Technical Reports

Capacity Building for Strengthening Transboundary Biodiversity Conservation of the Taninthayi Range in Myanmar
(Phase I, Stage I)
(PD 723/13 Rev.2 (F))

September 2020

Contents

I. Introduction to Project Area and Pilot Study Area

1.1 Tanintharyi Region

The Republic of the Union of Myanmar is geographically located in Southeast Asia and bordered on the north and northeast by China, on the east and southeast by Laos and Thailand, on the west by Bangladesh and India. Myanmar is endowed with a rich diversity of habitat types arising largely from its unusual ecology diversity.

The Tanintharyi Region (15° 05'- 9° 59'N, 97° 54' - 98° 32' W) is located in Southern Myanmar. It embraces 4 districts and 10 townships covering an area of about 43,345 km^2 and, had a population of 1,406,434 at the 2014 Census data. The northern boundary of the Tanintharyi Region is adjacent to Ye township, Mon State. It shares the border with Thailand in eastern part, and the Andaman sea in the west. The capital of the Tanintharyi Region is Dawei (Tavoy). There are many islands off the coast, the large Mergui Archipelago in the southern and central coastal areas. The area comprises 51 permanent forest estates, area covered with 1,398,421 ha; notified as Protected Area (3) sites, Reserved Forest (34) sites, and Protected Public Forest (17) sites, (Source: Planning and Statistics Division, 2019). The region has a complex topography that ranges from 0 m to 1350 m. The climate and rainfall pattern are highly distributed with spatial and temporal variability with the influence of many factors, the monsoon, various elevation, sea level, forest distribution. The rainfall pattern ranges from 2500 to 5500 mm in the whole region (Variabilities, Dry, & Zones, n.d.). The climate is tropical wet and dry and varies along an aridity gradient from the wetter coastal areas to drier parts inland.

There are differences between mountains and lowlands; and physical isolation of many remote communities from central towns and services. Only limited areas, bounded on one side by mountain ranges and on the other by sea/coastal mangroves, are suitable for industrial tree crops. Subsistence and shifting agriculture predominate in remote valleys and foothills. As the consequence of their physical isolation and limited economic potential, large areas retain significant forest cover and provide viable habitats for biodiversity. The physical, social and economic geography of the Tanintharyi Region all change substantially over short distances and short periods of time.

Currently, there are four protected areas designated in the Tenasserim Range. These include Taninthayi National Park (proposed), Taninthayi Nature Reserve, Mulayit Wildlife Sanctuary and Lenya National Park (proposed). Taninthayi National Park is the largest area and it is located to the left of Kaeng Krachan National Park in Thailand, while Taninthayi Nature Reserve is situated to the north and adjoins Thong Pha Phum and Sai Yok National Parks in Thailand (Figure 1). It is proposed that the planned project site in Myanmar will cover the Taninthayi Nature Reserve, the Taninthayi National Park and the remaining forest cover between these two protected areas. It is noted that the proposed corridor area will play a significant role in transboundary biodiversity conservation in the Tenasserim Range between Myanmar and Thailand as an ecological linkage between fragmented protected areas and migratory routes of mega-fauna like elephant and tiger. The project work will be concentrated on the proposed Taninthayi National Park and some effort to the Taninthayi corridor area (partial area) to support trans-boundary biodiversity conservation in the Taninthayi Range, in Myanmar.

Major economic development projects have been introduced, such as the Dawei Special Economic Zone and a hydro-electric dam in the Tanintharyi River basin. The initiatives raised by potentially affected communities and unresolved governance issues in several areas. There are conflicts era forest concessions for mining, timber and oil palm plantations remain problematic. Formal legal protection of forest areas has greatly increased. 2014 population census confirm wide differences in population density between urban and rural areas. Deeper understanding of population dynamics will be needed to assist the resettlement of internationally and internally displaced persons.

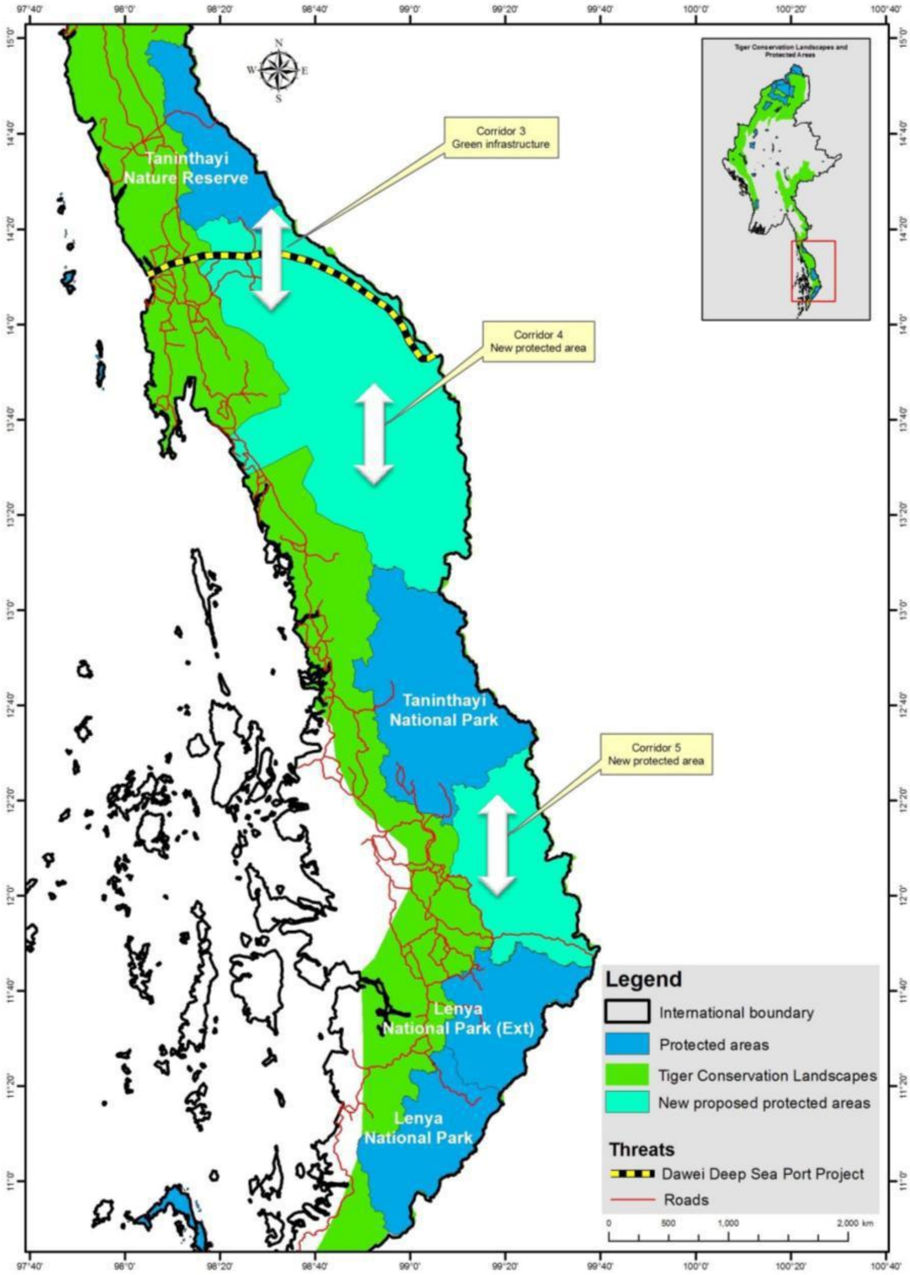

Figure 1. Proposed project area; Important corridors in Tiger Conservation Landscape in Myanmar

Source: Stocktaking Conference on Tiger Conservation -Case studies on habitat connectivity and threats in Tiger Conservation Landscapes of Myanmar

1.2 Tanintharyi Township, pilot project area

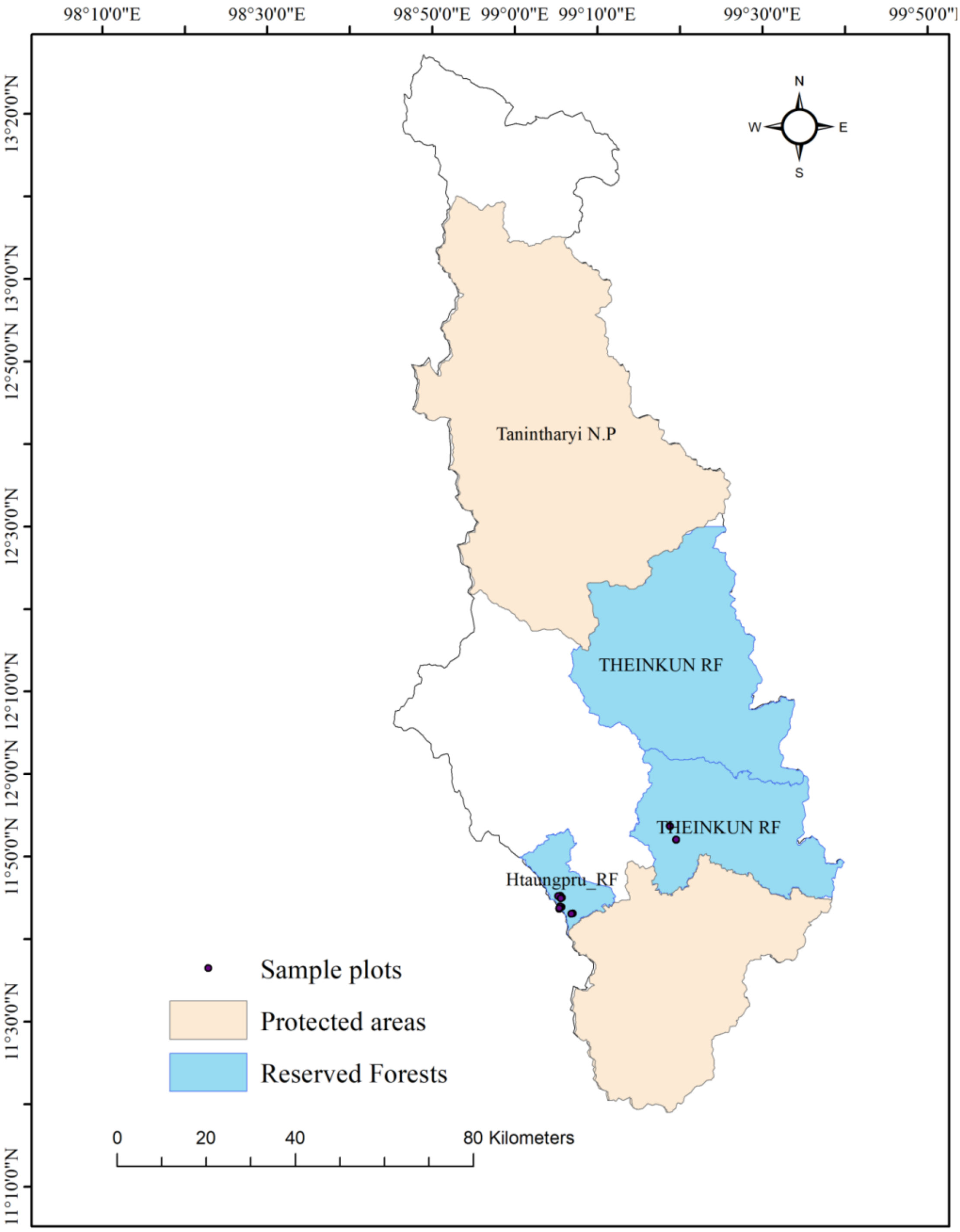

Figure 2. Study area of Tanintharyi Township, Myeik District, Tanintharyi Region

During Phase I – State I of the project, the proposed project activities focused on Tanintharyi Township located within Myeik District, Tanintharyi Region, Southern part of Myanmar. It is located between 11º20´ to 13º10´ North Latitude and 98º40´ to 99º40´ East Longitude. Tanintharyi Township is bordered with Thailand in east, Dawei District in north, Boatpyin Township in south, and Kyunsu Township, Myeik Township and Pulaw Township in west respectively. The area of the township is 4380.18 square miles (11344.61 km^2). About

64.33% of the area of the whole township was forested lands covering the area as 7298.57 km^2. Among those forested areas, 4735.32 km^2 has been declared and demarcated as reserved forests and recognized as permanent forest estate (PFE) administered by Forest Department. In total, there are six reserved forests in this township and those are Taungparu reserved forest, Mayingyi reserved forest, Thakyet reserved forest, Thein Kone reserved forest, Ngawon reserved forest, and Ngawon extended reserved forest. There are two proposed protected areas; namely Tanintharyi National Park and extended Leynyar National Park covering the area of 4447.85 km^2.

Previously, this study area was inaccessible due to the conflicts between the Government and ethnic armed organizations (especially Karen National Union – KNU) while some parts of the area were under the governance of KNU. After signing the National Ceased Fire Agreement between those EAOs and Central Government, those areas became accessible and development activities initiated by the Government as well as non-governmental organizations. Since previous time, some accessible areas became Palm oil plantations established by private companies and orchards where local people grow perennial fruit trees mixed with annual cash crops. As covered by tropical evergreen forests, many wild flora and fauna were abundant in this area showing the importance of biodiversity conservation.

II. Scaling up local livelihoods and peace in the Taninthayi Range in Myanmar for strengthening transboundary biodiversity conservation

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Key Words: biodiversity conservation, livelihoods, SMART Patrol, Taninthari, Myanmar

An important question for the effective and sustainable conservation of biodiversity is whether local needs and context are addressed with the active participation of all stakeholders. Myanmar has been regarded as one of the most biodiversity rich countries in the Asia-pacific region, but biodiversity resources have been dwindling for many years due to the lack of integrated capacity and necessary resources for the sound protection and management of biodiversity. To halt biodiversity lost and strengthen biodiversity conservation, the Forest Department, Ministry of Natural Resources and Environmental Conservation has been trying to expand Protected Areas (PAs) more than 10 percent of the total country's area but it has faced various challenges. These challenges include a critical lack of capacity and resources at the national and local levels, including limited biodiversity research at the Forest Research Institute; and lack of the effective participation of local stakeholders. A weak capacity of local community organizations has created some problems in consensus building in natural resource conservation and management associated to management of protected areas.

The Taninthayi Range along the border between Myanmar and Thailand has been recognized as a global important terrestrial eco-region containing some of the highest diversity of both bird and mammal species found in the Indo-Pacific region. Recent studies indicated that this eco-region is recognized as one of the world's largest populations of Asian elephants and tigers surviving in the forests along the border between Thailand and Myanmar. Karen and Mon people live in the Taninthayi Range and many other indigenous cultures call this area home as a template for sustainable use of the region's rich natural resources. In addition, limited capacity and resources for adequate biodiversity conservation, management and monitoring in Myanmar make it unable to contribute to the transboundary biodiversity conservation in this eco-region.

In order to address the problems associated with limited capacity and resources in biodiversity conservation and ineffective conservation of forest ecosystems and biodiversity in the Taninthayi Range in Myanmar, ITTO project entitled "Capacity Building for Strengthening Transboundary Biodiversity Conservation of the Taninthayi Range in Myanmar (PD 723/13 Rev.2 (F): Phase I, Stage I)" has started with financial contributions from the governments of the US and the Republic of Korea since August 2018.

The project has worked for improved capacity of the Forest Research Institute to design and implement biodiversity conservation, monitoring and research programmes in the Taninthayi Range; and ii) strengthening of local stakeholder participation and livelihoods of forest-dependent local communities. The project works with local forest department as well as line departments, local CSOs, NGOs and communities for the implementation of biodiversity conservation for their eventual transboundary biodiversity conservation work with Thailand's partners. Key areas that have been emphasized during project implementation include ecosystem management, biodiversity corridor, local livelihood improvement, multi-stakeholder participation at all levels, capacity building and sharing lessons learned.

Figure 1. Asian Black Bear (*Ursus thibetanus*) captured by camera trap set in natural forest of Tanintharyi Township

Working together with many partners for the biodiversity conservation of the Taninthayi Range, the project outputs have been delivered including the following:

Capacity building for biodiversity conservation and monitoring: National capacity and necessary resources for biodiversity conservation management and research in the Project area are substantially increased through organizing a series of technical trainings for the staff of local Forest Department, and local communities as well as village consultation process, village development zonation, and community-based natural resource management (CBNRM) with the support of national NGOs like WCS, Friends of Wildlife (FoW) and others.

SMART patrolling training for Forest Department Staff on 21 - 23 August 2019 at the FRI, Yezin; and training on development of community-based ecotourism for local communities on 23 - 25 September 2019 in Tanintharyi City. These technical training courses have contributed to the increased capacity of project staff, rangers, border patrol police, and local communities. In addition, necessary equipment (e.g., GPS, hand compasses, cameras and camera traps) were allocated to protected area staff and local staff for strengthening on-going monitoring system.

Figure 2. Forest Department staff doing practical works for forest inventory during training of biodiversity conservation, protected areas and habitat management at Mt. Popa

Park rangers and field level staff of Forest Department in the project areas have been trained, and have learned to use more effective tools in patrolling and in collecting data through SMART Patrol tool in the Taninthayi Hills and the adjoining forest areas. These trainings will also contribute to those who are working in border areas (eg. Kachin State, Kayah State, Kayin State, Chin State) in terms of reducing natural resource management conflicts. Technical and professional staff at regional and central levels are also increased their understanding of how to use systematic baseline data for biodiversity conservation.

The capacity of biodiversity research of the FRI has been increased through formulating and implementing long-term research plans focused on biodiversity conservation especially plant diversity (Flora of Myanmar). Survey on plant and wildlife in 15 plots (30 × 30 ft.) has been conducted and the number of wildlife species investigated is 25 sp. while bird species investigated are 30 sp. The provision of research capacity building trainings is especially important in the FRI, where staff have little or no access to training, and budgets for management are very small, and there are very few rangers and facilities on the ground.

Sustainable local livelihood improvement: Sustainable livelihoods of forest-dependent local communities have been enhanced to support the conservation of biodiversity in the project site with strengthening of local community organizations and networks. Community-based natural resource management activities have been intensively implemented in the Taninthayi National Park and its surrounding areas. Local communities have gained additional knowledge of alternative income-generating activities. Their livelihoods were improved and they will be less dependent on forest resources.

Training courses organized by the project include agroforestry and livelihood development activities for local communities on 9 - 11 September 2018 at Forest Plantation Camp, Chaung Naut Pyan Village, Tanintharyi Township. Furthermore, research on socioeconomic assessment of seven villages in border areas in Taninthayi Township and survey of wildlife and a data analysis for the socioeconomic assessment has been completed. Production of promising non-timber forest products in 6 villages, including firewood and charcoal utilization by local villagers, has been analysed.

Figure 3. Women making bamboo based handicrafts at Tanintharyi Township

Multi-stakeholder participation at all levels: In addition to encouraging local NGOs to share development experiences and provide support to integrated conservation development activities through the project, academic, researchers and local NGOs at regional and national levels were involved with providing some capacity building training.

A series of public awareness and stakeholders' consultation meetings have been organized. These include three workshops and five consultation meetings with local communities and related organizations from August 2018 to September 2019; a consultation workshop on promoting biodiversity conservation in trans-boundary areas on 26 June 2019 at the FRI in Yezin; a regional workshop on promoting trans-boundary biodiversity conservation in Tanintharyi Range on 26 September 2019 and a consultation meeting on strengthening community-based conservation organizations on 27 September 2019 at Myeik, Tanintharyi Region. In addition, education talks were taken place at Tanintharyi Township for 6 times. The project organized an event for the International Day of Forests at FRI, Yezin in March 2019 with partners.

Impacts of project intervention

Despite a short project period, there are many lessons learnt from the implementation of the project. Interesting project interventions include livelihood improvement activities by means of capacity building programs encompassing agroforestry approaches (integrated agriculture), hands-on training on production of bamboo-based handicrafts, and ecotourism development which can balance between livelihood security and biodiversity conservation. Local people residing in villages of Taninthayi Township actively took part in those extension activities were in line with their current needs of sustainable livelihood improvements.

"It learned about good agroforestry practices to make my lands more productive compared to our earlier practices focusing mostly on pure agriculture and fewer products" said Ms. Khin Mar Wai Ayetharyar Village, Tanintharyi Township, one of the female participants joined the training on agroforestry systems. "With improved incomes from my agroforestry activities, I can pay more support to increase biodiversity and improve soil fertility".

Figure 4. Local people explaining conventional agroforestry design practiced in their villages during an Agroforestry development training

Taninthayi Township is located in remote area as well as has once encountered conflicts with ethnic armed organizations (EAO), but has currently signed ceasefire deal with the Union Government. In this context, establishing and practicing good consultation process and mechanisms among different stakeholders is critical to the design and effective implementation of development initiatives balanced with nature conservation. The project filled this gap to initiate a coordination mechanism among different institutions by conducting series of consultation meetings and developing community based natural resource management (CBNRM) plans for four demonstration villages. One of the achievements of the project is that ethnic armed organizations (i.e Karen National Union-KNU which is a National Ceased Fire Agreement-NCA signed EAO) cooperated with the project team to conduct Plant Biodiversity Research and Wildlife Survey (especially setting a camera trap in the KNU controlled area).

"I really appreciate ITTO project's support to public raising awareness about forest and biodiversity, and cooperation opportunities with ethnic armed organizations in biodiversity conservation research," said Mr. Sein Win, Assistant Director of Myeik District Forest Department and Mr. Kaung Set Naing, a Range Officer of Local Forest Department. "We look forward to more working opportunities with ethnic armed organizations for biodiversity conservation and a more peaceful future."

The sustainability

Extending the project activities is the most important for the project sustainability. One of the important challenges is to build a sustainable political supporting system with involvement of multiple organizations and institutions from the local to the transboundary level and the national level. Facilitation, coordination, resource mobilization and law enforcement could be more effective only when the project receives political supports. Another challenge is the involvement of the relevant stakeholders in transboundary biodiversity conservation. Transboundary initiatives create additional demands on the administration of natural resources, policy development and harmonization, consultation processes, and implementation. Transboundary biodiversity conservation almost always includes a variety of actors so that it is very important to establish a trust and coordination mechanism among relevant stakeholders. Continued capacity building programmes are very crucial for all relevant stakeholders. Habitat management and conservation for the plants and wildlife plays a vital role in transboundary biodiversity conservation. In this regard, the technical details and baseline information about biodiversity, social, economic, cultural, legal etc. of the transboundary areas are inevitably needed to ensure the long-term success of the transboundary biodiversity conservation initiative. Supporting to the implementation of stage II of Phase I and Phase II is essential to strengthening institutional coordination mechanisms with neighboring country, Thailand to implement the effective management of wide-ranging species in the Taninthayi Range under a shared vision of enhancing long-term transboundary biodiversity conservation between Myanmar and Thailand.

III. Analysis of Forest Cover Change in Tanintharyi Region to the application of Biodiversity Conservation

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Executive Summary

Land use and land cover change is a major force of ecological change in tropical regions. The pattern and process of deforestation and forest degradation have thus received considerable attention in biodiversity conservation planning, ecological, socioeconomic, and policy studies to support effective management mechanisms. Realizing the need to provide information on the present status of forest cover change and deforestation rates of the past and present in the region and identify major land use and cover change areas for Tanintharyi region, Remote Sensing and GIS section of Forest Department conducted monitoring of land use and land cover of in and around Tanintharyi Region and creating wildlife corridor using 2005 Landsat 7 ETM, 2010 IRS Liss-3 and 2015 Lansat-8 OLI imageries. And deforestation was conducted by two areas; whole Tanintharyi Region, wildlife corridor by creating 10 km buffer area of sample villages. The projection and forecasting method were not applied in this study unlike the methods that was used in submitting FAO report. In this case, we estimated in utilizing the time-series satellite images. This study observed that closed forest lost about 20% during a period of 10 years. Open forest and rest categories increased over time. Similarly, deforestation rate of whole study area was normally found at first period. In a surprising way, we observed that forest was slightly regained in the second period due to the activities of reforestation, controlled illegal logging, natural regeneration from shifting cultivation. The results similarly revealed that the forest area within 10 km buffer area of sample village was seriously lost at first period, were increased and regained again at second period. However, forest was not recovered to the same situation as the beginning time. Forest was lost on different spatial area, based on the finding of forest recover around two sample villages in the north. Depending on the intense of human intervention and existing practices, forest area will change from time to time and space to space. Anthropogenic activities and human settlement were mainly related to the natural factors such as forest degradation, deforestation, and forest increment.

Analysis of Forest Cover Change in Tanintharyi Region to the application of Biodiversity Conservation

1. Introduction

Forest cover is a key attribute of local communities and affects the spatial organization of any given region. Changes in forest cover are influenced by spatially-varying biophysical and anthropogenic factors mainly associated with urban-rural, coastal-inland and elevation gradients (Ferrara, Carlucci, Grigoriadis, Corona, & Salvati, 2017). In tropical regions, deforestation and forest degradation are progressive processes that are advancing at an alarming rate (Verolme et al., 1999; Rudel and Roper, 1997; Laurance, 1999), resulting in the conversion of forest area into a mosaic of mature forest fragments, agriculture, and degraded habitat. Anchard et al., 2002 reported a rate of decline of humid tropical forest of 4.9 million ha per year. Fragmentation issues typically are related to deforestation and loss of forest cover within tropical, developing countries (Nagendra et al., 2004). It is widely recognized that human intervention in land utilization has changed forest cover over time. Land use change by human activities has become a proximate factor that catalyzes deforestation and forest degradation. Landscape patterns are used to quantitatively describe patch dynamics of landscapes (McMorrowa and Talipb, 2001). Satellite remote sensing has been widely used to detect forest change, assess rates of reforestation or deforestation, and update existing forest maps (Myers, 1980).

Myanmar’s burgeoning populations and high poverty levels have increased pressure on its natural resources and protected areas (Lwin et al., 1990). In 2001, a report of the Myanmar Ministry of Forestry identified the following major threats to forest and biodiversity: conversion of closed forests to other land uses. The 4th National Report on Biodiversity (2009) confirms that Myanmar is losing biodiversity due to socio-economic pressure (Isituto Oikos & BANCA, 2011). Agricultural expansion, shifting cultivation, conversion of forest to plantations are the main causes of habitat degradation and loss (FAO, 2010). Forest Resource Assessment (*Global Forest Resources Assessment 2015*, 2015) indicated that 50.2% of the total land area (676,577 km2) of the country covered with forests in 2005 (FAO, 2006). Continuously, Myanmar forests are rapidly decreasing from about 46.96% in (FAO, 2010) to about 42.92% (UN FAO, 2015) of the country's total land area. In the last 25 years, average deforestation rate in Myanmar has been about 1.2% per year; one of the highest rates in Asia and globally. Between 2010 and 2015 Myanmar had the third fastest forest loss rate in the world at an average annual deforestation rate of 1.7% (*Global Forest Resources Assessment 2015*).

Most of Myanmar's remaining large forests are located in the far north and south of the country, connecting to other extensive forests in India and Thailand. The Tanintharyi forests extend to Thailand's Western Forest Complex and Kaeng Krachan National Park. These areas are considered biodiversity hotspots and are supporting many endangered species, including tigers (*Panthera tigris*), Asian elephants (*Elephas maximus*), Gurney's pitta *(Pitta gurneyi)* and Asian tapir *(Tapirus indicus*). The Southern Forest Complex links three large and intact forest landscapes, including the Tanintharyi Hills, the Myinmolekat & Central Tanintharyi, and the Luwaing Reserve Forest and Hiungye Taung, jointly covering 1.7 million ha of intact forest. Tanintharyi Region is a relatively undeveloped area with high biodiversity and endemism whose natural capital provides invaluable ecosystem services underpinning the regional economy and socio-economic security. The region is of outstanding significance for biodiversity conservation - approximately 20% of Myanmar's Key Biodiversity Areas (KBAs) in Tanintharyi, classified under the Tanintharyi Range and Tanintharyi Marine priority conservation corridors.

Remote sensing method is employed in this study because it is a fast method of acquiring up-to-date information and offers a variety of benefits compared to other forms of data acquisition. Data from satellite imagery are not biased, unlike other means of data collection in which human irregularities and uncertainties are predominant. Using remote sensing techniques in this research, it is possible to measure occurrence and rate of environmental change in the Tanintharyi Region without being affected by insecurity anxiety in the region. The combination of different remote sensing and GIS methods provides valuable information for sustainable forest management in the region.

Landsat was mainly used in the present study because it has been shown in several other recent studies that it is good for preparing precise forest maps, observing changes at regular intervals of time, cost and time effective (Ayanlade & Howard, 2017). Using satellite data such as Landsat ETM, it is possible to examine both spatial and temporal changes in the forest because of its 16 days temporal resolution (Zhe Zhu and Curtis E. Woodcock, 2014). This research area has been experiencing with several threats to forest, especially land use land cover change; increasing in-migrant people, massive expansion of agricultural land like subsistence or large-scale permanent fruit orchards, conversion to palm oil and rubber plantation, illegal logging, shifting cultivation and unplanned development projects. This study attempts to use remote sensing to quantitatively examine spatiotemporal changes of forest cover in Tanintharyi Region. Thus, this study evaluated land use land cover (LULC) change during the period of 15 years, by the application of high technology such as Remote Sensing and GIS. We utilized the time series 2005 (Landsat-5 ETM), 2010 (IRS-Liss 3) and 2015 Landsat-8 imageries, that freely can be downloaded from Earth Explorer Website (USGS) Landsat images.

The primary purpose of this study is to support the information for improving transboundary biodiversity conservation with a focus on the work in the Tanintharyi Range. There are many objectives as follows:

1. Analysis on spatial-temporal changes of forest cover in Tanintharyi Region (2005-2010-2015)
2. Study on the deforestation rate in Tanintharyii Region (2005-2010-2015)
3. Investigation the land use land cover change around sample villages

2. Data and Method

2.1 Study Area

The study was carried out in the Tanintharyi Region (15° 05'- 9° 59'N, 97° 54' - 98° 32' W) located in Southern Myanmar. The study area embraces 4 districts and 10 townships. It covers an area of about 43,345 km^2 and had a population of 1,406,434 at the 2014 Census data. The northern boundary of the study area is adjacent to Ye township, Mon State. It shares the border with Thailand in eastern part. In the west, it is alongside of the Andaman sea. The capital of the Tanintharyi Region is Dawei (Tavoy). There are many islands off the coast, the large Mergui Archipelago in the southern and central coastal areas. The study area comprises 51 conserved forests, area covered with 1,398,421 ha; notified as Protected Area (3) sites, Reserved Forest (34) sites, and Protected Public Forest (17) sites, (Source: Planning and Statistics Division, 2019).

The study area has a complex topography that ranges from 0 m to 1350 m. The climate and rainfall pattern are highly distributed with spatial and temporal variability with the influence of many factors, the monsoon, various elevation, sea level, forest distribution. The rainfall pattern ranges from 2500 to 5500 mm in the study area (Variabilities, Dry, & Zones, n.d.). The climate of the study area is tropical wet and dry and varies along an aridity gradient from the wetter coastal areas to drier parts inland. The prevalence of persistent cloud cover throughout rainy season the year in November–March, limits the availability of clear images. The equatorial vegetation that once covered the study area has been replaced by habitation, secondary forests, agricultural development and shrub thicket.

2.1.1 Geography of Tanintharyi Region

There are differences between mountains and lowlands; and physical isolation of many remote communities from central towns and services. Only limited areas, bounded on one side by mountain ranges and on the other by sea/coastal mangroves, are suitable for industrial tree crops. Subsistence and shifting agriculture predominate in remote valleys and foothills. As the consequence of their physical isolation and limited economic potential, large areas retain significant forest cover and provide viable habitats for biodiversity. The physical, social and economic geography of the Tanintharyi Region all change substantially over short distances and short periods of time. The maps can provide as baseline for planning and implementing the region's social and economic development as well as enhancing its globally significant role in forest conservation.

2.1.2 Social and Economic Geography

Major economic development projects have been introduced, such as the Dawei Special Economic Zone and a hydro-electric dam in the Tanintharyi River basin. The initiatives raised by potentially affected communities and unresolved governance issues in several areas. There are conflicts era forest concessions for mining, timber and oil palm plantations remain problematic. Formal legal protection of forest areas has greatly increased. 2014 population census confirm wide differences in population density between urban and rural areas. Deeper understanding of population dynamics will be needed to assist the resettlement of internationally and internally displaced persons.

Table 1. describes the total and urban population by district, by sex in 2014 Census.

Total and urban population by District, by sex, 2014 Census(million)									
State/ Region and District	Population (urban + rural)				Urban population				Percent urban population
	Both sexes	Male	Femal e	Sex ratio	Both sexes	Male	Female	Sex ratio	
Union	50.27	24.22	26.05	93	14.88	7.11	7.76	91.6	29.6
Tanintharyi Region	1.41	0.70	0.70	99	0.34	0.16	0.17	95.1	24.0
Dawei	0.49	0.24	0.25	93.9	0.11	0.05	0.06	92.3	21.9
Myeik	0.69	0.35	0.35	99.5	0.15	0.07	0.08	93.5	21.8
Kawthoung	0.22	0.12	0.11	109.5	0.08	0.04	0.04	102. 4	35.7

2.2 Data

The study period for this research is the decade between 2005 and 2015. The multi-temporal data sets were used for spatial-temporal image analysis for the entire Tanintharyi Region, Southern Myanmar. A time series of satellite image dataset at 2005, 2010 and 2015 were used, and information about the data used in this study is listed in Table 2. Nine-fine spatial resolution, free and commercial satellite images (IRS LISS-3) were selected for the real time period 2000 Landsat and 2010-IRS Liss-3 and 2015 Landsat respectively. These Landsat images were made available to us at no cost through a NASA, USGS Earth Explorer website. We therefore selected from approximately the same season (December to April), to analyze the degradation and deforestation status of different forest types in the Tanintharyi Region. The projection and forecasting method were not applied in this study unlike the methods that was used in submitting FAO report. In this case, we estimated in utilizing the time-series satellite images' results.

Table 2. represents the dataset that was used in this study

Purposes	Data sources (Type/Resolution)
Image Classification	Landsat-7 ETM – 2005 (30 meter)
	IRS-Liss III- 2010 (23 meter)
	Landsat 8 OLI/TIRS – 2015 (30 meter)
Validation	Google Earth Pro Topo & historical maps, Field Inventory points
Auxiliary data	ASTER GDEM (Elevation Data)

2.2.1 Ancillary Data

Data on forest reserves, all GIS shapefiles such as roads, villages and historical maps, 50,000 scale UTM maps, in the Tanintharyi Region were collected from the archives of the Forest Department, Myanmar. These ancillary data were combined with remote sensing data in order to assist in image classification, which is not possible to clearly classify the land cover classes by remote sensing. Thus, these set of data (in Table 2) were used for validation and better interpretation of remote sensing analysis.

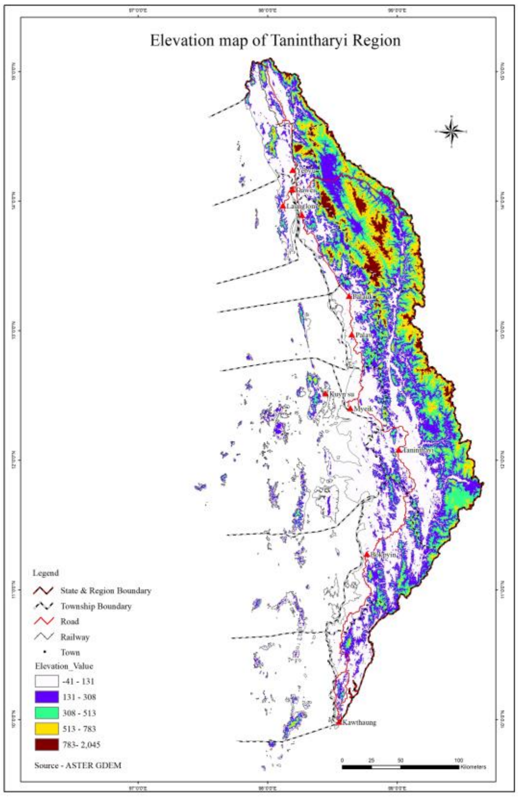

Figure 1. Slope condition in Tanintharyi Region

2.2.2 Image Classification

Image pre-processing was carried out in ArcMap 10.2 and ENVI 4.3 software packages. mage calibration, radiometric calibration and geometric and atmospheric correction were carried out to correct for sensor drift, differences due to variations in the solar angle, and atmospheric effects (Green et al., 2005). A mosaic of the Nine images was created to cover the study area and was then re-projected to the UTM WGS84 coordinate system with a spatial resampling of 30 m. Each mosaicked image was classified following the same method (Mondal & Southworth, 2010).

