybrid (507.40 and 513.30 q ha^{-1}).

The oil yield of sole *Mentha* sp. ranged between 159.60–314.33 kg ha^{-1}in year 1 and 137.55–296.46 kg ha^{-1} in year 2. The highest oil yield was from *M. cardiaca* when grown alone. The oil yield from sole crops was always found to be higher than inter-cropped species. The lowest oil yield was given by *M. piperata*. Among *Cymbopogon* species, the highest yield was of *C. martinii* and lowest of *C. flexuouses.*

5. Discussion

In this study the spacing of poplar was 5 m x 4 m (500 trees ha^{-1}) and that of *Eucalyptus* was 2.5 m x 2.5 m (1600 trees ha^{-1}) which is considered to be the best suitable spacing due to easy agricultural operations in the agroforestry system. The stands were inter-cropped with *Mentha* and *Cymbopogon* species so as to obtain maximum production of tree biomass without any detrimental effect on the growth and production of inte-rcrops. Lohani (1980) revealed that the volume production in close spacing of 2.5 m x 1.5 m and 2.5 m x 0.75 m in *Eucalyptus* is not significantly different while in other cases 2.5 m x 2.5 m spacing has given the highest volume (Singh *et al*., 1985; Chaturvedi, 1983).

The dbh of the poplar as well as *Eucalyptus* remained in a very narrow range in all the stands in a particular year and there was a variation of only 5 cm among all the trees of the age group. The overall height of poplar in an age group remained higher than that of *Eucalyptus* for the sole as well as inter-cropped stands. The height remained more in the treated than the sole stand of a particular age with maximum in *M. arvensis* treated stands in all the age groups of both poplar and *Eucalyptus* stands.

Singh *et al.* (1988) reported that the height and diameter of poplar trees grown in single rows on field bunds, roads or along irrigation channels ranged in an increasing order of 13–21.5 m (height) and 20–45 cm (dbh) from 3 to 7 years of age. Almost similar changes in the height and dbh were observed in the present study except that there was a perceptible increase in height as well as diameter in the stands treated with *M. arvensis* and *M. piperata* which has not been reported by Singh *et al.* (1988).

Mentha under poplar showed higher herbage and oil yield than *Mentha* under *Eucalyptus*. Due to the wide spacing practised for poplar than *Eucalyptus,* ploughing through tractor was properly done in the poplar stands which also removed the lateral (fibrous and thin) roots from the upper strata of soil. Thus there was no root competition for the uptake of nutrients from the soil of upper horizon between the tree and the understorey crops. The soil was loosened properly in the poplar stands due to harrowing in comparison to spade digging in *Eucalyptus* plantation. Thus the crop extracted maximum nutrients and moisture from the soil resulting in better yield. Arya *et al.* (1991) also reported a higher yield in inter-crops when lateral roots of the tree were removed by ploughing.

Herb and oil yield of *Cymbopogon* sp. was higher in inter-cropped poplar than with *Eucalyptus*. On the other hand, yield of *Cymbopogon* sp. was much higher in sole fields than inter-cropped with tree species. While considering the total herb and oil yield in a particular year, it was observed that the herb yield of *M. citrata* was highest and *M. piperata* was lowest under both tree species of two and three years in sole fields. Under six-and seven-year old trees, the highest herb yield was of *M. citrata* and lowest for *M. spicata*. The study also showed that oil yield of *M. cardiaca* was highest and lowest under early age group trees (two and three years) and in sole crops, but under old age group (six and seven years) trees, the yield of *M. arvensis* was highest. It also revealed that total herb yield of *C. martinii* was highest in each age group of trees, followed by *C. flexuouses* and *C. winterianus*. The present findings are in close agreement with those reported by Singh *et al.* (1989).

Kothari *et al.* (1987) reported a herb yield varying from 30.8 to 32.9 t ha^{-1} and oil yield varying from 181.3 to 193.4 kg ha^{-1} in the sole crop of *M. arvensis*. Singh *et al.* (1990) reported a herb yield varying from 216 to 300 q ha^{-1} with oil yield ranging from 91.9 to 140 kg ha^{-1} in the sole crops and 100.5 to 270.0 q ha^{-1} (herb yield) with oil yield of 46.8 to 124 kg ha^{-1} in *Mentha* sp. inter-cropped with *Eucalyptus*. In case of *Cymbopogon* sp. the value ranged between 157 and 520 q ha^{-1} (herb yield) with oil yield ranging from 64.7 to 185.6 kg ha^{-1} (sole crop) and 151.4 to 508.5 q ha^{-1} (herb yield) with oil yield ranging from 57.5 to 180 kg ha^{-1} (inter-cropped with *Eucalyptus*). The findings of this study are in close agreement with these reports.

References

Arya, S., Toky, O. P., Bisht, R. O. and Towar, R. 1991. *Prosopis cinenria*: Promising Multipurpose Tree for Arid Lands. *Agroforestry Today* 3(4): 13.

Chaturvedi, O. P. 1983. Biomass Structure, Productivity and Nutrient Cycling in *Pinus* Forests. *Ph.D. Thesis*, Kumaon University, Nainital, India.

Kothari, S. K., Singh, V. and Singh, K. 1987. Effects of Rates and Methods of Phosphorus Application on Herb and Oil Yields and Nutrient Concentrations in Japanese Mint *(Mentha arvensis)*. *J. Agric. Sci.* 108: 691-693.

Lohani, D. N. 1980. Studies on Spacing in *Eucalyptus* Plantations. U.P. Forest Bulletin No. 42.

Singh, K., Chauhan, H. S. Rajpout, D. K. and Singh, D. V. 1989. Report of a 60 Month Study on Litter Production, Changes in Soil Chemical Properties and Productivity under Poplar *(P. deltoides)* and *Eucalyptus* (*E.* hybrid) Interplanted with Aromatic Grasses. *Agroforestry Systems* 9: 37–45.

Singh, K., Ram, S. K., Singh, A. K. and Hussain, A. 1988. Poplar (*Populus deltoides* Batram Ex. Marshall) in Forest and Agroforestry Systems. *Indian Forester* 114(11): 814–818.

Singh, K., Singh, V. Singh, J. P. and Kothari , S. K. 1985. Cultivating Medicinal and Aromatic Plants along Agroforestry. *Indian Emr. Digest* 18 (9): 34–36.

Singh, K., Singh, V., Hussian, A. and Kothari, S. K. 1990. Aromatic Plants as Efficient Intercrops under Poplars (*P. deltoides*). *Indian Forester* 116(3): 189–193.

Valdiya, K. S. 1980. Stratigraphic Scheme of the Sedimentary Units of the Kumaon Lesser Himalaya. In: Valdiya, K. S. and Bhatiya, S. B. (eds.) Stratigraphy and Correlations of the Lesser Himalayan Formations. Hindustan Publication Corporation, New Delhi, India. pp. 7–48.

Mathema, P., Dutta, I. C., Balla, M. K. and Adhikary, S. N. (eds.). 1999. *Sustainable Forest Management.* Proceedings of an International Seminar, 31 August – 2 September 1998, Pokhara, Nepal.

Sustainable Management of *Leucaena leucocephala* based Silvi-pastoral System

J. N. Yadav

Abstract: This paper presents the results of a study on biomass productivity and nutrient composition of forage through management of *Leucaena leucocephala* var. K-8 trees by pollarding at 1, 1.5 and 2 m height and compared with un-pollarded trees of the same species. Significantly higher biomass and nutrient composition of N, P, K, Ca and Crude Protein (Cp) was recorded for 2 m pollarding height. Soil ameliorative efficiency among the treatments and soil enrichment potential in comparison to the adjoining unplanted natural grassland are also discussed.

1. Introduction

India is predominantly an agricultural country with a large bovine population (272.3 million) and cattle husbandry is an important subsidiary occupation of the farmers. It is paradoxical that despite having 55 million breedable cows and 32 million breedable buffaloes, the total milk production is only 55 million tonnes, whereas United States of America is producing 67 million tonnes of milk with only 10.2 million breedable milch cows. This is mainly due to low milk yield per animal. For successful livestock production, breeding, feeding and health of animals require adequate attention.

At present only 8.1 million ha (4.4% of total crop area) is under fodder crops. Opportunities for increasing the area under cultivated forages are remote, because of preferential need for human food. Forage obtained from agricultural land is able to meet only three-fifths of the requirement and the rest is met from forests and wastelands. Conservation of forest resources through regulated grazing and/or adoption of cut and carry system are essential for the sustainable management of forage and livestock development and for the protection of country's forest wealth.

Adoption of appropriate land use system is vital in hills to make the land economically productive. The physical characteristics of the land in Himachal Pradesh (HP) vary cognisably calling for specific land use systems as per local situations. In this context *Leucaena leucocephala* based silvi-pastoral land use has enormous scope for large-scale adoption.

The silvi-pastoral system integrates woody species (trees and shrubs) with grass or grass legume mixture, simultaneously or sequentially on the same piece of land. Not much information is available on *Leucaena leucocephala* var. K-based silvi-pastoral system and its management, especially in the midhills of HP where there is great potential for intensive livestock production. The present study was done to obtain information on the effect of pollarding height on leaf, branch wood and grass biomass productivity, nutrient composition of leaf and grass, and soil ameliorative efficiency.

2. Experimental methods

The study was conducted at the experimental silvi-pastoral plantation of July 1992 on degraded grassland. The plantation was done by the Department of Silviculture and Agroforestry, University of Horticulture and Forestry, Solan, HP, India. It is located at 30^0 51' N latitude and $76^0$11' E longitude with an elevation of 1200 m. Yearly maximum average temperature of this site was 24.62^{0}C and minimum average 12.89^0 during 1994–1996. The humidity varies between 40.5 to 88.75% with an annual average of 64.34%. Both early and late frosts are quite common. The average rainfall recorded during May 1994 to June 1996 was found to be 359 mm, most of which is concentrated in monsoon (June–September). Winter showers are common but the quantum of precipitation is low. The whole area has been reported to be a part of the outer Himalayas. The rocks exposed belong to Simala group of rock of Karol series, comprised by carbonaceous shales, calcarious shales, and dolomitic limestone with thin bands of intermittent shales,

The entire degraded grassland was divided into blocks. *Leucaena leucocephala* var. K-8 was planted in 4 x 2 m spacing in a Randomised Block Design with six replications. The space between rows was used for grass production and trees were pollarded at 1, 1.5 and 2 m from ground level and some trees left unpollarded. The trees were evaluated during 4^{th} year of plantation. The experiment was conducted under non-irrigated condition. Harvesting of all regenerated branches was done at fixed cutting height in each treatment. The fresh forage, non-edible branch woods and grass biomass were separated and weighed. For forage dry matter yield (leaf and grass), samples were dried in hot air oven at 65^0C for 36 hrs and branch wood were dried in hot air oven at 110^0C for 48 hrs and dry matter of components was worked out. The nutrient content of leaf and grasses i.e. Nitrogen (N), Phosphorus (P), Potassium (K), Calcium (Ca) and Crude Protein (Cp) were determined by chemical analysis.

Soil nutrients (pH, OC%, available N, P and K) were determined both from planted and unplanted area by analysing the composite soil samples collected from each treatment/plots. The data recorded for different parameters were subjected to appropriate statistical analysis as per the procedure recommended by Gomez and Gomez (1984).

3. Results and discussion

Biomass productivity

Dry forage and branch wood biomass of *Leucaena* under different pollarding height management (Table 1) showed that pollarding height significantly influenced leaf and branch wood biomass. It was recorded to be maximum 12.73 q.ha^{-1} and 58.58 q.ha^{-1} at 2 m pollarding height respectively, which were statistically significant over all other pollarding heights. The findings are in agreement with the observation of Hocking and Rao (1990), and Alferez (1978). Alferez (1978) reported that leaf production was primarily dependent on the number of buds that develop into new shoots on the stem and this varies with cutting height.

Table 1. Effect of pollarding height on leaf and branch biomass production of *Leucaena leucocephala* var. K-8

Pollarding height (m)	Leaf biomass (kg/tree)	Branchwood biomass (kg/tree)	Leaf biomass (q.ha^{-1})	Branch wood biomass (q.ha^{-1})
T_1: 1.0	0.63	2.58	7.88	32.23
T_2: 1.5	0.70	3.59	8.80	44.87
T_3: 2.0	1.02	4.69	12.73	58.58
T_4: Unpollarded tree	0.68	2.88	8.50	36.05
$SE_M\pm$	0.05	0.27	0.59	3.25
CD 0.05	0.14	0.80	1.77	9.81

The grass yield under *Leucaena* based silvi-pastoral system ranged from 93.95 q.ha^{-1} in T_4 to 95.54 q.ha^{-1} in T_1. However, T_2, T_3 and T_4 were at par (Table 2). Hazra and Patil (1986) and Katoch (1994) also reported non-significant differences in growth of grasses under *Leucaena*.

Table 2. Grass biomass under different treatments

Pollarding height (m)	Grass biomass (q.ha^{-1})
T_1: 1.0	95.54
T_2: 1.5	94.85
T_3: 2.0	94.15
T_4: Unpollarded tree	93.95
$SE_M \pm$	0.33
CD 0.05	1.01

Nutrient composition

Leaf nitrogen content varied from 3.50 to 3.80%. For 2 m cutting height, the value significantly exceeded over other treatments. T_2 and T_4 behaved statistically alike but proved significantly better than T_1 (Table 3). The leaf phosphorus content showed significant variation among different treatments. It recorded the highest (0.52%) under T_3 followed by T_4 (0.28%), T_1 (0.27%) and T_2 (0.25%). Potassium content in leaf differed significantly among different pollarding height and the order was $T_3>T_4>T_2>T_1$. Leaf calcium was found to be the lowest in unpollarded trees (2.18%) but depicted a significant improvement with increase in pollarding height. Crude protein content in leaf was maximum (23.75%) at 2 m pollarding height and minimum (21.87%) at 1 m pollarding height. Nitrogen content also followed a similar trend. The findings on N and Cp are in agreement with those of Karim *et al.* (1991) who reported increase in N yields/tree with increase in cutting height and cutting interval. Pathak and Patil (1982) also showed that biomass and N yield depend on coppicing height. N and Cp content were obtained in the same range as reported by Budelman (1989) and Gupta *et al.* (1982). The percent composition of the nutrients was in accordance with the values reported by Budelman (1989) and Adenge (1979).

Table 3. Nutrient content under different treatments

Pollarding height (m)	N(%)	P(%)	K(%)	Ca(%)	Cp(%)
T_1: 1.0	3.50	0.27	1.37	2.60	21.87
T_2: 1.5	3.66	0.25	1.42	2.70	22.87
T_3: 2.0	3.80	0.52	1.61	3.15	23.75
T_4: Unpollarded tree	3.60	0.28	1.46	2.18	22.50
$SE_M \pm$	0.030	0.001	0.006	0.018	0.191
CD 0.05	0.093	0.003	0.019	0.055	0.577

The results on the effect of pollarding height on grass nutrient under *Leucaena* based silvi-pastoral system (Table 4) showed that N content was maximum (2.17%) at 2 m pollarding height and minimum (1.82%) at 1 m pollarding height. The content obtained under different pollarding heights were significant and fell in the order of $T_3>T_2>T_4>T_1$. P content was found to be maximum (0.22%) in the unpollarded trees and minimum (0.15%) in 2 m pollarded trees. K content of grass showed significant differences among the different pollarding heights with a maximum value of 0.81% at 2 m pollarding height and minimum 0.66% at 1 m pollarding height. With respect to Ca content in the grass, T_2 (0.50%), T_3 (0.50%) and T_4 (0.49%) were statistically at par and were significantly different from T_1 (0.45%). The Cp content followed a trend similar to that of N content. The nutrient contents of grasses obtained were at the same range as reported by Singh (1975) and Katoch (1992). The effect of pollarding height on the nutrient contents though significant, seems to be negligible. Slight difference among the treatments may be due to pollarding height and soil fertility.

Table 4. Effect of pollarding height on grass nutrient content under *Leucaena leucocephala* var. K - 8

Pollarding height (m)	N(%)	P(%)	K(%)	Ca(%)	Cp(%)
T_1: 1.0	1.82	0.19	0.66	0.045	11.36
T_2: 1.5	1.96	0.17	0.74	0.50	12.27
T_3: 2.0	2.17	0.15	0.81	0.50	13.54
T_4: Unpollarded tree	1.91	0.22	0.70	0.49	11.92
$SE_M\pm$	0.011	0.004	0.006	0.003	0.069
CD 0.05	0.033	0.014	0.021	0.008	0.208

Soil analysis

The soil pH varied from 7.07 to 7.15 but was not influenced by the pollarding heights. Organic carbon content was found to vary from 1.20 to 1.63% where different treatments followed the pattern $T_3>T_2>T_4>T_1$. N content of soil was maximum (546.70 kg.ha^{-1} at 2 m. pollarding height, while the minimum N content (430.70 kg.ha^{-1}) was recorded when no pollarding was done. T_2, T_3 and T_4 showed significant differences while T_1 and T_2 were at par with each other. The maximum amount of P (33.97 kg. ha^{-1}) was obtained in unpollarded tree while pollarding at 2 m gave the minimum soil P (21.05 kg.ha^{-1}). T_4 and T_1 were statistically at par and significantly different as compared with T_2 and T_3. The K content of the soil ranged from 335.30 kg.ha^{-1} in 1.0 m. pollarding height to 346.60 kg.ha^{-1} at 2 m pollarding height. T_2 and T_4 behaved similarly but showed significant differences as compared with T_1 and T_3. The maximum content of OC, N and K at 2 m pollarding height may be due to higher biomass production and higher leaf decomposition.

The data of chemical properties of soil viz., pH, OC, N, P and K under the system are shown in Table 5. The results revealed that all the soil properties were significantly influenced by pollarding treatment, except for pH, which was found to be statistically non-significant. Litter fall and its decomposition are in line with findings of Siaw *et al.* (1991), while P content was recorded more in unpollarded trees. This may be attributed to the high leaf litter over the past years contributing to soil phosphorus.

Table 5. Effect of pollarding height on chemical properties of soils under *Leucaena* based silvi-pastoral system

Pollarding height (m)	pH	OC (%)	N (kg.ha^{-1})	P (kg.ha^{-1})	K (kg.ha^{-1})
T_1: 1.0	7.07	1.20	505.90	31.51	335.30
T_2: 1.5	7.15	1.50	485.03	23.89	339.20
T_3: 2.0	7.15	1.63	546.70	21.05	346.60
T_4: Unpollarded tree	7.13	1.27	430.70	33.97	339.60
$SE_M\pm$	0.09	0.01	12.61	1.70	0.61
CD 0.05	NS	0.02	38.03	5.14	1.85

Table 6 shows that the pH value was not significantly different as compared with the planted area but OC, N and P were lower than that of *Leucaena* planted area while available K was almost similar to that of planted area. On the basis of recorded data when we compared the soil nutrient status of both planted and unplanted areas, it was clear that the plantation of *Leucaena* increased the nutrient status of soil.

Table 6. Soil chemical characteristics of the unplanted (natural grassland) area adjoining the experimental plots

Soil chemical characteristics	Soil depth (0–15 cm)
pH	7.13
Organic (Carbon (%)	0.71
Available N kg.ha^{-1}	297.91
Available P Kg.ha^{-1}	16.87
Available K Kg.ha^{-1}	341.78

4. Conclusion

Management by pollarding at different heights indicated direct relation with biomass production in *Leucaena leucocephala* var. K-8. Considering the relative biomass production potential, leaf nutrient content and soil improvement ability, the *Leucaena* based silvipastoral system is promising for degraded sites with similar edaphoclimatic conditions as the midhills of Himachal Pradesh, India.

References

Adenge, J. A. 1979. A Note on the Nutrient and Mineral Composition of *Leucaena leucocephala* in Western Nigeria. *Animal Feed Sc. Technology* 4(3): 221–225.

Alferez, A. C. 1978. Management of Ipil ipil for Forage. International Consultation on Ipil ipil Research: Paper and Proceedings, Philippine Council for Agriculture and Resource Research, Laguna, Los Banos, The Philippines. pp. 51–56.

Budelman, A. 1989. Nutrient Composition of the Leaf Biomass of Three Selected Woody Leguminous Species, *Agroforestry Systems* 8: 39–51.

Gomez, K. A. and Gomez, A. A. 1984. *Statistical Procedure for Agriculture Research* (2nd Ed.), John Willey and Sons Inc., New York, USA.

Gupta, N. K., Chaudhari, D. K. and Suri, P. K. 1982. Nutritive Value of Some Fodder Trees. Proc. National Seminar on Chemistry, Industry and Citizen. Ind. Chem. Soc., Dehradun, India. pp.82–92.

Hazra, C. R. and Patil, B. D. 1986. Forage Production under Silvi-pastoral System. Light and Temperature Relations. *Ind. Jour. of Range Management* 7(1): 33–36.

Hocking, D. and Rao, D. G. 1990. Canopy Management Possibilities of Arboreal *Leucaena* in Mixed Sorghum and Livestock Small Farm Production Systems in Semi-arid India. *Agroforestry Systems* 10: 135–152.

Karim, A. B., Rhodes, E. R. and Savill, P.S. 1991. Effect of Cutting Height and Cutting Interval on Dry Matter Yield of *Leucaena leucocephala* (Lam) De Wite. *Agroforestry Systems* 16: 129–137.

Katoch, B. S. and Dogra, K. K. 1992. Studies on Carrying Capacity of Selected Pasture of Kangra and Simala Districts. Progress Report, Dept. of Animal Nutrition, College of Vet. & Anim. Sc., H. P. K. V. V., Palampur, HP, India. pp.1–16.

Katoch, D. C. 1994. Sustainable Silvi-pastoral System for Sub-tropical Rangelands Infested with *Lantana camara* L. In: Pathak P. S. *et al.* (eds.) *Agroforestry Systems for Degraded Lands* pp. 159–163.

Pathak, P. S. and Patil, B. D. 1982. Nodulation and Seedling Growth in *Leucaena leucocephala* Cultivars. *Leucaena Res. Report* 2:25.

Saierne A. R. and Seiffer, N. F. 1990. Cultivar of *Leucaena* tested in Santa Catarina. *Agropecuaria Catarinense* 3(1): 10–18.

Siaw D. E. K. A., Kang, B. I. and Okali, D. U. U. 1991. Alley Cropping with *Leucaena leucocephala* (Lim.) Dewit and *Acioa barreri* (Hook. F.) Engl. *Agroforestry Systems*, 219–231.

Singh, L. N. 1975. Botanical Composition, Herbage Production and Nutrient Status of Grasslands of H. P. *Forage Res.* (1): 40–46.

PART 3:

WATERSHED MANAGEMENT AND ENVIRONMENTAL CONSERVATION

Mathema, P., Dutta, I. C., Balla, M. K. and Adhikary, S. N. (eds.). 1999. *Sustainable Forest Management.* Proceedings of an International Seminar, 31 August – 2 September 1998, Pokhara, Nepal.

Integrated Watershed Management through Participatory Process

H. B. Acharya and L. Shrestha

Abstract: In the Nepalese rural society, it has been proved that the top-down approach of the government for the conservation of forest does not work since the local people have direct influence over the conservation and/or deterioration of the resource. Consequently, participatory approach has emerged whereby local inhabitants are directly involved in the management of local forest resources. This paper discusses the different approaches to participatory forest/watershed management. The evolution of participatory approach in soil conservation and watershed management is also discussed. The lessons learnt from three watershed management projects implemented in Kaski district, Nepal are also discussed.

1. Introduction

The Sixth Five Year Plan (1980–85) first incorporated the spirit of community participation in planning and implementation at the district level. However, due to the absence of legal framework for people's participation and lack of understanding of mechanisms, influential people tried to get all the benefits of a project's activities in the name of community participation.

Some of the problems concerning people's participation in watershed management in the past were as follows:

- Watershed management focused on public lands and activities such as conservation plantation and gulley control were popular. However, work was carried out by directly hiring local labourers or through a contractor and the beneficiaries were hardly involved.
- Users' committees were seldom formed. Participation was limited to the political leaders and local élite, and users' meetings were organised only for formality.
- Few activities such as water source protection, water supply and hill irrigation channel improvement received contributions from the people in terms of their labour.
- Women, underprivileged castes and minority ethnic communities were not adequately involved.

A major problem in attaining people's participation in conservation activities is that the people's priority needs are not always in accordance with conservation requirements. People in general, tend to take interest in the activities which produce personal, direct and short-term benefits, but not in the activities that produce indirect and long-term benefits as in environmental conservation.

Many of the past projects placed more emphasis on fulfilling physical targets in a short time. Assistance was given to the people in a spoon-feeding manner often through outside contractors by using wage labour. This spoilt the people's spirit of self-reliance and fostered dependency habits among the people. For example, most of the previous community plantations and nurseries were established and operated totally by the Community Forestry Development Project (CFDP). Many of these are not maintained anymore. This indicates the need of people's participation in their development activities and to ensure sustainability.

2. Different participatory approaches

User group and participatory approaches

The user group approach recently adopted by the community forestry programme was a step forward to generate real people's participation in forestry. Integrated projects such as Integrated Watershed Management Project (IWMP) of Phewa Tal and Begnas Tal Rupa Tal (BTRT) Watershed Management Project applied this concept to other activities as well. A user group is formed by identifying the beneficiaries of a development activity, depending on the type and scale of the activity the local situation and upon the consent of the users themselves. The groups are encouraged to raise their own funds and are given responsibility for planning, conservation and management.

Individual approach

Group approach is not always the most effective extension method. For instance, in agriculture and agroforestry sectors where farming is practised on individual basis, the concept has been developed by the integrated projects to appoint progressive and influential farmers as leader farmers. They are given incentives and training to introduce new farming or conservation techniques. They then assume the role of field extensionists within their communities. The advantage of this approach is that the projects do not have to contact all the community members but can expect good results by dealing with only a small number of people.

Grass- roots approach

The people directly engaged in forest utilisation are generally of lower social status, e.g. women, poor and children. In order to involve more women in development activities, majority of the projects are taking measures like:

- Employing female extensionists and motivators,
- Setting rules to include female members in local management committee,
- Subsidising women groups for their activities, and
- Organising workshops and training courses especially tailored for women.

Similarly, various income generation programmes have been conducted to provide extra income to the marginal farmers and occupational castes who do not have sufficient food production. Many projects also conducted conservation extension education in schools.

3. Emergence of participatory approach

The approach of people's participation in watershed management in Nepal has been evolving since 1974. In the initial phase (1974–1980), maps and aerial photos were used to assess land and forest resources. Applications for terrace improvement were collected from individual farmers. The project subsidised 80% of the cost of terrace improvement. All other activities were implemented by hiring contractors or local labourers. The projects themselves repaired and maintained the activities implemented.

In the second phase (1981–1985) village leaders were invited to assess their needs and to plan activities in the spirit of decentralisation. Some key villagers were also involved in implementation. The projects tried to educate the people that conservation activities will yield benefits in the future. Terrace improvement subsidies were reduced to 70%, so that more farmers could participate. After the promulgation of the Soil and Watershed Conservation Act in 1982, Catchment Conservation Committees (CCC) were established in a few districts in order to co-ordinate watershed management activities within the district.

In the third phase (1986–1990), biophysical characteristics were used for resource assessment. In line with the decentralisation policy, VDCs were involved in planning the activities. Subsidies for terrace improvement were further reduced to 50%. The user-developed works were repaired and maintained by the users themselves with the support of the project.

The Decentralisation Act 1982 authorised the formation of user groups for all rural development activities. Natural and planted forests were handed over to the communities to convert the government managed forests into user managed community forests.

In the period of 1991–1994, RRA/PRA surveys as well as biophysical characteristics were used to assess farmers' needs. Sub-watershed planning was institutionalised and on-farm conservation packages were developed. Up to 60% of the total resources was channelled to priority sub-watersheds and most activities were implemented through users. Guidelines for people's participation were produced and establishment of user's group to run Soil Conservation and Watershed Management (SCWM) activities was made mandatory.

4. Rationale

Development and management of land, water, forest and biodiversity resources should be integrated at all levels of natural resource development and management. As the climate, land, water, vegetation systems are inter-linked with each other in the mountain systems, from the mini watershed level to macro level, any change in one of the components of this system will affect the other, as each one influences the other to a larger or smaller degree. In small watersheds, this relationship is stronger and also extremely critical. Therefore, programmes on watershed management or studies on watersheds should be integrative and holistic.

High population growth rate is the principal cause of the increased heavy pressure on the natural resource base and the consequent decline in the quality of life. However, it is also equally true that natural factors, such as intense precipitation and fragile geology of the region also damage and destroy the productive bases and infrastructures, thereby overwhelmingly augmenting the pressure on the natural resource base and adding to the general degradation of the environment. Whereas human pressure could be tackled with increased economic opportunities and benefits, natural disasters caused by natural factors can be dealt only with adequate knowledge on the functioning of the natural system of the diverse ecosystems. Clearly this calls for an integrated understanding of the functioning and impacts of both human and the natural systems (ICIMOD, 1993).

A strong emphasis on economic and environmental complementarity is the most important and sustainable approach and it must be aimed at formulating and implementing policies, plans, and programmes for natural resources management. Adequate and active support from other sectors and the active participation of the people in decision-making and sharing of benefits are also crucial for success and sustainability.

Management systems at all levels must take into account the basic needs of the local people, help reduce the drudgery in life particularly for women and children, and provide direct economic benefits to the local people. New options of management must be capable of generating additional income at the local level; otherwise, it will not be acceptable to the people or sustainable in the long run (HMG/JICA, 1994).

HMG/JICA (1994) also found that an integrated approach incorporating activities to satisfy other priority needs should be considered in conservation activities. Among the general development needs, the concern over landslides and soil erosion occupies ninth place after income generation, irrigation, forest production, drinking water, power supply, motorable roads, health and sanitation, and food sufficiency.

5. Sectoral vs. integrated participatory approach

The District Forest Office has obtained successful results in forest management through participatory approach by integrating the community development activities with forestry. As the local community can use the funds generated from community forest for community development activities, their participation has increased and the result is good.

Also the environmental problem in the hills are occurring extensively rather than in small areas, costly and intensive measures do not always lead to good effects. A study done by HMG/JICA (1994) shows that to promote active participation of the people, an integrated approach that takes care of their various needs is more suitable than single sectoral approach. It would be essential to give authority to the people at the grass-roots level to make decision and take responsibility for implementation and maintenance

6. Comparative lessons learned

The lesson learned from Integrated Watershed Management Project (IWMP) of Phewa Tal; Begnas Tal Rupa Tal (BTRT) Watershed Management Project; and Community Development and Forest/Watershed Management Project and Greenery Promotion Co-operation Project (CDFWCP/GPCP) are very crucial for designing and implementing other watershed management projects in future.

Integrated Watershed Management Project of Phewa Tal (IWMP)

In collaboration with UNDP, FAO and FINNIDA, HMG implemented this project in the catchment area of Phewa Lake, Kaski district. The most important lesson learned is: integrated approach is more result-oriented than the sectoral approach in relation to conservation and management of watershed. Likewise, awareness building campaign and human resource development among the target groups is essential before carrying out any physical intervention. Even today, the positive impact of various technologies applied by the local people can be observed. In addition to it, the local people have been found to be aware about forest conservation, community forestry, planting trees and grasses in private land, as a consequence of the awareness building campaign of the project.

Despite such positive outcomes, local organisations were not established to ensure long-term sustainability of the activities. The user group concept, people's participation and process-oriented approach were not incorporated in this model. Similarly, no follow up phase was envisaged before the withdrawn of the project support. However, the different reports of IWMP indicate that the project has involved the local people in need identification only. Additionally, it also realised the importance of user groups, their participation in all phases of the project cycle, and directing benefits to the marginal farmers and low-income groups.

Begnas Tal Rupa Tal Watershed Management Project (BTRT)

The other model project on watershed management is BTRT as implemented by HMG in collaboration with CARE International Nepal in Kaski district covering the catchment area of Begnas and Rupa lakes for 13 years. This project has learned valuable lessons on the pros and cons of IWMP and modified its implementation strategies accordingly. However, the role of community in planning and implementation was very limited during the first five-year period. Community consultations took place primarily with formal local leaders, while women and disadvantaged groups were left out. The project could not address the needs of the average community members and the poor people. This resulted in the neglect of conservation structures after the project support was withdrawn. Based on the experience of the first five years, the implementation strategy was changed and community participation was initiated to develop a sense of ownership and sustainability of the completed activities. More emphasis was given to capacity building of the user groups instead of labour contribution. The concept of rural co-ordinating body of the user groups was introduced in the name of Community Development Conservation Committee (CDCC) as an entry point of project intervention.

The new strategy of BTRT brought a dramatic positive change in the community participation sector for the remaining eight years of the project. The institution building of the local organisations like CDCC, user groups, co-operatives and local NGOs are some outstanding examples. Such local co-operatives are operating credit schemes for their own members and making available necessary commodities at reasonable price. The local NGOs are providing appropriate technical support to the villagers, by charging a reasonable fee. The Coffee Development Board (CDB) and Kisan Dekhi Kisan Samma (NGO) and others have done a commendable job. In addition, some of the local farmers have also done exemplary work in the field of agroforestry and income generating activities.

In a nutshell, the BTRT can be considered as a technically integrated, community participation type of project with human resources development followed by the institutional development of the local organisations.

The project could not achieve satisfactory results on matters like gender balance since insignificant number of women and occupational caste people could participate in CDCC and user groups. Major decision making authority was the project staff and there was no follow-up phase. It is still too early to assess the impact of the completed activities since the support has been withdrawn just two years ago. A periodic monitoring and evaluation is still necessary to assess the long-term impact of the project.

Community Development and Forest/Watershed Conservation Project and Greenery Promotion Co-operation Project (CDFWCP/GPCP)

The CDFWCP/GPCP is another project directly related to forest/watershed implemented in Kaski and Parbat districts in collaboration with JICA/JOCV. It is being implemented since July 1994. Although the goal of the project is sustainable management of forest/watershed, the community development component has been integrated in the project. The project believes that the priority of rural people is community development activities like drinking water, irrigation, road, food security, income generation, etc. which need to be addressed together with forest/watershed conservation. Forest/watershed conservation does not work unless the community development activities are incorporated. Considering this, the project has incorporated various process-oriented components like participation of local NGOs, gender, decentralisation of power, reservation for women and occupational caste, and follow up phase in addition to other components that characterised IWMP and BTRT.

As far as the nature of this project is concerned, it is process-oriented rather than quantitative target based and addresses the needs, wishes and priorities of the target groups. Since the process is combined with too many software components and different direct and indirect stakeholders, this project is characterised by trial and error approach. During the first four years of project intervention, the operational guidelines have been modified two times with an aim to achieve more community participation especially of women, occupational caste and poor people. More power has been delegated in the subsequent years to Monitor/Promoter Team (M/P Team) stationed in the field and assisted by Multi-disciplinary team of expatriates and HMG officers.

The progress on forest/watershed management has been improving in each subsequent year following the demand-driven approach. Further, it is expected that more and more progress will be achieved in the coming years. The project has proven that unless the immediate needs are fulfilled, successful forest/watershed conservation cannot be expected. As a matter of fact, the hypothesis of fulfilling the immediate needs followed by forest/watershed conservation is a process which has been experimented successfully by CDFWCP/GPCP.

Specifically, CDFWCP/GPCP is a participatory project whereby technical component, needs and wishes of local people, gender, decentralisation and human resource development followed by the institutional building of the user groups have been integrated to conserve and manage the community resources. Activities driven by the user groups with the support of HMG, JICA, JOCV and NGO as direct stakeholders in the implementation team of this project is another unique characteristic. Unlike the other two projects, CDFWCP/GPCP have been implemented with the planning of three different phases; preparation, implementation and follow-up. Nevertheless, it has been learned that the process-oriented approach that integrates various social/technical components and involves larger number of stakeholders is not as easy as the target-oriented sectoral approach. Modifications are needed at different time intervals and accordingly, the project has identified its mistakes and taken timely corrective action.

7. Conclusion

It is hard to say which is the best among the three different models implemented for watershed management in Kaski district. All the three have their own strengths, constraints and limitations in concept and application. Although the model of CDFWCP/GPCP seems more attractive in concept, difficulties remain in its implementation. Further, the four-year period of CDFWCP/GPCP is not sufficient to draw a concrete conclusion. But one thing is clear: participatory process is the only viable approach for watershed management. Participatory approach is a dynamic phenomenon which should be refined and corrected as needed without hampering the sustainable conservation and management of watershed.

References

HMG/JICA. 1994. Forestry Extension Activities of Selected Project in the Western Development Region. *Project Report No. 2*. HMG/JICA, Kathmandu, Nepal.

ICIMOD. 1993. International Symposium on Mountain Environment and Development. ICIMOD, Kathmandu, Nepal.

Mathema, P., Dutta, I. C., Balla, M. K. and Adhikary, S. N. (eds.). 1999. *Sustainable Forest Management.* Proceedings of an International Seminar, 31 August – 2 September 1998, Pokhara, Nepal.

An Ecosystem Approach to Integrated Resource Management: Building from Experience in Participatory Watershed Management in Nepal

S. H. Achet

Abstract: Ecosystem approach to watershed management requires a system-based, problem-focused and improvement-oriented watershed analysis in relation to hydrological cycle and energy balance. The spatial system basis of the approach is a nested continuum of sub-watershed, watershed and basin. The temporal domain of the framework ranges from seasonal to annual, periodic and long-term perspectives. The salient features of the ecosystem approach combine technical, managerial, institutional, social, economic and environmental dimensions of participatory integrated resource management. The approach links purpose, output and activities in an integrated logical framework. The ecosystem approach accommodates Nepal's experience in participatory watershed management. The application tool of the approach is watershed analysis system. A future perspective of the approach is also presented in this paper.

1. Introduction

Ecosystem approach is the fundamental basis for sustainable natural resource management (FEMAT, 1993). Since a watershed integrates physical, biological, geo-morphological and social processes as well as people-resource interactions, the most appropriate basis for watershed management is the ecosystem approach. Different scales of watersheds constitute the basic units of management in mountain ecosystems. Obviously, ecosystem approach to watershed management embraces the water and energy budgets in a watershed in relation to the hydrological cycle. The approach can encompass soil-vegetation-atmosphere relationship as well as land-water interactions. In such a setting, the present situation of a watershed can be assessed. The cause-effect inter-linkages of the present situation reveal how the resources, processes and their interactions are equilibrating. This constitutes the basis for focusing on problems based on a cause-effect relationship. Furthermore, public issues and management concerns set the adaptive management course of watershed management. Therefore, an ecosystem approach to watershed management must logically be a system-based, problem-focused and improvement-oriented adaptive management system.

