Sustainable Forest Management in a Changing Climate

Participant's Reports

Workshop on Strategies and Approaches

Edited by Brad Seely and Guangyu Wang

Sustainable Forest Management in a Changing Climate

Participant's Report of Workshop on Strategies and Approaches

Presented by participants

Edited by Brad Seely and Guangyu Wang

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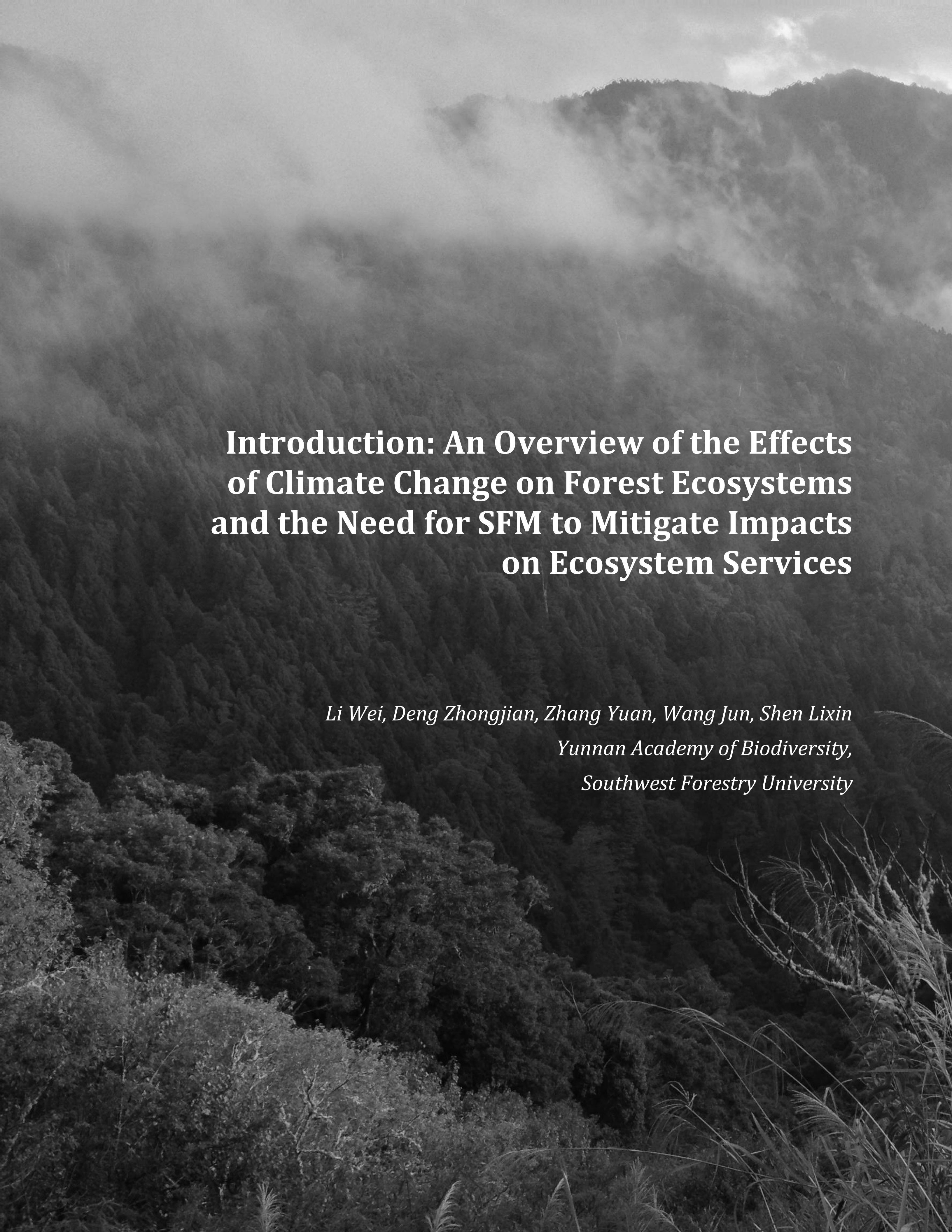

Introduction: An Overview of the Effects of Climate Change on Forest Ecosystems and the Need for SFM to Mitigate Impacts on Ecosystem Services

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Yunnan Academy of Biodiversity,
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Forest ecosystems provide essential ecosystem services for people and wildlife throughout the world. Not only are forests an indispensable source for economically important resources such as timber, pulp, and food, they are also critical for the cycling of carbon, nitrogen, phosphorous and other elements, the maintenance of precious water resources, and as reservoirs of biodiversity. It is not surprising that the development of human society relies heavily on forest ecosystems. However, many forest ecosystems and the communities that depend on them are vulnerable to anthropogenic climate change.

The trend of increasing temperatures, sea level rise and extreme weather events associated with climate change has received much attention globally. Although there is still considerable uncertainty surrounding the ability of scientists to accurately predict patterns of climate change in the future, it is abundantly clear that the steadily increasing concentration of carbon dioxide in the atmosphere has led to an associated increase in mean global temperatures (rising more than 0.6 degrees within the past century (IPCC 2007)). It has been generally accepted that the culprit for this dramatic change in the global climate is anthropogenic activities. If no actions are taken to curtail the negative impacts of such activities, there may be severe consequences over the next century for the health many forest ecosystems.

Many of the key ecosystem processes regulating the health and productivity of forests are closely related to climate and are therefore influenced by climate change. Rising temperatures, increasing frequencies of extreme weather events, unbalanced precipitation patterns, altered water distribution patterns and other climate-related events have imposed significant impacts on forest ecosystems. A common example is the gradual upward migration of forest vegetation in mountainous regions. Although some tree species are flexible in terms of their migration ability, those tree species that have limited migration ability, or have a difficult time to adapt rapidly to the changing local conditions are inevitably replaced by more adapted species, and they are doomed to the fate of extirpation or extinction (Ackerly 2003, Jump & Penuelas 2005, Bell & Collins 2008). The situation could be worse for forest diversity at the community level. Generally speaking, forest ecosystems are very sensitive to the events of climate change. Consequently, the size, area, structure and distribution of entire forest ecosystems may be altered dramatically in many parts of the world as the trend of climate change continues. In particular, long lasting drought or snow events could impose severe impacts on the health and resilience of forest ecosystems. For instance, in recent years, long-lasting drought events have led to the death of many tree species and related seedlings in many parts of China (Allen et al. 2010).

The indirect impacts of climate change on forest ecosystems may be even greater than the direct impacts. Increasing rates of fire and pest outbreaks represent two major indirect impacts of climate change on forest health. As global temperatures continue to increase along with increasing variability in precipitation patterns, there has been an associated increase in the frequency and intensity of forest fires. Moreover, an increase of temperature could be beneficial for some pest insects and pathogens. Not only are stressed trees more vulnerable to attacks from insects and pathogens, but many insects and pathogens may respond positively in terms of population dynamics and the optimal development range for these pests could be extended to a large scale. Predictions from different climate-based theoretical models have shown that climate change in the future could further promote large-scale pest outbreaks in forest ecosystems, and the consequences could be more severe than what we expect.

Climate change will also likely affect important functions and services provided by forest ecosystems. For example, the maintenance of productivity is essential to sustain the flow of forest resources for forest-dependent communities. Climate change may greatly alter forest production and thus directly or indirectly affect many different aspects of forest resources upon which many communities depend. While there are a few greenhouse studies that have shown that an increase of carbon dioxide concentration could help promote the growth rate of studied tree species (Rogers 1983; Brubaker 1986), it remains unclear whether an increase of carbon dioxide under natural environmental conditions would impose a similar influence on the development and production of forests at a longer time scale. Moreover, a change in abiotic (e.g., light intensity, nutrient availability, temperature, precipitation amount) and biotic (e.g., the intensity of intraspecific and interspecific competition, the predation effect) factors could also dramatically influence the physiological status of tree species, making it more difficult to predict accurately how forest vegetation will respond to an increase of carbon dioxide in the atmosphere.

It is widely accepted that forest ecosystems play a critical role in the maintenance of biodiversity. Under the influence of climate change, however, the optimal habitats and population size of many species may be severely threatened with some species driven near the brink of extinction. Species from high-latitude forests or temperate forests in the northern biosphere are particularly susceptible to climate change.

Likewise, rare species with small populations and limited distribution are vulnerable to the increasing frequency of extreme weather events. In addition to species richness, climate change could also negatively influence key components of biodiversity including genetic diversity and ecosystem diversity. For example, climate change could provide an opportunity for invasive species to expand their range as they tend to be better adapted persist in diverse climates. As such, they may outcompete and ultimately displace native species leading to the decrease of forest biodiversity (Massot et al. 2008, Bellard et al. 2012).

While vulnerable to climate change, well-managed forest ecosystems have significant potential for mitigating and reducing the broader negative impacts of climate change. For example, forest ecosystems represent the largest terrestrial carbon sink globally, with an enormous amount of carbon dioxide being stored in biomass and dead organic matter. In addition, the maintenance of forest biodiversity provides stability through time and enhances resilience with respect to external disturbances caused by climate change. Forests also play important roles in conserving water quality and increasing slope stability. Through these mechanisms healthy forest ecosystems play an essential role in minimizing the impacts of global climate change, and thus represent a vital resource that must be protected and conserved through effective management (Yachi & Loreau 1999; Fromentin et al. 2002; Morecroft et al. 2012).

The principle philosophy behind sustainable development is that natural resources required to meet human needs are used in a way that they will be available not only for present populations but also for future generations. Sustainable forest management is the management of forests according to the principles of sustainable development. In essence, the aim of sustainable forest management is to achieve the goal of environmentally appropriate, socially beneficial, and economically viable management of forests for present and future generations. In other words, the approach of sustainable forest management represents one of essential components for biodiversity conservation and environment protection, and functions as a mark of social progress and civilization.

In addition to human activities, forest fires and pest outbreaks represent the most common disturbance agents in forest ecosystems globally. Climate change would likely further intensify their negative impacts. Therefore, one significant component of sustainable forest management is to increase the resistance and resilience of forest ecosystems against catastrophic disturbance events. To achieve this goal, it is necessary, in many cases, to have human intervention (e.g., proper management and regeneration activities) so that a healthy and balanced forest ecosystem may be developed. For example, it is helpful to increase tree diversity because high diversity community could provide higher levels of ecosystem functions and services, and thus could more effectively mitigate the negative impacts of climate change. By contrast, tree monocultures are more vulnerable to pest outbreaks and an associated reduction in the flow of ecosystem services. In general it is good practice to include diverse tree species when regenerating forests to allow for adaption to the changing environment. Through this approach, the functions and services of the forest ecosystem could be maintained or even enhanced. Further, it is important to have a comprehensive disaster prevention system, and the development of tree species at different stages should be monitored through time so that prevention actions could be taken immediately once something goes wrong.

Sustainable forest management requires the cooperation among forestry, environmental protection, geology, meteorology, water conservancy and agricultural sectors. It relies on updated and adequate laws, regulations and guidelines to ensure effective implementation. The promotion of afforestation and reforestation, capacity building and active community engagement are all critical factors that need to be incorporated into the process of sustainable forest management. In particular, active community engagement could not only protect forest ecosystem from some of the harmful effects of rising global temperatures, but also provide opportunities for greater, more sustainable rural development and poverty alleviation through income generation and employment. In sum, sustainable forest management represents one of the essential components for biodiversity conservation and environmental protection It functions as a mark of social progress and civilization, and serves as a useful tool in effectively combating climate change. Since sustainable forest management is an evolving process, it requires that scientific knowledge and criteria for sustainable forest management must be constantly adapted to new circumstances. Finally, sustainable forest management should reflect the national context and the specific ecological and environmental conditions, as well as social, economic, political, cultural and spiritual dimensions.

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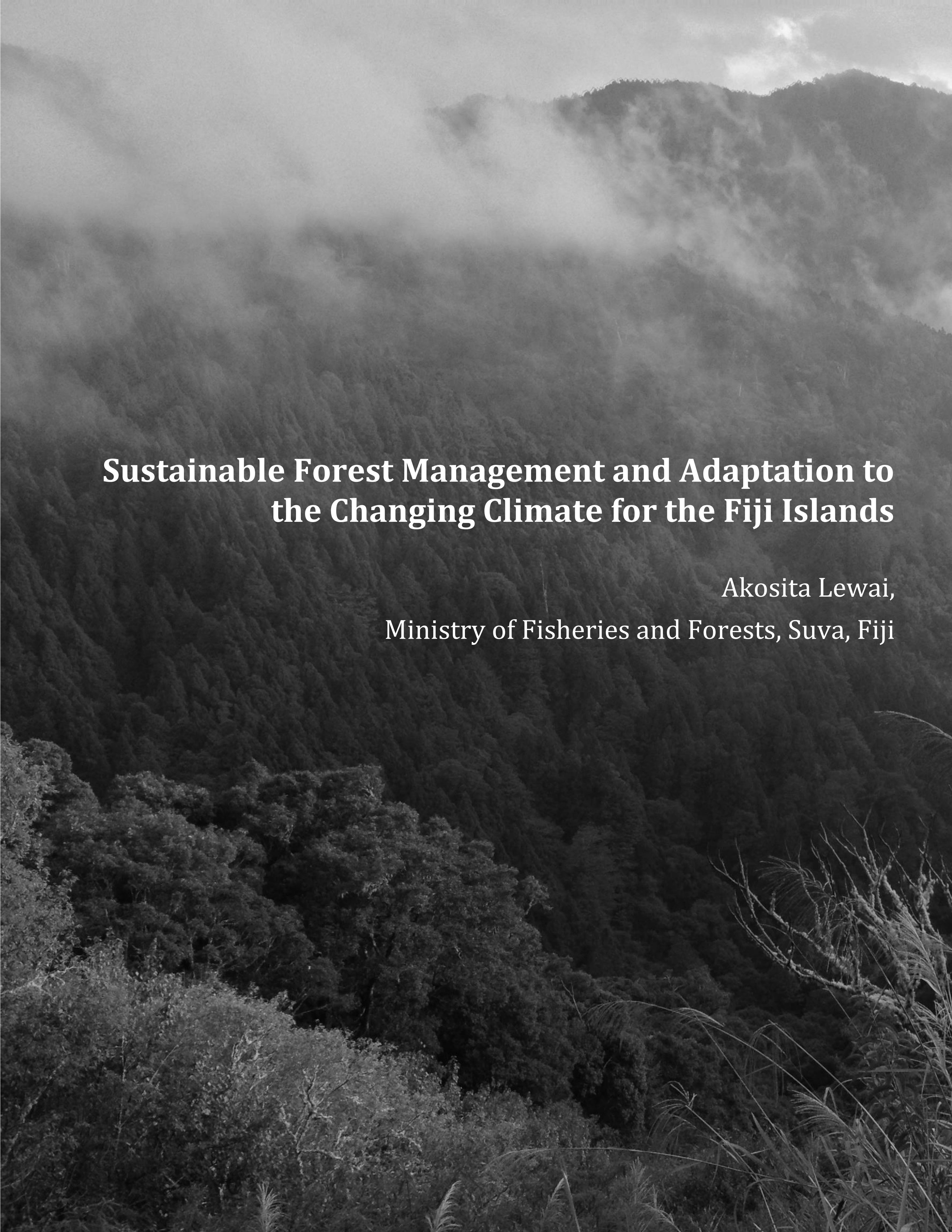

Sustainable Forest Management and Adaptation to the Changing Climate for the Fiji Islands

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Abstract:

In an effort to adapt to the changing climate, the Fiji Islands Forest Department amended the national forest policy to accommodate the global index and to recognize the role of sustainable forest management. The department has taken a more proactive approach to initiate these efforts in its policy integrating environmental, economic, social and cultural values. Permanent sample plots have been established and measured with the goal of providing information to support the calculation of the annual allowable cut. In addition, a National Forest Inventory is under construction to ensure that harvesting of indigenous species is done at a level that the native forests can biologically support. Measurement of the permanent sample plots will continue for the next 25 years. The recognition of the potential impacts of climate change has led to the formulation of the Fiji REDD policy in 2010. REDD pilot sites have been established in Viti Levu and Vanua Levu for analysis of carbon and setting baseline scenarios for the country.

Introduction

The Republic of the Fiji Islands, in the southern Pacific Ocean, is located approximately 3,100 km northeast of Sydney, Australia, and approximately 5,000 km southwest of Honolulu, Hawaii. It is made up of about 330 islands and about 500 more tiny atolls, islets, and reefs. The islands cover a total land area of 18,270 km^2. The island of Viti Levu (Big Fiji) covers about half of Fiji's area (10,429 km^2), and Vanua Levu (Big Land) about a third (5,556 km^2).

The large islands are of volcanic origin. Mount Tomaniivi, on Viti Levu, is the highest point at 1,324 m. A number of the smaller islands are coral formations, rising only a few meters above sea level. Nearly all the islands are surrounded by coral reefs. The major rivers on Viti Levu include the Rewa, Sigatoka, Nadi, and Ba. Dreketi is the largest river on Vanua Levu.

The climate in Fiji is tropical, but cooling winds make the climate relatively comfortable. Temperatures range from about 16° C to 32° C. December to April, which are also the rainy season, are the hottest months, with daily highs reaching 32° C. The windward (south-eastern) sides of the islands receive as much as 3,330 mm of rain a year, while the leeward northern sides receive about 2,540 mm. Heavy rains and cyclones often occur between November and April.