Maximum likelihood image classification was carried out to classify the image with eight classes of land use land cover(LULC) and then reclassify six LULC following these steps: Selection of training site; Selection of classification method; Accuracy assessment; Post-classification analysis and assessment of intra-annual rate of deforestation and forest degradation; and Change map production. After preparation of three forest cover maps, it was compared for change assessment (Ayanlade & Howard, 2017). Field inventory points that was conducted by Forest Department were only applied for field validation work and was also undertaken by using the Google Earth Pro, freely, Topographic and historical maps from Forest Department. Further, we used elevation data that was derived from ASTER GDEM when we encountered some categories that was unable to determine(Boundeth, Nanseki, Takeuchi, & Satho, 2012).

Land Use Land Cover (LULC) Definitions used

Forest	:	Land with tree crown cover (or equivalent stocking level) of more than 10 percent and area of more than 0.5 hectares (ha).
Closed Forests	:	Formations where trees in the various stories and the under growth cover a high proportion (> 40 percent) of the ground and do not have a continuous dense grass layer.
Open Forests	:	Formations with discontinuous tree layer but with coverage of at least 10 percent and less than 40 percent.
Mangrove Forests	:	Group of trees and shrubs that live in the coastal intertidal zone
Other Wooded Land	:	Land either with a crown cover (or equivalent stocking level) of 10 percent of trees
Other land	:	Land not classified as forest or other wooded land as defined above. It is included agricultural land, meadows and pastures, built-up areas, barren land, etc

2.2.4 Post-classification

Post-classification refinements, majority minority analysis and manual editing in ArcGIS Desktop were applied to reduce classification errors caused by the similarities in spectral responses of certain classes such as other wooded land and open forest and closed forest. Finally, a standard majority (ILWIS, 2005) and minority filter was run through the classified image for smoothing (Panta, Kim, & Joshi, 2009).

2.2.5 Analysis of the LULC changes around Villages

This study also assessed the land use land cover change of surrounded sample villages to apply in considering biodiversity and forest relationship. Hence, we used and created the 10 km buffer based the data of six sample villages that was surveyed for the purpose of socio-economic condition under this ITTO project.

2.2.6 Deforestation and forest degradation rates

By using the standard formula, deforestation and forest degradation rates were calculated. The following formula was used to estimate the rate of changes of forest cover between the period; 2005-2010, 2010-2015 and 2010-2015.

Deforestation = complete conversion of forest to non-forest

Gross forest degradation = closed forest to open forest (Uryu et al., 2008)

Forest cover and deforestation rates were calculated for the sub-time step datasets using the standardized approach proposed by Puyravaud, (2003).

$$Deforestation\ or\ Degradation\ rate\ per\ yr = \left\{\left[\frac{1}{time\ A2 - time\ A1}\right] * \log\left(\frac{A2}{A1}\right)\right\} * 100$$

Where:

A1 = Forest Area (Dense and Open forest) or Dense forest at beginning of time step

A2 = Forest Area (Dense and Open forest) or Dense forest at end of time step

Time A1 = Year and day count as digit number of beginning of time step

Time A2 = Year and day count as digit number of the end of time step

3. Results

3.1 Forest Cover Change in Tanintharyi Region

The results show that the forest vegetation in Tanintharyi Region has been under pressure. We classified six LULC categories; closed forest, open forest, mangrove forest, other wooded land, others and water. Comparative analysis of total areas of each LULC classes among three dates revealed that LULC classes altered noticeably in area (Figure 1, Table 1). In this study, there naturally exists less amount of mangrove forest alongside of the coastal area, particularly in some part of coastal side.

The dominant land-use/cover classes for all three studied periods, between the 2005 and 2015, were forests that includes closed and open forest, and third dominant class was other wooded lands.

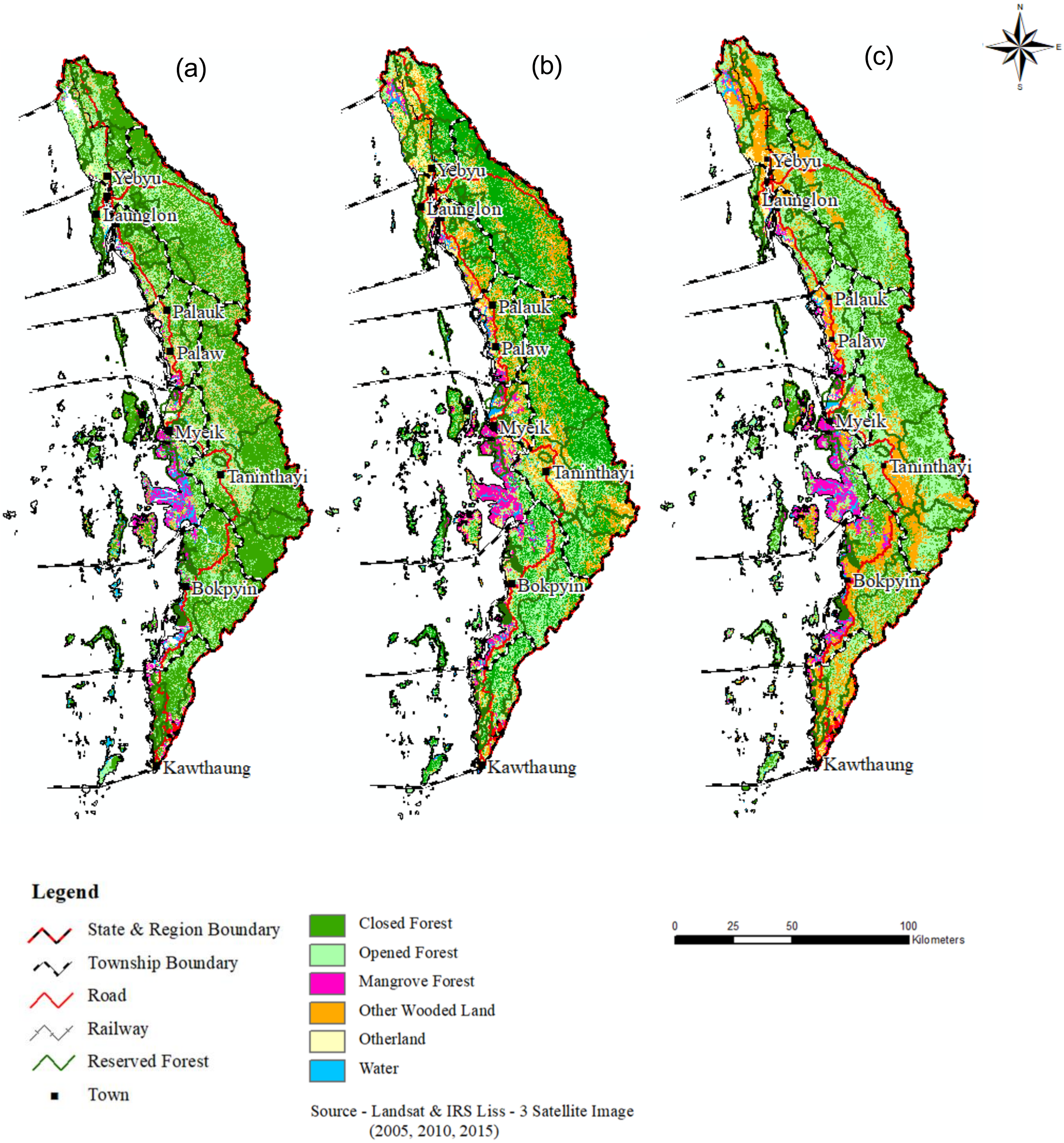

Figure 2. Land use land cover change in Tanintharyi Region over the study period, (a) 2005, (b) 2010 and (c) 2015.

Table 2 indicates that closed forest (CF) is the most common LULC class in first two periods, 2005 and 2010, with 46.24% and 39.09% respectively. However, CF was gradually deteriorated about 20%, 886,201.99 ha (net decrease) over 10 years and dropped as the second dominant class, covered with 25.81% in 2015, as Table 4. On the other hand, area total forest has not changed over 10 years. However, the conversion of land use land cover was seriously occurred each other categories within this study, shown in Fig 2 and Table 3.

Table 3. shows comparison of LULC change in Tanintharyi Region in three dates-2005, 2010 and 2015

LULC Classes	2005		2010		2015	
	Ha	%	Ha	%	Ha	%
Closed Forest	2,005,900.23	46.24	1,695,631.66	39.09	1,119,698.24	25.81
Opened Forest	765,996.68	17.66	1,034,185.81	23.84	1,641,334.24	37.84
Total Forest	**2,771,896.90**	**63.90**	**2,729,817.47**	**62.93**	**2,761,032.48**	**63.65**
Mangrove Forest	178,481.73	4.11	258,654.90	5.96	266,528.17	6.14
Other Wooded Land	595,414.13	13.73	796,554.14	18.36	999,828.36	23.05
Others	609,014.94	14.04	388,469.52	8.96	165,802.54	3.82
Water	183,048.88	4.22	164,360.55	3.79	144,665.03	3.33

Table 4. Comparison of area change (gain or loss) in Tanintharyi Region at 2005, 2010 and 2015

LULC Classes	2005-2010		2010-2015		2005-2015	
	Ha	%	Ha	%	Ha	%
Closed Forest	-310,268.57	-7.15	-575,933.42	-13.28	-886,201.99	-20.43
Opened Forest	268,189.13	6.18	607,148.44	14.00	875,337.56	20.18
Mangrove Forest	80,173.17	1.85	7,873.27	0.18	88,046.44	2.03
Other Wooded Land	-220,545.42	4.64	-203,274.22	-4.69	-649,197.46	-14.97
Others	-239,233.75	-5.52	-242,362.50	-5.59	-481,596.25	-11.10

In 2005, closed forest was the most dominant land cover within this study, covering about half of the whole region, 46.24%, 2005900.23 ha. In 2010, open forest gradually enlarged over time from 17.66% (765996.68 ha) in 2005 to 23.84% (1,034,185.81 ha) in 2010: to 37.84% (1,641,334.24 ha) in 2015 (Table 3). As closed forest was mainly affected, it was apparent that land use land cover change predominantly occurred over the time. Closed forest remarkably altered to open forest, then converted to other wooded land, eventually, transformed into other landuse category (such as village, urban, agriculture). Although closed forest was the dominant LULC category throughout the time, the result indicated that those areas distinctly decreased in proportion as 25.81 % (1,119,698.24 ha) in 2015. Besides, other wooded land was distinctly increased, from 13.73% (595,414.13) in 2005 to 18.36% (796,554.14 ha) in 2010 to 23.05% (999,828.36 ha) in 2015.

In 2005, Tanintharyi Region covering 3,868,011.48 ha, was primarily made up by three LULC classes: closed forests, open forests, mangrove forest and other wooded land. Other classes (combination of others and water) comprised 792063.81 ha (18.26%), 552830.07 ha (12.74 %), and 310467.56 ha (7.16 %) of study area by the years of 2005, 2010 and 2015 respectively. Forest deterioration and land cover change mostly affected on closed forest category that was located beside the main road, around the city, and settlement. In 2005, open forest covers most of the areas, e.g.; around the city, urban development, and villages settlement. The landscape dynamics of the Tanintharyi was observed in each class and highly transferred over time.

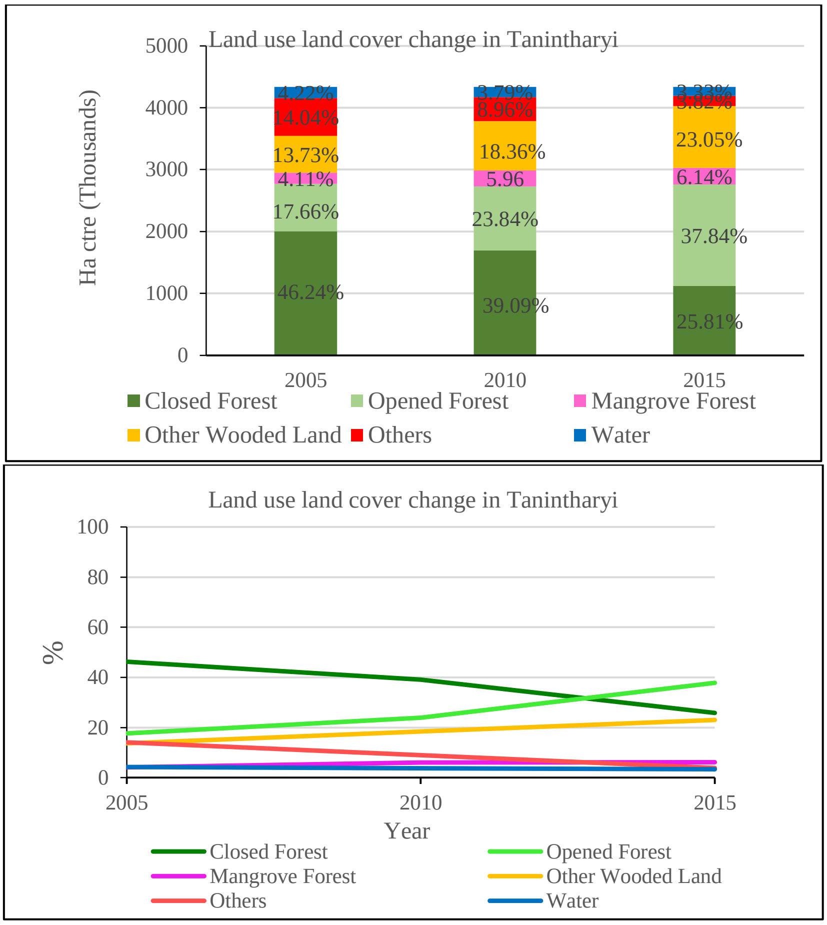

Figure 3. (a) and (b) Comparison analysis of land use land cover change in Tanintharyi based on three periods; 2005, 2010 and 2015

Closed forest in Tanintharyi Region was severely decreased and changed to open forest and other wooded land. Trajectories of forest change were more complex. Between 2010 and 2015, closed forest cover reduced about -13.28% (-575,933.42 ha) that was higher than -7.15% (-310,268.57 ha) during the first period at 2005-2010 (Table 4). The opposite trend was observed in the case of open forests for both periods; that category increased in 6.18% (268,189.13 ha) between 2005-2010, and 14.00% (607,148.44 ha) between 2010 and 2015 whereas almost half of the closed forest landscape at the 20.43% was removed respectively. Other wooded land was constantly higher in both periods. When we look at Table 5, the annual deforestation rate (-0.3%) in the first period was observed, after that, forest regeneration (0.22%) was found again in the second period.

Table 5 shows the situation of deforestation rate per year in Tanintharyi Region from 2005-2010-2015

Period	**Deforestation rate per year**
2005-2010	-0.30
2010-2015	0.22

3.2 Land Use Land Cover Change around Sample Villages and its Buffer

During the past 10 years, dense forest decreased from 44% in 2005 to 16% in 2010, to 16% in 2015 by conversion to degraded forest, named as open forest as 15.6% in 2015. Fig 4 shows the land use/land cover has sharply changed over the period from 2005 to 2015 in the study area. During the past 10 years, dense forest decreased about 44% by conversion to open forest/other wooded land or shrub on a large scale respectively. Forest area was particularly deteriorated over the first period from 2005 to 2010, that was declined from 82% (2005), to 43% (2010). In 2015, forest was regained about 8%, forest totally existed at 51% (79,717.52 ha), Table 6. Among of land use/land cover classes, other wooded land was greatly increased up to from 1 % to 42% during the study period.

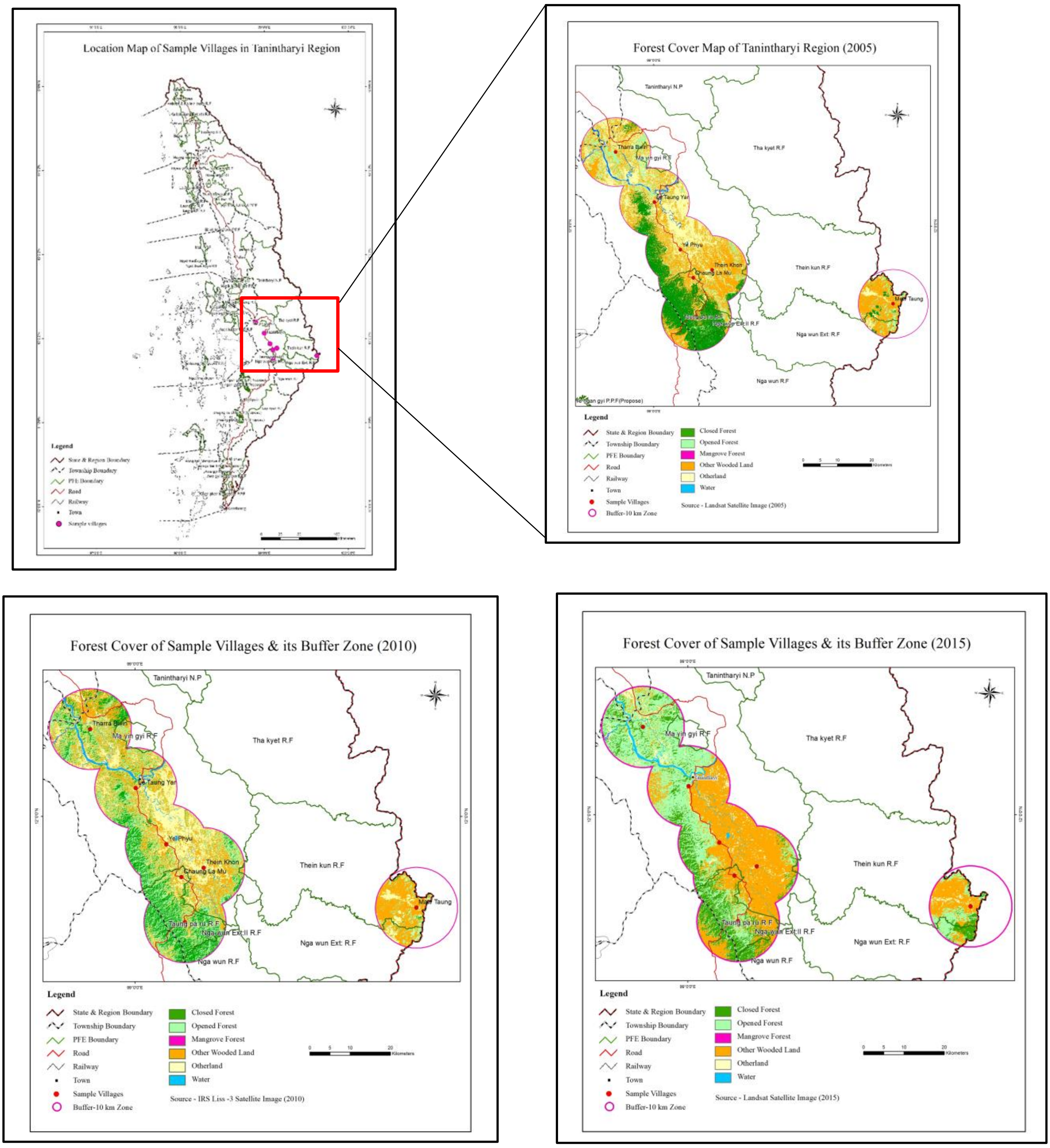

Figure 4. (a) Location of sample surveyed villages inside Tanintharyi Region, (b) forest cover of 10-km buffer area of sample villages in 2005, (c) in 2010, (d) in 2015.

At the beginning time, closed forest covered about 44% and open forest naturally distributed about 38%. Hence, the buffer area near the sample villages may be assumed as the forest covered area. At 2010, most of forest area was intensely converted to other wooded land. Particularly, we can find such kind of features at the low elevation area and shallow slope. There exists from 1% in 2005, 33% in 2010, 42% in 2015. In contrast, we can see the positive sign in forest area, open forest regained about 7% during the second period, from 28% in 2010 to 35% in 2015. Besides, closed forest was maintained at the stable condition in later period. Similarly, other land was increased at the first period, then, other land decreased in the second period.

Table 6 Forest Cover Change of sample villages and its buffer 10 km between 2005, 2010 & 2015

LULC Classes	**2005**		**2010**		**2015**	
	(Ha)	**(%)**	**(Ha)**	**(%)**	**(Ha)**	**(%)**
Closed Forest	69442.23	44.47	24832.99	15.90	24364.89	15.60
Opened Forest	58912.15	37.73	42957.04	27.51	55352.63	35.45
Total Forest	128354.40	82.20	67790.03	43.41	79717.52	51.05
Other Wooded Land	1988.16	1.27	51805.03	33.18	65471.60	41.93
Others	25812.45	16.53	36559.94	23.41	10965.87	7.02
Total	**156155.00**	**100.00**	**156155.00**	**100.00**	**156154.99**	**100.00**

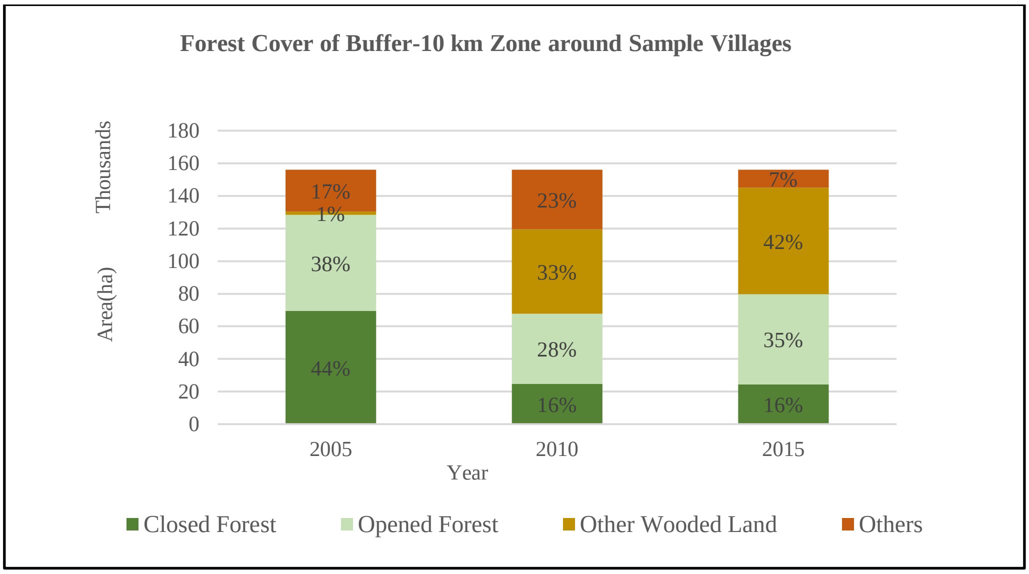

Figure 4 Comparison analysis of LULC change in the buffer-10 km zone around sample villages on three periods; 2005, 2010 and 2015

Forest surrounding the Tharra Bwin, Le Taung Yar and Maw Taung villages in the north was increased, as opposite side, forest around the remaining villages was decreased over time. The categories of open forest and other land was changed each other over time, dropping and retained depending on the time and natural factors like elevation, human intervention, respectively. This can be interpreted as the conversion of former upland rice areas to fallow forest and secondary forest.

4. Discussion

4.1 The status of the forests

Myanmar is still among the countries possessing the largest remaining forest cover in South-east Asia. Most forests are concentrated in Myanmar's hill and mountainous regions, including Kachin, Sagaing, Tanintharyi, Shan, and Chin. The Tanintharyi (Tenasserim) Mountain Range, along the border between Myanmar and Thailand, covers a global important terrestrial eco-region with a transition zone from continental dry evergreen forests common in the north to semi-evergreen rain forests to the south.

The southern tip of Tanintharyi has some of the last remnants of Sundaic rainforest in Southeast Asia (Eames *et al*. 2005). Tanintharyi's lowland forests currently support the largest remaining populations of Gurney's pitta in the world. Forests in the mountainous areas of the Tanintharyi play an important role in retaining sediment and maintaining clean water for downstream population centres. Mangroves forest and other coastal habitats in the region play an important role in protecting people who live along the coast from storms. These ecosystems support outstanding biodiversity including flagship species such as tiger (EN3), Asian elephant (EN), Asian tapir (VU), Sunda pangolin (CR), Gurney’s pitta (EN) - a species endemic to the Tanintharyi Region, plain pouched hornbill (VU), as well migratory water bird concentrations and diverse coral reef and seagrass communities. The region has great potential for long-term conservation of large landscape species (e.g. tiger, Asian elephant, Asian tapir, gaur and hornbills) through transboundary protected areas (PAs) within biodiversity conservation landscapes along the border with western and peninsular Thailand, linking with the Western Forest Complex and Kaeng Krachan National Park.

4.2 Forest Cover Change in Tanintharyi Region

This study observed that closed forest lost about 20% during a period of 10 years. Open forest and rest categories increased over time. Similarly, deforestation rate of whole study area was normally found at first period. In a surprising way, we observed that forest was slightly regained in the second period due to the activities of reforestation, controlled illegal logging, natural regeneration from shifting cultivation. Other wooded land was moderately increased as a result of clearing of the degraded forest to conversion of shifting cultivation, then permanent orchard. According to *Global Forest Resources Assessment 2015*, Myanmar was also defined as a third highest deforestation rate in the world. However, we observed that annual deforestation rate (-0.33%, 2010-2015) in Tanintharyi Region was still lower than the rate (-1.8%) of national net deforestation rate, FAO FRA 2015 (UN FAO, 2015). On the other hand, deforestation rate (0.008%) in Tanintharyi Nature Reserve, designated as a protected area, that was studied during the period: 2006-2010 (RS and GIS Section, 2012) was much lower than the annual rate of whole Tanintharyi Region, as a benefit of Protected Area demarcation. Densely populated and centrally located administrative units showed the greatest losses, while remote regions, such as Tanintharyi Region had losses below the global average. This dichotomy can be partly explained by the increasing resource demands of large populations in accessible areas and decreasing state control over forest resources in remote regions.

As a result of this study, forest degradation that was affected to closed forest was seriously observed. On the other hand, total forest was slightly increased as a result of recovered rate or reforestation. Hence, forest area increased in the late period and deforestation was occurred in the first period. Tanintharyi region was only experienced deforestation in the first period, however, forest degradation was distinctly happened in both periods.

Some of the primary drivers of deforestation in Myanmar include expansion of large commercial plantations (e.g. oil palm, rubber, sugar cane), agricultural conversion, reliance on fuelwood collection in rural communities, mining, and incursion into forestlands for small-scale permanent agriculture (including small plantation gardens for oil palm, rubber, and sugarcane), and shifting agriculture (Mon, Myat Su et al., 2012). Leimgruber, Peter et al., 2005 did observe that Tanintharyi Region is one hotspots of Myanmar’s 10 deforestation hotspots, identified ranging from 0.4% to 2.2%. Most of the deforestation hotspots also have unique fauna and flora and are of special conservation importance (Tordoff *et al.* 2006). Karen and Mon people live in the Tanintharyi Range and many other indigenous cultures call this area home as a template for sustainable use of the region’s rich natural resources. There is a long history settlement of four ethnic groups, namely, Kayin, Dawei, Mon and Burma. Kayin (Karen). Dawei tribes seem to be forerunners in the known history of settlement for more than 200 years. They settled the villages inside reserved forests and gradually extended horticultural farms for their livelihood (Min Thant Zin, 2009).

4.3 Forest Cover Change in Sample Villages and its Buffer

When we did compare between two periods, forest area in the 10-km buffer was seriously suffered at the first period. Forest areas were lost about half of the total area, from 82% in 2005 to 43% in 2010. During the second period, we assumed that local community noticed the importance and value of the forest existence as forest areas increase again up to 51% in 2015. If road development, mining and other activities leads to increase deforestation; such kind of pattern observed frequently around roads. When we look up the condition around the sample villages, land use land cover change was differently suffered over time because of not only the natural factors like elevation, slope but also the human factors such as village settlement, population, agricultural expansion, forest dependence intense. Forest increment was found at the late period. However, forest area was regained at the late period, particularly, open forest cover. On the other side, other wooded land that was assumed as the vegetation cover was similarly increased. We can summarize the buffer area of sample villages was occurred that dense forest degradation and deterioration was happened at the low elevation area and along the main road and urban area.

4.4 Major land cover change of forests

Spatial patterns of forest dynamics suggest three main processes of forest clearing, including broad-scale conversion and degradation of forests, broad-scale shifting cultivation, and conversion to commercial oil palm plantations. Broad-scale conversion and degradation of forests is the most common and includes (1) forest degradation resulted by fuelwood consumption (FAO 2001*b*), (2) unplanned and unrestricted rural agricultural expansion that is encouraged by local and divisional governments (Myint Aung, 2007), (3) conversion into aquaculture (i.e. shrimp farming in the Delta region), and (4) commercial clearcutting (Brunner *et al*. 1998; Global Witness 2003). Conversion to commercial oil palm plantations is occurring rapidly in lowland forests at the southern area of Tanintharyi Division (Aung Than, personal communication 2004) threatening a major biodiversity hotspot.

In this study, we can assume that forest degradation was more intense than deforestation patterns even though this study had not calculated the forest degradation rate. This pattern was truly identical with another results (Maw, 2018) that was studied for a protected area in Southern Myanmar. Maw, 2018 found that protected area experienced a lot of disturbances, forest degradation was found as the consequences of illegal logging and fuelwood extraction, particularly, done by ethnic groups in the northern part of Tanintharyi Region. Deforestation pattern was found from the results of unplanned development projects, extensive establishment of rubber and oil palm plantations, due to shifting cultivation, mining and human settlements, particularly by migrants' people from adjacent Mon Region and Ayeyarwaddy Region that was suffered by Nargis Storm 2008.

The Southern Forest Complex links three large and intact forest landscapes, including the Tanintharyi Hills, the Myinmolekat & Central Tanintharyi, and the Luwaing Reserve Forest and Hiungye Taung. The remote areas of Tanintharyi have very large tracts of intact forest remaining (Bhagwat et al., 2017). It has experienced substantial forest losses, usually along major river systems, newly constructed highways, or near existing development areas, such as commercial plantations. These patterns can be especially seen as well as along the new roads and pipelines crossing from Thailand into southern Myanmar.

The previous Myanmar military government initiated a military-sponsored industrial oil palm development program beginning in 1999 as part of its national self-sufficiency plan. In general, oil palms are a poor replacement for intact forest because they support fewer species and cause habitat fragmentation. This has been shown by research on the impacts of oil palm development in Thailand which predicted a severe decline in biodiversity, especially for globally threatened bird species. Habitat loss from oil palm may seriously compromise the long-term conservation of this critically endangered bird species in Myanmar.

In Southern Myanmar, unchecked and continued growth of oil palm, may pose a serious threat to the remaining large intact forests, specifically for the Myinmolektat and Tanintharyi Hills landscapes. While oil palm plantations only occur in Tanintharyi, other types of plantations such as rubber, betel nut, banana, and sugar cane are expanding throughout the country. Rubber is a rapidly expanding cash crop throughout the tropical and subtropical areas, and it can grow throughout much of Myanmar (Bhagwat et al., 2017). Both of these areas provide critical habitat for several endangered species, including tigers, elephants, Gurney's pitta, and tapir. Tanintharyi Region in southeastern Myanmar, particularly the southern portion, is the only place in the country that has a climate potentially suitable for oil palm cultivation, although there is a lack of studies that support those claims.

Similarly, new oil palm plantations are fragmenting Asian elephant habitats, increasing human elephant in Tanintharyi. As elephant habitats shrink, conflict will intensify with the potential for serious economic impacts for people, as well as increased human and elephant deaths. Oil palm development in Tanintharyi Region in the far southeastern part of Myanmar showcases the intersection of agribusiness and conversion timber in the country. Tanintharyi Region, especially in the southern half where oil palm concessions are mostly located, has some of the most extensive lowland HCVFs (high conservation value forest) in the country, largely under forest reserve protection, with unparalleled ecological diversity and value.

4.5 Weak institutional and individual capacity for management of PAs and buffer zones

This study observed that forest area was seriously lost at first period, regained again at second period. However, forest was not recovered to the same condition of the prior period. Forest was lost on different spatial area, based on the finding of forest recovering around two sample villages in the north. Depending on the intensity of anthropogenic and natural disturbances, forest area will change from time to time and space to space. Anthropogenic activities and human settlement were mainly related to the impacts on forest areas in the forms of forest degradation, deforestation, and forest increment. There are four existing PAs in Tanintharyi Region; however, site and buffer zone management were extremely weak. Only two of the PAs, Lampi Island and Tanintharyi Nature Reserve, have field staff on site and limited park management infrastructure. Those are the only PAs that have a management plan. Staff skills are also insufficient, particularly when it comes to law enforcement, habitat condition, species monitoring, park-neighbor relations, and landscape/seascape management. Systematic planning for conservation and management is mandatory for those PAs to ensure sustainability of diverse flora and fauna. There is no clear strategy for reducing threats coming from outside PAs such as encroachment or illegal activities within the PAs. In addition, there is a disconnection between PAs and local-level economic development and land use planning, resulting in increased pressure on biodiversity within the PAs and buffers, and increased degradation of natural habitats in the conservation priority corridors and around KBAs (Key Biodiversity Areas). Hundreds of thousands of refugee returnees, internally displaced persons, and poverty also exacerbate the threats to the biodiversity of the Tanintharyi Range, causing deforestation and increasing soil run-off and sedimentation. Large scale land use change through the development and subsequent replanting of plantations has even more dramatic effects on these processes.

5. Suggestion and Recommendations

- Landscape-level land-use planning using a High Conservation Value approach is proposed.
- A High Conservation Value (HCV) is a biological, ecological, social or cultural value of outstanding significance or critical importance.
- The HCV approach has proven useful for identifying environmental and social values in production landscapes. It can be used for a specific management unit or a whole landscape to guide management.
- Appropriate land management then includes a mosaic of protected areas, community forestry, sustainable plantations and settlements.

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IV. Socio-economic assessment of the local people living around Tanintharyi National Park

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Household's size

There were totally 7 villages which were studied. The average household's size was 5.14 residents with minimum one to maximum 10 people living (Table 1). The household's gender contribution was not recorded.

Table 1. Average household member in the study villages

Studied villages	Ave. HH member	HH_member range
Lae Taung	5.5 (±1.7)	3 – 9
Aye Tharyar	5.5 (±2.2)	2 – 10
Ye Phyu	5.5 (±1.9)	2 – 9
Ta Mote Chone	5.1 (±1.4)	3 – 8
Chaung Naut Pyan	4.6 (±1.2)	3 – 7
Thein Khon	4.6 (±1.8)	1 – 8
Thae Phyu	5.3 (±2.0)	1 - 8

Parenthesis showed standard deviation
Source: Data collection November, 2018

Respondents' age classes

The respondents' average was 48 year-old including the oldest of 78 year-olds and the youngest of 20 year-olds (Table 2). The average gender contribution of respondents was 79% male and 21 % female (Figure 1). At the Chaung Naut Pyan village, only male respondents were participated.