The objective of this paper is:

- to conceptualise an ecosystem approach to integrated watershed management,
- to integrate Nepal's experience in integrated watershed management with the approach,
- to outline an application tool for an ecosystem approach to integrated watershed management, and
- to present future perspective of watershed management in an ecosystem framework.

This paper outlines a purposeful paradigm shift from conventional watershed management to an ecosystem approach to participatory integrated resource management of human-dominated mountain watersheds.

2. The system perspective, problem focus and improvement orientation

The main system concerns, key problem area and major improvements needed in watershed can be defined based on realities. In Nepal's context, Table 1 shows an example of watershed management issues fitted in this conceptual basis. Some examples of the main system concerns to suit the purpose of watershed management could be as follows:

- Mountain watersheds at different scales can represent a physically and ecologically integrated system.
- River basin management can be specially focused on rivers originating from different ecological zones.
- Watershed condition in terms of severity of erosion in comparison to natural or well-managed condition could also constitute the system basis.
- Critical watershed in view of the desertification process based on problem identification and comprehensive remedial approach could also be conceived as a system.
- Ecosystem utilisation system that integrates soil, landscapes, land utilisation types and socio-technical and indigenous knowledge-based community land management comprising of site specific sub-systems could constitute an integrated system.

Similarly, some of the main problem focus to suit to a specific purpose could be based on:

- Watershed specific problems
- Desertification control
- Landslide control
- Preventive land hazard management
- Ecosystem utilisation priorities
- System of national, community and municipal watersheds
- Participatory local resource mobilisation
- Sediment control
- Water yield regulation

Specific result indicators could be defined to reflect this problem focus.

Table 1. An example showing watershed management issues pertaining to main system concerns, key problem areas and major improvement areas

Main system concerns	Key problem focus areas	Major improvement areas
Watershed scales	Erosion and land productivity	Participatory watershed management
Nested watersheds	Synchronous and non-synchronous Impacts	Land use improvement for each ecosystem
River basin management	Critical areas and processes	Integrated resource management
Critical watersheds	Natural hazard zoning	Hazard information system
Ecosystems by utilisation types	Ecosystem utilisation Priority Areas	Adaptive action programme
Desertified watersheds	Desertification control	Integrated system management
National watersheds	Land degradation	Resource conservation and management
Municipal watersheds	Water supply and water quality	Vegetation management
Community watersheds	Forest and watershed resource mobilisation	Farmers institution building

In the same way, improvement in the system could be dealt with using several approaches such as:

- Integrated resource management with a thrust on local community participation
- Theme-based watershed management
- Use of GIS and advanced tools for improving, understanding and management of the system
- Adaptive management linking basin management to plot and watershed level studies in nested framework
- Improving co-ordination and networking among land management agencies
- Hazard planning and management information system.

Mountain watersheds are sources of water, energy, power, food, fodder, biodiversity, medicinal herbs, etc. Mountain ecosystems have been managed by farmers to cope with the complex natural resource management problems in a range of details and differing perspectives. Many indigenous technologies have evolved from centuries of farmers' experience. In fact, there are enormous opportunities for indigenous technology knowledge, local resource mobilisation, centuries-old traditional management systems, participatory management, evolutionary institution building and social learning processes in mountain areas. These opportunities fit well in the system-based, problem-focused and improvement-oriented adaptive management in an ecosystem approach to integrated resource management.

3. Spatial domain of the ecosystem approach

A watershed represents a physically and ecologically integrated system. They are appropriate management domains for linking goals, purposes, outputs and activities in a nested continuum of site, watershed, river basin, province and region for watershed management. This nested continuum serves as a convenient spatial domain of an ecosystem approach to watershed management. Viewed in this context, an ecosystem approach to watershed management has many open fronts and endless opportunities to contribute to effective management of a site, watershed, river basin, province and region.

4. Temporal domain of the framework

The temporal domain of an ecosystem approach to integrated watershed management must accommodate centuries of experience in indigenous integrated resource management practices as well as periodic, annual and seasonal planning and management perspectives. Organised user groups and communities can have their own operational plans. Thus, planning and management based on experience on a long-term, periodic, annual and seasonal basis constitute the temporal domain of the ecosystem approach.

5. An integrated logical framework of the approach

Participatory integrated watershed management programme in Nepal has a wide range of goals, purposes, outputs and activities. Watershed management programme becomes meaningful when one logically links goals, purposes, results and activities. These management objectives are also relevant for project design, execution, and monitoring and evaluation. From an ecosystem perspective, this logical approach becomes enriched when one integrates system concerns, problem focus and improvement needs. Furthermore, the basis for the success in participatory integrated watershed management at the local farmers level has roots extended from farmer managed irrigation systems, community forestry and informal traditional institutions systems and local indigenous management approaches (Achet, 1998). Participatory analysis of these institutions in terms of their characteristics, strengths, threats, opportunities, weaknesses as well as public issues and management concerns can also be addressed in the logical framework. Therefore, suitable logical framework to accommodate ecosystem approach to watershed management can be an integrated logical global replacement framework of goals, purposes, outputs and activities embracing hierarchical of objectives, ecosystem approach and indigenous management systems. This integrated logical framework can be conveniently constructed as a matrix comprising of indicators, means of verification, assumptions and preconditions.

6. Dimensions and criteria of the ecosystem approach

From the ecosystem perspective, integrated watershed management must embody an environmentally sustainable approach. Furthermore, participatory integrated watershed management is also a social learning process of change, local empowerment and ownership. Therefore, in the context of natural resource management, participatory integrated watershed management must embrace people's local technological excellence and innovation. Besides, integrated watershed management should also be economically lucrative and environmentally friendly. So, integrated watershed management must include technical, economic, environmental, social and institutional dimensions. The criteria for analysing these dimensions could include the following criteria:

Technical dimension:

- technical appropriateness
- technical effectiveness
- erosion control index

Economic dimension:

- local employment and income
- cost effectiveness
- benefit-cost ratio

Environmental dimension:

- environmental conservation
- sustainability
- pollution control

Social dimension:

- participation
- social acceptability
- multiplier effect

Institutional dimension:

- local level planning
- institution building potential
- local self-help initiative.

Thus the preceding dimensions and corresponding criteria can be conveniently applied to the ecosystem approach to integrated resource management.

7. Watershed analysis system as an application tool of the approach

A good analytical basis is essential in order to apply ecosystem approach to watershed management. Such a basis can consist of maps, figures, graphs, tables and analytical tools. This analytical system effectively should link resources, processes (including people's activities) and their interactions on resources. In Nepal's context, issues to be dealt in the watershed analysis system are:

- assessment of the land degradation problem based on quantitative scientific tools and sound fundamental basis
- appraisal of various problems in different ecological regions in view of the local driving forces
- using advanced techniques in hydrological analysis
- matching a most effective approach to best management practices
- development of an integrated land use system comprising of land use, land capability, soils and ecosystem utilisation types
- improvement in land use needed for increasing output with minimum inputs
- incorporating socio-technical approaches blending local know how, socio-cultural setting and opportunities
- embracing natural realities in terms of geology, climate, rural life style and centuries of experience in private, community and public problem solving and resource management
- identification of different themes that deal with degraded land/vegetation/ water resource management
- matching appropriate packages for resource utilisation, conservation, and mobilisation for sustainable watershed management
- linking watershed management to address gender, equity, disadvantaged group issues, poverty alleviation, and designing watershed management as a practice for social transformation and economic development.

In view of Nepal's unique ecological and socio-economic setting, watershed analysis in mountain areas should also accommodate the following issues:

- extensive terracing and hill farming system
- soil fertility management for sustaining productivity
- farmer managed irrigation systems
- intensive agroforestry system for rainfed areas
- mountain farming systems approach
- community forest and local resource management
- local level decision-making.

All these issues can best be addressed in the ecosystem approach to participatory integrated watershed management.

Watershed analysis system must be a problem solving tool that:

- systematises management in a continuum of watershed, basin and region embracing location-specific hydrological cycle representing resources and processes unique to the mountain areas
- accommodates technical, economic, social, institutional and environmental dimensions and appropriate criteria
- consists of a suitable temporal basis ranging from an indicative plan to periodic plan to annual plan and community plan in a bottom-up fashion
- links an integrated logical framework of goals, purposes, outputs and activities designed in terms of objectively verifiable indicators, means of verification, assumptions and preconditions

- characterises strengths, threats, opportunities, weaknesses, public issues and management concerns of relevant institutions
- institutionalises inter-and intra-sectoral co-ordination and networking
- encompasses the recent paradigm shift in planning, programming and working strategies as well as participatory milestones.

Applying watershed analysis to ecosystem approach to watershed management requires:

- identification of critical watersheds as priority areas for intervention
- applying appropriate packages development to suit a particular problem
- farmers organisation building together with watershed planning and management
- embracing key characteristics of the participatory process in line with system concerns, problem focus and improvement needs
- using milestones of the participatory process
- upstream-downstream linkages.

Watershed analysis system can generate several scenarios as management options for mountain watershed in terms of hydro-power, food, fuel, fodder, biodiversity, medicinal herbs, tourism, aesthetics, indigenous technology knowledge, local resource mobilisation, centuries-old traditional management systems, participatory management, evolutionary institution building and social learning processes. This can eventually be a basis for a definitive course of social transformation through watershed management.

8. Building up from Nepal's experience in integrated watershed management

Nepal's watershed management problems have always been complex and challenging. Some of the proven adaptive management systems excelled over thousands of years to manage land-water interactions effectively include:

- extensive and elaborate terracing excelled over thousands of years
- a system of fertility management and erosion control that is unique to Nepal's topographic, geologic and climatic setting
- farmer managed irrigation systems patented as socio-management systems
- community-based approach to forest management and local resource mobilisation in the mountain areas
- intensive land use and agroforestry system suited to rainfed agriculture
- integrated farming system approach linking land utilisation, forestry, livestock and local infrastructure as well as resources
- Informal institutional approaches involving local decision making systems.

An ecosystem framework that integrates experience in participatory watershed management in Nepal must embody experience from this adaptive management process. The experience can be integrated at the system level, problem-focus level and activity level. In the present context, the following features of participatory integrated watershed management in Nepal are relevant for integration in the ecosystem approach.

- managing critical watershed districts based on state of erosion in comparison to natural or well managed conditions
- experience based on diverse case studies related to successful participatory watershed management
- gradual shift from government management to facilitated approach to local empowerment

- testing different institutional models such as single umbrella approach, multi-umbrella approach, integrated rural development approach
- thrust on institutionalisation of the successful approaches
- inter-sectoral and intra-sectoral co-ordination and networking
- evolving emphasis on integration of local farmers organisation building and sub-watershed management as a one step procedure.

The smallest management unit that constitutes the system basis is a sub-watershed. In Nepal, functional sub-watersheds of 5–25 km^2 are identified for management with emphasis on people's participation. Sub-watersheds are managed for a number of years ranging from 5–13 years. Thus the system basis for ecosystem approach to integrated resource management and local resource mobilisation is a sub-watershed. In this framework, the purpose focus of watershed management in Nepal can also address poverty alleviation and social change through conservation-oriented income generating activities. The emphasis areas of the watershed management programme in Nepal to suit this purpose focus are:

- land use planning
- land productivity conservation
- infrastructure protection
- natural hazard prevention
- people's participation.

Based on the experience of participatory integrated watershed management in Nepal, the following working strategies can be included at the activity level:

- integrated watershed management on a sub-watershed basis
- simple and clear-cut planning based on questions such as what? where? when? how much? who?
- participation from beginning to end
- local ownership and empowerment
- sustainable development ,co-ordination and networking
- wide participation of women and disadvantaged groups
- bio-engineering methods
- NGO as partner
- multiplying through extension.

The participatory emphasis on integrated watershed management in Nepal has the following key characteristics:

- formation of local user groups consisting of beneficiaries
- involvement in the planning, programming, implementation and decision making of activities
- entrusting management of public land for forestry and conservation activities
- group fund generation and mobilisation
- formalising user groups as registered institutions
- sharing part of the cost of conservation activities
- continuing user groups activities much beyond the construction phase of watershed management programmes.

This participatory emphasis can be result-oriented in the hierarchical logical framework of the ecosystem approach to integrated watershed management in Nepal. This is fully in conformity with the paradigm shift in the Ninth Plan (1997–2002) in participatory watershed management. Now the long list of activities of soil conservation and watershed management can be integrated to reflect the following key participatory programmes:

- user group identification and sensitisation
- user group formation
- user group mobilisation
- user group empowerment.

Since these programmes follow one after other these can be viewed as milestones of result-oriented participatory process.

The Ninth Plan (1997–2002) has also laid emphasis on expanding the programme to 75 districts and to cover 175 sub-watersheds on a participatory framework. The plan also recognises the special nature of upstream-downstream linkages in watershed management. This has broadened the scope of applicability of the ecosystem framework in participatory watershed management.

A study on Nepal's experience in farmers organisation building (Achet, 1998) concluded that the most suitable approach to farmers organisation building in participatory integrated watershed management is to combine watershed planning, local resource mobilisation and farmers organisation building as a one step procedure. This can also be accommodated as an institutional indicator of the ecosystem approach at the purpose, programme and activity level.

9. A forward perspective

Ecosystem approach to watershed management must not be a qualitative concept but a quantitative systems approach. From this viewpoint, benchmarks and changes resulting from an intended watershed management intervention need to be quantifiable. In this respect, benchmarks of ecosystem integrity, indicators of system equilibrium, productivity and trends of management improvements are issues needing supplementary contribution. On the other hand, there is an ever increasing emphasis on managing resources from a sustainable perspective and systems approach (Achet, 1997). Composite but a few meaningful quantitative measures of sustainable watershed management are needed to embrace sustainability of watershed management programmes.

An important concern of ecosystem approach to participatory integrated watershed management is how to attain sustainability in practical terms. In practice, sustainability is a function of technical, economic, social and institutional factors (Parker *et al.*, 1988). Some of the important sustainability issues to be addressed in the framework in future would be:

- how to enhance positive socio-economic change through participatory integrated watershed management as a social transformation mechanism for mountain watersheds
- getting full support of the people it affects through their governments, institutions, and their private activities (Rees, 1989) and self-help initiatives
- managing watersheds within their environmental capacity and maintaining ecological integrity
- institutionalising an adaptive organisational set-up that reorients for self-correction.

Evidently, an effective management information system must be an integral component of watershed management based on ecosystem perspective. Some important issues to be integrated in the system framework are local resource mobilisation, poverty alleviation, gender issues and participation of disadvantaged groups.

A forward perspective in ecosystem approach to integrated watershed management is that of modern technology. Effective watershed management in an ecosystem approach requires modelling and use of analytical tools such as remote sensing, GIS, programming, visualisation techniques and expert systems. One should remain observant of the techniques that could be borrowed from other disciplines including those from social sciences. It is important that we be able to answer questions based on different scenarios pertinent to the system basis, problem focus and improvement orientation. We must be able to provide choices, assess risks, determine driving forces and impacts of events as well as management options if ecosystem approach to watershed management is to be effective.

Clearly, ecosystem approach to watershed management requires interdisciplinary efforts which enable us to incorporate the vision from government, non-government organisations and general public making the planning process transparent, open and publicly accountable. Also, multidisciplinary initiatives enable effective communication and develop trust. Furthermore, the planning process becomes enriched through collective wisdom and innovation. Multidisciplinary planning is also an instrument for understanding people and natural resource relationship for exploring a range of economically viable, ecologically sustainable, socially justifiable options. By adopting multidisciplinary planning approach, we can gradually build up our ability to network, co-ordinate and reap benefits of co-operation.

Mountain watersheds represent a physically and ecologically integrated system. They are appropriate management units for linking policies, strategies and plan implementation in a nested continuum of site, watershed, river basin, province and region. Participatory dimension of watershed management makes it more process-oriented than a target-oriented programme.

References

Achet, S. H. 1998. Farmers Organisation Building for Integrated Watershed Management in Nepal, P. N. Sharma (ed.). PWMTA/FAO, (GCP/RAS/161/ NET) Kathmandu, Nepal. (In Press).

Achet, S. H. 1997. An Integrated Approach to Modeling the Impact of Timber Harvest on Streamflow: A GIS-based Hydrologic Model, *Ph.D. Dissertation,* University of Washington, USA.

FEMAT. 1993. Forest Ecosystem Management and Analysis Team Report. Forest Ecosystem Management: an Ecological, Economic and Social Assessment, USDA Forest Service.

Parker, J. K., Achet, S. H., Calnan, R., Fleming, W. and Joshi, M. D. 1988. Final Evaluation Report: Resource Conservation and Utilisation Project, Project No: 367-0132, USAID, Nepal, Tropical Research and Development Inc., USA.

Rees, W. A. 1989. Planning for Sustainable Development. A Resource Book. UBC Center for Human Settlements. British Columbia, Canada.

Mathema, P., Dutta, I. C., Balla, M. K. and Adhikary, S. N. (eds.). 1999. *Sustainable Forest Management*. Proceedings of an International Seminar, 31 August – 2 September 1998, Pokhara, Nepal.

Integrated Development and Sustainable Management of Bhitarli Mini-watershed in Garhwal Himalayas

M. C. Kukreti, P. Joshie and R. M. Singhal

Abstract: This paper describes the work of IDRC Project on Himalayan Eco-rehabilitation in a micro-watershed of Nalota Nadi in the Garhwal Himalayas of India. The local environmental factors are briefly described. The impacts of mining and quarrying on socio-economic conditions of the local people are discussed. The measures taken to improve the socio-economic conditions of the local people like improvement of degraded lands through silvi-pastoral plantation, agroforestry, horticulture, supply of improved varieties of seeds, etc. are mentioned.

1. Introduction

The rapidly growing population, widespread deforestation and excessive biotic pressure have resulted in severe ecological degradation of the watersheds in the central and north-western Himalayas. The extractive mining and quarrying industries using open cast mining on strips have done the maximum damage to Himalayan eco-system. Rehabilitation of such degraded lands through integrated watershed management strategies and with suitable mix of structural measures and low cost vegetation technologies, utilising local skills, materials, manpower and indigenous practices have been considered most appropriate for rehabilitating these high lands. The International Development and Research Centre (IDRC) Project on Himalayan Eco-rehabilitation, which envisages improvement and conservation of these degraded Himalayan ecosystems through economically viable, socially acceptable and environmentally sound, micro interventions with people's participation. A mini-watershed of Nalota Nadi, in the Garhwal Himalayas was selected for its integrated development and sustainable management. The programme includes conservation of its resources through bio-remedial strategies with active participation of the village communities at conceiving, planning, designing and implementing stages. For this purpose, a registered society under Societies Registration Act 1860 was formed in the name of *Gramin Mahila Kalyan Evam Van Sanrakshan Samiti* (Rural Women Welfare and Forest Conservation Committee) to work in the area.

2. Study area

Location and climate: The project area is located at 37 km from Dehradun and 10 km from Mussoorie along 30^0 25' to 30^0 30' N latitude and 78^0 0' to 78^0 05' E longitude. The region experiences an average annual precipitation of 2,225 mm of which 80% occurs from June to September–October. The remaining 20% are recorded as winter rains. The average temperature peaks during June to about 29^0 C and dips lowest in December–January to an average of 7^0 C. The minimum temperature goes below 0^0 C with a few days of frost/snowfall in December–January.

Topography: Topography is hilly with steep to highly steep slopes from bottom valley lands to the ridges at the top. High erosion due to construction of roads, mining and quarrying, and haphazard tree cutting has changed the topography of the area with predominance of deep gullies, drains and furrows. As the land is devoid of woody vegetation, landslides and landslips are frequent.

Vegetation: The ecological status of the vegetation in the area is of edaphic sub-climax as the vegetation changes as per the development of soil. The area lies in between the two climax vegetation viz. oak (*Quercus leucotrichophora*) at the hills with temperate climate and sal (*Shorea robusta*) forest in the Doon valley below with sub-tropical climate. The area becomes degraded and can be referred to a back seral stage whether it comes from either oak climax or sal forests accompanied with erosion.

Soil: The soil constituents vary: gravel 22–59%; fine gravel 13–25%; coarse sand 12.8–21.7%; fine sand 5.2–27.8%; and silt and clay 3.2–9.04%. In general, the soils below the mined area are fragmented with little of fine soil, sandy loam and clay.

3. Impact of mining and quarrying

Vegetation: The normal dry mixed deciduous forest gets degraded where more than 80% area comes under *Euphorbia* scrub or grassland. Here *Lantana camara, Saccharum spontaneum, Cymbopogon nardus, Eriophorum cosmosum, Eupatorium odoratum* and *Xanthium strumarium* come up gregariously. Under secondary succession *Parthenium hysterophorus* is encroaching the area in some patches.

Regression or degradation: Degradation of vegetation has reduced the diversity of species. Puri (1949) contended that ash (*Fraxinus* sp.) is the principal coloniser both in calcareous and noncalcareous wastes, partly because of high base status, high increased pH (more than 7.3, even 8–8.5). Balme (1953) recognised plant association from open calcareous grassland to moor land.

Reduction in biodiversity: Species like *Pittosporium eriocarpum, Sagertia oppositifolia, Sophora mollis, Dalbergia sissoo, Brassaiopsis sculeata, Leptodermis lanceolata, Tylophora himalaica, Barlaria cristata, Sapium insignii, Musa sapientum, Olea glandulifera* and *Periploca calophylla* are now extinct. In addition to these, a lot of pteridophytic ferns, mosses and algae disappeared due to drying of water resources after mining and quarrying.

Impact on microclimate: This is seen where perennial water sources dry up with reduction in humidity for want of a perennial wood cover. High fluctuations in both minimum and maximum temperatures and rainfall have resulted in excessive run-off particularly the peak rate damaging the watershed causing widening cum deepening of gullies, landslides, landslips and formation of deep vertical cuts.

Impact on land and water: Topsoil erosion has resulted in land devoid of soil and vegetation or grasslands with shrubs/scrubs where *Lantana camara* has invaded. These degraded grasslands do not bear a regular perennial water spring. Even the waterflow in rains is short lived with high peak rate of run-off of short duration causing severe damages e.g. land slides, gully extension, torrential floods with stream bank erosion, etc. Water quality is negatively affected e.g. high pH with high calcium, magnesium and sulphur content and becomes unfit for drinking. The high pH affects the land down below particularly in the period of active mining.

Impact on wildlife: The number and diversity of wildlife before mining activities started were high. Now many species are endangered or extinct e.g. bear, tiger, panther, squirrels, owls, cuckoo, magpie, cocks, fowls ducks etc. On the other hand, many species well suited to the changed environment are increasing and are damaging agricultural and plantation crops.

Impact on transport: The nearest local market is at Mussoorie and the business centre for limestone is Dehradun. Communication is poor in the region and the villagers have to walk long distances to access public transport. The roads built for mineral extraction and trucks carrying dolomite/marble mineral were often the only means of transportation in the region. Now after abandonment of the mining operations the trucks are also rarely available.

The people: The survey revealed that the total population of villages was 406 of which 268 people lived in Bhitarli and 138 in Basagad. The average family size varied from 4 to 8 and the average number of children varied from 3 to 5 per family. The scheduled caste population was 12.93% and is concentrated in a few hamlets where mining was actively done indicating their dependence on wage labour.

Of the 197 households, there were 326 workers. The farmers and non-farmers were equal in ratio. The concentration of farmers is higher (58.54%) in villages with no mines against those with operational mines (55.49%). In the abandoned mine areas the situation is mid way (53.40%). In far off villages devoid of mining, intensive agriculture is being practised with irrigation. Hathipaon, Kyarkuli and Makarata villages depend upon rainfed farming. Water source in these villages was reduced and dried. Here 70.59% of workers depended on wage labour for their livelihood.

Livestock population: The survey of livestock population revealed that each family had three cattle in abandoned mine villages, five cattle in villages under active mining and four cattle in villages with no mines. This indicates their increased dependence of milk selling for livelihood in the absence of opportunities for intensive agriculture. Even the villagers who were originally cultivators abandoned and left their productive fields after getting a job in the mines. The villagers extensively supplement stall feeding with grazing which is more in abandoned mine areas reflecting poor availability of grazing. The dependence of grazing was more in villages with operational mines where only 8.24% depend on stall-feeding alone.

Agriculture production: The 142.98 ha of total land for agriculture production is disbursed on an average of 0.83 ha / head in 173 landholders. The irrigation source was scarce except in Chandroti village. The production rate recorded is shown in Table 1.

Table 1. The production rate of different crops

Crop	Abandoned mine area	Active mining areas	No mine areas
Paddy (kharif)	3.48 q/ha	5.34 q/ha	16.90 q/ha
Maize (kharif)	3.44 q/ha	3.07 q/ha	11.31 q/ha
Wheat (rabi)	5.17 q/ha	1.30 q/ha	5.80 q/ha

Hathipaon, Kyarkuli and Makarata were severely affected for want of irrigation due to drying of water sources. This is due to higher proportion of agricultural land in no mine areas adopting intensive farming which is in consonance with occupation and distribution.

4. Activities of IDRC project:

Reforestation: Reforestation in the mined area and the abandoned mined area is being done with the co-operation of people. A nursery was established to raise the seedlings of *Cupresses torulosa, Aesculus indica, Quercus glauca, Prunus cerasoides, Grevillea robusta, Robinia pseudoacacia, Cedrus deodara, Pinus* *roxburghii*, *Toona ciliata*, *Jacaranda mimosifolia* etc. The shrubs consisted of *Coriaria nepalensis*, *Rosa macrophylla*, *Debrigeasia hypoleuca*, *Salix tetrasperma* and *Salix wallichiana*. The nursery raised seedlings were transplanted during 1991–97 at 1.5 m x 1.5 m spacing and the interspaces were planted with local grasses like *Saccharum bengalensis*, *Apluda mutica*, *Chrysopogon fulvus*, *Eulaliopsis binata* and *Eriophorum cosmosum*. *Imperata cylinderica* succeeded on accumulated clay deposits.

The field performances of tree species for stabilisation of mine-spoil at Lambidhar were taken for study. Five tree species were transplanted on bench terraces in the summer rains of 1995 and winter rains in early January 1996. The average survival and growth parameter data for height and collar diameter are presented in Table 2.

Table 2. Survival and growth of planted tree species

Species	Year of planting	No. of seedlings planted	Survival %	Average growth (Nov. 1997)	
				Height (cm)	Collar dia. (cm)
Acacia catechu	July 1995	145	44.1	17.0 ±7.7	0.71 ±0.24
Desmodium elegans	July 1995	223	83.9	56.0 ±76.5	0.83 ±0.45
Robinia pseudoacacia	July 1995	455	19.1	38.1 ±14.2	0.40 0.25
Aesculus indica	Jan. 1996	105	94.3	31.7 ±10.1	0.93 ±0.33
A. indica	Jan. 1996	66	75.7	30.5	0.82 ±0.37
Alnus nepalensis	July 1996	213	43.6	63.6	1.79 ±0.78
Alnus nepalensis	July 1996	259	59.4	63.1 ±58.4	1.68 ±0.70

Fodder tree plantation on the community land of Bhitarli and Basagad village consisted of *Dalbergia sissoo*, *Bauhinia variegata* and *Dendrocalamus strictus*. Their field performance after 4 months of transplanting at the end of October 1997 is presented in Table 3.

Table 3. Number of tree species planted and their survival

Species	No. of seedlings transplanted in July 1997	No. of surviving plants	Survival %
Dalbergia sissoo	200	23	11.5
Bauhinia variegata	629	183	29.1
Dendrocalamus strictus	351	82	23.4

The poor performance in survival is attributed to: continued heavy rainfall with surface soil saturation, its subsequent fall with landslide exposing sub-soil layer, shallow soil and lack of weeding.

Fodder plantations on terraced land*:* Three villages namely Basagad, Bhitarli and Kandriyana were selected for transplanting of fodder trees in the summer rains. The plantation programme was first initiated in July, 1996 at Basagad where 400 nursery seedlings were transplanted in the agricultural bench terraces/terrace risers of 13 farmers. The species consisted of *Grewia optiva*, *Celtis australis* and *Dendrocalamus strictus*. During 1997 Bhitarli and Basagad were selected for planting tree seedlings.

Agriculture: The area being mountainous, has bench terraces for cultivation. The terrace width is 3–6 m on the upper slopes. The terrace width gradually increases with the decrease in slope percent. Dryland farming depends on rainfall. In winter agriculture is rare except under irrigation. On the lower slopes with wide terraces and good soil moisture, farmers grow paddy under irrigated condition, maize, beans and cowpea. Under rainfed conditions, the upland paddy is raised with pulses. Vegetable cultivation is restricted around the homesteads where chillies, brinjal, onion, garlic, radish, potato, turmeric and ginger are grown. In summer rains cucurbit climbers like gourds, bottle gourds, bitter gourds are raised around the houses. To encourage good agricultural practices using improved seeds, some seeds were distributed to the farmers of Basagad and Bhitarli villages.

Horticulture development: Fruit saplings of mango, guava, lemon, litchi, jackfruit, persimmon etc. were distributed to 44 families in the four villages of Bhitarli mini-watershed. Altogether, 783 horticultural plants were transplanted in 1997 rains in the four villages of Basagad (89), Choti Bhitarli (41), Bari Bhitarli (538) and Kandriyana (115). The visit at three locations in October/November 1997 in village Bhitarli showed a survival of 75% for lemon followed by litchi (44.2%) and mango (40.0%).

Other extension activities: Under torrent training and flood control *Salix tetrasperma* was successfully planted on a large scale. In Lambidhar, *Salix babylonica* suited well. In landslide areas with exposure of the subsoil, *Saccharum bengalensis* was planted at wide spacing. Some *Agave cantala* have also been planted but showed limited growth.

Planned activities:

The following activities are planned for the coming days:

- About 30 ha wasteland of village *panchayat* will be put to silvi-pastoral plantation.
- Establishment of a local nursery for raising multipurpose tree species or local trees in Bhitarli.
- Providing Jersey cows to the local villagers at subsidised rate for dairy development.
- Fisheries development.
- Planting of *Morus alba* for sericulture development and basket making from its branches.
- Mushroom cultivation.
- Construction of a toe wall for debris retention beside reforestation in surface slides and gullies.
- Adult education for women.
- Sewing and stitching training programme.
- Training in furniture making.

References

Blame, C. E. 1953. Edaphic and Vegetational Zoning in the Carboniferous Limestone of the Derbyshire Dales. *J. Ecol.* 41: 331–334.

Puri, G. S. 1949. The Vegetation of Some Discussed Quarries at Ingleton, Yorkshire, England. *Ind. Bot. Soc.* 28: 212–220.

Mathema, P., Dutta, I. C., Balla, M. K. and Adhikary, S. N. (eds.). 1999. *Sustainable Forest Management.* Proceedings of an International Seminar, 31 August – 2 September 1998, Pokhara, Nepal.

Millions of Raindrops: Water Conservation in Rajasthan

A. Mishra

Abstract: Citing examples of traditional conservation techniques in Jaisalmer district of Rajasthan, India, the paper asserts that the local people are capable of solving their own problems. The development agencies should work towards reinstating the local people's self-respect and sense of identity that they have lost.

No society can exist on its own without regard for the environment. It has to create systems that help in adapting to the availability of resources, such as water, forest and land. In doing this, a society has to rise above technological systems and mould socio-cultural mechanisms that also find a place in its religion. Only after this can the system become strong enough to sustain the innumerable members of the society, thousands of villages and townships. Only then the society can tackle the problems of conservation of its land, water and forests. The society cannot restrict these life-supporting systems and techniques in the hands of "technicians" and "foresters". These techniques—so essential for the prosperity of the society—were handed over to the common people. The society incorporated these techniques into the cultural lives of the people characterised by the joys and the rhythms of the everyday life – where technique becomes culture.

And when this is done, the systems become edifices that go beyond space and time—self-sustaining and the lifeblood of social institutions. These dynamic institutions do not have—and do not need—any headquarters, annual budgets or projects. They are absorbed in the collective memory of the society. When a society organises itself for work of such magnitude, its planning is not restricted like that of a five-year plan or a decade-long programme that most of our governments and NGOs follow. Over such long periods of time, the technologies are not bound by textbooks. They assimilate in the lives of each and every member of the society, cutting through the barriers of caste, class and gender. Every member contributes to these socio-cultural mechanisms according to his/her capacity.

There is a lot of difference between culture and technology. All government organisations and NGOs in every one of their projects involving watershed development rely on elaborate surveys, A-frames, dumpy levels and other techniques with names that are difficult to remember. On one side of this "technological divide" are donor agencies, on the other are beneficiaries, at the very best, if not the labourers, cornered in their own land by an alien language of the "missionaries of parity". I believe that such "green" technological development projects, even when carried out with the best of intentions and honesty, leave a barren gap between the agencies and the beneficiaries. Even if the project is successful, it breaks the society's spirit of independence and self-confidence.

All governments, institutions and agencies are facing budget cutbacks these days. The subsidies on which such projects depend are too much, even for large organisations like the World Bank. Then where will the initiative to undertake work for such importance come from? It will only come about by restoring the confidence in our own social institutions; by recognising their strengths and the depth of their rich experience. Instead of looking down upon large sections of the society as illiterate, poor and weak, we need to reinstate their self-respect and their sense of identity that they have lost. These submissions can be made clearer through the example of arid and semi-arid regions of Rajasthan in India's Thar Desert.

The geography of Rajasthan is challenging, to put it lightly. Firstly, it has been understood as the land where the sun hardly ever seems to go down. Geography books describe the region as hot and arid. Temperatures touch 50^0 C in summers; water appears to be a rare commodity. Adding to this gloomy picture is the general remark that groundwater is also scarce, being usually available at depths of more than 300–400 ft. That too is largely saline.

Rajasthan is indeed a blessed land, for its people have nurtured and sustained rich and varied institutions and traditions of rain-water harvesting and water management to meet all their needs. So much so that the divine boon became synonymous with the resourcefulness, ability and skill of the people which did not allow even a drop of water to go waste !

Today there are 515 villages in the Jaisalmer district, out of which 462 are populated and 53 lie deserted. Except for one, all the other 514 villages have evidences of water availability. According to a State report, 99.78% of Jaisalmer's villages had their own water resources like wells, *baories, tankas, kundas, talabs,* and *kuinyas.* In contrast to this basic requirement and its fulfilment are other contemporary indicators of social and economic growth whose figures are far from satisfactory. The same government report says that out of 515 villages, only 19% are connected by modern roads; post and telegraph services cover just 30% while medical services run low at only 9% and electricity even lower at 4.5%.

Yet 99.78% of the villages had adequate water resources, all of which had been designed, financed and maintained by the society—neither by the government nor by NGOs. The society in this arid zone also designed very comprehensive forest conservation institutions. These are called *orans*. This name is derived from the Sanskrit word *aranya*, which means a forest. It is interesting to note that the *oran* institution was the strongest in areas where it was needed the most—in the arid zone. These sacred forests are attached to the village temple and are managed by the priests, not the foresters. Barbed-wire fencing, walls or ditches do not protect them. Sometimes spread over hundreds of hectares, these forests are protected by social fencing—by the villagers, devotees of the temple who follow strict rules of conservation. These were treated as reserve forests, no one was allowed to take out even twigs and leaves during the normal period. Only at the time of severe drought, the priest would perform a special *pooja* (prayer and worship) and would declare the forest open for the people who would take shelter with their cattle. It is interesting to note that even today we find that good track of *oran* where the state forest cannot show a single blade of grass.

All these institutions have been the lifeline and prosperity of the desert. They have withstood the test of time and change to become symbolic of the philosophy that not only links the past to the present but also harbours the potential to make the future like the past.

Mathema, P., Dutta, I. C., Balla, M. K. and Adhikary, S. N. (eds.). 1999. *Sustainable Forest Management.* Proceedings of an International Seminar, 31 August – 2 September 1998, Pokhara, Nepal.

Role of Bamboo Plantation in Environmental Conservation

S. M. Mishra

Abstract: Bamboo is a multipurpose plant that establishes and grows very fast. This paper presents the findings of the research carried out in 1995 in Kaski, Nepal. Bamboo plantation was the old practice of this area but it was done on small scale before 1980. The local people started planting bamboos in 1980 on large scale. It was found that offset planting of bamboos were done on the boundary of the homesteads, on the bunds of agricultural fields, in steep areas, in gullies and on the banks of streams to control erosion and improve environmental quality.

1. Introduction

Bamboo belongs to the grass family Poaceae (Gramineae) and is a multipurpose plant that establishes and grows very fast. It provides abundant quantity of materials for various purposes. Its foliage provides palatable source of animal fodder. The role of bamboo in soil conservation has been widely recognised. Its versatility has led to the coinage of such terms as "bamboo culture", "green gold", "poor man's timber", "friend of the people" and "cradle to coffin timber". (Singh *et al.*, 1990).

2. Study Area

The study area was Rakhi Village Development Committee (VDC) of Kaski district, located in the Mid-hills of Nepal. This VDC is located at a distance of 6 km to the east of Pokhara city. The area is located at 84^0 4' longitude and 28^0 13' latitude and between the elevations of 850 m to 1100 m. The climate of the area is sub-tropical: the average annual temperature ranges between 13.2 to 25.5^0 C and the average annual rainfall is 3,710 mm.

The total population of this VDC is 4,705 and there are about 1,030 households. The average household size is 4.57. *Brahmin, Chhetri, Kami, Damai* and *Sarki* are the main ethnic groups. Forestland and the majority of the settlements are on upper slopes and only few houses were seen in lowland.

Bamboo plantation was the old practice of this VDC, but was done on small scale before 1980. Due to heavy population and grazing pressure, the forest areas were extremely degraded in the 1970s. Fuelwood, fodder and timber were scarce commodities. Landslides, heavy soil erosion and gullies were quite common. As a result, people had to face many environmental problems like house destruction, heavy runoff and sedimentation in low land (agricultural land). Therefore to fulfil the basic needs of fuelwood, fodder, timber and to control landslides and soil erosion, people started planting bamboos and other tree species from 1980 onwards.