Fiji has a total land area of 1.827 million hectares of which 58% is covered with Forests, consisting of 85.3% natural forests, 2.4% pine *(Pinus Carribaea)* plantations and 5.0% of mahogany *(Sweitenia macrophylla)* plantations. Fiji' forests are home to at least 1,518 species of vascular plants, of which 50.1% are endemic and 9.9% of Fiji is protected under IUCN categories. The national program for the protection of Fiji's forest biodiversity is contained within Fiji's "National Biodiversity Strategy and Action Plan" (NBSAP 2010). Forest degradation due to number of issues ranging from economic, social, and demographic, were identified in 2009 as a major issue posing a great degree of threat to the sustainability of Fiji's forest ecosystems. *(State of the Forest Genetic Resources-Fiji; 2013)*

The roles and responsibilities of the Fiji Islands Forestry Department are the formulation and implementation of policy initiative and the administration of the regulatory framework to facilitate Sustainable Forest Management (SFM) in all types of forest. The vision of the department, "Our future generation inherits a prosperous & enhanced forest sector", is intended to enhance and improve livelihoods through SMART policies on sustainable forest resources.

SMART policies:
S – Simple
M - Measureable
A – Achievable
R – Realistic
T – Timely.

The first Forest Policy for Fiji was approved by the Legislative Assembly in 1950. Subsequently, the Forest Act was endorsed in 1953 to give legal effect to this policy. In 1988, the Government of Fiji initiated a Forest Sector Review with a comprehensive analysis of the sector and reformulated sectoral objectives, strategies and development programmes as a basis for the development of the forest sector. Although the review did not result in the formulation of a new forest policy, it initiated changes in the forestry legislation. The Forest Act was reviewed in early 1990 and replaced in 1992 by the Forest Decree, which simplifies, clarifies and updates its preceding legislation taking into account the need for sustainable forest management and changes in the policy environment.

Since the elaboration of the first forest policy, the perspectives on the role of forests for the society have changed and broadened considerably as a consequence of social, economic, environmental, cultural and political changes. In addition, as a result of the international forest-related discussion initiated by the 1992 UNCED conference in Rio and continued by the InterGovernmental Panel and Forum on Forests (IPF and IFF) and its successor the United Nations Forum on Forests (UNFF), the contribution of forests to the international conservation functions has become an important part of the national policy discussions.

There is rising pressure on forest resources in Fiji due to the increased demand for timber and other forest products and the ongoing conversion of forest land for other uses. Timber has become an important export commodity with government support for forest industry development. On the other hand, landowners aspirations for increased benefits from the use of their land need to be taken into account as well as the potential of forestry activities for improved livelihoods predominantly in the rural areas. With these challenges, today, the management of Fiji's forest resources to optimize their environmental, economic, social and cultural values, has become an urgent necessity.

In 2003, the Forestry Department stated the "…need to redefine Forest Policy to reflect the adoption of appropriate sustainable forest management system to ensure the full and successful implementation of current strategic directions and landowner aspiration on the management of their resources."

This need has been addressed by the elaboration of the new forest policy in a process that involved wide stakeholder consultation at the national and de-centralised level. With endorsement of the Rural Land Use Policy by Cabinet in 2005, the new Fiji Forest Policy can be put into an adequate policy framework for sustainable land use and elaborate on details to be addressed by a comprehensive sectoral policy.

The future development of the forest sector in Fiji must be firmly founded upon the sustainable utilization of natural resources and preservation of a healthy environment. To be able to contribute to Fiji's sustainable development, the forest sector must be based on sustainable forest management principles and direct its prime attention to improving the livelihoods of rural landowners. There is an urgent need to overcome the sector's current focus on timber production and to widen the perspective to a balanced attention to the multiple economic, ecological and social values of Fiji's forest resources. Consequently, a *vision* for the future forest sector would include:

- A permanent forest cover, including a protected forest area network, that provides the full range of ecological, economic and social functions for the local, national and global level;
- Forest management practices that provide high value goods and services by effective planning and utilization techniques while soil erosion and siltation in vulnerable watersheds are substantially reduced, balanced water supply is ensured, pollution avoided, and valuable biodiversity preserved;
- A thriving forest industry that provides stable employment and contributes significantly to national economic development by value-added processing and exports of quality products;
- Greatly improved rural livelihoods by substantial involvement of landowners and communities in sustainable management of their forest land and in forest-based industries;

- An institutional framework that encourages investment in sustainable forest management and forest industries with a forest administration that delivers high quality services that are widely sought and paid for by its clients.

To achieve this vision, the nation is obliged to address the following *broad strategies* (*cf* Rural Land Use Policy):

- Protecting the integrity of ecological systems and biodiversity
- Reducing the rates and areas of land degradation
- Maintaining and extending natural forest and forest plantations cover
- Rehabilitating areas of degraded natural forest remnants
- Preventing and controlling pollution
- Promoting sustainable forestry and agroforestry systems
- Fostering the involvement of landowners in the management and utilization of their own forests
- Implementing international environmental accords to which Fiji is signatory

Policies

Small islands, whether located in the tropics or higher latitudes, have characteristics which make them especially vulnerable to the effects of climate change including sea-level rise, and extreme events (very high confidence). Sea-level rise is expected to exacerbate inundation, storm surge, erosion and other coastal hazards, thus threatening vital infrastructure, settlements and facilities that support the livelihood of island communities (very high confidence). There is strong evidence that under most climate change scenarios, water resources in small islands are likely to be seriously compromised (very high confidence). It is very likely that subsistence and commercial agriculture on small islands will be adversely affected by climate change (high confidence). *IPCC 4th Assessment Report, 2007*

The Fiji Islands like any other Small Pacific Island countries are also affected with the challenges brought about with climate change. There are issues of rise in sea level for the low-lying islands and change in seasons and weather. To address these issues the Forestry department has put in place a REDD+ Policy for climate change adaptation and mitigation.

"The Fiji REDD-Plus Policy is implemented within the framework of the National Forest Policy of 2007 and contributes to the national Forest Sector goal:

‘Sustainable management of Fiji’s forests to maintain their natural potential and to achieve greater social, economic and environmental benefits for current and future generations’. In supporting the National Forest Policy, the Fiji REDD-Plus policy will: ‘contribute towards the development of a national carbon trading policy’ (Section 5.1, National Forest Policy) and ‘Strengthen the capacities to facilitate access to international financing mechanisms such as opportunities in the context of the UNFCCC’ (Policy field 6.6, National Forest Policy). The Fiji REDD-Plus Policy is aligned to the objectives of the Fiji Sustainable Economic and Empowerment Development Strategy (SEEDS) and will strive to contribute to the overall sustainable development of the Fiji Islands, including poverty reduction.

The Fiji REDD-Plus Policy will be implemented through a Fiji REDD-Plus Program, which will involve the participation of all relevant stakeholders coming from various sectors and agencies. The Fiji REDD-Plus Program aims to have Fiji achieve national REDD-readiness by 2012 and provide a framework to facilitate access to all available financing instruments for the REDD sector. The REDD-Plus Program will maximize benefits arising from carbon and climate-related financial instruments in order to:

- assist Fiji in retaining and enhancing the carbon in its forested landscapes;
- assist Fiji in achieving core forest sector goals as defined in the Fiji Forest Policy.

Other goals of the REDD-Plus Program include: a transition to sustainable forest management, reducing the loss of forest from the expansion of agricultural lands and other land use change, protecting indigenous forest areas of high cultural, biological diversity and ecosystem services value, increasing timber production from the plantation sector through afforestation/reforestation of non-forest lands (excluding wetlands/peatlands and indigenous palms), increasing agroforestry activities on non-forest lands (excluding wetlands/peatlands and indigenous palms), assisting Fiji in achieving its strategic goals in land-based development and environmental management.

The Fiji REDD-Plus Program will regularly review policy and technical issues in order to maintain alignment with ongoing international policy and technical development. The policy has also highlighted the safeguards to pilot project implementation.

Safeguards

The following will be ensured for all REDD-Plus initiatives and projects in Fiji:

- protection of and respect for the knowledge and rights of indigenous peoples (as stated in UNDRIP and UNCSICH and other international instruments);
- full and effective participation of indigenous people and other relevant stakeholders;

- equitable distribution of benefits to rights owners;
- consideration of gender issues in all phases of decision-making and implementation;
  - no conversion of natural forests but will reward the protection and conservation of natural forests and their ecosystem services, and will enhance other social and environmental benefits.

These initiatives and projects complement and are consistent with the objectives of the Fiji Sustainable Economic and Empowerment Development Strategy (SEEDS) and relevant international conventions and agreements.

Scope Of REDD-Plus Activities

The following activities are eligible for inclusion in a national/sub-national/Project scale Fiji REDD initiative:

- reducing emissions from deforestation via forest protection and improved forest management;
- reducing emissions from degradation via forest protection and improved forest management;
- afforestation/reforestation;
- forest/energy sector linkages (biomass electricity generation);
- forest/agriculture linkages (biomass residue);
- the linkage of afforestation and reforestation with REDD projects.

Governance

Through the Fiji REDD-plus program, a transparent multi-stakeholder governance structure will be developed. The governance structure will be capable of:

- ensuring the participation and consultation of all relevant stakeholders in REDD-Plus activities;
- delivering efficient and effective decisions;
- enhancing donor and buyer confidence;
- using existing structures and, where possible, modifying them to suit the implementation of the Fiji REDD-Plus Program;
- standing up to an independent, external, expert third party review.

Measuring, Reporting And Verification

The Fiji REDD-Plus Program will establish a forest carbon monitoring, reporting and verification (MRV) capability in line with the latest international good practice guidelines and guidance arising from the Intergovernmental Panel on Climate Change under the recognition that:

- eligibility for participation in international carbon and climate-related financial instruments is dependent on establishing and maintaining an MRV system and capability for the forest sector at the national and sub-national scale;
- such an MRV capability will provide benefits to other aspects of forest sector monitoring.

Pilot Projects

The Fiji REDD-Plus Program will benefit from 'learning-by-doing' and will therefore include pilot projects designed to assist in building capability in the design and implementation of REDD-Plus activities.

Engagement And Communication

Effective engagement with regard to international policy and technical issues at the UNFCCC and other relevant international/ regional forums, agencies, and countries will be strengthened. The Fiji REDD-Plus Program will put in place an effective communication and awareness strategy capable of ensuring an efficient, effective and transparent flow of information:

a) among people at the national level (government, industry, non-governmental organizations), local communities, landowners and other stakeholders;

b) between and within government departments and statutory bodies;

c) among national and international bodies and forums to enable more effective international policy and technical engagement.

Training

The Fiji REDD-Plus Program will develop an effective educational and training strategy capable of building policy and technical capacity.

Research

The Fiji REDD-Plus Program will undertake research, where necessary and with the approval of relevant authorities, to enable the achievement of its goals.

The REDD+ policy was endorsed in January 2011, and has identified activities that need to be completed including: the development of a national carbon inventory and global efforts to reduce greenhouse gas emissions; the socio-economic development of forest resource owners and local communities; relevant domestic legislation and policies and contribute to the implementation of international agreements, conventions and treaties that Fiji has associated itself with, signed or ratified; Fiji's efforts to conserve Fiji's natural forests and the valuable ecosystem services it provides and biological diversity and contribute to meeting Fiji's international commitments under the CBD (the Convention on Biological Diversity) and UNCCD (United Nations Convention to Combat Desertification).

Relevant Data

The relevant data at hand for the determination of strategies and adaptation to changing climate include:

(a) Forest Inventory data
    a. Database
    b. GIS Layers
(b) Soil data – GIS layers
(c) Digital Elevation Models
(d) Permanent Sample Plots
    a. Database
    b. GIS Layers
(e) Topographic information – GIS Layers
(f) Rainfall data – extracted from WorldClim

Case Studies:

Provided herewith are some case studies undertaken as part of the inventory development program and actions taken to highlight the pressing issues of climate change. There are three case studies highlighted in this report: National Forest Inventory, Permanent Sample Plots and Establishment of the REDD+ Pilot site.

Case Study 1: National Forest Inventory

The Forestry Department has conducted certain studies and analysis to manage its forest resources and such is the carrying out of its National Forest Inventory which to assess the quantity and quality of Fiji's remaining native forest through:

- identification and mapping of commercial forest areas;
- identification and mapping of non-commercial forest areas;
- calculation of the remaining timber volumes in both forest types;
- determination of the annual allowable cut;
- setting up of a forest monitoring system.

The most recent National Forest Inventory was undertaken in 2006 to 2007. There has been two previous inventories; the first one was conducted from 1966-1969 with collaboration from the Land Resources Department of England when Fiji was under its Colonial umbrella. The result of this inventory is its reports in three consecutive volumes and the forest type maps of the three islands namely; Viti Levu, Vanua Levu and Kadavu.

The second inventory was conducted from 1991-1994 with assistance and collaboration with GTZ and its consultants GOPA. This inventory introduced the use of satellite images and GIS to the department. The output of the inventory is the Forest Functions map; which was totally different to the forest type maps with classes divided into dense, medium dense and scattered forest with functions as multiple-use, protected forest and preserved forests.

The first phase of the inventory includes the analysis of satellite images to identify forested areas to aid in the establishment of random sample plots. There were only seven (7) islands identified for the inventory out of the more than three hundred (300) islands in Fiji. These seven islands have more than 80% of the total forest cover for the whole country. The work was divided into phases: remote sensing and mapping of forest types/ functions, field sampling in selected forest types, the production of forest maps 1:50,000, stand and stock tables for sampled strata, area and volume statistics.

Remote Sensing and Mapping

The analysis of the satellite images was something new. The previous forest inventories were undertaken abroad and did not capture the local knowledge of the Forestry Department. In the current process, most of these analyses were conducted locally, banking on local knowledge and experience as the main key.

One of the shortfalls was that there were not enough funds to purchase the more recent high-resolution images at the time. As such, Landsat 7 from 2000 and 2002 was utilized for analysis. About 30 scenes were selected, focusing on those with minimal or zero cloud cover. There was little correction done to the images except for some atmospheric analysis due to haze cover that can affect some analysis.

The first methodology on the images is to undertake semi-automatic classification for which the computer generates the coverage of the satellite images according to analysis and areas identified. Image masking was applied to the images; cloud mask, cloud shadow mask, water mask, mangrove mask, non-forest and plantation areas. The masking is undertaken to remove these areas from the image such it is left with forest areas only. These forest areas are then further classified to determine the coverage.

For mapping purposes the viewers displayed the topographic map, previous forest function map (from the NFI of 1991) and the satellite image to enable accurate mapping of the forest area. The semi-automatic classification had some setbacks including the creation of salt and pepper effects on the map due to automated classification errors on adjacent pixels.

The other option is to change the methodology of the mapping to visual interpretation. The satellite images were calibrated to show contrast on all the scenes or images thus mapping is conducted after workshops and communication with the field teams on the ground. Mapping of the forest cover was depicted from the analysis and extensive mapping of areas, which the operator identifies as being forest. There was extensive ground verification undertaken to ensure that the map has the most minimum mapping error of which more than 80% of the map were ensured to be correct.

There were 1022 random sample plots distributed for the collection of information. It was distributed according to forest coverage and not due to area (Figure 1). The classification unit is provinces, which were later divided into islands. The fieldwork took approximately two years to complete. The maps had to be verified again due to data from the field. There was extensive verification carried out even after the fieldwork to ensure that the map produced has minimal errors. The classification on the forest cover had also changed from Density in the previous inventory to Coverage - widely determined by canopy.

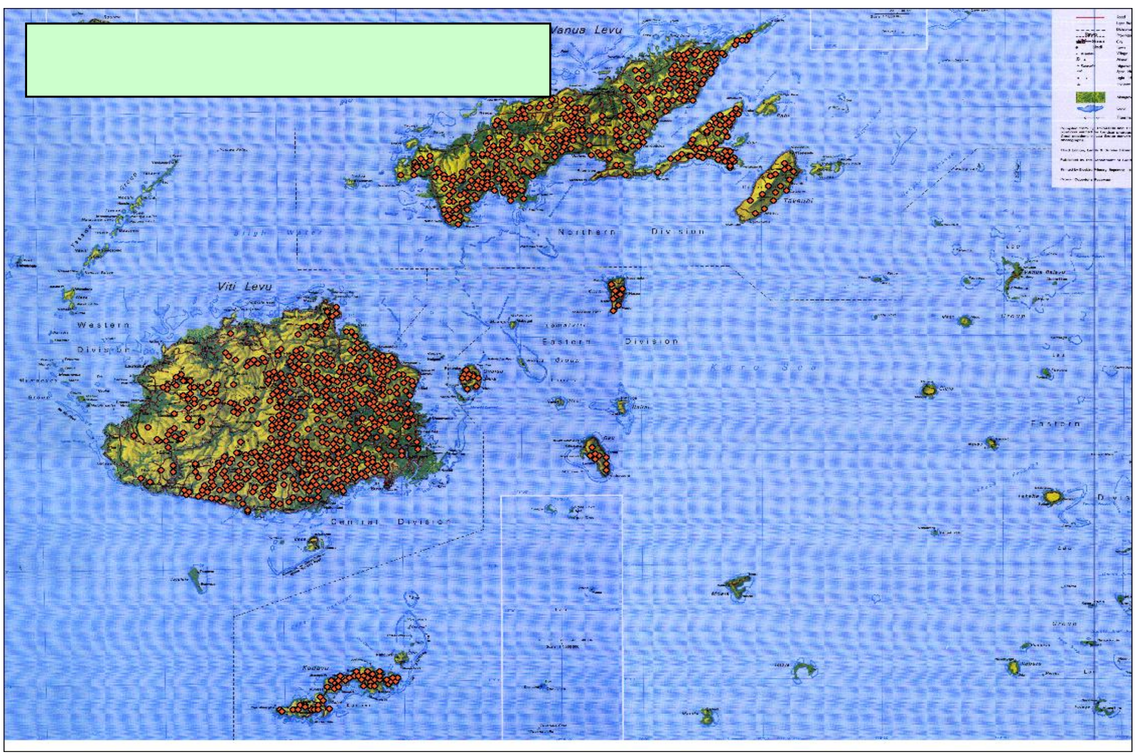

Figure 1. Distribution of sampling points for verifying and improving the forest inventory

On completion of the National Forest Inventory, it came into mind that there is no Annual Allowable Cut quota on any native species. Such logging of native and indigenous forest can escalate at a fast pace without being monitored. This identified the need to develop another project to determine the growth rate of each species and to support the calculation of ecosystem carbon sequestration and storage.

