PHASE 2 OF ITTO PROJECT PD 30/97 REV. 6 (F): MANAGEMENT OF FORESTS ESTABLISHED THROUGH REHABILITATION OF DEGRADED FORESTS BY LOCAL COMMUNITIES IN GHANA

Technical report on

Local knowledge on tree values and strategies for managing smallholder forest plantations in three reserves, Ghana

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Abstract

Many forest fringe community members have considerable knowledge of the values of the forest resources they use. In general however, little attention has been given to the relevance of quantitative forms of such knowledge for resource management. Quantitative research method involving a questionnaire survey of a sample of 92 farm households in six communities engaged in smallholder forest plantations establishment in two degraded forest reserve was used to identify tree values and strategies for management. Principal component analysis, one-way analysis of variance, Chi-square Kruskall Wallis and Mann Whitney statistical techniques were employed to analyze the data. Although there were no significant differences between communities on the factor scores for habitat for wildlife and recreation values from the established plantations, the result showed that the mean factor score for the habitat for wildlife value was in the order of 0.416 (Twumkrom) >-0.004(Abonsrakrom)>-0.479(Ntabene)>-0.605(Nsugwansua); whilst that of recreation value was in order of 0.384 (Ntabene)>0.208 (Twumkrom)>-0.056 (Abonsrakrom)>-0.798(Nsugwansua). The paper concludes that the identification of these values and strategies provide important information for improved management of these smallholder forest plantations and similar ones outside the study area.

Key words: Forest plantation values; principal component analysis; local knowledge; management strategies

Introduction

Many forest communities have considerable knowledge of the natural resources they use (ref). Such knowledge can potentially inform scientific approaches to management, either as a source of baseline data to fill information gaps that cannot otherwise be addressed or to provide alternative management approaches from which scientists and managers might learn (ref). In general, however, little attention has been given to the relevance of quantitative forms of such knowledge for resource management (ref). Much discussion has focused on the integration of traditional ecological knowledge (TEK) into management, but less attention has been paid to identifying specific areas where it is most useful and where it may be most problematic (ref). Introducing management plans to manage the plantations established by local communities on the degraded state-managed forest reserves without understanding the knowledge of the local people would hinder the successful implementation of such official management plan.

The aim of this work is to identify the local knowledge and practices in the management of the plantation established on degraded forest land to support the development of management plans. The specific objective is to identify values of forest plantations and analyze strategies for managing such plantation established on degraded reserves based on local community's knowledge.

Plantation forest ecosystem service values: theoretical perspective

Forest ecosystem services are critical to the wellbeing of every society (MA, 2005). Forest ecosystem values spans both the biotic and abiotic components of the forest. People derive lots of benefits from the output of forest ecosystem structure, functions, services and processes as well as the interactions between these components. The Millennium Ecosystem Assessment broadly classifies these benefits into provisioning, regulating, cultural and supporting services (MA, 2005). This classification enhances decision-making on goods and services produced from a forest stand as well as how to effectively manage the resource (de Groot *et al*., 2002; MA, 2005). Some forest ecosystem services can be measured in monetary terms whilst others are not measurable through quantitative economic approaches (Costanza *et al*., 1997; Merlo, 2005). In order to quantify forest ecosystem services and effectively manage them, there was a need to properly categorize the myriads of goods and services forests produce with clear distinctions between functions, processes and benefits (Costanza, 2008). The total economic value framework which is the sum of use, option and non-use values was developed to deal with the categorization issue (Pearce and Moran, 1994; de Groot *et al*., 2002; Costanza, 2008).