Table 2. Age contribution of respondents in the study villages

Studied villages	Res. Ave. age (yrs)	Age classes range (yrs)	Male res. ave. age (yrs)	Female res. Ave. age (yrs)
Lae Taung	47.5 (±14.6)	25 – 70	43.90	65.50
Aye Tharyar	46.5 (±8.6)	30 – 62	45.90	48.29
Ye Phyu	42.3 (±14.2)	20 – 73	46.18	34.00
Ta Mote Chone	56.9 (±12.8)	36 – 78	57.00	56.00
Chaung Naut Pyan	43.3 (±8.5)	31 – 64	43.29	
Thein Khon	52.3 (±8.6)	33 – 65	52.94	51.30
Thae Phyu	49.9 (±8.2)	35 - 61	50.21	46.00

Parenthesis showed standard deviation

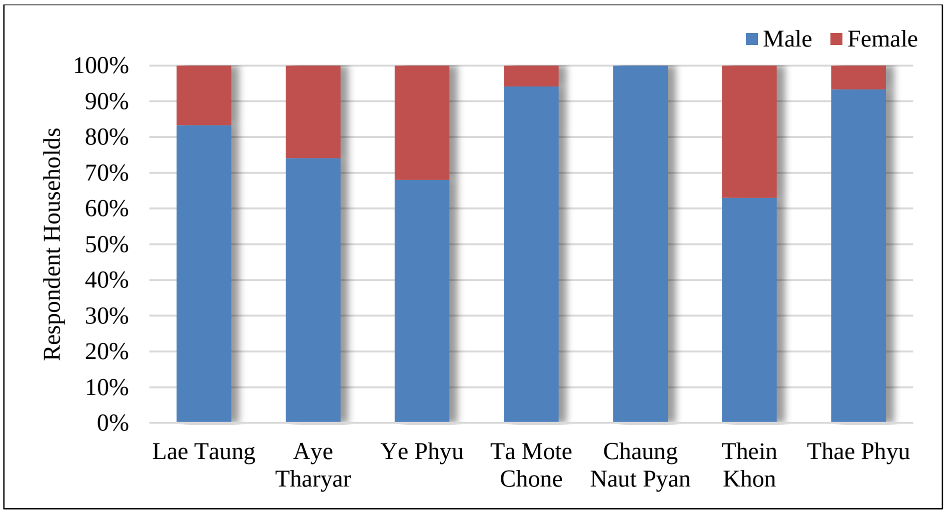

Figure 1. The gender contribution of respondent households

Household's Education level

The respondents were asked questions related to literacy, school attendance and the highest level of education they had completed. Even though the respondents' education level is explored, it won't represent the education level of the study communities. The communities' literacy information including literate and illiterate is shown in Figure 2. The highest education like university level was found in Thein Kone village (Table 3). During the household interview, the respondents mentioned “when they were young, they had no chance to go to school, and there were no school near their village. But most of them attend the elementary school then they shopped their education and did work for their household's livelihood'. This shows that the highest percentage was found in elementary education level. The communities' education levels of each studied villages were shown in Figure 3.

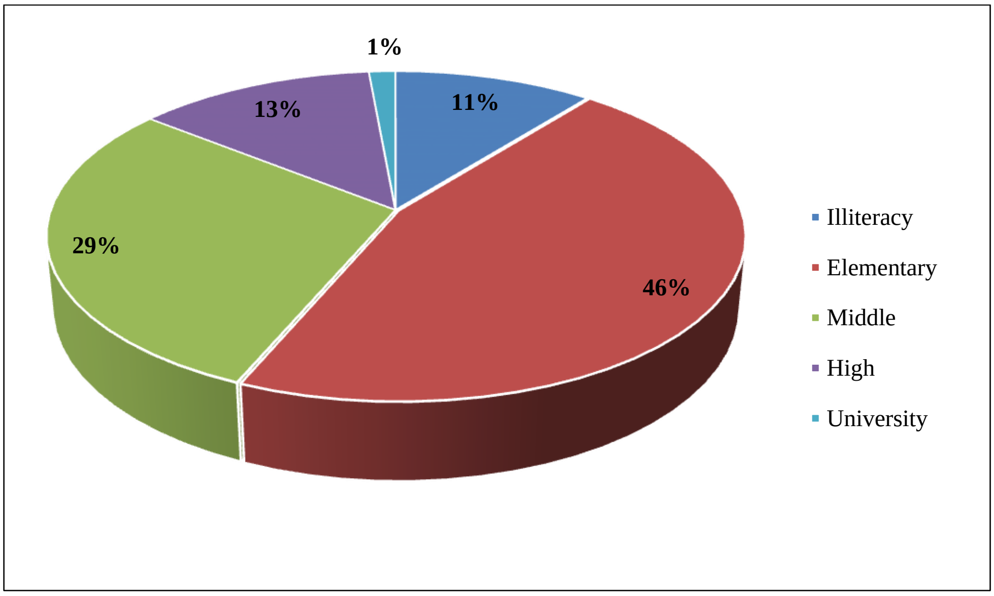

Figure 2. The education level in the study area

Table 3. The education level of respondents in the study villages (same as Figure 3)

Studied villages	Illiteracy	Elementary	Middle	High	University
Lae Taung (n= 12)	1 (8%)	6 (50%)	5 (42%)		
Aye Tharyar (n= 27)	4 (15%)	16 (59%)	5 (19%)	2 (7%)	
Ye Phyu (n= 25)	1 (4%)	11 (44%)	9 (36%)	4 (16%)	
Ta Mote Chone (n= 17)	2 (12%)	12 (71%)	1(6%)	2 (12%)	
Chaung Naut Pyan (n= 17)	1 (6%)	3 (18%)	8 (47%)	5 (29%)	
Thein Khon (n= 27)	5 (19%)	10 (37%)	7 (26%)	3 (11%)	2 (7%)
Thae Phyu (n= 15)	1 (7%)	6 (40%)	6 (40%)	2 (13%)	

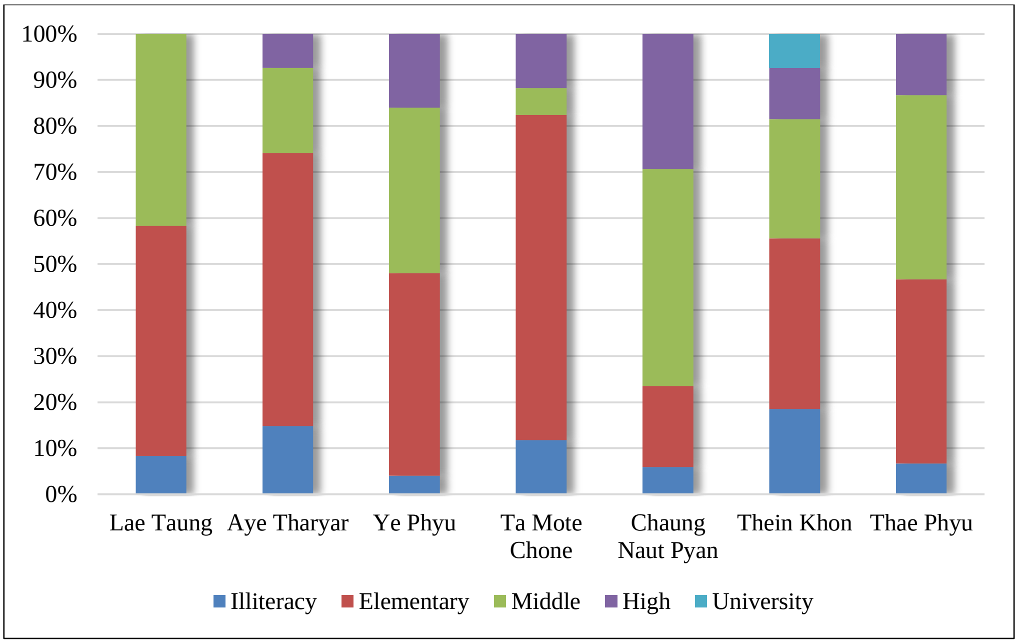

Figure 3. The education level of respondents in the study villages

Table 4. Average age (years) contribution at the respondents' different education levels

Studied villages	Illiteracy	Elementary	Middle	High	University
Lae Taung (n= 12)	65.0	55.5	34.4		
Aye Tharyar (n= 27)	49.3	48.1	41.6	41.0	
Ye Phyu (n= 25)	55.0	42.3	39.8	44.8	
Ta Mote Chone (n= 17)	56.0	60.2	60.0	37.0	
Chaung Naut Pyan (n= 17)	40.0	55.3	40.0	42.0	
Thein Khon (n= 27)	54.4	54.7	50.3	50.0	46.0
Thae Phyu (n= 15)	56.0	45.3	52.7	52.5	

Household's agricultural land size

In Myanmar, the land ownership for houses (building) and cultivation is issued by the government (Settlement and Land Records Department - SLRD). The communities can officially own the land for houses under the grant land title[1]. The household in the study villages own land for their living (house) but most of the household do not own land for cultivation. There are two types of cultivation in the studied villages - land for paddy field[2] and land for garden (perennial plants).

Almost all of the household in the studied villages own land for living (house), but most of the house do not own land for cultivation. Approximately, 91% of household have their crop cultivating land (Table 5), but most of the cultivation land are not officially owned by the households. Average cultivating land area possessed by the household is 16.7 Ac. In the studied villages, several type of cultivating land are found via land for paddy, garden, Taungya (shifting cultivation for paddy). All the cultivation farms are rain-fed. Figure 4 shows the household percentage with different cultivating land.

Table 5. Average cultivating land area possessed by household in the study villages

Studied villages	% household which possessed cultivating land	Ave. land size (Ac)	Land size range (Ac)
Lae Taung	100%	17.6 (±14.6)	3 – 50
Aye Tharyar	89%	14.1 (±11.9)	0 – 50
Ye Phyu	80%	10.8 (±19.9)	0 – 100
Ta Mote Chone	94%	39.6 (±76.2)	5 – 320
Chaung Naut Pyan	94%	10.9 (±8.4)	5 – 40
Thein Khon	96%	16.8 (±13.9)	3 – 55
Thae Phyu	87%	6.9 (±6.3)	0 - 24

The crop such as areca palm, coconut, banana, mango, cashew nut, pineapple, durian, rubber, lemon and coffee are planted in their garden. Although areca palm is the main garden crop in all studied villages, rubber and cashew nut are also mostly found in the garden.

[1] *Grant land (Land Nationalization Act 1953) is owned by the government. Land at the disposal of government may be disposed of by grant or lease to any person or entity for a stipulated period with is explicitly spelt out in the document well known in the Myanmar language as "Ga-yan", an apparent direct adoption of the word "Grant". The lease period could range from 10 years, to 30 years to 90 years etc., which is extendible upon application. It is transferable and the owner is legally bound to pay land revenue with regard to it* (UNHABITAT, UNHCR, & Norwegian Ministry of Foreign Affair, 2011).

[2] *By 2012 Farmland Act, farm Land (Le-Land) Land mainly for growing irrigated or rain fed rice paddy. It is not in a rotational fallow system* (Displcement Solutions, 2015)

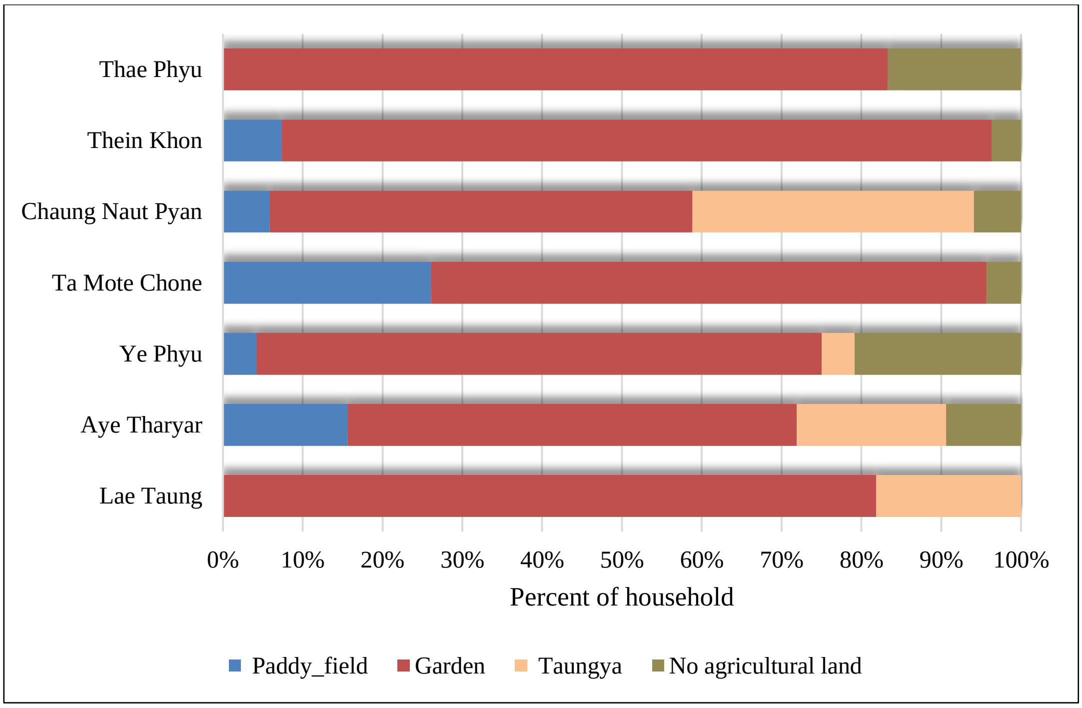

Figure 4. Percentage of household which possess different cultivation land types

Households' Livelihood activities

According to household survey, household activities are recorded including flows as well as stocks which could contribute to household consumption and cash generation. Agricultural activities, small stalls at home and daily wages jobs, are listed as cash income activities and animal husbandry is regarded as liquid asset. The garden activity was found as the main livelihood activity which was 79% of total respondent HH, and livestock was shown the second livelihood activity as 59% which was not only for HH's income but also for subsistence use (Figure 5). Figure 6 shows the HH's livelihood activities of study villages.

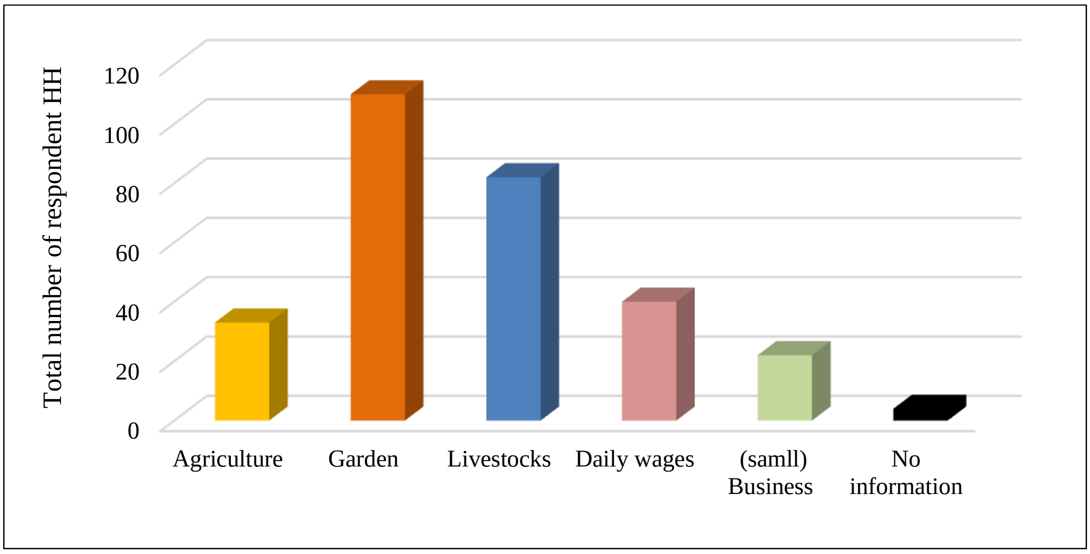

Figure 5. Households' livelihood activities in the study area

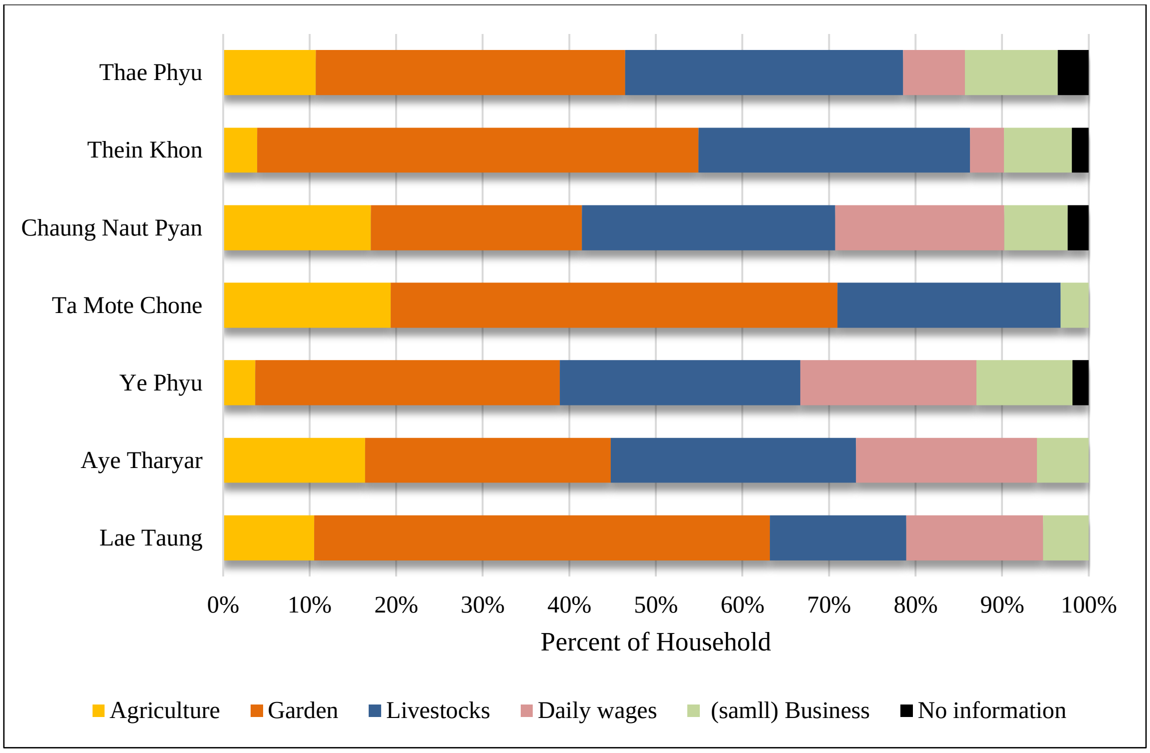

Figure 6. Percentage of household which engage in different household activities and occupation for their livelihoods

Household's annual income

To estimate household annual income, household activities are grouped into five groups as agriculture, garden, daily wages, owned business, salary (company and non-government staff) and livestock (Figure 7). This household annual income estimation is both cash and subsistence. Figure 8 shows the contribution of household activities to annual total income. Overall, garden income is the highest contributor to total household income (96%) followed by salary (87%), owned business (55%), daily wages (40%), livestock (17%) and agriculture (10%). Among the studied villages, Lae Taung, Ta Mote Chone and Chaung Naut Pyan, these three villages work mainly on the garden for their livelihood.

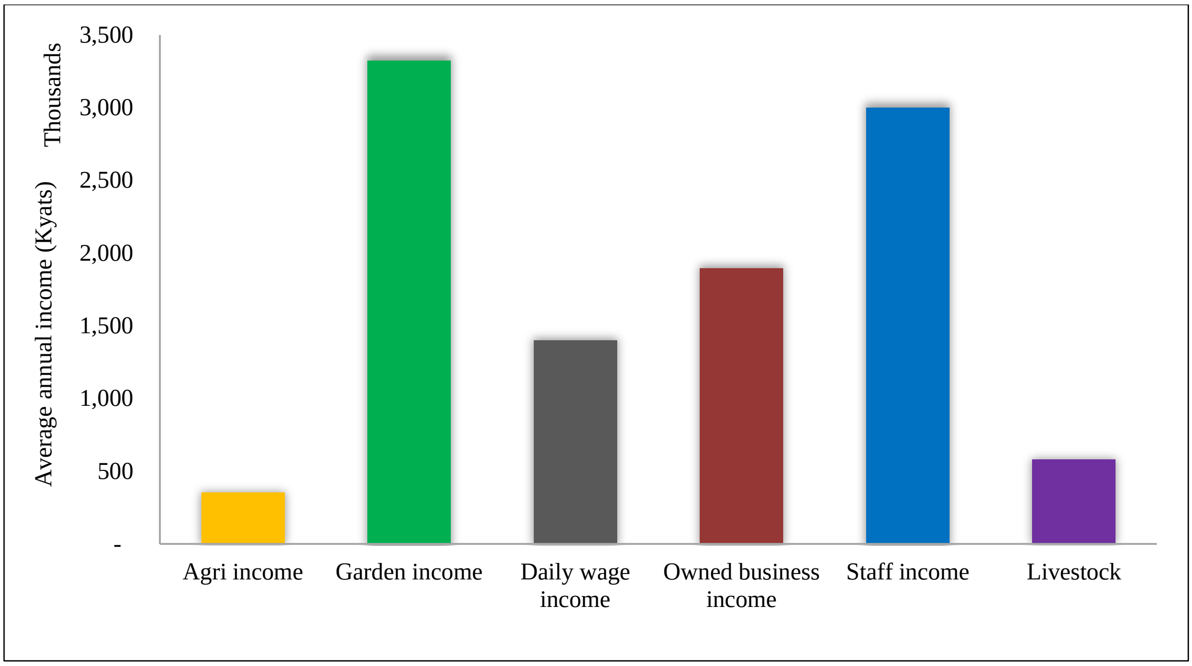

Figure 7. Average annual income based in the livelihood activities

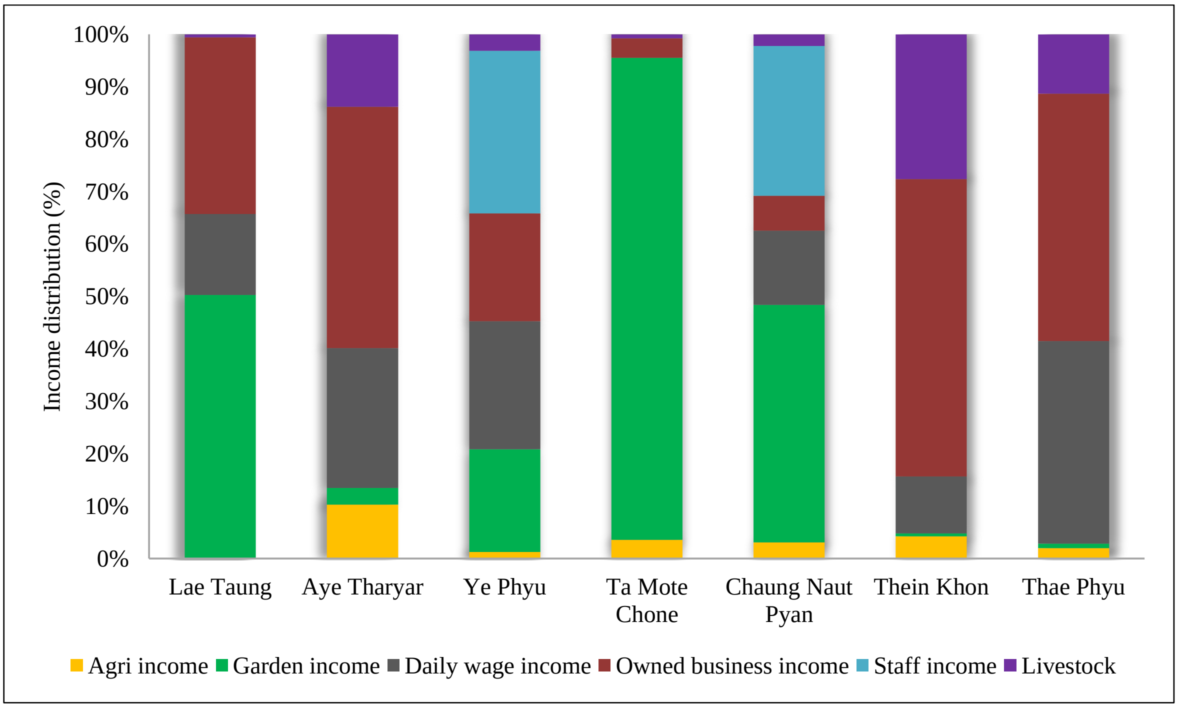

Figure 8. Percentage of income distribution bases on their livelihood activities

V. Wildlife Resources in Tanintharyi Township, Tanintharyi Region in Myanmar

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1. Introduction

This is the first time that the Forest Department in Myanmar is working together with ITTO to protect and conserve trans-boundary biodiversity and wildlife resources in the project of "Capacity Building for Enhancing Trans-boundary Biodiversity Conservation in Tanintharyi Region, Myanmar: Phase I of Stage I" in order to promote cooperation for trans-boundary biodiversity conservation between Myanmar and Thailand. Due to the location along the border with Thailand, Tanintharyi region also has great potential for long-term conservation of large landscape species through trans-boundary protected areas (PAs) within biodiversity conservation landscapes. However, the immediate threats of deforestation such as land use change from forest land to oil palm plantations and areca palm plantations, illegal logging, forest encroachment, industrial development and unsustainable fishing practices require urgent actions to conserve biodiversity and the socio-economic security of local people in the region.

In this study in Tanintharyi Township, we surveyed the information of existing wildlife species including mammals and birds species. Wildlife study and survey in Tanintharyi Township provided up to date data of existing wildlife species as well as new knowledge of ecology and distribution of localized wildlife species. This data will be very helpful for the knowledge of wildlife habitat and wildlife management in cooperation between Myanmar and Thailand in the future.

Therefore, the main objective of this research was to conduct research on wildlife resources assessment including bird species in the Tanintharyi Township. The specific objectives of the research were as follows;

- To assess the wildlife resources localized in the Tanintharyi Township
- To collect current status of the habitats for wildlife
- To collect information on the status of other bird species

2. Literature Review

The available information of wildlife species occured in Tanintharyi Region were searched from many available sources from the Nature and Wildlife Conservation Division in the head-quarter of the Forest Department, journals, books, articles and from internet websites.

2.1 Diversity of Wildlife Resources in Tanintharyi Region

A total of 122 bird species, 71 different butterfly species, 20 mammal species, 6 species of lizard, 8 species of frog, 4 species of snake, 29 tree species, 12 bamboo species and forest types were recorded in the biodiversity survey of BANCA in the Ngawun Reserved Forest in the Tanintharyi Region (BANCA, 2014). Globally threatened species of bird and mammals were recorded. According to the (IUCN, 2013), two Endangered (EN) species namely White-handed Gibbon *Hylobat eslar* and Asian Elephant *Elephas maximus*, and four Vulnerable (VU) species namely Slow Loris *Nycticebus coucang*, Stump-tailed Macaque *Maca caarctoides*, Sambar *Rusa unicolor* and Southern Serow *Capricornis sumatraensis* can be recorded (BANCA, 2014). According to the IUCN Red List (2014), one species can be classified as Endangered (EN), Gurney's Pitta *Pitta gurneyi*, and three species as Vulnerable (VU), Large Green Pigeon *Treon capellei*, Plain-pouched Hornbill *Aceros subruficollis* and Great Slaty Woodpecker *Mulleripicus pulverulentus* (BANCA, 2014).

The survey emphasized more on bird and butterfly species than the species of herpeto fauna and mammal (BANCA, 2014). In the study area, the Red-whiskered Bulbul, the most common bird in the country, was not recorded because Bulbul and the Asian Paradise Flycatcher were hunted or captured by both local people and people from other regions by using mist-nets for trading to Thailand (BANCA, 2014).

2.2 Diversity of Bird Species in Tanintharyi Region

Total of 206 bird species including Gurney's Pitta were recorded during the survey in the proposed Lenya National Park, south Tanintharyi (Tenasserim) in degraded primary and bamboo forest in May 2015 (FFI, 2015). Gurney's Pitta *Pitta gurneyi* is the only bird species endemic to peninsular Thailand and Myanmar. It is designated as Endangered by IUCN Red List and it was initially thought to be extinct for some time after 1952, but was rediscovered in 1986 in Thailand. The search for Gurney's Pitta in Myanmar was started in 2003 and it was discovered that the species occurs at four sites with a maximum of 10-12 pairs at one location in Tanintharyi (FFI, 2015). A total of six Gurney's Pittas were recorded in primary degraded (also which close to limestone), secondary and bamboo forest in the proposed Lenya National Park in Tanintharyi. One new recorded shore bird species for Myanmar, Spectacled Spider hunter *Arachnothera flavigaster*, was recorded in the survey of FFI in 2015.

3. Study Area

Tanintharyi Region is a long and narrow strip of land with an area of 16,735 square miles. It has a tropical climate with temperature ranging from 20 ºC to 38 ºC and receives the south-west monsoon starting from mid-May till the end of September. The dry season is much shorter as compared to the rest of the country and the total annual rainfall is also greater. The main agricultural crops are paddy, areca palm, coconut, rubber and nipa palm (dhani). Moreover, banana, tapioca, rambutan, durian and mango trees are also grown on a large scale. Oil producing oil palm was grown in a special project during the past decades. This study was conducted in the Tanintharyi Township and its border area to the Boak Pyin Township.

The surveys in Tanintharyi Township and its border areas found that there were forest land encroachments for agricultural crops especially establishment of gardens growing areca palm. Illegal logging is also a serious problem to the reserved forests of the region. Wildlife poaching and trapping are the issues in the study area as this might lead to decrease of the small populations of large mammals. Both legal and illegal wildlife trading can be found at the border between Thailand and Myanmar, i.e. Maw Taung market. Human disturbances were found in the reserves with some activities of logging and collecting non-timber forest products, i.e. bamboo, bamboo shoots, edible insects, wild fruits, seeds and medicinal plants. Lastly, hidden land mines in the reserved forests between Tanintharyi Township and Boakpyin Township are still dangerous and sensitive issues.

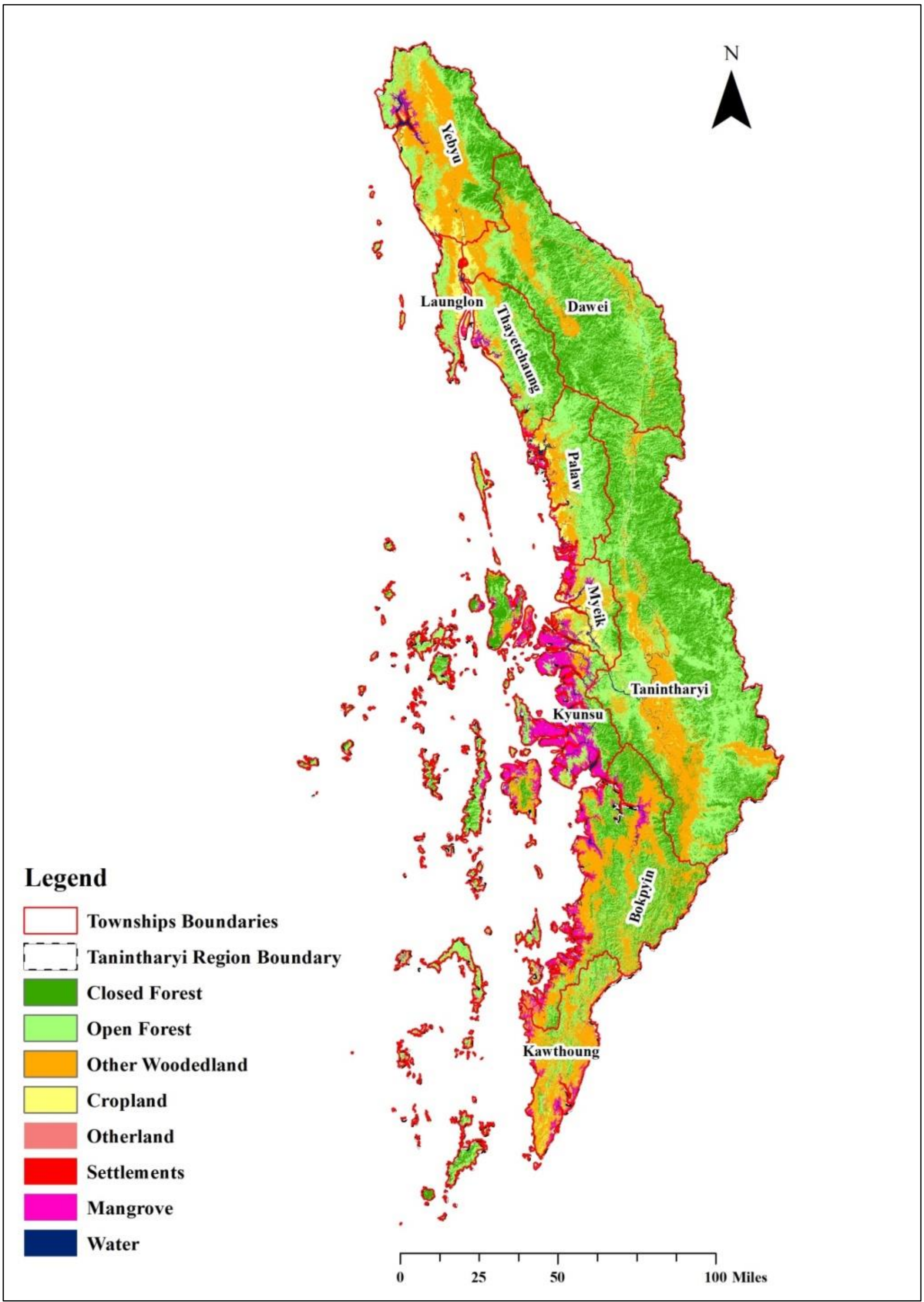


Figure 1. Location of Tanintharyi Township and Tanintharyi Region

4. Wildlife Studies

Methodology Approaches

Local village surveys and focused group discussions were used in this study in order to list mostly found wildlife species and mostly used and important wildlife species together with the participation of local people. Wildlife species from focus group discussions and interviews which were undertaken in six villages in the Tanintharyi Township were recorded in this study.

Site selection for wildlife survey by camera trapping was based on the sites selected for flora survey undertaken in Taungpru Reserved Forest and Thein Khun Reserved Forest by the project team during 2019. There were mainly two subjects represented (Mammals and Birds) for the wildlife survey. Field surveys were conducted on foot by following routes across the forest floor using the knowledge of local guides working in a group of six (four local guides and two researchers). The presence of mammals and others were assessed by infra-red camera trapping in the study sites.

The presence of birds is one indicator of biodiversity richness in the study area. Therefore, field observation for bird status was conducted each day during the survey period between 6:30 am to 7:00 pm. The survey area was assessed by foot using different paths originating from base camp (Tanintharyi Township Forest Department plantation site in Taung fru Reserved Forest). The presence of bird species and their habitats were recorded by using Sony Cyber shot DSC-H400 camera.



Wildlife Survey Team

5. Results

5.1 Village Surveys

Village surveys and focus group discussions were done in six villages in the Theinkhun Village Tract in Tanintharyi Township (Table 1). Each focus group discussion in each village was done with 10 to 15 people including the heads of the villages, the elders, the local hunters and the villagers. According to the results of focus group discussions and village meetings, the mostly used wildlife species for the local people were listed together with the full participation of local people (Table 2).

Table 1. Villages Profile for Wildlife Survey

Village Name	Township/Village Tract	Households	Population	Established Year
1. Chaung Naut Pyan	Tanintharyi/ Theinkhun	57	132	2009
2. Tarpalet	Tanintharyi/ Theinkhun	110	600	2004
3. Chaung La Mu	Tanintharyi/ Theinkhun	420	2035	2002
4. Aye Thar Yar	Tanintharyi/ Theinkhun	163	726	2004
5. Thae Phyu	Tanintharyi/ Theinkhun	160	898	About 100 yrs
6. Thein Khun	Tanintharyi/ Theinkhun	328	1685	About 100 yrs

Photos of focus group discussions in the study villages

The village surveys in Tanintharyi Township found that most important wildlife for the villagers included the wildlife that was used mainly for substantial consumption purposes (Table 2). There were forest land encroachments for agricultural crops and areca palm plantation. Regarding mitigation of the threats to wildlife and their habitats in the study area, patrolling and protection should be strengthened. An Education Program with focus on targeting local communities nearby and inside the Reserved Forests should be considered and be implemented. Raising the local people's awareness on regarding forest and wildlife conservation is very important issue. Increased Wildlife Conservation in Tanintharyi Region is broadly needed. It should be carried out through collaboration between the local people, forestry officials, NGOs, INGOs and also the border country, Thailand. A future wildlife ecological research and population monitoring program for important wildlife species of Tanintharyi Region needs to be carried out more than before.

Table 2. Results of Focus Group Discussions for Wildlife Survey

Village Name	Most Important Wildlife
1. Thae Phyu	Various Kinds of Fishes, Red Jungle Fowl, Wild Boar
2. Tarpalet	Wild Boar, Boa Snake, Wild Cat, Red Muntjac, Kestrel
3. Chaung Naut Pyan	Rhesus Monkey, Various Kinds of Fishes, Gurney's Pitta, Great Hornbill, Wild Boar
4. Chaung La Mu	Various Kinds of Fishes, Oriented Pied Hornbill, Wild Boar, Fogs
5. Aye Thar Yar	Wild Boar, Various Kinds of fishes, Oriented Pied Hornbill, Boa Snake
6. Thein Khun	Various Kinds of Fishes, Red Jungle Fowl, Wild Boar, Boa Snake

5.2 Mammals Survey

Vertebrate animals that have backbones and hair and produce milk for their newborns make up the class Mammalia. Over 5,400 living species of mammals exist all over world. And mammals can be divided into 29 different orders, such as carnivores, whales, bats, rodents, and primates. The survey team studied mammals and their diversity and distribution in the study area which is situated between Tanintharyi and Boakpyin Townships (Figure 2).