Case Study 2: Establishment of Permanent Sample Plots

The main objective of this study was to guide the establishment of an Annual Allowable Cut (AAC) for Fiji's natural forest to ensure that harvesting is done at a level that the forest can biologically support. There were one hundred sample plots distributed in the two main islands of Viti Levu and Vanua Levu (Figures 2 & 3).

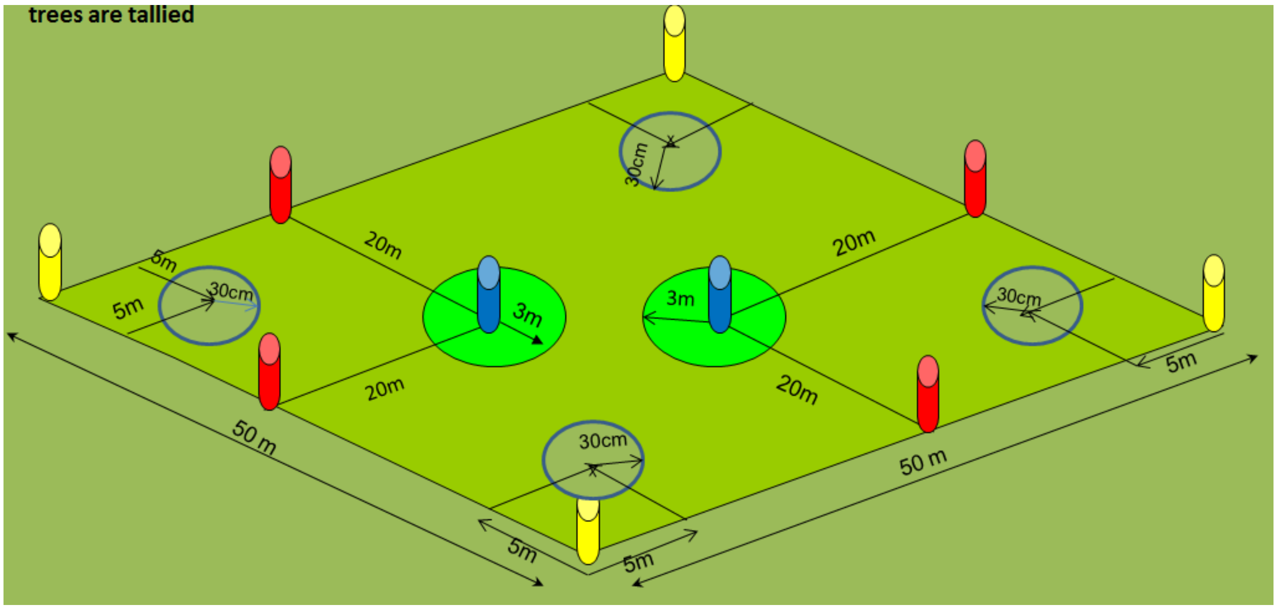

Figure 2. A schematic showing the plot layout used in the permanent sampling plots. See text for details.

Main Plot

- 50m by 50m
- Measure all trees with diameter greater than 30 cm in diameter using a diameter tape and recorded in the field recording form. The trees are identified, numbered using yellow paint and recorded in the field recording form.
- Tree heights measure using Height Pole.
- Record if the trees bear fruits or seeds during the time of assessment
- Record if there is any dead trees standing or alive within the plot.

Sub Plots

- 20m by 20m
- All regeneration trees which are GREATER THAN EQUAL TO 10cm diameter but LESS THAN EQUAL TO 29.9 cm
- The trees are identified, numbered using red paint and recorded.
- The tree heights are measured using a Height pole.

- Record if the trees bear fruits or seeds during the time of assessment
- Record if there is any dead trees standing or alive within the plot.

Circular Plots

- All regeneration trees less than one meter are identified tallied on to the field form.
- Also for those trees which are greater than or equal to one meter height and less than 3cm DBH.
- Measure trees greater than equal to 3cm dbh but less than equal to 9.9cm. The color that is being used is blue paint.
- Three meters stick stress out to the circumference of the circular plot. Fishing line or ribbons at the end to locate the circumference of the plot. Clockwise identify the tree species and count the trees making sure not miss a single tree or recount an existing tree.

Biomass Plots

- The 4 corner of the 50 x 50m plot (5m by 5m from main plot)
- All the dead organic matters found on the spots are collected and stored in a plastic bags
- Wet weights are recorded on a digital scale and then dried-up on a oven and then weigh again to record the dry weight.

The biomass circular plot was also included in the sampling to determine the carbon stocking for which no previous record was kept. The project is into its second cycle of which the first set of recording was completed in December 2012. The sampling is set for the next twenty-five years thus to be able to set harvesting quota on each native species that is harvest from Fiji's forests.

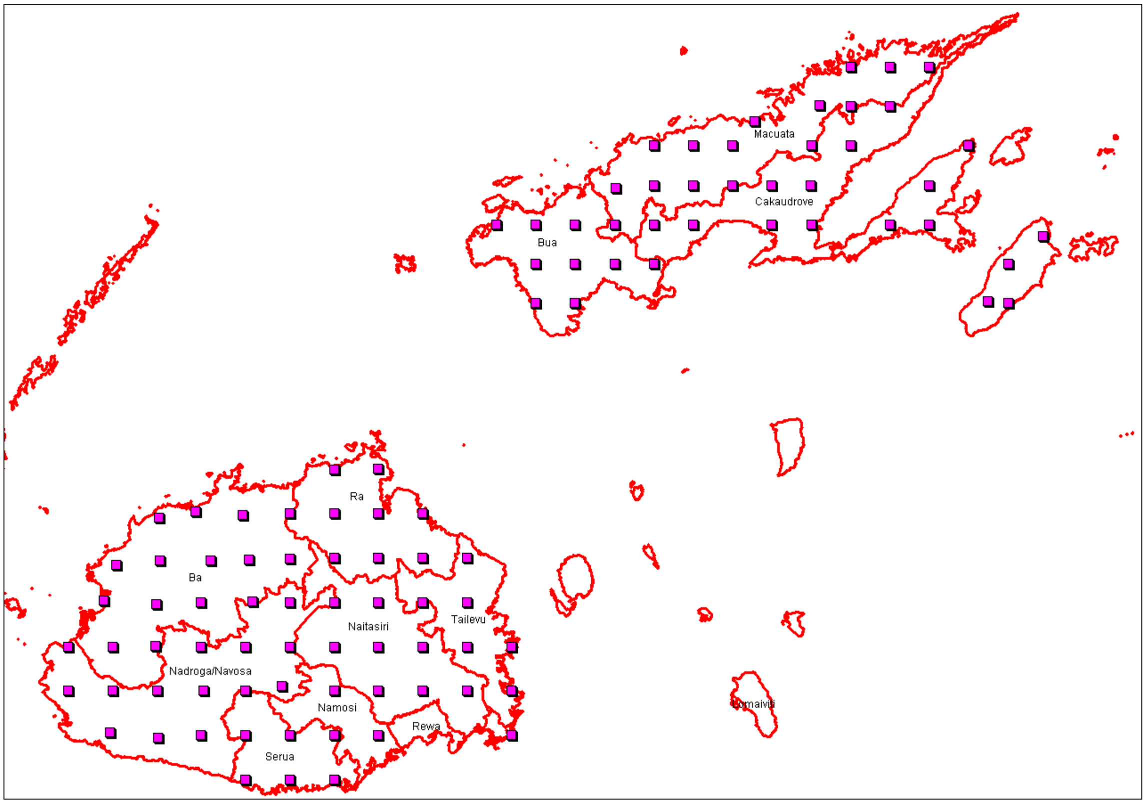

Figure 3. A map showing the distribution of the permanent sample plot locations on the two main islands.

Case Study 3: Establishment of the REDD+ Pilot Site

The REDD policy, initiated by the government with close collaboration with GIZ, includes the following components.

- The Fiji REDD-Plus Policy is implemented within the framework of the National Forest Policy 2007 and contributes to the national Forest Sector goal: 'Sustainable management of Fiji's forests to maintain their natural potential and to achieve greater social, economic and environmental benefits for current and future generations'.
- In supporting the National Forest Policy, the Fiji REDD-Plus policy will: 'contribute towards the development of a national carbon trading policy' (Section 5.1, National Forest Policy) and 'strengthen the capacities to facilitate access to international financing mechanisms such as opportunities in the context of the UNFCCC' (Policy field 6.6, National Forest Policy).
- The Fiji REDD-Plus Policy is aligned to the objectives of the Fiji Sustainable Economic and Empowerment Development Strategy (SEEDS) and will strive to contribute to the overall sustainable development of the Fiji Islands, including poverty reduction.

In a nutshell this clearly outlines that the REDD Plus policy is in line with the Forest Policy and the determination and calculation of forest carbon. The Fiji REDD-Plus Program will benefit from 'learning-by-doing' and will therefore include pilot projects designed to assist in building capability in the design and implementation of REDD-Plus activities. This however led to the establishment of the pilot site of *Mataqali Emalu* on Viti Levu and the second pilot site in Vunivia, Vanua Levu.

There have been fifty-four plots established in the pilot site, on Lowland, Upland and Cloud Forest areas Figure 4. The different elevation and classes is to determine the carbon content in different elevation and climatic conditions.

The plot uses the same plot layouts for the Permanent Sample Plots, which is 50m by 50m main plot, sub-plots, circular plot and biomass plots.

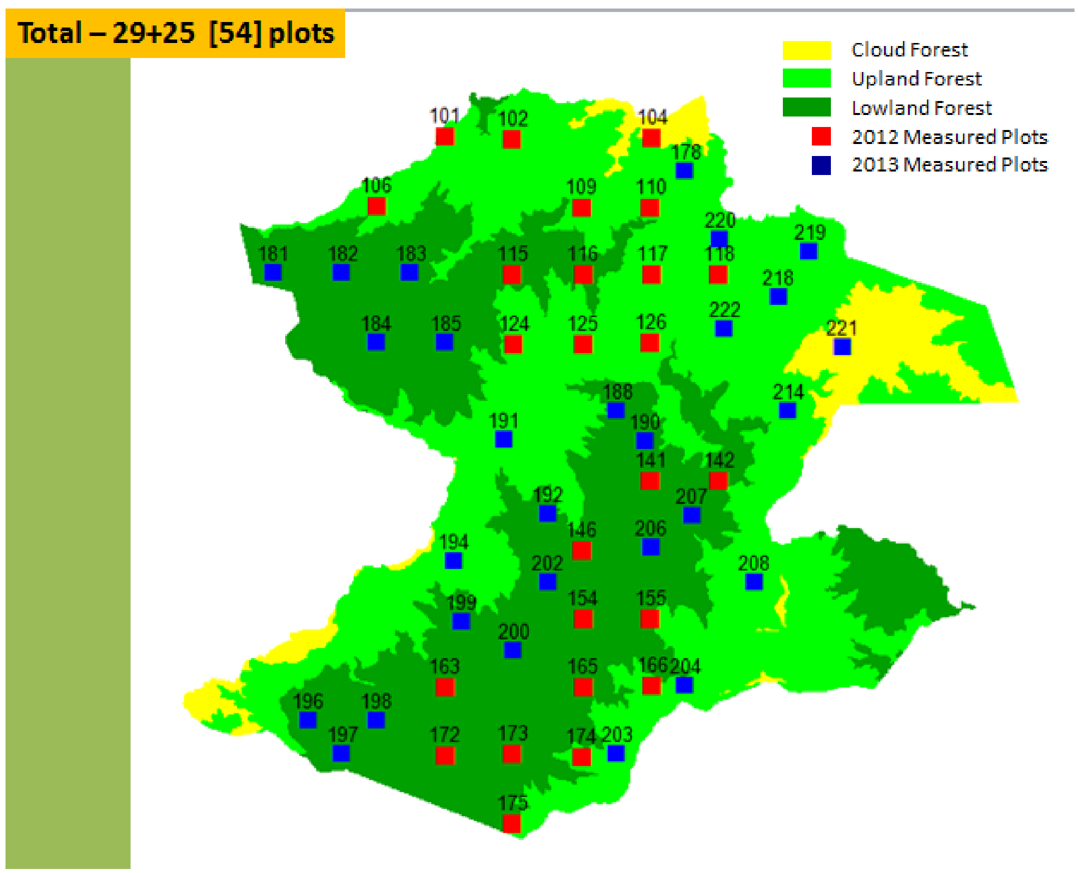

Figure 4. A map showing the distribution of biomass carbon plots in the REDD-Plus pilot project.

Conclusions

There are different methodologies for determining the extent of climate change impacts and each country's experience is unique. For the Pacific region, climate change is an everyday issue through its effect on the rise in sea levels. There are many countries that will be submerged in years to come with the pressing issues of climate change and more must be done to combat this issue as adaptation measures are limited.

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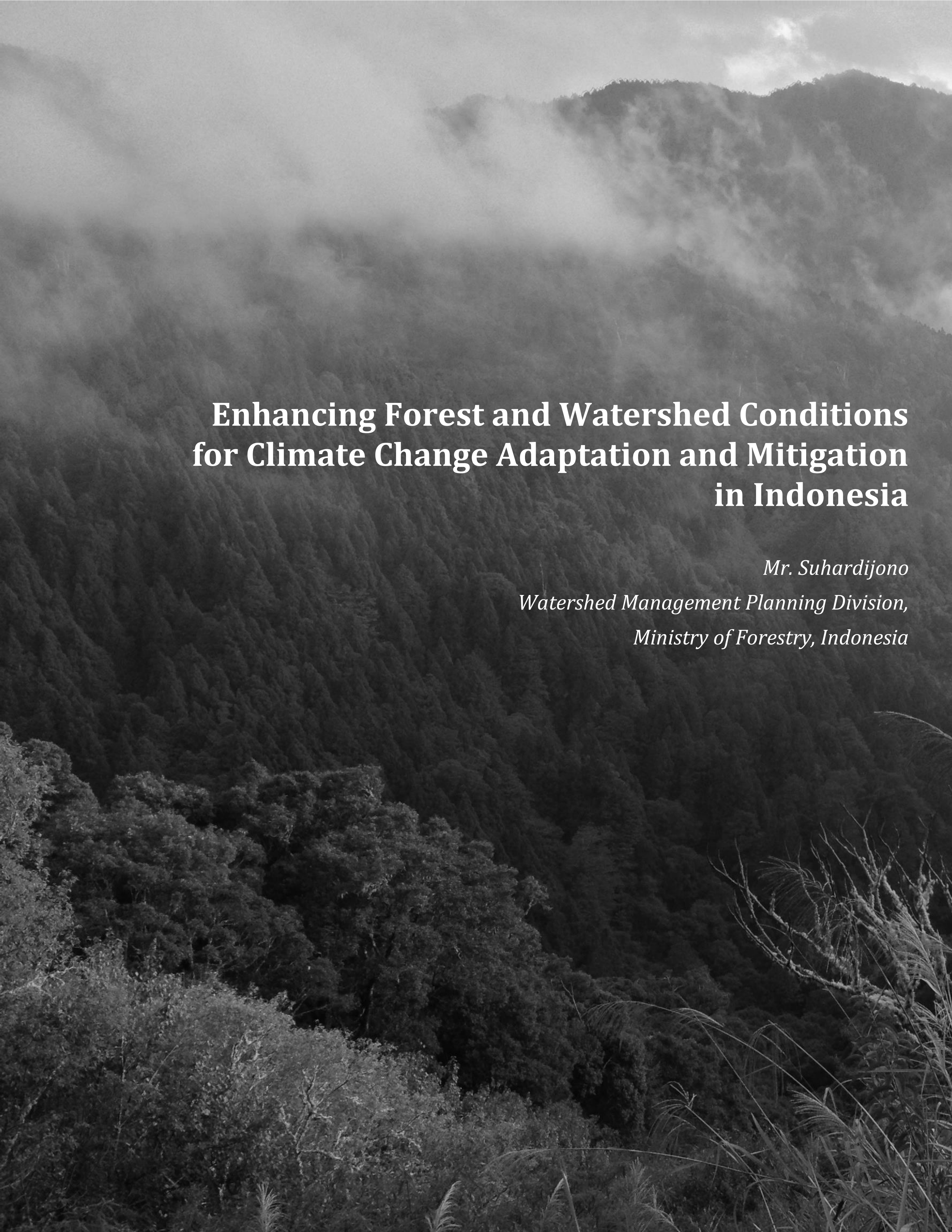

Enhancing Forest and Watershed Conditions for Climate Change Adaptation and Mitigation in Indonesia

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Enhancing Forest and Watershed Conditions for Climate Change Adaptation and Mitigation in Indonesia

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Introduction

Climate change has becomes an important issue and is already having dramatic effects on forests, watersheds, natural resources and people's livelihoods. Poor people in developing countries, including Indonesia, are affected climate change because they live and work in the areas where natural disasters are common such as flood plains, mountainsides and deltas. Accordingly, watershed management has become an important part of national development in Indonesia, especially with respect to the forestry sector. Forests in Indonesia represent about 68.4 % of total land base. There are total of 17,088 watersheds within Indonesia and they are used for the basis of sustainable forest management units. The key components of forest management in Indonesia as stated in Forestry Law No. 41 (1999) include the following priorities with respect to forest development:

- to ensure the adequate existence of forest area scattered through out watersheds or islands;
- to optimize ecosystem services provided by forests;
- to increase the welfare of people living within forested areas;
- to increase the carrying capacity of watersheds to support community livelihood;
- to guarantee the distribution of forest resources equitably among the community.

From the objectives of forestry development mentioned above, it is clear that the Government of Indonesia is trying to conserve its forests whlie protecting watersheds.