Use value of forest ecosystem refers to the current and future direct and indirect physical interactions with forest goods (e.g. timber, Non-timber forest products (NTFPs), hunting, carbon sequestration, water regulation, culture and heritage) (Fisher and Turner, 2008). The present value of maintaining several future possible uses of forest ecosystem services is referred to as option value (e.g. hoping to visit Kakum or Mole National park in Ghana in future). Non-use values reflect the satisfaction individuals derive from the knowledge that forest ecosystems are conserved (Pagiola *et al*., 2002). Existence value is a non-use value people hold for just knowing that forests ecosystems exists (Adger *et al.,* 1995). Bequest value, another type of non-use value is the value people hold from the knowledge that people would also have the option of enjoying forest ecosystem services (Boyd and Banzhaf, 2007).

It is also important to acknowledge the fact that forests have intrinsic value independent of human preferences (MA, 2005). Local communities living in or close to forest reserves have substantial knowledge of some forest ecosystem services since they have ecological and socio-economic interactions with the goods and services provided by forests (Fisher and Christopher, 2007). Like other organism, humans influence the processes taking place in forests. People demand a variety of services from forest ecosystems and as such, effective management is required to decide the mix of services to provide whist ensuring ecological resilience (MA, 2005; Polasky, 2009).

Methodology

Study area

The study was conducted in Begoro, Dormaa and Offinso forest districts in 2013. In the Dormaa, three communities (Abonsrakrom, Twumkrum and Ntabene), in the Begoro, two communities (Ahinkwa and Olantan) and in the Offinso district one community (Nsugunsua) were involved. The main criterion for the selection of individual farmers in these communities was their involvement in plantation establishment and management under the International Tropical Timber Organization (ITTO) project number PD 530/08 Rev.3 (F)) (Table 1)

Table 1: Location of studied community and plantation sites in Dormaa, Begoro and Offinso forest districts

Name of Community	Location of Community	Plot location in Reserve	Name of forest reserve
	N07^{o} 20.051'	N 07^{o} 21.427'	

Abonsrakrom(Old Plot)	W 002° 49.079' N07° 20.051'	W 002° 49.259' N 07° 21.461'	Pamu Berekum
Abonsrakrom(New Plot)	W 002° 49.079' N 07° 20.831'	W002° 49.489' N 07° 22.155'	Pamu Berekum
Twumkrom (Old Plot)	W002° 47.813' N 07° 26.144'	W 002° 48.219' N 07° 26.779'	Pamu Berekum
Ntabene (Old Plot)	W 002° 52.269'	W 002° 50.820'	Pamu Berekum
Nsungunsua (old plot)			Afrensua Brohama
Nsungunsua (New plot)			Afrensua Brohama
Olantan (old plot)			Southern scarp
Olantan (New plot)			Southern scarp
Ahinkwa (old plot)			Southern scarp
Ahinkwa (New plot			Southern Scarp

Data collection and analysis

The data was collected using questionnaire survey. Forest values were identified from literature and focus group discussions with farmers and expert groups and the survey respondents were asked to rate them in order of importance on a Likert scale of 1 to 5. Five (5) was assigned the most important forest value and one assigned to the least important. The data was analyzed using frequency tables, Mann Whitney and Kruskall Wallis Chi square statistical techniques to identify the important relationships among the variables relating to the forest values by the different community groups. Principal component analysis was also done to identify underlying factor structure of the forest values of the smallholder plantation. Factor analyses generally identify a small set of factors that represents the underlying relationships among a group of related variables. It is for this

reason the factor approach was employed to identify such underlying small set of factors for the small holder forest plantation values. Factor scores were generated from the principal components and stored. These were further analyzed using one analysis of variance to determine the impact of the different communities and their plantations on these factor scores.

Results and discussion

Socioeconomic profile

Majority of the respondents listed farming as their primary occupation. Participation of women was recorded in all study communities with the exception of Nsugunsua community. In some cases, they formed the majority of respondents interviewed. This was not surprising as it is well-established that women are active participants in small holder forest plantation schemes in Ghana (Abugre *et al*., 2010). Almost all respondents were married. Marriage provides an avenue to obtain extra labour for farm activities hence, the high percentages recorded in all the communities (Boateng, 2008). A significant portion of respondents had attained Middle School Leaving Certificate eduction (an equivalent of ten years school) with the exception of farmers from Olantan and Nsugunsua communities. Although secular education is not a prerequisite to obtain knowledge about forest values or engage in forestry activities, it influences farmer's ability to engage in sustainable forest management to some extent (Owubah *et al*., 2001; Ardayfio-Schandorf *et al*., 2007).