3. Methodology

A reconnaissance survey of the study area was first carried out to collect some general information. Random household survey was done to collect socio-economic data. Questionnaire survey, group discussion, individual interviews were done to get the information on ethnicity, land holding, agricultural land, planting technique, number of bamboo clumps planted, and purpose for bamboo plantations. Key informant survey was also carried out for cross checking the data. Random forest sampling was done to obtain the density of naturally regenerated forest crops of age 8 to 10 years by using quadrates of size 20' x 20'. Similarly, crop density of naturally regenerated trees of 8 to 10 years old in private lands was also obtained through quadrates of the same size. Fifty quadrates were taken for this purpose. Rhizome system was observed by making ditches of 2' length, 2' width and 2' depth around the bamboo clumps. Roots of bamboos were collected from 1' x 1' x 2' ditches at 5' distance from bamboo clumps and weighed..

4. Results and discussion

The average number of clumps was found to be 8 clumps/household. Offset planting of bamboos was done by collecting the propagules from old clumps. It was observed during the field visit that plantations of bamboos had been done on the boundary of homesteads at lower slopes, steep areas near settlements, at the banks of the streams and in the gullies formed before 1980. Some bamboo clumps were also found on the bunds of agricultural fields. The survival percentage of offset planting reported by the people was 95% whereas the survival percentage of bamboo plantation from seedlings was reported to be only 25%.

Maximum number of bamboo clumps was found in the lands of upper caste group. Fifty two percent households of this group had bamboo clumps in the range of 5–8 clumps. Twenty four percent households of middle caste group had planted bamboo clumps in the range of 5–8 clumps. Out of 50 random samples, only one household of lower caste group had bamboo clumps in the range of 8–10.

It was observed that 60% farmers had agricultural land in the range of 15–20 *ropanis* (1 *ropani* = 0.052 ha). Eighty percent of households planted 5–8 bamboo clumps. Fifty-four percent of households having 15–20 *ropanis* agricultural land had planted 5–8 bamboo clumps. It may be concluded that there was no linear relationship between size of agricultural land and bamboo plantations. Three households had land holding below 10 *ropanis*. Fifteen samples were within the range of 10–15 *ropanis*. Twenty households had 15–20 *ropanis* and 24% samples had more than 20 *ropanis*.

Correlation between total land, agricultural land and bamboo plantation (no of clumps) have been worked out to study the relationship among the three variables. The correlation coefficient between total land and agricultural land is 0.8659 which is highly significant at 1 % level of significance. It indicates that villagers with more land put more area under agriculture operation. The relationship between total land and bamboo plantation has been worked out as 0.8208 which is also significant. It shows that farmers who owned large area of land plant a higher number of bamboo clumps.

Tama bans (*Dendrocalamus hamiltonii*), dhanu bans (*Bambusa balcooa*) and sate bans (*Bambusa* sp.) were found in the study area. Sympodial rhizomes of these bamboo species were observed but rhizomes system of sate bamboo was more intricate than the other two species. The roots of ten-year-old bamboo clumps of tama, dhanu and sate bamboos at 5' distance from the clump in (1' x 1' x 2') ditch size were collected and were found to be120 g, 160 g and 190 g per ditch respectively. The rooting system of sate bamboo was found to be very intricate. The fine roots of sate bamboo were observed up to 50' distance from the bamboo clumps. The rooting system of bamboos can bind the soil up to a considerable distance thus preventing soil erosion. It indicates that bamboos are very useful for soil conservation and environmental protection due to their intricate rhizome and root system.

Bamboo culms were used for fuelwood, its foliage for fodder and mature culms in fencing and house construction. Culms of tama bamboo are used in cottage industry, and young shoots as vegetable. Due to multiple uses of bamboos by local people, the pressure on natural forest was reported to be reduced. Therefore, natural regeneration of chilaune (*Schima wallichii*) and katus (*Castanopsis* sp.) has occurred in the forest area. Natural regeneration of chilaune was also noticed on private land of local people. Natural regeneration of sal (*Shorea robusta*) was also reported by some.

Majority of the people reported that bamboos were planted to fulfil the basic requirements of fuelwood, fodder and timber; to control soil erosion and landslides; to minimise the soil deposition in low lands (agricultural land); and to control gully formation near settlements. The clumps were found to be playing the roles of windbreak and shelterbelt. It was also noticed that the bamboo clumps had become suitable habitat for birds like doves, woodpeckers and common mynas.

Several naturally regenerated clumps of small bamboos (*Arundinaria* sp.) were observed during the field visit in the area concerned. Along with the tree crops some species of grasses like imperata, saccharum had also come up at several places, which were used as livestock feed. It was reported that grasses were also helpful for erosion and runoff control.

It was also reported by the local people that agricultural productivity was increased by one *muri/ropani* (1 *muri* =70 kg approx.) for both paddy and wheat. This perhaps is due to the improvement in soil nutrient status.

Due to dense branching pattern and larger crown diameter of bamboo clumps, the effect of rainfall on the ground below the clumps was found to be low. It was reported by the local people that soil erosion, landslides, gully formation, heavy runoff, and floods have been controlled for the last five years compared to the period before 1980. It was reported that low land holding and getting propagules were the main constraints for bamboo multiplication.

5. Conclusion

Offset planting of bamboos was found to be very successful in the study area. The intricate rooting system of bamboos were found to be quite useful for soil conservation. Bamboo plantation was helping to conserve the natural environment of the study area.

Reference

Singh, B. G. *et al.* 1990. Some Interesting Facts about Two Most Popular Bamboo Species of India. In: Proc. of National Seminar on Bamboo, 19–20 December 1990.

Mathema, P., Dutta, I. C., Balla, M. K. and Adhikary, S. N. (eds.). 1999. *Sustainable Forest Management.* Proceedings of an International Seminar, 31 August – 2 September 1998, Pokhara, Nepal.

An Emerging Model for Participatory Watershed Management Based on Experience in the Bhusunde Khola Watershed, Nepal

F. M. J. Ohler

Abstract: Experiences of the Nepal component of the Inter-Regional Project for Participatory Upland Conservation and Development are presented. In addition to discussing various aspects of community-based organisations, the conservation and development activities undertaken by them in collaboration with the project, other line-agencies, NGOs and local administrative bodies are briefly reviewed. Based on the experience, an emerging model for participatory watershed management is presented. The concept of participatory watershed management is described as a process involving a large proportion of the watershed population in appraisal, planning, funding, implementation, monitoring and evaluation of conservation and development activities. Fourteen field level steps in participatory watershed management, the sequence of events and their time frame are described.

1. Inter-Regional Project for Participatory Upland Conservation and Development

The Italian funded and FAO executed "Inter-Regional Project for Participatory Upland Conservation and Development", GCP/INT/542/ITA (or PUCD project) includes five country components: Bolivia, Burundi, Tunisia, Nepal and Pakistan. The project's development objective is the improved management of upland watersheds through an effective participation of local communities in a continuing process of planning and implementation, ensuring that the long-term social, economic systems requirements of rural communities concerned are fully taken into account and balanced with downstream interests. The interaction and exchange of information between the different country components has enriched the methods and process employed in all the participating countries. In Nepal, the Department of Soil Conservation and Watershed Management of the Ministry of Forests and Soil Conservation was designated as the national counterpart agency responsible for project implementation. The Bhusunde Khola watershed in Gorkha District was selected as project area, and field activities started in the second half of 1992.

2. Bhusunde Khola watershed

The Bhusunde Khola watershed, with a total area of 32 km^2, is located within the Middle Hills of Gorkha District. It covers the main part of four Village Development Committees (VDCs) and has a population of approximately 12,000. Altitude ranges from 500–1500 m, and topography is steep: approximately 70% of the area have slopes in excess of 30%. Annual total rainfall is about 1,900 mm. Some two-thirds of the watershed is under cultivation, with irrigated paddy in the valley and level terraces of the lower slopes, and dryland crops on the sloping terraces in the upper parts of the watershed. The average family landholding is just under 1 ha, with under 0.2 ha per person. Although subsistence farming is the norm, only about 20% of the households produce enough food for their own consumption. This is to a certain extent compensated through seasonal out-migration of men. There are no roads in the area and all transport is done on foot. Households are clustered in small settlements with upland fields, forests, gullies and grazing lands in between. There are many ethnic groups in the area. Numerically dominant are high caste Hindu groups (*Brahmin, Chhetri*), other ethnic groups include *Newar, Gurung, Kumal, Baram, Kami, Damai* and *Sarki*.

3. Community organisation

3.1. User groups

In Nepal, user groups are the accepted community-based organisations through which field activities are implemented. The term user group has legal implications and covers a wider array of community organisations than the term suggests, including women groups and forest user groups (FUGs). The project works only with active user groups defined by: regular meetings and record keeping; regular self-managed group savings and related credit schemes; and self-initiated activities.

Groups that do not match these criteria, but want to participate in the programme, are targeted for specific capacity building training. There are now about 100 user groups in the watershed, or about one user group per 120 inhabitants. At least one-quarter of the concerned population is member of a user group and about one-third of the women in the project area are members of an active user group. When we consider that individual members usually represent a whole household, it would seem that as many as two-thirds of the households are represented in one of the active user groups. This is a very large proportion, considering that these user groups are voluntary non-governmental grass-roots organisations. User group numbers and membership, especially of women groups, continue to increase, and in some communities virtually all households are represented in active user groups.

3.2. User group impact

Clearly the user group organisation can be quite effective and has huge appeal. User groups have in particular been able to address issues that individuals or individual households cannot tackle. This first became evident in Nepal with the creation, legal endorsement, and subsequent proliferation of FUGs. However, other user groups in the Bhusunde Khola watershed have had some major impacts:

- numerous small scale works of public nature were implemented, usually with the co-operation of the project or other organisations and institutions;
- a much increased capacity of the population at large to organise effective local organisations;
- increased self-esteem, self-reliance and social status of women as user group members;
- a self-generated and ever increasing source of assets and funds that can be used for development purposes;
- women, who usually do not own land, have gained access to communal lands through their female dominated user groups. This usually concerns the production of vegetables, but is now spreading into control of forests also (through female dominated FUGs).

3.3. User groups and money

The user groups of the Bhusunde Khola watershed are accumulating funds and assets in an impressive manner. By pooling their individual resources in user group funds, to which the individuals still have access, the scarcity of money is in effect being reduced. In this manner most households are now saving money. Though the total amount of money held by the user groups is still very moderate (US$ 10–15 thousand) from the local (rural) point of view, this is quite substantial. After all, one should not forget that these are subsistence farmers, cash starved and with little money. However, what is important is that the money saved is actually being used in the following ways:

- user groups are lending money to their members at reduced rates as compared to private money lenders;
- some user groups in effect create jobs when they employ teachers or forest watchers, (partly) paid from user group funds, or when they spend money to maintain water taps, trails, and the like;
- all user groups are trying to identify income generating opportunities, both for groups and individuals;
- older user groups, with substantial funds, often invest their money in communal structures, such as community houses, schools and temples.

Money is power, and it seems no coincidence that so many women, through their female dominated user groups, are empowering themselves by gradually accumulating substantial funds to which they have access, and over which they have decision-making authority. User group funds are changing the socio-economic landscape of the watershed.

3.4. Female dominated user groups

Many more women are active in user groups than men are and there are many more active female-dominated user groups than male-dominated user groups. The question is why. Some of the reasons for the more active role the women are playing in the user groups in the Bhusunde Khola watershed could be:

- women have more to gain, socially, legally and economically from the formation of user groups than men;
- women are better skilled in managing internal conflicts within their user groups, ensuring continuation, where male-dominated groups might become inactive (e.g. leadership conflicts);
- women are generally more honest and prudent in handling money and goods that belong to the user group;
- men are often seasonally absent;
- women are often left behind to take care of family and farm, and seek insurance and mutual support through group membership; and
- the particular attention the project has been paying since 1995 to the capacity building of female-dominated user groups (specific training and Female Group Promoters).

3.5. Forest User Groups (FUGs)

Under the 1993 Forest Act and the 1995 Forest Rules, provision is made for the handing over of State forests to local communities, organised into FUGs. Particular procedures need to be followed, including identification of actual forest users, drawing up of a FUG constitution, demarcation of the forest, preparation of an operational plan, and, finally registration with the District Forest Office. These procedures can take anywhere from 6 months to several years to complete, depending for instance on the existence of ownership and user rights conflicts. There are dozens of small (less than 5 ha) and a few sizeable (more than 50 ha) forest patches in the Bhusunde Khola watershed. Some have longstanding FUGs deciding on issues such as protection, controlled grazing and harvesting. However less than ten of these groups have gone through the full procedure and become registered with fully handed over forest.

4. Participatory appraisal, planning, monitoring and evaluation

The participatory development approach advocated by the project needed to be adjusted to the actual field situation in Nepal and put to practice. This has been a process of trial and error, resulting in a gradual evolution and improvement of actual participatory methods employed. Many problems were encountered, including:

- the question of scale, or what should be the smallest territorial unit for participatory planning;
- the discrepancy between villagers' initial expectations (immediate benefits) and the need to reinforce local community organisations (user groups capacity building) before sustainable results can be achieved;
- the wide range of problems confronting villagers as compared to the actual mandate of the project (e.g. improved natural resources management versus the need for education and health services) and its very modest financial means;
- how to involve disadvantaged groups in the decision making process (notably women and certain ethnic groups).

Participatory planning in 1992 was almost random, but it became more tructured, involving Participatory Rural Appraisal (PRA) and ward-level plans in 1993. It was subsequently scaled down to settlements or communities in 1995, and further down to "real" user groups in 1996. Community Action Plans (CAPs) have become more and more realistic in each planning cycle, starting from pure wish-lists, to actual achievable user group-based CAPs. The scope of activities included in participatory plans increased from pure physical works, traditionally within the mandate of the Department of Soil Conservation and Watershed Management to include more farming systems-oriented activities, income generating activities, social services and cultural activities.

PRA is used as a capacity building tool to improve the understanding of the local communities of their own situation, living conditions and environment, their local resources, land use, farming systems, constraints and opportunities. This is done in order to set the stage for a participatory planning of conservation and development activities that would fit into an integrated and participatory watershed management framework. Such a PRA is followed by a Participatory Planning exercise to prepare a detailed plan for conservation and development activities, as well as training, to be implemented by the local population (user group), usually with the support of the project, other line-agencies, NGOs, and local administrative bodies (VDCs).

CAPs and user group action plans indicate in the form of a table what the planned activities are, where they should be done and when, the number of beneficiary households, what the project should do, what other institutions should do, and what the community should do. These were further subjected to participatory feasibility analysis focussing on social, technical and environmental aspects, while economic aspects were considered less relevant by both staff and villagers. Communities constantly monitor and evaluate whatever is going on in their surroundings, though in an informal way. However, there are at least five different types of more formal monitoring by user groups:

- the time that each user group member spends in the completion of a particular activity;
- the quantity of local material provided by the user groups in the implementation of physical activities;
- the self-generated and self-operated saving and credit schemes;
- the income generated—at the user group level—by vegetable production by women groups;
- the mating frequency of improved breeding bucks.

Community level evaluation is done through Participatory Evaluation and Re-Planning (PERP) workshops. In each workshop participating user groups typically consist of a ward level user group, one or more women groups, a FUG and a disadvantaged minority group. The latest round of participatory evaluation and re- planning exercises, between November 1997 and January 1998, involved 40 user groups, and had some 800 active participants (over 600 were women farmers). Participatory evaluation tools include: impact assessment, identification and mapping of changes in the community, assessment of works done, observation walks, and strength, weakness and opportunity analysis. This community level evaluation focuses on implemented activities. As far as non-accomplished activities are concerned, if they are still considered relevant, the PERP workshops are used to re-schedule their implementation in the following year.

5. Effectiveness of participatory methods

The activities selected by user groups in their CAPs are in general very consistent with the results of the PRA exercises. Almost all activities selected are based on problem ranking exercises. The fact that many selected activities have to be funded by the user groups, or would need assistance from institutions other than the project, is proof that these CAPs are truly the communities' own plans. There is, however, a discrepancy between the problems apparent from PRA data, such as poverty and food insufficiency, and problems ranked during the planning part of the process. It is, for instance, remarkable that none of the CAPs to date included plans on basic food crop production interventions, except for irrigation facilities. This is probably due to two reasons:

- the perception that irrigation is a solution upon which all other crop production improvements would depend;
- the PRA-based planning methods used focus at communities rather than at individual households, resulting primarily in activities that will benefit the community.

Clearly, there is scope for further improvement. Participatory methods that focus on the improvement of the production of specific crops need to be adopted and modified for upland crop production. Such methods have been developed and are very effective in Integrated Pest Management (IPM) for irrigated paddy production in Southeast Asia, the so-called Farmers Field Schools.

6. Conservation and development activities

Poor peasant communities are clearly willing to contribute a large share of the costs of development activities targeted at improving their own living conditions, especially when they are fully involved in the planning and implementation process. Some important activities, however, demand more unskilled labour inputs than the direct beneficiaries can provide. This is the case for instance with gully control and trail improvement works, but sometimes also in small-scale hill irrigation works, especially where the number of beneficiary farmers is relatively small.

Basically, only field activities identified and requested by local communities through participatory planning methods are supported by the project. Clear modalities for cost-sharing and participatory implementation of field activities are a key factor in the negotiation process. It is important to note that the project has always operated on a very low budget, despite which many field activities could be supported, thanks to the major contribution from local communities in these activities, and to the involvement of other line-agencies, NGOs and local administrative bodies. These activities include: (a) Conservation activities: gully control and landslide treatment including gabion boxes filled with stones accompanied by biological conservation measures, private and community nurseries, conservation plantations (the planting of trees and grasses in degraded land), distribution of trees for private plantations, and handing over of natural forest patches as community forests to FUGs and (b) small-scale infrastructures: water source protection, which includes capturing of a source and construction of a water holding tank and installation of one or more (drinking) water taps per source, which is by far the most popular activity, trail improvement, which also prevents gully formation, and improvement of small-scale hill irrigation channels. People's contribution in kind and labour is usually around 50% of the total cost of these activities.

Farming systems improvement included specific training courses; the provision of fruit trees, paid for by farmers, but transported by the project; provision of fodder trees, grasses and leguminous cover crops, paid for by farmers; provision of improved breeding bucks to women groups, who paid for them; and demonstration of apiculture through distribution of improved bee hives.

Income generating activities included: provision of small-scale rice and oil mills to active women user groups (who contributed up to 40% of the total cost), mills are also important time saving innovations; a dairy collection centre, which was not successful; vegetable farming, especially popular with women groups; medicinal herb farming; and most widespread of all, self-generated and self-managed saving and credit schemes.

Social services, included: assistance in the construction of community houses (with some project subsidy) and temples (without project subsidy). Assistance in the provision of improved cooking stoves and latrines, schools and health posts was requested by some villages, but appeared difficult within the scope and/or time-frame of the project.

7. Training and capacity building

User group capacity building training was crucial for the formation of viable user groups. This included: adult literacy classes for women of disadvantaged ethnic groups, women group leadership and management, user group self-reliance, forest user group formation and management, disadvantaged groups capacity building, account and record keeping, group enterprise and income generation, and inter-group linkages and experience sharing. Apart from these, actual on-site capacity building events took place regularly during interaction between project staff and user groups, such as during the PRA/planning and evaluation exercises. The fact that the number of female dominated user groups continues to increase, and the dynamism of the group formation process in general, call for a regular (annual) staging of three kinds of training: (i) user group leadership and self-reliance, (ii) user group constitution formulation, and (iii) accounting and record keeping. Technical skills training can also be very useful, but great care should be taken to provide training on realistic subjects only. Many technical training events were organised, including: nursery techniques, irrigation techniques, bee keeping, smokeless stove demonstrations, horticulture demonstrations, mushroom production, livestock development, compost making, vegetable production, medicinal herb production, and blacksmith training.

Staff training was also felt to be essential. Every step in the participatory development process had specific training needs, which all had to be developed by the project. Training in participatory methods was the most important and included subjects like participatory rural appraisal, community-based participatory monitoring, evaluation and re-planning, and participatory feasibility analysis. Project self-evaluation workshops provided a mechanism for staff to directly influence project policy.

Extension and training material produced by the project includes video films, brochures, guidelines for PRA in watershed management in Nepali and English, and the "Group Promoters Handbook" as well as the "Group Enterprise Resource Book", which were translated from English into Nepali.

8. Emerging model for participatory watershed management

8.1. The concept of participatory watershed management

Participatory watershed management is a process involving a large proportion of the watershed population in appraisal, planning, funding, implementation, monitoring and evaluation of conservation and development activities, and does not resemble more traditional top-down watershed management practices. The combination of all Community Action Plans, prepared by scores of user groups representing a majority of the population of a watershed, is the closest thing the project has developed to a participatory watershed management plan. Such a participatory watershed management programme can only be accomplished through capable and active Community Based Organisations (in the case of Nepal, user groups). Capacity building of user groups, including women groups and disadvantaged ethnic/caste groups, requires a set of continuing relevant training and support activities as an integral component of the participatory watershed management programme.

8.2. Field level steps and sequence of events in participatory watershed management

This description does not deal with the selection procedures of priority watersheds, but with field level steps and the sequence of events in selected watersheds. The references made to the time period required refer to the duration of the process in a given working area, not to staff input requirements. The steps include:

(i) Inventory of existing and potential user groups, as well as other actors, such as NGOs and line agencies in the watershed.

(ii) Start-up workshops with the existing and potential user groups, as well as other actors, in which objectives, working methods and co-operation criteria are presented and discussed, and in which the user groups, NGOs and line agencies present their objectives and programmes. This is also an important first step in the co-ordination of various development efforts made by different actors and stakeholders. The eligibility criteria for co-operation with user groups are to ensure that only genuine and active groups will take part in the process.

(iii) Assessment of user groups and start of the user group capacity building process, according to specific needs. Support consists of regular interaction through a Group Promoter, who attends user group meetings, and an Area Facilitator, as well as specific training, such as adult literacy classes, which are often needed for women groups, group formation, leadership, self-reliance, record and account keeping. This process is further monitored and adjusted through monthly interaction meetings between project staff and representatives of all user groups. Steps (i) to (iii) require a period of 6 to 12 months (depending on literacy skills), by the end of which a dense network of active and increasingly capable and active user groups with their own funds and resources, and with a membership covering the majority of households, will be in place.

(iv) PRA at the user group level as a capacity building exercise. As a result, user groups will have an improved understanding of their own environment and living conditions, local resources, constraints and opportunities.

(v) Participatory planning and preparation of Community or User Group Action Plans. The combined plans result in a wide range of training and physical activities.

(vi) Participatory Feasibility Analyses using technical, social, environmental and economic criteria.

(vii) Village and District-level Co-ordination workshops, in which line-agencies, NGOs and representatives of elected local administrative bodies participate, and in which the Community Action Plans are presented and compared with plans and targets of these, and in which support is solicited for the implementation of the plans.

Steps (iv) to (vii) require a period of about four months, and result in a realistic set of activities to be implemented in a collaborative effort by user groups supported by the project, line agencies, NGOs, and local Government.

(viii) Detailed design of activities with an engineering component and drawing up of an agreement with user groups for their implementation.

(ix) Participatory implementation of activities agreed in step (viii).

(x) Conducting requested technical and administrative capacity building training, including continued support from group promoters.

(xi) Collection of demand and funds from user groups for the purchase of good quality fruit tree saplings and improved seeds, as well as genetically improved domestic animals, and logistic support in the purchase and transport of these.

(xii) Handing over procedures of suitable patches of state forests as community forests to FUGs.

(xiii) Continued monthly interaction meetings between project staff and user group representatives, which serve as a participatory monitoring mechanism for activities implementation.

Steps (viii) to (xiii) take about 12 months, by the end of which progressively significant improvements in living conditions can be found (e.g. better drinking water supply and credit availability from group savings). The user groups will also have become more experienced, more confident and with a stronger organisational capacity. Some activities, such as gully control and forest hand over, may take more than 12 months to complete.

(xiv) Participatory Evaluation and Re-Planning workshops, in which user groups evaluate their own performance, and the activities they implemented, or had planned to implement. A new Community or User Group Action Plan is then drawn up, re-phasing outstanding activities, and including new physical and training activities.

Step (xiv) takes about two months, and is followed by step (vi) and subsequently steps (vii-xiv). This cycle of events can continue for any number of years. The minimum requirement for sustainability of the participatory process is probably three full planning, implementation and evaluation cycles. Four to five years after the start of the programme (step i), and after going through three full planning, implementation and evaluation cycles, and continued capacity building support, the user groups can be considered sustainable, self-reliant, and capable of independently and successfully soliciting support from line-agencies, NGOs and Local Government. Living conditions, resource base and natural resource management will have improved, and could further improve without project support. Participatory watershed management requires multi-disciplinary support teams, with competence in social (e.g. group formation, PRA techniques), technical (e.g. agriculture, forestry, engineering), administrative (e.g. account and record keeping) and training (e.g. capacity building) matters. These different capacities cannot be found in any single line-agency or NGO. Co-operation, and where possible co-ordination among different institutions, is necessary.

Participatory watershed management cannot be captured in fixed target-oriented programmes. High level of flexibility is required to adapt to the actual field situation in every particular watershed, and most important of all, to leave sufficient room for grass-roots generated Community Action Plans. Flexibility of programmes and budgets needs to be coupled with transparency and accountability of the allocated resources.

8.3. Policy and legal environment

Participatory watershed management can be successful only if it is supported by participatory policies and legislation. At the policy level this means clear guidelines for the different concerned line-agencies to work with and through community-based organisations, such as user groups. At the legislation level, unambiguous recognition of community-based organisations or user groups as legal entities, with the right to open bank accounts and hold assets, including special categories for the management of particular resources, such as forests and water. In the concerned line-agencies and administrative bodies, it is necessary to have decision-making authority at local level. In other words, decentralisation is an important element that should be reflected at policy and legislation level. Last but not least, this needs to be complemented with democratic standards and working methods: user groups need to be democratic, local administrative bodies need to be elected and to be held responsible to the electorate, and the concerned line-agencies and their staff need to be open, transparent and accountable.

Mathema, P., Dutta, I. C., Balla, M. K. and Adhikary, S. N. (eds.). 1999. *Sustainable Forest Management*. Proceedings of an International Seminar, 31 August – 2 September 1998, Pokhara, Nepal.

People's Participation in Mountain Watershed Management: Lessons for the 21st Century

P. N. Sharma

Abstract: This paper discusses sustainable participatory watershed management based on the indigenous knowledge of the people. The essential key elements in participatory processes for integrated watershed management and lessons learned from the recent case studies on people's participation in watershed management are summarised as an aid to reorienting the integrated watershed management programmes to be more participatory in the next century. In this way the professionals can assist in building up of the confidence of the people in their own social institutions for sustainable watershed management.

1. Introduction

Mountain watersheds are characterised by high degree of inaccessibility, fragility, marginality and diversity having their own special niche opportunities and human adaptation mechanisms (Jodha *et al.*, 1992). While there are limited lessons to be learned from recent watershed management (WM) efforts which might have been successful in certain pockets at mountain watershed rehabilitation, a lot can be learned from indigenous efforts made by the people from time immemorial in all aspects of participatory watershed management (Mishra, 1996a,b; Sheena and Mishra, 1998). Mishra (1997) stated "*While 'watershed management' term may not have been used beyond half a century, the issues enveloped in the term conservation, protection and development of forest, land and water resources are as old as civilisation itself. No society could have existed on its own without regard for these. It has to create systems that help in adapting to the availability of these resources. In doing this, a society has to rise above mere technological systems and mould them into socio-cultural mechanisms that also find a place in its religion. Instead of looking down upon large sections of our society as illiterate, poor and weak, we need to reinstate their self-respect and their sense of identity that they have lost. It is by building on the age-old indigenous knowledge of our society and its confidence in its capacity that foundations of sustainable watershed management can be laid*".

2. Conventional vs. new paradigm of participatory watershed management

The above thinking and an analysis of other case studies of people's participation in WM (Sharma, 1997) as well as new knowledge based on many failed experience in the last ten years or so (Dent, 1997), has given rise to a new paradigm of people's participation in WM. This new paradigm addresses the watershed degradation problem as perceived by farmers and gives economically viable, environmentally sustainable production-oriented, conservation alternatives that are built upon their indigenous knowledge for their overall development. Based on this, participatory and sustainable integrated watershed management can be redefined as: "utilisation and conservation of land, water, and forest resources at farm household and community (or given watershed) level for continuously improved livelihood and human development" (Sharma *et al.*, 1997).

Table 1. Conventional vs. new participatory WM paradigm

Conventional approach	New approach
Based on technology and ideas from the professionals	Based on indigenous technology, traditions and cosmic vision of local people
Executing agency driven	Participatory, farmer driven
Target based	Participatory process based
Aimed at soil, water and forest conservation only	Aimed at Natural Resource Management (NRM) for overall human development
Transfer of technology (TOT) extension method	Farmer first approach married to TOT
Extension and scientist led	Farmer-led facilitated by professionals
Top-down planning, M & E	Participatory planning, M & E
Land use based on land capability	Land use based on land suitability and people's needs/preferences
Did not consider structural issues e.g. land ownership, farmer's organisation	Land use titling and farmers' organisation at fore-front of participatory WM
Aimed at long term benefits	Aimed at quick as well as long term net benefit generation
Empowered the agents of technology transfer i.e. officials	Aimed at people's empowerment
Attended to selected generally better off farmers	Aimed at marginal, small and poor farmers and gender equity
Tended to be grabbed by single sector	Multi-sectoral and multi-disciplinary
Engineering structures prioritised	Based on bio-engineering and agroforestry
Incentives and aid used for people's participation	Investment at the disposal of the farmers
Did not encourage people's initiatives	Based on people's initiative
Disjointed and arbitrary, based on large watersheds	Farming systems as well as common property management based on small watershed

3. Participatory approaches

There are two schools of thought on people's empowerment. One is that empowerment of people will result in disempowerment of professionals and technicians. Thus the latter will resist the process. However, the other school of thought believes that empowerment of people will result in more empowerment of the professionals and development agents as they gain more love and trust of the people. This will happen when the professionals and development agents become true facilitators. Participatory approaches fall under two broad categories:

3.1. Indigenous or traditional efforts

These are based on ancient rituals and culture of people. These efforts are long-lasting; structured around human development in harmony with nature and the cosmic world; and meet requirements mainly through existing endogenous funding channels.

3.2. Facilitated efforts

These are helped by various means by development agents. These efforts are either co-opted (by incentives, policy instruments or demanding free labour in return for development aid) or coerced participation. They are usually successful on a short-time basis but not sustainable in the long-term. One of the key elements for such successful projects is envisioning for a higher (cosmic) human dimension where project activities are integrated into the culture of people (e.g. by converting the various maintenance and operational activities into rituals as a duty and/or service to the God). The participatory process can develop an innovative mix of traditional and "imported" know-how, according to each context specificity.

4. Participatory processes in watershed management

For achieving the goals of participatory watershed management as defined above, a new thinking is required (Sharma and Krosschell, 1997). Farmers need to become equal partners in development, their local knowledge and capability for continued experimentation and innovation needs to be recognised so that it re-establishes their confidence and voluntary sprit in managing their natural resources as they have done for centuries.

Here, a synthesis of the key elements of the participatory processes for assured people's participation in integrated/comprehensive mountain watershed management is presented. This synthesis is based on the case studies of participatory watershed management so far available as well as some of the recent farmer-led or farmer-based or user-based experiences which are being gained today around the world (Patel, 1997; Sharma and Wagley, 1996; Sharma, 1996; Sharma, 1997; Sheena and Mishra, 1998).

The key elements of participatory processes for integrated WM can overlap, can be continuous activities as well as can be in sequence, depending on the need. They consist of the following:

4.1. Farmers' and professionals' envisioning in accordance with their cosmic vision

Participatory watershed management should result into an improved livelihood style in harmony with nature based on the cosmic vision of a community. The cosmic vision being defined as the people's relationship with nature and the universe in accordance with the dominant philosophy of life in a particular community. Better morals should be added to combine the moral knowledge and practice, and thereby making the community healthier and happier.

Once the people attain a certain level of awareness, some sort of voluntary code of conduct pertaining to community and society could be laid down and a social structure (e.g. farmers' organisations) could be created to sustain it. However, if a social organisation is already in existence, it could be used for the purpose. Besides, envisioning is a continuous activity and should not be used in isolation of the objectives of participatory WM. Also, envisioning should not be misunderstood as religious conversion or abstract preaching.

For successful WM it is imperative that the facilitators/trainers themselves inculcate good moral and ethical standards so that they are able to impress upon common peoples' virtues of better moral practices on strong moral footings. The envisioning process should result into farmers' and professionals' awakening and mobilisation for their own integrated watershed management.

4.2. Farmers' empowerment and ownership

Empowering farmers and institutionalising their ownership of integrated WM programmes and processes require that their constitutional rights (individually or in groups) are allowed to be availed unhindered and farmers are facilitated to use them. These include: the right to organise i.e. farmers' organisation, right to use/own land and other resources i.e. land use titling, and equity among all sections of society specially as related to gender concerns and disadvantaged groups.

In addition to ownership of land, water and forest resources, farmers' group formation and networking helps them better institutionalise the empowerment process. This requires an integrated and well co-ordinated approach at farmers' field and community levels by all the concerned implementing agencies. Lack of investment is not necessarily the problem. But improving farmers' receiving mechanism with proper checks and balances and avoiding abuse of funds are key issues in farmers' ownership of the investments. The resources from local banks/district programmes and other local resources must be facilitated for integrated WM.

The strategy for farmers' ownership of the WM programme, therefore, consists of: facilitation of the empowerment process (not imposition); guaranteed long term ownership or usufruct rights of land and other resources to the farmers, change in attitude of government departments; farmers' capacity building; investments to farmers; and technical support to rebuild the confidence of the people.

This needs GO/NGO technical agents with persistence, commitment, innovation, dedication and better communication skills to assist in farmers' alternate institution building. This type of planning and implementation would be based on farmers' traditional processes and as far as possible on indigenous technologies. Subsidies, if any, should be replaced by investments if the WM programmes are to sustain themselves.

4.3. Land use titling/tenure

Control over land resources (by both men and women) is a pre-requisite to farmers' participation in WM programme as has been amply demonstrated by many case studies of successful participatory WM programmes. Empowerment is linked to control over resources which is in turn linked to ownership. Hence, land ownership is the key element to facilitate people's participation. The different types of land ownership (public, private and community lands), and tenureship will allow differently for empowerment. Therefore, they require different approaches to management of these lands. This requires a change of attitudes among all concerned so that the empowering process can help farmers to better handle the pressures from vested interests. Land tenure systems vary in different countries. Today various approaches are being tried by individual governments in the region for land use titling with limited success although good examples e.g. in community forestry in Nepal (Kanel, 1997), CARL in Philippines (Escano, 1997), Family contract system in China (Deyi, 1995), etc. are available.

4.4. Integration of gender concerns

A majority of the farmers in the mountain watersheds are women. They spent long hours on agricultural as well as other natural resources management activities in addition to keeping the home hearth fires burning, in most of the Asian countries. However, till very recently the WM policy-makers, planners as well as technicians have not realised this. Thus, many of the WM professionals working in the field are not fully aware of the gender issues. Hence, urgent action is needed to correct the imbalance caused by the lack of awareness to integrate the gender concerns. There are many myths about women farmers e.g. that they only do domestic work, that a given technology is good for both men and women, that women are incompetent to work as well as man, that women's concerns can be expressed correctly by their male relatives etc. (Krosschell, 1997). These myths need to be broken so that the real farmers/land users (both women and men) in a mountain watershed can participate. Also special efforts at confidence building of women farmers are needed, as they have been the most neglected farmers in Asia in the last century. To do this, the gender concerns and remedy for alleviating inequalities (also for disadvantaged classes/castes) need to be designed and mainstreamed into watershed development programmes. A gender audit in WM programme planning, implementation, monitoring and evaluation is essential. Ask at every step: are women (as well as other disadvantaged groups) better off with the WM programme implementation or not?

4.5. Assured and quick benefit generation

It is by now very clear that unless the WM activities result in quick (preferably within a crop season or a year) net direct benefits to the participating farmers, their participation should not be expected. Without this, there will not be any on-farm level conservation and better utilisation of natural resources. On common property resources also, if they are to be managed better by the people, they must produce quick benefits to them. Thus, gender sensitive activities assuring quick economic benefits, along with environmental and social benefits, are needed. Hence, if a WM activity does not result in quick and assured benefits, the people will not implement it.

The quick income generating activities could be a combination of both mechanical as well as biological (agro-horticultural-forestry) activities for land, water and forest conservation. In addition they should be labour and input saving. Many examples of activities are available which produce direct benefits within a crop season. Incorporation of better agronomic practices, cash crops, animal husbandry, off-farm income generation, better storage of farm produce, value added products, marketing and rural infrastructure (e.g. farm roads, rural roads) requires attention. Community facilities (e.g. ponds, community forestry) which result into direct farmers' income generation need to be strengthened. This requires promotion of farmers' capacity for investments. Thus rather than subsidies, incentives or other forms of government doles, promotion of investment from both farmers as well as government programmes is needed for quick economic, environmental and social benefit generation.

5. Lessons for future

- Build participatory watershed programmes based on the indigenous knowledge and traditional social institutions of the watershed populations and strengthen their confidence in their age-old strengths in land, water and forest management.

- Participatory WM should result into holistic human development. Thus, the goal of the WM programmes need to be re-framed to encompass management of natural resources of a watershed for overall human development.

- The integrated WM should be based on the dominant cultural and value system in relation to the dominant thoughts of a society with nature and the universe.

Thus, spiritual or other ways of Man's role in Nature and the Universe (cosmic vision) should become a continuous activity of the WM programmes. The education and training programmes also need to integrate them into their curricula.

- Alternate ways of strengthening farmers' organisation for their empowerment need to be integrated into the WM programmes. This will include farmer-led WM planning, farmer-led WM implementation, farmer-managed funding and investments (e.g. rotating funds), and participatory monitoring and evaluation to feed back corrections into the WM programmes. This is to be within the framework of commonly agreed constitutions of the farmers' organisations which is respected by all participants. As far as possible, conflict resolution should be based on the dominant cultural values of the people rather than based on only legal deterrents. Clear rules and sanctions, clear leadership, clear decision-making procedures and a clear role of the organisations are important as well. A mechanism for communication among all members and equitable distribution of benefits are important for organisation building. All this will help develop a sustainable way of life by managing the watersheds sustainably. Thus, the WM programmes should introduce the mechanisms by which the WM process becomes part of the culture of the people.