Overview of Forest Management

Indonesia has vast area of forest landbase totaling about 130.68 million ha. The Ministry of Forestry implements the management of forest resources. There are 5 principal forest types defined including:

- Production forest: A forest area that can be exploited to produce both timber and/or non-timber forest products through selective cutting or clear cutting methods. The area of this forest is about 32.6 million ha.
- Restricted production forest: A production forest area that has specific fragile conditions such as topography, soil type and rainfall, and the

production of timber is limited by minimum timber diameters, depending on the species present. The area of this forest is about 24.46 million hectare.

- Converted production forest: A production forest area in which its status can be converted into other use of land through releasing or exchanging forest area constituted under Ministry of Forestry. The area of this forest is about 17.94 million ha.
- Conservation forest: A forest area that has specific features and is intended to conserve biodiversity including flora and fauna. The area of this forest is about 26.82 million ha.
- Protection forest: A forest area specifically designated for protecting of life-support systems such as water, flood and drought mitigation, erosion and sediment control, maintenance of soil fertility, protection from sea level raise.

Distribution of forest area is scatted in almost all islands and mainly located in five big islands including: Sumatra, Kalimantan, Sulawesi, Papua and Java islands. The condition and area of forest cover are divided into five categories as follows:

- Primary or virgin forest about 41.26 million ha
- Secondary forest (forest that have already been harvested through selective cutting) about 45.55 million ha
- Plantation forest about 2.82 million ha
- Degraded forest about 41.05 million ha

Watersheds where degraded forests exist are designated as vulnerable because they can easily contribute to disasters such as flood, erosion and sedimentation, landslide, etc. These watersheds have been identified as a high priority for management to improve ecosystem function. There are about 41.05 million ha of degraded forest in this high priority category.

There are about 8.07 million ha of private forest in Indonesia and this plays an important role in the timber industry and in supporting the livelihoods of people in rural areas.

In terms of institutional structure, the management of forest in Indonesia is mainly divided into 3 categories including:

- conservation and forest protection;
- harvesting landbase;
- forested areas in need of rehabilitation.

History of Forest Management

The forestry sector in Indonesia has long history. It started long before the country got independence in 1945. Indonesia was occupied by the Netherlands for over 350 years ending in 1942. During the occupation, the exploitation of forest resources became an important economic engine for the Netherlands. Forest resource management was centered on Java Island and the dominant species planted was teak (*Tectona grandis*). After the Netherlands occupation, the government of Indonesia has continued to manage forest resources in Java through the establishment of a State Forest Enterprise called Perum Perhutanai that is still managing forests in Java Island today.

Starting in the mid 1970's the Government of Indonesia expanded forest resource management to the Kalimantan and Sumatera islands. Forest resource management at that time was concentrated in harvesting timber in natural forests by implementing mainly selective cutting methods. In the era of mid 1970's until the late 1990's forest exploitation, conducted by private forest concessions, was one of the most important government economic activities, resulting in considerable revenue and job creation. Towards the end of this period, exploitation spread to other islands including Sulawesi, Papua, Maluku, and others.

After three decades of forest exploitation, the Government of Indonesia realized that a considerable amount of forest degradation had occurred because of inappropriate implementation of the selective cutting method and the weakness of government supervision. As a result, there are large areas of degraded forest contributing to erosion, sedimentation, flooding during rainy season, and drought during dry season.

Responding to the situation, in the late 1990's, the government implemented policy to reduce forest exploitation and increase forest rehabilitation. At the same time, the government began a watershed management program, focused not only forest and critical land rehabilitation, but also on implementing an erosion and sediment control program, the establishment of soil conservation structures, and community empowerment by promoting of stakeholders participation, etc. This program continues now and the government is still concentrating to rehabilitate degraded forest and to reforest critical land outside of the current forest area. They are also promoting the development of private forest plantations. All of these programs are set up within a watershed management-planning program.

Sustainable Forest Management Policy

The Government of Indonesia has made clear commitments towards sustainable forest resource management. It is clearly stated in the national constitution called UUD 1945 in article 33. Specifically, it states that all natural resources are managed by the government to increase the welfare of people's livelihood. More recently watershed management has become very important with respect to forest development and it has been used as the fundamental unit of forest management planning. In addition, starting the mid 2000's, the paradigm in forest management changed from timber management towards forest resource management including a focus non-timber values including ecosystem services.

To implement development programs in all sectors including forestry the government, through the National Planning Bureau, has set up a mid-term development program (Mid-Term National Development Planning) for the years 2010-2014. There are six main policies in the mid-term forestry development plan including:

- Strengthening forest boundary and inventory
- Rehabilitation of degraded forest and improving watershed condition
- Forest fire prevention
- Protection of biodiversity
- Revitalization of forest harvesting and industry
- Community empowerment surrounding forest area

Future discussions will be focused on the policies designed to increase the rehabilitation of degraded forest land. To implement this policy, a program has been set up called Strengthening Watershed Function and Capacity Based on Community Empowerment Program. The key objectives of this program include:

- Rehabilitation of degraded forest and land including mangrove, coastal forest and peat swamp forest.
- Establishment of community forestry
- Development of private forest
- Development of seed source stand
- Establishment of village forest
- Establishment of integrated watershed management planning

Policy and Strategy on Climate Change Mitigation and Adaptation

The role of forests in climate change mitigation and adaptation is focused on maximizing carbon sequestration in forest ecosystems. The president of the Republic of Indonesia stated the country's commitment on climate change mitigation during the G20 Conference in Pittsburgh and COP 15. By the year 2020 Indonesia will reduce carbon emissions up to 41%, with 26 % through coming from domestic efforts and 15 % through international support. This policy has been stated in the National Action Plan on Climate Change Mitigation (2011). The National Action Plan there includes 5 main sectors: Forestry and Peat Land, Agriculture, Energy and Transportation, Industry and Waste. The reduction target for carbon emissions is shown in Table 1. The forestry sector including peat land has a very important role in the climate change mitigation and adaptation program in Indonesia.

Table 1. Projected carbon emission reductions by sector with and without international support.

SECTOR	Indonesia (26%) (Gton CO2e)	Total with International (41%) (Gton CO2e)
Forestry and peat land	0.672	1.039
Agriculture	0.008	0.011
Energy and transportation	0.036	0.056
Industry	0.001	0.005
Waste	0.048	0.078
Total	0.767	1.189

The following objectives have been identified to guide the implementation of the National Action Plan for the forestry and peat land sector:

- Reduce deforestation and degradation rate
- Increase planting to raise carbon absorption
- Protect forest from fire and illegal logging
- Manage drainage in peat land area
- Stabilize water level in drainage system
- Optimize forest and water resource without conducting deforestation
- Implement appropriate technology for land and agriculture management with minimum carbon emission.

Forest and Land Rehabilitation to Support Climate Change Mitigation

To implement the objectives of National Action Plan the Ministry of Forestry has set up several regulations for planning. There are three levels of planning that must be addressed prior to funding and implementation:

Technical planning for forest and land rehabilitation within watersheds
Management planning for forest and land rehabilitation (5-yr plans)
Annual planning for forest and land rehabilitation, established by district forestry agency

Perhaps the biggest problem of forest resource management in Indonesia is degradation. There are about 41.05 million ha of degraded forest area with an annual degradation rate of about 1.08 million ha per year. However, the forest and land rehabilitation program conducted by the government every year only estimates about 500 ha per year. The demand for forest area to be used for other purposes is rising. For example, there are a lot of mining companies operating in forest areas based on permits issued from Minister of Forestry. The use of forest area for mining activities is mitigated in terms of the forestry sector as the mining companies are responsible for:

- Forest reclamation in its concession area
- Compulsory planting for watershed rehabilitation outside of concession area

It is hoped that these regulations will increase the rate of rehabilitation and local communities will get more benefit from rehabilitation and plantation program economically and ecologically. The Ministry of Forestry initiated the Community Nursery program in 2010 to support the rehabilitation program. Community Nurseries built in 2010 totalled 8,000 units and each unit produced 50,000 seedlings. Each community nursery is managed by a group of 10-20 farmers. Total seedling production in 2010 was 400 million seedlings. All of the seedlings have been planted as part of the private forest development program in 2011 with a total plantation area of about 400,000 ha. The Government of Indonesia has continued to increase the Community Nursery Program as it is has been effective in rehabilitating degraded forest and critical land. They have focused on the Community Nursery Program because one of the key limiting factors for the success of the Forest Rehabilitation Program is the availability of good quality seedlings for planting large areas.

The implementation of the Forest Rehabilitation Program has been challenging as it consists of many activities and involves many institutions from central, provincial and district governments. Some of the key challenges include:

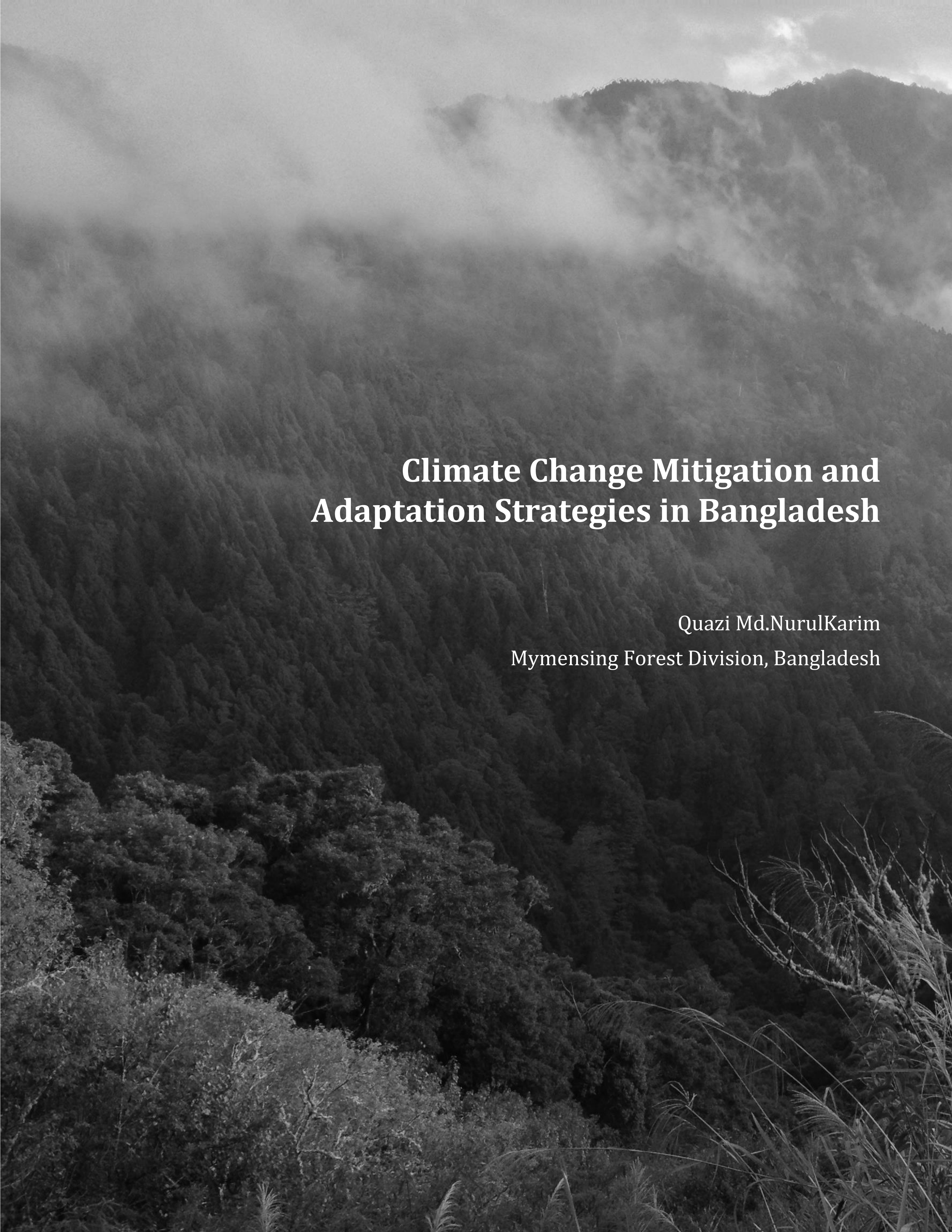
- vast area of degraded forest;
- difficult accessibility;
- expensive transportation costs;
- lack of human resources;
- lack of funding;
- lack of coordination among the levels of government;
- widespread forest encroachment by local communities.

The successful implementation of the rehabilitation program depends on a number of factors including the quality of human resources, particularly those at the district level, and on appropriate species selection. With respect to human resources, the government conducts training programs both for district forestry officials and for farmers. Species selection is important as it influences the types of products that can be generated as well as the success of the plantation. The main tree species selected by farmers include the following:

- For wood production: *Albizzia falcataria, Swietenia macrophila, Tectona grandis, Acacia mangium, Acacia auriculiformis*

- For fruit production: *Durio zibethinus, Mangifera indica, Nephelium lappaecium*

- For fuel production: *Leucaena glauca, Leucaena lecocephala, Gliricidea sp, Calliandra sp*



Climate Change Mitigation and Adaptation Strategies in Bangladesh

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Climate Change Mitigation and Adaptation Strategies in Bangladesh

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Abstract:

Although its emission of greenhouse gasses is one of the world's lowest per capita, Bangladesh is heavily impacted by climate change. In an effort to mitigate and adapt to climate change impacts, Bangladesh has implemented the Climate Change Strategy and Action Plan (BCCSAP) in 2009. The country has established its Climate Change Trust Fund from its own revenue allocating 25 billion taka (BDT) for the past four years. In addition, the Bangladesh Climate Change Resilience Fund (BCCRF) has been established with international support. International organizations (UK, Sweden, EU and Denmark) allocated US$ 125 million towards this purpose. In 2012 Bangladesh prepared a REDD+ Readiness Roadmap with technical support from UNDP and FAO. A total of 194 projects have been established through Bangladesh Climate Change Trust Fund (BCCTF) with committed expenditure of 15.14 billion BDT. A total of 19 projects have been successfully completed to date.

As awareness increases among stakeholders and users of forest resources, political commitment and capacity will likely increase. One of the key objectives is to reduce the dependencies on forest resources while creating alternative energy resources. In addition, it is important to maintain transparency, accountability and wide participation with respect to the use of BCCTF and BCCRF funds.

Introduction:

Bangladesh, like many sub-continental Asian countries, is dependent on Himalayan-Hindukush landscapes within the Tibet plateau for fresh water resources. Many important perennial rivers originate from glaciers and watersheds in this area feeding huge river basins and deltas in Bangladesh inhabited by large impoverished populations with great dependence on natural resources including forests and waters. A country of 160 million people with the highest population density of the world (1033.5 people/km^2), Bangladesh is one of the most vulnerable countries in the world with respect to climate change. Floods, tropical cyclones, storm surges and droughts are likely to become more frequent and severe as climate change progresses.

According to a recent forest resources assessment (FAO 2010), 11% of the country's land mass is under forest cover while 90% of the people living in villages depend on natural resources (wetlands and forests). As a result, forests in Bangladesh are under tremendous pressure. According to FAO (2010) forest cover in Bangladesh declined an average 0.17% per year between 1990 and 2010. Deforestation is caused by many factors including rapid urbanization, industrialization, agriculture expansion, shifting cultivation, lack of effective implementation of forest policy and laws in the forest land and resource management, etc.

Policy development with respect to Forest Management and Climate Change:

Forest Management:

In an effort to stem deforestation and forest degradation, the Bangladesh Forest Department (BFD) has strengthened forest protection by revising the Forest Act of 1927 and created the Social Forestry Rules. It has also taken initiatives for drafting co-management rules and revenue sharing mechanisms included within the Social Forestry Rules. In addition, parliament has approved the Wildlife Preservation and Safety Act (2012).

Climate Change Adaptation:

Climate change is a threat to global civilization. Bangladesh is amongst the countries most vulnerable to climate change. Its national growth and development is hindered due to floods, droughts, cyclones, salinity ingress and sea level rise. The Bangladesh government has focused on the national capacity to address negative impacts of climate change developing the Bangladesh Climate Change Strategy and Action Plan (BCCSAP) in 2009.

Bangladesh was among the first developing countries to produce an integrated climate change action plan with domestic funding (Bangladesh Climate Change Trust Fund-BCCTF). The main objective of the fund is to increase the capacity of local people to adapt to climate change and to reduce vulnerability through the implementation of projects. Several laws, guidelines and policies have been established to ensure proper management of the fund. A total of 11.55 billion BDT has been allocated to total of 194 Projects with a committed expenditure of 15.14 billion BDT. To date 19 projects have been successfully completed. While adaptation has been given the highest priority in the selection and funding of projects (77%), there has also been a commitment to greenhouse gas (GHG) mitigation projects (23%). This is significant considering the Bangladesh represents only (0.3%) of global GHG emissions.

Projects funded through BCCTF have provided a range of benefits to climate vulnerable communities including: the provision cyclone tolerant houses, ensuring safe drinking water for women and children, production of stress tolerant rice-wheat-oilseed varieties, improving sanitation, construction of rubber dams for irrigation, repair and construction of embankments in coastal and river erosion prone areas, protection of river banks, improvement of drainage systems, excavation and re-excavation of canals and rivers, cropping system improvement in drought and coastal saline areas, land reclamation through construction of cross-dams, creation of coastal green belts to protect coastal areas, biodiversity conservation and reduction of greenhouse gas (GHG) emissions. The Climate Change Trust Fund is also developing skilled human resources through awarding Scholarships for PhD and M Phil researchers on climate change issues.

International Support

In addition to domestic funds, international funds including the Bangladesh Climate Change Resilience Fund (BCCRF) have been established with the support from international organizations. Achievements of BCCRF include the following:

- Development partners already allocated US$ 125 million (UK, Sweden, EU and Denmark);
- US$ 200 million under consideration by the various Development Partners;
- Two projects approved (Cyclone shelter for coastal areas and afforestation) and (Climate Resilient Participatory Afforestation and Reforestation Project).

Bangladesh has also prepared a REDD+ Readiness Roadmap with technical support from UNDP and FAO in 2012 as part of its climate change mitigation and adaptation strategy.