Table 2: Socio economic characteristics of respondents

Characteristics	Dormaa			Begoro		Offinso
	Ntabene	Twumkrom	Abonsrakrom	Ahenkwa	Olantan	Nsugunsua
Number interviewed	5	9	39	19	9	11
Mean age	57	52	51	50	39	49
Primary occupation	Farming 100%	Farming 100%	Farming 97%	Farming 90%	Farming 89%	Farming 100%
Women	60%	22%	62%	26%	44%	
Education	MSLC* 60%	MSLC 68%	MSLC 62%	MSLC 44%	MSLC 0%	MSLC 0%
Marital status	80% married;	100% married	80% Married	90% Married	Married 78%	Married 91%

Middle School Leaving Certificate (MSLC*) is equivalent to 10 years of school from the beginning

Principal components

The correlation matrix (spearman rank correlation coefficient) is shown in Table 3. There are no strong correlations between variables from the study matrix. But it appears that the correlations are strong enough for the principal component analysis (PCA).

Table 3: Spearman rank correlations between measures of forest plantation values in

Value measure	1	2	3	4	5	6	7	8	9	10	11	12
1)Water quality	1											
2)Wildlife	.10	1										
3)Cultural use	.08	-.04	1									
4)Hunting	-.02	-.39	.05	1								
5)Spiritual use	-.37	-.24	.06	.18	1							
6)Natural forest	.33	.51	-.14	-.09	-.29	1						
7)Medicinal plants	-.01	.10	.01	.03	.07	-.10	1					
8)Food gathering	-.10	-.08	.42	-.13	.02	-.35	.19	1				
9)Recreation	-.17	.10	.43	.10	-.02	-.12	.03	.36	1			
10)NTFP	-.23	.30	-.17	-.16	.03	.20	.13	-.12	-.12	1		
11)Ecotourism	.07	.22	.41	0.12	-.10	.03	.03	.26	.52	.02	1	
12) Timber	-.05	.30	-.02	.17	-.16	.08	-.04	-.09	.13	-.10	.26	1

The Bartlett's test of sphericity was significant ($p<0.001$) rejecting the hypothesis that there is no correlation among the study variables. Five components have Eigen value greater than one and jointly explain 69.7 percent of the variance (19.99, 17.87, 12.59, 10.90, and 8.40). This indicates possible existence of five components in the data as the structure. However, the screen plot revealed the existence of two components.

Structure of forest plantation values

The component loadings after varimax rotation are shown in Table 4. The interpretation of the component solution was based on component loadings. The components were labelled according to these loadings. The names of components were given according to the greatest loading to each component in Table 4.

Table 4: Varimax rotated component loadings for plantation forest values for all study communities and Dormaa study communities in Ghana

	All communities combined		Dormaa communities	
Forest values	1	2	1	2
Recreation	0.785		0.781	
Tourism	0.743		0.738	
Cultural use	0.734		0.721	

Food gathering	0.644		0.700	
Wildlife Habitat		0.807		0.816
Natural forest		0.751		0.741
Spiritual use		-0.603		-0.640
Water quality		0.418		0.393
Timber		0.364		0.327
Hunting and fishing		-0.328		-0.327
% Variance	19.543	18.328	19.616	18.678
Accumulated %		37.869		38.294

Coefficients less than 0.3 are not reported

Economic values for NTFPS and Medicinal plants did load on any of components and were subsequently removed and the analyses run again. The results of the structure of the plantation forest values are recreation that is direct use value on one hand and habitat for wildlife which is an indirect use value (Table 4). This finding shows the recreation and wildlife habitat importance of the plantation forest that the local communities have established. It implied the planning of these plantations should gear towards the ecosystem health in general and recreation and wildlife habitat protection, aside the timber. Aesthetic appeal of the restored portion of the degraded forest probably account for the high loading on the recreation and habitat for wildlife values measures in the factor analysis. The factor loading using all communities combined and only the Dormaa forest district study communities did not differ significantly (Table 4). The data in the Begoro (Olantan and Ahenkwa) and the Offinso (Nsugwansua) forest districts were too small for the factor analysis to be done separately for them.