- Most education and training programmes need to update their curricula to train professionals to facilitate the process of farmers' decision-making, farmers' empowerment, farmers' organisation building and farmers' own management of the WM programmes.

- The investments into the WM programmes should be designed at the national level and made available to the farmers or other users through national channels. In most countries, bank loans exist for farmers. However, farmer managed funding is more effective, less misused and results into better-managed community and household resources.

- A policy framework exists in almost all countries which allows the community and public lands to be titled to the people. The WM programmes should facilitate this process and help land titling to the people. As far as possible, the land titling authority should be designed into the WM programmes.

- Quick benefit generation should be the primary concern of the development activities. Farming systems improvement and common property resource development should pursue this in an ecologically sound manner. Water being the primary natural constraint in mountainous and rainfed areas, its harvesting and conservation can help increase the sustainability of watershed resources.

- Gender concerns have received only lip service in most WM programmes in Asia. This is creating a situation where more than half of the population (women) either do not benefit or become worse off. Affirmative action policies have limited impact.

- Most WM related professionals and technicians are not prepared in the above elements of the participatory processes. Hence, considerable efforts will have to be made to update their curricula so that facilitators of the participatory processes can be trained.

6. Conclusion

Participatory process requires an appreciation of women/men farmers' knowledge and their social institutions. For this, thorough and continuous dialogue among all stakeholders is important to achieve true participatory watershed management. The result of such an approach will be the boosting of confidence of both women and men farmers and the spreading of innovative ideas from farmer to farmer. By this it is hoped that the professionals can be prepared such that *"Instead of looking down upon large sections of our society as illiterate, poor and weak, we reinstate their self-respect and their sense of identity that have been lost. It is by building on the age old indigenous knowledge in our society that foundations of sustainable watershed management can be laid" (Mishra, 1997).*

References

Dent, F. J. 1995. A Framework for Land Rehabilitation. RAPA/FAO, Bangkok, Thailand.

Deyi, W. 1995. Status of Watershed Management in China. In: Sharma, P. N. and Wagley. M. P. (eds.). Status of Watershed Management in Asia. *Field Doc. 1*, PWMTA/FAO, Kathmandu, Nepal.

Escano, L. R. 1997. Implementation of Land Use Titling in the Philippines. In: Sharma, P. N. (ed.).Participatory Processes for Integrated Watershed Management. *Field Doc. 7*, PWMTA/FAO, Kathmandu, Nepal.

Jodha, N. S., Banskota, M. and Partap, T. 1992. *Sustainable Mountain Agriculture Vol. 1, Perspective and Issues.* Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi, India.

Kanel, K. 1996. Lessons from Community Forestry in Nepal. In: Sharma P. N. (ed.). Recent Development, Status and Gaps in Participatory Watershed Management Education and Training in Asia, *Field Doc. 6*, PMWTA/FAO, Kathmandu, Nepal.

Krosschell, C. G. 1997. Integration of Gender Concerns in Participatory Watershed Management: A Review and some Suggestions. In: Sharma, P. N. (ed.). Participatory Processes for Integrated Watershed Management. *Field Doc. 7*, PMWTA/FAO, Kathmandu, Nepal.

Mishra, A. 1996a. *Drops of Silver from Rajasthan, India* (in Hindi). Gandhi Peace Foundation, New Delhi, India.

Mishra, A. 1996b. *Even Today These Reservoirs are Full* (in Hindi). Gandhi Peace Foundation, New Delhi, India.

Mishra, A. 1997. Indigenous Knowledge Systems. *Asian WATMANET Newsletter No. 13*, PMWTA/FAO, Kathmandu, Nepal.

Patel, J. 1997. *Story of a Rivulet from Death to Rebirth.* Tarun Bharat Sangh, Alwar, India.

Sanders, D. W., 1990, New Strategies for Soil Conservation, *Jr. of Soil Conservation* (USA), 45(5): 511–516.

Sharma P. N. and Krosschell C. 1997. An Approach to Farmer Led Sustainable Participatory Watershed Management. In: Sharma, P. N. (ed.). Recent Developments, Status and Gaps in Participatory Watershed Management Education and Training in Asia. *Field Doc. 6*, PMWTA/FAO, Kathmandu, Nepal.

Sharma, P. N. and Wagley, M. P. (eds.), 1996. Case Studies of People's Participation in Watershed Management in Asia, Part I: China, Nepal and India, *Field Doc. No. 4*, PMWTA/FAO, Kathmandu, Nepal.

Sharma, P. N., Mishra, B., Dent, F. J., Achet, S. H., Escano, J., Gamage, H. and Gunawardhana, E. R. N. 1997. Key Elements of Participatory Processes for Integrated Watershed Management. In: Sharma, P. N. (ed.). Participatory Processes for Integrated Watershed Management. *Field Doc. 7*, PMWTA/FAO, Kathmandu, Nepal.

Sharma, P.N., 1997. An Analysis of and Lessons Learned from Case Studies of Participatory Watershed Management in Asia. In: Sharma, P. N. (ed.). Participatory Processes for Integrated Watershed Management. *Field Doc. 7*, PMWTA/FAO, Kathmandu, Nepal.

Sheena and Mishra, A. 1998. Ripples of the Society, People's Movements for Watershed Development, Gandhi Peace Foundation, New Delhi, *Field Doc. 14*, PMWTA/FAO, Kathmandu, Nepal.

Mathema, P., Dutta, I. C., Balla, M. K. and Adhikary, S. N. (eds.). 1999. *Sustainable Forest Management.* Proceedings of an International Seminar, 31 August – 2 September 1998, Pokhara, Nepal.

Runoff and Water Quality from Paired Watersheds: Automated Monitoring Instrumentation and Data Acquisition Techniques

P. P. Sharma, E. C. Dorsey, J. F. Moncrief and S. C. Gupta

Abstract: Paired watersheds are often used to evaluate the effect of best management practices (BMP) on runoff and water quality. The technique includes a period of pre-BMP and post-BMP monitoring of runoff and water quality parameters and application of regression analysis to evaluate the effects of proposed BMP. The success of BMP evaluation depends upon the frequency and accuracy of monitored runoff and water quality data. A combination of flumes, flow measuring devices, automated data loggers, rainfall intensity recorders, other micro-meteorological sensors, and automatic water samplers can be used to continuously monitor hydrologic events from a confined watershed. The monitored data can be transferred to a computer through data storage modules or by directly linking with a computer over telephone or cellular modems. Data from paired watershed studies of runoff and water quality in Minnesota, USA show that such a set-up can be robust and accurate in both temperate and warmer climatic regimes.

1. Introduction

Successful management of soil and water is critical to sustain both *in situ* biomass productivity and environmental quality of downstream aquatic ecosystems. According to widely accepted interpretation of soil deterioration in the hills of Nepal, population pressure has forced hill farmers to extend their farming activities to steeper slopes (Sill and Kirkby, 1991). The shift in land use has accelerated rates of erosion and gully formation in the hills. Soil erosion deteriorates soil quality and reduces crop yields. The process reduces infiltration and increases runoff shifting water routing from that of percolation, ground water recharge, and subsurface flow to that of instantaneous overland flow with adverse downstream effects of flooding and sedimentation. The challenge for resource managers and farmers is to find ecologically sustainable best management practices (BMPs) that include forestry and farming practices which protect soil against raindrop and flow impact. Such practices need to improve soil quality and biomass productivity, reduce load of sediments and pollutants to downstream waterways while economically sustaining the livelihood of upland farmers.

Forest researchers have pioneered the paired watershed experimental approach to demonstrate and evaluate field scale effects of BMP's over conventional logging and other silvicultural practices (Wilm, 1949). Increasingly, environmental scientists and agriculturists have adopted the paired watershed research techniques to evaluate effect of BMPs, such as conservation practices and non-point source pollution of downstream water bodies (Clausen *et al.*, 1996; Edwards *et al.*, 1993). The historical "Phewa Tal Watershed Management Project" in Pokhara was the first initiative of paired watershed research and demonstration of BMP in Nepal.

The basic approach of a paired watershed study design requires a minimum of two similar watersheds (control and treatment) and two periods of study (calibration and treatment). During the calibration period, the two watersheds are treated identically with conventional management practices and paired runoff and water quality data are collected. Such paired data could be annual means or totals. For shorter studies (less than years), the observations could be seasonal, monthly, or event-based.

During the treatment period, one watershed is treated with a BMP while the control watershed remains in the original management (Table 1).

Table 1. Schedule of BMP implementation

Period	Watershed	
	Control	Treated
Calibration	No BMP	No BMP
Treatment	No BMP	BMP

Source: Clausen and Spooner (1993)

The basis of the paired watershed approach is that there is a quantifiable relationship between paired runoff and water quality data for the two watersheds, and that this relationship is valid until a major change is made in one of the watersheds. At that time, a new relationship will exist. This basis does not require that the quality of runoff be statistically the same for the two watersheds; but rather that the relationship between paired observations of water quality remains the same over time except for the influence of the BMP. The advantages of paired watershed approach are that climate and hydrologic differences from year to year are statistically controlled, watersheds need not be identical, area considered is larger than a plot, and the water quantity and quality changes can be attributed to the treatment alone rather than watershed differences (Kovner and Evans, 1954; Hewlett, 1971; Hewlett and Pienaar, 1973). However, the paired watersheds must respond in a consistent manner to climate effects (Clausen *et al.*, 1996)

The fundamental assumption of paired or multiple watershed study is availability of quality data from a large set of paired observations of watershed runoff due to precipitation events. Assuming normal frequency distribution of precipitation during the calibration and treatment periods, the number of recorded event increases in proportion to availability of sampling resources. Manual sampling of flow and water samples for quality assessment suffers from imprecision, human error, inability to sample short time intervals and during nights or periods of extreme weather. When severe thunderstorm occurs during the day or night, it is inconceivable to assume that human help will be available to sample the event continuously.

Conversely, if instrumentation is available for on-site automated flow monitoring, water sample collection, and data storage and transfer, the quality and quantity of event data increase significantly. The instrumentation captures continuous rainfall-runoff data at desired short time intervals (even < 1 minute) allowing discretisation of distinct events over a period of observation. The automated data acquisition technology improves data quality and interpretation. Moreover, it captures the event at its best time allowing measurement of peak flows and erosion rates during intense thunderstorms. The automation technology minimises data turn around time and reduces the overall time needed to evaluate the treatment response.

2. Paired watershed study at Morris, Minnesota

Currently as a biomass energy project, alfalfa (*Medicago sativa* L.) is being promoted in western Minnesota to harvest the leaves for animal feed and stems to generate electricity. As a perennial, leguminous crop grown with minimum inputs, introduction of alfalfa in row cropped corn (*Zea mays* L.) and soybean {*Glycine max* (L.) Merr.} field has potential to improve both *in situ* soil quality and downstream water quality. A paired watershed study is being conducted at Morris, Minnesota to document the runoff and water quality effects of continuous alfalfa over annually cultivated corn-soybean fields.

2.1. Establishment of paired watershed treatments

Four field size watersheds laying east-west and draining south were selected on the eastern half of West Central Experiment Station Field E-5 at Morris in Stevens County, Minnesota. The study area is dominated by gently sloping to hilly, well-drained Buse-Barnes-Forman soil association, which is mostly loam or clay loam. The dominant soil series at the watershed experiment site includes the well drained, gently (2–6%) to moderately sloped (6–12%), Barnes-Buse loam (Lewis *et al.,* 1971).

All four fields were under wheat (*Triticum aestivum L.*) in 1995 and were chisel ploughed in the fall after harvest of the wheat crop. The eastern (0.65 ha with designation Plot-5) and the western (1.78 ha with designation Plot-8) fields were seeded with alfalfa on May 28, 1996. During 1997 and 1998, three cuttings of alfalfa (June, July and August) were taken at approximately 1/10th boom stage.

The central two watersheds designated for corn-soybean rotation was seeded with corn in 1996, soybean in 1997, and corn in 1998. During spring, corn was planted in 76 cm rows and soybean was drilled in 18 cm rows, approximately on contour for both crops. Corn was harvested for grain in October – November and ploughed using a chisel plough with more than 50% residue on the surface. Soybean was harvested in October with about 30% residue left on the surface. Fertility was maintained for modest productivity levels with application of anhydrous ammonia before planting corn and soybean. Residual herbicides recommended for corn and soybean were used each year for weed control.

2.1. Flow measuring devices and data acquisition

Earthen berms were constructed to guide water towards a pair of fibreglass flumes at the downslope end of each field. A 15 cm Parshall flume was located at the convergence point of the berms, and water then passed through a 10 cm Palmer Bowlus flume at the down slope end. The two flumes were selected to accommodate both large and small flows expected to occur during runoff events. The Parshall flumes were installed and levelled during the fall of 1996. The smaller Palmer-Bowlus flumes were installed and levelled during second week of March 1997, just before the beginning of the snowmelt event. Along the side of the two flumes at each watershed, an instrument shelter was constructed to house a data logger, a water sampler, and a nitrogen gas cylinder. The equipment was powered by 12 V marine batteries, which were continuously recharged through a 110 V electrical power source connected to each instrument shelter. Alternatively, solar cells can be used to recharge the batteries.

The level of water in the flumes was measured with a pressure differential transducer connected with tygon tubing to a gauging tube at each flume. The tygon tubing carried N-gas at a constant rate. The pressure with which N-gas bubbles out of water is proportional to the height of water in the flume. The pressure difference is measured in voltage with the transducer. Each transducer was individually calibrated to convert volt readings into height of water, which was then used to calculate the flow rate passing through the flumes. A recording raingauge and thermocouples were connected to the data logger to measure rainfall, water and air temperatures.

A 24-1litre-bottle water sampler in the instrument shelter periodically sampled runoff water during flow periods. The data-logger was programmed to read the instruments every 30 seconds. Whenever there was a minimum depth of flow, the programme triggered the sampler to collect runoff water every five minutes to 20 minutes depending upon the desired composite sample size. For spring-melt runoff events, one bottle collected water for every two or three hours. For summer rainstorms, the samples were collected every 30 minutes. The field samples were transported the same day to the University of Minnesota, Soil, Water and Climate Laboratory at St. Paul for determination of water quality parameters. For this study, sediment load, biochemical oxygen demand, chemical oxygen demand, dissolved phosphorus, bio-available phosphorus, total phosphorus, ammonium, and nitrate nitrogen were chosen as parameters that would affect the quality of streams and rivers.

A data storage module connected to the data logger stores the data at specified intervals. Depending on the frequency of observation and on the frequency and duration of runoff events, a storage module holds data for about three to seven days. The storage module can be detached from the data logger, taken to a desktop personal computer, and data transferred for processing by application software. Alternatively, a portable PC can be taken to the site and data retrieved. For remote sites, radio frequency modems can be used to acquire data from office location.

3. Example flow and water quality data from the Morris watershed study

The monthly temperature at Morris ranges from an average minimum of about –23° C in January to an average maximum of about 26° C in June. Average total annual precipitation is about 600 mm which varies from about 17 mm in December through February to about 100 mm in June. From November to beginning of April, the precipitation is mostly snow. Snowmelt runoff in the spring significantly contributes to soil water recharge and replenishes streams and lakes in these parts of the Northern Great Plains.

Hydrographs of snowmelt runoff and rainfall-runoff demonstrate the high accuracy of the instrumentation. Snowmelt runoff is a function of heat energy available to melt the snow. The runoff rate is proportional to diurnal temperature distribution. The snowmelt rate increases in the afternoon and slows down to near freezing during early morning hours. The rainfall-runoff, on the other hand, depends upon rainfall intensity. The data clearly demonstrate the lag between peak rainfall intensity and peak runoff rate. The instrumentation records the rainfall and runoff patterns during the rainstorm in detail providing quality hydrographs for further analysis.

Table 2 summarises the average amounts of precipitation, runoff, soil loss, and sediment load per unit of total runoff during spring of 1997 and 1998. Winter of 1996–97 had about twice the amount of snow and total precipitation than 1997–98. From both alfalfa and corn fields in 1997, more than half of total precipitation was recorded as runoff with remaining water recharging the soil. During the snowmelt of 1998 on alfalfa fields, about 75% of precipitation water were measured as runoff suggesting about 25% recharge into the soil. The reverse (75% recharge, 25% runoff) was observed for soybean plots.

There is an advantage of having more than one pair of similar watersheds at the same study site. Without waiting for the traditional calibration and treatment periods to evaluate the effect of BMP, the treatment effects for multiple watersheds can be analysed using a simple 2-way analysis of variance (ANOVA) method with year and rotation as factors (Table 3). The 2-way ANOVA model assumes that the effect of replicated fields is insignificant, and that the data follow the rules of normal distribution with equal variance (Snedecor and Cochran, 1980). As shown in Table 2, the year to year variation on runoff and sediment load was more significant than rotational effects. Based on the observations of snowmelt data of the past two years, alfalfa fields seem to produce more snowmelt runoff than corn-soybean fields. However, runoff coming from corn and soybean fields carried more sediment.

Table 2. Summary of precipitation[1], runoff, and soil loss during snowmelt events of 1997 and 1998

Previous Crop/Residue	Snowmelt Year	Snow and Rain (mm)	Runoff (mm)	Soil Loss (kg/ha)	Sediment Load/Unit Runoff (kg/ha. mm)
Alfalfa	1997	196	131	243	1.85
	1998	96	71	223	3.14
Corn	1997	196	104	496	4.76
Soybean	1998	96	24	152	6.30

[1] From November 1 to April 15

Table 3. Significance statistics by 2-factor ANOVA

Effect of	On parameter	p>F
Rotation	runoff, sediment load	0.12
Year	runoff, sediment load	0.02
Rotation x Year	sediment load	0.03

4. Conclusion

The success of watershed scale evaluation of BMPs to reduce erosion and improve water quality depends upon the availability of quantity and quality of flow and pollutant transport data. Watershed scale water quality monitoring experiments in Minnesota, USA demonstrate the feasibility of using automated instrumentation to record runoff and water quality during both snowmelt and rainfall-runoff events. The automated data acquisition system captures each big and small hydrologic event with sufficient temporal frequency. The advantage of such instrumentation is: (a) the availability of quality data for proper interpretation and (b) faster turn around time in terms of data analysis and completion of research projects.

In today's prices, it costs about US$ 10,000 to set up the instrumentation at each site. Such a data acquisition system may seem difficult to obtain, and expensive to install and maintain in Nepal. Security of instrumentation may be another concern, which can be managed with manpower in Nepal. With advances in electronic communication devices, availability of faster computers at cheaper prices, and rapid dissemination of information and technology from developed countries, it is possible to make such a system operational. The widespread uses of computers, geographic information systems, and Internet technology in Nepal are examples that substantiate the feasibility of transfer of such data-acquisition technology in the near future. The advantages of using automated data acquisition system to objectively evaluate the watershed scale effects of BMPs are tremendous especially when working with participatory watershed management projects.

References

Clausen, J. C., Jokela, W. C., Potter III, F. I. and Williams, J. W. 1996. Paired Watershed Comparison of Tillage Effects on Runoff, Sediment, and Pesticide Losses. *J. Environ. Qual.* 25: 1000–1007.

Edwards, W. M., Triplett, G. B., Van Doren, D. M., Owens, L. B., Redmond, C. E. and Dick, W. A. 1993. Tillage Studies with a Corn-Soybean Rotation: Hydrology and Sediment Loss. *Soil Sci. Soc. Am. J.* 57: 1051–1055.

Hewlett, J. D. 1971. Comments on the Catchment Experiment to Determine Vegetal Effects on Water Yield. *Water Res. Bull.* 7: 376–381.

Hewlett, J. D. and Pienaar, L. 1973. Design and Analysis of the Catchment Experiment. In; White, E. H. (ed.) Proc. Symp. Use of Small Watersheds. Univ. of Kentucky, Lexington, USA. pp. 88–106.

Kovner, J. L., and Evans, T. C. 1954. A Method for Determining the Minimum Duration of Watershed Experiments. *Trans. Am. Geophys. Union* 35: 608–612.

Lewis, R., Royce, D. E., Demartelaere, E. and Miller, E. L. 1971. Soil Survey of Stevens County, Minnesota. USDA-SCS.

Sill, M. and Kirkby, J. 1991. *The Atlas of Nepal in the Modern World.* Earthscan Publications Ltd., London, UK.

Snedecor, G. W., and Cochran, W. G. 1980. *Statistical Methods.* 7th Edition. The Iowa State University Press, Ames, Iowa, USA.

Wilm, H. G. 1949. How Long should Experimental Watersheds be Calibrated? *Trans. Am. Geophys. Union* Part II 30(2): 618–622.

Mathema, P., Dutta, I. C., Balla, M. K. and Adhikary, S. N. (eds.). 1999. *Sustainable Forest Management.* Proceedings of an International Seminar, 31 August – 2 September 1998, Pokhara, Nepal.

Future Climate Change Induced Social and Economic Impacts on Sustainable Management of Coniferous Forests of Pakistan

K. M. Siddiqui

Abstract: The ecological, social and economic impacts of climate change on the mountain coniferous forests of Pakistan are discussed. The results are based on a study using the BIOME3 computer model. The periods of the study were: 1990–2020, 2020–50, and 2050–80 with a climatic change rate of 0.3° C rise in temperature and precipitation change of 0%, +1% and –1% per decade with 1990 as the base year. In addition, the current atmospheric CO_2 concentration of 350 ppmv is expected to increase to 425 ppmv in 2020, 500 ppmv in 2050 and 575 ppmv in 2080. Nine forest types were simulated. Of these, three biomes showed reduction in their area and five showed increase in their area as a result of climate change. Net primary productivity increased in all biomes and scenarios. However, there is a possibility of forest dieback occurring before the forest dominant types have enough time to adjust to changed climate. There would also be a time lag before forests could migrate to new sites. In the intervening period, they would be vulnerable to environmental and socio-economic disturbances, e. g., erosion, deforestation, landuse changes, etc. Thus, the overall impact of climate change on forest ecosystems could be negative, which may have serious implications for their sustainable management. Some management measures are proposed to cope with this situation.

1. Introduction

Natural forests and man-made tree plantations cover 4.224 million ha or 4.8% of the total land area of Pakistan (Anon., 1992; Amjad *et al.*, 1996). Agriculture is practised on 20.58 million ha or 23.4% and livestock grazing on 28.509 million ha or 32.4% of the area. The balance of 34.67 million ha or 39.4% consists of snow, glaciers, rocks, deserts, tidal flats, water bodies, river beds, lakes, dams, towns, cities, etc. The non-productive use of most of the land area is due to arid climate with less than 250 mm annual rainfall over more than 70% of the country. Forest area is also small and scattered for the same reason, as natural tree growth is not possible in low rainfall areas (Siddiqui, 1997). Further, all the forested area does not have dense tree cover. Rather, 93% of coniferous forests, 34% of riverain forests, 58% of mangrove forests and 46% of irrigated plantations have low density tree growth (Anon., 1992). Pakistan has a rich and diversified flora because of the wide variety of soils, topography and climatic conditions. Nine broad forest types are recognised in Pakistan (Champion *et al.*, 1965).

The natural forests all over Pakistan have been subjected to deforestation for growing agricultural crops, grazing domestic animals and obtaining fuelwood and timber over thousands of years. Consequently, these have been reduced to small and scattered patches. Deforestation is also partly responsible for creation of widespread aridity, which in turn has hindered forest regeneration, growth and development thus further aggravating the forest deficient situation in the country. The process of deforestation is still going on. Current rate of forest depletion is estimated at 0.9% by FAO. Presently, the coniferous forests in the northern mountain regions are particularly under heavy social and economic pressure (Knudsen, 1994). The population density in the inhabitable areas of mountain regions is fairly high. It is estimated to be 8.45 million or 6.5% of the total population. The population pressure for crop, orchards and grazing land tends to be very high. It has been the cause of natural resource degradation during the last 150 years.

The natural forests with an area of 3.1 million ha in northern mountain regions have considerable ecological, socio-economic, commercial and environmental importance. Of these, the coniferous forest on 1.9 million ha provide timber, fuelwood, non-wood forest produce, hydroelectric power, drinking and irrigation water, minerals, soil nutrients, and places for tourism and recreation. The growing stock of these forests is estimated to be 231.589 million m^3 which is worth Rs. 1,115 billion (Anon., 1992). The annual income from these forests is estimated to be Rs. 2,500 million under current conservative management system. Other tangible benefits of these forests are: grazing worth Rs. 500 million and medicinal plants and other products worth Rs. 140 million. The mountain regions are important centres of biodiversity. Their glaciers, flora and fauna are indicators of climate change. The altitudinal pattern of vegetation in northem regions of Pakistan follows latitudinal pattern of vegetation found globally. Hence forest types in higher altitudes in Pakistan are similar to those growing in temperate latitudes. These forests are expected to face a combined effect of climate change and socio-economic pressures in future.

2. Forest management objectives

The scientific management of coniferous forests in the reserved areas of the Himalayan regions was started more than one hundred years ago to assure sustained supplies of timber to government works and communication departments. It was based on the principles of sustained yield and normal forests developed in Central Europe. However, it has generally been practised at low intensity to protect watersheds by maintaining a permanent vegetation cover on them for sustained supply of adequate river water for irrigation and power generation. This practice is still continued in more or less original form, though the objectives of forest management were never realised throughout this period. In lower reaches, the sub-tropical forests are now managed under shelter-wood and selection systems with natural regeneration and rotation of 80–120 years. These forests have degraded considerably due to heavy cutting, uncontrolled grazing and frequent fires by the people living in their proximity. Similar is the situation in case of scrub forests in sub-mountainous tracts. On the other hand, moist temperate forests are managed under selection system, which means scattered and selective felling of trees of certain fixed size.

Till recently, very little investment for the development of mountain forest resource and upliftment of socio-economic conditions of the people living in their vicinity has been made. These areas were generally marginalised in all development activities due to difficulty of terrain and absence of communication facilities. On the other hand, the natural resources of the mountains were extensively and intensively exploited for short-term gains of the people resulting in long-term loss to the ecosystems. Currently, there is complete official ban on green tree felling in these forests. However, in practice, it is going on at a very high rate (Payr, 1997). According to Khattak (1992), the annual firewood drain exceeds three times the increment put by the coniferous forests, and grazing intensity is more than eight times their forage productivity due to increase in human and cattle populations over the years. This situation is expected to continue and further degradation of the natural resources will continue unless massive measures are taken. Climate change is expected to further aggravate the situation.

3. Impacts of climate change on coniferous forests

It is now well established that global warming to an extent of 1–3.5° C increase in mean surface temperature would occur by the year 2100. This would exert significant effect on our social and economic systems as well as on extent, composition and distribution of natural ecosystems, especially forested areas (Anon, 1996). A study was carried out by the author to simulate impacts of climate change on natural ecosystems in Pakistan in general and forest ecosystems in northem mountain areas of the country in particular, with the assistance of UNEP (Siddiqui *et al.*, 1997). This was done through BIOME3 model (Haxeltine, 1996). The expected changes in the distribution of different forest types (biomes), and their productivity were determined for the year 2020, 2050 and 2080 taking 30-year average for the period 1961–90 as the base line. Further, climate scenarios were developed by assuming a change of temperature of +0.3° C/decade, and rate of change of precipitation of 0%, +1% and –1% per decade, again with 1990 as the base year. In addition, the current atmospheric CO_2 concentration was taken as 350 ppmv (parts per million by volume) which was to increase to 425 ppmv in 2020, 500 ppmv in 2050 and 575 ppmv in 2080. The study was focused on coniferous forests for their perceived sensitivity to climate change. The results are briefly described below.

Impact of increased CO_2 concentration: The model predicted that increased CO_2 concentration in the atmosphere leads to a large increase in photosynthetic rates due to its fertilisation effect and/or reduction in transpiration rate, reflected in increased Net Primary Productivity (NPP) or above ground productivity. However, in actual practice, this increase may not occur due to limited soil nutrient availability.

Combined impact of increased CO_2 concentration and temperature: As per the simulation model, this in general results in northwards and upward movement of cold and temperate conifer forests, which is in agreement with the findings of IPCC Report (Anon., 1996). As temperature and CO_2 increase, cold conifer forests displace cold conifer/mixed woodlands and alpine tundras in areas, which do not support a forest cover. Further, the temperate conifer forest belt moves northwards in areas occupied by the cold conifer forests; which, in turn, is displaced in lower and warmer areas by the northward and upward movement of the warm conifer forests. The later are however, not displaced by another forest type to any significant extent because temperature increase is not large to produce tropical conditions.

Combined effects of increased temperature and precipitation: Temperature and precipitation are two most important elements of climate and together have a number of first order effects on forest distribution, composition and growth. The result of increase in temperature are: timber line moving up the mountain slopes, disappearance of alpine grasslands in those areas where mountain tops are just above timber line, changes in plant composition, cover and location. An increase in forested area in Pakistan is also expected with increase in precipitation as forests would move into new areas which are now too dry to support tree vegetation. This increase is especially high for the warm conifer biome. Increasing precipitation also causes a reduction in the area occupied by cold conifer woodland, which is more open with a lower canopy cover and stand density than the cold conifer forest. Areas of different biomes under current and changed climates simulated with the help of model are given in Table 1 and 2.

Table 1. Areas simulated for different biomes under current[1] and changed[2] climates

	Biome type	Area (10^6 ha)									
		Current	2020			2050			2080		
		1961-90	-P	OP	+P	-P	OP	+P	-P	OP	+P
1	Alpine tundra	5.9	4.9	4.9	4.0	4.0	4.0	3.6	3.6	3.6	3.6
2	Cold conifer/mixed woodlands	1.0	1.2	1.2	1.1	1.5	1.4	1.2	1.4	1.3	1.1
3	Cold conifer/mixed forests	3.1	3.5	3.5	3.6	3.6	3.8	3.9	3.3	3.5	3.6
4	Temperate conifer/mixed forests	3.8	4.1	4.1	4.1	4.0	4.1	4.1	4.5	4.6	4.6
5	Warm conifer/mixed forests	4.3	5.4	5.9	5.9	6.4	6.9	7.2	6.7	7.4	8.2
6	Xerophytic woods/shrubs	6.0	6.0	5.8	6.0	5.9	5.8	5.9	6.0	6.0	6.0
7	Grasslands/arid woodlands	0.7	0.4	0.5	0.5	0.3	0.3	0.3	0.3	0.3	0.4
8	Steppe-Grasslands/arid woodlands	33.3	34.9	35.8	36.7	36.1	37.4	39.0	36.5	38.7	39.9
9	Deserts	28.6	26.3	25.0	23.8	24.8	23.0	21.0	24.4	21.3	19.1
	Total	86.7	86.7	86.8	86.7	86.7	86.8	86.7	86.8	86.8	86.5

1. Based on average yearly climatic data for the period 1961 to 1990.
2. Based on the assumption that there will be an overall change of –3%, 0%, and +3% in precipitation coupled with a 0.9° C increase in temperature in 2020; a –6%, 0%, and +6% change in precipitation and 1.8° C increase in temperature in 2050, and -9%, 0%, and +9% change in precipitation, and supported by a 2.7° C increase in temperature.

Table 2. Percentage changes in areas of different biomes under changed climate

Biome type	Percentages								
	2020			2050			2080		
	-P	0P	+P	-P	0P	+P	-P	0P	+P
1. Alpine tundra	-16.7	-16.7	-16.7	-31.5	-31.5	-31.5	-38.9	-38.9	-38.9
2. Cold conifer/Mixed woodlands	22.2	22.2	11.1	5.6	44.4	22.2	44.4	33.3	11.1
3. Cold conifer/Mixed forests	10.3	10.3	13.8	13.8	20.7	24.1	6.9	10.3	13.8
4. Temperate conifer/Mixed forests	5.6	5.6	5.6	2.8	5.6	5.6	16.7	19.4	19.4
5. Warm conifer/Mixed forests	22.0	22.0	34.1	43.9	56.1	63.4	51.2	68.3	85.4
6. Xerophytic woods/Scrubs	0.0	0.0	0.0	-1.8	-3.6	-1.8	0.0	0.0	0.0
7. Grassland/Arid woodlands	-42.9	-28.6	-28.6	-57.1	-57.1	-57.1	-57.1	-57.1	-28.6
8. Steppe/Arid shrublands	5.2	8.1	10.7	9.1	13.0	17.6	10.1	16.9	20.5
9.Deserts	-7.6	-7.6	-16.3	-12.9	-19.3	-26.1	-14.4	-25.4	-33.0

Simulated changes in NPP: The Net Primary Productivity (NPP) is the rate at which an ecosystem fixes carbon by photosynthesis from the atmosphere (gross primary productivity) minus the rate at which it returns carbon to the atmosphere by respiration. Table 3 shows the average model-simulated NPP for different biomes due to changes in precipitation, temperature, and atmospheric CO_2 concentration. Table 4 shows variable increases in the NPP of all forest biomes with changes in climate. However, as against other biomes, the warm conifers exhibit a continuous upward trend from an increase of 16.4% for decreased precipitation in 2020 to more than 50% increase in its NPP in 2080. Thus these forests will become denser with more closed canopy in 2080 if not disturbed.

Table 3. Average Net Primary Productivity (NPP) for different biomes under present and changed climate

Biome type	Average NPP gC m^{-2} yr^{-1}(tC km^{-2} yr^{-1})									
	1961–90	2020			2050			2080		
		-P	0P	+P	-P	0P	+P	-P	0P	+P
1. Alpine tundra	94	103	104	104	115	117	118	130	133	136
2. Cold conifer/Mixed woodlands	161	176	178	176	184	180	177	196	197	191
3. Cold conifer/Mixed forests	331	354	355	353	380	381	381	394	400	402
4. Temperate conifer/Mixed forests	639	722	728	735	784	797	803	819	829	845
5. Warm conifer/Mixed forests	653	761	763	776	857	876	898	939	972	1000
6. Xerophytic woods/Scrubs	393	443	434	439	482	482	488	520	524	521
7. Grasslands/Arid woodlands	322	341	319	321	367	348	364	352	342	335
8. Steppe/Arid shrublands	139	163	165	167	182	189	195	199	210	221
9. Deserts	61	70	70	70	77	78	79	84	85	89

Table. 4. Percentage changes in average NPP of different biomes

Biome type	2020			2050			2080		
	-P	0P	+P	-P	0P	+P	-P	0P	+P
1. Alpine tundra	9.6	10.6	10.6	22.3	24.4	25.5	38.3	41.5	44.7
2. Cold conifer/Mixed woodlands	9.3	10.6	9.3	14.3	11.8	9.9	21.7	22.4	18.4
3. Cold conifer/Mixed forests	6.9	7.3	6.6	14.8	15.1	15.1	19.0	20.8	21.5
4. Temperate conifer/Mixed forests	13.1	13.9	15.0	22.7	24.7	25.6	28.2	29.8	32.3
5. Warm conifer/Mixed forests	16.4	16.9	18.9	31.3	34.1	37.5	43.7	48.9	53.1
6. Xerophytic woods/Scrubs	12.6	10.5	11.7	22.6	22.6	24.3	32.2	33.4	32.7
7. Grasslands/Arid woodlands	5.8	-1.1	-0.5	13.7	8.0	13.0	9.0	5.9	3.9
8. Steppe/Arid shrublands	16.7	18.0	19.7	30.5	35.4	40.0	42.5	50.4	58.6
9. Deserts	14.5	14.7	14.9	26.9	28.5	30.0	37.7	40.7	45.7

Specific Impacts on coniferous forests and forestry: Important impacts of a change in climate on the coniferous forests of northern Pakistan include: i) changes in area, ii) changes in productivity, and iii) changes in species composition. The total area of three main coniferous forest biomes (cold, temperate, and warm conifer) increased under all three climate change scenarios of increases in temperature, precipitation, and CO_2 concentration (Table 5).

Table 5. Increase in coniferous forest area and the NPP under changed climate scenarios

	Area						
	1961-90	2020	% increase[1]	2050	% increase	2080	% increase
Total potential coniferous forest area[2]	106	120	13.2	141	33.0	152	43.4
Average NPP per unit area	541	621	14.8	661	22.2	749	38.4

1. with respect to the base year data, 1961-90.
2. includes: i) cold coniferous/mixed forests; ii) temperate coniferous/mixed forests; and iii) warm coniferous/mixed forests.

The model predicts an increase of about one-third in the potential coniferous forest area with simultaneous 22% increase in its average NPP by the year 2050. Similarly, the coniferous forest area will increase by 43% and its NPP by 38% by 2080. However, a large part of the area simulated as forest in the model is actually degraded land or land under agriculture, orchards and grazing. Further, the model predicts only that there will be potential for an expansion in the forested area under the climate change scenarios. The actual change in forest area would however, depend mostly upon the ability of the species to migrate to new areas as well as on the activities of human beings in the forested areas.

The simulations also indicate as to how the optimal tree species for different areas might change with climate change as well as areas that are currently not suitable for forestry might become so as the climate changes. For the coniferous forest biomes under the 2050 climate change scenario (increased precipitation), the model predicts a change to a new type of biome over about 26% of the cold coniferous forests, over about 18% of the temperate coniferous forests, and no change for the warm conifers. These predictions for the year 2050 may be interpreted as follows:

- About half of area, where the natural vegetation is currently cold conifer, would change to a new dominant vegetation type: mostly to the temperate coniferous biome. In terms of actual changes in species composition, this would mean that in many areas where fir (*Abies pindrow)* and spruce (*Picea smithiana*) are currently dominant, more temperate coniferous species such as deodar (*Cedrus deodara)* and blue pine (*Pinus wallichiana*) would predominate.

- About 18% of the area currently occupied by temperate coniferous trees, would be replaced by warm conifers and chir pine (*Pinus roxburghii*) would move into areas currently occupied by fir, blue pine and deodar thus adding to its extent without acceding any ground to any other biome, up or down. Virtually none of the areas currently occupied by chir pine would change to a new biome and thus there would be little change in the species composition in areas currently occupied by this pine.
- Almost three-fourths of the area currently occupied by grasslands/arid woodlands would change to new biomes of higher order.

However, a greater number of fire outbreaks, erratic rainfall and pressure of human activities may not allow some species to move to new locations. The physical barriers, e. g. cropland, orchards and topographic features, may also hinder the movement of the species. Some economically important species, such as, deodar and fir will almost certainly decline in area and number due to interaction of climate change and socio-economic pressures, while others like chir pine and blue pine, which are tolerant to water stress, fire and grazing pressure, may increase due to reduced competition from associated species.

4. Socio-economic implications of ecological changes

The above-mentioned ecological changes of increase and shift in the extent, density cover and plant composition of cold, temperate and warm conifer forests, predicted by this study, may have the following socio-economic implications for future sustainable management of coniferous forests in Pakistan.