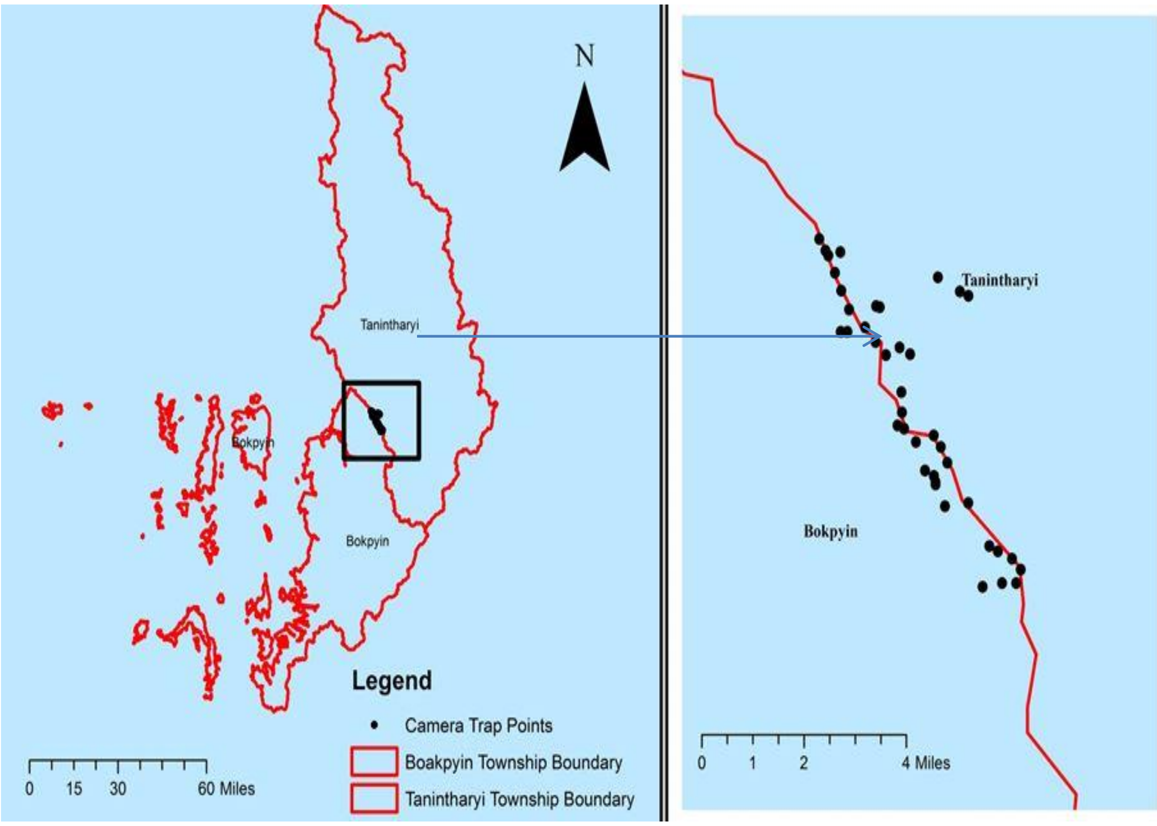


Figure 2. Location of Camera Trap Points for Wildlife Survey

In the study area, mammals are known to be abundant. But, the population of some species has decreased gradually due to illegal wildlife trade by hunting and trapping. Some animals form a source of food for the local communities. However, there is the indirect protection of wildlife species in some areas of Tanintharyi Township because of the control of the Karen National Union (KNU). Thein Khun Reserved Forest region is under the control of KNU and the hunting of endangered wildlife is banned in the area. Most people adhere to this ban since the KNU may use force when a hunter is discovered.

In Tanintharyi Township, there were palm oil companies in the area during the past decades which logged trees for establishing large-scale palm oil plantations. They had constructed many roads and this makes hunting in the jungle more convenient for the hunters. Taking advantages of this network of roads, hunting activities have increased. In addition hunting has increased because employees of these logging companies settled in the area and involved in extraction of resources.

All the found species in this study were 17 species. One of the important mammals were Wild Elephants (*Elephas maximus*) which were commonly seen in the border areas between Tanintharyi Township and Boakpyin Township.

Wild Elephants (*Elephas maximus*)

Wild Elephants (*Elephas maximus*)

Some large mammals recorded from camera traps were Asian Black Bear (*Ursus thibetanus*), Leopard (*Neofelis nebulosa*), Leopard Cat (*Prionailurus bengalensis*), Stumped Tailed Macaque (*Macaca arctoides*), Wild Boar (*Sus scrofa*) and Malayan Tapir (*Acrocodia indica*). In addition, Large Indian Civet (Zibetha indica), Marbled Cat (*Pardofelis marmorata*), Red Muntjac (*Muntiacus* muntjak), Malayan Procupine (*Hystrix brachyuran*), Lesser Mousedeer (*Tragulus kanchil*), Large Toothed Ferret Badger (*Melogale personata*), Yellow Throated Marten (*Martes flavigula*), Red Jungle Fowl (*Gallus gallus*), Great Argus (*Polyplectron bicalcaratum*) and Fea's Muntjac (*Muntiacus feae*) were known from camera trap photos.

5.3 Recorded camera trap photos of Wildlife in Tanintharyi Township and Boakpyin Township

Clouded Leopard (*Prionailurus bengalensi*)

Marbled Cat (*Pardofelis marmorata*)

Leopard (*Neofelis nebulosa*)

Asian Black Bear (*Ursus thibetanus*)

Red Muntjac (*Muntiacus* muntjak)

Malayan Procupine (*Hystrix brachyuran*)

Lesser Mousedeer (*Tragulus kanchil*)

Stumped Tailed Macaque (*Macaca arctoides*)

Large Toothed Ferret Badger (*Melogale personata*)

Yellow Throated Marten (*Martes flavigula*)

Red Jungle Fowl (Gallus gallus)

Great Argus (*Polyplectron bicalcaratum*)

Great Argus (*Polyplectron bicalcaratum*)

Malayan Tapir (*Acrocodia indica*)

Wild Boar (*Sus scrofa*)

Fea’s Muntjac (*Muntiacus feae*)

5.4 Birds Survey

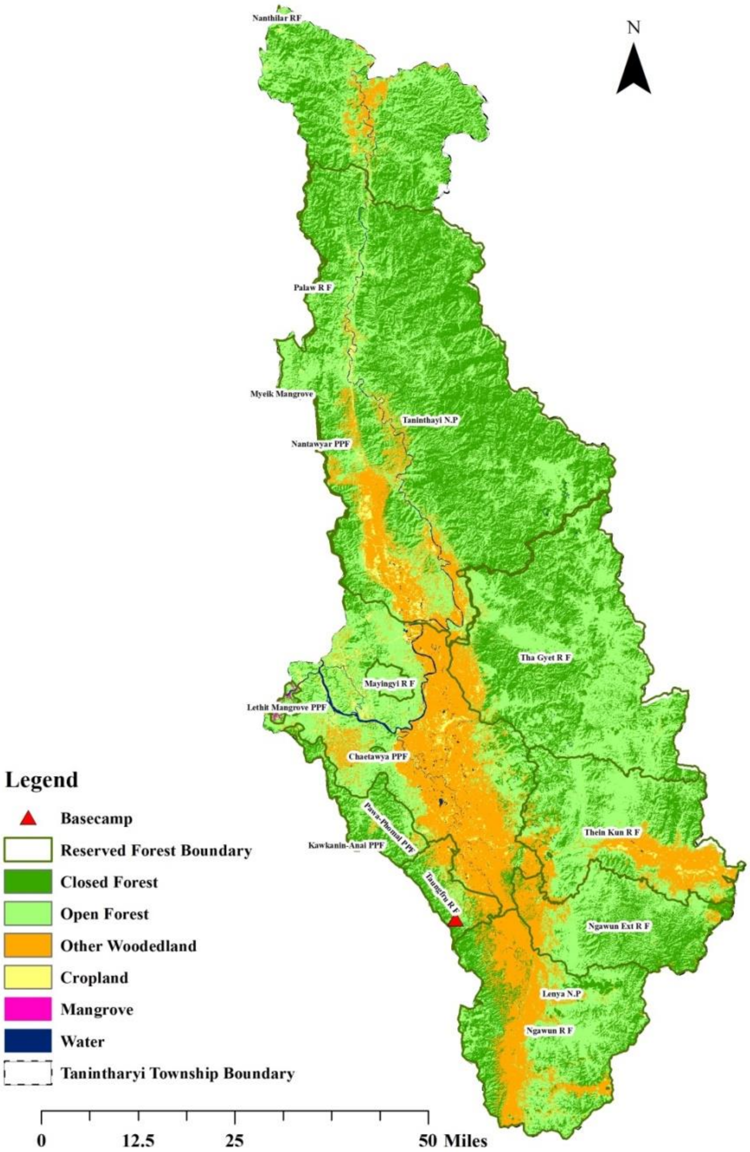


Figure 3. Location of Base Camp for Bird Survey

Birds are one of the best known and most highly valued creatures of the world, comprising more than eleven thousand species, an extraordinary variety, ranging from hummingbirds to ostriches, from penguins to eagles. Each species is unique, in its appearance, in its habits and in where it is found. Some occur in huge numbers and others are represented by only a handful of remaining individuals; some are relatively sedentary, with individuals spending their entire lives in an area of a few hectares, while others undertake extraordinary annual migrations, covering literally half the world. Myanmar supports one of the richest and most diverse bird communities in mainland Southeast Asia. More than 1000 species inhabit in Myanmar, nearly 10% of the world bird species. Applying the IUCN Redlist criteria there are 57 Globally Threatened bird species found in Myanmar. Twelve of these species are Critically Endangered, fifteen Endangered and twenty-six thirty are vulnerable species. In addition, the country holds ten endemic species.

The southern part of Myanmar, Tanintharyi formerly known as Tenasserim Region possesses the long coastal area in parallel with the vast area of tropical evergreen forest ranges result in high biodiversity and is home to many key and threatened wild flora and fauna. As bird species richness is likely to abundant in nearer to Equator, Tanintharyi Region holds over 600 species of birds, approximately 60% of the bird species in Myanmar. So, Tanintharyi serves as a very important hotspot to support habitats for Endangered and Threatened avifauna. Tanintharyi Township is included in Myeik District and located in the central part of the Tenasserim Region with a size of 2800000 acres wide and bordered by Thailand, Myeik Township, Kyun-su Township, Palaw Township, and Dawei Township. There are six permanent forest estates namely Thagyet Reserve Forest, Thein Khun RF, Mayingyi RF, Taungpru RF, Ngawon RF and Ngawon extended RF, and one proposed Tanintharyi National Park. Approximately 65% (180,000 acres) of the Township area is forested area.

Bird survey was conducted in Compartments (30, 31, 35, 36, 37, 38, and 39) of Taungpru Reserve Forest during February 2019 and February 2020. In total, 124 bird species was recorded. Eighty-eight species are residents; twenty-eight are migratory bird species while eight are unknown species and needed to be identified. Among them, five species are Globally Threatened Species, one endangered and four vulnerable species and five are nearly threatened species according to IUCN red list.

Greater Green-leaf bird (*Chloropsis sonnerati*) is one of the endangered species that inhabits in lowland evergreen forest. In this study, this bird species was recorded in areca palm plantation adjoining with secondary forest. However, this species cannot be found frequently in this area, and we found only once it during survey. Population of this species is decreasing due to the trapping, hunting and degradation of habitats. Four Vulnerable species are Plain-pouched Hornbill (*Rhyticeros subruficollis*), Great Hornbill (*Buceros bicornis*), Wreathed Hornbill and Great-slaty Woodpecker. Due to the loss of primary forest, habitats degradation and hunting on these vulnerable species, their populations are also decreasing.

In addition to bird species, three primates species have been recorded namely: White-handed Gibbon (*Hylobates lar*); Banded Leaf Monkey (*Prebytis femoralis*); and Dusky Langur (*Trachypithecus obscurus*). The White-handed Gibbon is cited as endangered species and the last two leaf monkey are nearly threatened species by IUCN Redlist categories. The White-handed Gibbons are found in areas of forest plantations adjoining with old-growth forests. Although the local forest dwellers rarely hunt on gibbons, they are threatened by loss of habitats and fragmentation due to the expansion of oil-palm plantations by companies and area palm plantations established by local community.

The langurs are under high pressure from hunting. People usually consume intestines of those monkeys by assuming that those are good for health and strength. If law enforcement is still weak on protection of those wild animals, their population will be decreased and threatened to be extinct. Nevertheless, Tanintharyi is still serving as a home for many tropical wild flora and fauna and I believe that at least two critically endangered birds namely Helmeted Hornbill and Gurney' Pitta might be inhabited somewhere in Taungpru Reserve Forest. Taungpru Reserve Forest is also providing healthy and safe niches to many other mammals like tapirs, bears and elephants.

The base camp for bird survey is located in the Tanintharyi Township (Figure 3). It is also the camp for forest plantations established by the Tanintharyi Township Forest Department. There were oil palm plantations and shifting cultivation along the side of the main road as well. The degraded, secondary and degraded primary forests could be seen along way to the camp. Surveys were conducted along the main road, forest plantations, the logged tracks and hunter's trails from each direction of the camp. There were 32 bird species recorded in this survey conducted during 2019 (Table 3). They included Hair Crested Drongo, Common Hill Myna, Blacked Naped Oriole, Chestnut Breasted Malkoha, Oriented Pied Hornbill, Taiga Flycatcher, White-throated Kingfisher, Blacked Thighed Falconet, Spotted Dove, Red Breasted Parakeet, Asian Fairy Bluebird, Common Kestral, Greater Flameback Female, Red Wattled Lapwing, White Billied Woodpecker, Greater Racket Tailed Drongo, Black Crested Bulbul, Dollar Bird, Blue Rock Thrush, Black Shoulder Kite, Collared Falconet, Long-tailed Shrike, Great Hornbill, Ashy Drongo, Pale Blued Flycatcher, White Bellied Munia, Bronzed Drongo, Plain Prinia, Refuscent Prinia, Tiger Shrike, Thick Billed Green Pigeon (Male) and Vernal Hanging Parrot.

Table 3. List of bird species recorded in Tanintharyi Township, Tanintharyi Region

No	Common Name	*Scientific Name*	Migratory or Residence	IUCN Redlist Status	Habitat Type
1	Ashy Drongo	*Dicrurus leucophaeus*	Migratory	LC	Secondary Forest and Semi-Evergreen Forest
2	Ashy-headed Green-Pigeon	*Treron phayrei*	Resident	LC	Degraded Forest and Semi-Evergreen Forest
3	Asian Fairy-bluebird	*Irena puella*	Resident	LC	Secondary Forest and Semi-Evergreen Forest
4	Asian Openbill	*Anastomus oscitans*	Resident	LC	Rice Field and Stream
5	Asian Paradise-flycatcher	*Terpsiphone paradisi*	Resident	LC	Semi-Evergreen Forest
6	Barn Swallow	*Hemipus picatus*	Migratory	LC	Telephone Cable
7	Barred Bottomquail	*Turnix suscitator*	Resident	LC	Pyinkadoo Plantation
8	Bar-winged Flycatcher-shrike	*Hemipus picatus*	Resident	LC	Secondary Forest and Semi-Evergreen Forest
9	Black Baza	*Aviceda leuphotes*	Migratory	LC	Semi-Evergreen Forest
10	Black Magpie	*Platysmurus leucopterus*	Resident	LC	Semi-Evergreen Forest
11	Black-and-red Broadbill	*Cymbirhynchus macrorhynchos*	Resident	LC	Secondary Forest and Semi-Evergreen Forest
12	Black-crested	*Rubigula flaviventris*	Resident	LC	Secondary Forest and Semi-Evergreen Forest

No	Common Name	*Scientific Name*	Migratory or Residence	IUCN Redlist Status	Habitat Type
	Bulbul				
13	Black-headed Bulbul	*Brachypodius atriceps*	Resident	LC	Secondary Forest and Semi-Evergreen Forest
14	Black-naped Monarch	*Hypothymis azurea*	Resident	LC	Secondary Forest
15	Black-naped Oriole	*Oriolus chinensis*	Resident	LC	Secondary Forest and Semi-Evergreen Forest
16	Black-shoulder Kite	*Elanus caeruleus*	Resident	LC	Semi-Evergreen Forest
17	Black-thighedFalconet	*Microhierax fringillarius*	Resident	LC	Semi-Evergreen Forest
18	Black-winged Cuckoo-shrike	*Lalage melaschistos*	Migratory	LC	Semi-evergreen Forest
19	Blue Rocktrush	*Monticola solitarius*	Migratory	LC	Residential Area
20	Blue-eared Barbet	*Psilopogon cyanotis*	Resident	LC	Semi-Evergreen Forest
21	Blue-tailed Bee-eater	*Merops philippinus*	Migratory	LC	Secondary Forest and Semi-Evergreen Forest
22	Blue-winged Leafbird	*Chloropsis cochinchinnensis*	Resident	LC	Semi-Evergreen Forest
23	Bronzed Drongo	*Dicrurus aeneus*	Resident	LC	Secondary Forest
24	Bronze-winged Jacana	*Metopidius indicus*	Resident	LC	Pond
25	Brown Shrike	*Lanius cristatus*	Migratory	LC	Pyinkadoo Plantation
26	Chestnut-bellied Malkhoha	*Phaenicophaeus sumatranus*	Resident	NT	Semi-Evergreen Forest
27	Chestnut-headed Bee-Eater	*Merops leschenaulti*	Migratory	LC	Semi-Evergreen Forest

No	Common Name	*Scientific Name*	Migratory or Residence	IUCN Redlist Status	Habitat Type
28	Chinese Pond-heron	*Ardeola bacchus*	Migratory	LC	Pond
29	Collared Falconet	*Microhierax caerulescens*	Resident	LC	Semi-evergreen Forest
30	Common Flameback	*Dinopium javanense*	Resident	LC	Semi-evergreen Forest
31	Blue-tailed Bee-eater	*Merops philippinus*	Migratory	LC	Secondary Forest and Semi-Evergreen Forest
32	Blue-winged Leafbird	*Chloropsis cochinchinnensis*	Resident	LC	Semi-Evergreen Forest
33	Bronzed Drongo	*Dicrurus aeneus*	Resident	LC	Secondary Forest
34	Bronze-winged Jacana	*Metopidius indicus*	Resident	LC	Pond
35	Brown Shrike	*Lanius cristatus*	Migratory	LC	Pyinkadoo Plantation
36	Chestnut-bellied Malkhoha	*Phaenicophaeus sumatranus*	Resident	NT	Semi-Evergreen Forest
37	Chestnut-headed Bee-Eater	*Merops leschenaulti*	Migratory	LC	Semi-Evergreen Forest
38	Chinese Pond-heron	*Ardeola bacchus*	Migratory	LC	Pond
39	Collared Falconet	*Microhierax caerulescens*	Resident	LC	Semi-evergreen Forest
40	Common Flameback	*Dinopium javanense*	Resident	LC	Semi-evergreen Forest
41	Eastern Stonechat	*Saxicola maurus*	Resident	LC	Pyinkadoo Plantation
42	Emerald Dove	*Chalcophaps indica*	Resident	LC	Seondary Forest
43	Eye-Browed Trush	*Turdus obscurus*	Migratory	LC	Secondary Forest
44	Feiry Miniivet	*Pericrocotus igneus*	Resident	NT	Edge of Semi-Evergreen Forest
45	Forest	*Dendronanthus*	Migratory	LC	Open

No	Common Name	*Scientific Name*	Migratory or Residence	IUCN Redlist Status	Habitat Type
	Wagtail	*indicus*			Area(Steet,Stream,Plantation)
46	Golden Babbler	*Cyanoderma chrysaeum*	Resident	LC	Secondary Forest
47	Golden Crested Myna	*Ampeliceps coronatus*	Resident	LC	Semi-Evergreen Forest
48	Great Egret	*Ardea alba*	Resident	LC	Pond
49	Great Hornbill	*Buceros bicornis*	Resident	VU	Semi-Evergreen Forest
50	Great Slaty Woodpecker	*Mulleripicus pulverulentus*	Resident	VU	Semi-Evergreen Forest
51	Greater Coucal	*Centropus sinensis*	Resident	LC	Secondary Forest
52	Greater Flameback	*Chrysocolaptes guttacristatus*	Resident	LC	Semi-Evergreen Forest
53	Greater Green Leafbird	*Chloropsis sonnerati*	Resident	En	Edge of Semi-Evergreen Forest
54	Greater Racquet-tailed Drongo	*Dicrurus paradiseus*	Resident	LC	Secondary Forest
55	Green-billed Malkhoha	*Phaenicophaeus tristis*	Resident	LC	Secondary Forest
56	Grey Capped Pygmy Woopecker	*Picoides canicapillus*	Resident	LC	Semi-Evergreen Forest
57	Grey Headed Lapwing	*Vanellus cinereus*	Migratory	LC	Pond
58	Grey Headed Swamphen	*Porphyrio poliocephalus*	Resident	LC	Pond
59	Grey Heron	*Ardea cinerea*	Migratory	LC	Pond
60	Grey Rumped Treeswift	*Hemiprocne longipennis*	Resident	LC	Edge of Semi-Evergreen Forest
61	Grey Wagtail	*Motacilla cinerea*	Migratory	LC	Open Area(Steet,Stream,Plantation)

No	Common Name	*Scientific Name*	Migratory or Residence	IUCN Redlist Status	Habitat Type
62	Grey-Eyed Bulbul	*Iole propinqua*	Resident	LC	Semi-Evergreen Forest
63	Grey-headed Canary-flycatcher	*Culicicapa ceylonensis*	Resident	LC	Semi-evergreen Forest
64	House Swallow	*Hirundo javanica*	Resident	LC	Telephpne Cable
65	Indian Roller	*Coracias affinis*	Resident	LC	Open Area
66	Jungle Crow	*Corvus macrorhynchos*	Resident	LC	Secondary Forest
67	Jungle Myna	*Acridotheres fuscus*	Resident	LC	Edge of Semi-Evergreen Forest
68	Little Commorant	*Microcarbo niger*	Resident	LC	Pond
69	Little Egret	*Egretta garzetta*	Migratory	LC	Edge of Semi-Evergreen Forest
70	Long Tailed Shrike	*Lanius schach*	Migratory	LC	Pyinkadoo Plantation
71	Olive-backed Woodpecker	*Dinopium rafflesii*	Resident	LC	Semi-evergreen Forest
72	Olive-winged Bulbul	*Pycnonotus plumosus*	Resident	LC	Secondary Forest
73	Oriental Honey Buzzard	*Pernis ptilorhynchus*	Migratory	LC	Secondary Forest
74	Oriental Pied Hornbill	*Anthracoceros albirostris*	Resident	LC	Secondary Forest
75	Pale Blue Flycatcher	*Cyornis unicolor*	Resident	LC	Semi-Evergreen Forest
76	Pheasent-Tailed Jacana	*Hydrophasianus chirurgus*	Migratory	LC	Pond
77	Plain Pounched Hornbill	*Rhyticeros subruficollis*	Resident	VU	Semi-Evergreen Forest
78	Plain Prinia	*Prinia inornata*	Resident	LC	Pyinkadoo Plantation
79	Puff-throated Babbler	*Alophoixus pallidus*	Resident	LC	Secondary Forest
80	Purple Heron	*Ardea purpurea*	Migratory	LC	Pond

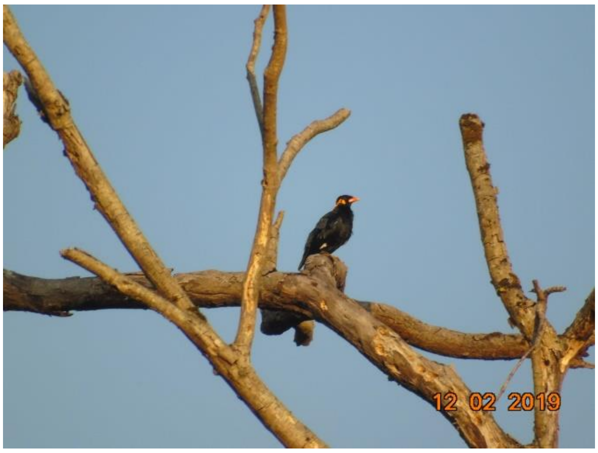
No	Common Name	*Scientific Name*	Migratory or Residence	IUCN Redlist Status	Habitat Type
81	Racquet-tailed Treepie	*Crypsirina temia*	Resident	LC	Secondary Forest
82	Raffle's Malkhoha	*Rhinortha chlorophaea*	Resident	LC	Semi-Evergreen Forest
83	Red Bearded Bee-Eater	*Nyctyornis amictus*	Resident	LC	Semi-Evergreen Forest(Stream Bank)
84	Red JungleFowl	*Gallus gallus*	Resident	LC	Secondary Forest and Semi-Evergreen Forest
85	Red-breasted Parakeet	*Psittacula alexandri*	Resident	NT	Secondary Forest, Pyinkdoo Plantation,Oil-PalmPlantation
86	Red-collared Dove	*Streptopelia manquebarica*	Resident	LC	Semi-Evergreen Forest
87	Red-wattle Lapwing	*Vanellus indicus*	Resident	LC	Pond And Stream
88	River Lapwing	*Vanellus duvaucelii*	Resident	NT	Stream, River
89	Ruby-cheeked Sunbird	*Chalcoparia singalensis*	Resident	LC	Secondary Forest
90	Rufescent Prinia	*Prinia rufescens*	Resident	LC	Pyinkadoo Plantation
91	Scarlet-backed Flowerpecker	*Dicaeum cruentatum*	Resident	LC	Mixed Decious Forest
92	Shikra	*Accipiter badius*	Resident	LC	Forest Plantation
93	Southern Brown Hornbill	*Banded Langur (Presbytis femoralis) ( ) IUCN Redlist-Vulnerable Species*	Resident	NT	Semi-Evergreen Forest
94	Spectacled Spiderhunter	*Arachnothera robusta*	Resident	LC	Semi-Evergreen Forest
95	Spotted Dove	*Streptopelia chinensis*	Resident	LC	Open Area
96	Stripe-throated	*Pycnonotus finlaysoni*	Resident	LC	Secondary Forest

No	Common Name	*Scientific Name*	Migratory or Residence	IUCN Redlist Status	Habitat Type
	Bulbul				
97	Swiftlet	Apodidae Family	Resident	LC	Open Area
98	Taiga Flycatcher	*Ficedula albicilla*	Resident	LC	Secondary Forest
99	Thicked-billed Green-pigeon	*Treron curvirostra*	Resident	LC	Secondary Forest and Semi-Evergreen Forest
100	Tickell's Blue Flycatcher	*Cyornis tickelliae*	Resident	LC	Secondary Forest
101	Tiger Shrike	*Lanius tigrinus*	Migratory	LC	Forest Plantation
102	Velvet-fronted Nuthatch	*Sitta frontalis*	Resident	LC	Semi-Evergreen Forest
103	Vernal Hanging Parrot	*Loriculus vernalis*	Migratory	LC	Semi-Evergreen Forest
104	Vertider Flycatcher	*Eumyias thalassinus*	Migratory	LC	Semi-Evergreen Forest
105	White-belliedMunia	*Lonchura leucogastra*	Resident	LC	Taungya Rice Field
106	White-bellied Woodpecker	*Dryocopus javensis*	Resident	LC	Semi-Evergreen Forest
107	White-browed Piculet	*Sasia ochracea*	Resident	LC	Secondary Forest
108	White-eyed Buzzard	*Butastur teesa*	Resident	LC	Semi-Evergreen Forest
109	White-rumped Munia	*Lonchura striata*	Resident	LC	Taungya Rice Field
110	White-rumped Shama	*Kittacincla malabarica*	Resident	LC	Secondary Forest
111	White-tailed Stonechat	*Saxicola leucurus*	Resident	LC	Pyinkadoo Plantation
112	White-	*Halcyon*	Resident	LC	Pond And Stream

No	Common Name	*Scientific Name*	Migratory or Residence	IUCN Redlist Status	Habitat Type
	throated Kingfisher	*smyrnensis*			
113	Wood Sandpiper	*Tringa glareola*	Migratory	LC	Pond
114	Wreathed Hornbill	*Rhyticeros undulatus*	Resident	VU	Semi-evergreen Forest
115	Yellow-browed Warbler	*Phylloscopus inornatus*	Migratory	LC	Secondary Forest
116	Yellow-vented Bulbul	*Pycnonotus goiavier*	Resident	LC	Secondary Forest and Pyinkaoo Plantation

5.5 Recorded bird photos in the Tanintharyi Township

Hair Crested Drongo (*Dicrurus hottentottus)*



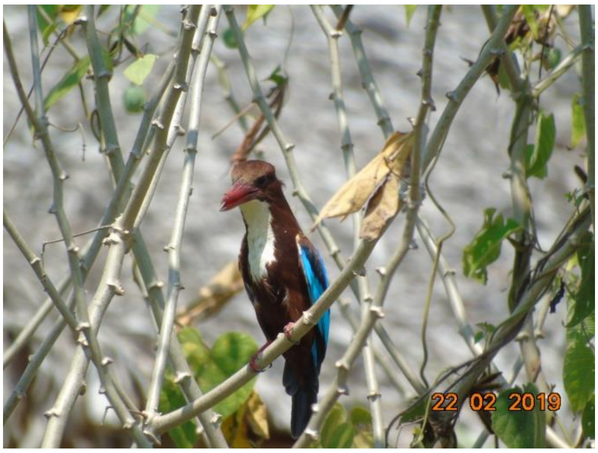
Common Hill Myna (*Gracula religiosa)*

Blacked Naped Oriole (*Oriolus xanthornus)*

Chestnut Breasted Malkoha (*Zanclostomus* *curvirostris)*

Oriented Pied Hornbill (*Anthracoceros albirostris)*

Taiga Flycatcher (*Terpsiphone paradise)*

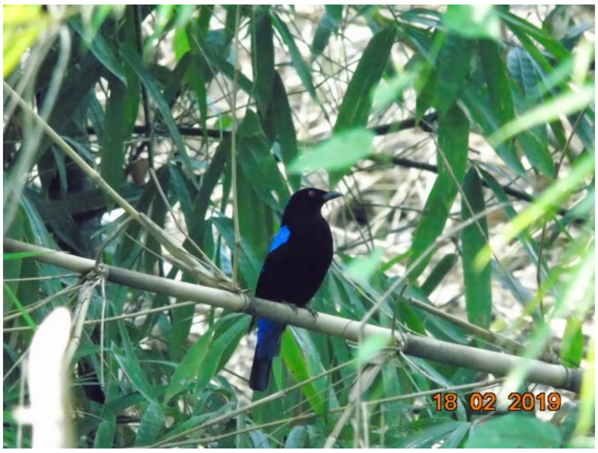


White Throated Kingfisher (*Halcyon smyrnensis)*

Blacked Thighed Falconet (*Microhierax fringillarius)*

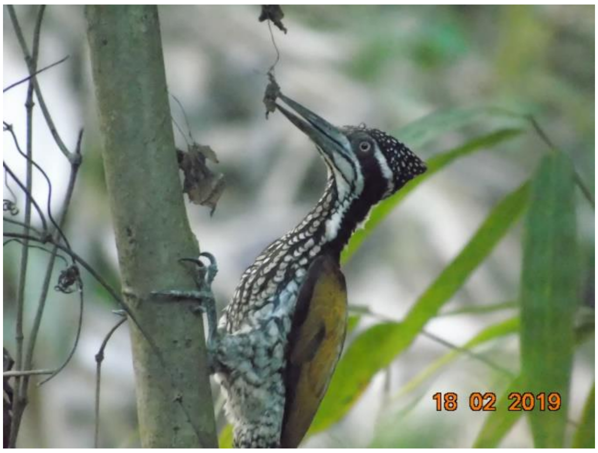
Spotted Dove (*Streptopelia chinensis)*

Red Breasted Parakeet (*Psittacula alexandri)*



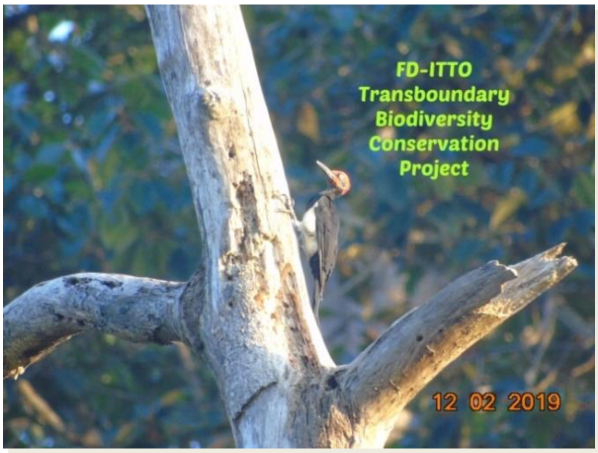
Asian Fairy Blue Bird (*Irena puella)*

Common Kestrel (*Falco tinnunculus)*



Greater Flameback Female (*Chrysocolaptes lucidus)*

Red Wattled Lapwing (*Vanellus indicus)*



White Billied Woodpecker (*Dryocopus javensis)*

Greater Racket Tailed Drongo (*Dicrurus paradiseus)*

Black Crested Bulbul (*Pycnonotus flaviventris)*

Dollar Bird (*Eurystomus orientalis)*

Blue Rock Thrush (*Monticola solitaries)*

Black Shoulder Knite (*Elanus caerulus)*

Collared Falconet (*Microhierax caerulescens)*

Long Tailed Shrike (*Lanius cristatus)*

Great Hornbill (*Buceros bicornis)*

Ashy Drongo (*Dicrurus leucophaeus)*

Pale Blued Flycatcher (*Cyornis unicolor)*

White Bellied Munia (*Lonchura leucogastra)*

Bronzed Drongo (*Dicrurus aeneus)*

Plain Prinia (*Prinia inornata)*

Refuscent Prinia (*Prinia rufescens)*

Tiger Shrike (*Lanius tigrinus)*

Thick Billed Green Pigeon (Male) (*Treron curvirostra)*

Vernal Hanging Parrot (*Loriculus vernalis)*

6. Conclusions

The studies by ITTO Project team conducted direct sighting, camera trap setting in focal study sites, interviews, and also literature reviews for the wildlife resources in Tanintharyi Region. The important mammals included Asian Black Bear (*Ursus thibetanus*), Leopard (*Neofelis nebulosa*), Leopard Cat (*Prionailurus bengalensis*), Stumped Tailed Macaque (*Macaca arctoides*), Wild Boar (*Sus scrofa*) and Malayan Tapir (*Acrocodia indica*). In addition, Large Indian Civet (Zibetha indica), Marbled Cat (*Pardofelis marmorata*), Red Muntjac (*Muntiacus* muntjak), Malayan Procupine (*Hystrix brachyuran*), Lesser Mousedeer (*Tragulus kanchil*), Large Toothed Ferret Badger (*Melogale personata*), Yellow Throated Marten (*Martes flavigula*), Red Jungle Fowl (*Gallus gallus*), Great Argus (*Polyplectron bicalcaratum*) and Fea's Muntjac (*Muntiacus feae*) were known from camera trap photos. There were 16 wildlife and 32 bird species recorded in this survey.

For better understanding of most important wildlife species and the threats to wildlife, the survey team conducted focus group discussions and interviews in the villages in Tanintharyi Township. Wildlife poaching, illegal logging and forest land encroachment were reported as the major threats to wildlife and their habitats. In the future surveys, the research on wildlife ecology and their habitats need to be made for the mitigation of threats and conservation of wildlife resources between trans-boundary areas. SMART patrolling techniques were the main topic being presented to participants during the trainings in the study area. Also, knowledge on conservation of wildlife resources in the study area was provided through discussions and interviews with local communities.