Factor scores distribution

The factors scores of the two principal components (recreation and habitat for wildlife) identified from the principal components analysis were generated for further analysis (Figure 2). The established smallholder forest plantation for Abonsrakrom community respondents appears to record a higher factors scores for habitat for wildlife than for recreation. Same is recorded for Twumkum community in quadrant 2. In Ntabene community their plantation record higher factor scores in recreation compared to wildlife habitat in quadrant 4. In Nsugwansua community's the plantation recorded the least factor score for both principal components; but the scores appear slightly higher in habitat for wildlife than for recreation in quadrant 3(Figure 3).

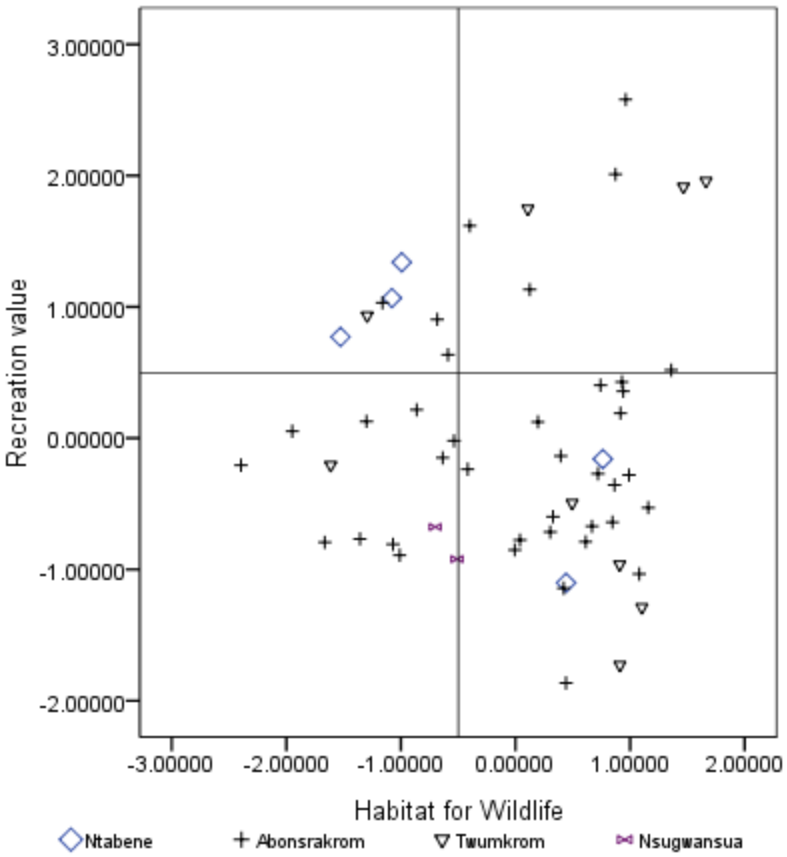

Fig 1: Distribution (factor scores) of respondents in six study communities on two principal components (PCs) by communities. PC1 (recreation value) is used as the y-axis and PC2 (Forest plantation creates habitat for wildlife to multiple) as the x-axis