The above data show that area of alpine tundra decreases by about 17% in its extent in 2020, by about 32% in 2050 and by about 39% in 2080 to make way for trees. This will also result in reduction in alpine grazing areas which will adversely affect the socio-economic conditions of transhumant graziers. The remaining pastures would either come under increased grazing pressure resulting in their deterioration or the graziers would be compelled to reduce their herds or take them to the cold and temperate forests in search of fodder. This would also hinder the migration of cold conifer species to tundra areas.

The movement of one biome into one at higher elevation and increase in the areas of temperate and warm conifer forests may not actually happen due to a number of natural and man-made reasons. These include the possibility of *in situ* dieback occurring before the new dominant tree species has had time to migrate to the new sites due to, for example, absence of migration corridors. The sites, where fir is currently dominant may become warm causing its dieback. If this site is to be occupied by temperate conifers with changed climate then there would be time lag before blue pine and deodar could migrate to it and become fully established on it. During the intervening period, the ecosystem would be vulnerable to environmental and socio-economic disturbance e. g. erosion, deforestation, land-use change, increased availability of timber in the market, etc.

Increased socio-economic pressure due to increase in human and cattle populations which may also further aggravate the situation, and the net advantage of increase in forested area with climate change may become negligible.

5. Conclusion and recommendations

The overall impact of climate change on forest ecosystems in the mountain regions of Pakistan could be negative and management strategies will have to be formulated and implemented to cope with combined changes brought about by climatic, environmental and socio-economic conditions in the forestry sector in coming decades. Future management of the coniferous forests will have to be intensive and participatory in nature with heavy dependence on artificial planting in natural forests and on private farm and community lands with species, which besides being fast growing and providing needed products should also be able to adapt to a wide range of temperature and moisture regimes. Local people need to be involved in planning as well as execution of all management activities with emphasis on conservation of natural resources and biological diversity as well as prevention of forest fires. All land uses—forestry, agriculture, horticulture and grazing—should be integrated according to existing physiographic, climatic and edaphic conditions. Due consideration should be given to improving wood-use efficiency, and financial assistance to the people to prevent forest depletion. The main objectives of management should be welfare of local people; sustained and adequate supply of river water downstream for power generation and irrigation; and for conservation of biodiversity.

References

Amjad, M., Khan, N., and Shah, H. 1996. Forestry Statistics of Pakistan. Pakistan Forest Institute, Peshawar, Pakistan.

Anon. 1992. Forestry Sector Master Plan: National Perspective. Govemment of Pakistan, Planning and Development Division, Islamabad, Pakistan.

Anon. 1996. Climate Change 1993. Impacts, Adaptations and Mitigation of Climate Change: Scientific-Technical Analysis. Cambridge Univ. Press, Cambridge, UK.

Champion, H. G., Seth, S. K. and Khattak, G. M. 1965. *Manual of Silviculture.* Pakistan Forest Institute, Peshawar, Pakistan.

Haxeltine, A. 1996. *Modelling the Vegetation of the Earth.* Department of Ecology, Plant Ecology, Lund Univ., Sweden.

Khattak, A. K. 1992. Development of a Model Forest Management Plan for the Panjul Forest in Western Himalaya (Pakistan). Schriftenreihe Dev Forstwissen Schaftlichen Fakultat Ded Universitat Munchen and Dev Bayer, Forstlichen Versuchs-und Forschungsanstalt, Germany.

Knudsen, A. J. 1994. Deforestation and Entrepreneurship in NWFP, Pakistan. Chr. Michelsen Institute, Fantoftvegan, Norway.

Payr, G. 1997. Personal Communication

Siddiqui, K. M. 1997. *Forestry and Environment.* Pakistan Forest Institute, Peshawar, Pakistan.

Siddiqui, K. M., Mohammad, I. and Ayaz, M. 1997. Climate Change Impact and Adaptation Strategies for Forestry Sector in Pakistan. Pakistan Forest Institute, Peshawar, Pakistan.

Mathema, P., Dutta, I. C., Balla, M. K. and Adhikary, S. N. (eds.). 1999. *Sustainable Forest Management.* Proceedings of an International Seminar, 31 August – 2 September 1998, Pokhara, Nepal.

Sedimentation Monitoring of Phewa Lake, Kaski, Nepal

K. M. Sthapit and M. K. Balla

Abstract: This paper presents the results of the sedimentation survey done in Phewa Lake in February 1998. The total capacity of the lake is estimated to be 42.2 million m^3. About 74% of the coverage area and 87% of the water volume are in the Main Reservoir area. Similarly, 10 % of the coverage area and 8% of the water volume are in the River Channel. Only 16 % of the coverage area and 5% of the water volume are in the Silt Trap Area.

The annual sedimentation in Phewa Lake for the period from March 1990 to February 1998 is about 180,000 m^3 and in the Silt Trap Area alone, it is about 94,000 m^3. The total estimated average sediment contribution rate from the watershed is about 15 m^3 per ha for the same period. About 25.5 ha of delta has been formed at the mouth of the Harpan Khola between 1973 to 1990. Similarly, the delta expansion continued by 12.9 ha between 1989 to 1994 and 4.6 ha between 1994 to 1996. On an average, delta formation has been at a rate of about 2 ha annually since 1973. If this average annual sedimentation rate continues, 80% of the lake's capacity would be silted up in the next 190 years virtually making it useless. The Silt Trap Area depending upon the situation of Harpan Khola, will be completely filled up between 24 to 33 years reducing 16% (68 ha) of the lake area.

1. Introduction

Phewa Lake (in Nepali Phewa Tal) covering an area of about 439 ha is one of the prominent tourist attractions of Pokhara, the second largest tourist town of Nepal. This lake supplies water to generate one megawatt of hydropower and to irrigate approximately 320 ha of agricultural land. Conservation of the lake from sedimentation is of national importance. The lake watershed lies in a fragile physiographic region, which experiences intense monsoon rainfall events. It is one of the highest rainfall-receiving watersheds of Nepal. Intensive land use and construction of roads without due consideration to conservation measures are the major causes of the erosion processes in the watershed. This has transported an enormous amount of sediment to the lake thus reducing its capacity. Sedimentation monitoring of the lake became necessary for formulating strategies for soil conservation and watershed management and also for the management of the lake water for tourism, irrigation and hydropower production.

A sedimentation survey was carried out from 12 to 19 February 1998. The Department of Soil Conservation and Watershed Management had carried out sedimentation survey of the lake regularly since March 1990. This paper is based on the results of six surveys. Data from 1990 and follow-up data from May 1991, April 1992, December 1992, January 1994 and February 1998 have been used for analysis.

2. Phewa lake watershed

Phewa Lake watershed is situated in the western part of Pokhara Valley of Kaski District in the Western Development Region of Nepal (Figure 1). The watershed covers an area of 123 km^2. The lake outlet, which is at an elevation of 784 m marks the lowest part of the watershed whereas the Panchase ridge situated in the western part of the watershed is 2,589 m. Sidhane and Andheri Khola are the two major tributaries draining about 24.5% and 28.4% of the total watershed. Watershed areas (such as that of Marse) directly draining to the valley of the watershed accounts about 24.6% and the watershed directly draining to the lake account about 18.7% of the total watershed.

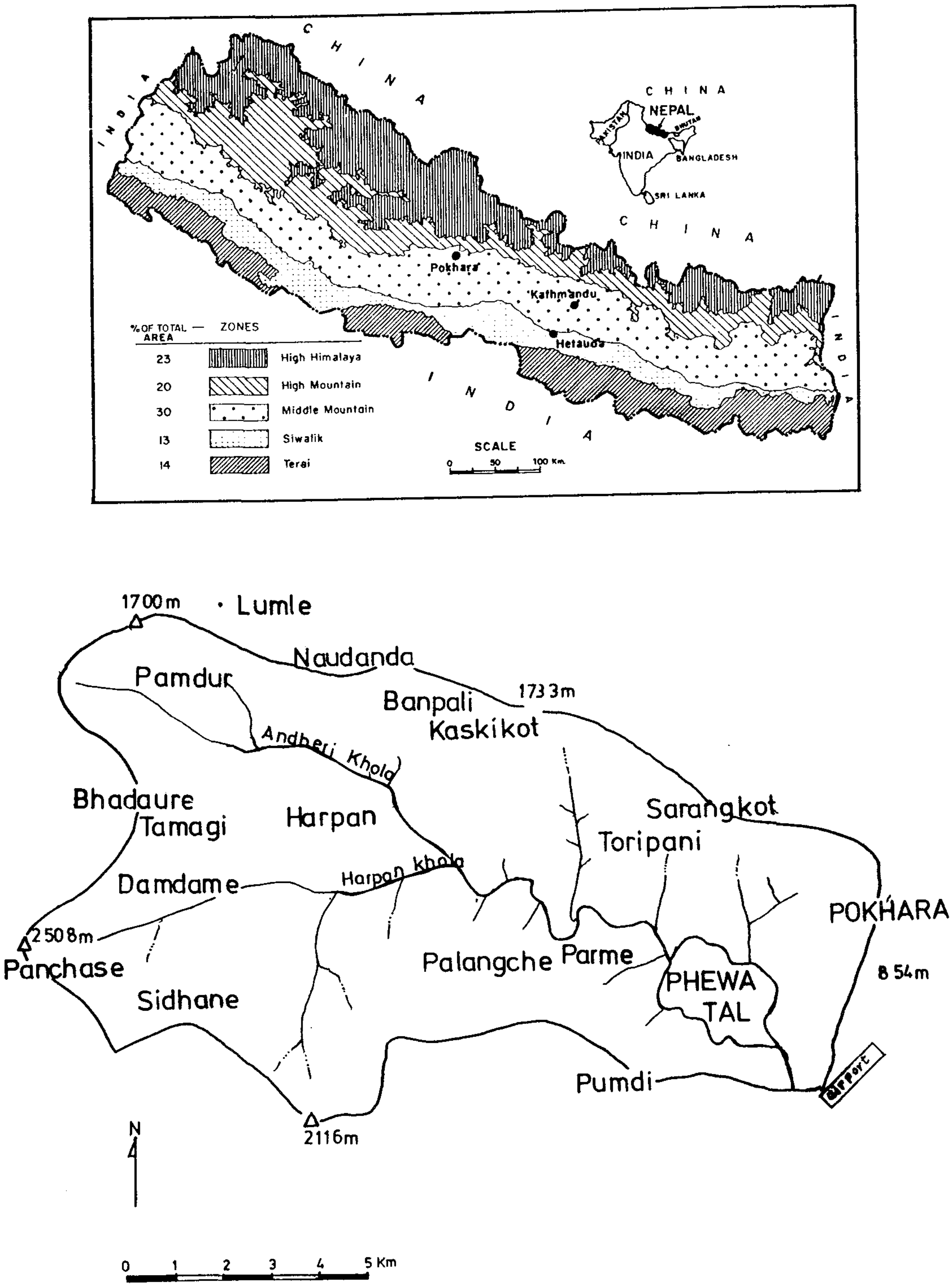


Figure 1. Location and orientation map of Phewa watershed

The mean annual rainfall (1971 to 1997) varies from 3,857 mm at Pokhara Airport (elevation 854 m) to 5,275 mm at Lumle (elevation 1,662 m), which is located in north west of the watershed. More than two-thirds of the annual rainfall occurs between June and September. Nine percent of the watershed area is too steep with over 60% slope, about 55% of the watershed area is in the slope class 30–60% and 13% of the area is in the slope class with less than 15% (IWMP, 1992).

Agriculture constitutes about 36% of the watershed area, forestry about 47%, shrubland about 2% and grazing and grasslands about 3%. The lake area covers about 439 ha and wet land covers about 66 ha. Abandoned and barren lands cover about 39 and 53 ha respectively. Landslides and gullies cover about 97 ha. However, many landslides have been stabilised with various conservation efforts. Out of 36% (or 4,448 ha) of agriculture land, only 47 ha of land is sloping terraces, about 83% is level terraces, 8% is valley cultivation and 7% is fan cultivation.

3. Survey programme

The survey was initiated in May 1990 by the FINNIDA assisted Integrated Watershed Management Project under the Department of Soil Conservation and Watershed Management. Since then surveys had been carried out annually till January 1994. With the lapse of four years, the present survey was carried out as the sixth effort.

Twenty benchmarks were established around the lake in the spring of 1990 and four additional benchmarks were added in March 1992 (nos. 21 to 24), to improve the coverage in the "Silt Trap area (I)" (Figure 2). The surveys in May 1990, May 1991, April 1992, December 1992, January 1994 and February 1998 were carried out using 12, 10, 11, 15, 19 and 18 lines of measurements respectively. Two benchmarks namely 7B and 7C were established between benchmarks 7 to 10 making a straight line. Also BM 7A was established in the north-east of benchmark 7, since locating BM 7 became too difficult due to low land.

The lake was divided into three parts for the study (Figure 2):

- Silt Trap Area (I): the western part of the lake consisting of the two bays. This part is heavily affected by sedimentation. Ten survey lines are established in this area.
- Main Reservoir Area (II): the main open lake area between the silt trap area and the Barahi-temple island. Eight survey lines are established in this area.
- River Channel Area (III): The portion from Barahi-temple island to the Pardi Dam. No fixed survey lines are established in this part. Free echo-sounding without stretching the rope but, directing the boat from one prominent mark to another prominent mark was carried out for preparing the bathymetric map.

4. Methods

4.1. Echo-sounding survey

The sedimentation survey of March 1990 was used as the base line information on the lake bed with reference to the highest water level + 794.15 m. The depth of water in the lake was measured from a rowboat with an echo-sounding instrument. The measured water depth is related to the reference water level (i.e. 794.15 m). Average water depth between benchmark to benchmark was computed for each cross-sectional profile using the reference water level. Any decrease in water depth indicates deposition (sedimentation of the lake) and any increase in water depth indicates erosion of the lake bottom. The sediment deposition or erosion is computed by multiplying the mean of the average water depths of two

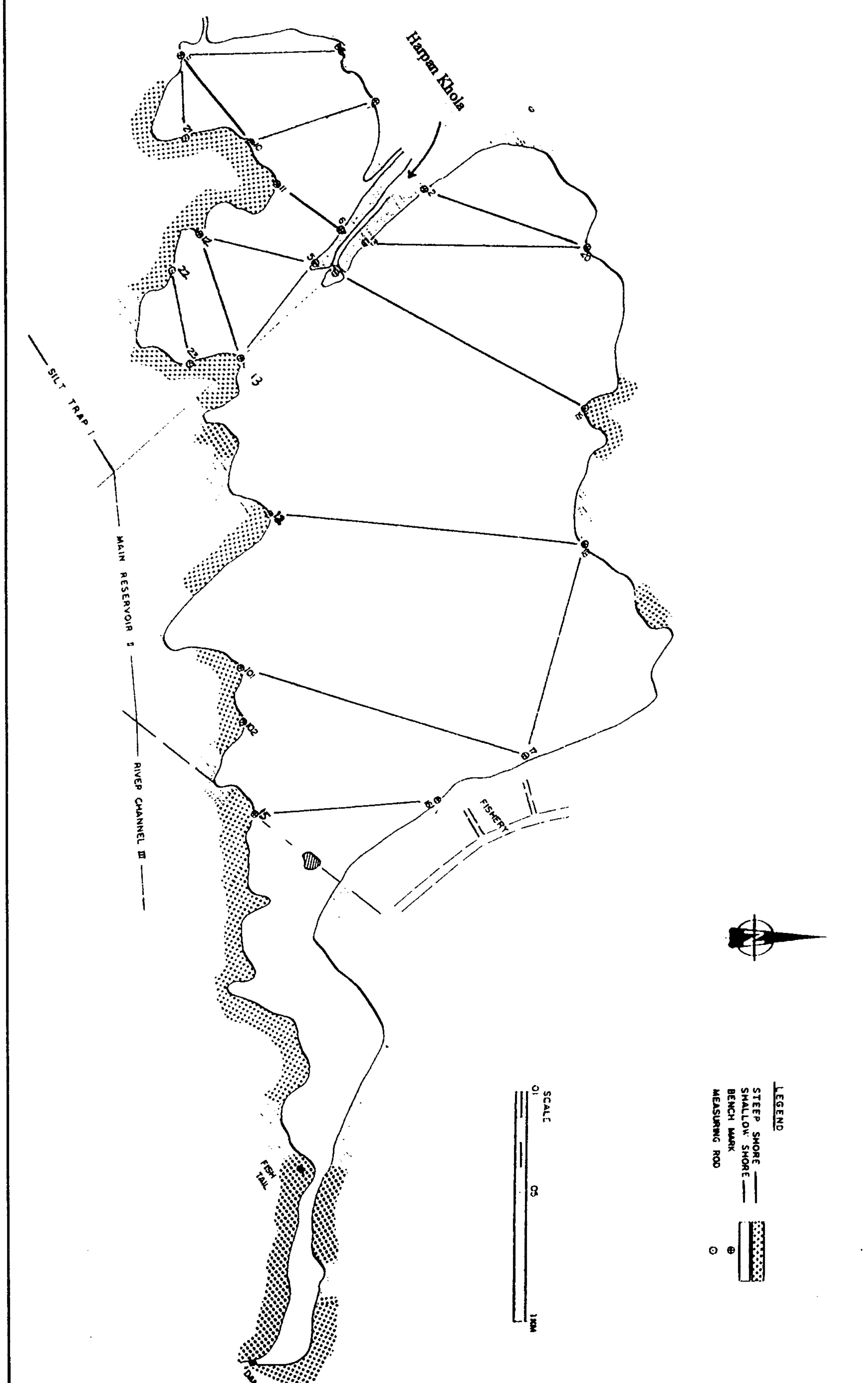


Figure 2. Map of Phewa Lake showing survey lines, February 1998

cross-sections by the area of the reservoir surface between those two cross-sections. It is believed that this method is reliable for estimating sediment deposition as this minimises errors.

The instrument used was a micro-processor-controlled depth recorder PS-20R Portable Precision Echo Sounder manufactured by Kaijo Dennico Co. Ltd., Japan. It continuously records depth to the bottom of the lake as the boat moves along a survey line.

The positioning of the survey line is fixed by stretching a rope between two benchmarks so that measurement can be made along the same fixed line repeatedly. The rope is marked at every 25 m interval and these positions are recorded in the chart during the echo-sounding survey. This ensures the location of the measurements with reference to the benchmark. Sounding is done during calm (windless) weather to assure easy boat handling and accurate measurements along a straight line. When the water depth was less than 2–3 m and the profile was not clear, the water depth was measured manually using measuring rod or rope with stone and incorporated with the echo-sounding graphs for the analysis.

The distance and water depth were recorded manually from the sounding profile and processes to estimate the average water depth using Microsoft Excel software.

4.2. Aerial photographs

Aerial photographs of 1973, 1989, 1991, 1994 and 1996 were also used to assess the growth of the delta over a long time period. The photographs helped to understand the sedimentation process near the river mouth and clearly show the growth of delta.

5. Results

5.1. Water depth

With respect to the reference water level (794.15 m), the maximum and the average water depth measured in March 1990, May 1991, April 1992, December 1992, January 1994, and February 1998 surveys are presented in Table 1 and changes in average water depth are given in Table 2.

During the February 1998 survey, the maximum depth measured with respect to the reference water level of 794.15 m in the lake was 23.62 m, whereas the estimated average water depth for the whole lake was about 9.60 m.

The changes in the maximum and average water depth do not follow the uniform declining trend (Table 1). The reasons might be one or more of the following:

- the accuracy of the instrument is not adequate for the slow sedimentation,
- the errors in measurement due to deviation in the survey line due to wind or not stretching the rope properly,
- the reference level at the Pardi Dam was not accurately recorded, since the marking in the scale is of 5 cm range,
- errors in reading the graphs, and
- the section has sedimentation in one season and erosion in another season due to change in under water current.

Also sediment distribution in the main reservoir due to its large size will be so thin that annual change in the average water depth may not be significant here.

Table 1. Maximum and average water depth in Phewa Lake

	Maximum depth (m)						Average depth (m)					
Lines	Mar'90	May'91	Apr'92	Dec'92	Jan'94	Feb'98	Mar'90	May'91	Apr'92	Dec'92	Jan'94	Feb'98
Silt trap area (I)												
13 to 4	9.03	8.91	9.32	10.36	9.52	10.62	5.11	4.56	5.23	5.40	5.06	4.29
5 to 13					8.62	10.63	4.76	4.69	4.62	4.46	4.52	3.14
13 to 12	7.68	7.33	7.43	7.59	6.93	6.28	6.81	6.39	6.60	6.70	6.02	4.88
12 to 5	6.66	6.18	6.00	6.22	6.40	6.38	3.75	3.48	3.47	3.35	3.41	2.76
6 to 11	4.68	4.54	4.51	4.49	4.42	10.53	2.56	2.49	2.23	2.07	1.49	1.52
10 to 7	5.68	5.29		5.21	5.31	5.18	3.26	2.91		2.70	2.15	1.98
8 to 9	3.58	4.04	3.97	3.77	4.23	4.07	2.50	2.83	2.78	2.66	2.72	2.50
9 to 10				5.79	5.68	5.83				4.46	4.45	4.24
9 to 21			5.91		6.07	5.95			4.59		4.65	4.53
22 to 23						10.57					8.96	8.27
Main reservoir (II)												
14 to 3	21.85	22.13		22.86	22.56	22.06	14.74	14.50		15.07	14.82	14.67
16 to 15	17.60	17.49	17.65	19.27	17.74	17.82	7.49	7.65	7.56	7.48	7.51	7.46
17 to 18	9.45		9.51	10.01	9.37	9.51	7.35		7.13	7.57	7.18	6.95
2 to 20	14.33			15.36	14.38	14.51	8.82			9.01	8.64	8.79
3 to 20					14.77	14.71					9.53	9.26
14 to 18					23.40	23.62					13.88	13.99
4 to 19					16.20	16.60					12.80	12.64
17 to 101					22.60	22.46					9.90	9.76

Table 2. Water depth changes in Phewa Lake

Lines	Depth change (m)						
	Mar'90 to May'91	May'91 to Apr'92	Apr'92 to Dec'92	Dec'92 to Jan'94	Mar'90 to Jan'94	Mar'90 to Feb'98	Jan'94 to Feb'98
Silt trap area							
13 to 4	-0.55	0.67	0.17	-0.34	-0.05	-0.82	-0.77
5 to 13	-0.07	-0.07	-0.16	0.06	-0.24	-1.62	-1.38
13 to 12	-0.42	0.21	0.10	-0.68	-0.79	-1.93	-1.14
12 to 5	-0.27	-0.01	-0.12	0.06	-0.34	-0.99	-0.65
6 to 11			-0.16	-0.58	-1.07	-1.04	0.03
10 to 7	-0.35			-0.55	-1.11	-1.28	-0.17
8 to 9	0.33	-0.05	-0.12	0.06	0.22	0.00	-0.22
9 to 10				-0.01			-0.21
9 to 21							-0.12
22 to 23							-0.69
Main reservoir							
14 To 3	-0.24			-0.25	0.08	-0.07	-0.15
16 to 15	0.16	-0.09	-0.08	0.03	0.02	-0.03	-0.05
17 to 18			0.44	-0.39	-0.17	-0.40	-0.23
2 to 20				-0.37	-0.18	-0.03	0.15
3 to 20							-0.27
14 to 18							0.11
4 to 19							-0.16
17 to 101							-0.14
19 to 4							-0.16

5.2. Lake's storage capacity

During the highest water level, the area of lake is 439 ha and the total capacity of the lake is estimated to be 42.2 million m^3 (February 1998). About 74% of the coverage area and 87% of the water volume are in the Main Reservoir area (II). Similarly 10% of the coverage area and 8% of the water volume are in the River Channel (III). Only 16% of the coverage area and 5% of the water volume are in the Silt Trap Area.

5.3. Sedimentation

Generally, Phewa Lake has broad and gentle sloped lake bottom except at the gorge portion. The sediment distribution is quite thin and in many places is beyond the accuracy of the instrument for the sediment computation on annual basis. The sedimentation up to January 1994 had been computed by the Department of Soil Conservation and Watershed Management. The deposition or erosion of sediment is computed by multiplying the mean of the average water depths of two cross-sections by the area of the reservoir surface between those two cross-sections (Table 3).

The sediment deposited in the main reservoir is calculated by multiplying the average depth of the cross sections and the area of the reservoir surface between those cross-sections. The total sediment deposited in the whole lake during 1990 to 1991, 1990 to April 1992, 1990 to December 1992 and 1990 to January 1994 were estimated as 177,260; 417,600; 545,330 and 859,490 m^3 respectively (DSC, 1994). Therefore, the average annual sediment deposition in the lake was estimated to be 213,620 m^3 for the period 1990 to 1994. The sediment deposited in the silt trap area during 1990 to 1991, 1990 to April 1992, 1990 to December 1992 and 1990 to January 1994 were estimated as 129,020; 212,600; 267,980 and 480,670 m^3 respectively. (DSC, 1994) Therefore, average annual sediment deposition in the silt trap area is estimated as 120,170 m^3 for the period 1990 to 1994.

Analysis showed that the total sediment deposited in the main reservoir and silt trap area are 307000 m^3 and 271000 m^3 respectively for a period of about four years (January 1994 to February 1998), and 578,000 m^3 for the whole Phewa Lake. Therefore, the mean annual estimated sedimentation rate during January 1994 to February 1998 in the main reservoir and silt trap areas are about 76,750 and 67,750 m^3 respectively and for the whole Phewa Lake, it is about 144,500 m^3.

The total estimated average sediment contribution rate from the watershed is about 17 m^3 per ha for the period from 1990 to 1994 (DSC, 1994), about 12 m^3 per ha for the period 1994 to 1998 and 15 m^3 per ha for the period from 1990 to 1998. The average annual sedimentation rate in the Phewa Lake for the period from March 1990 to February 1998 is about 180,000 m^3 and in the silt trap area, it is about 94,000 m^3.

5.4. Delta formation

Rapid sedimentation in the lake started the formation of a delta at the mouth of Harpan Khola. The delta formation was assessed by comparing the aerial photographs of 1973, 1989, 1991, 1994 and 1996. The area of the delta exposed depends on the water level and presumably when the aerial photographs were taken, the lake had different water levels. The delta as exposed in different aerial photographs was mapped at 1:10,000 scale map showing the silt trap area. With the limitation of the different water level in the lake, about 25.5 ha of delta is formed between 1973 to 1990. Similarly, the delta expansion continued by an additional 12.9 ha between 1990 to 1994 and 4.6 ha between 1994 to 1996. On an average, delta formation has continued at the rate of about 2 ha annually since 1973.

Table 3. Sediment calculation, Phewa Lake echo-sounding survey, January 1994 to February 1998

Cross section	With reference to the highest water level (794.15 m)					Change in water volume (ha-m)	Remarks
	Surface area of Lake in ha	Average water depth (m)		Volume of Water in (ha-m)			
		Jan '94	Feb '98	Jan '94	Feb '98	Jan '94 to Feb '98	
Main reservoir							
Line 15 to 16 and 17 to 101	35.5	8.7	8.6	309	305	-3.4	The total area of the lake does not tally since the lake area Downstream from 15 to 16 section is not included because of lack of survey lines.
Line 17 to 101,17 to 18 & 14 to 18	95.2	10.3	10.2	982	974	-8.2	
Line 14 to 18, 19 to 4 & 14 to 3	78.0	13.8	13.8	1079	1073	-5.2	
Line 19 to 4 & 3 to 20	41.5	11.2	11.0	463	454	-8.9	
Line 3 to 20 & 2 to 20	8.5	9.1	9.0	77	77	-0.5	The sedimentation in the Main Reservoir is estimated
Line 13 to 4 & 14 to 3	3.4	9.9	9.5	34	32	-1.6	As 30.7 ha.m and 27.1 ha.m in the Silt Trap area.
Triangle							
Line 2 to 20	13.7	8.64	8.79	40	39	-1.0	
Line 17 to 18	23.9	7.18	6.95	57	55	-1.9	Total sedimentation of the Phewa lake between January 1994 to February 1998 is 57.8 ha. m
	37.6					-2.9	
	299.7	78.9	77.8	3040.9	3010.2	-30.7	
Silt trap							
Line 13 to 4 & 13 to 5	2.0	4.79	3.72	9.7	7.6	-2.2	
Line 12 to 13, 13 to 5 & 12 to 5	9.7	4.65	3.59	45.1	34.8	-10.2	
22 to 23 & 12 to 13	6.8	7.49	6.58	51.0	44.8	-6.2	
Line 12 to 5 & 6 to 11	8.6	2.45	2.14	21.1	18.4	-2.6	
6 to 11 &7 to 10	13.4	1.82	1.75	24.4	23.5	-0.9	
Line 7 to 10, 9 to 10 & 8 to 9	15.1	3.11	2.91	46.9	43.9	-3.0	
Line 9 to 10 & 9 to 21	3.4	4.55	4.39	15.5	14.9	-0.6	
Triangle							
Line 22 to 23	3.8	8.96	8.27	11.5	10.6	-0.9	
Line 8 to 9	4.2	2.72	2.50	3.9	3.6	-0.3	
Line 9 to 21	2.3	4.65	4.53	3.5	3.4	-0.1	
Total	69.5	45.2	40.4	232.7	205.6	-27.1	
Grand total	369.1	124.1	118.2	3273.6	3215.8	-57.8	

5.5. Life span of the lake

The capacity of the lake is estimated as 42.18 million m^3 with highest water level of +794.15 m. If the lake is considered to be dead, when 80% of the storage is silted up and if the annual sedimentation rate of about 180,000 m^3 continues, the lake will be dead in about 190 years.

With the annual average sedimentation of about 94,000 m^3 in the silt trap area of about 68 ha it will be completely filled in the next 24 years. However, the result depends on how the Harpan Khola shifts within the deltas. The aerial photographs of 1989 and 1991 indicated that the Harpan Khola was draining in the upstream part of the silt trap area. Similarly, aerial photograph of March 1994 indicated that the Harpan Khola shifted to drain in the downstream part of the silt trap area, whereas the aerial photograph of February 1996 indicated that the Harpan Khola started draining to the main reservoir area. Therefore, prior to 1996, the Harpan Khola was mainly draining to the silt trap area allowing it to silt up quickly. Since then the river was directly draining to the main reservoir near the end part of the silt trap area. This is one of the reasons why the annual sedimentation of silt trap area between 1994 to 1996 was only 67,750 m^3 compared to 120,170 m^3 for the period of 1990 to 1994.

If the sedimentation rate of 67,750 m^3 continues in the silt trap area, it will be completely filled up only in the next 33 years. The growth of the delta at the rate of about 2 ha per year also indicates that in about 33 years the silt trap area of about 68 ha will be completely silted up. Therefore, depending upon the situation of Harpan Khola, the silt trap area will be completely filled up in between 24 to 33 years, thus reducing the lake area by 16%.

6. Issues and discussion

6.1. Soil conservation and watershed management

Soil Conservation and Watershed Management Programmes have been implemented in the Phewa watershed since 1974. The main conservation measures were: planting of trees and grasses on degraded lands, introducing fruit trees on marginal lands, on-farm conservation, conservation ponds maintenance, road-slope stabilisation, irrigation canal improvement, trail improvement, gully and landslide stabilisation, torrent control, stream bank protection, and promotion of community forestry. Compared to the Soil Conservation and Watershed Management Programmes proposed by "Watershed Management Plan of Phewa Tal Watershed" prepared in 1992, the scale of conservation intervention so far carried out under the Department of Soil Conservation and Watershed Management in the watershed in the last 23 years has been negligible. This is more so in the case of forest and pasture improvement and management, stream bank protection and on-farm conservation activities. Therefore, there is a great need for extensive conservation intervention to significantly reduce sedimentation in the lake. Today the challenge is to develop a package of conservation measures that would be socially acceptable and economically regenerative so that the measures will be adopted by the people themselves. Experience has shown that landslide and stream bank cutting contributes most of the sediment in the lake, therefore landslide treatment and stream bank protection measures should be emphasised if the sedimentation of the lake is to be significantly reduced.

Since 1990, four main roads namely: Naudanda–Silinge Bot (about 10 km); Naudanda-Adhikari Gaon (about 5 km); Kalanchowk–Chapakot Ghanti Chhina (about 16 km) and Kande–Bhadaure Deorali (about 5 km) have been constructed by the local initiative.

Road construction without proper conservation measures has been one of the main causes of sediment contribution. Similarly, about 6 km of Pokhara–Baglung Road passes through the Phewa watershed. Therefore, environment friendly road design and necessary conservation measures should be an integral part of road construction.

In general, the data indicates that during pre-monsoon (March to June), when the plant cover is poor and the soil is much disturbed by ploughing, the soil loss is more than during the monsoon season. Therefore, conservation farming that introduces cover crops during the period of March to June is essential to protect the soil from erosion in the watershed and to reduce sedimentation in the lake.

6.2. Prioritisation of sub-watersheds

The sediment contribution from the sub-watershed areas directly draining into the lake will be more than the distant sub-watersheds. This will be more so in case of the sub-watershed lying in the southern aspect. The sub-watershed in the south and north aspects directly draining to the lake constitute 13.7% and 5% of the total watershed area, respectively. Similarly, watershed in the south and north aspects draining to the valley area constitute 14.2% and 10.4% of the watershed area, respectively.

The sub-watersheds draining to the valley and directly draining to the silt trap area have more landslide areas demanding more attention in the landslide and gully control works. IWMP (1992) ranked the watershed directly draining to the silt trap area as top priority sub-watershed for the Soil Conservation and Watershed Management Programmes. Since then many of the landslides have been stabilised and forests now cover 63% of the watershed. Therefore, this watershed may not be in top priority anymore.

The watershed of Pokhre Byase Khola drains to the river channel area of the lake in the south. More than half of it is urban and about 22% is covered by forest. And also most of the flow during the monsoon goes outside the lake because of its location close to the dam outlet and irrigation channel at the east bank. IWMP (1992) ranked the sub-watershed at twelfth. The sub-watershed draining to the river channel at the northern aspect is mostly forest. Therefore, from the sediment point of view, these sub-watersheds are not considered to be priority watersheds.

Sediment transportation efficiency in the watershed is affected by the slope gradient of the river system. The river systems directly draining to the silt trap area in the northern aspects have the greatest slope gradient. The river systems draining to the valley in the northern and southern aspect also have steep slope gradient. Therefore, sub-watersheds of the southern aspect of the watershed draining to the valley and sub-watersheds draining directly to the silt trap area should be prioritised for Soil Conservation and Watershed Management Programmes.

6.3. Sediment management

Sediment management within the watershed is an important activity for the conservation of a reservoir or lake. The Phewa watershed has a valley and fan cultivation of about 376 and 327 ha, respectively. These account for about 3.1% and 2.7% of the total watershed areas and about 10% and 9% of the total agriculture lands, respectively. This is the area where paddy is grown annually. Fortunately or unfortunately, nutrient laden silt from the mountain watershed contributes in maintaining the productivity of paddy in the valley without much external input. Therefore, necessary measures to trap the silt from the mountain watershed in those valley and fan cultivation areas could be a potential measure in the sediment management in the watershed to conserve the lake. Also, sediment management should include construction of sediment traps in the watershed.

7. Conclusions

If the sedimentation rate of about 180,000 m^3 continues, 80% of Phewa lake's storage capacity would be silted up in the next 190 years. The silt trap area depending upon the situation of Harpan Khola, will be completely filled up in between 24 to 33 years.

Due to its large size, the annual change in the average water in the main reservoir may not be significant, therefore sediment monitoring survey is recommended every five years. For a more reliable sedimentation record, survey lines need to be added and some benchmarks need to be replaced or repaired.

Sediment monitoring is a tool to guide the concerned agencies for the formulation of necessary strategies to protect the lake from sedimentation. Long term sedimentation monitoring is essential for a better understanding of lake sedimentation process. Similarly, studies to understand the relationships between climate and erosion processes in the watershed and sedimentation in the lake are needed.

References

DSC. 1994. Sedimentation Survey of Phewa Lake, January-1994. Department of Soil Conservation, Babar Mahal, Kathmandu, Nepal.

IWMP, 1992. Integrated Watershed Management Plan for Phewa Tal Watershed. Integrated Watershed Management Project, Phewa Tal and Kulekhani Watersheds. Department of Soil Conservation, Babar Mahal, Kathmandu, Nepal.

Mathema, P., Dutta, I. C., Balla, M. K. and Adhikary, S. N. (eds.). 1999. *Sustainable Forest Management.* Proceedings of an International Seminar, 31 August – 2 September 1998, Pokhara, Nepal.

Participatory Planning, Monitoring and Evaluation Process in Integrated Watershed Management

M. P. Wagley

Abstract: Sustainable integrated watershed management approach needs participatory planning, monitoring and evaluation (PPME). PPME is a process in which local communities are involved at all stages of project cycle. PPME is a dynamic and creative approach for community development which should be developed and carried out by the local community themselves based on their own indicators and judgement.

PPME helps in organising and empowering the farmers to take leadership in the decision-making process. It helps reverse the traditional practices and top-down planning and development approach by devolving the leadership and decision-making role to local communities. It also strengthens the abilities of local communities to identify their needs and objectives and to monitor and evaluate these needs within the project environment. This paper discusses the methods and steps to develop indicators, norms and formats for PPME process which can be easily adopted by local farmers.

1. Introduction

Watershed management not only initiates physical development of natural resources but more importantly community development as well. Development of a community is a process which primarily begins with identifying their problems and needs, and doing something about it. Watershed management programmes in the past suffered severe setbacks because of the passive role assigned to the local people in the overall management and implementation of the programme. Now, various concepts and models of participatory planning are developed in order to meet specific and sustainable integrated watershed management objectives. In this context, this paper highlights participatory planning, monitoring and evaluation approach for sustainable integrated watershed management. Key elements of participation, their indicators, various steps, methods and importance of participatory planning monitoring and evaluation (PPME) in watershed management are discussed.

2. Participatory approach

The term "participatory" connotes different things to different projects and people. In general, it means involving the users, farmers or beneficiary groups in a development programme. It begins at the initial stages of identifying, selecting, designing and planning through the implementation, monitoring and evaluation stages and lasts up to the follow-up or maintenance stage. It requires willingness and commitment of the community to work voluntarily and to contribute their time, energy and labour in order to achieve the intended objectives of a particular programme. However, at a more dynamic level and in terms of mobilising the community towards development, participatory approach involves active collaboration of all groups such as policy-makers, officials and beneficiaries. In other words, involvement of all kinds of beneficiaries (primary, secondary and tertiary) is essential in participatory watershed management.