Current Status of Forest Inventory

A country level National Forest Assessment (NFA) was undertaken from 2005 to 2007 with the technical assistance of FAO. Topographical sheets of 1: 50,000 scale maps produced by the Survey of Bangladesh were used to delineate specific forest type and land use tracts. A total 299 tracts were identified and systematically distributed throughout the country at an interval of 15 degrees latitude and 10 degrees longitude. A globally harmonized classification system was developed and five major land use classes were identified for the inventory and 29 specific land use classes were identified for field data collection. Classification was based upon socio-economic, environmental and productivity factors associated with a wide range of variables and data collected using a number of different methods. Data resources included Landsat satellite images in combination with field data collected for ground truthing. In addition to the NFA, carbon inventories and Protected Areas (PAs) were created.

Community-based Adaptation to Climate Change through Coastal Afforestation

A project entitled ‘Community based Adaptation to Climate Change through Coastal Afforestation’ was established as a joint initiative by the Government of Bangladesh (GOB) and United Nations Development Program (UNDP). The $5.823 million project is being implemented by the UNDP under Least Developed Countries Fund (LDCF) of the Global Environment Facilities (GEF) to reduce climate vulnerability in four coastal districts including: Barguna, Bhola, Noakhali and Chittagong. Beginning in 2009, the pilot project provided access for 33,770 landless people in coastal districts to otherwise unusable government lands to grow fruit, vegetables and fish. It has also attempted to reduce greenhouse gases and to protect the land and people from further storms and erosion by planting new *mangroves species* along the coast.

Initial results from the project suggest that it has enhanced the resilience of coastal ecosystems by increasing forest coverage and creating livelihood diversification in vulnerable communities. Multiple social, ecological and institutional factors important for reducing coastal vulnerability have been integrated in the projects. Some of the key benefits from the project features include: the establishment of innovative land management and livelihood diversification practices, enhanced social equity through ownership, capacity building of diverse stakeholders, and improved access to local government supports and services. Some of the key results of the project since inception to current observations have been summarized in this report.

Enhancing Resilience through the Establishment of Protective Ecosystems

Coastal afforestation through mangrove afforestation (Figure 1) in more 6,000 ha of newly accreted lands has improved land stabilization. It also helps in maintaining protective green coverage in the coastal areas and providing security for local communities. Model plantations (Figure 2) have introduced 10 new mangrove species to coastal forests enhancing species diversity and providing additional resilience with respect to climate change. The project established 95 ha of model plantations and involved 143 coastal families. This type of plantation has been shown to enrich plant density per unit area, and to contribute to reducing wind velocity, tidal surges and other climatic events. Long-term spatial and temporal risk management with respect to the protection of coastal communities is also considered in the establishment of different types of afforestation interventions.

Figure 1: Mangrove afforestation in newly accreted coastal lands.

Figure 2: Model Plantation.

Figure 3: Mound Plantation.

Mound and dyke plantations (Figure 3) have also been used to reclaim unused coastal lands to accommodate non-mangrove species in salinity dominated coastal belts by involving local communities. These methods also help to increase species heterogeneity in coastal landscapes with improved functional diversity to manage risks in coastal areas. As of today, 112 ha of dyke plantations have been planned involving the participation of 896 families. In addition a total 332 ha of mound plantations have been established involving 554 coastal families under a benefit sharing approach. These afforestation projects have provided income opportunities through cash for work for more than 12,300 coastal people for jobs such as nursery bed preparation, seedling production, planting and maintenance.

In addition to these activities, more than 3400 coastal households are currently involved as long-term beneficiaries of the strip plantations in four project sites. These projects are intended to improve the resilience of protective ecosystem and to protect critical infrastructure of the coastal areas including embankment and roads through community engagement. These projects have also contributed to both adaptation and global mitigation efforts. With a total of 6,372 ha of coastal afforestation, the projects areas are projected to absorb more than 63, 7200 tons of carbon dioxide annually.

Enhancing resilience of Coastal Communities through Livelihood Diversification

Innovative Land Use Projects

Projects funded through the BCCRF have also provided innovative land uses and diversification of livelihood practices over traditional income generation sources in coastal areas. The multi-level resource management practices under the project support have helped to establish recurrent income generation options to coastal households. Restoration of coastal fallow lands under the project for community based resource generation through ditch and dyke structures has created a new ownership opportunities for the beneficiaries. In addition, access to land with improved resource management practices has helped to secure seasonal food production and income.

Table-1: Intervention-wise annual income and beneficiary groups of Triple F model

Beneficiary Group*	Household income before project interventions	After Agriculture interventions		After Fisheries interventions		After Livestock interventions	
		Income (BDT)	Beneficiaries (%)	Income (BDT)	Beneficiaries (%)	Income (BDT)	Beneficiaries (%)
A	<2000	500 – 3,000	23.08	500 – 5,000	6.82	500 – 2,000	38.64
B	2000-3500	3,001 – 5,000	30.77	5,001 – 10,000	65.91	2,001 – 3,000	31.82
C	3500-6500	5,001 – 10,000	38.46	10,001 – 20,000	25	3,001 – 6,000	27.27
D	6500-10000	10,001 – 15,000	7.69	20,001 – 30,000	2.27	6,001 – 9,000	2.27

*Groups were categorized based on baseline income of each beneficiary family

The innovative adaptation practice has helped marginalized coastal people to improve their household food security and to generate additional income. The ditch and dyke method is currently benefiting 320 coastal families by allowing them to produce different vegetables on their dykes within two seasons securing their household food and generating income up to 20,000-25,000 BDT from the sale of vegetables (Table 1). Moreover, Fish cultivation in the ditch system is providing household protein sources and income for poor households in coastal areas. Rainwater harvesting creates freshwater fish cultivation and irrigation for extended fish culture throughout the year. Each family is able to produce 400-500kg of fish providing protein and income generation through the sale of extra production.

Figure 4: Multi-level resource generation practices

Improved Agricultural Practices

Several projects have focused on improved agricultural practices to enhance community resilience.

- **Salt tolerant and high yielding rice variety**

The increased frequency of intense precipitation events has increased the problem of water logged soils and coastal flooding. Accordingly traditional rice cultivation has become increasingly difficult in coastal areas. One project has focused on the cultivation of salt tolerant rice variety (BR 47) as a potential crop for coastal areas. Since introduction in 2010, the variety increased rice production and land coverage in consecutive years. The rice production technique improved the farmers' capacity to use of fallow lands in salinity affected in coastal areas. Compared to other local varieties the new variety has yielded three times more rice production in project areas. The high yielding capacity of the rice variety has helped to secure household foods for coastal people and enhanced their capacity to manage climate change related risks that could lead to lower production seasons with the traditional agricultural cropping practices.

Figure 5: Shifting land use of single to double crop with salt tolerant rice variety

- **Salt tolerant and high yielding fruit varieties**

Another project has focused on the use of introduced fruit varieties Guava and BAU Kul to provide a new way of rational land use for homestead horticulture in coastal areas. Mostly using fallow lands and dykes around homesteads, fruit cultivation is providing seasonal food and income to poor families. These introduced fruit varieties have been found to be in high demand for household food consumption and local markets. Since the project training and demonstration with support from the Department of Agriculture Extension Services, beneficiary households started harvesting of the fruit varieties two times a year. Each beneficiary generates BDT 10,000-15,000 from selling of the fruit varieties. The income has provided economic benefits for marginalized coastal families who have limited livelihood options.

While the livelihoods of coastal people are increasingly threatened with changing weather and extreme events, the diversified use of homestead areas motivated them to maximize their land uses and secure household food security. The high yielding quality and size of the Guava has raised local people's acceptance to cultivate the varieties. Guava serves as substitute for apples in vulnerable coastal areas, and with its high pectin content the fruit variety can be easily used for the preparation of jam and jelly.

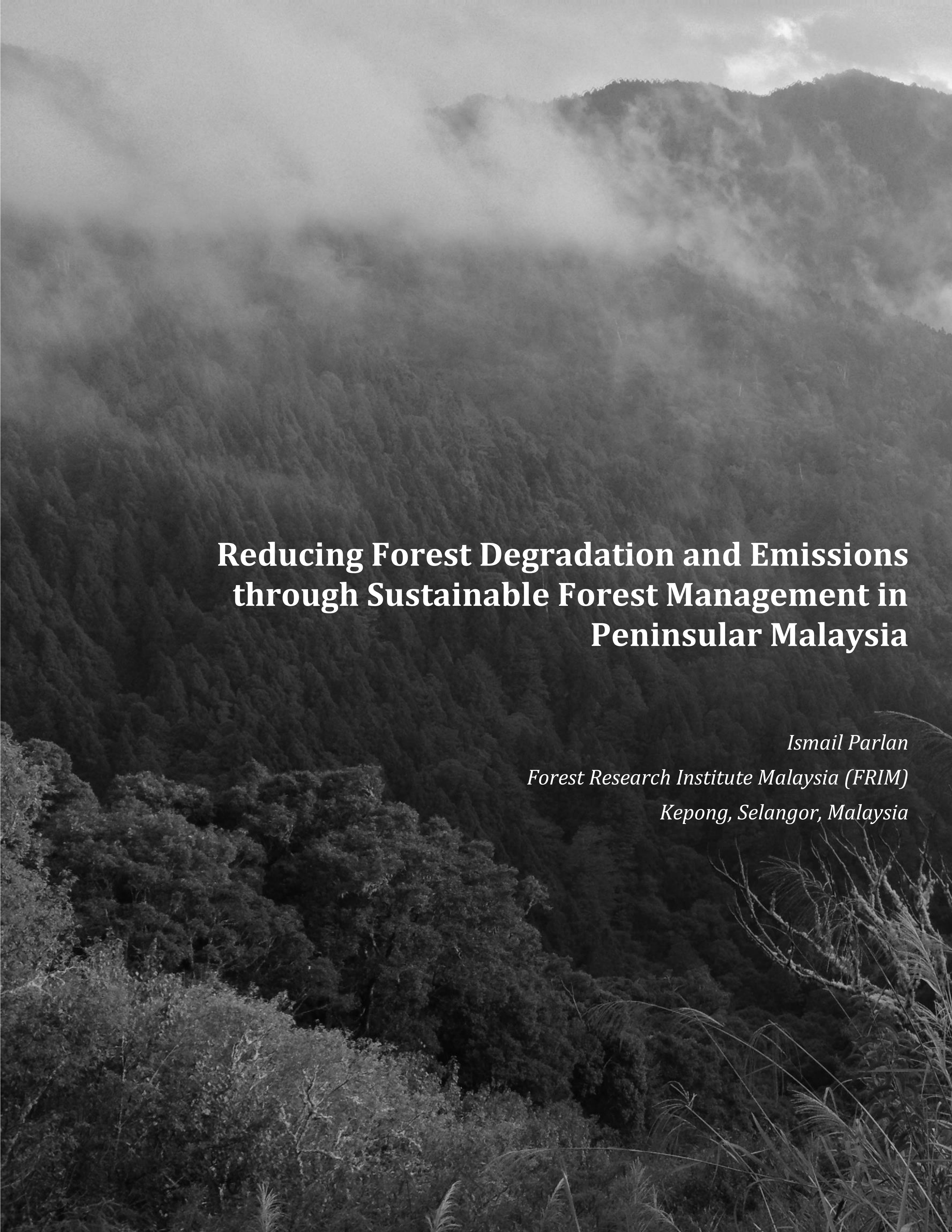
Capacity Building and Strengthening Community-Institutional Linkages

One of the objectives of the funding was to strengthen linkages between communities and institution. Towards this end, a database of government officials working at the district level was compiled in four project sites. Proper understanding on climate change risks, impacts and adaptation measures is limited within local and district-level institutions. District-level training programs have been established to enhance community knowledge. The project has developed a briefing note, a fact sheet, two brochures and training modules as immediate tools for capacity building and has organized 12 district and 24 upazila level training workshops.

Figure 6: Capacity building of local government institutions.

Mainstreaming Women's Role in Adaptation

Another key objective of the funding was to enhance the role of women in climate change adaptation. Accordingly another project has focused on women's involvement with the objective of developing their roles in local adaptation decision making, resource planning and implementation processes. In each project site, women beneficiaries participated in training measures for addressing climate change related risks in household livelihood security and identified their valuable roles and skills required for empowering in the long-run. The project involved 6,389 women in forestry, agriculture, aquaculture and livestock based training and income generating activities. A total 5,543 women beneficiaries received training on climate change related risk management and diversified livelihood practices including mangrove and non-mangrove nursery management, dyke plantation, agriculture and advanced aquaculture in project sites. Women beneficiaries learned about nursery preparation and planting methods, diversification of homestead crops, and cultivation and maintenance activities. Finally, women are now able to claim additional support from service delivery government departments and take advanced measures for livelihood protection to help ensure household income security.



Reducing Forest Degradation and Emissions through Sustainable Forest Management in Peninsular Malaysia

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Kepong, Selangor, Malaysia

Abstract

With more than 18 million ha of its land covered with natural forest, Malaysia enjoys one of the highest percentages of forested land among tropical countries. Consequently, the timber and timber products industry are very important and play a significant role in Malaysia's economy. At the same time, there is also an increasing recognition of the protective roles of the forests such as the conservation of biodiversity, protection of soil and water resources and stabilizing the climate. As such, Malaysia has accorded the management of the forests on a sustainable basis a high priority. Forest management in Malaysia is based on the Selective Management System, which involves the selection of a management regime to optimize not only the objectives of efficient and economic harvesting and sustained yield but, more importantly, to ensure that forest development is ecologically and environmentally sustainable. However, forest degradation in terms of carbon stocks is occurring in production forests as a result of logging operations. Harvesting operations in Malaysia in the past have also been reported to be damaging, but of late, significant improvements have been made. The extent of current forest degradation in terms of carbon stocks need to be further studied as it is still not well understood in Malaysia. Reports have indicated that improved forest management could reduce degradation and associated carbon emissions. However, all these studies are confined to specific areas and with limited information for scaling up activities. Here I describe a project designed to assess the potential for the enhancement of climate change mitigation through reduced emissions from forest degradation in Malaysia. Specifically, the project will determine emissions from forest degradation in logged forests and assess the value of enhancing forest management practices to reduce emissions from forest degradation. Financial evaluations of the improved management practices will be undertaken to provide avenues for assessing payment for ecosystem services.

Introduction

The forestry sector is one of the important economic drivers in Malaysia. Malaysia also recognizes the immense importance of the forest resource in providing environmental protection, particularly with respect to climate change. In this regard the issue of deforestation and forest degradation, being addressed under the UNFCCC, is a relevant and important issue for Malaysia. Malaysia has ratified both the UNFCCC in July 1994 and the Kyoto Protocol in September 2002 (Wan Razali 2008). The ratification of these international frameworks signifies the commitment of Malaysia in addressing the problems of climate change and sets the stage for further work on the issue. Malaysia's best practices approach to forest management has been successful in conserving biological resources and carbon stocks by avoiding the deforestation and forest degradation.

The role of forest management in climate change continues to be one of the most contentious issues in negotiations under the UNFCCC and the Kyoto Protocol. Under the Protocol, developed countries (Annex 1 countries) are committed to reduce their emissions of greenhouse gasses (GHG) to about 5% below their 1990 emissions levels. Since efforts to achieve their commitments are costly, the protocol introduces flexible mechanisms such the clean development mechanism (CDM) to assist in achieving their targets. Under the CDM, developed countries may collaborate with developing countries by investing in projects that reduce emissions or that enhance absorption of the GHGs. With respect to forestry, afforestation and reforestations projects are eligible. To ensure that projects are developed according to the priorities of the country, Malaysia has set up an Institutional Framework to address climate change issues and CDM projects (Samsudin et al. 2005).

Deforestation has been the cause of many problems facing the world today including erosion, loss of biodiversity through extinction of plant and animal species, and increased atmospheric carbon dioxide. Deforestation can also significantly impact soils and watercourses. Generally, the effects on soils are all adverse, but they do depend on location, mode of clearance, and soil sensitivity, (e.g. vegetation is slow to recover in very cold or very arid areas, while exposed soils are more likely to suffer where there is intense rainfall or strong sunshine). Often logging roads are cut into tropical forests so that tractors and log-haulers can get in and this causes major erosion problems. Changes in the tree canopy caused by cutting can alter the forest microclimate and affect the diversity and growth of other trees, low-growing plants and wildlife. The other major consequences of deforestation to be considered are the possible climate impacts.

Malaysia is still relatively well covered with natural forest that amounts to an area of 18.56 million ha or approximately 57% of the total land area in year 2007 (JPSM 2007; Thang 2007) as shown in Table 1 and Figure 1. A large proportion of this is located in Sabah and Sarawak with 61% and 67% forested areas, respectively. The total forest area within the country, legally designated as Permanent Reserved Forest (PRF), was estimated at 14.3 million ha or about 44% of the total land area (FRA 2010). Based on the forest regions, there are 4,696,000, 3,605,000 and

6,000,000 ha of PRF in Peninsular Malaysia, Sabah and Sarawak, respectively (FRA 2010). Forests under the PRF must be managed sustainably for protection, production, amenities, research and education purposes for the benefit of present and future generations.

Under the present National Forestry Policy (NFP), all remaining forested areas within the country are broadly classified according to productive, protective and amenity purposes so as to balance the needs for timber production and environmental protection (Figure 2). Forests play a vital role in the fight against global warming representing the largest terrestrial store of carbon and the third largest source of carbon emissions (due to loss of forest area). Malaysia, like many developing countries, lost forest area through conversion to agricultural, industrial, recreational and urban development uses.