7. Recommendations

Based on the surveys and work in Tanintharyi Township, we would like to suggest that future training, future surveys, research and activities for protection of wildlife species and mitigation of the threats to wildlife and their habitats should be prioritized. It is found that Tanntharyi Township is lacking a wildlife species list and thus it is suggested that the area should be targeted for more detailed survey for wildlife. The mammals and birds reported in this study are quite similar to the species reported in the past studies which were conducted in other parts of Tanintharyi Region. However, the data on Herptiles (Reptiles and Amphibians) and fishes were not reported in this study. In order to fill the gaps of Herptiles and fishes, they should be more focused in the future studies. Knowledge and skill of wildlife ecology will be helpful for Forest Department staff to survey, and monitor wildlife and to manage their reserves for effective conservation work. Therefore, more trainings and extension programs should be supported to the respective staffs. Moreover, nature and wildlife education for local people should be promoted in the study area. During ITTO Trans-boundary biodiversity conservation project phase I of stage I during 2018 and 2019, the villagers in the study area were assisted and supported with education and training programs about SMART patrolling and wildlife conservation. It is suggested that law enforcement and effective patrolling system will support the biodiversity conservation of the Reserved Forests. Benefits from good protection strategies and law enforcement activities would help in conservation for significant wildlife species and their natural habitats of Tanintharyi Region for benefit of next generation.

8. References

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VI. Species Composition and Stand Structure of Natural Forests in Tanintharyi Township, Tanintharyi Region

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Abstract

The study was conducted in Tanintharyi Township located within Myeik District, Tanintharyi Region, Southern part of Myanmar. Forest inventory and flora surveys were conducted in the project area to provide the fundamental information of developing forest management plans. We arbitrarily laid out 15 sample plots (30 m × 30 m) across those study sites. In each sample plot, diameter at breast height for all trees (≥ 5 cm in DBH), and top height (in meters) were measured while counting the number of those stems. In addition, specimens of all measured trees were collected for subsequent identification for their scientific nomenclature. In total, there are 920 individuals occupied by 67 species occurred in 29 families for all sample plots. The results of family composition show that those forests are relatively tropical evergreen forests. The Shannon diversity index value showed higher diversity for the study sites (3.498) while the typical values are generally between 1.5 and 3.5 in most ecologically studies. The value of Simpson diversity index (1-D) was 0.959 indicating the higher diversity values and possessing less single most dominant species in this area. According to the stem-diameter distribution pattern, the highest number of stems was found in the smallest diameter classes meaning the highest proportion of small trees in the forest. However, the diameter distribution curve did not follow the inverse-J shape which is the typical form of undisturbed natural forests. According to this finding, we can prove that those forests have been disturbed especially anthropogenic disturbances such as logging, pole cutting, etc., in previous time. But it seems there is still no disturbance at this current time.

Keywords: Forest disturbances, Species composition, Stand structure, Stem-diameter distribution

Species Composition and Stand Structure of Natural Forests in Tanintharyi Township, Tanintharyi Region

1. Introduction

Tropical forests are more diverse terrestrial ecosystem than sub-tropical forests and other montane ecosystem (Devi and Yadava 2006). The Taninthayi (Tenasserim) Mountain Range, along the border between Myanmar and Thailand, covers a global important terrestrial eco-region with a transition zone from continental dry evergreen forests common in the north to semi-evergreen rain forests to the south. As a consequence, they contain some of the highest diversity of both flora and fauna not only in Myanmar but in Southeast Asia Region. But nowadays, those tropical forested areas are facing numerous challenges to ensure their sustainability (Sarvade, Gupta, and Singh 2016).

Similarly, the outstanding biodiversity features and diversity of the Taninthayi Range are vulnerable due to poaching, fragmentation and encroachment for agriculture, illegal logging, settlements inside and around the park, and human-elephant conflicts. Unsustainable harvesting of non-timber forest products is prevalent throughout the eco-region. Some areas have been subjected to seasonal forest fires, the impacts of which are unclear. Therefore, long-term viability of biodiversity in the Taninthayi depends on promoting systematic management of the natural forests with the active involvement of the local communities. This can provide the natural habitats for the wildlife species as well as the fulfilling of the basic needs of the people.

In order to formulate the community based forest management as well as ecosystem-based forest management plans, the very first task to do is to document the flora and fauna diversity of the area. Accordingly, forest inventory and flora surveys were conducted in the project area to provide the fundamental information of developing forest management plans.

2. Objectives of the study

The current surveys were conducted to fulfill the following objectives;

1) To explore the species composition, species richness and diversity of the plants grown naturally in the forests;
2) To identify the stand structural characteristics of those natural forests; and
3) To provide the basic information in order to support development of sustainable forest management plan/ habitat restoration plan.

3. Research Team

The following researchers and staff of Forest Research Institute and Tanintharyi Township Forest Department joined the activities of forest inventory and plant survey.

No.	Name	Title	Position	Task
1	Dr. Mu Mu Aung	Researcher	Forest Research Institute	Plant identification

2	Dr. Inkyin Khaing	Assistant Director	Forest Research Institute	Forest Inventory
3	Dr. Phyu Phyu Lwin	Staff Officer	Forest Research Institute	Forest Inventory, Data Analysis, Paper Writing
4	Ms. Tin Hnaung Aye	Range Officer	Forest Research Institute	Forest Inventory, Data Input
5	Ms. Phyu Phyu Hnin	Research Assistant-2	Forest Research Institute	Plant survey, specimen collection
6	Mr. Ye Yint Tun	Research Assistant-3	Forest Research Institute	Forest Inventory, Plant survey, Data Input
7	Mr. Nyi Lwin Soe	Project Secretary	FD-ITTO Biodiversity Project	Logistics arrangement
8	Mr. Zayar Moe	Deputy Range Officer	Tanintharyi Township Forest Department	Forest Inventory, Liaison Officer
9	Mr. Myat Aye	Deputy Range Officer	Tanintharyi Township Forest Department	Forest Inventory, Liaison Officer
10	Mr. Hla Myo Aung	Deputy Range Officer	Forest Research Institute	Plant survey, specimen collection

4. Methodology

4.1 Study Area

The study was conducted in Tanintharyi Township located within Myeik District, Tanintharyi Region, and Southern part of Myanmar (Figure 1). It is located between 11º20´ to 13º10´ North Latitude and 98º40´ to 99º40´ East Longitude. Tanintharyi Township is bordered with Thailand in east, Dawei District in north, Boatpyin Township in south, and Kyunsu Township, Myeik Township and Pulaw Township in west respectively. The area of the township is 4380.18 square miles (11344.61 km^2). About 64.33% of the area of the whole township was forested lands covering the area as 7298.57 km^2. Among those forested areas, 4735.32 km^2 has been declared and demarcated as reserved forests and recognized as permanent forest estate (PFE) administered by Forest Department. In total, there are six reserved forests in this township and those are Taungparu reserved forest, Mayingyi reserved forest, Thakyet reserved forest, Thein Kone reserved forest, Ngawon reserved forest, and Ngawon extension forest. There are two proposed protected areas; namely Tanintharyi National Park and Leynyar extension National Park covering the area of 4447.85 km^2.

Previously, this study area was inaccessible due to the safety conditions while some parts of the area was under the governance of ethnic armed groups, some areas were free from human disturbance while only accessible areas were encroached. Those accessible areas became Palm oil plantations established by private companies, and orchards where local people grow perennial fruit trees mixed with annual cash crops. Because of limited land areas for cultivation, land issues and land ownership conflicts were common in this area. But as covered by tropical evergreen forests, many wild flora and fauna were abundant in this area showing the importance of biodiversity conservation.

For conducting forest inventory and flora survey, we selected two reserved forests; Taungpharu reserved forest and Thein Kone reserved forest within Tanintharyi Township and those two reserves are adjacent with the proposed Tanintharyi National Park which is inaccessible for concerning safety.

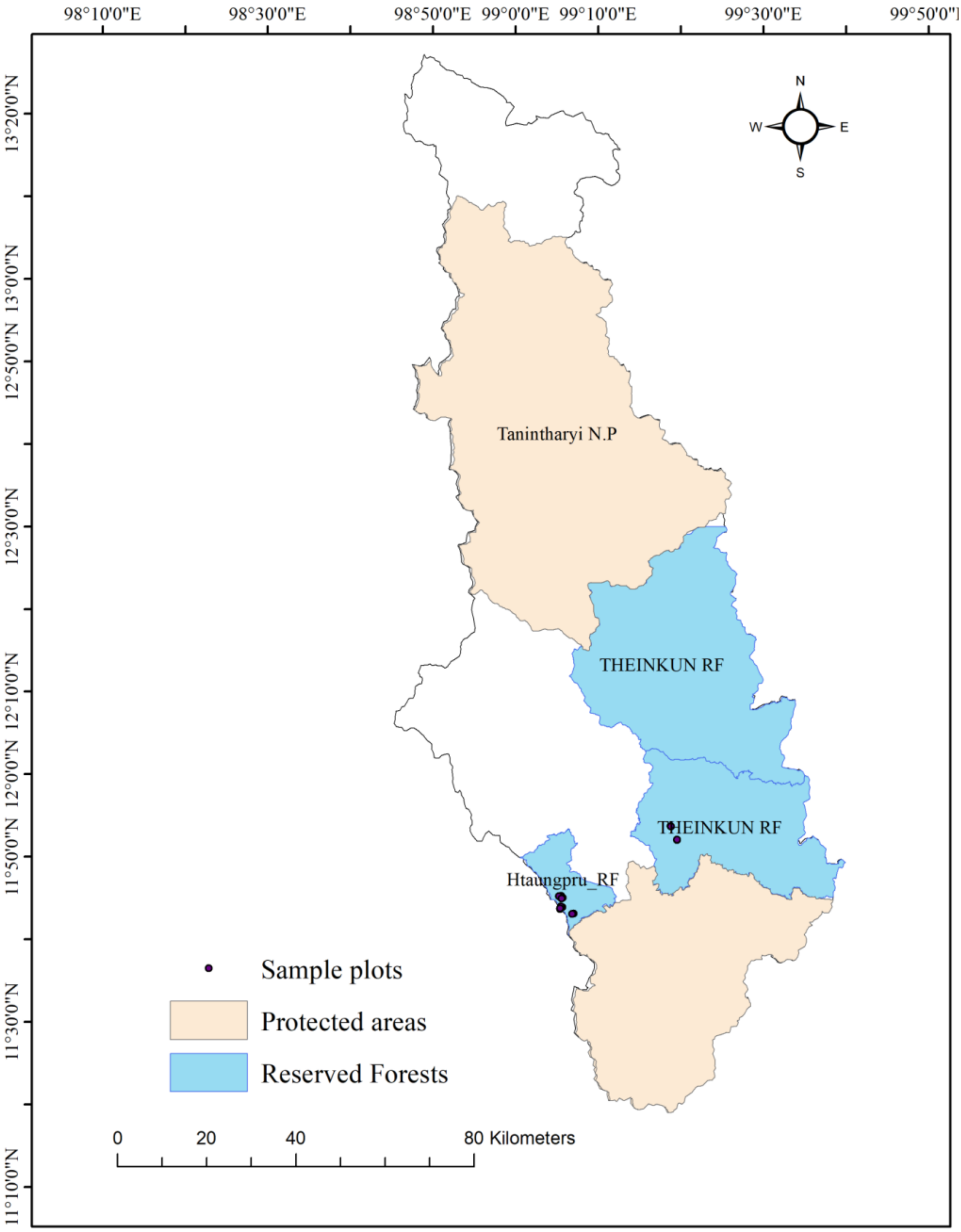

Figure 1. Study area of Tanintharyi Township, Myeik District, Tanintharyi Region

4.2 Forest Inventory and Flora Survey

To collect floral and structural data from the forests at the two sites, we arbitrarily laid out 15 sample plots (30 m × 30 m) across those study sites. Eleven plots were sampled in Taungpharu reserved forests while the rest four plots were laid out in Thein Kone reserved forest. Proposed Tanintharyi National Park was not included in conducting forest inventory activities because of safety reason while those areas are also part of the areas governed by ethnic armed group. But the topography, climate conditions and age, and species composition of the forests among proposed Tanintharyi National Park and those two reserved forests were similar and this is the reason conducting the surveys in those areas. To reduce the effect of spatial autocorrelation for covering the variation of floral composition, sample plots were separated from each other by at least 500 m. To avoid sampling early stages of regeneration, we selected forests with a minimum canopy height of 12 m. Data were collected from November 2018 to January 2019. In each sample plot, we measured the diameter at breast height (DBH) and the height of all trees (with ≥5 cm DBH and ≥2 m in height). We measured tree heights using a Vertex IV hypsometer (Haglöf Sweden AB). For multi-stemmed individuals, we measured each stem with DBH ≥5 cm. Specimens of leaves, shoots, fruits, seeds, flowers, and barks wherever available were collected from each species with their local names for the later identification. The specimens were sent to the Herbarium of Forest Research Institute, Myanmar, for taxonomic identification. We followed the nomenclature of Kress et al. (2003) and Gardner et al. (2000). For forest inventory, we only measured trees, while other plants, such as climbers, shrubs, and herbs, were excluded.

4.3 Data analysis

For numerical analyses, we organized our collected data into two matrices, namely species matrix and environmental matrix. The 15 plots were put as row headings for both matrices. The total 67 species were put as column headings for the species matrix, while each cell contained the number of stems of each species that occurred in each plot. For the environmental matrix, we put the variables as elevation, reserved forests, and coordinates for each plot.

Data analyses were conducted by using Biodiversity R package developed in R-statistics. To determine species composition, the results will be shown as pooled data for all sample plots as well as values for each sample plot. Number of species, genera and family were recorded. Actual species richness and Jackknife’s estimates of species richness were determined. For species diversity, two common diversity indices namely Shannon Index and Simpson Index were calculated for pooled data as well as for each plot. The SHANNON Index (H′) expresses the information content per individual within an infinite population and it is regarded as a reasonable measurement of heterogeneity (Peet, 1974). Only considering number of species and relative number of individuals is not strongly enough to define species diversity in a stand. The index according to SIMPSON (1949) avoids that disadvantage. It gives the probability of any two individuals drawn at random from an infinitely large community belonging to different species (Brodbeck, 2004). It is common practice among ecologists to complete the description of a community by one or two numbers expressing the "diversity" or the "evenness" of the community (Heip *et al.*, 1998). In addition to diversity indices, identification of evenness also plays an important role in describing the condition of a stand because evenness can describe the distribution of individuals over species. For measuring relative abundance or evenness of species in a particular area, the SHANNON

Evenness (E%) was calculated. As this paper aims to present species composition, diversity, and stand structure, we did not apply the environmental matrix.

To determine stand structural characteristics, we calculated the mean DBH (cm), maximum tree height (m), total basal area (m^2), stem density, and sprouting ratio (%) (= sprouting stem / total stem x 100 where sprouting stems are the total number of multi-stemmed individuals) for each plot. For comparative analyses of stand structural and species compositional attributes, we first checked normality using the Shapiro–Wilk test (Shapiro and Wilk 1965) and for homogeneity of variance using Levene's test at the $P < 0.05$ significant level (Olkin 1960). As normality and homogeneity were rejected for some of our observed attributes, we applied the nonparametric Kruskal–Wallis test to compare all data attributes among stand types. To clearly determine the impact of disturbance on forest structure, we first classified DBH values of all measured stems into classes at 5-cm intervals. We then compared the stem-diameter distribution among stand types using the Kolmogorov–Smirnov test.

5. Results and Discussions

5.1 Species composition, stem density, diversity and evenness at site level

Table 1. Ten most common tree families found in Natural Forests in Natural Forest in Taungpharu reserved forest and Thein Kone reserved forest of Tanintharyi Township

Family	Density (no. of stems)	Mean DBH (±SD) (cm)	Total BA (m^2)
Euphorbiaceae	143	14.44 (±14.01)	12.00
Dipterocarpaceae	104	22.00 (±22.74)	8.14
Lauraceae	101	16.21(±15.18)	3.89
Myrtaceae	80	21.72(±15.51)	4.46
Anacardiaceae	63	16.37(±11.39)	1.96
Lamiaceae	57	20.05(±17.85)	20.15
Sapindaceae	55	15.14(±8.25)	8.08
Malvaceae	55	23.02 (±17.80)	3.63
Rubiaceae	51	15.49(±17.83)	2.21
Sapotaceae	45	17.42(±13.97)	1.75

In total, there are 940 individuals occupied by 67 species occurred in 29 families for all sample plots. Still, there are 20 individuals as unknown species which could not be identified taxonomically because of incomplete specimens as well as inaccessible to collect their specimens. The five most common families are Euphorbiaceae (143 individuals), Dipterocarpaceae (104 individuals), Lauraceae (101 individuals), Myrtaceae (80 individuals), and Anacardiceae (63 individuals) . The results of family composition show that those forests are relatively tropical evergreen forests. Although the family Euphorbiaceae belongs to the most occurrences in stem densities, Lamiaceae was found to occupy the highest values in total basal areas among all families (Table 1). The list of all species, their abundance and their respective families are shown in Table 2. According to (Tang et al. 2011), Euphorbiaceae was mostly found in limestone forests in tropical areas, and it is a distinctive forest formation, found within the tropical-rain forest regions of south-eastern Asia ("Limestone Forest - Oxford Reference" n.d.). Therefore some part of the forests of this area would be limestone forests as found in result.

Table 2. Species, their abundance and families found in Natural Forest in Taungpharu reserved forest and Thein Kone reserved forest of Tanintharyi Township

No	Family and species	Number of species
1	**Anacardiaceae**	**63**
	Swintonia floribunda Griff.	26
	Bouea burmanica Griff.	19
	Spondias sp.	12
	Swintonia schwenkii (Teijsm. & Binn.) Teijsm. & Binn.	6
2	**Annonaceae**	**30**
	Annonaceae species	30
3	**Bignoniaceae**	**3**
	Heterophragma adenophylla (Wall.) Seem. ex Benth. & Hook.	3
4	**Bombacaceae**	**1**
	Durio sp.	1
5	**Celastraceae**	**15**
	Lophopetalum fimbriatum Wight	3
	Lophopetalum fimbriatum Wight	4
	Microtropis bivalvis (Jack.) Wall.	8
6	**Clusiaceae**	**2**
	Garcinia heterandra Wall.	2
7	**Combretaceae**	**2**
	Anogeissus acuminata Wall.	1
	Terminalia catappa L.	1
8	**Dipterocarpaceae**	**104**
	Dipterocarpus sp.	57
	Hopea helferi (Dyer) Brandis	11
	Shorea farinosa Fischer	29
	Shorea gratissima Dyer	1
	Shorea sp.	5
	Melia sp.	1
9	**Ebenaceae**	**13**
	Diospyros kurzii Hiern.	8
	Diospyros sp.	5
10	**Elaeocarpaceae**	**1**
	Elaeocarpus griffithii (Wight) A. Gray	1
11	**Euphorbiaceae**	**143**
	Aporusa villosula Kurz	24
	Aporusa wallichii Hook. f.	83
	Baccaurea sapida Muell. Arg.	16
	Croton sp.	20

No	Family and species	Number of species
12	**Fabaceae**	**4**
	Abarema bigemina (L.) Kosterm.	1
	Dialium indum L.	3
13	**Gnetaceae**	**1**
	Gnetum gnemon L.	1
14	**Hypericaceae**	**37**
	Mesua nervosa Planch. & Triana	37
15	**Lamiaceae**	**57**
	Gmelina arborea Roxb.	34
	Vitex coriacea C.B. Clarke	23
16	**Lauraceae**	**101**
	Cinnamomum verum Presl	8
	Litsea elongata (Nees) Benth.	1
	Litsea laurifolia (Jacq.) Kurz	1
	Nothaphoebe condensa Ridley	62
	Phoebe tavoyana (Meissner) Hook. f.	29
17	**Magnoliaceae**	**3**
	Micheli sp.	1
	Michelia champaca L.	2
18	**Malvaceae**	**55**
	Colona sp.	1
	Eriolaena candollei Wall.	1
	Pentace burmanica Kurz.	51
	Pterospermum jackianum Wall. ex Mast.	1
	Sterculia sp.	1
19	**Meliaceae**	**8**
	Chisocheton sp.	4
	Sandoricum koetjape (Burm. f.) Merr.	4
20	**Moraceae**	**12**
	Ficus sp.	1
	(blank)	11
21	**Myristicaceae**	**20**
	Myristica angustifolia Roxb.	20
22	**Myrtaceae**	**80**
	Syzygium subrufum (King) Masam.	1
	Syzygium pachyphyllum (Kurz) Merr. & L.M. Perry	2
	Syzygium sp.	72
	Syzygium thumra (Roxb.) Merr. & L.M. Perry	2
	Syzygium zeylanicum (L.) DC.	3
23	**Opiliaceae**	**2**
	Champereia manillana (Blume) Merr.	2
24	**Polygalaceae**	**6**
	Xanthophyllum griffithii Hook. f. ex A.W. Benn.	6
24	**Rubiaceae**	**51**

No	Family and species	Number of species
	Tabernaemontana ophiorrhizoides Kurz	15
	Tarenna sp.	36
25	**Sapindaceae**	**55**
	Nephelium sp.	47
	Nephelium ramboutan-ake (Labill.) Leenh.	8
26	**Sapotaceae**	**45**
	Mimusops elengi L.	1
	Palaquium obovatum (Griff.) Engl.	34
	Payena sp.	10
27	**Theaceae**	**3**
	Ternstroemia penangiana Choisy	3
28	**Thymelaeaceae**	**2**
	Aquilaria sp.	2
29	**Ulmaceae**	**1**
	Celtis sp.	1
30	Unknown stems	20
	Grand Total	**940**

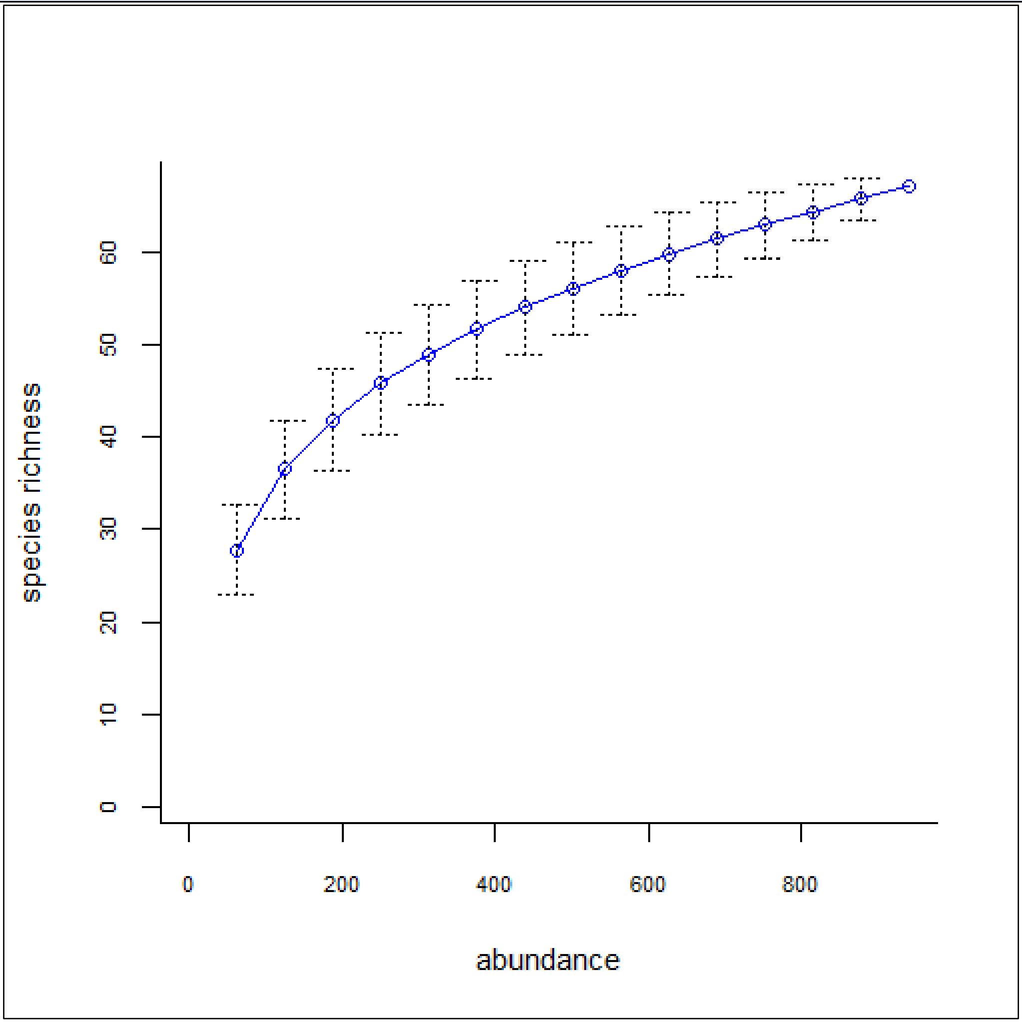

Figure 2. Species accumulation curve for all sample plots in natural forests of Tanintharyi Township

We used the Jackknife estimator of species richness to check the actual number of species which can be found in this area. Traditionally ecologists have used the number of species observed in a sample, S0 which means the actual number of species found in all sample plots, to estimate species richness (S) , realizing that S0 is a lower bound for S. One alternative to S0 is to use a nonparametric procedure such as jackknife resampling. The jackknife is useful because it is known to reduce bias and, for estimates of species richness, it has a closed form. Another useful characteristic of the jackknife estimator of species richness is that the estimator is based on the presence or absence of a species in a given plot rather than on the abundance of the species (Smith and Pontius 2005).We applied both 1st order and 2nd order estimators while the 1st order Jackknife estimator of species richness confirmed that the number of species would be 89 while the 2nd order estimated that the number of species to be found in this area would be 104.

The Shannon diversity index value showed higher diversity for the study sites (3.498) while the typical values are generally between 1.5 and 3.5 in most ecologically studies, and the index is rarely greater than 4.0 (Magurran 2004). The value of Simpson diversity index (1-D) was 0.959 indicating the higher diversity values and possessing less single most dominant species in this area. On the other hand, The Shannon Evenness was found as 49.32% that means the number of individuals represented by each tree species are not evenly distributed across the study site. The results of species richness, diversity indices and evenness values were shown in table 3.

Table 3. Species richness, stem density, diversity and evenness of natural forests of Tanintharyi Township

No.	Variables	Pooled data (all plots included)
1	Species Richness(S)	67
2	Density (no. of stems/ha)	696
3	Jackknife estimate of species richness (1st order)	89
4	Jackknife estimate of species richness (2nd order)	104
5	Shannon Diversity Index (H)	3.498
6	Simpson Diversity Index (1-D)	0.959
7	Shannon Evenness (E%)	49.32

As the number of stems counted in all fifteen sample plots was 940, we found out that the species accumulation curve did not stabilize within the area analyzed for all surveyed plots (Figure 2). That means we can still find some more new species if we can conduct some more replications of floral surveys and forest inventory.

5.2 Species composition, stem density, diversity and evenness at plot level

The species richness occurred in fifteen sample plots ranged from 35 species in plot 14 as the highest number of species to 8 species in plot 15 as the lowest. In terms of abundance, we found that plot 14 has the highest number of stems (117 stems) while plot 15 has the lowest number of stems (11). In terms of species diversity indices, the values of Shannon Diversity Index ranged from 2.02 as minimum to 3.26 as the maximum, indicating that all plots occupied relatively high in species diversity as the values did not fall under 1.5 as described by (Magurran 2004). The Simpson Diversity index (1-D) values ranged from

0.860 to 0.958 showing the diversity of species composition in those plots. We also calculated the species evenness of all plots while plot 12 has the lowest values (58.47%) and plot 15 represents the highest value in species evenness (94.21%). The species richness, abundance, diversity indices and evenness values for each plot were shown in Table 4.

Table 4. The species richness, abundance, diversity indices and evenness values for each sample plot in natural forests of Tanintharyi Township

Plots	Richness (S0)	Abundance (no. of stems)	Shannon	Simpson	Logalpha	Evenness
P01	21	59	2.76	0.923	11.65	75.32%
P02	20	68	2.6	0.903	9.55	67.30%
P03	16	41	2.48	0.893	9.65	74.39%
P04	19	56	2.57	0.897	10.13	68.96%
P05	15	77	2.3	0.871	5.56	66.61%
P06	22	64	2.7	0.901	11.85	67.73%
P07	23	62	2.95	0.938	13.24	82.98%
P08	20	59	2.79	0.928	10.65	81.12%
P09	20	40	2.84	0.933	15.92	85.38%
P10	25	91	2.87	0.923	11.38	70.88%
P11	22	46	2.79	0.921	16.54	73.89%
P12	18	83	2.35	0.851	7.08	58.47%
P13	27	66	3.05	0.938	17.06	78.47%
P14	35	117	3.26	0.953	16.92	74.28%
P15	8	11	2.02	0.86	13.19	94.21%

5.3 Stand structural characteristics at site level

Stand structure of natural forests of Tanintharyi Township was firstly shown by the values of mean DBH (Diameter at breast height in cm), total basal area (in m^2), and average top heights of the trees (in m) (Table 5). As the trees in those plots ranges by different sizes from small trees to large trees, the values of standard deviation (SD) became larger (Table 5). The mean DBH values range from 11.22 cm (plot 05) to 33.57 cm (plot 15) as the largest. The total basal area of the plots was ranging from 1.24 m^2 to 4.78 m^2. The mean top height of the trees was found 11.59 m as the lowest through 22.06 m as the highest.

Table 5. Stand structural components of the plots in natural forests of Tanintharyi Township, Tanintharyi Region

Plots	Mean DBH (cm)	Total BA(m^2)	mean top height (m)
P01	16.66 (±11.97)	1.94	17.10(±8.82)
P02	22.30(±19.34)	4.62	18.20(±10.72)
P03	23.82(±17.29)	2.78	22.06(±10.17)
P04	22.51(±18.06)	3.64	16.41(±9.48)
P05	11.22(±7.87)	1.13	11.71(±6.08)
P06	18.52(±14.04)	2.70	17.71(±11.72)
P07	21.25(±18.35)	3.81	18.26(±10.94)
P08	19.00(±16.32)	2.89	21.41(±13.09)
P09	28.82(±26.59)	4.78	18.52(±9.58)
P10	17.43(±12.83)	3.33	14.63(±7.16)
P11	22.49(±21.06)	3.40	16.09(±11.65)
P12	15.06(±17.28)	3.40	11.59(±6.09)
P13	22.77(±20.23)	4.78	14.94(±9.00)
P14	14.68(±12.97)	3.51	12.18(±5.20)
P15	33.57(±18.43)	1.24	19.96(±5.59)
Grand Total	**18.98 (±17.01)**	**47.94**	**15.85**(±9.55)

We also identified the stem-diameter distribution of the trees found in all sample plots to define the stand structure of the forests (Figure 3). We firstly classified the stems into ten classes with 5 cm diameter intervals. The highest number of stems was found in the smallest diameter classes meaning the highest proportion of small trees in the forest. However, the diameter distribution curve did not follow the inverse-J shape which is the typical form of undisturbed natural forests. According to this finding, we can prove that those forests have been disturbed especially anthropogenic disturbances such as logging, pole cutting, etc., in previous time. But it seems there is still no disturbance at this current time.

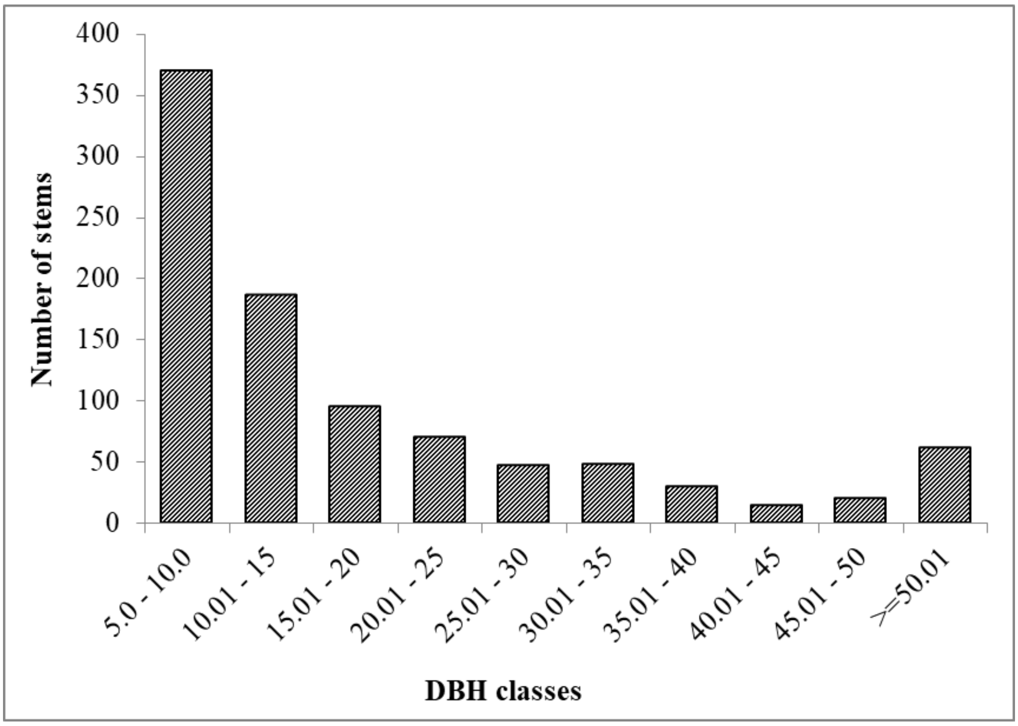

Figure 3. Stem-diameter distribution of the natural forests in Tanintharyi Township, Tanintharyi Region

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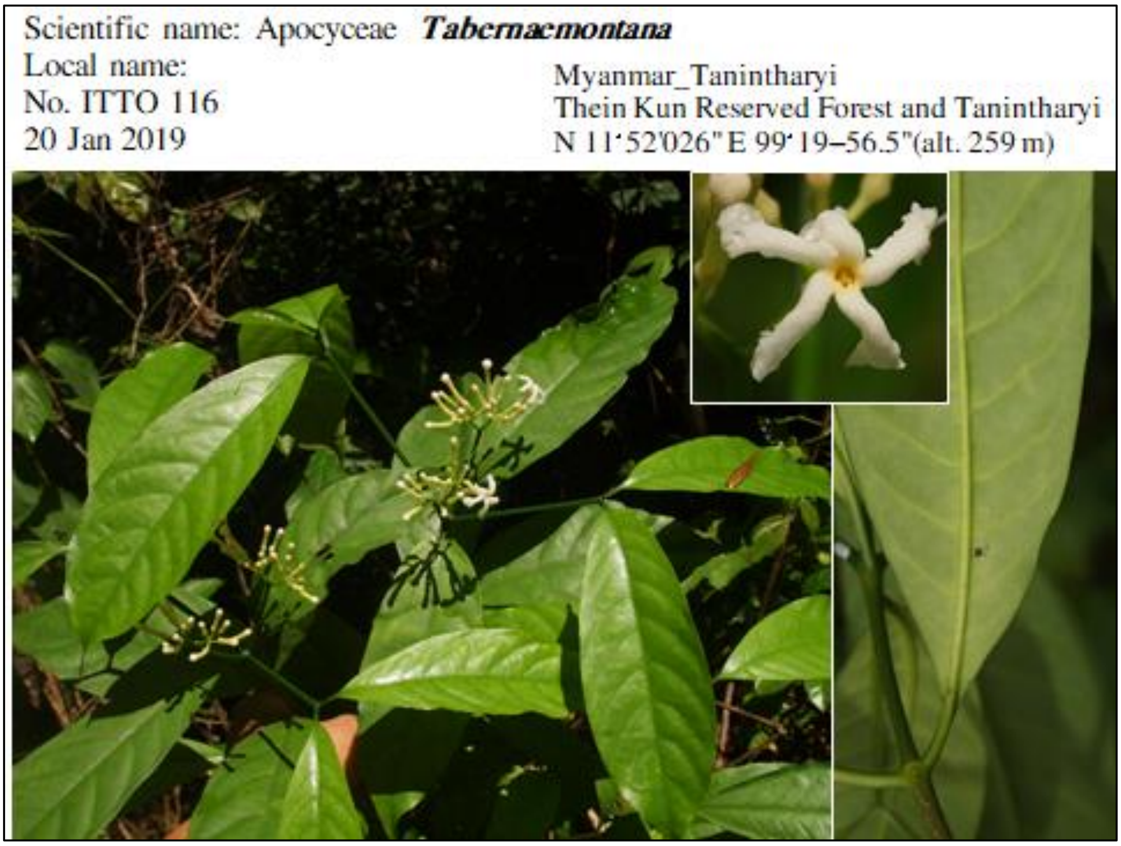
7. Photos Records

Callicarpa species

Chassalia species

Gnctum gnemon



Tabernae montana

Scientific name: Lauraceae ***Actinodaphne sesquipedalis*** Hook. f. & Thomson ex Meissner
Local name:
No. ITTO 120
20 Jan 2019

Myanmar_Tanintharyi
Thein Kun Reserved Forest and Tanintharyi
N 11˙52'026" E 99˙19–56.5"(alt. 259 m)

Actinodaphne sesquipedalis

Scientific name: Ebenaceae *Diospyros* sp.
Local name:
No. ITTO 100
20 Jan 2019

Myanmar:_Tanintharyi Region, Taninthayi Township,
Thein Kun Reserved Forest and Tanintharyi
N 11˙52'026" E 99˙19–56.5"((alt. 259 m)

Diospyros species

Durio mansonii

Payena oleifera

Syzygium species

Taungpharu reserved forest

Thein Kon reserved Forest

Research Team


Measuring tree height by Vertex hypsometer


Specimen collection for tree identification

Measuring tree diameter

Research team

VII. Utilization of Non-Timber Forest Products by local people in Tanintharyi Township, Tanintharyi Region

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(email: phyuphyulwin08@gmail.com)

Abstract

The study was conducted in Tanintharyi Township located within Myeik District, Tanintharyi Region, Southern part of Myanmar. we selected the sample villages by two groups; one village group representing the local inhabitants while another group representing migrants so that we can take samples to represent the population for exploring utilization of non-timber products by local communities including the migrators. Primary data was collected by means of questionnaires surveys combined with face-to-face interviews. In total, there were 107 sampled respondents from six villages belonging to two village tracts. About 64% of the respondents were migrated to this area because they settled in this area after moving in as workers of Palm oil companies. About 91% of the sample households earned their livings by means of farming in orchards, planting perennial fruit trees. About 49% of the respondents owned farmlands less than 5 hectares while the rest own farmlands more than 5 hectares. We found out that people in this area are mostly dependent on production of agricultural products from their orchards as their main income source. Although they use NTFPs, they did not produce and trade in the markets as commercial products. Consequently, we could not count monetary return for extraction of NTFPs by local people in this area as their utilization pattern is rather subsistence scale, and not commercial purposes. Accordingly, we collected the traditional knowledge of local people in using NTFPs in this current research as ethno-botanical information. The most common bamboo species naturally grown in this area and used by local people is Waya in local name whose scientific name is *Gigantochloa nigrociliata* (Buse) Kurz. In average, each household usually consume about 90 culms annually ranging from 10 culms as minimum to 500 culms as maximum number used by some households. In this area, there are varieties of rattan species used by local people. , we found out that local people utilized varieties of non-timber forest products for multiple purposes including food, medicinal plants, firewood, and different apparatus. They usually collect those NTFPs from the nearby natural forests. The NTFP categories include seeds, fruits, roofing materials, leaves, rhizomes, stems, roots, mushrooms and medicinal plants. Hence, the results show that NTFPs contribute the livelihood security of the people in this study area as subsistent skill. It indicates the importance of applying systematic management and effective conservation measures to ensure the sustainability of those natural resources.