Sustainable and sound participatory approach should be designed to: develop self-reliance; develop responsibility; create awareness; mobilise self-help group; empower the poor; contribute human resources; organise for collective action; and make people feel part of the action.

Participatory approach requires willingness to work voluntarily; dedication; contribution of time, energy and labour; commitment and feeling of responsibility on the part of the participating groups.

3. Participatory planning

Participatory integrated watershed planning is a process which brings the community (primary stakeholder) to the centre of decision-making. It is also an interactive planning process that helps the community to identify and analyse their needs, problems, constraints, opportunities and alternatives based on which the community prepares its own plans and programmes. In a participatory planning process, all relevant actors such as women, minority group, farmers, poor, rich, young and old are brought together for an integrative planning exercise. Participatory planning, being an interactive process provides equal opportunity to all in preparing a participatory plan and developing mechanisms for conflict resolution and consensus building. It initiates a process for community development with special focus on integrated watershed management. The process helps create a sense of ownership and awareness. It also strengthens the planning and decision-making capabilities of resource poor community inhabiting a watershed. Participatory planning: helps a community to make a plan according to their needs. It emphasises mobilising local resources and helps translate the plan into reality.

3.1. Process for participatory planning

Participatory planning involves several stages that need to be completed by the interactive and collective action of the community. The process starts with identification, assessment and analysis of bio-physical, socio-economic, cultural and institutional aspects of local environment to prepare a participatory watershed management plan.

Stage I: At this stage, the community will try to understand the existing situation of their natural resources. The community will become familiar with their problems, constraints, and opportunities for the management and sustainable utilisation of watershed resources. Various PRA tools can be used to accomplish these tasks. Most appropriate tools are: Participatory Watershed Mapping, Transect Walk, Pie Chart, Participatory Discussion, Seasonal Calendar, etc.

Stage II: At this stage, the social and cultural set-up of the community living in the watershed will be identified. The role of local institutions and various other organisations which are working in the watershed will also be assessed through interactions and participation of local community. Gender issues and their roles in terms of resource benefits will be identified. This information will help examine the community's ability and their level of maturity for implementing participatory watershed plan in future. Several PRA tools such as Social Mapping, Time-line, Venn Diagram and Participatory Discussion can be used to collect the required information.

Stage III: At this stage, a need assessment exercise will be carried out. Identification of problems and constraints, assessment of needs, possible solution, alternatives and envisaged actions or possible ways to address the problems and their prioritisation will be done. These assessments will be done through interactive and collective thoughts and reflections of the group participating in this exercise. Matrix Ranking and Participatory Discussion are the PRA tools to be used in need assessment exercise.

Stage IV: The next step is community envisioning. It includes identification of the community's vision on common matters. The main purpose of community envisioning is consensus building and to make the local people capable of choosing the best possible watershed management programmes based on common concern or interest. This exercise not only assists in identifying the common interest of the community but also helps in decision-making, creating awareness and consensus building. The PRA tool to be used at this stage is Participatory Discussion.

Stage V: This is a stage for preparing a draft version of participatory watershed management plan. The draft plan will be prepared by an active participation of the community and is based on the information collected from the above mentioned exercises. The representatives of the community, with the help of motivators, prepare the plan based on locally available resources, the community's implementation ability, knowledge, skills and expertise. The plan should be cost effective and based on the community's ability to contribute. The contents of the plan should be simple and clear.

Stage VI: At this stage, the draft version of the plan will be made public. All the participating members of the community will be invited in the presentation of the draft plan. Valid comments and suggestions from the members should be taken into consideration. Finally, there should be a general consensus and commitment from the community for the approval of the plan.

Stage VII: After the plan is approved, the community, with the help of motivators, needs to develop a participatory monitoring and evaluation mechanism for the participatory plan.

4. Process for developing participatory monitoring and evaluation mechanisms (PME)

4.1. Participatory monitoring

Participatory monitoring is a process in which the community takes responsibility for monitoring the activities proposed in the participatory watershed plan. In participatory monitoring approach, representatives from the community should be elected to form a small participatory monitoring group. The task of this monitoring group is to review each activity at all levels of implementation and to ensure proper and timely implementation of plans. Corrective actions are also taken, if necessary.

Participatory monitoring is a self-monitoring process which is to be carried out by the participatory groups. Therefore, monitoring system should be designed by the group for its own use. Monitoring group should also be responsible for generating monitoring indicators. Measuring, recording processing and communicating the indicators should also be done by the monitoring group. Group promoters or facilitators should support the monitoring group for generating monitoring indicators and other measurements. In a broad sense, monitoring is to assess inputs and outputs of the activities. Therefore, the monitoring indicators should be based on inputs and outputs of the activities.

4.2. Participatory evaluation

Participatory evaluation is a process in which the monitoring groups take overall responsibilities for systematic analysis of data on indicators. It should be carried out at regular intervals. After analysing the data, the groups should adjust, re-define or re-organise the activities of the participatory plan as necessary. Group promoters or facilitators should provide necessary training and support to the groups to carry out participatory monitoring and evaluation. In general, evaluation process should also evaluate the impacts of the activities. Therefore, the indicators for evaluation should be based on impact of the activities.

4.3. Participatory monitoring and evaluation (PME)

PME is a process which allows continuous monitoring and evaluation of planned activities to assess the inputs, outputs and their impacts in the watershed area. PME can also be used to assess whether the participatory watershed plan is sustainable in terms of physical and socio-economic sense. The PME should address the following issues of participatory watershed management plan:

- ***effectiveness*** of the plan, i.e. whether the participatory plan has achieved the desired results
- ***efficiency*** of the plan, i.e. whether the local resources have been wisely and timely used according to the plan
- ***relevance*** of the plan, whether the plan has been effective in addressing the community needs
- ***impact*** of the plan, i.e. whether any change has occurred after implementing the plan.

PME system should consists of the following:

- developing indicators for inputs/outputs and effects/impacts
- selecting and designing data collection techniques
- identifying appropriate tabulation methods and techniques for analysing data
- reporting system.

For PME of integrated watershed management activities, understanding of the following levels of inputs, outputs and impacts are imperative:

Inputs - goods, services, money, labour, time, skill, knowledge, technology and other resources to be provided for an activity Examples: seedlings, seeds, water, fertiliser, wire, cement, stone, sand, soil, bamboo, etc.

Outputs - specific products or services which an activity is expected to produce from its inputs in order to achieve the planned objectives. Examples: plantation done, check dam constructed, nursery established, water sources protected, embankments constructed, roads constructed, area fenced, user groups formed, forest handed over, forest demarcated, terraces improved, etc.

Impacts - overall outcome of the specific effects of project or programme. Impacts may be defined as the change in the condition of things resulting from the project or programme. Examples: Physical environment stabilised, soil erosion controlled, degraded land rehabilitated, income of local farmers increased, productivity of land improved, etc.

4.4. PME charts and formats

Data collected from PME system should be presented in a readable format, charts and graphs. Formats should represent all levels of inputs, outputs and impacts in each activity of the plan. The formats should be as simple as possible so that any member of the community can easily understand and fill in the information. The information can be recorded by figures, diagrams or by any other symbols, or locally available materials.

4.5. Steps of PME

PME group should follow the following steps:

- understand the goal and objectives
- identify the activities
- develop indicators to measure inputs/outputs and impacts
- develop tools to measure the indicators
- present the information in simple formats and
- develop charts for each activity including the plan of action, target and achievement.

4.6. Indicators

An indicator is the parameter to measure changes and assess the results or progress of an activity. Depending upon the objectives, indicators should be developed for each activity. Indicators should be Specific (S), Measurable (M), Attainable (A), Realistic (R) and Time-bound (T), i.e. SMART. The indicators should reflect: target group, quantity, quality, place, site or location and time.

Example: For a specific objective like "the incomes of 100 farmer households in the Jhiku Khola watershed are to be increased by 20% yearly". In this statement the indicators to be measured are: target group (farmers household); quantity (100 farmers); quality (20%); site (Jhiku Khola); and time (yearly).

Examples of some indicators

(a) Indicators for Organisation Strengthening:

- number of villagers who know or who have heard about organisation or groups
- frequency of attendance of participants at meetings
- number of meetings held per month
- changing size of membership in the organisation.

(b) Indicators for Group Participation:

- number of groups or rural organisation formed
- number of members in groups
- social composition of groups
- number and attendance at meetings
- number of person-days of labour contributed
- local knowledge and skills used for local planning, materials and money contributed by group
- number of members assuming the responsibilities of office bearers
- funds collected form local sources and used for maintenance work
- participation of members

- amount of savings mobilised
- capacity for maintaining local facilities.

(c) Indicators for Soil Conservation Activities:

- degree of rehabilitation of degraded and critical areas
- community forests protected, managed and utilised
- forest area increased
- biodiversity protected and increased
- landslides, soil erosion, and floods decreased
- water source protected and increased
- decreased incidence of environment related diseases, disasters and accidents.

The indicators for assessing monitoring and evaluation must be identified at the time of setting the objectives and goals of watershed management plan. The group must develop indicators in order to avoid negative consequences. Pre-identification of indicators enables participating community to follow appropriate and positive actions in order to achieve the intended objectives of the participatory plan. This will also increase awareness in the community about the importance of PME and help them change their priorities and actions, which in turn, helps sustaining the projects and programmes.

4.7. Tools

After designing the indicators, tools to measure the indicators should be decided upon. Some PRA tools can be used to collect data and information, e.g. participatory field visits, group discussion among members of the community; and interview with individual farmer/member. At the community level, the participatory M/E groups can also collect the data through group discussion among themselves and direct observation of activities at the site. Data should be collected in a simple form, in the local language and at regular intervals.

4.8. Application of PME

PME has been found valuable for small-scale rural development projects. Participatory monitoring and evaluation of a project is entirely the responsibility of the participating community. It is a self-reliance and self-help-oriented practice for project monitoring and evaluation. PME serves three purposes:

- improves the farmers' efficiency and effectiveness in project management and decision-making
- increases awareness and understanding of the various aspects of project planning and implementation
- strengthens and enhances the spirit of collaborative action and networking.

4.9. Advantages of PME

PME is a participatory process which not only enhances the capability of individual people to plan and manage their own resources but also empowers and equips groups to make appropriate management decisions by enhancing their knowledge, skills and capability. It will help the community to manage their resources sustainably through participatory collaborative action.

PART 4:

WILDLIFE AND BUFFER ZONE MANAGEMENT

Mathema, P., Dutta, I. C., Balla, M. K. and Adhikary, S. N. (eds.). 1999. *Sustainable Forest Management.* Proceedings of an International Seminar, 31 August – 2 September 1998, Pokhara, Nepal.

Participatory Protected Area Management in India: Prospects and Problems

P. C. Kotwal

Abstract: Rural communities depend on nearby forests and protected areas for fuelwood, grazing and other forest products. Wildlife cannot be protected without safeguarding the livelihood of local people. The forest dwellers should be involved and their traditional knowledge should be duly recognised in protected area management. Therefore participation of local people in protected area management is the need of time. This paper discusses some of the approaches followed in India.

1. Introduction

The strategy of protected areas for *in situ* conservation of biodiversity has evolved to allow natural processes to continue and to protect natural forests from destruction due to various developmental activities. In India the concept of protected areas started during British period by the princely states in the form of special hunting areas for the kings. These areas were dense natural forests rich in wild animals. Barring the king, nobody was allowed to make any disturbance in the hunting area. These hunting areas were protected and many of them later on became protected areas (PAs).

The local people's traditional conservation ethics are reflected in the form of sacred groves which are spread in rural areas all over the country. These are small groves of natural forest or old trees religiously protected by the local people since time immemorial. Such traditional ways of conservation have attracted the attention of scientists and several publications have also come out (WWF, 1996; RCNAEB, 1997).

During 1930s several sanctuaries were declared for conservation of wildlife *in situ*. These sanctuaries continued to receive special conservation status even after independence. Some more were declared and notified as national parks under the existing rules at that time. Realising the importance of conservation, protection and management of wildlife, a comprehensive Wildlife (Protection) Act, 1972 was promulgated. Thereafter, most of the protected areas were declared in the form of national parks and sanctuaries. At present there are 85 National Parks (35,919 km^2) and 448 Wildlife Sanctuaries (1,12,274 km^2) in India (GOI, 1997). These belong to IUCN category II and V. There is a plan to have 5% of the geographical area of the country under protected areas representing different biogeographic regions of the country (Rodgers and Panwar, 1988). Accordingly, there will be 148 National Parks and 508 Wildlife Sanctuaries in the country.

These protected areas are spread over the length and breadth of the country. Although, most of these protected areas exist in remote rural areas with relatively low density of human population, about five million people are affected by the protected areas and also affect the protected areas in several ways. Actually, this is a cause and effect phenomenon and requires study on the past background of the people, the forest and their inter-relationships.

The PAs are meant for wildlife conservation and the management activities directed towards maintaining them in pristine wilderness. The people in and around the PAs are seriously affected due to restriction of their access to the protected areas for their daily requirements of fuelwood, cattle grazing, medicinal and food plants, etc. The declaration of PAs resulted in the denial of erstwhile privilege of using forest resources by the local communities. The increased number of wildlife also damage crops, livestock and other property. The problem has assumed more serious proportion particularly to the communities living within PAs for whom there is a general provision of relocation outside and away from the PAs although, this has been a stupendous task.

Several people have argued that the rights of local people do not receive the same attention as the wildlife in the PAs. Many conservationists, however, counteract by arguing that the access of local people to forest resources is restricted only to protected areas comprising about 4.6% of the geographical area of the country, which contain 49,219 species of flora and 81,251 species of fauna. The remaining 95% area is still left for use by human beings including tribals. The requirements of wildlife and local people are different and do not go together particularly within the protected areas (Table 1).

Table 1. The requirements of wildlife and local people

Wildlife	Local people	Remarks
Shelter: tranquillity and isolation from human disturbance	House for living: safety from any possible damage by wild animals	Point of possible conflict
Water: for drinking and other needs	Water: for self, cattle and irrigation	Conflict if the water point is common
Food: variety of natural vegetation for herbivores, adequate prey base for carnivores	Livelihood: agriculture, cattle rearing, forest produce collection	Conflicts on all points
Protection: from animal poaching, forest cutting, fire, diseases, etc.	Developmental activities: roads, electricity, school, hospital, market, etc.	Conflicts on all points

The demands of the local people have also increased over a period of time, while the forest resources have been constantly depleting in extent and content. Several instances of conflicts between man and wildlife have been recorded. The wild animals are usually blamed for damage to man and his property. However, a rational analysis of the situation reveals that man is encroaching upon the habitat and food of wild animals.

2. The conflicts

The protected areas generally contain more and better resources utilisable by the local public. The need and availability of the resource force the local people to break the legal barriers and enter the protected areas. The following types of conflicts have been noticed in India which may be common to most of the protected areas under similar conditions:

- collection of fuelwood and small timber
- grazing of cattle
- collection of non-wood forest products
- fishing
- hunting - traditional as well as planned
- illegal collection of wildlife products such as bones, antlers, pelt, etc.
- crop raiding by wild herbivores
- damage to houses and other property by elephants
- cattle lifting/man killing by carnivores
- non-living resources, such as minerals, stones, etc.
- restriction on thorough-fare through PAs
- aesthetic and religious spots inside PAs
- use of common water source by wild animals, cattle and men
- lghting fire in antagonism
- shelter to terrorists.

3. Problems of local communities

The local communities living in and around the protected areas face a lot of problems, some of which are:

- lack of alternative sources of fuelwood, food plants, medicinal plants and other non-timber forest produce
- total dependence on marginal farmlands which are inadequate to fulfil the requirements of the local population
- irregular rain and lack of irrigation facilities
- large number of poor quality cattle
- poverty
- lack of education facilities
- lack of awareness of various developmental programmes
- lack of communication and remoteness of the areas from the centre of power and developed areas
- poor general hygiene and lack of medical facilities
- lack of drinking water
- lack of alternative sources of employment
- unemployed youth with little awareness and not being able to follow the traditional rural life and at the same time not able to do anything else
- local political diversions
- traditional misconceptions and myths.

4. Protected areas management problems

Several problems are being faced in the management of PAs. Most of the problems are due to vastness of the areas where a lot of utilisable resources of various types of plants and animals occur. People living in and around these areas freely utilise these resources as per their requirements and convenience. Sustainable harvest has been traditionally practised by local people. However, greedy contractors and middle men instigate the forest dependent communities to gather as much forest products as possible. As a result of which destructive harvest is done. Instead of plucking the fruit the whole trees are felled (e.g. *Emblica officinalis, Buchanania lanzan*). Useful herbaceous plants are totally uprooted (e.g. *Chlorophytum tuberosum, Curcuma angustifolia*). Thus the forest resources are used as a common property resource and this damages the plant and animal resources. The resource managers also face many problems pertaining to PAs. The local people enter the forests daily to meet their bonafide domestic requirements as well as for sale and this inevitably causes several conflicts. This situation leads to non-co-operation of local people in the management of protected areas.

5. Need of participation

The need of people's participation in wildlife management was realised in 1980s. According to the World Conservation Strategy, the behaviour of entire societies towards the biosphere must be transformed if the achievements of conservation objectives are to be assured. A new ethic embracing plants, animals and people is required for human societies to live in harmony with natural world on which they depend for survival and well being. Until people understand why they should safeguard ecosystems and species, they will not do so. There are two problems:

- inadequate public participation in conservation/development decisions
- insufficient environment education.

Local community involvement and consultation and other forms of public participation in planning, decision making and management are valuable means of testing and integrating economic, social and ecological objectives. Participation tends to build public confidence and improves the people's understanding of conservation and implementation. Use of mass media and educational institutions has been envisaged.

6. Joint Forest Management

Several State Governments have issued resolutions on Joint Forest Management (JFM), wherein the local people are involved in management, protection and sharing of usufruct benefits from the forests. JFM has been quite encouraging in terms of eliciting the support of local people in protection and management of forests. So far over 20,000 VFC/FPC (Village Forest Committee/Forest Protection Committee) have been formed in India involving nearly 3 million people.

7. Eco-development

In several PAs eco-development programmes have started to resolve the conflicts between the protected areas and the people. These programmes are meant to reduce the dependence of local people on protected areas, to provide them alternatives and to elicit their support in wildlife protection. Eco-development envisages ecologically sound development to achieve harmony between man and nature. This approach is aimed at harmonising social and economic needs in tune with ecological objectives. It is based on the principles of self-reliance, satisfaction of basic needs, and symbiosis between man and nature on sustainable basis without polluting, exhausting or adversely affecting natural resources (Kotwal and Singhal, 1994).

The activities pertaining to eco-development in PAs need to be meticulously identified such that these do not attract more human population in the vicinity of PAs and do not defeat the objectives. While preparing eco-development plan for a protected area, detailed microplans need to be prepared in consultation with the villagers. A sense of belonging to the PAs need to be developed among the villagers by their close association in management and by providing them earning opportunities through tourism and other suitable means. Actually the participation should start right from planning stage to implementation and benefit sharing (Pabla *et al.,* 1995).

8. Joint Forest Management (JFM) vs. Participatory Protected Area Management (PPAM)

In JFM the participation is aimed at sharing direct and relatively short-term benefits through timber and non-timber harvest. PPAM addresses both long-term and short-term benefits. Ecotourism has the potential to provide quick returns to people. However, conservation efforts improve agriculture through prevention of soil erosion and conservation of moisture. The basic difference between JFM and PPAM is that, in the former there is a provision of direct sharing of the usufruct benefits in the form of timber, fuelwood, grass and NTFP, but in the latter such benefits are not possible. But in PPAM the benefits of tourism may be diverted to local people rather than having big hotels in the protected areas. The local people can also be encouraged to sell local crafts/arts to the visitors. The remaining problems of unemployment, fuelwood and cattle grazing can also be adequately addressed through eco-development activities. One possible way could be shifting them to neighbouring areas outside the PAs where developmental activities can be started.

In PPAM the management emphasis is on continuance of delicate dynamic natural processes. This calls for professional management inputs. The PAs have no direct consumptive utilitarian values but they do have existence and other non-consumptive values which can be tapped in favour of local people. Table 2 compares the different aspects of JFM and PPAM.

Table 2. Joint Forest Management and Participatory Protected Area Management

Particulars	JFM	PPAM
Problems	▪ Fuelwood ▪ Grazing ▪ NTFP	▪ Fuelwood ▪ Grazing ▪ NTFP ▪ Crop raiding ▪ Killing of humans and domestic animals ▪ Property damage
Suggested solutions	▪ Controlled use ▪ Rotational grazing ▪ Plantation	▪ Alternate site for habitation ▪ Earmarked use site
Strategy	▪ Village Forest Committee Forest Protection Committees (VFC/FPC)	* Eco-development Committees
Participation	▪ Protection ▪ Development of forest	Protection of PA from ▪ Poaching, fire ▪ Prevention of damage from animals
Involvement	▪ Local people's involvement in ▪ Planning, execution and sharing of usufruct benefits	▪ Employment in PA management ▪ Wildlife tourism

9. Points to consider

- ***Employment:*** Large number of local people is employed in PAs for various works. On average 100 workers are required to manage a PA of 100 km^2. Accordingly, about 1.5 million persons are regularly engaged in PAs. (1.482 million km^2 area) of the country. The local people are suitable since they are aware of the local conditions, and know the people, and dialect. Literate locals with some training can work as guides.
- ***Income generation:*** The local people can be given adequate training and financial support for local crafts/arts and other eco-friendly income generating activities.
- ***Tourist facilities:*** There is a great potential for local inhabitants to develop moderate lodging, boarding and excursion facilities for visitors. Big hotels should be discouraged.
- ***Relations with neighbouring community:*** The locally recruited PA staff have the potential to maintain the PA's goodwill with neighbouring community.
- ***Eco-developemnt works:*** These can be planned and executed with an active participation of the local people. Site specific micro plan at village level should be prepared.
- ***Irrigation:*** Most of the people around PAs are farmers and lack irrigation facilities. Construction of small dams and ponds for irrigation would enable them to take several crops in a year which in turn will improve production and economy.
- ***Sense of belonging:*** When people start getting benefits from PAs then they may bear some losses in the form of crop raiding, cattle killing by wild animals and certain other restrictions.

Some of the above have been practised in PAs like Kanha National Park and Bandhavgarh National Park. Seven PAs namely, Buxa, Gir, Nagarhole, Palamau, Pench, Periyar and Ranthambhore, have been selected for systematic Eco-development activities under GEF (Global Environment Facility) for which detailed eco-development plans have been prepared (World Bank, 1996).

References

GOI. 1997. *National Action Plan for Biodiversity Conservation.* Ministry of Environment and Forests, Government of India, New Delhi, India.

Kotwal, P. C. and Singhal, R. 1994. *Eco-development of Pench National Park in Madhya Pradesh*, Report of IIFM, Bhopal, India.

Pabla, H. S., Pandey, S. and Badola, R. 1995. *Guidelines for Eco-development Planning for India*. Wildlife Institute of India, Dehradun, India.

RCNAEB. 1997. *Sacred Groves of Rajasthan. Relevance of Afforestation and Eco-development.* Regional Centre for National Afforestation and Eco-Development Board, New Delhi, India.

Rodgers, W. A. and Panwar, H.S. 1988. Planning Wildlife. *Protected Area Network in India. Vol.I & II.* Wildlife Institute of India, Dehradun, India.

World Bank. 1996. *Staff Appraisal Report*, India Eco-development Project. Report No.14914-IN. South Asia Department-II, Agriculture and Water Division, The World Bank, Washington DC, USA.

WWF. 1996. *The Sacred and Protected Groves of Andhra Pradesh.* WWF - India. Andhra Pradesh State Office, Hyderabad, India.

Mathema, P., Dutta, I. C., Balla, M. K. and Adhikary, S. N. (eds.). 1999. *Sustainable Forest Management.* Proceedings of an International Seminar, 31 August – 2 September 1998, Pokhara, Nepal.

Community-based Ecotourism: A New Management Alternative for Sustainable Development of Community Forestry

S. K. Shrestha and S. N. Adhikary

Abstract: This paper highlights the concept of community-based ecotourism as an alternative management tool in the community forest management plan either in integration with traditional extraction oriented management or solely for ecotourism management. It presents the case of community-based ecotourism in Bagmara Community Forest which is being managed on multiple forest use basis. It explicitly shows that community forests have tourism potential, if planned and managed carefully. Community forests can be managed sustainably not only for meeting people's basic needs, and conservation of biodiversity but also for drawing direct economic and developmental benefits for the people via community-based ecotourism. Recommendations are made to assess the ecotourism potentials of all community forests and train foresters in ecotourism planning and development.

1. Community-based ecotourism

Recent trend in tourism shows that the demand for natural areas like forests, and national parks is increasing rapidly throughout the world for diversified ecotourism activities. Many developing nations, including Nepal, are trying to exploit this opportunity by integrating ecotourism development in their sustainable rural development plan. Developing countries still have tremendous natural resources having tourist attraction.

Involvement of local communities in the planning and management of natural resources is a key feature of development policies of many developing countries. Therefore, the above mentioned western style ecotourism, which lacks community participation in planning and management, is of very little use for developing countries, specially for community development and equitable benefit distribution. As such, developing nations are putting more emphasis on community-based ecotourism. It stresses people's participation in the planning and management of ecotourism so that the community becomes able to derive sustainable benefits from it along with conservation of local resources.

2. Potentials of ecotourism in community forestry

For the last two decades, community forestry (CF) has been standing as the backbone of Nepal's forestry sector. Under the highly progressive policy of CF management, local communities can establish Forest User Groups (FUGs) and manage the local forests for their own use. Objectively, the policy emphasises the fulfilment of needs of forestry products of the community and enhancement of the quality of rural life through the generation of income and employment from forestry sector. The major strategy adopted to achieve the objectives is active participation of local communities in the planning, management and sustainable utilisation of forest resources.

Galvanised by some encouraging results of CF programmes in forest conservation and development, Nepal aims to hand over about 61% of its forest area to the local communities. Until the end of fiscal year 1997 (2054/55), approximately 12% forest area covering 362,551.5 ha has already been handed over to 5,355 Forest User Groups (Joshi, 1997). Following the success of CF, the buffer zone legislation published in Nepal Gazette (1996) also approves community participation in buffer zone management. The objective of the CF and buffer zone management is not only to manage and supply the forest products on a sustainable basis to the community but also to find ways to disseminate the economic and developmental benefits.

Until recently, the traditional CF management approach has been relying heavily on consumptive use of forest resources which is dominated by production of firewood, timber, fodder and various other non-wood forest products. Now, attempts are being made to link CF with income generation enterprise development. In this regard, ecotourism is emerging as a new management option which seems compatible with CF both in objectives and process of meeting the objectives. It will be very naïve to state that ecotourism is a suitable management option to link enterprise development with all CFs of the country. For a larger number of CFs, traditional extraction-oriented approach is inevitable.

Ecotourism might be a viable option only to those CFs which possess some real tourist attractions such as pristine forests with high scenic value, good biodiversity with plants and animals of tourist attraction, historical and religious sites, interesting culture, etc. Its practical implementation and chances of being success will be, however, much higher in those CFs which are located surrounding popular tourist centres like Kathmandu, Pokhara, Chitwan, Bardia, Lumbini, Gorkha, Langtang, Mt. Everest, etc. However, poor accessibility, poor communication and other infrastructure facilities, lack of necessary skills and knowledge, and shortage of financial resources, will make it extremely difficult to plan and develop in some areas in spite of presence of abundant tourism resources.

3. Ecotourism in community development and sustainability of forest

There are several attributes of community-based ecotourism that make it compatible with CF. For example, both of these stress conservation of forest and other local resources, sustainable community development, and income and employment to the community through active participation of communities.

Ecotourism can contribute to the sustainability of forests as it is largely based on non-consumptive use of forest and other natural resources. Hence, deriving direct economic benefit without destroying forest and associated biodiversity might strongly motivate community to protect their forests. The ecotourists bring the much-needed money to the rural community as entry fee, and charges for facilities and services. The tourism money will have manifold economic effect on community development and their environment. For example, it will help to diversify local economy by creating new employment opportunities for the local people, generate revenue for community development works, such as school, roads, drinking water, health, sanitation, and environmental conservation.

The ecotourists are believed to be environmentally conscious people and possess great respect for local natural resources and socio-cultural values. They are there to admire, enjoy and experience the local environment and hence they will try best to keep the integrity of the forest area. Ecotourists are aware of the rural environment and they neither expect very high quality facilities and services nor encourage development of obstentive structures in forest areas. They are prepared to withstand some hardship of the local environment.

Ecotourism will put several new demands on forests and other resources. While meeting these demands, some impacts on community forest and other natural resources are inevitable. Since ecotourism is essentially a small-scale tourism, a part of the earnings made from ecotourism can be used to heal up these damages. If needed, an appropriate forest management plan could be integrated for the sustainable extraction of vital and economically important forest products.

4. The Case of Bagmara community forest

This paper presents the Biodiversity Conservation Network (BCN) model from Bagmara Community Forest (BCF) which might be the best option from the CF management point of view. Following the success of BCF, some developments in this regard, are also taking place in Kumroj CF in Chitwan district, and Shrijana and Sankarnagar CFs in Rupandehi district.

The information presented here was collected through field visits made in 1996, 1997 and 1998 and published literature. During field visits, beside on-site observation of the BCF, formal and informal interviews were carried out with FUG executive committee members including the chairperson, King Mahendra Trust for Nature Conservation (KMTNC) staff, national park staff, tour guides and hoteliers.

Bagmara Community Forest is located in the Bachauli Village Development Committee (VDC) in the buffer zone of Royal Chitwan National Park (RCNP), which receives more than 80,000 tourists every year. The BCF covers an area of 400 ha of plantation and regenerating mixed reverain forest dominated by *Acacia catechu, Dalbergia sissoo, Bombax ceiba, Eugenia operculata, Mallotus philippinensis* and grassland. The forest was officially handed over to the FUG in 1995.

4.1. History of tourism development in Bagmara Community Forest

Once an area of dense forest and famous for tiger hunting, the Bagmara forest was critically degraded due to uncontrolled exploitation of the forest for firewood, fodder and grazing needs. Some parts of the land were also encroached for cultivation. Due to the scarcity of forest products, the local community's pressure on RCNP was intersitified. For extending wildlife habitat and meeting the community's need for forestry products, the Nepal Conservation Research and Training Centre (NCRTC) with the financial assistance from BCN and participation of local community, initiated a plantation programme in 32 ha area in Bagmara in 1989. About 348 ha of degraded forest land adjacent to the plantation area was also included in it and was protected by fencing. In the earlier stages, the community was suspicious about BCF but, once they started to derive some real benefits, they also helped in the management of BCF.

Due to community protection and management, there was vigorous regeneration of the once degraded forest. Many wildlife species became permanent residents or frequent visitors to the area. These developments slowly started to attract tourists to the BCF. Local tour guides have been pivotal to bring the tourists to the area. In the early years, the tourists visiting the BCF were mostly those who were unable to get elephant ride inside the national park. Later in 1994, BCN initiated a programme to test an enterprise-oriented approach in the community-based biodiversity conservation. It aimed to promote local guardianship of biodiversity interlinked with income generating enterprises by organising tourism activities. BCF was officially opened for tourism in October 1995.

4.2. Management

The management responsibility of BCF rests with the Forest Users' Committee which consists of 19 members elected for five years' term by the general assembly of the FUG. The Committee also consists of some technical staff from NCRTC. BCF has its own operational plan approved by the District Forest Office. Currently, the BCF is being managed on multiple use basis where ecotourism is integrated with traditional community forestry practices. It explicitly shows that if the community forests having some tourism potential are planned carefully for ecotourism, they can be managed for meeting people's basic needs, conservation of biodiversity and drawing direct economic and developmental benefits.

Integration of traditional CF practices with forest-based enterprise development is the main feature of BCF management plan. The major strategies adopted to achieve the goal of BCF are: formulation of policies and plan through people's participation, zoning of the forest for traditional CF practices and ecotourism development, increment in forest production, linking CF with ecotourism development and equitable benefit sharing.

The traditional CF practices involve biodiversity conservation, protection of degraded land for natural regeneration, plantation of locally growing multi-purpose tree species, and application of different silvicultural operations in different management zones for enhancing forest production.

The sustainable ecotourism development plan includes; (i) planning and development of different ecologically compatible attractions for tourists such as jungle walk, elephant ride, wildlife observation and bird watching, overnight *machan* stay, canoeing in Budi Rapti, and Tharu culture observation in the village; (ii) regulation of tourists, elephants and canoes by defining entry point and routes, putting limits on their per day entry; (iii) monitoring of tourism impacts; (iv) generation of revenue through entry fee and charges for the use of different facilities; and (v) marketing of BCF in Sauraha with the help of local tourism operators. The marketing plan of the BCF is now being extended to Kathmandu and abroad through brochure and tourism operators. The community is also trying to establish linkages with the government, KMTNC, and various other tourism agencies at local and national level for capability building in conservation and entrepreneurship development.

4.3. Benefits

Conservation benefits

- **Forest conservation:** BCF area was utterly degraded and a large piece of the area was also encroached for agriculture. Now, the community involvement in BCF has been successful in developing a good forest consisting of both plantation and natural regeneration. This not only has reduced the hardship they were facing from scarcity of forest products but also has improved the aesthetic value of the area.
- **Improved plant diversity:** There are 61 species of trees, 70 species of shrubs including 17 climbers, more than 50 species of herbs, 5 species of orchids, 26 species of grasses, 15 species of pteridophytes, 4 species of mushrooms, and many more species of lower plant groups (Rizal, 1997)
- **Improved and extended habitat for wildlife:** The success of BCF has improved the habitat quality of the area and at the same time has helped to provide additional shelter to the wildlife of the national park. As a result, many wildlife species are now becoming permanent residents or frequent visitors to the area. For example, 15 rhinoceros have become resident in the community forest while many more use the area frequently for different purposes. The important wildlife species that can be frequently observed in the forest are: hare, jackal, sambar, spotted deer, hog deer, python, yellow-throated martin, monkeys, wild boar and different varieties of fishing cats. Similarly, 192 species of birds are reported from the forest while the Budi Rapti river provides shelter to many varieties of fishes and marsh crocodile (Rizal, 1997).
- **Natural buffering:** BCF has been successful in reducing the pressure of community on the core area of the national park. At the same time the cases related to crop damage by wildlife have also been reduced. For example, the incidence or rhino raid on crop fields has dropped from an average 12 raids/night to 2 raids/night (Rizal, 1997). Because of these buffering

effects, it is also being realised that BCF has been successful in reducing the conflicts between the park and the community.

- **Reduced flooding:** In 1990 and 1993, floods devastated many villages of Chitwan including Bagmara. But now BCF has created a natural barrier against flooding in the Bagmara area. Besides, some soil conservation works have also been done to reduce flooding damage.

- **Increased community awareness for conservation:** With increased tourism activities people are becoming aware of the value of their natural and cultural resources. As a result, the feeling of conservation of natural resources and cultural heritage is gradually growing among the local people.

- **Fund for conservation:** Earning from ecotourism has made the FUG self-sufficient to fund conservation activities such as habitat improvement for wildlife through creation of grassland, construction of a mud-filled dam to create suitable aquatic habitat where marsh crocodiles have been released. Besides, the revenue is also being used for conservation education, plantation, fencing, and installation of energy saving devices.

Benefits to the community

- **Sustainable supply of forest products:** BCF has been successful in constantly supplying the basic forestry needs to the users since 1992. In 1992, about 90,000 kg of thatch grass and nearly 360,000 kg (1,2000 *bharis*, 1 *bhari* = 30 kg) of fuelwood were extracted to distribute among the local people. Similarly, in 1993 about 30,000 kg of fuelwood; in 1995 about 134,250 kg of branches, 339,880 kg of logs and 47,630 kg twigs; and in 1996 about 474,135 kg of fuelwood were extracted by silvicultural operation including uprooting of old roots (Anon., 1996). In addition to this, the users are freely allowed to collect about 2,400 tonnes of grass and fodder annually. It is also estimated that after three years, BCF will be capable in meeting the fuelwood demand of the users sustainably (Rizal, 1997)

- **Revenue for the community:** Total revenue generated up to the end of March 1996 was Rs. 769,639.00 (US$ 11,840.60) which included Rs. 415,586.00 (US$ 6,393.63) from the sale of forest products extracted in various silvicultural operation and Rs. 354,053.00 (US$ 5,446.97) from tourism related activities like entry fees, elephant ride, nature walk, *machan* stay, community consultation fee, and canoeing. It reached Rs. 856,511.00 (US$ 13,177.10) by the end of May 1996 (Anon., 1996). The *machan* fee is US$ 10/person/night. It contributed Rs. 12,140 (US$ 225.64[1]) in the first month of its opening. It is estimated that BCF will make US$ 8,000.00/year from *machan*, US$ 21,600.00/year from entry fee and license (tourist, elephant, canoe) while US$ 26,429.00/year from the extraction of forest products from the plantation (Rizal, 1997).

- **Income and employment generation:** Direct employment generated from BCF includes hiring of five forest guards and one office secretary. Besides, many local people are working as nature guides, and many are employed in various other tourism-oriented jobs in Sauraha. Similarly, the people are getting much higher value for their land, which hiked from US$ 4000.00/*bigha*[2] to US$ 32,000.00/*bigha* (Rizal, 1997)

---

1 The exchange rate of 1996 (US$ 1 = Rs. 53.80), all other estimates are at the present rate of 1 US$ = NRs 65.00

2 1 *bigha* = 0.68 ha

- **Community development:** The community is using the revenue collected to fund both its conservation and local development programmes. The major community development investment made by the FUG is on the development of schools, providing soft loans for income generation or installing energy saving devices, construction of road, and for health and sanitation project.
- **Community strengthening:** The successful work of BCF has made the community proud of themselves. At the same time, the local institutions are becoming more equipped and confident that if necessary skills and knowledge are provided, they would be capable of planning and managing their resources sustainably for personal and community development. Currently, KMTNC, Department of National Parks and Wildlife Conservation, Department of Forest and various other governmental and non-governmental organisations are organising various programmes to provide skill development training to the community.