One way analysis of variance of factor scores

A one-way between-groups analysis of variance was conducted to explore the impact of community on levels of factor scores for habitat for wildlife component from the PCs. The subjects were divided into four communities including Ntabene, Twumkrom, and Abronsrakrom in the Dormaa plantation site and Nsugwansua in the Offinso plantation site. The Begoro communities could not yield any factors scores because of the limited data points. There was no statistically significant difference at the $p<0.05$ level on the factor scores for wildlife habitat [F (3, 51) =1.15, p=0.34] and medium effect size (Eta squared =0.06). The mean factor score for the four communities were in the order of 0.416 (Twumkrom) > -0.004 (Abonsrakrom) > -0.479(Ntabene)> -0.605 (Nsugwansua) (Figure 2). The implication of this result show Twumkrom community forest plantation provides the highest habitat for wildlife service, whilst the forest plantations of Nsugwansua community provide the least.

A similar one way analysis variance conducted for the recreation factor score for the second component of the PCA, to test the impact of the community on it was also statistically insignificant [F(3, 51)=0.48] with a small effect size (Eta squared =0.05). The mean factor score for the four communities were in the order of 0.384 (Ntabene)>0.208 (Twumkrom)>-0.056 (Abonsrakrom) >-0.798(Nsugwansua) (Figure 2). This result implies Ntabene community's forest plantation provides the highest recreational services whilst the forest plantation of Nsugwansua community provides the least.

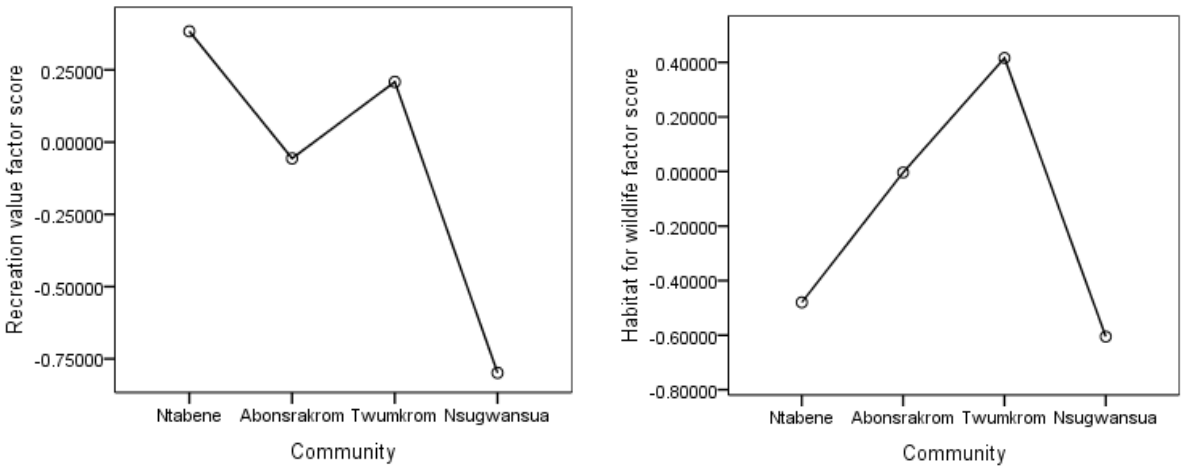

Figure 2: Mean factor scores for recreation and habitat for wildlife components of PCA

Rating of forest plantation benefits

Mean and standard deviation of forest values rating among respondents in the three forest districts study sites Dormaa, Begoro, Offinso are stated in Table 5. Water quality improvement arising from the established plantation is rated as most important with an index of 4.8 (0.69). Timber value, food gathering and medicinal plants supply from these plantations are also rated most important. Tourism/recreation, cultural and spiritual uses of these plantations are rated as the least important (Table 5). Rating of water quality improvement from the plantation was significantly different among the communities (X^2=18.7, DF=5, p=0.002). The communities in Dormaa rated the water quality higher than the Begoro and Nsugunsua communities. For instance, in Ntabene and Nsugunsua communities there was significant difference in the rating (p=0.02); Abonsrakrom and Ahinkwa (p=0.006) and Abonsrakrom and Nsugwansua (p=0.005). Nsugunsua has the lowest rating for water quality improvement from the plantation.