Table 1. Total forested land and distribution of forest cover by major forest types in 2007 (millions of ha)

Region	**Land area**	**Dry Inland forest**	**Swamp forest**	**Mangrove**	**Forest plantation**	**Total forested area**	**Forested area (%)**
Peninsular Malaysia	13.16	5.34	0.30	0.10	0.10	5.84	44.4
Sabah	7.37	3.85	0.12	0.32	0.20	4.49	60.9
Sarawak	12.30	6.76	1.14	0.14	0.19	8.23	66.9
Total	32.83	15.95	1.56	0.56	0.49	18.56	56.5

Sources: JPSM (2007); FD Sabah (2007); FD Sarawak (2007)

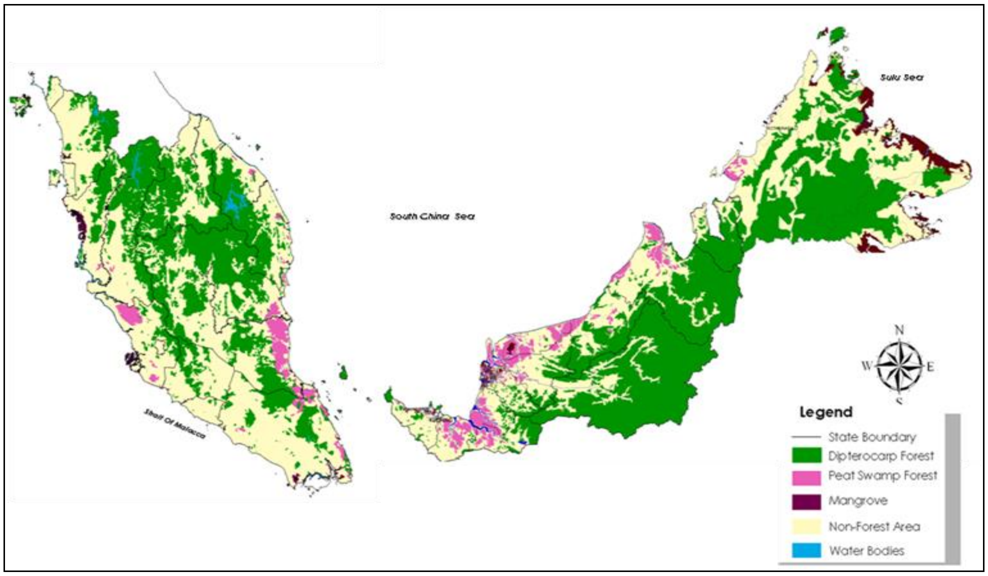

Figure 1. Forest areas in Malaysia

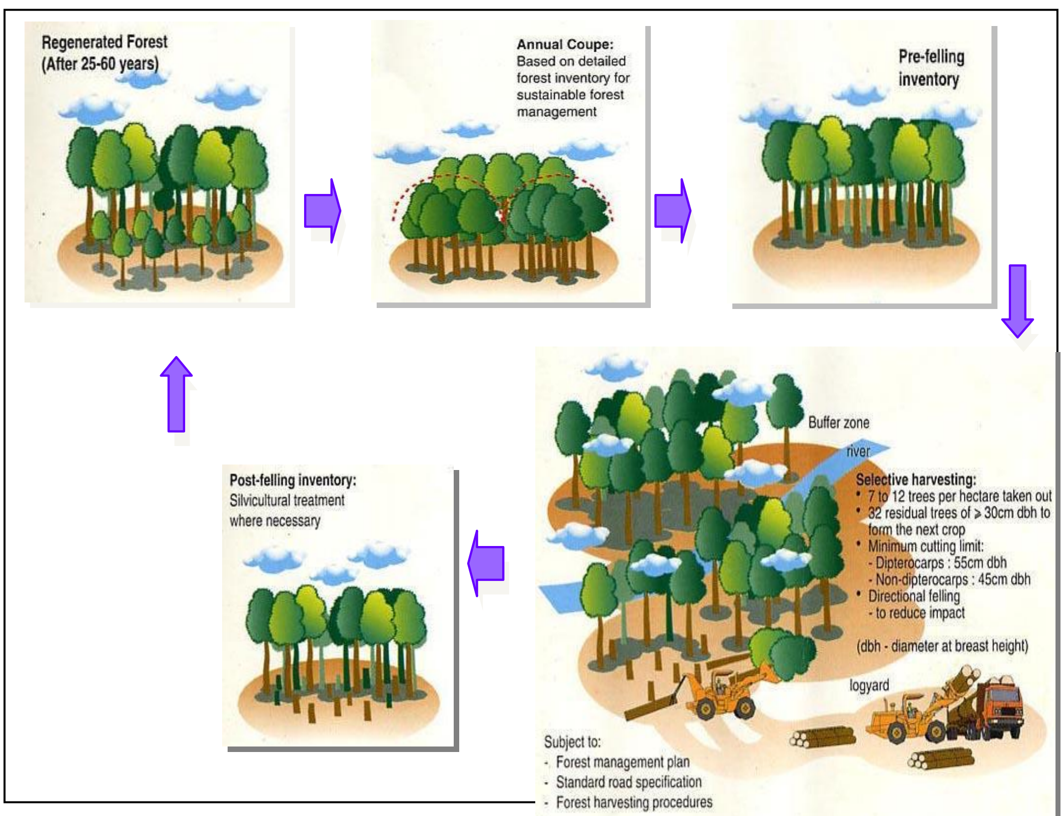

Figure 2. Sustainable forest management practices in Peninsular Malaysia (Source: FDPM)

All inland production forests in Peninsular Malaysia are currently managed under the Selective Management System (SMS). The system allows trees to be removed based on a flexible cutting regime where all trees above a prescribed cutting limit are removed. The determination of the cutting limit takes into consideration the existing growing stock, its increment and mortality, and a specified future crop at the end of a 30-year cutting cycle. However, there are concerns that the assumptions for the above factors in the implementation of SMS are not being met consistently and thus affecting the productivity of the residual stands. In addition, traditional ground-based logging practices have been reported to be damaging to the residual stand and the surrounding environment.

The introduction of Reduced Impact Logging (RIL) systems and practices has reduced the amount of damage associated with logging and improved stand conditions. More improvements to the current management practices are required to further enhance the productivity of the residual stand and reduce forest degradation in terms of total carbon stocks as well as other ecological factors. However, such sustainable forest management practices can be costly to the logging operators as well as the government. The REDD+ mechanism, currently being discussed under the UNFCCC, provides an incentive that may encourage implementation of improved management practices to reduce forest degradation.

Policy Development with Respect to Forest Management and Climate Change

Malaysia recognizes the concerns from various parties, both local and international, on the threats posed by climate change and the contribution of the forestry sector to emissions due to deforestation and forest degradation. Deforestation is defined as the transition from any forest type to non-forest type that involves a land use change; whereas, forest degradation is best described as the transition from a closed to an open or fragmented forest with no land use change. Malaysia has shown strong commitment in implementing sustainable forest management while supporting global efforts to curb deforestation and forest degradation. In this respect, Malaysia's invaluable forests need to be conserved and managed on a sustainable basis to prevent depletion and degradation of forest resources. There is a need for a better understanding of the impacts of management policies and practices on forest ecosystems and on overall emissions of CO_2.

Sustainable Forest Management (SFM) is one of the avenues proposed for reducing emissions from tropical deforestation and forest degradation. Under the SFM practices, forest degradation from harvesting activities is minimized in permanent production forests. Harvesting within the Permanent Reserved Forests (PRFs) is managed sustainably under the Selective Management System (SMS) based on a 30-year cutting cycle. However, there is a gap in information pertaining to rates of deforestation and forest degradation at the national level, as well as the drivers of deforestation and forest degradation in the past and present. As such, a new REDD project will established to provide a holistic approach with a better assessment of the situation. The project will be implemented in a pilot area involving a forest management unit such as the State of Pahang. Thus, the implementation of the project will involve the Forestry Department (FD) of Pahang. However, since the project deals with REDD cooperation with Federal agencies including the Ministry of Natural Resources and Environment (NRE) and the Forestry Department Headquarters Peninsular Malaysia (FDPM) will be essential.

Current Status of Forest Inventory and Growth and Yield Information

A National Forest Inventory (NFI) is conducted by FDPM in every five years in Malaysia. Nonetheless, it only covers forest areas in the Peninsular Malaysia. Growth and yield plots were established by the FDPM throughout forest areas in the Peninsular Malaysia. All relevant information on forest inventory and growth & yield information must be obtained from the FDPM.

Current Climate Change and Regional Action Plan (Adaptation and Mitigation Strategies)

A National Policy on Climate Change for Malaysia was adopted in 20 November 2009. The main objectives of the National Policy on Climate Change include mainstreaming climate change through the wise management of resources and enhanced environmental conservation. The policy also aims to strengthen institutional and implementation capacity to better harmonize opportunities to reduce the negative impacts of climate change. The policy is based on the principles of sustainable development, coordinated implementation, effective participation and common but differentiated responsibilities.

Climate Data Set (Weather Station Data Availability)

Climate data are available from the Malaysia Meteorological Department (MMD) who are responsible for collecting and managing the weather data throughout the country.

Regional Case Study

A case study project is currently being developed by the Forest Research Institute of Malaysia (FRIM). Both FRIM and the FDPM are under the NRE thus providing a direct link between research and policy formulation that is based on existing government structures (thereby increasing sustainability). The FDPM also provides an institutional avenue to link the project research activities into the FD Pahang planning processes. A Project Steering Committee (PSC) has been established to govern the implementation of the project. The PSC will provide guidance on matters pertaining to the implementation of the project and will ensure that the project is directed towards achieving its intended goals. It will enable the coordination of different agencies involved in the project. A national Technical Working Group (TWG) will be established to provide advice on technical issues as well as to provide the linkage with State Forestry Department decision-making processes.

The project will be conducted mainly through the implementation at the forest management Unit Level designated as the state of Pahang. Pahang is the largest state in Peninsular Malaysia consisting of about 3.6 million ha, of which 1.98 million ha or 55% is consists of forests. The forestry sector in Pahang is economically important and continues to contribute significantly to the states socio-economic development. Pahang also has the largest protected areas in Malaysia consisting of national parks and watersheds. There are significant populations of local communities and Orang Asli (aborigines) in the state of Pahang that are dependent on the forest for subsistence. They will be consulted in the project planning and implementation and their representatives will be able to participate in the project monitoring through the PSC.

This project has four outputs to be achieved as follows:

Output 1: Estimated national forest degradation

In addition to deforestation, forest degradation has also been identified as an important source of emissions from the forestry sector. Continuous and unabated degradation will lead to deforestation. In most tropical countries including Malaysia, there are concerns that production forests set aside to be managed on a sustainable basis often will experience degradation due to poor management systems and poor logging practices. In this regard, the forest area will experience degradation after each cutting cycle. In many cases the forest will not be fully recovered before the subsequent cut is carried out, thus resulting in a depletion of the carbon stock. In Malaysia, the extent of forest degradation in terms of carbon stocks is still not well defined. To this end research activities will be conducted to ascertain the extent of forest degradation. Baseline information on the level of forest carbon stocks as well other values such species composition and forest structure will be assessed before and after logging under current forest management prescriptions and logging techniques. Assessment of carbon stocks will also be made to assess changes in forest carbon stocks for forest of various temporal categories such second and third cutting cycles. Data on the extent of forest degradation in Peninsular Malaysia will be made available to all major stakeholders.

Output 2: Reduced forest degradation at the forest management unit

Attempts will be made to measure the extent of forest degradation within the Pahang forest management unit. Although forest operations are conducted in the production forests by compartments, often the year after logging will not be sufficient to indicate the degree of forest recovery or the level of forest degradation.

Since the logged forests are being managed on a 30-year cutting cycle, measures of degradation will have to take into consideration the age after logging and the ability of forest to recover within the cutting cycle. In addition, improved protocols will be introduced and tested to enhance carbon retention and reduce degradation. In particular, reduced impact logging systems designed to reduce the construction of skid trails and maintain forest structure will be tested to assess their potential for enhancing current management practices. Changes in carbon stocks under the improved forest management prescriptions and logging techniques will be assessed and compared with current practice. Other aspects such as forest structure and species composition will also be assessed to better understand the value of forest in additions to carbon stocks.

Output 3: Established incentives for carbon and ecosystems services

The success of participation and implementation of projects under the REDD+ in mitigating climate change will depend on the modalities still being negotiated under the UNFCCC as well as the costs involved. It is thus pertinent to understand the costs involved in implementing REDD+ projects. Since additional efforts are being carried out to further reduce degradation and enhance sustainable forest management, the cost involved and opportunity cost foregone by forest owners must be taken into account. Such information will also be useful for requesting incentives for the protection of ecosystems services. Enhanced ecosystems services from the forest from improved management will also result in an increase in the benefits rendered to forest dependent communities. An improved residual stand will result in better conservation of flora and fauna as well as improve forest recovery. This will result in added benefit to the forest communities.

A document on the provision of incentives for carbon and other ecosystem services will be developed and presented to key stakeholders including the Pahang State Economic Planning Unit, Pahang State, and Federal Forestry Departments as well as relevant Federal Ministries. Based on the feedback received, the incentive mechanism will be finalized and submitted to the Pahang State Government for consideration. These documents will be made available to the public in the projects website to be developed.

Output 4: Strengthened capacity of stakeholders and communities

As the research project involves exploring new areas in the planning and management of forest in relation to climate change it is expected that many new skills and capacity can be built. The input from external experts working together with local experts will be very valuable including the exchange of skills and experience. It is thus important that the project be implemented focusing on this capacity building both via on-the-job training as well as through more formal classroom training involving not only FRIM personnel but also relevant people from other agencies and organisations. The project should be undertaken in such a manner that by the end of the project, sufficient skill would have been built locally to enable effective implementation of nation-wide climate change policies and action plans. Trained personnel will also be able to transfer knowledge and technologies to be applied in other parts of the country and the region.

Summary

The general objective of this project is to utilize sustainable forest management (SFM) as a mitigation tool in combating climate change. As the deforestation rate is relatively stable in Malaysia, the emissions to be accounted for through the REDD mechanism would most likely come from the reduction of forest degradation in Peninsular Malaysia. The specific objective is narrowed down to improve knowledge on reduction of forest degradation and enhance payments for ecosystem services. Assessment of national forest degradation could be done based on identification of drivers and documentation of the forestry data supporting the cause of forest degradation. Guidelines and policy tools will be developed later to monitor and report national forest degradation in the country. In addition, the project will also study the economic aspect of establishing incentives in reducing forest degradation for carbon and ecosystems services. Opportunity cost for implementing the program will be evaluated, and suitable incentives procedures will be recommended for minimizing forest degradation through sustainable forest management practices.

Another key objective of this project is to build capacity amongst stakeholders and communities on the importance of SFM and climate change mitigation. This could be implemented through awareness programs such as organizing workshops and meetings for policy makers and forest managers. Information on the project's findings could be disseminated as well for better understanding of forest degradation in the country through outreach activities (i.e. publications, seminars, workshops).

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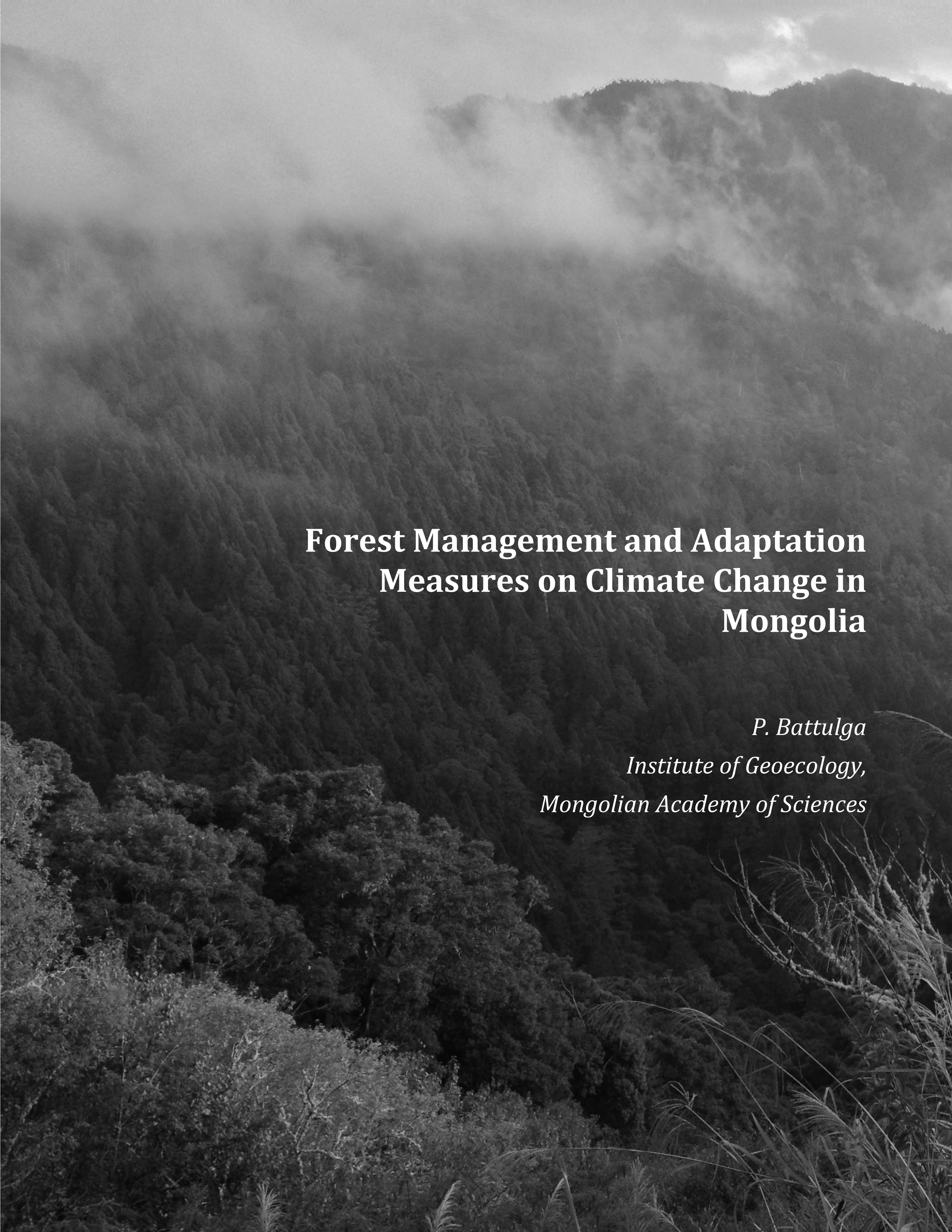

Forest Management and Adaptation Measures on Climate Change in Mongolia

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Introduction

Continuous change in Mongolia's climate has been observed in recent years. Between 1940 and 2007 the mean air temperature increased by 2.1^{0}C overall, by 1.9 to 2.3^{0}C in the mountain region and by 1.6^0 to 1.7^0 C in the Gobi and steppe regions. During the same period Mongolia's total annual rainfall has decreased by 1.7 to 12.5% in the Gobi region and increased by 3.5 to 9.3% in the eastern and western regions, respectively. The total forested area of Mongolia was 18.6 million ha in 2010 and 18.8 million ha in 2000, a decrease 20,000 ha in 10 years. Mongolia's forests are also subject to many disturbances. A total of 1190.4 thousand ha yr^{-1} of forests are damaged from forest fires, 95.6 thousand ha yr^{-1} are damaged from water stress, 249.1 thousand ha yr^{-1} are harvested for lumber, and 0.9 thousand ha yr^{-1} are damaged by natural disasters. These are the main factors that contributed to degradation forest resources.