Key Words: Ethno-botany, Livelihood Security, Medicinal Plants, Non-Timber Forest Products

Utilization of Non-Timber Forest Products by local people in Tanintharyi Township, Tanintharyi Region

1. Introduction

Approximately 80% of the populations of developing countries use Non-timber Forest Products (NTFPs) to meet their health and nutritional needs, and several million households worldwide use these products for subsistence consumption and/or income generation (FAO 1997). Types of NTFPs include food, beverages, spices, flavorings, perfumes, medicines, paints, polishes, construction materials, and extracts used in the chemical industry. Currently, at least 150 NTFPs are significant in terms of international trade, including honey, gums, rattan, bamboo, cork, nuts, mushrooms, essential oils and plants or animal parts used for pharmaceutical products (FAO 1997).

NTFPs have three main functions in the household economy of rural communities living in or adjacent to the forest (Heubach, K., et al., 2011). Firstly, they help to fulfill households' subsistence and consumption needs in terms of e.g. energy and nutrition as well as medical and construction purposes. Secondly, they serve as a secondary income opportunity to support households at the time of crises (e.g. income shortages from other income sources, e.g. crop failure) and thirdly, some NTFPs provide regular cash income in some areas of tropical areas (Angelsen and Wunder, 2003; Shackleton et al., 2007). In another term, they serve to stabilize household economies and play an important supplemental or fallback role (Godoy *et al.* 2000; Pattanayak & Sills 2001).

As Myanmar is also one of the tropical countries and rich in biodiversity occurred in different types of forests including mangroves and temperate forests, numerous varieties of forest resources exist in Myanmar. Most of the people in Myanmar (about 70% of the country population) reside in rural areas; their livelihood is totally related with natural forests. Some people earn their income by extraction of forest products from natural forests while some convert forests to agricultural lands to do their farming practices. Accordingly, it is apparent that forest resources including NTFPs have been contributing the livelihood security of the people in rural areas of the countries. However, excessive and unsystematic extraction of forest products leads to the destruction and shortage of those products in natural forests. This highlights the importance of systematic management and extraction of the forest products to ensure their sustainability. In this context, documentation of the forest products utilized by people is mandatory as the first step to implement the systematic management of those resources.

The Taninthayi (Tenasserim) Mountain Range, along the border between Myanmar and Thailand, covers a global important terrestrial eco-region with a transition zone from continental dry evergreen forests common in the north to semi-evergreen rain forests to the south. As a consequence, they contain some of the highest diversity of both bird and mammal species found in the Indo-Pacific region. However, the outstanding biodiversity features and cultural diversity of the Taninthayi Range are vulnerable due to poaching, fragmentation and encroachment for agriculture, illegal logging, settlements inside and around the park, and human-elephant conflicts. In addition, limited capacity and resources for adequate biodiversity conservation, management and monitoring in Myanmar make it unable to contribute to the transboundary biodiversity conservation in this eco-region. Hence, inventory and documentation of the resources such as wild flora and fauna including NTFPs is one of the important tasks to support implementation of effective conservation measures.

2. Objectives of the study

This study was conducted to fulfill the following objectives:

1) To document the different categories of NTFPs utilized by local people in their daily lives;
2) To understand the contributions of NTFPs to the livelihoods of local people; and
3) To record the utilization patterns for different NTFPs in the study area to support the effective management and conservation activities.

3. Research Team

The following researchers and staff of Forest Research Institute and Tanintharyi Township Forest Department joined the activities of village meetings and household surveys for assessment of non-timber forest products in Tanintharyi Township.

No.	Name	Position	Task
1	Dr. Phyu Phyu Lwin	Staff Officer	Village meetings, household surveys, Data Input, Data Analysis, Paper Writing
2	U Aye Chan Maung	Staff Officer	Household surveys
3	Daw Tin Hnaung Aye	Range Officer	Village meetings, household surveys
4	Mr. Ye Yint Tun	Research Assistant-3	Village meetings, household surveys
5	Mr. Nyi Lwin Soe	Project Secretary	Logistics arrangement
6	Mr. Zayar Moe	Deputy Range Officer	Liaison Officer

4. Methodology

4.1 Study Area

The study was conducted in Tanintharyi Township located within Myeik District, Tanintharyi Region, Southern part of Myanmar. It is located between 11º20´ to 13º10´ North Latitude and 98º40´ to 99º40´ East Longitude (Figure 1). Tanintharyi Township is bordered with Thailand in east, Dawei District in north, Boatpyin Township in south, and Kyunsu Township, Myeik Township and Pulaw Township in west respectively. The area of the township is 4380.18 square miles (11344.61 km^2). About 64.33% of the area of the whole township was forested lands covering the area as 7298.57 km^2. Among those forested areas, 4735.32 km^2 has been declared and demarcated as reserved forests and recognized as permanent forest estate (PFE) administered by Forest Department. In total, there are six reserved forests in this township and those are Taungparu reserved forest, Mayingyi reserved forest, Thakyet reserved forest, Thein Kone reserved forest, Ngawon reserved forest, and Ngawon extension forest. There are two proposed protected areas; namely Tanintharyi National Park and Leynyar extension National Park covering the area of 4447.85 km^2.

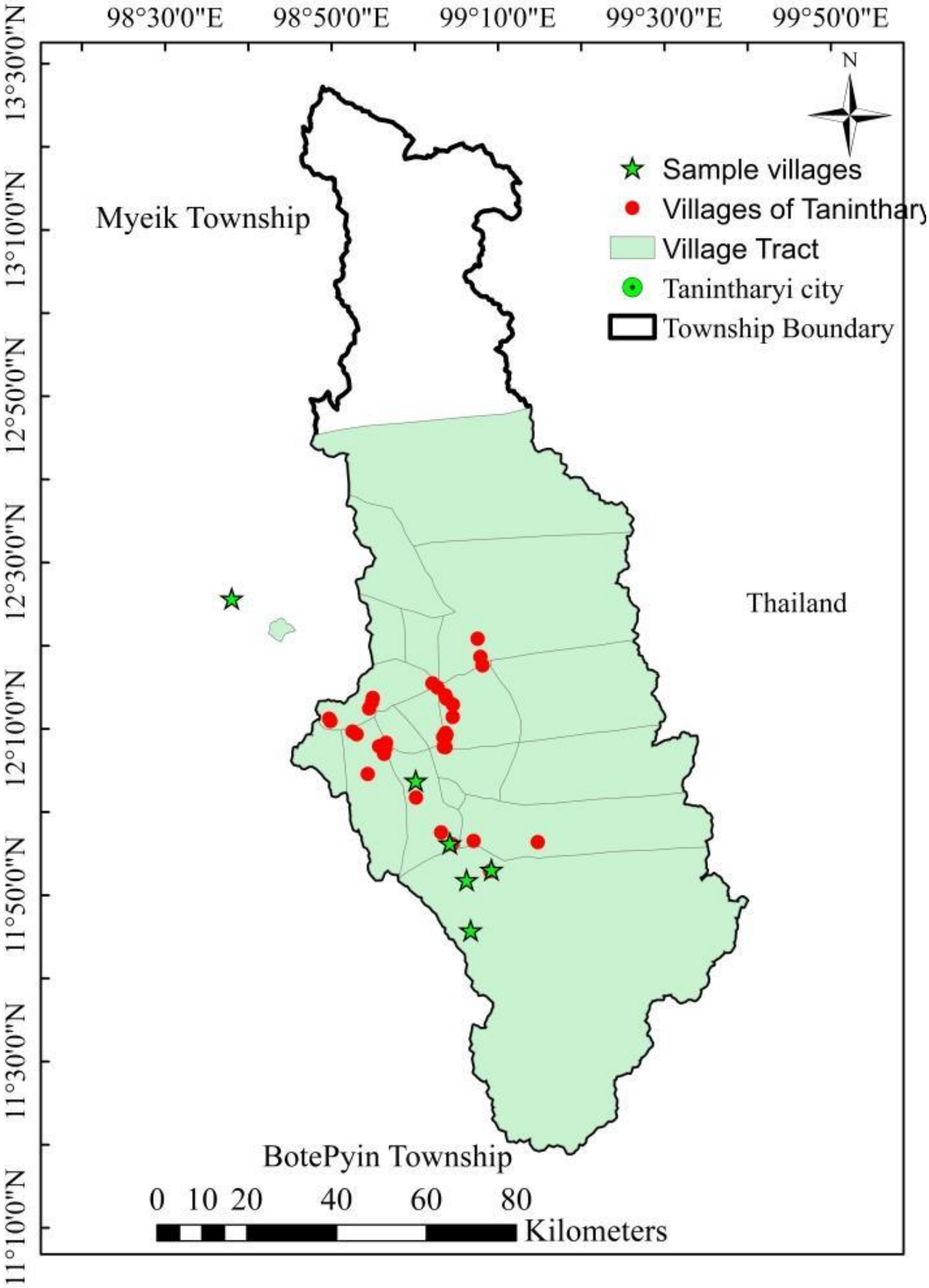

Figure 1. Study Area which is Tanintharyi Township, Tanintharyi Region and location of sample villages

The total number of village tracts (group of villages) was nineteen while there are 214 villages representing those nineteen village tracts in Tanintharyi Township. The major ethnic groups residing in the township are Bamar, Tai-Shan, Kayin and Mon. Some parts of the area are resided by the natives while some areas were occupied by the people migrated from other regions of Myanmar. Those people came to this area as the labors of palm oil companies doing agricultural business growing extensive areas of palm oil plantations in that area. Later on, those labors resided in that area by many reasons including marriage with local residents, doing farming, and other businesses for their livings.

4.2 Data Collection

For conducting data collection, we selected the sample villages by two groups; one village group representing the local inhabitants while another group representing migrants so that we can take samples to represent the population for exploring utilization of non-timber products by local communities including the migrators. Villages and respective stakeholders were first identified in the study sites through key informants' interviews by visiting local Forest Department, village heads and elders assisted by secondary data collection by reviewing reports, scholar articles and documents. Primary data was collected by means of questionnaires surveys combined with face-to-face interviews. In some areas where language barrier was encountered, local guides assisted us in translation or subsequent explanation of the questions. We conducted semi-structured questionnaire surveys during November 2018 and January 2019.

4.3 Data Analysis

Data input and statistical analysis of the survey data was conducted using Microsoft excel and R statistical software. The socio-demographic information of the households was shown by descriptive statistics. Comparison was done between two village groups. Chi-squared test was applied for categorical data such as age group, education, and Kruskal-wallis test was used to compare among the continuous variables, e.g., land holdings. The use patterns of non-timber forest products by those households were described by narrative forms.

5. Results and Discussions

5.1 General information of the sample villages and sample respondents

In total, there were 107 respondents from six sample villages belonging to two village tracts (Table 1). Village tract means a group of villages located nearby and organized according to the legal administration structure. The name of the two village tracts are Thein Kone village tract resided by mostly migrated people while another one is Ban La Mut village tract which is mostly resided by local residents. In each village tract, we sampled three villages for data collection. The name of the sample villages, and the number of respondents we surveyed during our data collection were shown in Table 1. Villages included in Thein Kone village tract were established in recent decades by occupying the natural forests and vacant lands of the township area for their livings. On the other hand, villages included in Ban La Mut village tract were established since long time ago which means the ages of those villages were more than 100 years (personal interview).

Table 1. Sample villages and sample respondents for documentation of NTFPs in Tanintharyi Township, Tanintharyi Region

Village Tracts	Villages						Total
	V1 (Chaung La Mu)	V2 (Tar Pa Lat)	V3 (Aye Thar Yar)	V4 (Yan Pho)	V5 (Nyaung Pin Gone)	V6 (Ban La Mut)	
Thein Kone	38	5	12				55
Ban La Mut				19	16	17	52
Total	**38**	**5**	**12**	**19**	**16**	**17**	**107**

5.2 Socio-demographic and socio-economic information of the respondents

Table 2 summarizes the socio-demographic and socio-economic information of the respondents including gender, age, education, household size, their residential status, income, land holdings and the primary livelihood patterns. About 63% of the respondents were male, and most of the respondents were involved in middle-aged classes (Table 2). About 64% of the respondents were migrated to this area because they settled in this area after moving in as workers of palm oil companies. The education level of most of the respondents was primary school and middle school whereas only 4 respondents were graduated persons. We classified the household size into two classes: households with less than or equal five members; and households constituted with more than five members. As a result, about 56% of respondents were from households with less than or equal five family members.

Table 2. Socio-demographic and socio-economic information of the respondents in Tanintharyi Township, Tanintharyi Region (n=107)

Variables	Village tracts			χ^2	df	P
	VT-1 (n=55)	VT-2 (n=52)	Total			
1. Gender						
Male	37	22	67	1.048	1	0.306
Female	18	30	40			
2. Age						
<25	6	1	7			
26-40	19	8	27	12.974	3	0.005
41-60	27	32	59			
>61	3	11	14			
3. Residential status						
resident	2	37	39	52.603	1	0.000

Variables	Village tracts			χ^2	df	P
	VT-1 (n=55)	VT-2 (n=52)	Total			
migrate	53	15	68			
4. Education						
no formal school	4	2	6			
Primary school	16	25	41	4.713	4	0.318
Secondary school	25	19	44			
High school	7	5	12			
graduated	3	1	4			
5. Household size						
<=5	28	32	60	1.226	1	0.268
>=6	27	20	47			
6. Income class (USD)						
<2000	26	13	39			
2000-4000	12	12	24	8.596	4	0.072
4000-6000	5	8	13			
6000-8000	2	8	10			
>8000	10	11	21			
7. Land holdings (ha)						
<5	21	31	52			
5.01-10	18	16	34			
10.01-15	7	3	10	8.939	4	0.063
15.01-20	2	1	3			
>15	5	0	5			
8. Primary occupation						
Orchard	49	48	97			
Casual labor	3	1	4			
Grocery store	1	3	4	4.920	5	0.426
Middle men/Traders	1	0	1			
Upland field/ Kaing	1	0	1			

As a tradition, most of the family members work for their own jobs and rarely, they hire other labors to work in their fields. In addition, they cannot memorize the cost of inputs to produce their agricultural products as well as their living expenses. In this case, we could have documented only their gross income, not net income. We classified people income into five classes by converting into US dollars from Myanmar Kyats and shown in Table 2. The result showed that about 36% (39 respondents) earned their yearly income less than 2000 USD. About 49% of the respondents owned farmlands (cultivated lands) less than 5 hectares. The findings also showed that about 91% of the sample households earned their livings by means of farming in orchards. The different types of land holdings and the crops grown in each type of farmland are listed in Table 3.

Table 3. Types of farmlands and different crops growing in each respective type of land

No.	Types of Farmland	Crops
1	Palm-oil plantations (by private companies)	Palm oil
2	Orchards (by local communities)	Areca palm, banana, cashew nuts, rubber, seasonal fruits
3	Upland field / kaing	Annual cash crops and vegetables
4	Lowland paddy field	Paddy
5	Fallow forests	Fallows for firewood cutting and orchard expansion in the future

5.3 Different income sources and contribution of NTFPs

Table 4. Different income sources and contribution to total household incomes of the respondents in Tanintharyi Township, Tanintharyi Region (n=107)

Variables	Village tracts		Mann-Whitney U test	
	VT-1 (n=55)	VT-2 (n=52)	U	P
Total annual gross income (USD)				
Mean (±SD)	3776 (4098)	5562 (4447)	994	0.007
Median	2013	4441		
Total annual farm income (USD)				
Mean (±SD)	2460 (3740)	4485 (3935)	906.5	0.001
Median	533	3850		
Total annual off-farm income (USD)				
Mean (±SD)	1161 (1642)	1050 (1894)	1225.5	0.184
Median	960	0		
Total annual income by livestock rearing (USD)				
Mean (±SD)	155 (810)	27 (104)	1296	0.210
Median	0	0		

During the survey, we tried to record the contribution of non-timber forest products (NTFPs) to their total income of the households. Nevertheless, we found out that people in this area are mostly dependent on production of agricultural products from their orchards as their main income source. Although they use NTFPs, they did not produce and trade in the markets as commercial products. Consequently, we could not count monetary return for extraction of NTFPs by local people in this area as their utilization pattern is rather subsistence scale, and not commercial purposes. Accordingly, we collected the traditional knowledge of local people in using NTFPs in this current research as ethno-botanical information.

According to the findings of the survey, we defined three different income sources; farm income, off-farm income and income by livestock rearing. During the survey, we found out that people in this area have a tradition of rearing livestock animals as one of their income sources. Accordingly, we put income from livestock breeding as one of the categories of income generation. In total, there are only five respondents who earn a certain amount of income by NTFPs. Therefore, we added that proportion into their off-farm income in calculation. Other options of income generation that contributed to off-farm income were grocery stores, middle men, and casual labor. The farm income is the monetary return calculated from the market prices of each crops and their respective yields by farming in previous years. The result showed statistically significant difference between two village tracts regarding total annual gross income and total annual farm income (Table 4). But no difference was found for off-farm income and livestock income between two village tracts. The detailed information of different income sources and their contribution to total household income are listed in table 4.

Figure 2 showed the proportion of each income category into total annual income of two village tracts. In village tract one which have been established recently and mostly resided by migrate people, farm income contributed 65% of total income of the households while off-farm income contributed 31% and livestock income by 4%. On the other hand, farm income contributed 81% of total income for households resided in village tract 2 whereas 19% of income was supported through off-farm income. In this village tract 2, there was no contribution of income from livestock rearing.

As new villages were appeared recently, the age of some orchards cleared to grow their perennial crops were still young not enough to produce yields. This is the reason some people in this village tract relied on off-farm income for their living more than those in village tract 2 (Figure 2). In addition, they are also dependent on livestock rearing to earn income. Meanwhile the people do not earn enough income from their orchards, they probably conduct other off-farm income including livestock rearing.

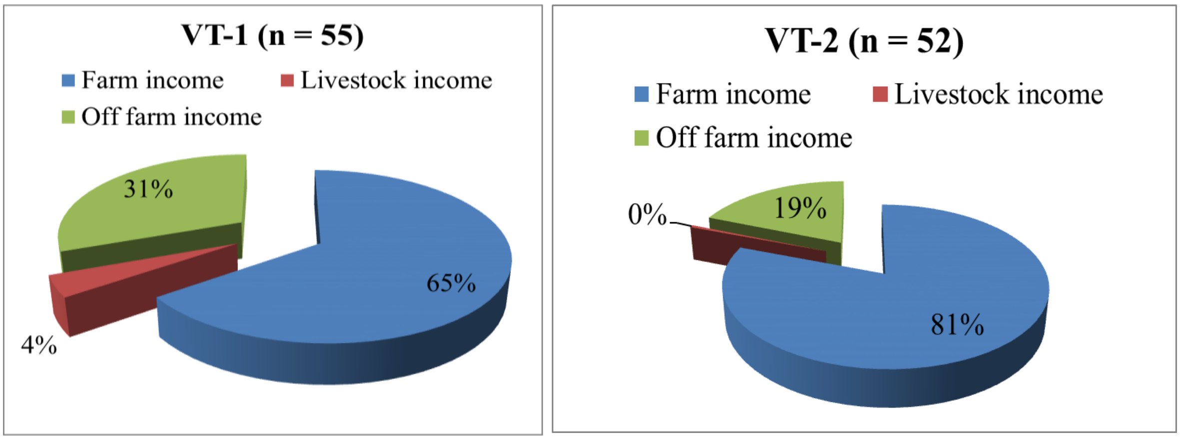

Figure 2. Proportion of different income sources to total annual gross income of the households in two village tracts

5.4 Use patterns of Non-timber forest products by local people

5.4.1 Uses of bamboo and rattan by local people

People in this village use bamboo for multiple purposes including household utensils, tools to be applied for their farming, fencing for their home gardens and orchards, and walls and floors for houses, etc,. The most common bamboo species naturally grown in this area and used by local people is Waya in local name whose scientific name is *Gigantochloa nigrociliata* (Buse) Kurz. In average, each household usually consume about 90 culms annually ranging from 10 culms as minimum to 500 culms as maximum number used by some households. They usually collect bamboo culms from nearby forests as well as from bamboo clumps grown in their orchards, and rarely buy from others. Therefore, there is no market for bamboo and bamboo based products especially value-added products in this area although bamboo resources are abundant.

The price for bamboos in this area is relatively low because it cost about 100 kyats (~0.1USD). According to those findings, we provide recommendations to enhance income by producing value-added products from bamboo resources. To implement it, technology should be transferred to the local communities as the first step, followed by market development, branding, processing and packaging. Sustainable management of bamboo forests and proper extraction methods should be applied to produce high qualified bamboo culms in a sustainable way.

Rattan is one of the most important NTFPs in this area and used by almost all the respondents according to survey. In this area, there are varieties of rattan species used by local people. They use rattan for weaving baskets, different utensils for their farming, and rattan buds for food. Nonetheless, they collected rattan from nearby natural forests while systematic management and collection are lack. In addition, there are illegal cutting from outsiders to sell as raw materials in border market (field survey). As a result, rattan resources became scarce in this area and thus the findings highlighted to conserve rattan resources sustainably.

5.4.2 Other NTFPs categories utilized by local people

According to the survey, we found out that local people utilized varieties of non-timber forest products for multiple purposes including food, medicinal purposes, firewood, and different apparatus. They usually collect those NTFPs from the nearby natural forests. The NTFP categories include seeds, fruits, roofing materials, leaves, rhizomes, stems, roots, mushrooms and medicinal plants. The list of all NTFPs utilized by local people in the study area is listed in table 5.

Table 5. List of NTFPs, utilization patterns by local people in selected villages of Tanintharyi Township, Tanintharyi Region

No.	Items (Common name/local name)	Scientific Name	Use parts	Utilization pattern
1	Kanzaw oil (Honey tree in common name)	*Bassia longifolia* Linn	Oil from seeds	Traditional medicines to cure diseases in body organs
2	Honey			To mix with kanzaw oil and drink together, to use honey only for multiple purposes as well as to cure for stomach ache
3	Tapin-shwe-htee	*Biophytum sensitivum*	All plant parts	Traditional medicine as anti-diabetes, anti-inflammatory
4	Sin_tone_ma_nwe:	*Stephania rotumda*	Roots and stems (climbers)	Traditional medicine to remedy hypertension, diabetes
5	Orchid (thazin) rhizomes		Rhizomes	Flowers for commercial purposes
6	Ta nyin	*Gnetum gnemon*	Leaves	Food: tender leaves as salad and soup and side dish
7	Kun-sa-gamone	*Kaempferia galanga* Linn.	Rhizomes	Insect bites, Sore-eye, inflammation, wounds, giddiness, palpitation, as antiaging agent, poisoning, poor appetite and in digestion and for general purposes.
8	Tapin taing mya nan	*Vitis repens* Wight & Arn.	Whole plant	Sore, carbuncles, ulcers, hepatitis and jaundice, peptic ulcer, tumors and hypertension
9	Nanwin (Turmeric)	*Curcuma longa* Linn.	Rhizomes	Used for multi-purposes as traditional medicines
10	Taw Shaut Khar		Roots	Anti-inflammatory
11	Than ma naing Kyauk ma naing	*Alysicarpus vaginalis* DC.	Whole plants	Medicines: used to remedy diarrhea and kidney problems by boiling the whole plants

No.	Items (Common name/local name)	Scientific Name	Use parts	Utilization pattern
12	Taung tan gyi	*Premna integrifolia* Linn.	Barks and woods	Medicine: anti-inflammatory
13	Pan Shwe War		Whole plants	Medicine to remedy ache
14	Za yit yoe	*Lasia spinosa* (L.) Thwaites	Shoots	Food as tender shoots in the soup or side dishes
15	Kyar ma naing			Traditional medicine to remedy anti-inflammatory
16	Gone Min	*Amomun corynostachyum* Wall.	Whole plants	Traditional medicine as remedies for vomiting, flu and fever
17	Mazeli	*Cassia siamea* Linn.	Tender leaves and flowers	Traditional medicine to remedy different types of disesases
18	Kant kalar	*Gisekia pharnaceoides* Linn	Whole plants	Traditional medicine
19	Germany weed		Whole plants	Leaves by boiling to apply on wounds
20	Ka dat (three leaved caper)	*Crataeva religiosa* Forst	Leaves, bark and roots	Tender leaves for food, bark and roots for medicinal purposes
21	Kin pon chin	*Acacia concinna* (Willd.) DC.	Leaves and fruits	Tender leaves for food, fruits to bed used in shampoo
22	Myin Khwar	*Hydrocotyle asiatica* Linn	Leaves	Food as well as medicine to get clear vision
23	Kyaung shar	*Oroxylum indicum* Vent	Leaves and fruits	Food as well as traditional medicine
24	Wild banana buds		Buds	food
25	Kyeik mhan leaves	*Eclipta alba* Hassk.	Leaves and roots	Traditional medicine
26	Hti ka yone	*Mimosa pudica* Linn	Whole plant	Traditional medicine
27	Sular naphar	*Oldenlandia corymbosa* Linn.	Whole plant	Traditional medicine
28	Orchids	Orchidaceae	Whole plant	Ornamental plants as well as traditional medicine

6. Conclusions

Although people in this study area were not dependent on NTFPs for their income generation, they totally rely on those NTFPs for other purposes including medicines, food sources, household utensils, fodder and construction materials. Hence, the results show that NTFPs contribute the livelihood security of the people in this study area as subsistent skill. It indicates the importance of applying systematic management and effective conservation measures to ensure the sustainability of those natural resources. In addition, we recommend to enhance the capacity building of the local communities relating the production of value-added products from non-timber forest products to create income from NTFPs. Meanwhile the awareness raising of people should also be promoted to improve their participation in conservation and sustainable management of forest resources including NTFPs.

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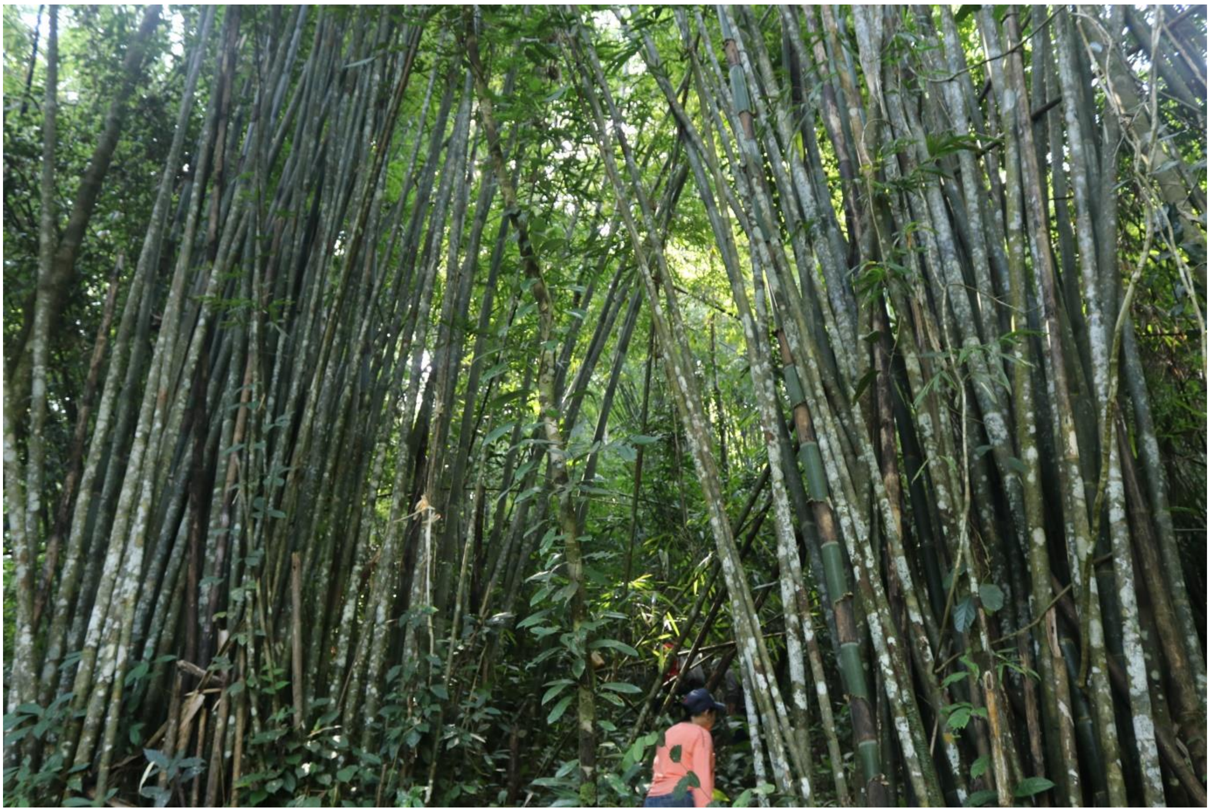
8. Photos



Bamboo species commonly used by local people (*Gigantochloa nigrociliata* (Buse) Kurz.)

Kanzaw oil (*Bassia longifolia* Linn)

Taung tan gyi (*Premna integrifolia* Linn.)

Orchids

Thazin (rhizomes)

Data collection (interviews with the local people)

Data collection (interviews with the local people)

Data collection (interviews with the local people)

Bamboo and rattan products in the market

VIII. Carbon Storage Potential and its relation to Stand Structure of Natural Forests in Tanintharyi Township, Tanintharyi Region

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Abstract

Myanmar is one of the developing countries and facing some deforestation and degradation problems like other countries. The climate change mitigation activities have been done during the recent years. Reducing Emission from Deforestation and Forest Degradation (REDD+) activities have been conducted in Myanmar since 2006. As the assessment of carbon storage is the first and foremost important step in the management, the researches related on carbon storage potential of forests have been emphasized in Myanmar. But still we have limited information to cover the forest types in Myanmar, especially in trans-boundary region like Tanintharyi region. It is a tropical evergreen forest type and situated along the boundary of Myanmar and Thailand, composing diverse species. Therefore, we conducted the study in those areas, called Tanintharyi Township, Myeik District, Tanintharyi Region, Southern part of Myanmar. The main objectives are to investigate the aboveground carbon storage potential of forests in Tanintharyi region and to find the factors related to carbon storage of forests. The sample plots were carried out (30 m × 30 m) with stratified sampling method across the sites, covering 13,500 sq meter. The diameter and height of all trees greater than 5 cm in diameter are measured, and the species composition and carbon storage are calculated. According to the results, the high aboveground biomass and carbon storage potential of forests was found in the Tanintharyi region with an average amount of 411.11± 172.44 ton per ha and 193.22± 81.05 ton per ha, respectively. In dense forests with less disturbance areas, the average carbon storage showed 329.292±0.07 ton per ha. Moreover, the study highlighted that the carbon storage distribution in a forest mostly relied on the stand structure and growth of the forests although elevation and soil properties were the associated factors. The results provide the basic information in order to support the development of sustainable forest management plan and the national REDD+ program.

Keywords: Aboveground biomass, Aboveground carbon, Diameter distribution, Growth, Stand structure

Carbon Storage Potential and its Relation to Stand Structure of Natural Forests in Tanintharyi Township, Myeik District, Tanintharyi Region of Myanmar

1. Introduction

The forests covers about one third of the global land area. The forests have been broadly considered as either a biggest sink or a source of carbon because of its capacity of carbon storage (Köhl et al. 2015, Khaine and Woo 2015). Tropical forests have been accepted as one of the important forest types among the world forests for regulating climate change because of its tremendous extent of coverage and dense structure taking account into huge amount of carbon storage and other environmental services. On the other hand, the carbon emission from deforestation and forest degradation is largely found in the tropical forests due to several natural and anthropogenic factors (LeQuéré et al. 2015; Sarvade et al. 2016; Thompson et al. 2014). For this, the tropical forests conservation and rehabilitation activities have been widely used for both climate mitigation and adaptation measures. Globally, the climate change mitigation and adaptation activities have been emphasizing under the United Nation Forum on Climate Change Committee (UNFCCC) program and Intergovernmental Panel on Climate Change (IPCC). In addition to that, Reducing Emission from Deforestation and Forest Degradation (REDD+) activities have been developing a decade ago.

The management of existing forests to be under sustainability and to promote the carbon storage basically relies on the assessment and research outputs of those existing forest conditions. Therefore, the researches related on carbon storage potential of forests have been considered as essential and conducted the researches in recent years. The potential of carbon storage of forests varied not only among forests in different regions but also among different forest types regions (Cardinale et al. 2000; Khaine and Woo 2015). For this, the researches on carbon storage of forests are necessary to conduct in each and every sites, regions and forest types.

Myanmar is one of the developing countries and facing some deforestation and degradation problems like other countries. Reducing Emission from Deforestation and Forest Degradation (REDD+) activities have been conducted in Myanmar since 2006. There are six main forest types ranging from tropical evergreen to dry and Indaing forests due to a wide range of rainfall and temperature. As a result, a diverse flora and fauna along with different forest types and site conditions have been occurred in Myanmar. Therefore, through the conservation of the forests, we have been emphasizing on the assessment of carbon storage of different forests. The main aims are to support sustainable forest management and the national database through giving the basic scientific data relating on the carbon storage potential and its related factors of forests to be considered for forest management. There are some factors that affect the carbon storage of forests and we need to understand this aspect in order to enhance their storage potential on carbon (Cai et al. 2016).

Although the researches related on carbon storage potential of forests in Myanmar are conducted in recent years, there is still limited information on different forests types and has not been covered the different regions yet, especially in Tanintharyi region which is the southernmost part of Myanmar. It is situated along the border of Myanmar and Thailand, and the forest types composed of the dry evergreen forests in the north to semi evergreen rain forests in the south of the region. Those forests are under the deforestation and degradation problems except some portions of strictly protected areas. Therefore, this study will focus on the assessment of carbon storage potential and its relation to stand structure of forest with the aim to support natural forest management and REDD+ climate change mitigation activities.