Table 5: Rating of forest values on highest importance (5) to the lowest importance (1) by respondents in the study communities in their respective forest reserves

	Afrensua-Brohama			Southern scarp			Pamu Berekum		
Value measure	N	Mean	Std. Deviation	N	Mean	Std. Deviation	N	Mean	Std. Deviation
Water quality	10	3.9	1.20	21	4.33	1.02	53	4.79	0.69
Wildlife	11	3.45	0.93	21	3.24	1.22	53	3.3	1.30
Cultural use	6	1.67	1.21	5	1.6	0.55	53	1.85	0.84
Hunting	5	2.6	0.55	11	2.55	1.13	53	3.43	1.28
Spiritual use	3	1	0	1	1	.	53	1.75	0.83
Natural forest	10	2.8	1.40	8	4	0.76	53	3.36	1.35
Medicinal plants	9	2.89	1.54	20	3.6	1.19	53	4.04	1.13
Food gathering	5	5	0	17	4.06	0.97	53	4.36	0.83
Recreation	6	1.17	0.41	4	1.25	0.5	53	1.96	1.3
NTFP	9	3.56	1.13	21	3.48	0.87	53	3.64	0.96
Tourism	4	1.25	0.5	6	1.33	0.52	53	2.02	1.14
Timber	9	4	0.87	24	3.46	1.35	53	4.77	0.67

N=Number of respondents from study

Ranking of forest plantation benefits

The ranking of the top five forest benefits is presented in Table 6. The mean indicates the average ranking score obtained by each forest value. The most important forest plantation benefit was water quality, with the lowest mean ranking score of 1.84. This is consistent with the rating result (Table 6). This is not surprising as respondents' primary occupation is farming which is very much dependent on availability of water for irrigation where and when soil moisture is less. Aside the irrigation purpose, local households depend on streams and other water catchments for water to use domestically where portable water is lacking (Willis, 2002). The second and third most important benefit were economic value from timber ($\bar{x}$ = 2.35) and food gathering ($\bar{x}$ = 2.88) respectively. The economic value from timber and food gathering values contribute significantly to income diversification and dietary needs of farmers (Oduro, 2002; Blay *et al*., 2008). Medicinal plant value had the highest mean ranking score ($\bar{x}$ = 3.53) and was the least ranked benefit.

Table 6: Ranking of top 5 forest benefits on 1-5 importance scale, 1 is the most important

	N=respondents	Minimum	Maximum	Mean	Std. Dev
Water quality	50	1	5	1.84	1.13
Economic value from timber	52	1	5	2.35	1.33
Food gathering	40	1	5	2.88	1.29
Natural forest	20	1	5	3.4	1.23

Medicinal plants	34	1	5	3.53	1.24

No significant difference among farmers in communities on water quality (H Ch sq =2.55, DF=2, p=0.28). Same for male and female in the communities on water quality (U Ch sq =247.5, Z=-1.34, P=0.18). Significant difference among farmers in the different communities on economic value from timber (H Ch sq =8.78, DF=2, p=0.01). Abonsrakrom and Twumkrom (p<0.01), Twumkrom (p=0.07). No significant difference among farmers in communities for the remaining