Since 1970, Mongolia has been receiving information and images from the analogue Polar Orbit satellite. However, remotes sensing has improved with the establishment of a digital information station in 1987, and since 2007 Mongolia has been receiving satellite images of resolution of 250m from MODIS and the geostationary FY2C satellite which have increased monitoring quality significantly.

A detailed Forest Management Plan for Mongolia (2011-2015) was developed in 2010, which clearly laid out plans for forest utilization and rehabilitation. In 2011, the draft National Environmental Action Plan (NEAP) of Mongolia was developed through an initiative of the Ministry of Nature, Environment and Tourism, with the assistance and close coordination of the World Bank.

National Environmental Action Plan of Mongolia

The Action Plan was developed in accordance with the necessity of furthering environmental policy reforms using continuous planning principles. Problem issues were first defined, then the current state of the environment assessed and evaluated. Evaluations included the administrative capacity of the environmental sector, financing systems, strategies, objectives and proposed activities through 2021 and their performances were defined in the context of climate change projections. The scientific group of the Geo Ecological Institute was the lead agency in the development of this Action Plan. The participation of citizens, economic entities and local and central governments was deemed a high priority during the development and discussion of the draft Action Plan.

Key Objectives of NEAP

The primary objective of the National Environmental Action Plan is to identify and implement prioritized projects and cross-sector activities to address the stated targets and strategies of the Environmental Policy Reform within the framework of the Comprehensive Policy on National Development.

Specific objectives include the following:

- Creation of an integrated management system for natural resources and the environment capable of supporting ecosystem sustainability, assessing the number, distribution, and interdependencies land, forest, water, plant, animal and mineral resources, and ensuring planning and coordination of environmental projects and programs.
- Development of a cross-sector coordination and management system capable of addressing ecological roles and responsibilities and building capacity through education on sustainable development.
- Influence people's behavior to adopt a culture of ecological protection and develop new approaches for adaptation to further changes in climate.

The scope and phases of the NEAP

The National Environmental Action Plan covers the following strategies on environmental policy reform and actions to be implemented at the national level:

- Improving the living environment by reducing environmental pollution and degradation
- Preventing water scarcity and pollution by accumulating water in storage and using water resources more efficiently
- Establishing sustainable land use management
- Creating sustainable management for forest conservation, utilization and rehabilitation
- Protecting biological diversity, utilizing natural resources in a sustainable manner, rehabilitating in case of damage, and preventing species extinction
- Reducing the negative consequences of desertification and climate change
- Forming a development path for a "Green Economy"

STRATEGIC MEASURES

The most significant forest policy measures at the national level have been identified as follows:

Forest Management

• Introduce remote sensing technology and geographical information systems for determine of forest conditions and to develop the forest inventory

• Supporting forest inventory enterprises for all types of ownership, forest inventory capacity will be increased by 1.5-2.0 times.

• Thinning and pruning in selected forest areas will be conducted by jobless people and youth with support from professional institutions and forest owners to enhance tree growth and improve wood quality.

• Forest fire prevention and management plans will be developed with expenditures budgeted and financed in annual local budgets.

• Create forest fire prevention breaks and forest dividing lines in state border zones and some required areas.

• Detect fires and fight hot spots using satellite information and air guard for forest fire monitoring and fire prevention groups.

• Provide natural disaster and fire fighting units with communications means and fire fighting equipment.

• Reduce forest fires with minimal losses by seeding clouds to increase rainfall.

• Take measures for the prevention forest damage through insect and disease by intensifying research work.

• Modernize laboratory research, laboratory equipment and provide qualified personnel for fighting harmful insects and disease.

• Promote biological and environmental friendly technology for fighting harmful insects and to organize necessary produce in the country.

Forest harvesting and wood utilization

• Determine annual allowable harvest volume through the use of growth and yield information in combination with improved inventories.

• Improve procedures for allocating forest resources and forest harvesting technology to promote natural regeneration.

• Consolidate the management of forest resources to an economic entity or organization with the capacity to combine logging, reforestation and forest protection.

• Cease cutting of young and immature stands.

• Protect forests from fuel wood harvesting. In the Gobi zones wholesale trade centers of fire wood and timber consumer goods will be established.

• Consider the extension of forest roads for forest protection, silvicultural management and wood utilization.

• Limit export of wood and timber products, and encourage a policy of wood import.

• Replace railway sleepers with non-wood alternative materials

• Reduce wastage of logging, and utilize tree tops, branches of trees, sawdust, bark, low quality wood and off-cuts by employing mechanical and chemical treatments

• Develop long-term plans to supply internal and external markets with forest products including: essential oil out of conifers, vitamin powder, medicine extract, pine-tar oil, resin out of larch and pine trees, charcoal out of birch.

• Develop technology and initiatives for enhanced use of birch including parquet flooring, construction of wooden parts and other wood products.

• Establishment of small and medium sized wood processing factories that are able to compete on the market by modernizing the furniture and wood products industries.

• Create favourable conditions for the establishment of factories to produce particle board, single layer board, plywood, and veneer.

• Establishment of small and medium sized wood processing factories combining traditional and modern technology to produce consumer timber goods for countryside herdsmen will be supported.

• Develop inventories of non-timber forest products period for each region.

• Instructions, recommendations and a handbook will be compiled and followed to improve use of non-wood products such as pine seeds, berries, mushrooms and medicinal plants

• Support an increase in household income by promoting non-wood product processing and adding to its assortments.

Forest conservation

• Organize seed collection based on genetic selection evaluation and set up seed harvesting sites in each forest vegetation zone.

• Establish tree seed analysis laboratories with improved facilities and equipment.

• Establish seed tree plantations with selection of superior trees.

• Provide financial support for the establishment of tree breeding nurseries for the greening of settlements, reforestation and the creation of shelterbelts to combat desertification and soil degradation in pasture and crop land.

• Expand reforestation work by 10 thousand ha annually by recruiting local citizens, youth and the public community to assist in seed collection and the planting of tree seedlings.

• Provide portable equipment for forest nursery and reforestation work.

• Introduce suitable technology to help guide natural forest regeneration and tree planting activities in accordance with forest vegetation zones and regions.

• Implement regulations for conducting reforestation with respect to monitoring, evaluation and procedures for financing and transferring to state forest land.

• Reduce desertification through the creation of forest strips and small stands to protect cropland and pastures.

• Enhance plantation develop through changes in ownership laws

Technology transfer and forestry research

• Intensify scientific investigations for the development of modern technology for forest protection, utilization, regeneration, and sustainable management.

• Utilize output from scientific research to support: the development of the special protected area's management, protection of forest biodiversity, conservation of soil and water resources and the reduction of desertification.

• Conduct research in the field wood products development using a wide range of materials.

• Promote the institutional structure of research institutions of the forestry, forest harvesting and wood processing industry.

Human resource development

• The significance of forest resources and legislation related to forest management will be widely advertised and publicized.

• Local authorities will be trained and educated in the field of forest legislation, the development of forest inventories, forest protection, forest resource use and reforestation.

• Improve the quality of education in National Universities and colleges that train forest specialists

• Trained experts who currently work in forestry will be enrolled in short term and long-term training either in Mongolia or abroad.

• Forest owners and workers with qualifications who are able to run forest industry processing will be trained and re-trained in accordance with a special plan.

• Inter-governmental agreements on fighting and prevention of trans-boundary forest fires will be signed with neighbouring countries.

The Mongolian Second National Communication under the United Nations Framework Convention on Climate Changes (UNFCCC) summarizes the measures and actions which have been taken by the Government of Mongolia to meet its commitments and obligations under UNFCCC, government policy and strategies to solve climate change challenges, and key findings results of climate change research and studies conducted in Mongolia.

Policies and measures on adaptation to climate change

- Improve forest management
  The following major mitigation options have been identified for the forestry sector. 1) Natural regeneration; 2) Plantation forestry; 3) Agro-forestry; 4) Shelter belts; and 5) Bioelectricity;
- Reduce emissions from deforestation and forest degradation, improve sustainable management of forests and enhance forest carbon stocks in Mongolian forest sector
  There is potential for the reduction of GHG emission from deforestation and forest degradation in Mongolia. Therefore, it is possible to initiate and implement a REDD project in Mongolia through reforestation activities by community based forest management improvement and sustainable use of forest resources.

Table 1. Adaptation strategy and policy and measures by sector in Mongolia.

Sector	**Strategy**	**Policy and Measures**
Forestry	Ensured sustainability of forest resources	Strengthening forest resources protection and conservation management
		Expanding green areas and trees in urban areas
		Supporting tree-planting initiatives of individuals and organizations, and introduction of advanced technologies
		Increased resources of shrubs and bushes in the Gobi desert area through appropriate solutions of household fire fuels

Adaptation measures, needs, challenges and opportunities

Various adaptation options and measures to reduce the adverse impacts of climate change were identified in the National Action Plan on climate change updated in 2010.

Depending on factors such as climate change and harmful human activities, forest ecosystems are being changed though the deterioration of forest resources, epidemic of insects and diseases, and frequent forest fires, etc. However, these changes are not being recorded properly because a systematic monitoring system of forest inventories does not exist in Mongolia.

Supporting natural ecosystems adaptation

Conservation of Mongolian ecosystems means protection of rangeland from degradation and the restoration of degraded land at the lowest possible cost. One of the best practices for the protection of ecosystems is to establish a network of protected areas including ecosystems of representative regions that have natural and economic significance.

In 2008, 14% of the total territory, which is 61 areas of 21.9 million ha were taken under state protection. The Millennium Development Goals aim to have 30% of the total land under protection in the future.

Adaptation measures in forestry

The main approach towards the protection of forest resources is to enhance the protected area network. Recently, the Parliament of Mongolia endorsed a new law banning mining activities in forest and water resource areas. The Millennium Development Goals based Comprehensive National Development Strategy stated the importance of sustainable utilization of forest resources through forest protection, restoration and maintaining ecological balances. The strategy can be implemented through the following measures:

- Organizing afforestation activities in at least 12 thousand ha areas in a year and implementation of the Government 'Green Belt' program on land of at least 200 ha.
- Ensuring tree and bush seed production of at least 5 tons and planting 30 million seedlings per year
- Conducting surveys of forest insects and diseases distribution (1,200 thousand ha yr^{-1}) and implementing actions against harmful forest insects and diseases (68.5 thousand ha yr^{-1}).
- Regulation of annual logging. Logging areas can be established as 20-30 thousand ha yr^{-1} depending on tree species, quantity and capacity.
- Strengthening forest fire prevention and fighting systems.

- Introduction of enhanced forestry management methods. Community ownership on 20 percent of the total forest fund by local communities and forestry groups should be established to ensure forest protection restoration and proper utilization of forest resources, etc.

Biomass Case Study: Siberian Larch

With the growing concern about predicted global warming, the idea of biomass production and storage in forest stands and their role in the carbon cycle draws public attention. Mongol Altai mountain ranges located at 44^0-50^0N, 88^0-96^0E, 1,000-1,800kms from capital city of Ulaanbaatar stretches approximately 800km from the northwest to the southeast. The forests distributed in Mongol-Altai mountain range represent the southwestern boundary of Mongolian forest distribution and are located far from the massive forest of Northern Mongolia. The forests have a patchy distribution within limited areas and grow slowly under sub-boreal, sub-arid and strongly continental climates. They are commonly referred to as “relic forests”.

Siberian larch (*Larix sibirica* Ledeb.) is Mongolia's dominant tree species, which covers 80 % of the forested area of the country (*Tsogtbaatar 2004*). Forests in Mongolia are not systematically managed with a methodology that would ensure sustainability. Rather, logging is largely driven by the demand for construction timber and fuelwood for which permits are sold by the government. The logging is conducted by local stakeholders including pastoral nomads and wood traders who have no specific training in forestry (*Lkhagvadorj et al. 2013*). A considerable part of this wood is harvested illegally (*Erdenechuluun 2006*).

A study was conducted to measure biomass in these forests using allometric biomass equations. The selection of allometric regression models for estimating the above-ground biomass y (in kg dry weight) of larch from DBH D (in cm) and tree height H (in m) followed Hosoda & Iehara (2010), who modeled the above-ground biomass in *Larix kaempferi* and two further species of coniferous trees:

$$y = aD^b \quad (1)$$

$$y = a(D^2 H)^b \quad (2)$$

$$y = aD^b H^c \quad (3)$$

$$y = (D^2 H)/(a+bD) \quad (4)$$

Biomass functions were established to estimate aboveground biomass of Siberian larch (*Larix sibirica*) in the Altai Mountains of Mongolia. The functions are based on biomass sampling of trees from 18 different sites, which represent the driest locations within the natural range of *L. sibirica*. The best performing regression model was found for the equations $y = (D^2 H)/(a+bD)$ for stem biomass, $y = aD^b$ for branch biomass, and $y=aD^b H^c$ for needle biomass, where D is the stem diameter at breast height and H is the tree height. The robustness of the biomass functions was assessed by comparison with equations that had been previously published from a plantation in Iceland. There, $y=aD^b H^c$ was found to be the most significant model for stem and total aboveground biomasses.

Applying the equations from Iceland for estimating the aboveground biomass of trees from Mongolia resulted in the underestimation of the biomass in large-diameter trees and the overestimation of the biomass in thin trees. The underestimation of thick-stemmed trees is probably attributable to the higher wood density, which has to be expected under the ultra-continental climate of Mongolia compared to the oceanic climate of Iceland. The overestimation of the biomass in trees with low stem diameter is probably due to the high density of young growth in the not systematically managed forests of the Mongolian Altai Mountains, which inhibits branching, whereas the plantations in Iceland are likely to have been planted in lower densities (Battulga et al., 2013).

Initial results show that three-quarters (76.2%) of the total aboveground biomass was allocated in the trunk, whereas the branches accounted for 19.1% and the foliage 5±0%.

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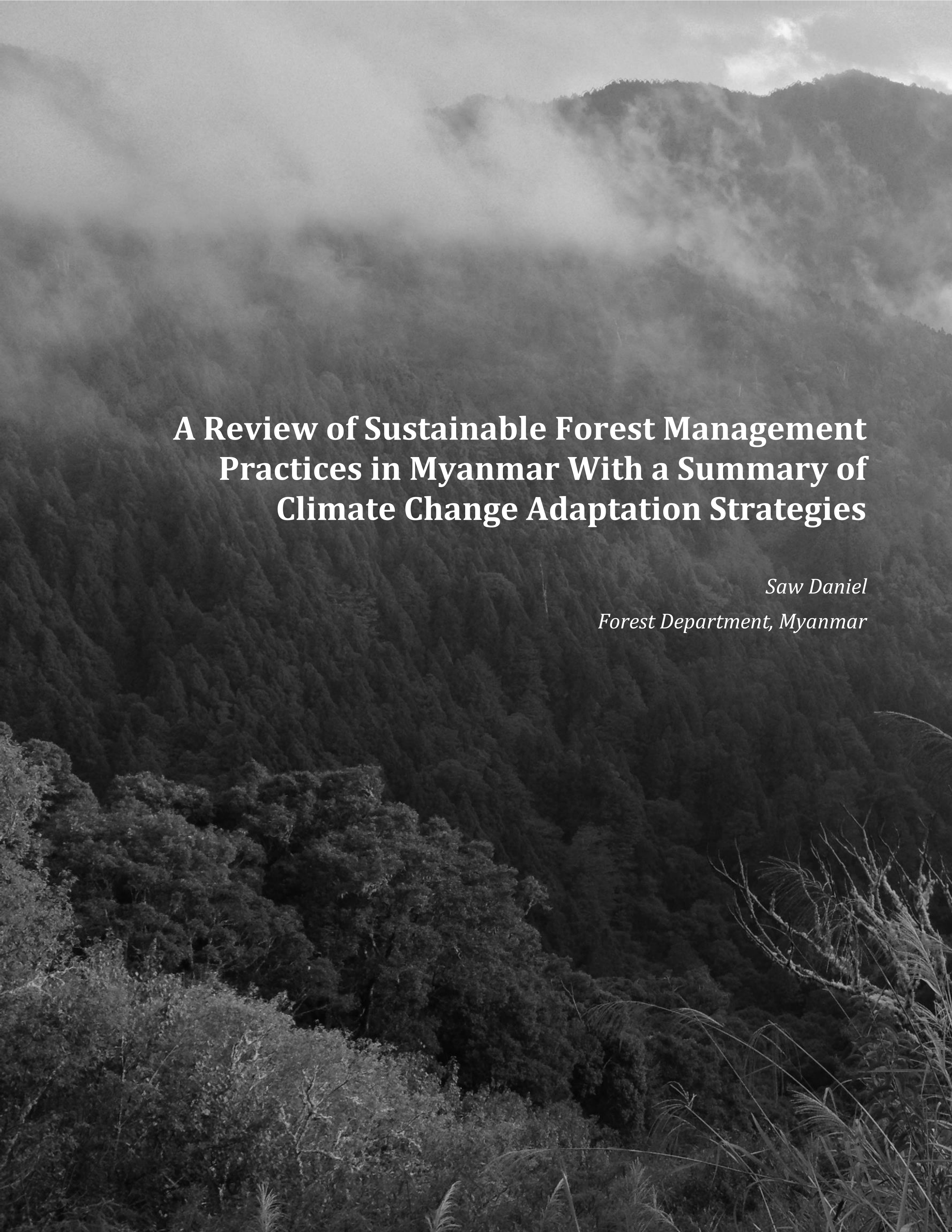

A Review of Sustainable Forest Management Practices in Myanmar With a Summary of Climate Change Adaptation Strategies

Saw Daniel

Forest Department, Myanmar

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Introduction

Forests in Myanmar play a vital role in stabilizing environmentally critical areas such as coastal areas, dry zones, and hilly regions by providing protection against natural disasters. Myanmar forests have extremely high floral and faunal diversity. They harbour about 7,000 species of vascular plants including 1,696 species of climbers, 65 species of rattans, and 841 species of orchids. Eighty-five species of trees have been identified premium sources of timber. More than 25,000 species of vascular plants, about 300 species of mammals, 360 species of reptiles and more than 1,000 species of birds also inhabit within the country.