5. Conclusion and recommendations

Community-based ecotourism, although a new concept possesses tremendous potential for integrating with CF management with entrepreneurship development. It is applicable particularly in those CFs which have resources that are of tourism interest and are located near popular tourist centres. We need to make an inventory to identify all suitable community forests where ecotourism could be incorporated. It is also essential to assess the strengths and weaknesses of BCN model and other available ecotourism models for development of new models suitable for other potential areas. For this, forest officers and protected area managers must be properly trained to develop skills for assessing tourism potential, and planning and development of community-based ecotourism.

References

Anon. 1996. Bagmara Community Forestry. *Prakriti* (Bulletin of the King Mahendra Trust for Nature Conservation) 1(1): 4–5.

Joshi, A. L. 1997. The Status of Community Forestry in Nepal. A Report Submitted to ANSAB, Kathmandu, Nepal.

Rizal, A. 1997. The Bagmara Community Forest: An Example of Linkages between Community Forestry and Ecotourism. Paper Presented at the International Seminar on Ecotourism for Forest Conservation and Community Development, 28–31 January 1997, Chiang Mai, Thailand.

Mathema, P., Dutta, I. C., Balla, M. K. and Adhikary, S. N. (eds.). 1999. *Sustainable Forest Management.* Proceedings of an International Seminar, 31 August – 2 September 1998, Pokhara, Nepal.

Population Dynamics and Conservation Aspects of Blackbuck (*Antilope cervicapra*) in Khairapur, Nepal

K. M. Tamang and S. K. Shrestha

Abstract: Population characteristics, dynamics and habitat relations of the surviving population of blackbuck (*Antilope cervicapra*) in Nepal were studied between May 1995 and April 1996 in Khairapur, Bardia. Total population counts in May 1995 and March 1996 when blackbuck were most concentrated around Khairapur and Pataha in the study area yielded 102 animals in 1995 and 111 in 1996. An apparent 8.8% increase in population occurred between 1995 and 1996. The large population of adult female indicated that potential population increase was greater than actually observed. The data suggested mortality of fawns caused the low increase.

The loss of habitat due to rapid human population growth and large natural areas converted to agriculture have resulted in a serious threat to the very survival of this species. The present habitat of 290 ha is too small for the blackbuck population. Recommendations for blackbuck conservation include continued protection by Royal Bardia National Park (RBNP). Recognising the importance of preserving the only population of blackbuck in the country, the present habitat should be declared as a Blackbuck Sanctuary equivalent to a Wildlife Sanctuary and accorded appropriate protection. Grazing by domestic livestock and harassment by village dogs should be eliminated. Reintroduction or introduction of blackbuck into other suitable habitat should also be considered.

1. Introduction

Blackbuck (*Antilope cervicapra*), popularly known as "Krishnasaar" in Nepal, once occurred extensively from Pakistan along the foot of the Himalayas from Punjab through Uttar Pradesh and Nepal to West Bengal and Bangladesh as well as throughout peninsular India but not in Ceylon (Lydekker, 1924). Once considered as one of the most common animal in the sub-continent, it now occurs only in scattered populations in India. In Nepal, Khairapur of Bardia district holds the last remnant population of blackbuck. The blackbuck is the sole representative of the genus *Antilope* in India and Nepal.

The blackbuck is an animal of the open, flat to slightly undulating terrain reaching its greatest abundance in areas covered with thorn and dry deciduous forest. It is readily adaptable to wasteland, marginal agricultural land and cultivated areas. It lives on open plain and avoids hilly and forested areas (Walker, 1964). Its preference for open habitat makes it highly vulnerable to hunting. As it came into increasing conflict with agriculturists, it was exterminated over much of its range. The loss of habitat due to the exponential human population growth and large natural areas converted every year to agriculture have resulted in a serious threat to the very survival of this species.

Scattered populations of blackbuck occurred in Kanchanpur, Bardia and Banke districts in Western Nepal as late as 1960s. The precarious status of blackbuck was reported after they observed two small separate herds of blackbuck, one in Bhagwanpur Jamuni of Banke district and the other in Khairapur of Bardia district (Dinerstein, 1975; Wegge and Wilson, 1976).

The decimation of blackbuck has been so complete through loss of habitat, over hunting, competition from domestic livestock and direct human encroachment that it has reached a critical stage. The last remnant population of blackbuck in Nepal presently occurs in and around Khairapur village in Bardia district. A study was done to find a possible solution to save the very last population of an endangered species on the verge of extinction. This paper presents the findings of that study.

2. The study area

The study was carried out in Khairapur and surrounding areas situated approximately 4 km. north west of Gularia; the headquarters of Bardia district in west Nepal. The relatively small study area of approximately 290 ha is protected and administered by the Royal Bardia National Park (RBNP), although the area itself is well outside of the park boundaries. Khairapur study area can be reached by motorable fair-weather roads from Gularia (November to May) and by foot during monsoon.

The average annual maximum and minimum temperature is 30.5^0 C and 17.7^0 C, respectively. The average annual rainfall for the area is 1560 mm. About 90% of precipitation falls during the monsoon (mid June–September). The study area is more or less flat land sloping towards the south. The elevation is about 152 m above mean sea level. Standing water is available in the old riverbed most of the year but disappear in most places during the hot season (March–June).

The main animals presently found in and around the study area are: blackbuck, ryhesus monkey (*Macaca mulatta*), common langur (*Presbytis entellus*), leopard, jungle cat (*Felis chaus*), common mongoose (*Herpestes edwardsi*), jackal (*Canis aureus*), Indian fox (*Vulpes bengalensis*), five-striped palm squirrel (*Funambulus pennanti*), porcupine (Hystrix indica), hare (*Lepus nigricollis*), wildboar, chital and striped hyena (*Hyaena hyaena*). Varied species of birds occur in abundance but were not recorded.

Most of the study area consists of overgrazed open wasteland, cultivation and scattered patches of forest land. Vegetation on forest patches consists of degraded khair-sissoo forest presently with scattered khair (*Acacia catechu*), sissoo (*Dalbergia sissoo*), simal (*Bombax ceiba*) and karma (*Adina cordifolia*) trees with *Mallotus philippinensis*, *Colebrookia oppositifolia*, *Clerodendron viscosum*, *Zizyphus mauritiana*, *Eupatorium odoratum*, *Adhatoda vasica*, *Cassia tora*, etc. as understory indicating excessive overgrazing from village livestock.

The overgrazed open wasteland has many grass species like *Cynodon dactylon, Chrysopogon aciculatus, Sitaria glauca, Eragrostis coercta, Eleucine indica, Sporobolus diander, Panicum* sp., *Pespalum distichum, Saccharum spontaneum, S. munja, Imperata cylindrica, Desmostachya bipinnata* and *Vetiveria zizanoides. Cyperus* sp., *Cannabis sativa, Cassia tora, Artemisia vulgaris, Asparagus racemosus, A. adscendens, Oxalis comiculatus, and Ipomoea fistulosa* are also found.

3. Population dynamics

3.1. Population counts

Direct counting of the animals with binocular was carried out to determine the total size, age and sex composition of the blackbuck population. Visibility was excellent most of the time in open habitat conditions and it was possible to cover the relatively small core study area of less than 300 ha on a daily basis by foot. However, the animals were constantly on the move at all times of the day and roamed around extensively several kilometres in all directions due to continuous disturbances from people and their activities in the area, and from the grazing and browsing activities by cattle and goats. The use of a bicycle became helpful to cover the area and the surrounding villages.

Animals were tallied by sex, herd size, according to the type of habitat and its activities noted as per the prescribed form. Animals were classified as young, yearling and adult. Precise age classification was difficult for the young because of births throughout the year. Animals less than about six months were classified as young. Classification was relatively easy for yearling and adult male because of their distinct coloration. The horns are without a spiral in yearling buck. Yearling and adult females were distinguished by their relative sizes. With enough field experience and with the aid of a binocular in an open habitat, this simple classification became practical. Animals could be observed often at close range (30–40 m) by foot if approached slowly. Even young ones could be sexed with careful observation.

Heard composition counts throughout the study period (1 May 1995–30 April 1996) were used to determine average herd size, herd composition and sex and age ratios. A qualified field assistant with requisite prior field experience at RBNP carried out composition counts, observed behaviour, noted food habit and recorded mortality and natality information throughout the study period.

3.2. Herd size and composition

Herd size varied considerably with season, time of the day, availability of food and the amount of disturbance from the activities of the human population and their livestock. Most of the animals were observed at Pataha, Panditpur, Turantpur, Khairapur, and Solalpur in open overgrazed wasteland and surrounding cultivated areas. Average herd size was six animals, derived from 2,986 herds observed during the study period, May 1995–April 1996 (Table 1). One-third (34%) were observed as single individuals (Table 1). Over 80% of these individuals were males. Animals gathered in large herds during the hot part of the day for rest before noon and early afternoons. Maximum herd sizes of over 40 animals were observed in the month of May, June and July. One-third (32%) of the herds were observed in groups of six or more animals.

Table 1. Herd sizes of blackbuck Khairapur, Bardia, Nepal, May 1995–April 1996

Month	Number of herds	Average herd size	Herd sizes - %							
			1	2	3	4	5	6 - 10	11 - 20	21+
May '95	462	5.7	35	14	11	6	4	17	9	5
June	373	6.9	30	12	8	6	7	17	11	8
July	325	6.9	30	12	9	9	5	16	9	10
August	222	5.0	42	12	10	6	7	10	9	3
September	167	4.8	39	15	10	5	4	13	10	4
October	158	5.7	41	15	11	3	3	10	10	7
November	172	6.5	34	10	9	1	4	20	15	7
December	196	5.8	37	12	5	3	6	14	21	2
January '96	202	6.5	27	14	10	3	8	11	21	5
February	228	4.4	29	17	10	8	7	21	5	3
March	290	5.1	38	15	8	6	4	14	10	5
April	191	6.2	31	16	6	5	6	15	15	6
Average		**5.8**	**34**	**14**	**9**	**5**	**5**	**15**	**12**	**5**

The blackbuck population at Khairapur has fluctuated between 92 and 190 individuals from 1987 to 1994 (Table 2).

Table 2. The population of Khairapur blackbuck from 1987 to 1993

Year	Estimated population	Source
1987	158	Bhatta (1987)
1988	190	Bauer (1989)
1990	178	RBNP
1991	162	Subedi (1991)
1992	100	RBNP
1993	92	Nepal (1994)

Total counts were possible occasionally without duplication when the population was concentrated in Pataha and surrounding open areas, and the animals were in an undisturbed situation. The population was counted on May 22, 1995 and March 16, 1996 and was 102 and 111 respectively (Table 3).

Table 3. The Composition of the Khairapur blackbuck population in 1995 and 1996

Date	Adult male	Yearling male	Adult female	Yearling female	Young	Total
May 22, 1995	21	12	44	15	10	102
March 16, 1996	27	9	48	13	14	111

3.3. Sex and age composition

Table 4 presents the sex ratio of 56 bucks to 100 does in 1995 and 59 bucks to 100 does in 1996. The sex ratio was in favour of females. A similar disproportion in sex ratio for blackbuck has been observed in previous studies at Khairapur (Bauer and Ellenberg, 1988; Subedi, 1991; and Nepal, 1994) and also in studies elsewhere (Schaller, 1967). An unequal sex ratio at birth, higher mortality in young males and selective hunting of males may be reasons for this disparity. The ratio of youngs to 100 does was 17:100 in 1995 and 23:100 in 1996 (Table 4) or 10% of the total population in 1995 and 13% of population in 1996.

Table 4. Age and sex ratio of Khairapur blackbuck population in 1995 and 1996

Date	Size of population	Bucks :	100 Does :	Young
May 22, 1995	102	56	100	17
March 16, 1996	111	59	100	23

4. Reproduction

Various studies have reported different rutting periods for blackbuck. Lydekker (1924) noted that mating occurred in February and March. Others have observed fawns born throughout the year (Sterndale, 1884 and Brander, 1923 quoted in Schaller, 1967; and Sinha, 1990) indicating mating occurred throughout the year. According to Schaller (1967), two definite rutting peaks were observed at Kanha in Madhya Pradesh, India: one in April and the other from mid-August to mid-October. Sexual behaviour, such as chasing and mounting, gave an indication of the rutting season. At Khairapur the bucks were sexually active every month of the year. Successful copulations were observed each month, with higher frequency in March, April, July and August.

Fawns were born throughout the year. However, more fawns were born in the month of January, February, March and April in Khairapur. With a gestation period of around six and a half months, this may perhaps indicate a peak-rutting season in July – October for Khairapur population. The doe withdraws from the herd and gives birth to her young in a secluded spot usually close to shrubs, bushes, along hedges of *Ipomaea fistulosa* or in *Cajanus cajan* (pigeon pea) fields. Although the female rejoins the herd after a couple of days, the female and young together joins the herd after a week or two.

5. Mortality

From the observations made at Khairapur, it seems obvious with low number of young in relation to the female population that mortality among youngs were rather high. Nine animals: two adult males, two adult females, two young males and three young females, were killed by village dogs during the study period. Royal Bardia National Park (RBNP) in a press release in Gularia at the end of July 1995 mentioned fourteen blackbucks killed by dogs in a period of four months (*Kantipur*: Newspaper, Shrawan 15, 2052). These figures do not include the animals killed during the night when the dogs are quite active. Apart from actual deaths caused by dogs, the blackbucks scatter and run in all directions and were observed to go as far south as the Indian border (about 5 km.) and as far west as Tarataal villages (8–10 km) when pursued by these dogs. Such encounters possibly take a heavy toll among the pregnant females and the young ones. It was reported that a campaign organised by the RBNP in 1994 to kill the dogs was vigorously protested and resisted by the surrounding villagers.

Leopard, the only predator, is a rare visitor to the area and would find it difficult to stalk the animals successfully in the kind of open habitat the blackbuck inhabits. Occasional jackal and hyena are not likely predators except cleaning the dead and diseased animals.

Several poaching cases were prosecuted by the forest office at Gularia prior to the study period (Chowdhury, DFO–pers. comm.). Poaching from vehicles at night was occasionally reported by the villagers. Because it happens at night and takes place in open cultivated fields in the surrounding villages, the RBNP guards stationed on site are ineffective to deal with this problem. The extermination of blackbuck from Banke district and the decline of the population in Bardia as well as the shift of blackbuck from Mainapokhar area to the present study area was probably due to excessive poaching and related harassment.

6. Behaviour

Blackbucks are gregarious and gather in herds. The composition and social structure of the herds undergo continuous changes during the year. Sometimes herds are loose aggregations of bucks and does. During rutting season, each mature buck attempts to collect a harem of does. He defends his harem of does and territory against other males. During this time, bachelor bucks of all age groups are formed. The mature buck establishes a territory from which any intruding buck is vigorously chased away. Fecal deposits on certain locations and secretions from the preorbital glands deposited on grass and bushes serve to mark the territory (Schaller 1967; Prasad 1989). Although our observations indicated exhibition of definite territorial habits, the territories were not maintained for long as mentioned by Schaller (1967). This may be because of the relative small size of the core habitat, constant daily disturbance from people and livestock activities, year-round sexual activities, continuous harassment and chasing by the dogs, etc. When molested the blackbuck were constantly changing their ground and herd composition became fluid. When not molested, the blackbucks were very regular in their habits and behaviour congregating in the same place day after day. Herds of over 40 animals were observed when things were calm and undisturbed for awhile.

The blackbucks tolerate temperatures above 30° C very well and remain in the open even during hot weather. In the study area, widely scattered patches of *Cajanus cajan* and hedges of *Ipomaea fistulosa* were observed to provide shelter during hot weather from March to June. The daily routine of grazing starts early in the morning around six to ten and in the afternoon about two to six or seven in the evening with intermittent grazing during the day. Since the blackbuck moved into the cultivations during the night, grazing perhaps continues in the night. The complaint against blackbuck damage to crops mainly occurs during the night, especially in winter and spring.

The alert posture consists of standing erect with the neck held vertically and its short tail raised. The animals when approached by a man crowd together and flee. Blackbuck in flight usually trot or gallop but sometimes bounds along stiff-legged, hitting the ground with all four feet in unison, a unique gait called "stotting" or "spronking." Such spronking on the part of one animal usually make others do the same and all spronk in single file. Fawns spronk in play when only a few days old.

The blackbuck asserts its dominance with the head-up display. The buck raises his muzzle so high that the horns lie almost alongside the neck, the ears are folded back, lowered and held laterally exposing the white insides; the short tail is raised and curved up, making the white patch on the rump conspicuous. The preorbital glands are everted. The buck approaches his opponent in this posture, sometimes bobbing the head up and down, flashing his white chin and muttering a series of harsh grunts and jerking his head with each sound. When asserting his dominance a buck may chase another for twenty metres or more with horns lowered. Sparring was infrequent during such encounters but serious injuries resulted when it occurred. Several adult males had broken horns, either one or both, during the study period as a result perhaps of such encounters.

7. Food Habits

Blackbuck has a preference for open habitat with low growing grasses and tend to avoid environment dominated by tall grasses (Schaller, 1967). The blackbuck is both a grazer and a browser and primarily uses xerophytic plants (Berwick, 1974). Studies on the seasonal differences in food habits showed that the blackbuck is primarily a grazer when succulent grasses are available during the monsoon and consumed more browse when depletion of grasses forced a greater dependency on leaf litter, flowers and fruits (Berwick, 1974). In areas of severe habitat decline, the blackbuck depended on cereal crops (Walker, 1964; Lehmkul, 1980). Basically, blackbucks are grazers and this natural tendency makes them agricultural pests in certain parts of India (Cary, 1976). Mungall (1978) summarised the food habits of the blackbuck by noting that under all range conditions, the vegetation use by blackbuck reflects the general vegetative composition (Mungall, 1978).

Observations were made of the plants blackbuck ate during the study period (May 1995 – April 1966) and noted, while carrying out herd composition counts. Blackbuck diet varied in different seasons of the year depending upon what was available. With the onset of monsoon in June forage quality improved and succulent grasses became available. Among the grasses eaten were: *Cynodon dactylon, Chrysopogon aciculatus, Sitaria glauca, Eragrostis coercta, Eleucine indica, Sporobolus diander, Panicum* sp., *Pespalum distichum, Saccharum spontaneum, S. munja, Imperata cylindrica, Desmostachya bipinnata* and *Vetiveria zizanoides*. Some of the above grasses although normally considered unpalatable are consumed because of the intense overgrazing and competition in the study area by domestic livestock. Grazing and cutting induce a gradual drying of the habitat and a change to communities dominated by *Imperata cylindrica, Sacaharum spontaneum, Desmostachya bipinnata* etc. *Chrysopogon aciculatus* is one of the most resistant grasses to trampling and grazing and is not considered as a desirable forage because the sharp seed can injure grazing animals. Thus under continuous heavy grazing pressure, the blackbuck seems to consume less desirable grasses as well.

As the vegetation grows older and more fibrous after the monsoon, other food sources become available in the surrounding cultivated areas. In winter (December–February), blackbucks eat *Lens esculenta*, *Phaseolus mungo*, mustard (*Brassica compestris*), peanut (*Arachis hypogaea*), gram (*Cicer arietinum*) in addition to the grasses. Young shoots of wheat (*Triticum aestivum*) are eaten after it is sown.

In March–June, blackbucks depend on whatever grasses are available since it is a dry period and grasses become scant and stubby. During this period blackbucks were observed browsing on leaves *of Zizyphus mauritiana, Acacia catechu, Dalbergia sissoo, Ipomoea fistulosa, Oxalis corniculatus* etc. normally considered less desirable forage. Young shoots of corn (*Zea mays*) are also eaten. Pigeon pea (*Cajanus cajan*) leaves are eaten throughout the year and provide good shelter at all times since it is 2 m or more in height.

Bhandari (1994) made an assessment of the food habits of blackbuck in the study area from December 1992–April 1993 based on faecal analysis to determine the occurrence of different plants in the faeces of blackbuck. The average intake of crops in winter season were much higher 54% than during summer season 33%. Utilisation of grasses in the summer season were 68% and during the winter, it constituted 46% (Bhandari, 1994).

Blackbucks were observed drinking occasionally in the morning and in the late afternoon during hot weather (March–June). Whether the animals drank daily or at intervals was not known. Since the study area happens to be in an old Babai riverbed, water was available and within their reach even during the hot weather. Schaller (1967) never saw blackbuck drink in Kanha Park even during the hottest part of the year. Lydekker (1924) and Blanford (1888) noted that the blackbuck rarely drank.

8. Factors affecting blackbuck survival

Poaching

One of the main reasons for the present precarious status of the blackbuck was probably due to widespread poaching in the past. The species is most vulnerable to hunting and poaching due to its habitat requirement and preference for open plains. Blackbuck horns marked with rings and spirals make attractive prized trophies. Poachers, however, go not only for horns but for meat as well, not sparing even the pregnant female and young which are most vulnerable.

Predation

The village dogs in packs chase and harass the blackbuck all the time, sometimes reportedly with the assistance and encouragement of the villagers. RBNP reported fourteen animals killed in four months. Out of the nine, five were young, two female and two male adults. The most vulnerable are young and pregnant females. Pregnant female may abort from such harassment and have serious adverse effect on reproduction. The reported cases, however, are only known casualties that happened during daylight hours. Casualties during the night go unreported and remain unknown since the villagers are reluctant to report. The stray dogs from the surrounding villages is presently the single most menacing factor, which in combination with others could lead to the extermination of this species in Nepal. Hyenas and jackals are mostly scavengers. Hyenas are rather rare in the forest areas. No kills were reported from these two predators.

Habitat destruction

Loss of open plains with short grasses and shrubs, due to encroachment by human settlers in combination with other factors, has contributed to the present critical status of blackbuck. In addition to this, the present habitat is relatively too small for its long term survival and welfare.

Overgrazing

The whole of the blackbuck habitat at Khairapur is subject to excessive domestic livestock grazing. Livestock utilising the blackbuck habitat in 1988 were cattle 671, buffalo 108, goats 32 – a total of 811 (Bauer and Ellenberg, 1988). Bhandari (1994) estimated livestock number of between 1100 – 1200 in 1994. There is no control on livestock grazing in the government owned forestland and 85 ha of land acquired for blackbuck. It is obvious that the overgrazing and competition between livestock and blackbuck is intense. It is no wonder then that the blackbuck partially depend on agricultural crops for their forage.

Diseases

No mortality of blackbuck due to disease was reported. However, there is always a danger of such occurrence since the blackbuck and domestic livestock exist in such a close association.

Inbreeding

Some reports have suggested that the blackbuck at Khairapur had reached a low of three individuals in 1973 and it gradually built up over the years to the present population [Bauer and Ellenberg (1988); Subedi (1991); and Nepal (1994)]. Although the accuracy of the above number cannot be confirmed, it is true nevertheless that the numbers then were very low. As there are no other blackbuck population left anywhere, the danger related to inbreeding is serious and very real.

Visitors

The present blackbuck habitat being in the middle of villages in an open environment is exposed to all kinds of disturbance from the people at all times. Since the area is accessible most of the year, visitors with vehicles reportedly cause a great deal of disturbance to the animals in trying to get a closer look at their spronking while in flight.

9. Recommendations

The key to the survival of blackbuck in the wild in the long run is the maintenance of its habitat. The habitat must be sufficiently large to support a viable self-sustaining population of blackbuck at natural densities. The effect of human population growth with consequent habitat alteration and disturbance over the past generation or two has overwhelmed the blackbuck population in Nepal. The only surviving population in the country is now isolated and confined to Khairapur in Bardia. The population of blackbuck has proved its resilience and seems to be stable and maintaining itself under the existing environmental conditions. Confrontation with man and his activities such as mortality as a result of killing by village dogs and the lack of suitable additional habitat areas for the establishment of new populations are factors that limit its abundance and distribution. The following recommendations are offered for consideration by the Department of National Park and Wildlife Conservation (DNPWC) and other concerned authorities in the Government.

1. The blackbuck population at Khairapur survives in a very fragile environment which can be upset very easily by small changes in the present existing circumstances. Royal Bardia National Park (RBNP) and its personnel at the guard post at Pataha (Khairapur) must be commended for their dedication in the protection of the existing blackbuck that has enabled animals to survive and maintain a stable population. This good work must continue. The RBNP Guard Post should be strengthened as necessary.

2. Preservation of the existing blackbuck population in such a small core area of 290 ha may not be possible in the long run since the pressure from human population and related activities increase. The long outstanding acquisition of 102 ha of "ailani" land and an additional 90 ha of privately owned land should be resolved by providing adequate budget for compensation. This will ensure further security in terms of habitat needs and increase the core area to 482 ha.

3. Recognising the importance of preserving the only population of blackbuck in the country the present habitat should be declared as a "Blackbuck Sanctuary" equivalent to a Wildlife Sanctuary with a Gazette notification under the provisions in the National Parks and Wildlife Conservation Act of 1973. Necessary rules and regulations should be framed and published in the gazette notification to provide it a legal basis.

4. Grazing of domestic livestock from the surrounding villages in the core area should be stopped, since compensation has already been paid to the villagers. Crop damage by blackbuck may decrease with the availability of more forage from the increase in core habitat by stopping of livestock grazing in the land already acquired and paid for.

5. Mortality of blackbuck from village dogs is really serious. Control of dog population in the neighbouring villages has been tried and checked before by RBNP and guard post personnel on site. Since this problem takes a heavy toll on blackbuck fawns, pregnant females and others, efforts to control dog population should be continued and strengthened.

6. The above two recommendations (3 and 4) will be difficult to implement under the present circumstances. Payment of compensation in cash to individual farmer is not recommended since no amount will be adequate or satisfactory and claims will be overly exaggerated. Instead, a health clinic with adequate supplies and health assistant may be a better way to compensate the villagers surrounding Khairapur. This has been done successfully outside of Thakurdwara (RBNP). Public relation efforts from RBNP personnel in convincing the people on this score along with conservation education related to the importance of protecting blackbuck through the village development committees may help in obtaining co-operation from the villagers. Adequate budget should be provided for this purpose.

7. Visitors' access to the core blackbuck area should be controlled to minimise disturbances. Vehicular traffic to the area should be limited to one road leading to the guard post at Pataha. A simple shaded thatch hut close to the post with benches and tables should suffice for the visitors to view the animals and take pictures from a respectable distance without following the animals. Leaflets or

brochures explaining the importance of blackbuck conservation should be prepared in Nepali and English and distributed to the visitors as well as to the village development committees for distribution to the surrounding village farmers.

8. A simple management plan should be prepared for the blackbuck in Khairapur (or the blackbuck sanctuary) explaining the objectives with clear prescriptions or directives to be followed and implemented for the long-term preservation of blackbuck.

9. There have been suggestions to fence the Khairapur blackbuck area. Fencing is not only expensive and impractical but also unnatural and inadvisable. One of the main reasons the blackbuck population in Khairapur has survived till now, is that it has escape route to open areas all around and scatter in all directions to cope with the adversities / challenges it has to face for its survival.

10. Surveys to find a suitable habitat for introduction of blackbuck should be given top priority. Detailed study of alternative habitat should be carried out in order to determine that the proposed introduction area meets the critical biotic and abiotic habitat needs of blackbuck. The selected area should meet the year-round needs of the animals in terms of food water and cover so that the released animals will stay in the area and not disperse to other areas. Other factors such as release of animals in a social group, a suitable season for release etc. should be considered beforehand. The chance of success will be enhanced by releasing large number of animals and follow-up releases over a period of time, if necessary.

Monitoring, study and research work should be continued for a long period of time after release of the animals to assess their impact on the environment and for proper management. In brief, reintroduction programmes should include acquisition and reintroduction of indigenous species. Reintroduction is necessarily a long-term process and sustained effort in subsequent releases after the initial reintroduction may be essential for a successful establishment of viable populations of these animals in their natural habitat.

References

Bauer, J. J. 1988. A Preliminary Assessment of the Reintroduction Success of the Asian One-horned Rhinoceros (*Rhinoceros unicornis*) in Bardia Wildlife Reserve, Nepal. *Tigerpaper* 15 (4): 26–32.

Bauer, J. J. and Ellenberg, H. 1988. Status and Management of Blackbuck (*Antilope cervicapra*) in Nepal - with Observations on Behaviour and Factors affecting its Population Size. DNPWC/FAO Project, Nep/85/011, Kathmandu, Nepal.

Berwick, S. H. 1974. The Community of Wild Ruminants in the Gir Forest Ecosystem, India. *Ph.D. Dissertation,* Yale University, USA.

Bhandari, K. 1994. An Assessment of Food Habit and Habitat Utilization of Blackbuck (*Antilope cervicapra*) in Bardia. *A Project Paper Submitted in Partial Fulfilment for M.Sc. in Zoology,* Tribhuvan University, Kathmandu, Nepal.

Bhatta, S. R. 1987. Study of Blackbuck Population at Khairapur, Bardia district. *A Project Paper Submitted in Partial Fulfilment for B.Sc. Forestry,* Institute of Forestry, Tribhuvan University, Pokhara, Nepal.

Blanford, W. T. 1888. Mammalia of British India (including Ceylon and Burma). Taylor and Francis, London, UK.

Cary, E. R. 1976. Blackbuck Menu. *Texas Parks and Wildlife* 34 (4): 16–18.

Dinerstein, E. 1975. A Status Report on the Blackbuck of Bardia District. DNPWC, Kathmandu, Nepal.

Lehmkul, J. F. 1980. Some Aspects of the Life History of Blackbuck in Nepal. *J. Bombay Nat. His. Soc.* 77 (3): 444– 449.

Lydekker, R. 1924. *The Game Animals of India, Burma, Malaya and Tibet.* London, UK.

Mungall, E. C. 1978. The Indian Blackbuck Antelope: A Texas View. *Kleberg Studies in Natural Resources. No. 3.*

Nepal, R. P. 1994. The Status of Blackbuck (*Antilope cervicapra*) Population in Bardia. *A Project Paper Submitted in Partial Fulfillment of the Requirements for M.Sc in Zoology,* Tribhuvan University, Kathmandu, Nepal.

Prasad, N. L. N. S. 1989. Territoriality in Indian Blackbuck, (*Antilope cervicapra*). *J. Bombay Nat. Hist. Soc.* 86:187–193.

Schaller, G. B. 1967. *The Deer and the Tiger.* The University of Chicago Press, Chicago, USA.

Sinha, N. K. 1990. Study on Blackbuck (*Antilope cervicapra*), around Jodhpur, Rajasthan. In: Majupuria, T. C. (ed.). *Wildlife Wealth of India (Resources and Management).* pp. 467–477.

Subedi, B. R. 1991. Problems and Prospects of Blackbuck Protection at Khairapur, Bardia. *A Project Paper Submitted in Partial Fulfillment for B.Sc. Forestry* at Institute of Forestry/Tribhuwan University, Pokhara, Nepal.

Walker, E. P. 1964. *Mammals of the World.* John Hopkins Press, Baltimore, USA.

Wegge, P. and Wilson, P. 1976. The Blackbuck in Banke District. Report to HMG, Kathmandu, Nepal.

Mathema, P., Dutta, I. C., Balla, M. K. and Adhikary, S. N. (eds.). 1999. *Sustainable Forest Management.* Proceedings of an International Seminar, 31 August – 2 September 1998, Pokhara, Nepal.

Musk Deer Farming to Conserve the Endangered but Economically Potential Species of the Himalayas

I. Tewari and R. P. Singh

Abstract: The Himalayan musk deer *(Moschus moschiferous)* is categorised as highly endangered because of excessive poaching for the costly musk found in the musk sac of the male musk deer. To save this species from extinction and to draw economic benefits, suitable conservation strategies, along with musk deer farming is the need of the day. Beside some sanctuaries and national parks, three musk deer rearing centres are in operation in India. Important information and data have also been generated regarding its life cycle. The Mehruri Musk Deer Centre has been successful in the collection of musk without killing the animal. It is clear that if farming is promoted at suitable elevation (above 3000 m) and proper attention is given to breeding, this endangered species can be saved and multiplied as well as significant economic benefits can be drawn.

1. Introduction

The musk deer, *Moschus moschiferous* Linnaeus (Tsalkin 1947) has been serving mankind for various economic, aesthetic and socio-religious purposes since time immemorial. In the Red Data Book of International Union for Conservation of Nature and Natural Resources, the species is listed as "Endangered" and has been listed in Appendix I of CITES. According to 1972 Wildlife Protection Act of India and 1991 Wildlife Protection Amendment Act of India, musk deer comes under Schedule 1 of the "endangered and rare species" and the hunters and poachers are liable to be severely prosecuted with long imprisonment.

The gelatinous, brown musk secreted by musk gland today fetches US$ 40,000–60,000 per kg in international market (Green and Singh, 1982). Further, a pair of musk deer can fetch millions of rupees in the international market. Normally about 150 deer are killed for one kg of musk (Doval, 1989). The present global fashion of preferring natural products may further increase the consumption of musk.

2. Distribution

As far as global distribution of musk deer is concerned, it extends across the Himalayas from north-west Pakistan to Arunanchal Pradesh of India, including the Nepal Himalayas, south-west China, Tibet, Mangolia and up to north-eastern Siberia in the Ussuri region of Russia. The presence of musk deer has also been reported from certain parts of Myanmar and Korean peninsula (Prof I. Prakash, FNA, Jodhpur - personal communication). In south-eastern Himalayan region the habitat of this species is above 3000 m. In India, the deer in the natural habitat is found in Jammu and Kashmir province covering many forest divisions. In Himachal Pradesh the species is found in Kinnaur and Rajgarh. In Uttar Pradesh hills it is found in Badrinath and Tons, Darma and Byans, and Johar and Munsyar forest divisions. It is also found in Sikkim and Arunanchal Pradesh but specific distribution is not known (CCRAS, Annual Reports 1972 to 1985).

3. Farming of musk deer

Besides preserving this animal in its natural habitat, there is a very serious need of saving this rare and endangered species. In fact the countries of former USSR (mainly Russia) and China realised this fact during 1950s and established musk deer farms for their rearing and breeding. In these farms techniques were also standardised to collect musk from the abdomen (musk gland) of male deer without killing them. Information on various aspects of life cycle of this animal was also generated (Ustinov, 1969). The musk deer habitat is associated with alpine, sub-alpine and scrub zone (above coniferous forests). It particularly favours steep slopes and narrow gullies where stunted bushes of *Ribena* sp., *Femula* sp., *Rhododendron* sp., *Juniperus* sp., *Betula* sp. *Quercus semecarpifolia*, *Abies pindrow*, *Cedrus deodara*, *Berberis* sp., etc. occur. In severe winters nothing is available in the abode of musk deer except concentrate food such as bark of trees, lichens, mosses, leaves of rare plants, few grasses, and seeds. During spring, summer and rainy season it browses on leaves, tender parts of plants, mushroom, lichen and certain epiphytes. The captive farming should always be preferred near its natural habitat zone so that it can acclimatise itself easily. In India, however, some of the captive centres and farms have been established at lower altitudes around 2200–2500 m.

In India three musk deer farms viz. Kufri Musk Deer Farm, Himachal Pradesh (H. P.); Kanchula Kharak Musk Deer Farm in Chamoli, Garhwal, Uttar Pradesh (U. P.); and Mehruri Musk Deer Farm near Almora, Kumaun, U. P. are the centres where breeding and rearing of this animal has been attempted. Information and data have also been generated on different aspects of the life cycle of this animal.

3.1. Specific requirements of musk deer farms

The essential requirements of the musk deer farms are as follows:

- The elevation of the farm should be around 3000 m.
- The farm should be 2–3 km away from human habitat.
- Space required for each animal is 50 m x 50 m within stockades. A wooden cabin with asbestos roof should be made. The farms should be enclosed with 4 m high wire net engrooved in 60 cm high cemented wall to protect it from leopards and to prevent the deer from escaping.
- To protect it from soil borne diseases it should be well examined that the soil should not be too moist. There should be proper arrangement of clean drinking water. Some salt-licks should be made in the captivity zone.
- The area where farm is proposed should have ample fodder and vegetation preferred by the deer.
- Proper veterinary and animal husbandry facilities should be provided to the deer.
- There should be 2–3 guard quarters within the farm structure.

3.2. Behaviour in captive farms

In the early hours of morning, the musk deer jumps and leaps for 15–20 minutes. Females are faster than males. Sometimes they nibble on leftover vegetative material. The animals sometimes enjoy each other's company and show love to young ones, which is a natural herd extinct.

Animals in the farm and stockades are found cheerful at temperatures around 15° C. With rise in temperature above 20° C restlessness is visible and animal search for moist places. In the cloudy summer days the animal feels rejuvenated. During heavy rainfall or hailstorm the animal takes shelter in the cabins constructed inside the stockades. With the advent of snowfall it feels exhilarated and takes brisk leaps. It avoids excessive snowfall and prefers to rest at dry places. The animal enjoys moonlight.

3.3. Preference of food

The young and adult animals, in the stockades, prefer the leaves of *Persecaria nepalensis*, especially during monsoon season. They relish *Jasminium officinalis*, *Launea nudicalulis*, *Bergenia* sp., *Holloboelia talifolia*, *Viola serpens*, *Chrysanthemum* sp., *Polygonium* sp. (Sathya Kumar and Prasad, 1990), flowers of *Rhododendron arboreum*, leaves of *Strobilanthes dalhousianus*, *Pyrus pashia*, *Prunus domestica, Rubus nutans*, *Smilax* sp., *Quercus leucotrichophora*, *Q. glauca*, *Arundinaria falcata*, *Usnea* lichen, *Agaricus* mushroom, etc. Although musk deer rely on wild plants, the farm food consists of wild as well as agricultural feed. Musk deer seems to have appetite for 60–70 different varieties of food species in the farm. It also prefers juicy fruits like wild apple, pear, white melon, etc. In captivity it is found to relish milk of any form, soaked gram and wheat. On an average an adult musk deer takes 2–2.5 kg of fodder, 3 kg in summer and 3.5 kg during monsoon season. It takes 50–60 ml water per intake, 2–6 times daily depending upon the season.

3.4. Reproductive phase

By nature musk deer is a timid and solitary animal. The average body weight of the Himalayan musk deer is 9.6–11.2 kg (Green and Singh 1982) and looks like a medium sized goat without horns. The males have long canines. The rut takes place during winter. The heat period in Himalayan musk deer has been observed from the onset of winter to the commencement of spring. Males attain maturity at 2 years of age (McNeely, 1973) and females attain maturity in 18–19 months (Shapisnikov, 1956). Soon after the first snowfall in November, the females start to exhibit the sign of heat. This lasts from November to March. On an average the heat extends up to 48 hours. Approximately at the age of 2.5 years the male is capable of performing more than three copulations a day, one cycle of copulation takes 5–10 minutes.