Strategies for managing forest plantation

Ensuring collaboration between community members and FSD staff was agreed upon by all communities as an effective way of managing established forest plantations. This is particularly important as a united front need to be put up to stem illegalities out of small holder plantations and by extension, forest reserves (Robledo, 2014). Mistrust of forestry officials or sidelining of local communities would further deepen forest loss (Marfo, 2010). Early provision of logistics was again agreed upon by all the communities as crucial. Respondents suggested that timely supply of seedlings, wellington boots, cutlasses and other equipment pertinent to forest establishment and maintenance would facilitate their activities (Nanang and Nunifu, 2015). These supplies, especially tree seedlings should be made available to farmers preferably before the cropping season so they can prepare their plots and intercrop the trees in time. The late supply of logistics hampers plantation establishment as these peasant farmers cannot afford them. To that end, farmers suggested the institution of a financial support scheme. The communities in Dormaa suggested fire management strategies. Over the years, forest plantations in these communities have been razed by anthropogenic fires (Appiah *et al.*, 2010; Blay *et al*., 2014). Strategies proposed to deal with these fire instances have yielded little fruit. As such, farmers demanded an innovation in battling wildfire to augment existing ones (North *et al*., 2015). Educating farmers not to leave patches of bushes on their plots was identified as one way to deal with wildfires as these patches which are mostly grassland serve as biomass which fuels fires.

Begoro and Offinso communities were particular about the benefit sharing document which spells out profits due them when trees are harvested in future (Agyeman *et al*., 2003). The farmers were of the view that their tree tenure security is assured only when all parties to the agreement have appended their signature (Blay *et al*., 2014). This they said would give them some confidence in the promises of forestry officials. Regular meeting among stakeholders was also highlighted by all the communities. Periodic interactions between stakeholders would enhance the identification, discussion and resolution of emerging issues (Omoro and Glover, 2013). Another strategy suggested by the farmers was the FSD intensifying their patrol and monitoring activities. Ntabene, Abonsrakrom, Twumkrom and Ahinkwa communities went further to propose the inclusion of external

security (e.g. military) in such patrols and also, the mounting of signpost to delineate forest boundaries and to deter offenders.

Table 3: Strategies for managing established forest plantations

	% total respondents in communities (N= 89)					
Strategies to manage established plantation	Ntabene	Abonsrakrom	Twumkrom	Olantan	Ahinkwa	Nsugunsua
Reduce work load of tree growers	1%	11%	3%	0%	0%	0%
Provide financial support to farmers	1%	15%	5%	0%	2%	1%
Hire labour to clear boundary and protect against fire	3%	15%	1%	0%	0%	0%
Ensure collaboration between community members and FSD	2%	18%	3%	6%	9%	2%
Early provision of logistics	2%	23%	1%	2%	5%	7%
Spot weeding and boundary cleaning	2%	18%	3%	0%	0%	0%
Intensive patrol and monitoring by FSD officials	3%	18%	3%	2%	1%	1%
Regular meeting among stakeholders	1%	21%	1%	1%	3%	1%
Early planting of seedlings	1%	23%	0%	0%	1%	5%
Educate community to prevent bush in the plots	1%	15%	1%	0%	1%	1%
External security to guard forest and mounting of sign post to deter offenders	1%	14%	1%	0%	5%	0%
Creation of green belt against fire	2%	17%	1%	0%	0%	2%
Benefits sharing agreements should be signed	0%	0%	0%	2%	3%	3%

Conclusion

This paper evaluated local knowledge on tree values and strategies for managing smallholder forest plantations in three forest reserves in Ghana. The findings reveal that improvement in water quality as a result of the forest plantation was rated as most important by the communities. Timber value, food gathering and medicinal plants supply from these plantations are also rated most important whilst tourism/recreation, cultural and spiritual uses of these plantations were rated as the least important. The water quality benefit was again ranked as the most important amongst forest values identified.

Farmers contributed valuable suggestions on strategies to manage established plantations. They were of the view that effective collaboration between community members and FSD staff holds prospects for fostering a united front to battle further degradation of forests. Again, timely supply of logistics pertinent to plantation establishment and maintenance is crucial to the successes of small holder plantations. Farmers in Dormaa communities

stressed on the need for innovative fire management approaches to curb recurrent wildfires whilst their counterparts in Begoro and Offinso highlighted the need for the benefit sharing document to be signed so as to allay their fears regarding tree tenure. Regular interactions between stakeholders were also considered key to the identification discussion and resolution of emerging issues concerning such small holder plantations.

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