2. Objectives of the study

The main objectives of the study are as fallow;

1) To investigate the aboveground carbon storage potential of forests in Tanintharyi region;
2) To find the factors in relation to aboveground carbon storage of forests; and
3) To provide the basic information in order to support the development of sustainable forest management plan and the national REDD+ program.

3. Research team

The following researchers and staff of Forest Research Institute and Tanintharyi Township Forest Department joined in data collection as a research team.

No.	Name	Title	Position	Task
1	Dr. Mu Mu Aung	Researcher	Forest Research Institute	Plant identification
2	Dr. Inkyin Khaing	Assistant Director	Forest Research Institute	Forest Inventory, Paper writing
3	Dr. Phyu Phyu Lwin	Staff Officer	Forest Research Institute	Forest Inventory
4	Ms. Tin Hnaung Aye	Range Officer	Forest Research Institute	Forest Inventory, Data Input
5	Ms. Phyu Phyu Hnin	Research Assistant-2	Forest Research Institute	Plant survey, specimen collection
6	Mr. Ye Yint Tun	Research Assistant-3	Forest Research Institute	Forest Inventory, Plant survey, Data Input

7	Mr. Nyi Lwin Soe	Project Secretary	FD-ITTO Biodiversity Project	Logistics arrangement
8	Mr. Zayar Moe	Deputy Range Officer	Tanintharyi Township Forest Department	Forest Inventory, Liaison Officer
9	Mr. Myat Aye	Deputy Range Officer	Tanintharyi Township Forest Department	Forest Inventory, Liaison Officer
10	Mr. Hla Myo Aung	Deputy Range Officer	Forest Research Institute	Plant survey, specimen collection

4. Methodology

4.1 Study Area

The study site was located in Tanintharyi Township, Myeik District, Tanintharyi Region, Southern part of Myanmar between the latitude of 11º20´ to 13º10´ North and the longitude of 98º40´ to 99º40´ East. Tanintharyi Township is bordered with Thailand in the east, Dawei District in the north, Boatpyin Township in the south, and Kyunsu Township, Myeik Township and Pulaw Township in the west (Figures 1 and 2). The township area covers 4380.18 square miles (11344.61 km^2), of which, the forest areas cover about 64.33% of the total township area covering the area as 7298.57 km^2.

Among those forested areas, 4735.32 km^2 has been declared and demarcated as reserved forests and recognized as permanent forest estate (PFE) administered by Forest Department. In total, there are six reserved forests in this township and those are Taungparu reserved forest, Mayingyi reserved forest, Thakyet reserved forest, Thein Kone reserved forest, Ngawon reserved forest, and Ngawon extension forest. There are two proposed protected areas; namely Tanintharyi National Park and Leynyar extension National Park covering the area of 4447.85 km^2.

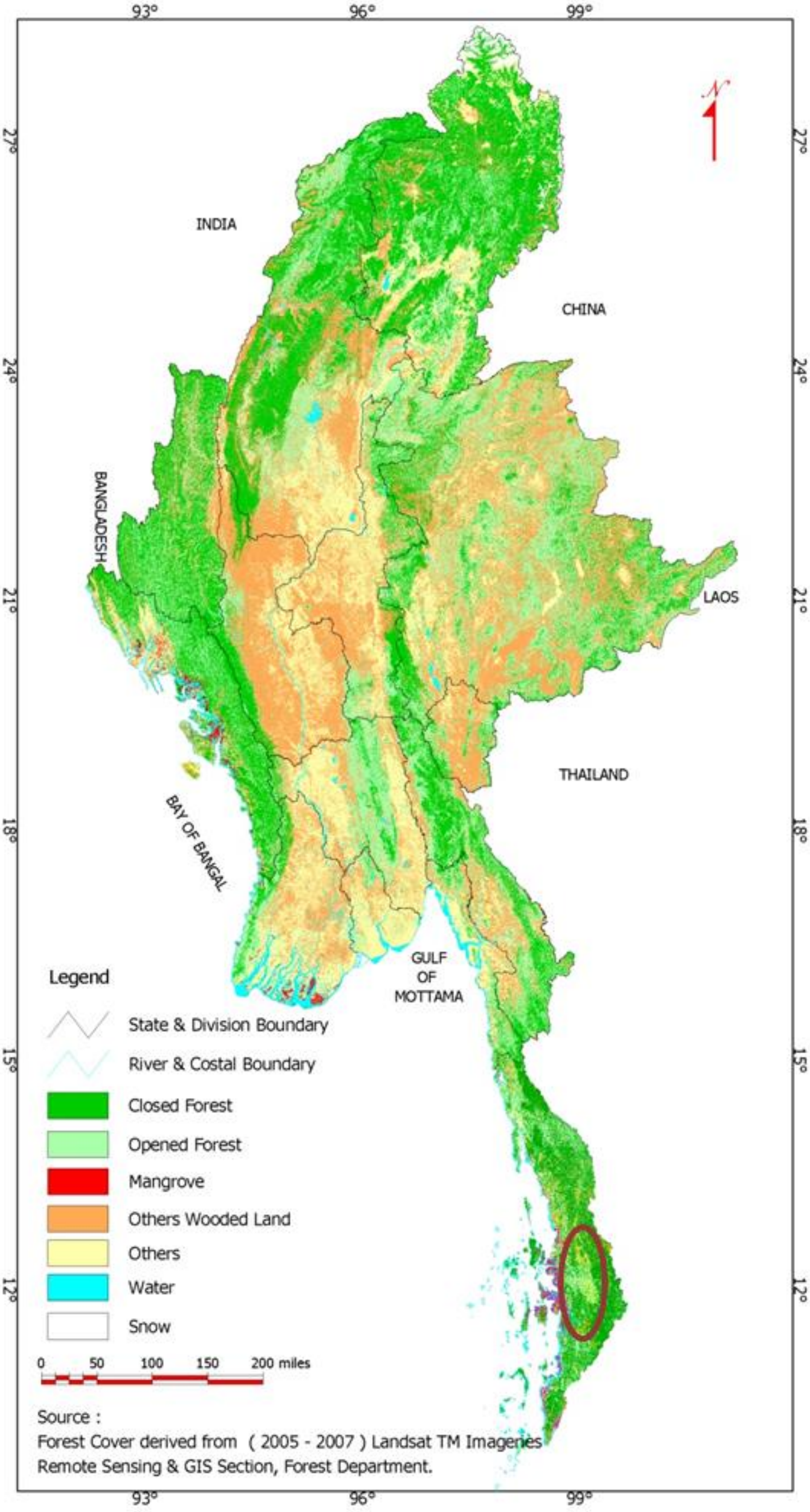


Figure 1. Map showing the study area in Myanmar

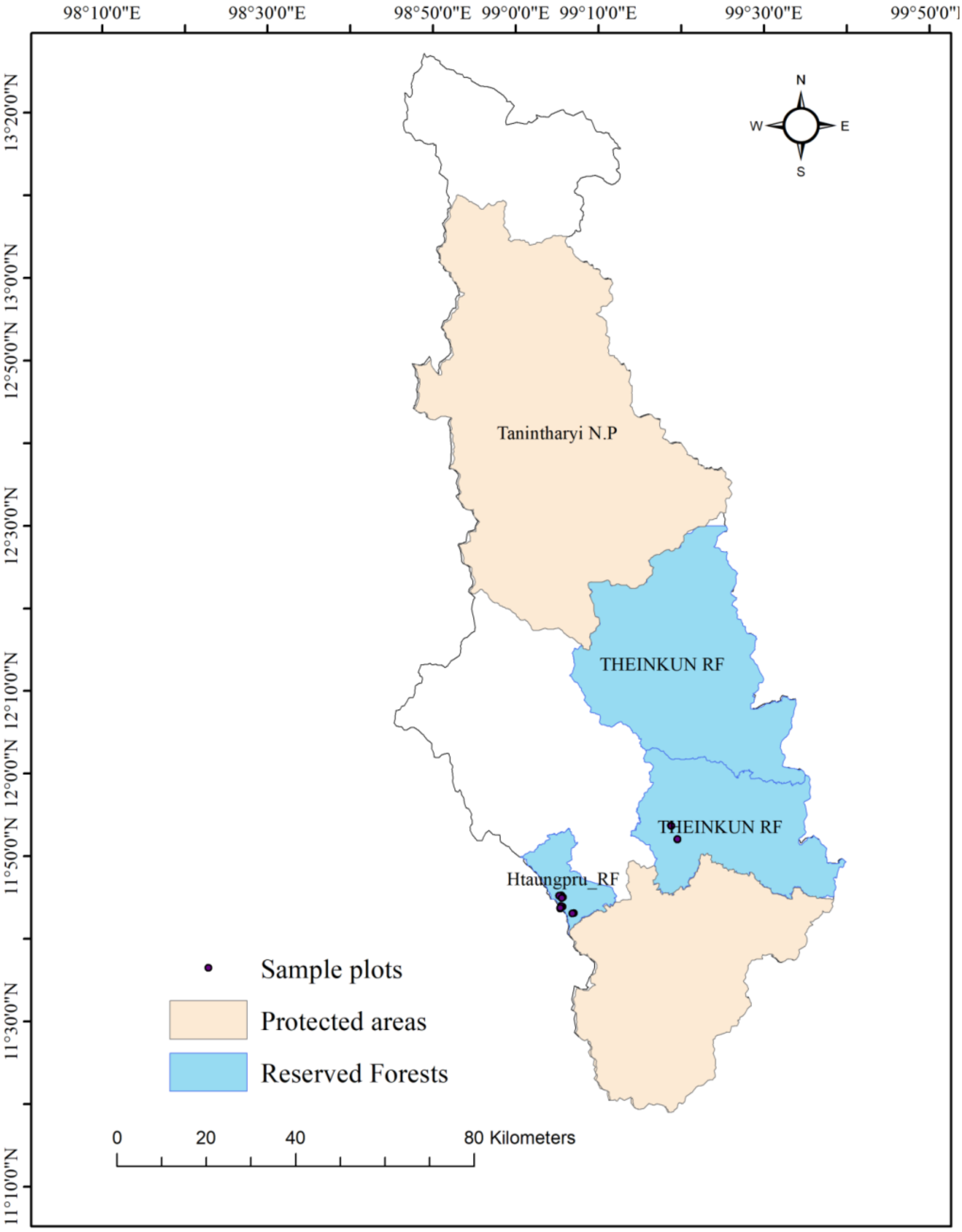


Figure 2. Study area of Tanintharyi Township, Myeik District, Tanintharyi Region

The average annual rainfall of the study site is 2,035 mm based on the average of 1982 to 2014 weather forecast data.

The forest type is tropical evergreen forest having many wild plants species and the trees are abundant in the study area. Although some forests found as very dense condition with wide range of species distribution, some areas have disturbances such as encroachment and illegal cutting, in some place, the forests have been converted into palm oil plantations and orchards mixing with crops and fruit trees. Some forests areas are under the governance of ethnic armed groups.

Two reserved forests, namely, Taungpharu reserved forest and Thein Kone reserved forest in Tanintharyi Township were selected as the field collection sites for this study. The collection sites ranged from the very less disturbed forests to high disturbance areas. The local condition and topographical range as well as the conservation of local villagers and staffs are considered when selecting the study sites and setting sample plots.

4.2 Field Inventory and Data Collection

The sample plots were laid down using the stratified sampling methods. The plots in the same site were set up based on the elevation aspect. The distance from one plot to anther is at least 500 m. The plot size is 900 m^2 with the design of (30 m × 30 m) square plots across the study sites. A total of fifteen sample plots covering different forest conditions were laid down in the study area. Eleven sample plots were in the Taungpharu reserved forests and another four sample plots were placed in the Thein Kone reserved forest.

We avoided sampling the early stage of regeneration by selecting the forests with a minimum canopy height of 12 m. The data collection was done from November 2018 to January 2019. The diameter at breast height (dbh) and the height of all trees having greater than 5 cm in diameter and 2 m in height (≥5 cm DBH and ≥2 m in height) were measured in all of the sample plots (30 m x 30 m) in the study area. Vertex IV hypsometer was used for measuring tree height (Haglöf Sweden AB). The tree identification was done by tree identification team from Forest Research Institute of Myanmar following the guidelines and database of Kress et al. (2003) and Gardner et al. (2000).

4.3 Data analysis

As species diversity and composition was emphasized in another research of our team conducting the same samples plots, we neither calculated nor find out repeatedly. We will refer those results/data if it is necessary. The dominance species were identified based on the importance value index (IVI) referred from Lwin et al. 2019. For species diversity, two commonly accepted diversity indices, namely, Shannon index (Shannon 1949) and Simpson index (Simpson 1949) were used to show the diversity of forests. For the calculation of the carbon storage potential of forests, the biomass regression model of Brown *et al.* (1989) was used with the carbon conversion factor of 0.47 (IPCC 2006).

To discover the distribution of carbon storage of dominant trees in the total storage, five most dominant species were selected and calculated in this study. To fix the ratio of the number of dominant species to total number of species in percentage,

$$DC\ (\%) = (n_{dom} / N) \times 100$$

where, DC = the ratio of the number of dominant species to total number of species in percentage, n_{dom} = number of dominant species and N = total number of species of each area.

The diameter ranged distribution of carbon was calculated to see the variation of carbon. The relation analysis was done using environmental factors such as the elevation and soil factors and the structure factors. Coordination, correlation and regression analyses were done using SPSS and R packages and software.

5. Results and Discussions

5.1 Species diversity

A total 67 species with 29 families are found in the study area. The most common families of the forests are Euphorbiaceae, Dipterocarpaceae, Lauraceae, Myrtaceae, and Anacardiceae. Those are the common families found in the tropical evergreen forests types and so the result showed the forests in the study area is still holding as the tropical evergreen forests. The results of family composition show that those forests are relatively tropical evergreen forests.

The most dominant species are *Mesua nervosa* Planch. &Triana (Kant kaw) (Family: Hypericaceae), *Swintonia floribunda* Griff. (Taung Thet Yet) (Family: Anacardiaceae), *Aporusa wallichii* Hook. F. (Ka Tot) (Family: Euphorbiaceae), *Nephelium* sp. (Taw Kyet Mout) (Family: Spindaceae), and *Gmelina arborea* Roxb. (Yamanay) (Family: Lamiaceae). Regarding to species diversity, the results showed the diverse species composition having the high Shannon diversity index value of 3.498 and the Simpson diversity index (1-D) of 0.959.

Table 1. The five most dominant families and species in the study area

Dominant family of forests	Dominant species of forests
Euphorbiaceae	*Mesua nervosa* Planch. &Triana (Kant kaw)
Dipterocarpaceae	*Swintonia floribunda* Griff. (Taung Thet Yet)
Lauraceae	*Aporusa wallichii* Hook. F. (Ka Tot)
Myrtaceae	*Nephelium* sp. (Taw Kyet Mout)
Anacardiaceae	*Gmelina arborea* Roxb. (Yamanay)

5.2 Forest Growth

The forest growth varied with an average diameter of 11.22 ±7.87 cm to 33.57 ± 18.43 cm. The mean height of top trees varied from 11.59 m as the lowest and 22.06 m as the highest. The average species density of forests is 696 ± 263.21 stem per ha ranging the minimum in disturbed forests area to the maximum in dense forest cover areas. As the diameter ranges varied among the sites, the basal area also varied among the sites covering 13.78 to 53.08 m^2 per ha. The diameter distribution of forests showed the highest density in lower diameter class having sustainable conditions of the forests for the future if some other high disturbances will not affect the current situation.

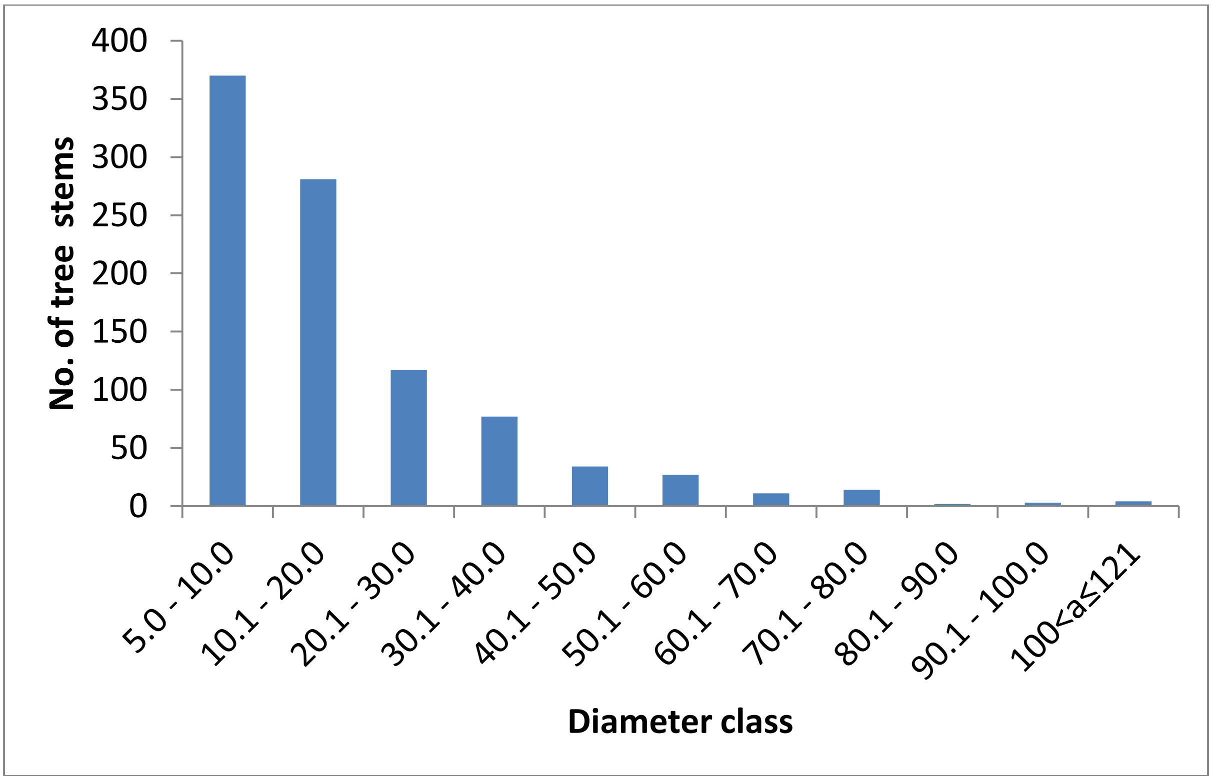


Figure 3. Diameter distribution of forests in the study area

5.3 Aboveground carbon storage potential of forests

The aboveground biomass and carbon storage potential of forests is high accounting an average of 411.11± 172.44 ton per ha and 193.22± 81.05 ton per ha, respectively. This amount is similar with the findings of Panama forests by Rui-Jaen and Potvin 2010. The carbon storage potential is significantly higher than the forests in the sites having the average annual rainfall of 685 to 1000 mm (Khaine and Woo 2017).

The results also showed the carbon storage potential of forests varied among forests in the study areas based on the location and disturbances. In good forest which has less disturbance stored higher amount of carbon (329.292±0.07 ton/ha). That higher amount of carbon is relatively higher than the deciduous forests in Myanmar, the Colombia forests and the Panama forests (Khaine and Woo 2017; Phillips et al. 2016; Rui-Jaen and Potvin 2010). But in high disturbance areas, the carbon storage of forests is much pretty low as 55.46±9.40 ton/ha although the evergreen forests species are still found in the area. Careful consideration should be taken for the sustainable management in the Tanintharyi region.

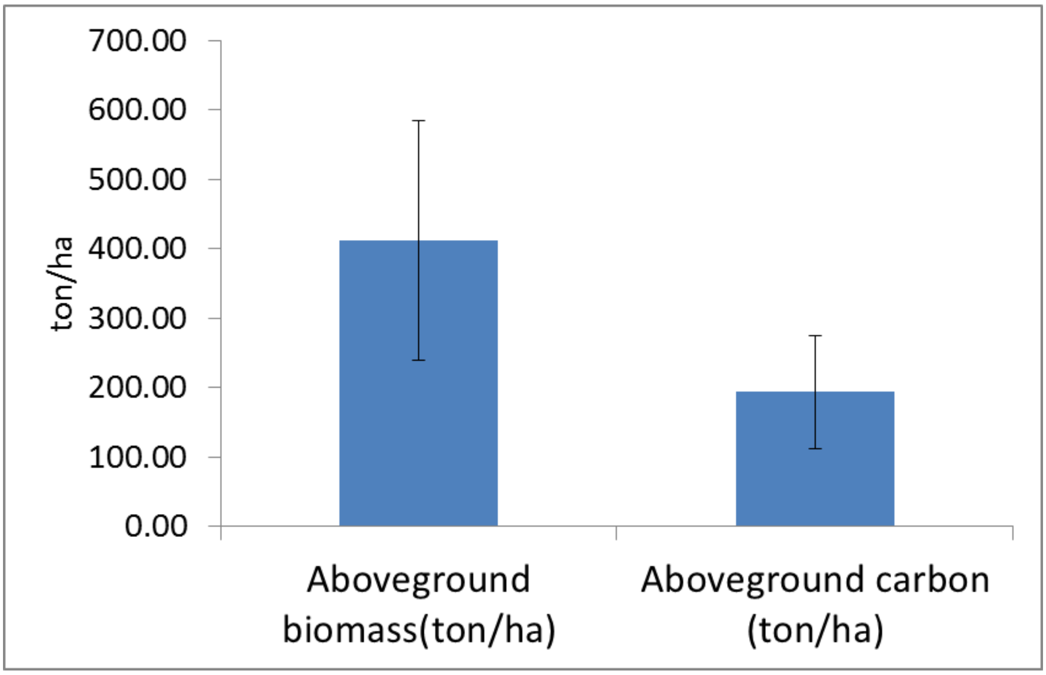
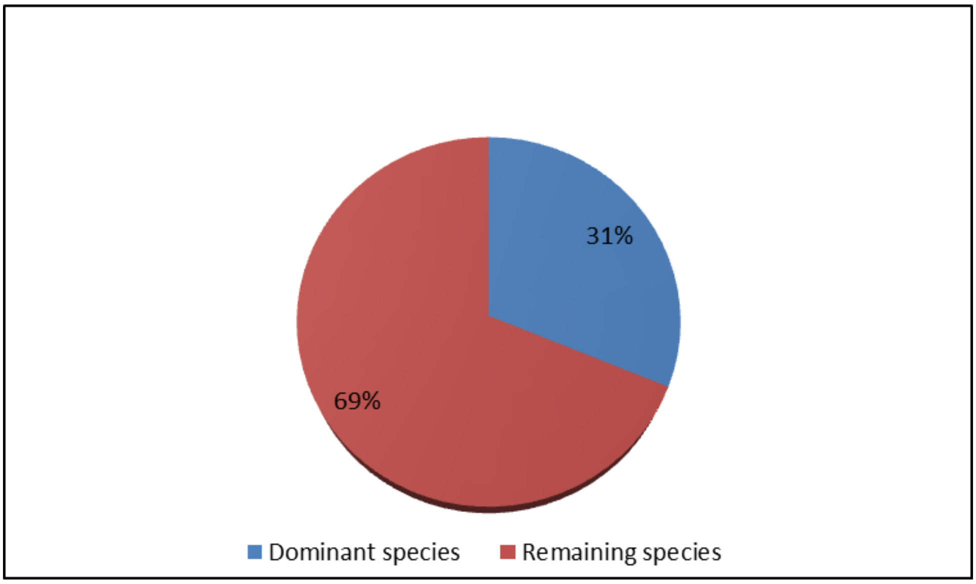


Figure 4. Aboveground biomass and carbon storage of forests in the study area

5.4 Distribution of dominant species in aboveground carbon storage of forests

The results indicated that the five most dominant species, *Mesua nervosa* Planch. &Triana (Kant kaw) (Family: Hypericaceae), *Swintonia floribunda* Griff. (Taung Thet Yet) (Family: Anacardiaceae), *Aporusa wallichii* Hook. F. (Ka Tot) (Family: Euphorbiaceae), *Nephelium* sp. (Taw Kyet Mout) (Family: Spindaceae), and *Gmelina arborea* Roxb. (Yamanay) (Family: Lamiaceae), contributed 31% of the total aboveground carbon storage of the forests. It highlighted their importance in either diversity or carbon storage management.

However, among first five dominant species, the basal area is also influenced on the carbon storage of those species. For example, *Aporusa wallichii* Hook. F. (Ka Tot) is the third most dominant species but that species stood as the second most carbon storage of species. Likewise, *Gmelina arborea* Roxb., the fifth most dominant species, showed the third most highest carbon storage. The following figures showed the contribution of dominant species to the aboveground carbon storage of forests.



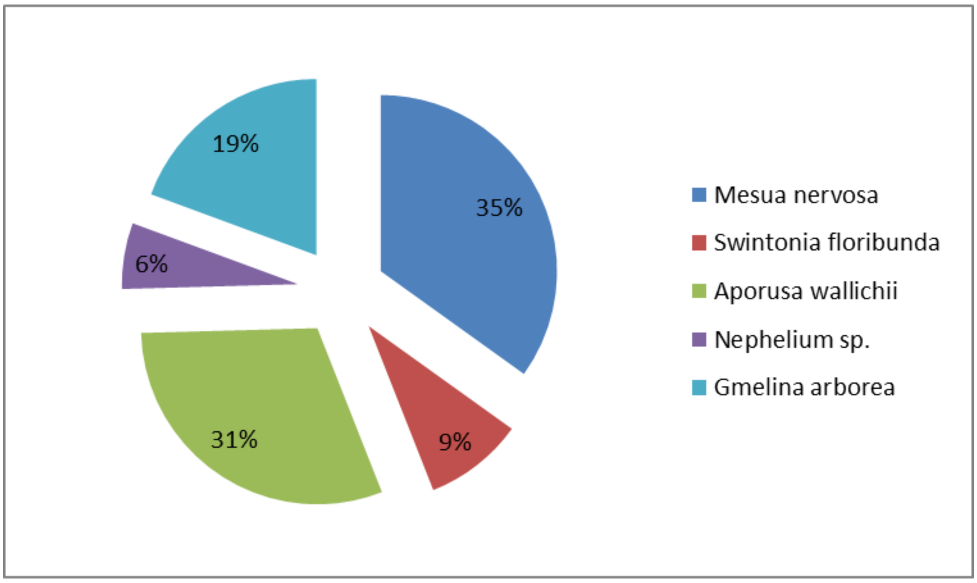


Figure 5. Percentage of aboveground carbon storage of dominant species to total storage of forests in the study area

5.5 Distribution of aboveground carbon over diameter classes

The distribution of aboveground carbon storage among diameter classes was explored in this study with the aim to highlight the focus diameter class in the carbon management that could be one of the supportive factors for preparation of forest management master plan. According to the results, the highest carbon storage (15% of the total storage) was found in the diameter class of 50.1 cm to 60.0 cm, and then followed by the diameter class of 30.1 cm to 40.0 cm representing 14% of the total storage, and by the diameter class of 70.1 cm to 80.0 cm representing 13% of the total storage.

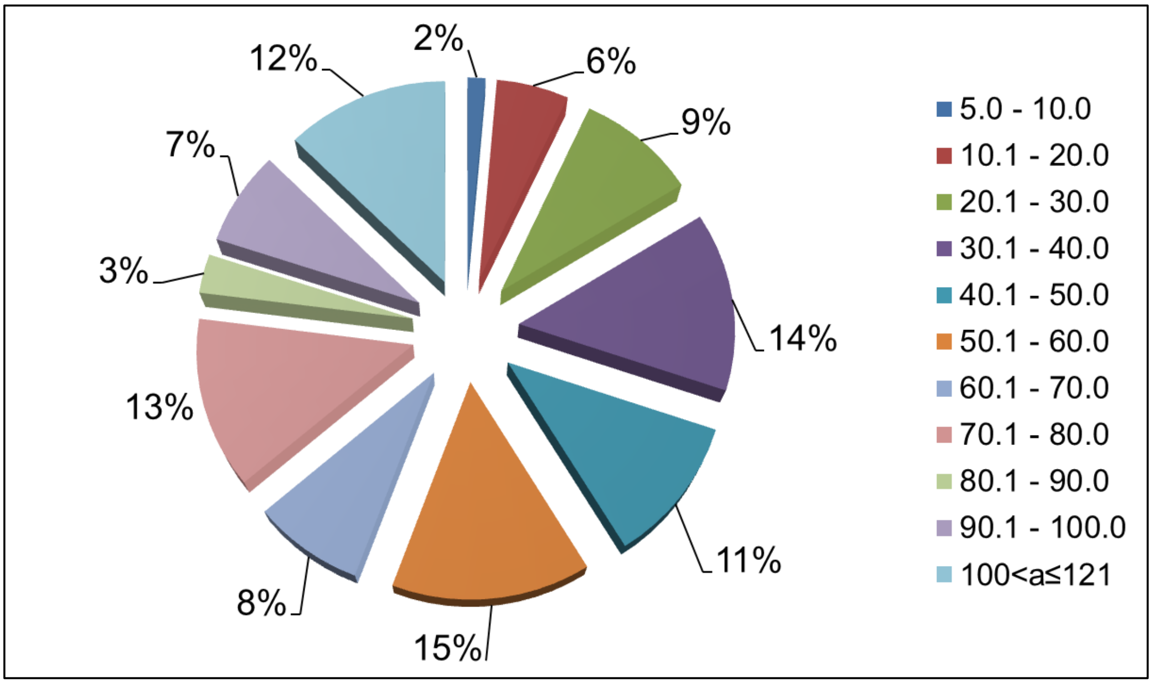


Figure 6. Aboveground carbon storage of forests among diameter classes

Moreover, this study agreed with the statement of the tree density of could affect the aboveground carbon storage of forests positively (Figure 6). In more detail, the effect was much more higher in the higher diameter classes (Figure 6). In the higher diameter classes, 90.1 cm - 100.0 cm and 100.1 cm - 121.0 cm, the carbon storages were higher in comparison with the smaller most diameter classes although the overall density of the higher class had less density. It was clearly by the effect of basal area and diameter of trees. The distribution of carbon and density of trees among diameter classes is shown in the figure 6.

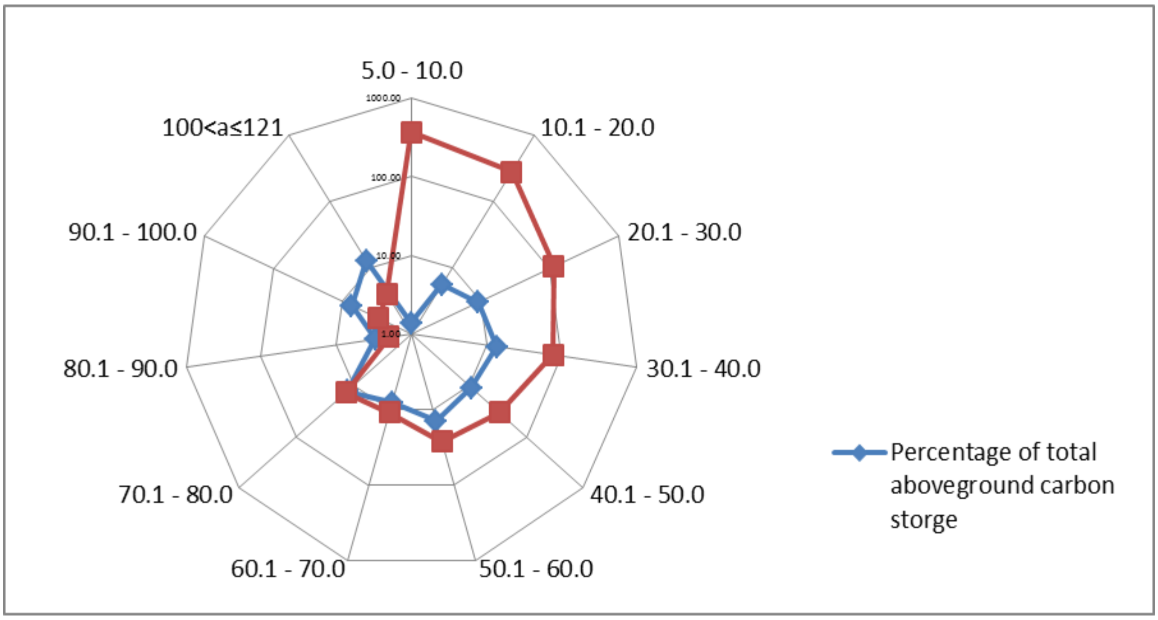


Figure 7. Diagram showing no. of tree stems and the percentage of carbon storage in total aboveground carbon storage across diameter classes

5.6 Factors affecting the aboveground carbon storage of forests

The correspondence analysis results showed the aboveground carbon of the forests was overwhelmed by the stand structure, tree growth, the elevation and soil properties. Therefore, those factors were considered for the variation of aboveground carbon storage in the region. This is the general truth of statement and we also agreed. But, the factor, the variation of the locality of sites, has to be taken into careful consideration. When we analyzed the results with different elevation and soil properties at the same sites, the results showed a significant relationship with negative correlation among species/carbon and elevation because there are no deviation factors for the relationship. When the analysis was taken in the different localities, elevation and soil properties could not showed a significant trend line because there are some deviation factors such as site aspects, rainfall, slope, etc.

Like this study, where the analysis is done in different sites/location, the strand structure and tree growth is most reliable factors when estimating or guessing the aboveground carbon among different locational forests in a comparative way.

The relationship coefficient of the elevation and carbon was 0.23 while the soil properties showed 0.31. The stand structure and growth to the aboveground carbon showed 0.65 and 0.90, respectively.

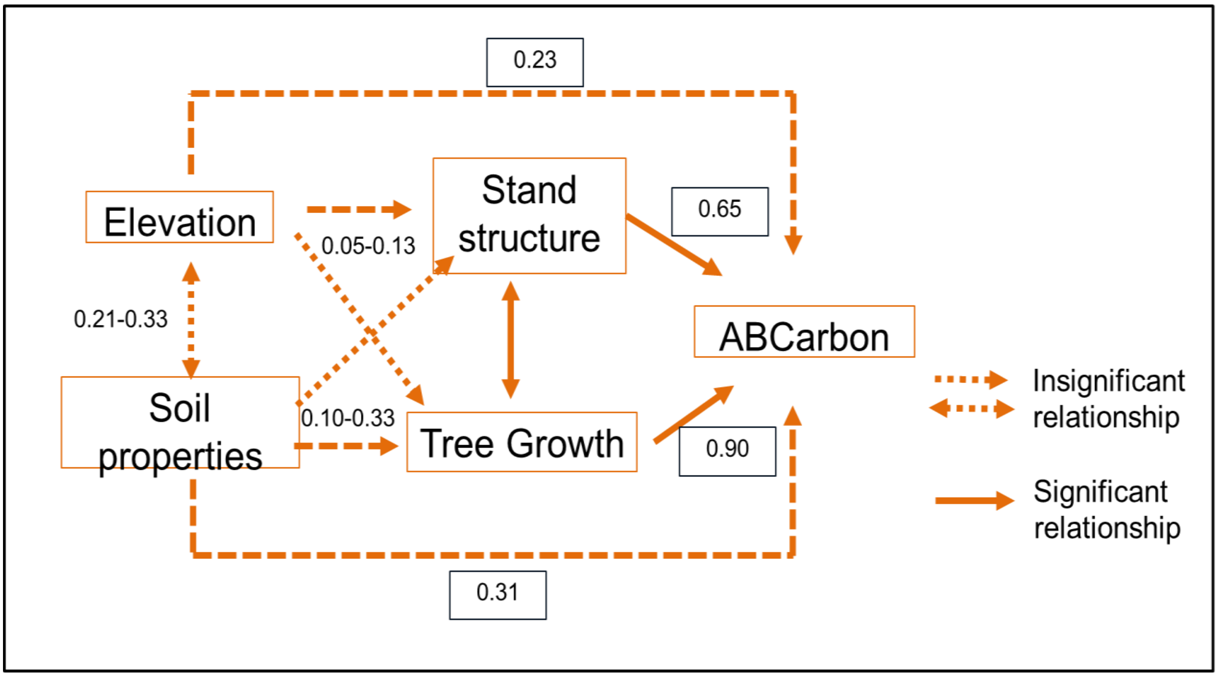


Figure 8. The environmental and structural parameters related to carbon storage of forests

6. Conclusion

The tropical forests in Tanintharyi region have a significant potential of carbon storage. Its wide range of diversity, diameter distribution and tree growth indicated the high potential of forests relating to carbon if the current situation is not severely disturbed by anthropogenic and natural factors. The average amount of aboveground biomass and carbon storage of forests was 411.11± 172.44 ton per ha and 193.22± 81.05 ton per ha, respectively. Still, we can find the high carbon storage in dense forests areas. In good forests, the average aboveground carbon storage was 329.292±0.07 ton per ha.