The period of pregnancy ranges from 198 to 204 days. The pregnant deer shows very high inclination towards salt as compared to other individuals in the stockade. Frequent urination occurs just before labour pains. As soon as the young is delivered, the mother cleans it by licking at first the slime of the amniotic fluid from the mouth, eyes, nose, ear, back, abdomen and limbs. Within half an hour the placenta is also expelled. As soon as the young one stands up it searches for the mother's teats. An animal over the age of 110 days has seldom been found to suck mother's milk.

3.5. Diseases

The first and foremost symptom of ailment is that the nose of the deer appears to be dry and excessive secretion occurs from eyes. Diarrhorea is a common disease encountered in the farms. Giving *Angelica glauca* powder dissolved in cold water cures it. Constipation is also common, which is cured by giving the animal tea like preparation of *Angelica glauca* powder. A disease called pasteurellosis is reported to be highly fatal to musk deer reared in captivity in the Himalayan region (Ashraf, 1991). Lungworm infection has been particularly considered as a predisposing factor for outbreak of pasteurellosis. Eight out of 21 musk deer in Kanchula Kharak Musk Deer Farm died in a short period of three months. The death of one of the autopsied musk deer was attributed to verminous pneumonia (due to heavy infection of lungworm), while the death of another was attributed to pasteurellosis. The lungworm infection is thus predicted to be an inciting factor for the flare up of pasteurellosis. Alopecia (hair loss) is also a disease but rarely encountered. This happens especially in the winters and it is due to deficiency of vitamins and minerals.

Field rats have been found to attack the hooves of the deer during night. Painting of hooves with tincture iodine or benzene and bandaging helps recovery and wards off the rats. Even the plaster of raw turmeric and *Orchis mascula* makes an excellent bandage for wounds. For bleeding wounds, cleaning the affected part with boric acid powder dissolved in lukewarm water followed by application of tincture benzoin is very effective.

3.6. Musk pod and musk

The musk pod is present only in the male deer. In the male individuals the musk gland is visible just below the umbilicus when they attain the age of 3 to 4 months. During this age, it is of the size of the raspberry and very soft to feel. When the deer is 136 weeks old the musk pod attains its full development i.e. 4 cm.

The weight of the musk pod (including hairs) varies from 40 to 70g and contains 10 to 40g of fresh musk in semi-solid state. The musk contains an alkaloid-muscone which is the main constituent responsible for its quality. The ferrons present in musk attracts the female deer. Steroids, esters, proteins, waxes, urogeni salts are other important constituents of musk. Androsterone is also reported to be present in musk. The musk is produced from the age of 2 years up to 14 years. A single male after 4 years of age produces 30 to 40g of musk. This quantity is reproduced annually after six months of extraction (Joshi *et al.,* 1993). Thus throughout its life span of about 16 years, a musk deer can provide a minimum of 360g of musk valued at about 450 thousand rupees.

3.7. Musk extraction

In captivity, musk can easily be extracted without killing or harming the animal. This is done by immobilising the animal either by tranquillising or by physical restraint and scooping out the sticky musk through the opening in the musk pod on the abdomen (Joshi *et al* 1993; Venugopal Rao *et al.,* 1993). In fact the deer can be "milked" for musk twice a year after temporarily anaesthetising the animal. This clearly contradicts the traditional misconception that musk can be procured only after killing the deer. If proper musk deer farms are established in the Himalayan region above 2500 m elevation with facilities for animal care, killing of musk deer for precious musk will stop completely.

4. Conservation strategy

Large-scale killing of this animal for musk is the most important factor for the decline in the population throughout the regions of its occurrence. In the Himalayan region the poaching of musk deer is highly organised and poachers operate in groups. The most discriminate method of picking the male is by shooting. However, this method is not favoured by the hunters because of the risk of detection by forest officials. So, snares, poisoned spears and tracking dogs are used by poachers to kill the animal. The second most important factor for the decline of the species is habitat destruction. In the Himalayan region, sub-alpine forests and scrub are used at an accelerating rate for fuel, fodder and timber; rather than selective thinning large stands of trees are felled completely.

Future conservation of musk deer requires the following strategies:

- Poaching must be controlled more effectively.
- Natural habitats of the musk deer should be protected with stricter legislation and law enforcement.
- Musk deer areas should be earmarked and local folks, who have right over

the forest should be trained in techniques of extracting musk without killing the animals. The male deer can be caught once or twice a year and after musk extraction, should be released back into the forests. This practice is well followed in China (Joshi *et al.*, 1993).

- A village level co-operative of musk deer farming can be introduced throughout the areas of its natural occurrence.
- Musk deer farms and sanctuaries are good propositions for conservation of species. However, these farms and sanctuaries are located in different altitudes and animals inside these have to be fed on the native vegetation or the vegetation in vicinity. In the musk deer centre at Almora, it has been found that change in food habits did not have any direct bearing on the size of pod and quality of musk (Joshi *et al.*, 1993). Therefore, vegetable diet can easily be substituted by cereals and pulses, especially in musk deer rearing farms.
- Musk from India, Nepal and Bhutan is often smuggled to the west and Japan via Hong Kong. In Japan it is valued for its medicinal properties while in the west it is mainly used in perfumery. Co-ordinated action at official level is required to curb this traffic by increasing vigilance at ports.
- Human activities and the flow of tourists around the musk deer farms and sanctuaries should be minimised to the maximum possible extent.
- Large-scale scientific farming of musk deer should be promoted its natural habitats in the Himalayas.

References

Ashraf, N. V. K. 1991. Do Predisposing Factors Determines Pasteurellosis Epidemic. *WWI Newsletter* 6(2): 15–16.

Doval, N. K. 1989. Saved from the Brink. *The Hindu* (Weekly Edition) 2 August 1989, pp.20.

Green, M. J. B. and Singh, A. N. 1982. The Ecology of and Conservation of the Himalayan Musk Deer. In: Saharia, V. B. (ed.). *Wildlife in India,* Natraj Publishers, Dehradun, India. pp.173–190.

Joshi, G. C., Tiwari, K. C., Tiwari, R. N. and Pandey, G. 1993. Conservation Strategy and Some Studies on Habitat Ecology of Musk Deer (*Moschus moschiferous*)-A Vanishing Species. *Indian Forester* 119 (10): 798–803.

McNeely, J. 1973. *Musk Deer, Kastori - A Report.* Department of National Parks and Wildlife Conservation, Kathmandu, Nepal.

Sathya Kumar, S. and Prasad, S. N. 1990. Reintroducing Captive Himalayan Musk Deer. *Zoo's Print* VI (7).

Shaposhnikov, F. D. 1956. Material on the Ecology of the Musk Deer in the North Eastern Alti. *Zool. Zhurnal* 35: 1084–1093.

Ustinov, S. K. 1969. Winter Feeding of Musk Deer (*Moschus moschiferous*) in the East Syane. *Zool. Zhurnal* 48(10): 1558–1563.

Venugopal Rao, S., Singh N., Uniyal, M. R. and Ghosh, D. 1993. Some Experiences on Extraction of Musk from Live Musk Deer. *Proc. Silver Jubilee, Tarikhet Celebrations of IIADR and Seminar on Medicinal Plant Research*, CCRAS, New Delhi, India. pp.31.

Mathema, P., Dutta, I. C., Balla, M. K. and Adhikary, S. N. (eds.). 1999. *Sustainable Forest Management.* Proceedings of an International Seminar, 31 August – 2 September 1998, Pokhara, Nepal.

Protected Area Buffer Zone for Sustainable Natural Resource Management

B. B. Thapa

Abstract: Nepal has established 15 protected areas covering more than 16.5 percent of the country's total land in different geographical locations not only for wildlife management but also for tourism and community development. However, the protected areas have created some conflicts with the local community. This paper discusses the importance of protected area and buffer zone for sustainable natural resource management. A range of important aspects such as status of the protected areas, management problems, development and status of buffer zones in Nepal and legislative policy of the buffer zone have been discussed. The paper also presents some future directions which may provide valuable suggestions for those involved/interested in the conservation of protected area and management of buffer zones.

1. Status of protected areas in Nepal

The concept of protected area (national parks and reserves) in Nepal was primarily initiated for the protection of wildlife, especially, endangered species (Upreti, 1991). Since 1973, Nepal has established an extensive network of protected areas now covering more than 16.5 percent of the country's total land area (see Table 1). Currently, this includes eight national parks, three wildlife reserves, three conservation areas, one watershed and wildlife reserve and one hunting reserve. Two of the national parks, Royal Chitwan and Sagarmatha, are listed by the UNESCO World Heritage Convention as World Heritage Sites. The Kosi Tappu Wildlife Reserve was designated in 1987 as a Wetland of International Importance under the Ramsar Wetland Convention.

All the parks and protected areas are either inhabited by humans or are close to human settlements. These people are dependent on park resources for their survival. Displacement of these populations may not be economically feasible or socially justifiable. Overseas examples of such action have been highly unsuccessful. Thus, in principle, the integration of the ways of life of the protected area inhabitants into the park system may be the better alternative.

2. Management problems in protected areas

In Nepal, establishment of protected area system offered the best possible opportunity to save some representative samples of ecosystem. These protected habitats further allowed many endangered species of flora and fauna to flourish once again. However, if we look back to the other side of the effect of the establishment of protected areas, there have been a number of negative consequences. Since the establishment of national parks and reserves, local people living in and around the protected areas have suffered from some social and economic problems.

Mishra (1984) and Sharma (1991) have mentioned several problems faced by the local communities. These include collection of firewood and fodder, grazing of livestock, collection of timber, wild animal raiding crops, killing of livestock by large carnivores, herbal plant collection, fishing, loss of human life by wild animals, confrontation with army personnel and park staff, social, economic and cultural disruptions by tourists. Realising the fact of the above problems, His Majesty's Government has made the fourth amendment to the National Parks and Wildlife Conservation Act 1973. The fourth amendment 1992 provides the provision of buffer zone for the betterment of the community associated with the protected areas.

Table 1. Protected areas of Nepal

Protected areas	Established year	Area (km^2)
Royal Chitwan National Park	1973	932
Langtang National Park	1976	1710
Sagarmatha National Park	1976	1148
Rara National Park	1976	106
Shey Phoksundo National Park	1984	3555
Khaptad National Park	1984	225
Royal Bardia National Park	1988	968
Makalu Barun National Park	1991	1500
Royal Suklaphanta Wildlife Reserve	1976	305
Kosi Tappu Wildlife Reserve	1976	175
Parsa Wildlife Reserve	1984	499
Sivapuri Watershed & Wildlife Reserve	1984	144
Makalu Barun Conservation Area	1991	830
Annpurna Conservation Area	1992	7629
Kanchanjunga Conservation Area	1997	1700
Dhorpatan Hunting Reserve	1987	1325
Total Area	–	22,751

3. Development of protected area buffer zone

The buffer zone concept was first developed by UNESCO to provide an additional layer of protection around protected areas. This concept has emerged as an exciting new direction as well as a massive challenge for protected area managers (Sherpa, 1993). There are many definitions of buffer zone. Sayer (1991) defined buffer zone as "a zone peripheral to a national park or equivalent reserve, where restrictions are placed upon resource use or special development measures are undertaken to enhance the conservation value of the area". This definition of buffer zone emphasises conservation of resources and enhancement of resources for local people thus creating a balance between conservation and utilisation.

Similarly, the National Parks and Wildlife Conservation Act has defined "buffer zone" as an area set aside around national parks or reserves for granting opportunities to use forest products on a regular basis by local people. However, this definition has not covered the provision to establish a buffer zone inside the protected area. The fact is that most of the mountain parks or reserves require buffer zones within their boundaries (Thagunna, 1995).

Moreover, buffer zone programme combines two primary aims for development. The first is wise use of resource for poor rural people and the second is to conserve the biodiversity in perpetuity. Therefore, buffer zone provides not only an additional layer of protection to existing protected area but also gives an opportunity of sustainable resource use to local people. In addition to this, buffer zone also provides additional habitat for wildlife.

4. Status of protected area buffer zone in Nepal

It is stated above that the history of buffer zone in Nepal's protected areas is relatively short. The Department of National Parks and Wildlife Conservation (DNPWC) prepared a brief concept paper on buffer zone in 1984. The paper focused the need to prevent the rapid forest degradation and addressed the growing resource demands of the communities on the fringe of the parks and reserves (Sherpa, 1993).

In terms of actual application, the Makalu-Barun was the first protected area designated according to core–buffer concept. A 1,500 km^2 area which is free from human settlement was declared under national park status, whereas 830 km^2 adjoining area with more than 3,200 resident people was established under conservation area status. Prior to Makalu-Barun, two land areas adjacent to Royal Bardia National Park were demarcated as buffer zone but their management system failed to develop because of the lack of a legislative mandate (Sherpa, 1993).

The actual buffer zone concept received concrete legal impetus after the enactment of the National Parks and Wildlife Conservation (4th amendment) Act, 1992. To date, besides the Makalu-Barun, three other national parks; Royal Chitwan, Royal Bardia and Langtang have established buffer zones. The other national parks and reserves have also identified and proposed their buffer zones but have not been gazetted yet (see Table 2).

Table 2. Status of buffer zone in Nepal

Protected areas	Area of buffer zone (km^2)	Remarks
Royal Chitwan National Park	750	Gazetted
Langtang National Park	420	,,
Sagarmatha National Park	Area not available	Proposed
Rara National Park	,,	,,
Shey Phoksundo National Park	,,	,,
Khaptad National Park	,,	,,
Royal Bardia National Park	640	Gazetted
Makalu Barun National Park	830	,,
Royal Suklaphanta Wildlife Reserve	Area not available	Proposed
Kosi Tappu Wildlife Reserve	136	,,
Parsa Wildlife Reserve	367	,,
Dhorpatan Hunting Reserve	525	,,

After the gazetting of buffer zones in all national parks and reserves, protected area system in Nepal will cover more than 21 percent of the country's area. This means that compared to its size, Nepal will have the largest proportion of protected area coverage in South and Central Asia.

5. Legislative policy applicable in buffer zone

Buffer zone development is a new policy which emerged in Nepal's policy documents only in early 1990s. Traditionally, a buffer zone is only a protected layer where land use is partially restricted. These layers have been considered as a means to postpone the inevitable consequences affecting protected area (Sharma, 1998). In the case of Nepal, buffer zones have been developed to focus on the special needs of the local communities who are likely to be adversely affected by conservation measures. It has adopted the "Impact Zone" concept developed by Sharma and Shaw (1992), cited in Sharma (1998).

There are two most important pieces of legislation to manage buffer zone in Nepal: National Parks and Wildlife Conservation Act, 1973 and its subsequent amendments, and Buffer Zone Management Regulations, 1996. According to Buffer Zone Management Regulations, buffer zone is defined as the area surrounding a park or a reserve encompassing forests, agricultural lands, settlements, village, open space and many other land use forms (HMG/N, 1996, cited in Sharma, 1998). The regulation provides an opportunity to the park/reserve warden to design programmes that are compatible with park/reserve management. The Act provides 30–50 percent of the revenues generated by the park or reserve to be retained for community development.

Sharma (1998) analysed buffer zone policy of the Royal Chitwan National Park and suggested that the Buffer Zone Management Regulations and the forthcoming Buffer Zone Management Guidelines (under preparation) provide mechanism to mobilise people's participation for community development. Sharma (1998) has further pointed out the following about the regulations.

- The households in a distinct settlement (called unit) are mobilised to form the user group (UG).
- User group or several small groups form user committee (UC). The UC has a minimum of nine members elected by user group members or their representatives.
- The UCs perform co-ordinating and supporting roles between UGs and Buffer Zone Office to mobilise resources and to design and implement programmes.
- The UCs facilitate the flow of the share of government revenue committed for community development fund proposals submitted by user groups.
- The buffer zone warden is the point of official contact for various UC offices spread over the buffer zone. The Chairpersons of the UCs are the members of the buffer zone development council of which the buffer zone warden is the member secretary of the council.

The Buffer Zone Management Regulation (BZMR) is the main policy document which provides legislative power to park wardens to facilitate formation of user groups/committees and to co-ordinate the activities of various line agencies operating in the buffer zone. The park warden's active role in seeking co-operation of the government line agencies and NGOs to promote a growth in a pattern consistent with the protected area's objectives is equally important (Sharma, 1998).

A major discrepancy in the BZMR is that it has not clearly talked about the formation of UG, for example: how much area should be covered by each UG and what are the criteria, such as, local need base, resource use base or political or natural boundary base. Another important aspect left out by the BZMR is that it has made no provision of granting government owned land to groups of poor local people for leasehold forestry purpose (Sharma, 1998).

However, it is expected that the Buffer Zone Management Guidelines will be prepared in the near future and that document will elaborate the provisions made in the Buffer Zone Management Regulation to clarify matters causing ambiguities in implementation. There are some other regulations related to natural resource management in the buffer zone.

6. Suggestions for sustainable development of buffer zone

- All protected area should have buffer zone management plan that addresses resource management, community development, ecotourism, and co-operation with other government and non-government agencies.
- Buffer zone should be managed through the mechanism of user groups with the balance of community development and nature conservation.
- The prime reason of buffer zone establishment is to reduce conflict between park authorities and local people. To do this conservation education is important for local people.
- Buffer zones are created not only for biodiversity conservation but also to provide recreational opportunities for the visiting public. Thus, special areas/sites in the buffer zone should be managed for ecotourism.
- Unique/special natural/cultural sites in the buffer zone should be managed to conserve them such as Brandavar Forest in Royal Chitwan National Park.
- Patches of forest and barren lands in the buffer zone should be managed as community forests.
- Compensation should be given to the local people if wildlife damages their crops, or kills livestock.
- Poor local people should be encouraged to take up employment opportunity in buffer zone.
- Trained park staff-members are always needed for buffer zone management thus effective training should be provided to improve skill of park staff.

References

Mishra, H. R. 1984. A Delicate Balance Tigers, Rhinoceros, Tourists and Park Management vs. the Needs of Local People in Royal Chitwan National Park. In: Mcneely, J. and Millers, K. R. (eds.). *National Parks, Conservation and Development*. Smithsonian Institute Press, Washington, DC, USA.

Sayer, J. 1991. Buffer Zone in Rain Forest: Facts and Fantasy. *Parks* 2: 20–24.

Sharma, U. R. 1991. Park–People Interactions in Royal Chitwan National Park, Nepal, *Ph.D. Dissertation*. University of Arizona, Tucson, USA.

Sharma, U. R. 1998. Buffer Zone Policy Analysis of the Royal Chitwan National Park, King Mahendra Trust for Nature Conservation, Kathmandu, Nepal.

Sherpa, L. N. 1993. Guidelines for Buffer Zone Identification. *Protected Area Buffer Zone Working Paper No. 1.* Department of National Parks and Wildlife Conservation, Kathmandu, Nepal.

Thagunna, S. S. 1995. The Role of Buffer Zone in Protected Areas: A Review and Synthesis of the Case of Nepal. *Unpublished Master's Thesis,* Lincoln University, New Zealand.

Upreti, B. N. 1991. National Parks and Protected Areas. In: Background Papers. *National Conservation Strategy for Nepal*, Vol. 2. The World Conservation Union (IUCN), Kathmandu, Nepal.

Appendix I: Non-Timber Forest Products in Dolakha and Ramechhap, Nepal: A Poster Exhibition

During the Seminar, the Nepal Swiss Community Forestry Project presented an exhibition on Non-Timber Forest Products (NTFPs) found in Dolakha and Ramechhap districts of Nepal. The purpose of the exhibition was to display some commercially important plants of the hills and their products; to disseminate information on their harvesting, processing and marketing; and to make people aware of the potentialities and risks of their management.

The exhibition showed some of the plants from the hills categorised into seven groups according to their utilisation. For each plant species, information on the following topics was presented: botanical description, ecology, religious significance, harvesting methods, processing techniques and marketing of products. The following plants and information on them were presented in the exhibition:

Medicinal plants

chiraito	*(Swertia chirayita)*
nagbeli	*(Lycopodium clavatum)*
lauth salla	*(Taxus baccata)*

Fibre yielding

argeli	*(Edgeworthia gardneri)*
lokta	*(Daphne bholua)*
allo	*(Giradinia diversifolia)*
hattibar	*(Agave* sp.)

Handicrafts

bamboos	(*Dendrocalamus* sp., *Bambusa* sp., *Drepanostachyum* sp., *Phyllostachys* sp., *Aurndinaria* sp.)

Essential oil

timur	*(Zanthoxylum armatum)*
sunpati	*(Rhododendron anthopogon)*
dhupi	*(Jumiperus recurva and J. indica)*
dhasingre	*(Ganltheria fragrantissima)*
jatamasi	*(Nardostachys grandiflora)*

Dyes

majitho	*(Rubia manjith)*
padamchal	*(Rheum australe)*
amala	*(Emblica ofticinalis)*
okhar	*(Juglans regia)*
chutro	*(Berberis aristata)*

Spices

alaichi	*(Elittaria cardomomum)*

Fruits

lapsi	*(Choerospondias axillaris)*

Appendix II: List of Participants and Contributors*

China

Chuo, M.
Chinese Academy of Forestry
Beijing
Tel: 86-10-6496057
E-mail: machuo@public.bta.net.cn

Egypt

Shereif, M. M.
Under Secretary for Afforestation
Ministry of Agriculture and Land
Reclamation, Cairo
Tel: 202-3373790
Fax: 202-3354983

India

Chakravarti, V.
Centre of Minor Forest Products
Indirapuram, Dehradun
Tel: 91-135-621302
E-mail: shivamft@giasdl01.vsnl.net.in

Debnath, D.
Faculty, Sociology and Social
Anthropology
Indian Institute of Forest Management
Bhopal
Tel: 91-755-575716, 573799
E-mail: ddebnath@iifmb.non.mid.in

*** Joshie, P.**
IDRC Project on Eco-rehabilitation
Dehradun

Khurana, D. K.
Faculty, College of Forestry
Y.S. Parmar University of Horticulture and
Forestry, Nauni, Solan
E-mail: tgri@yspunf.hp.nic.com

Kotwal, P. C.
Faculty, Indian Institute of Forest
Management, Bhopal
Tel: 91-755-575716, 575998
E-mail: iifmmail@iifmb.ren.nic.in

Kukreti, M. C.
IDRC Project, ICFRE,
Dehradun
Tel: 91-135-759203

Melkania, U.
Faculty, North Eastern Regional Institute
of Science and Technology
Nirjuli, Itanagar
Tel: 91-360-257401-404
E-mail: forest@nerist.ernet.in

Mishra, A.
Gandhi Peace Foundation
New Delhi
Tel: 91-11-323491,3237493
Fax: 3236734

*** Rai, S. N.**
Ex- Visiting Scholar
Tropical Forest Management
IOF/ITTO Project
Present Address:
Principal Chief Conservator
Karnataka

Singh, J.
Principal
State Forest Service College
Dehradun
Tel: 91-135-754648
Fax: 91-135-756168

Singh, R. P.
Faculty
Kumaun University
Nainital
Tel: 91-5942 35197
Fax: 91-5942-35576

*** Singhal, R. M.**
IDRC Project on Eco-rehabilitation
Dehradun

Tiwari, I.
Kumaun University
Nainital
Tel: 91-5942-35197

Nepal

Acharya, H. B.
Assistant Soil Conservation Officer
District Soil Conservation Office
Kaski, Pokhara
Tel: 977-61-20312
Fax: 977-61 20481

Acharya, T. P.
Faculty, IOF, Pokhara
Tel: 977-61-20467, 20469
E-mail: iof@forestry.mos.com.np

Achet, S. H.
Deputy Director General
Department of Soil Conservation & Watershed Management
Kathmandu
Tel: 977-1-220828, 220857
Fax: 977-1-221067
E-mail: dosc@wlink.com.np

Adhikary, S. N.
Faculty, IOF, Pokhara
Tel: 977-61-21563
E-mail: itto@iof.mos.com.np.

Amatya, S. M.
Deputy Director General
Dept. of Forest Research and Survey
Kathmandu
Tel: 977-1-220493
Fax: 977-1-220159
E-mail: frisp@mos.com.np

Ansari, Y.
Faculty, IOF, Hetauda
Tel: 977-57-20453

Balla, M. K.
Faculty, IOF, Pokhara
Tel: 977-61-20467, 20469
E-mail: iof@mos.com.np

Baral, N. R.
DFO, Sindhupalchowk
Chautara
Tel: 977-11-29546

Baral, S. R.
Information Officer
Dept. of Forest Research and Survey
Kathmandu
Tel: 977-1-220671, 220481
E-mail: foresc@wlink.com.np

Chaurasia, J. P.
Faculty, IOF, Hetauda
Tel: 977-57-20470

Chowdhury, S. D.
Faculty, IOF, Hetauda
Tel: 977-57-20453

Dahal, K. R.
Faculty, IAAS, Rampur,
Chitwan
Tel: 977-56-29303
E-mail: hechitwan@wlink.com.np

Das, A. K.
Dean, IOF, Pokhara
Tel: 977-61-20467
E-mail: iof@forestry.mos.com.np

Dhoubhadel, S. P.
Faculty, IOF, Pokhara
Tel: 977-61-20469
E-mail: iof@forestry.mos.com.np

Dutta, I. C.
Ex- Dean and Faculty
IOF, Pokhara
Tel: 977-61-20467, 20469
E-mail: iof@forestry.mos.com.np

Gurung, S. B.
Faculty, IAAS, Rampur,
Chitwan
Tel: 977-56-29302, 29303
E-mail: iaas@perl.wlink.com.np

Gyawali, A. R.
Faculty, IOF, Pokhara,Nepal
Tel: 977-61-20467, 20469
E-mail: iof@forestry.mos.com.np

*** Joshi, A. L.**
Chief Planning Officer
Ministry of Forest & Soil Conservation
Kathmandu
Tel: 977-1-223862
Fax: 977-1-262599
E-mail: mfsc@singhdbr.mos.com.np

Haque, M. S.
Faculty, IOF, Hetauda
Tel: 977-57-20453

*** Hartz, T.**
Forestry Advisor
Butwal Plywood Factory Pvt. Ltd.
Butwal
Tel: 977-71-40898
Fax: 977-71-40465
Email: ts@hartz.starcom.wlink.com.np

Indu, I. P.
Faculty, IOF, Pokhara
Tel: 977-61-20467, 20469
E-mail: iof@forestry.mos.com.np

Kafle, S. K.
District Planning Officer
UNDP – Local Governance Programme
Kathmandu

Karki, I. S.
Director General
Dept. of Forest
Kathmandu
Tel: 977-1-227574
E-mail: cftp@wlink.com.np

Karmacharya, S. B.
Faculty, Trichandra Campus
Kathmandu
Tel: (R) 977-1-613353

Kayastha, B. P.
Ex- Dean, IOF, Pokhara
Ex- Visiting Scholar
Agroforestry/Silviculture, IOF/ITTO Project
Tel: (R) 977-1-415833

Khan, M. H.
Campus Chief, IOF, Pokhara
Tel: 977-61-20467, 20469
E-mail: iof@forestry.mos.com.np

Khan, R. A.
Faculty, IOF, Pokhara
Tel: 977-61-20467, 20469
E-mail: iof@forestry.mos.com.np

Khanal, B. B.
Faculty, IOF, Pokhara
Tel: 977-61-20469
E-mail: iof@forestry.mos.com.np

Lakhe, S. P.
Faculty, IOF, Hetauda
Tel: 977-57-20453

Mahato, B.
Faculty, IOF, Pokhara
Tel: 977-61-20469
E-mail: iof@forestry.mos.com.np

Mallik, A. K.
Campus Chief, IOF, Hetauda
Tel: 977-57-20453

Mishra, S. M.
Faculty, IOF, Pokhara
Tel: 977-61-20467, 20469
E-mail: iof@forestry.mos.com.np

Myint, A. K.
Forest Resources Specialist
ICIMOD,
Kathmandu
Tel: 977-1-525313
E-mail: a.k.myint@usa.net

Øllgaard, M.
Regional Programme Advisor
DANIDA/NARMSAP
Regional Programme Office
Pokhara
Tel: 977-61-22488
E-mail: cftp@wlink.com.np

Ohler, F. M. J.
Chief Technical Advisor
FAO, Kathmandu
Tel: 977-1-220301, 227632
E-mail: fmjohler@ccsl.com.np

Pandey, R. K.
Faculty, IOF, Hetauda
Tel: 977-57-20453

Parajuli, D. P.
Ex-Visiting Scholar
Forest Utilisation/NTFP, IOF/ITTO Project
Present Address:
Chief Planning Officer
Ministry of Forests & Soil Conservation
Kathmandu
Tel: 977-224892
Fax: 977-1-262599
E-mail: mfsc@singhdbr.mos.com.np

Pokharel, K. P.
Asst, Planning Officer
Ministry of Forest & Soil Conservation,
Kathmandu
Tel: 977-1-223862
Fax: 977-1-262599
E-mail: mfsc@singhdbr.mos.com.np

Pokharel, B. K.
Asst. Forest Officer
Department of Forest
Kathmandu
Tel: 977-1-247599
E-mail: cftp@wlink.com.np

Pokharel, R. K.
Faculty, IOF, Pokhara
Tel: 977-61-20469
E-mail: ridish@recons.mos.com.np

Rasaily, N.
Faculty, IOF, Pokhara
Tel: 977-61-20469

Schuler, K.
Team Leader
Nepal-Swiss Community Forestry Project
Kathmandu
E-mail: nscfp@wlink.com.np

Sharma, P. N.
Regional Co-ordinator
PWMTA/FAO
Kathmandu
Tel/Fax: 977-1-225144
E-mail: sharma@pwmta.wlink.com.np

Shrestha, B. M.
Faculty, IOF, Pokhara
Tel: 977-61-20467, 20469
E-mail: iof@forestry.mos.com.np

Shrestha, K. M.
Faculty, IOF, Pokhara
Tel: 977-61-20467
E-mail: iof@forestry.mos.com.np

Shrestha, L. S.
Faculty, IOF, Hetauda
Tel: 977-57-20453

Shrestha, S. K.
Faculty, IOF, Pokhara
Tel: 977-61-20467,
E-mail: iof@forestry.mos.com.np

Shrivastava, A. K.
Faculty, IOF, Hetauda
Tel: 977-57-20453, 20618

Singh, B. K.
Community Development Advisor
Hill Leasehold Forestry & Forage
Development Project
Kathmandu
Tel: 977-1-227632, 228377
Fax:. 977-1-242640
E-mail: fao@hlffdp.wlink.com.np

Sthapit, K. M.
Ex- Visiting Scholar
Watershed Management/Environmental
Science, IOF/ITTO Project
Present Address:
Soil Conservation and Watershed
Management Component,
NARMSAP, Kathmandu
Tel: 977-1-223999, 241487
Fax: 977-1-241487
E-mail: nepdkwmp@mos.com.np

Tamang, K. M.
Ex- Visiting Scholar
Natural Resource Conservation/Wildlife
Management, IOF/ITTO Project
Tel: 977-1-524927

Tamrakar, J. K.
Project Co-ordinator
Hill Leasehold Forestry & Forage
Development Project
Kathmandu
Tel: 977-1-227632, 228377
Fax: 977-1-242640
E-mail: fao@hlffdp.wlink.com.np

*** Thapa, B. B.**
Conservation Officer
Dept. of National Parks and Wildlife
Conservation
Kathmandu
Tel: 977-1-220912, 220850

Tiwari, K. R.
Faculty, IOF, Pokhara
Tel: 977-61-20467, 20469
E-mail: iof@forestry.mos.com.np

*** Tiwari, S.**
Forest Officer
Dept. of Forest
Kathmandu
Tel: 977-1-248881
E-mail: cftp@wlink.com.np

Trivedi, R. C.
Faculty, IOF, Hetauda
Tel: 977-57-20453

Upadhyaya, C. P.
Faculty, IOF, Pokhara
Tel: 977-61-20467
E-mail: iof@forestry.mos.com.np

Wagley, M.
Director General
Department of Soil Conservation &
Watershed Management
Kathmandu
Tel: 977-1-220828, 220857
Fax: 977-1-221067
E-mail: dosc@wlink.com.np

Yadav, J. N.
Faculty, IOF, Hetauda
Tel: 977-57-20453

Yadav, R. L.
Faculty, IOF, Hetauda
Tel: 977-57-20453

Netherlands

*** Brouwer, J.**
Faculty
Wageningen Agricultural University
Wageningen

Pakistan

*** Ayaz, M.**
Logging Officer
Pakistan Forestry Institute
Peshawar
Tel: 92-91-42662

Siddiqui, K. M.
Consultant
Environment and Forestry
Peshawar
Tel: 92-91-517553
E-mail: khalid_m@geocities.com

Suleman, K. M.
Senior Pulp & Paper Officer
Pakistan Forestry Institute
Peshawar
Tel: 92-91-42662

Philippines

Pulhin, J. M.
Faculty, College of Forestry and Natural Resources, UP Los Banos,
College, Laguna
Tel: 63-49-5363493
E-mail: jmp@mudspring.uplb.edu.ph

Sweden

Skarner, G.
Senior Rural Dev. and Forestry Consultant
Jaakko Pöyry Cons. AB
Lipingo
Tel: 46 873 14500
E-mail: goran.skarner@jpq.se

Thailand

Raintree, J. B.
Consultant
Thai Botanicals Co. Ltd
Nonthburi
Tel: 662-981-2751
E-mail: johnraintree@hotmail.com

Kashio, M.
Regional Forest Resources Officer
FAO Regional Office for Asia and the Pacific
Bangkok

USA

*** Dorsey, E. C.**
Scientist
University of Minnesota
St. Paul, Minnesota
Tel: 1-612-6256787

*** Gupta, S. C.**
Professor
University of Minnesota
St. Paul, Minnesota
Tel: 1-612-6256787

*** Moncrief, J. F.**
Professor
University of Minnesota
St. Paul, Minnesota
Tel: 1-612-6256787

Nair, P. K.
Professor
SFRC, Univ. of Florida
Gainesville
Tel: 1-352-8460880
E-mail: pkn@gnv.ifas.ufl.edn

Sharma, P. P.
Research Associate
University of Minnesota
St. Paul, Minnesota
Tel: 1-612-6256787
E-mail: pshrma@soil.umn.edu

Vietnam

Nham, V.
Faculty
Forestry College of Vietnam

*** Did not participate in the Seminar but contributed paper**

Observers

India

Jarang, K.
Member
Future Generations
Naharlaga, Arunachal Pradesh

Rijiju, K.
P. O. Nafra West Kameng Dist.
Arunachal Pradesh

Tada, N.
East Kameng
Arunachal Pradesh

Nepal

Acharya, M.
Faculty, IOF, Pokhara
Tel: 977-61-20467
E-mail: iof@forestry.mos.com.np

Beek, R. aus der
Nepal-Swiss Community Forestry
Project, Kathmandu
E-Mail: nscfp@wlink.com.np

Chhetri, S.
Faculty, IOF, Pokhara
Tel: 977-61-20467
E-mail: iof@forestry.mos.com.np

Dhakal, C. P.
Faculty, IOF, Pokhara
Tel: 977-61-20467
E-mail: iof@forestry.mos.com.np

Lekhak, H. D.
Ex- Dean, IOF, Pokhara
Faculty, Central Dept. of Botany
Tribhuvan University, Kathmandu

Gurung, C. B.
Faculty, IOF, Pokhara
Tel: 977-61-20467
E-mail: iof@forestry.mos.com.np

Gurung, P. K.
Faculty, IOF, Pokhara
Tel: 977-61-20467
E-mail: iof@forestry.mos.com.np

Haque, M.
Ex- Dean, IOF, Pokhara
Present Address:
Advisor, Dabur Nepal
Kathmandu
Tel: 977-1-475964
E-mail: nepal@dabur.wlink.com.np

Heyojoo, B. P.
Faculty, IOF, Pokhara
Tel: 977-61-20467
E-mail: iof@forestry.mos.com.np

Karki, T. B.
Ex- Dean, IOF
Present Address:
Faculty, Central Dept. of Zoology
Tribhuvan University, Kathmandu
Tel: 977-1-521185

Koirala, R. K.
Faculty, IOF, Pokhara
Tel: 977-61-20467
E-mail: iof@forestry.mos.com.np

Pandey, J. N.
Faculty, IOF, Pokhara
Tel: 977-61-20467
E-mail: iof@forestry.mos.com.np

Prajapati, K. P.
Ex- Dean, IOF, Pokhara
Present Address:
Dudhpati, Bhaktapur
Tel: 977-1-610462

Rai, C.
Nepal-Swiss Communty Forestry
Project, Jawalakhel
Kathmandu
E-mail: nscfp@wlink.com.np

Rajbhandari, M. D.
Ex- Dean, IOF, Pokhara
Tel: 977-1-227614

Regmi, R. R.
Faculty, IOF, Pokhara
Tel: 977-61-20467
E-mail: iof@forestry.mos.com.np

Rudder, W. R.
Resident Representative
FAO Nepal Office
Pulchowk
Tel: 977-1-522990
E-mail: fao–npl@field.fao.org

Sharma, K. P.
Faculty, IOF, Pokhara
Tel: 977-61-20467
E-mail: iof@forestry.mos.com.np

Shrestha, A.
Faculty, IOF, Pokhara
Tel: 977-61-20467
E-mail: iof@forestry.mos.com.np

Shrestha, B.
Faculty, IOF, Pokhara
Tel: 977-61-20467
E-mail: iof@forestry.mos.com.np

Shrestha, L.
Field Manager, TOLI
c/o District Soil Conservation Office
Pokhara

Shrestha, P. M.
FAO Nepal Office,
Pulchowk, Lalitpur
Tel: 977-1-522990
E-mail: fao–npl@field.fao.org

Singh, A.
Faculty, IOF, Pokhara
Tel: 977-1-20467, 20469
E-mail: iof@forestry.mos.com.np

Subedi, B. P.
Faculty, IOF, Pokhara
Tel: 977-61-20467, 20469
E-mail: iof@forestry.mos.com.np

Thakur, D. N.
Faculty, IOF, Pokhara
Tel: 977-61-20467, 20469
E-mail: iof@forestry.mos.com.np

Thapa, Y. B.
District Forest Officer
Bara

Tripathi, H.
Faculty, IOF, Pokhara
Tel: 977-61-20467
E-mail: iof@forestry.mos.com.np