In the estimation of carbon storage, the role of dominant species should not be neglected. The contribution of the first five most dominant species composed 31.2 percent of the total storage. Special attention to dominant species is essential not only for diversity but also for carbon and yield management. Along with this, the significant effect of diameter distribution on carbon could not be refused in all aspects. In general, we can guess the carbon storage is greater in higher diameter class than lower diameter class. We support the above statement with a data showing the highest carbon storage (15% of the total storage) was found in the diameter class of 50.1 cm to 60.0 cm, then followed by the diameter class of 30.1 cm to 40.0 cm representing 14% of the total storage, and the diameter class of 70.1 cm to 80.0 cm representing 13% of the total storage. The diameter class of 100.1 cm - 121.0 cm composed 12% of the total storage. The significant evidence was found structure and growth relations to carbon although additional associated factors such as elevation and soil properties should not be neglected. In conclusion, the forests in the Tanintharyi region have the high carbon storage potential and the structure and growth aspects should be more emphasized for developing carbon management plan and sustainable forest management plan.

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IX. Species distribution patterns influenced by edaphic factors in Natural Forests of Tanintharyi Township

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Abstract

Soil and vegetation are complexly interrelated so the growth and reproduction of terrestrial ecosystems such as forests cannot be understood without knowledge about the soil. Moreover, previous studies have confirmed that topography, and locations of the forests also influenced on tree species composition and their distribution pattern in association with different degrees of anthropogenic disturbances. Therefore, we examined the influences of topography and edaphic factors on species composition and distribution so that the research results are to be able to support integrated and sustainable management of the forests in Tanintharyi Mountain Ranges. The study was conducted in Tanintharyi Township located within Myeik District, Tanintharyi Region, Southern part of Myanmar. To collect floral and structural data from the forests at the two sites (two reserved forests named Taungpharu reserved forest and Thein Kone reserved forest), we arbitrarily laid out 15 sample plots (30 m × 30 m) across those study sites. In each sample plot, we measured the diameter at breast height (DBH) and the height of all trees (with ≥5 cm DBH and ≥2 m in height). In the sample quadrats, soil samples were collected from two layers (0-10 cm, and 10-20 cm). For each bundle of soil sample, physical and chemical properties were analyzed. Physical properties include soil textural characteristics by examining particle size distribution (%) of sand, silt and clay. For soil chemical properties, we determined soil pH, total nitrogen (%), available phosphorous (%), extractable potassium (%) and organic matter content (%).Canonical correspondence analysis (CCA) ordination was conducted using the species matrix and environmental matrix. The 15 plots were put as row headings for both matrices. The total 67 species were put as column headings for the species matrix, while each cell contained the total basal area of each species that occurred in each plot. For the environmental matrix, we put the variables as topography (elevation), soil chemical and physical variables for each sample quadrat. In total, there are 940 individuals occupied by 67 species occurred in 29 families for all sample plots. Severe water percolation and subsequent leaching of salt compounds from the soil resulted in lower values of soil pH. The resulting soils are therefore, naturally moderate to strongly acidic soil. Most of the soils were sandy-loam, some were loam and silt loam, and only small numbers of soil samples indicated as clay-loam soil. CCA ordination resulted that the first three canonical axes explained 43% of the total variation in the species distribution data. The strong species-environment correlations of the CCA ordination indicate that most of the variation in species composition and distribution between stands is explained by the environmental variables used in this study. However, different degrees of anthropogenic disturbances had happened in this area: that can explain the rest variation percentage of species assemblages in this area and it indicates to conduct further studies in the future regarding the influences of human disturbances on forest growth.

Keywords: Canonical correspondence analysis, soil properties, species assemblages topographic factors.

Species distribution patterns influenced by edaphic factors in Natural Forests of Tanintharyi Township

1. Introduction

Tropical forests are more diverse terrestrial ecosystem than temperate forests, sub-tropical forests and other ecosystems (Devi and Yadava 2006). But nowadays, those tropical forested areas are facing numerous challenges to ensure their sustainability (Sarvade, Gupta, and Singh 2016). Myanmar possesses one of the richest biodiversity in the Indo-Pacific region and has one of the highest proportions of forest cover in mainland Southeast Asia (FRA 2005). However, forest areas of Myanmar are also under severe pressure from population growth, increased resource utilization and demand for resources from neighboring countries (Aung et al., 2004).

The Taninthayi (Tenasserim) Mountain Range, along the border between Myanmar and Thailand, covers a global important terrestrial eco-region with a transition zone from continental dry evergreen forests common in the north to semi-evergreen rain forests to the south. As a consequence, they contain some of the highest diversity of both flora and fauna not only in Myanmar but in Southeast Asia Region. Similarly, the outstanding biodiversity features and diversity of the Taninthayi Range are vulnerable due to poaching, fragmentation and encroachment for agriculture, illegal logging, settlements inside and around the park, and human-elephant conflicts. Unsustainable harvesting of non-timber forest products is prevalent throughout the eco-region. Some areas have been subjected to seasonal forest fires, the impacts of which are unclear. Therefore, long-term viability of biodiversity in the Taninthayi depends on promoting systematic management of the natural forests with the active involvement of the local communities. This can provide the natural habitats for the wildlife species as well as the fulfilling of the basic needs of the people.

Knowledge of forest structure, composition and diversity at different levels of human disturbance would facilitate the creation and implementation of more effective conservation measures. Understanding the response of forest vegetation to different intensities of human disturbance would help to identify where conservation efforts should be given priority, and thereby enable the efficient use of limited conservation funds (James et al. 2001, Bhuyan et al. 2003).

In addition, the functioning of most ecosystems is generally influenced by availability of nutrients (Kaushalendra Kumar Jha, 2014). Soil and vegetation are complexly interrelated so the growth and reproduction of terrestrial ecosystems such as forests cannot be understood without knowledge about the soil (B. Takoutsing, et al., 2015). Moreover, different tree species can differ significantly in their influence on soil properties as well as soil fertility (Augusto et al. 2002). Accordingly, the species composition, diversity and their distribution are dependent on the factors: topography (elevation, slope, aspect, etc,.), their locations (distance from settlements, roads, etc.,), and edaphic factors (soil properties). Therefore, we examined the influences of topography and edaphic factors on species composition and distribution so that the research results are to be able to support integrated and sustainable management of the forests in Tanintharyi Mountain Ranges.

2. Research team

The following researchers and staff of Forest Research Institute and Tanintharyi Township Forest Department joined in data collection as a research team.

No.	Name	Title	Position	Task
1	Dr. Mu Mu Aung	Researcher	Forest Research Institute	Plant identification
2	Dr. Inkyin Khaing	Assistant Director	Forest Research Institute	Forest Inventory
3	Dr. Phyu Phyu Lwin	Staff Officer	Forest Research Institute	Forest Inventory, Data Input, Data Analysis, Paper Writing
4	Ms. Swe Swe Tun	Assistant Research Officer	Forest Research Institute	Laboratory works for soil properties assessment
5	Ms. Tin Hnaung Aye	Range Officer	Forest Research Institute	Forest Inventory, Data Input
6	Ms. Phyu Phyu Hnin	Research Assistant-2	Forest Research Institute	Plant survey, specimen collection
7	Mr. Ye Yint Tun	Research Assistant-3	Forest Research Institute	Forest Inventory, Plant survey, Data Input, Soil specimen collection
8	Mr. Nyi Lwin Soe	Project Secretary	FD-ITTO Biodiversity Project	Logistics arrangement
9	Mr. Zayar Moe	Deputy Range Officer	Tanintharyi Township Forest Department	Forest Inventory, Liaison Officer
10	Mr. Myat Aye	Deputy Range Officer	Tanintharyi Township Forest Department	Forest Inventory, Liaison Officer
11	Mr. Hla Myo Aung	Deputy Range Officer	Forest Research Institute	Plant survey, specimen collection, Soil specimen collection

3. Methodology

3.1 Study Area

The study was conducted in Tanintharyi Township located within Myeik District, Tanintharyi Region, Southern part of Myanmar. It is located between 11º20´ to 13º10´ North Latitude and 98º40´ to 99º40´ East Longitude. Tanintharyi Township is bordered with Thailand in east, Dawei District in north, Boatpyin Township in south, and Kyunsu Township, Myeik Township and Pulaw Township in west respectively. The area of the township is 4380.18 square miles (11344.61 km^2). About 64.33% of the area of the whole township was forested lands covering the area as 7298.57 km^2. Among those forested areas, 4735.32 km^2 has been declared and demarcated as reserved forests and recognized as permanent forest estate (PFE) administered by Forest Department. In total, there are six reserved forests in this township and those are Taungparu reserved forest, Mayingyi reserved forest, Thakyet reserved forest, Thein Kone reserved forest, Ngawon reserved forest, and Ngawon extension forest. There are two proposed protected areas; namely Tanintharyi National Park and Leynyar extension National Park covering the area of 4447.85 km^2.

The total number of village tracts (group of villages) was nineteen while there are 214 villages representing those nineteen village tracts in Tanintharyi Township. The major ethnic groups residing in the township are Bamar, Tai-Shan, Kayin and Mon. Some parts of the area are resided by the natives while some areas were occupied by the people migrated from other regions of Myanmar. Those people came to this area as the labors of palm oil companies doing agricultural business by growing extensive areas of palm oil plantations in that area. Later on, those labors resided in that area by many reasons including marriage with local residents, doing farming, and other businesses for their livings.

Although the proportion of forested areas was quite high, deforestation and forest degradation also happened in this area. The main drivers of deforestation include conversion of forests for extensive agriculture (palm oil plantations), clearing forests for conducting small-scaled agriculture by local people (doing orchards to grow areca palm trees) and settlement. Forest degradation in this area was caused mainly by illegal logging, hunting, collection of firewood and other forest products. However, the degree of deforestation was relatively higher than that of forest degradation. Accordingly, fragmentation is the major problem in that area followed by the impact of deforestation as mosaic pattern. This can lead to altering species composition, biodiversity and fragmentation of natural habitats for wildlife species.

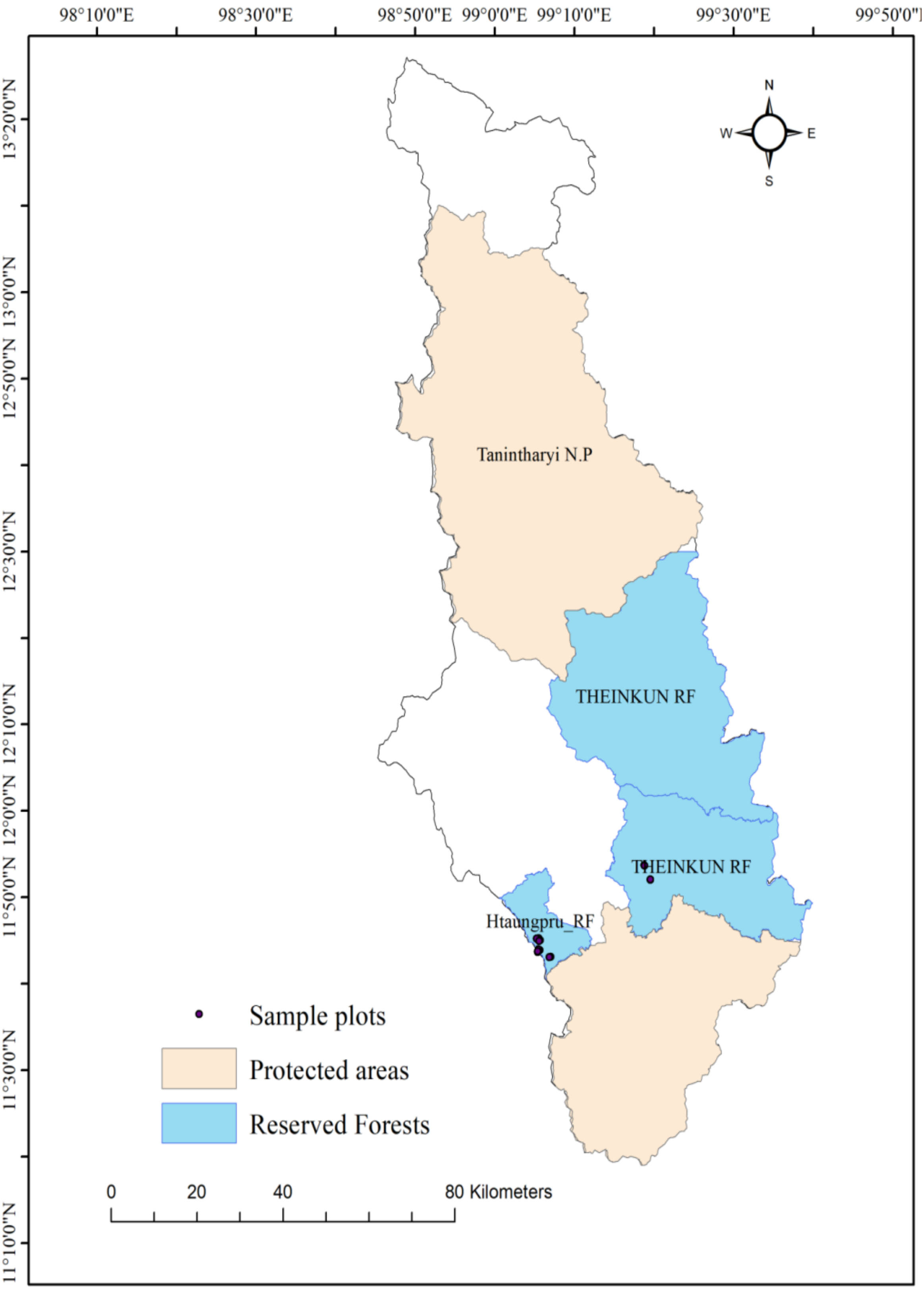

*Figure **1**. Study Area which is Tanintharyi Township, Tanintharyi Region and location of sample villages*

3.2 Data collection

3.2.1 Forest Inventory and soil sampling

To collect floral and structural data from the forests at the two sites (two reserved forests named Taungpharu reserved forest and Thein Kone reserved forest), we arbitrarily laid out 15 sample plots (30 m × 30 m) across those study sites. Eleven plots were sampled in Taungpharu reserved forest while the rest four plots were laid out in Thein Kone reserved forest (Figure 1). Proposed Tanintharyi National Park was not included in conducting forest inventory activities because of safety reason while those areas are also part of the areas governed by ethnic armed organization (EAO). But the topography, climate conditions and age, and species composition of the forests among proposed Tanintharyi National Park and those two reserved forests were similar and this is the reason conducting the surveys in those areas. To reduce the effect of spatial autocorrelation for covering the variation of floral composition, sample plots were separated from each other by at least 500 m. To avoid sampling early stages of regeneration, we selected forests with a minimum canopy height of 12 m. Data were collected from November 2018 to January 2019. In each sample plot, we measured the diameter at breast height (DBH) and the height of all trees (with ≥5 cm DBH and ≥2 m in height). We measured tree heights using a Vertex IV hypsometer (Haglöf Sweden AB). For multi-stemmed individuals, we measured each stem with DBH ≥5 cm. Specimens of leaves, shoots, fruits, seeds, flowers, and barks wherever available were collected from each species with their local names for the later identification. The specimens were sent to the Herbarium of Forest Research Institute, Myanmar, for taxonomic identification. We followed the nomenclature of Kress et al. (2003) and Gardner et al. (2000). For forest inventory, we only measured trees, while other plants, such as climbers, shrubs, and herbs, were excluded.

In the sample quadrats, soil samples were collected from two layers (0-10 cm, and 10-20 cm). These two depths are typically used in soil analysis because they represent chemical and textural characteristics of the top soil layer that result from different processes during soil formation (Santos, 2007: cited in Martins, et al., 2015).Three sample points laid out in each sample quadrat by locating triangle from the center of the sample quadrat. This mean three replicate measurements were applied for soil sampling.

3.2.2 Laboratory analysis

Soil samples were analyzed in the soil laboratory of Forest Research Institute, Yezin. Replicated soil samples from the same layer of the sample quadrats were pooled for the laboratory analyses. Consequently, there were two soil samples from two layers for each sample quadrat. For each bundle of soil sample, physical and chemical properties were analyzed. Physical properties include soil textural characteristics by examining particle size distribution (%) of sand, silt and clay. For soil chemical properties, we determined soil pH, total nitrogen (%), available phosphorous (%), extractable potassium (%) and organic matter content (%).

3.2.3 Data analyses

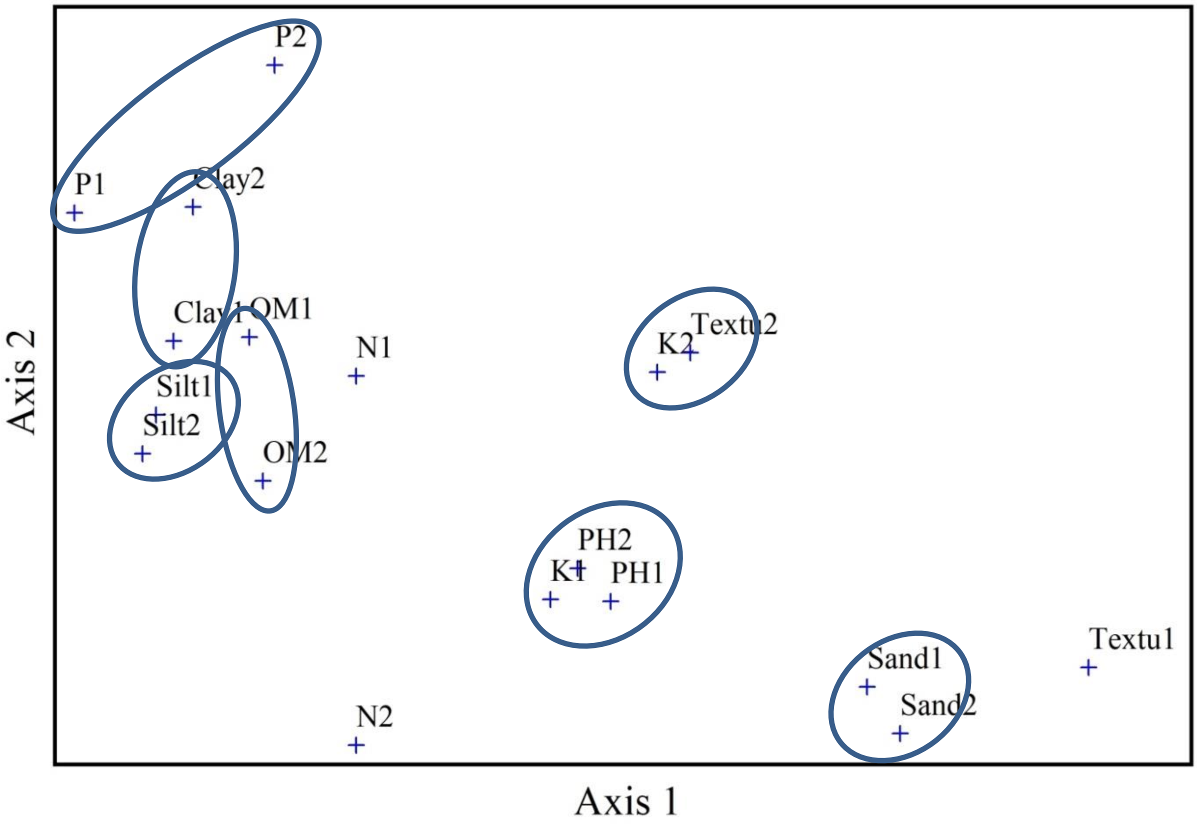

*Figure **2**. Principal component analysis examining the correlations of the 18 soil variables from two different layers in 15 quadrats in natural forests of Tanintharyi Township. The first two principle components (PCs) explained 54.55% of the toral variance (40.73% and 13.82% for PC1 and PC2 respectively). Oval shapes indicate collinear relationships within individual soil properties among two layers. P = Avaliable phosphorous; OM = Organic matter; K = Extractable potassium; N = Avaiable nitrogen; 1 = 0-10 layers; and 2 = 10-20 layer.*

For numerical analyses, we organized our collected data into two matrices: namely species matrix and environmental matrix. The 15 plots were put as row headings for both matrices. The total 67 species were put as column headings for the species matrix, while each cell contained the total basal area of each species that occurred in each plot. For the environmental matrix, we put the variables as topography (elevation), soil chemical and physical variables for each sample quadrat. The summarized information of each sample quadrat and the study area include species richness, diversity and evenness indices, the dominant tree families and species. Data analyses were conducted by using Biodiversity R package developed in R-statistics. To determine stand structural characteristics, we calculated the mean DBH (cm), maximum tree height (m), total basal area (m^2), and stem density for each plot. We first classified DBH values of all measured stems into classes at 5-cm intervals. We then prepared the stem-diameter distribution for graphical illustration.

Canonical correspondence analysis (CCA) ordination was conducted using the species matrix and environmental matrix. Since we measured soil samples from two layers in sample quadrats, there were high numbers of environmental variables which is soil properties (9 properties x 2 layers = 18 variables). Accordingly, the data were reduced by applying principle component analysis (PCA) of the correlations among environmental variables to identify and remove strongly related (collinear) variables prior to performing the CCA analysis. As resulted by PCA ordination, we selected the lower layer (15-30 cm) as a proxy layer for the entire soil profile to be applied in CCA (Figure 2). CCA was performed to determine the association between species and soil conditions. In CCA, environmental variables with a correlation of greater than 0.6 with major three axes were interpreted as strong variables that influenced species composition and their distribution. Both PCA and CCA ordinations were performed by PC-ORD software (McCune & Mefford 1999).

4. Results and Discussions

4.1 Species composition and stand structural characteristics

In total, there are 940 individuals occupied by 67 species occurred in 29 families for all sample plots. Still, there are 20 individuals as unknown species which could not be identified taxonomically because of incomplete specimens as well as inaccessible location to collect their specimens. The five most common families are Euphorbiaceae (143 individuals), Dipterocarpaceae (104 individuals), Lauraceae (101 individuals), Myrtaceae (80 individuals), and Anacardiceae (63 individuals). The results of family composition show that those forests are relatively tropical evergreen forests.

We applied both 1st order and 2nd order estimators while the 1st order Jackknife estimator of species richness confirmed that the number of species would be 89 while the 2nd order estimated that the number of species to be found in this area would be 104. The Shannon diversity index value showed higher diversity for the study sites (3.498) while the typical values are generally between 1.5 and 3.5 in most ecologically studies, and the index is rarely greater than 4.0 (Magurran 2004). The value of Simpson diversity index (1-D) was 0.959 indicating the higher diversity values and possessing less single most dominant species in this area. On the other hand, The Shannon Evenness was found as 49.32% that means the number of individuals represented by each tree species are not evenly distributed across the study site. The results of species richness, diversity indices and evenness values were shown in table 1.

Table 1. Species richness, stem density, diversity and evenness of natural forests of Tanintharyi Township

No.	Variables	Results
1	No. of species	67
2	No. of Families	29
3	Density (no. of stems/ha)	696
4	Jackknife estimate of species richness (1^{st} order)	89
5	Jackknife estimate of species richness (2^{nd} order)	104
6	Shannon Diversity Index (H)	3.498
7	Simpson Diversity Index (1-D)	0.959
8	Shannon Evenness (E%)	49.32

Stand structure of natural forests of Tanintharyi Township was firstly shown by the values of mean DBH (Diameter at breast height in cm), total basal area (in m^2), and average top heights of the trees (in m) (Table 2) for each sample quadrat (30 x 30 m). As the trees in those plots ranges by different sizes from small trees to large trees, the values of standard deviation (SD) became larger (Table 2). The mean DBH values range from 11.22 cm (plot 05) to 33.57 cm (plot 15) as the largest. The total basal area of the plots was ranging from 1.24 m^2 to 4.78 m^2. The mean top height of the trees was found 11.59 m as the lowest through 22.06 m as the highest.

Table 2. Stand structural components of the plots in natural forests of Tanintharyi Township, Tanintharyi Region

Plots	Mean DBH (cm)	Total BA(m^2)	mean top height (m)
P01	16.66 (±11.97)	1.94	17.10(±8.82)
P02	22.30(±19.34)	4.62	18.20(±10.72)
P03	23.82(±17.29)	2.78	22.06(±10.17)

Plots	Mean DBH (cm)	Total BA(m^2)	mean top height (m)
P04	22.51(±18.06)	3.64	16.41(±9.48)
P05	11.22(±7.87)	1.13	11.71(±6.08)
P06	18.52(±14.04)	2.70	17.71(±11.72)
P07	21.25(±18.35)	3.81	18.26(±10.94)
P08	19.00(±16.32)	2.89	21.41(±13.09)
P09	28.82(±26.59)	4.78	18.52(±9.58)
P10	17.43(±12.83)	3.33	14.63(±7.16)
P11	22.49(±21.06)	3.40	16.09(±11.65)
P12	15.06(±17.28)	3.40	11.59(±6.09)
P13	22.77(±20.23)	4.78	14.94(±9.00)
P14	14.68(±12.97)	3.51	12.18(±5.20)
P15	33.57(±18.43)	1.24	19.96(±5.59)
Grand Total	**18.98 (±17.01)**	**47.94**	**15.85**(±9.55)

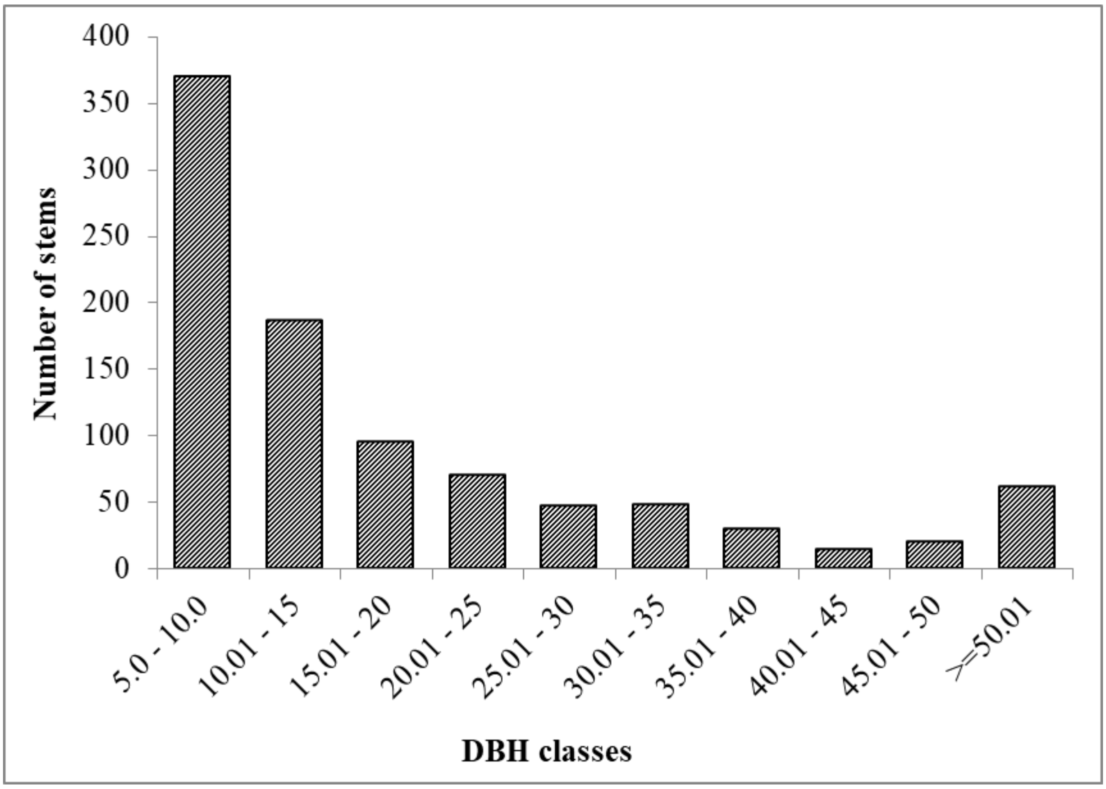

Figure 3. Stem-diameter distribution of the natural forests in Tanintharyi Township, Tanintharyi Region

We also identified the stem-diameter distribution of the trees found in all sample plots to define the stand structure of the forests (Figure 3). We firstly classified the stems into ten classes with 5 cm diameter intervals. The highest number of stems was found in the smallest diameter classes meaning the highest proportion of small trees in the forest. However, the diameter distribution curve did not follow the inverse-J shape which is the typical form of undisturbed natural forests. According to this finding, we can prove that those forests have been disturbed especially anthropogenic disturbances such as logging, pole cutting, etc., in previous time. But it seems there is still no disturbance at this current time.

4.2 Association between species distribution and edaphic factors

Table 3 summarized the physical and chemical properties of soil samples collected from two different layers in the 15 quadrats (30 x 30m) in Taungparu reserved forest and Theinkone reserved forest of Tanintharyi Township. The soil pH of the study area (4.22±0.36) indicates markedly low values and it could be the nature of the forests as they belong to tropical rain forests located in areas with high precipitation. Severe water percolation and subsequent leaching of salt compounds from the soil resulted in lower values of soil pH (Juo & Franzleubbers 2003). The resulting soils are therefore, naturally moderate to strongly acidic soil (SRDI 1976: cit. f Biswas et. al., 2012). The organic matter content of the sampled soils ranged 4.27 (±1.39), indicating a relatively high content of organic matter in the soils (Biswas et. al., 2012) resulted from the accumulation of litters and decomposition under severe rain. Soil water holding capacity is largely determined by soil texture (Ramade 1981) with sandy soils mostly having low water-holding capacity, whereas soils with higher clay content often have a higher capacity. The results show that most of the soil samples were composed with higher sand content followed by silt content and then lastly by some proportion of clay content. As a result, most of the soils were sandy-loam, some were loam and silt loam, and only small numbers of soil samples indicated as clay-loam soil.

Table **3**. Physiochemical properties (mean±SD) of soil collected from different layers in 15 quadrats (30 x 30 m) in Tanintharyi Township, Tanintharyi Region

Soil layers	Soil PH	Total N (%)	Ava_P (%)	Ext K (%)	OM (%)	Sand(%)	Silt(%)	Clay(%)
0-10cm	4.14 (0.41)	0.0946 (0.056)	0.00006 (0.00004)	0.006 (0.004)	5.53 (2.39)	52.2 (14.54)	48.4 (15.27)	15.2 (5.92)
10-20cm	4.22 (0.36)	0.0595 (0.0229)	0.00007 (0.00006)	0.006 (0.003)	4.27 (1.39)	48.4 (15.27)	31.47 (10.4)	19(8.43)

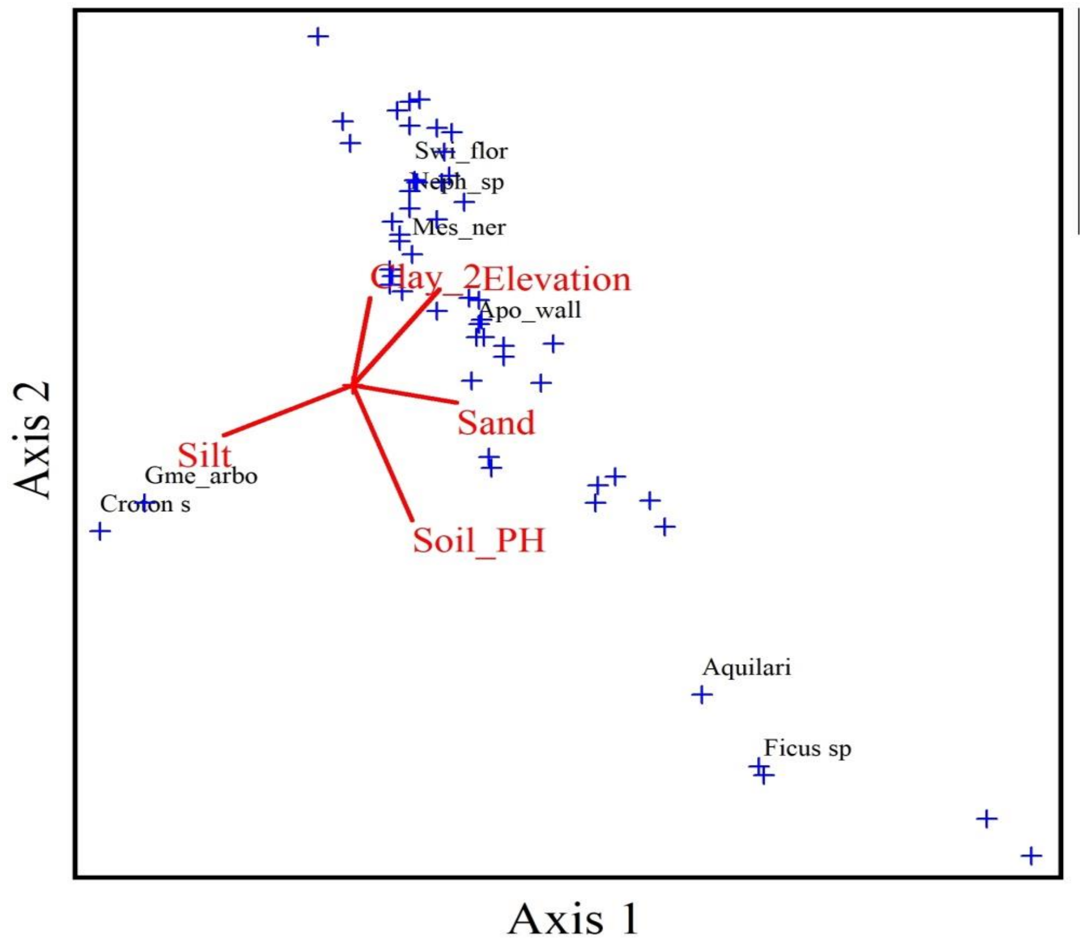

*Figure **4**. Canonical Correspondence analysis (CCA) ordination based on the basal area of woody plant species and selected nine environmental variables of sample quadrats (topography and edaphic factors)*

CCA ordination resulted that the first three canonical axes explained 43% of the total variation in the species distribution data (Table 4). The first CCA axis was strongly and positively correlated with silt content and negatively correlated with elevation, available phosphorous, and proportion of potassium. The second CCA axis was strongly and positively correlated with soil pH. Those correlation coefficients revealed that the first axis is a topographic gradient as well as associated with soil physiochemical properties. The second axis is a soil acidity and alkalinity gradient. Some species such as *Gmelina arborea*, and *Croton* species preferred soils dominated with silt texture (Figure 4). *Ficus* species and *Aquilaria* species are dominant in soils with higher pH values. Most species prefer clay soils with low pH values located in higher elevation. This indicates that the different species distribution pattern is associated with topography, and edaphic factors. In detail, the strong species-environment correlations of the CCA ordination indicate that most of the variation in species composition and distribution between stands is explained by the environmental variables used in this study. However, different degrees of anthropogenic disturbances had happened in this area: that can explain the rest variation percentage of species assemblages in this area and it indicates to conduct further studies in the future regarding the influences of human disturbances on forest growth.

Table **4**. Summary of CCA of 67 species found in 12 sample quadrats (Environmental variables that are strongly correlated with any of major three CCA axes are indicated by asterisks (i.e., correlation coefficient greater than (0.6) with any major axes.)

	Axis 1	**Axis 2**	**Axis 3**
Eigen value	0.803	0.507	0.372
Species-Environment correlations	0.994	0.992	0.963
% of variance explained	20.5	13.0	9.5
Cumulative % explained	20.5	33.5	43.0
Correlations			
Elevation*	-0.624	-0.280	-0.001
Soil PH*	0.114	0.872	-0.112
Total Nitrogen	0.408	0.030	0.297
Available Phosphorous*	-0.508	-0.067	-0.429
Potassium*	-0.659	-0.131	-0.308
Organic matter	0.277	-0.062	-0.044
Sand(%)	-0.389	0.361	0.308
Silt (%)*	0.660	-0.088	-0.443
Clay (%)	-0.315	-0.413	-0.084

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6. Photo records

Collecting soil samples in sample quadrats

Natural Forests in Tanintharyi Township, Tanintharyi Region

Collection of specimens for taxonomic identification

Measuring stand structural attributes of the forests

Measuring stand structural attributes of the forests

Field survey team


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