Location

The Republic of the Union of Myanmar (Myanmar) is situated on the western end of Southeast Asia (between 9º 55’, 28º15’ N and 92º 10', 01º 10' E). It is bordered by the Andaman Sea and the Bay of Bengal (2,330 km), Thailand (2,325 km), Laos (235 km), China (2,185 km), India (1,454 km) and Bangladesh (258 km). Myanmar is the largest country in Southeast Asia, covering approximately 676,578 km^2 and extending 800 km east to west and 1,300 km north to south (Figure 1).

Administrative Units

Myanmar is divided into 14 administrative units comprising seven States (Kachin, Kayah, Kayin, Chin, Mon, Shan and Rakhine) and seven Regions (Magway, Mandalay, Sagaing, Bago, Tanintharyi, Ayeyarwady and Yangon). Yangon is the largest city in the country. However, the smaller but more central Naypyitaw serves as the capital. States and Regions are subdivided into districts, which are further subdivided into townships, sub-townships, wards, village tracts and villages.

Population

Myanmar has an estimated population of 54.6 million (73 people per km^2). Approximately 67% of the population live in rural areas with 33% living in urban areas. The majority of the population is concentrated in the Ayeyarwaddy basin, situated in between the Rakhine Yoma and the Shan Plateau. This includes the areas in the Central Belt (Sagaing, Magway and Mandalay Regions), the Ayeyarwady Delta, Yangon Deltaic region and parts of the Shan Plateau. Regions are predominantly inhabited by the dominant ethnic group Bamar. States are essentially Regions that are inhabited by other ethnic groups.

Economy

Myanmar's economy is one of the least developed in the world. In the past, GDP growth has been relatively slow averaging ~2.9% annually. A change of government in 2011, however, induced a number of policy reforms that increased GDP growth to 10% per annum. In 2011, Agriculture contributed ~43% to GDP, services ~36.6% and industry ~20.5%. Agriculture, forestry, and fisheries constitute the largest contribution to the economy. Approximately 75% of the rural population rely on the agriculture, livestock and fisheries sectors for their livelihoods. Other major livelihood activities in Myanmar utilize the following major products:

i) wood and wood products; ii) copper; iii) tin; iv) tungsten; v) iron; vi) cement; vii) construction materials; viii) pharmaceuticals; ix) fertilizer; x) natural gas; xi) garments; xii) jade; and xiii) gems.

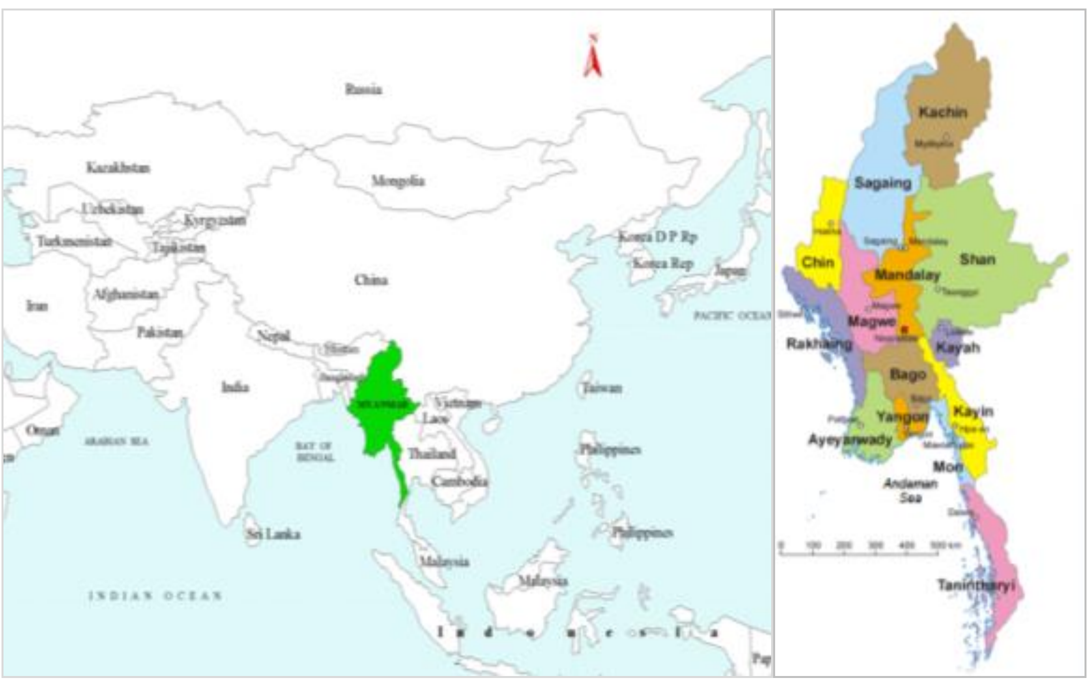

Figure 1. Map showing the location of Myanmar (left) and its state and regions (right)

Physical Features and Topography

Myanmar slopes from an elevation of 5,881 m in the extreme north at Mount Hkakabo (the country's highest peak) to the Ayeyarwady (Irrawaddy) and Sittang (Sittoung) river deltas at sea level in the south. There are three main mountain ranges, the i) Rakhine Yoma (western range 400 km including the Patkai, Naga, Mizo, Chin and Arakan hills/mountains), ii) Bago Yoma/Pegu Mountains (south-central range 435 km), and ii) the Shan Plateau (eastern range). The mountain ranges divide the country into three river systems, the: i) Ayeyarwady, which is the longest river system in Myanmar (Irrawaddy), ii) Sittoung; and ii) Salween (Thanlwin). The Ayeyarwady (2,170 km long), with its major tributary the Chindwin (960 km) has a vast drainage area (~255,081 km^2) that supports a range of socio-economic sectors and livelihoods in the country. As the Ayeyarwady enters the sea it forms a delta of ~50,400 km2.

The country as a whole can be divided into three main zones: i) Central Dry; ii) Coastal; and iii) Hilly. These zones can be further subdivided in eight physiographic regions: i) Northern Hilly; ii) Central Dry; iii) Rakhine Coastal; iv) Western Hilly; v) Eastern Hilly (Shan Plateau); vi) Ayeyarwaddy Delta; vii) Yangon Deltaic; and viii) Southern Coastal (including Tanintharyi coastal strip).

Climate

Myanmar has a tropical to subtropical monsoon climate with three seasons: i) hot, dry inter-monsoonal (mid-February to mid-May); ii) rainy southwest monsoon (mid-May to late October); and iii) cool relatively dry northeast monsoon (late October to mid-February). Mean annual rainfall is the lowest in the Central Dry Zone (500-1,000 mm yr^{-1}), increases in the Eastern and Northern Hilly regions, and is the highest in the Southern and Rakhine Coastal regions (2,500 – 5,500 mm yr^{-1}). Mean temperature ranges from 32°C in the coastal and delta areas to 21°C in the northern lowlands. Seasonal temperatures generally vary greatly throughout most of Myanmar. In the Central Dry Zone temperatures range from a maximum of 40-43°C in the hot/dry season to10-15°C in the cool/relatively dry season and decrease to -1ºC or 0ºC at times in the highlands. Seasonal temperatures do not vary much in the southern parts of the country. Myanmar's west coast is subject to frequent tropical storms and cyclones during October to December with a secondary peak in April to May.

Forest Resources

Myanmar is rich in natural forests and approximately half (49% or ~317,730 km2) of the total land area is forested. Forest type and distribution is mostly dependent upon the landscape of the country.

- the delta and coastal regions are comprised of mangrove and estuarine forests;
- the arid and semi-arid regions are comprised of deciduous and dipterocarpus forests;
- the low rainfall areas (particularly the Central Dry Zone and surrounding areas) are comprised of dry thorn and scrubland forests;

- the high rainfall regions are comprised of evergreen forests, and
- the subtropical high altitudinal areas are comprised of hill evergreen and sub-alpine forests.

The forests in Myanmar underpin the development of a range of socio-economic sectors and local livelihoods. Forests provide revenue from the supply of forest products and services. They also provide a number of ecological supporting functions such as sequestering carbon, regulating microclimates, protecting topsoil from rain and sun, stabilizing soils and providing habitats for globally important animal/plant species. e.g. Bengal tigers and Asian elephants.

Policy, Legislation and Institutional Arrangement

Myanmar Forest Policy has been formulated in a holistic and balanced manner within the overall context of the environment and sustainable development. In order to achieve broader national goals and objectives, the policy has identified six imperatives that must be given the highest priority. Forest management in Myanmar had functioned legally under the Forest Act of 1902 until 1992. During 90 years of its enforcement, the Forest Act of 1902 was amended several times to suit the changing political and socio-economic conditions in the country. The Forest Law, enacted in November 1992 to conform to current concepts and situations, highlights forest protection, environmental and biodiversity conservation. It also established permanent forest estates (PFEs) and the protected areas system (PAS). The law also provides opportunities for the promotion of private sector involvement in reforestation and timber trade, and decentralizes management responsibilities. Along with the 1992 Forest Law, new set of forest rules were promulgated in 1995. As mandated by the Forest Law, the Forest Department (FD) is the main institution responsible for the protection and conservation of wildlife, and the sustainable management of forest resources including forest restoration and rehabilitation activities.

The 1995 Myanmar Forest Policy formalizes the commitment and intent of the government to ensure the sustainable development of forest resources for social, environmental and economic purposes. The policy paves the way for prudent use and enhanced benefit from the forest while maintaining the integrity ecosystems and environmental balance. Six imperatives identified in the policy are:

(1) protection of soil, water, wildlife, biodiversity and the environment;

(2) sustainability of forest resources to ensure perpetual supply of both tangible and intangible benefits accrued from the forests for the present and future generations;

(3) basic needs of the people for fuel, shelter, food and recreation;

(4) efficiency to harness, in a socio-environmentally friendly manner, the full economic potential of the forest resources;

(5) participation of the people in the conservation and utilization of forests; and

(6) public awareness about the vital role of forests in the well-being and socio-economic development of the nation.

Development of Policy Instruments and Guidelines

***Criteria and indicators* (C&I):**

Identification of Myanmar's C&I for SFM at both national and Forest Management Unit (FMU) levels was completed in October 1999, and formally approved by the Ministry of Forestry. The document, which is based on C&I from the International Tropical Timber Organization (ITTO) in 1998, contains 7 criteria at both national and FMU levels. There are 78 indicators and 257 required activities at the national level, and 73 indicators and 217 activities at the FMU level with standards of performance for each activity. The Forest Department has been testing the adequacy and application of Myanmar's C&I at FMU level for further improvement.

***Code of practice for forest harvesting*:**

The Ministry of Forestry developed the National Code of Forest Harvesting Practices in Myanmar in 1999 with FAO's financial and technical assistance. A number of training courses have been provided to the staff of the Extraction Department of MTE to ensure a thorough understanding and immediate implementation in the field. Pilot implementation of the applicability of the Code at the field level was tested in the Paukkhaung model forest. On the basis of the findings, the Code is being reviewed and will be revised accordingly.

Forest Management Planning

The National Forestry Master Plan (NFMP) was initiated by the Forest Department in 1998 as a National Forest Programme (NFP) exercise for a 30-year period from 2001-02 to 2030-31. The plan comprises 19 chapters reflecting not only the current status of the forests in Myanmar but also social and macro-economic policies of the country. The plan has been approved by MOF. In addition to the interest of country's economic development, the plan also focuses on the development of rural communities and consists of strategies for poverty alleviation through the creation of job opportunities, permission of use of forestlands, extraction of non-wood forest products, and the diversification of sources of energy and income through extension activities such as training and demonstrations. Establishment of forest plantations, community forestry development, bio-energy, non-wood forest products, human resource development, and forestry extension are the major components of the NFMP. The NFMP will be implemented in cooperation with other related ministries, including Ministry of Agriculture and Irrigation Department, Ministry of Energy, Ministry of Livestock Breeding and Fisheries, and Ministry of Progress of Border Areas and National Races and Development Affairs among others.

For administrative purposes, the country was divided into forest districts. Each Forest District is a forest management unit (FMU), for which a separate management plan called a working plan is formulated and implemented. A medium-term plan for 10 years had its annual yield checked at mid-term and revised at the termination of the period. All forestry activities were carried out strictly as prescribed in the plan. Management plans divide the forest districts into Working Circles (WCs) on the basis of forest types, accessibility, management objectives, nature and form of forest produce available. The Myanmar Selection System (MSS) is applied in all the WCs comprising natural forests.

In 1996, the Forest Department launched a special operation to update and reformulate the old working plans in line with modern forestry concepts. The new forest management plans at the civil district level place emphasis not only on timber production but also on non-wood forest products (NWFPs), biodiversity conservation and the socioeconomic well being of local people. New management plans for 65 districts covering the whole of the country have already been formulated, and adopted for action with the approval of the Ministry of Forestry (MOF), which was recently changed to Ministry of Environmental Conservation and Forestry (MOECAF).

Silvicultural Systems for Natural Forest Management

The management of natural teak forests in Myanmar was founded on a concept that has gradually evolved to become known as the Myanmar Selection System (MSS). The MSS, a combined exploitation and cultural system, has been the main silvicultural system practised in the management of natural teak bearing forests in Myanmar. The system involves the adoption of a felling cycle of 30 years, prescription of exploitable sizes of trees, girdling of teak, selection marking of other hardwoods for felling, removal of less valuable trees interfering with the growth of teak, thinning of congested teak stands, enumeration of future yield trees and fixing of annual allowable cuts (AAC) for teak and other hardwoods. Exploitable limits are fixed at sizes beyond which trees are not expected to put on appreciable increment and their retention would only impede new regeneration. However, it is not rigidly prescribed that all and only trees of the exploitable limits are selected for felling. Unhealthy trees that cannot attain the exploitable sizes, but are marketable, are also selected for cutting. If seed-bearers are scarce, a few high quality stems of and above the exploitable size may be retained as seed trees. Trees left standing at the time of the selection are recorded down to specific sizes for calculating the future yield. The AAC is revised periodically, in accordance with the existing stock.

Two major silvicultural treatments are being practiced in natural forests. Depending on the structural characteristics and regeneration potential of the forest, either improvement operations or enrichment plantings are applied. Improvement felling is usually done in the natural forests in conjunction with girdling operations in order to enhance natural regeneration, establishment and growth of commercially important species. Cleaning, climber cutting and coppicing are also done to improve natural regeneration. The effectiveness of the treatment relies on the existing regeneration of desirable species that have already established. Two types of enrichment planting, namely, gap planting and line planting are practiced. Gaps created in the natural forests are planted with suitable tree species and valuable species introduced in areas where the forest density and the composition of commercial tree species are low with a view to enriching existing forests. However, line enrichment is more common today because of difficulties in control and retracing irregularly spaced gaps for tending operations.

At present, Myanmar is marching towards democratization and a market-oriented economy under reform strategies. Existing policies, laws, regulations and practices are being reviewed and amended as required. Log export will be banned on 1st April 2014, which will increase supply of raw material and production of value-added finished products.

Plantation Forestry and Re-afforestation Program

Myanmar initiated the formation of teak plantations as early as 1856 on a small scale using the Taungya method. Although afforestation gained momentum in the early 1960s, large-scale plantation forestry had not begun until 1980. More than 30,000 ha of forest plantations had annually been formed in the 1980s. Since then the annual plantation program has been intensified gradually till it has reached the present target of over 40,000 ha. This annual planting target includes over 30,000 ha planted by the Forest Department and about 10,000 ha planted by the Dry Zone Greening Department (DZGD) for greening the Central Dry Zone of Myanmar. Plantation forestry, however, has always been supplemental to the natural forest management and existing natural forests will not be substituted with plantations as clearly stated in Myanmar Forest Policy, 1995. The objectives were to rehabilitate degraded forest lands, restore deforested areas and supplement various timber yields from the natural forests. The Forest Department establishes four types of plantations, namely commercial plantation, village supply plantation, industrial plantation and watershed plantation. Since 2006, the private sector has allowed to establish teak plantations. Some 20,000 ha of teak plantations have been successfully established by private sector to date.

Rehabilitation of Mangrove Forests

Mangrove forests are found at three geographical locations along the coast of Myanmar, concentrated particularly in the delta of Ayeyarwaddy River. Depletion of mangrove forests has resulted in the loss of coastline protection, decreased crop production, and declines in fish and prawn catches among other things. Most of remaining mangrove forests suffers from various levels of degradation. As such, the rehabilitation of these forests has become a crucial issue. The Forest Department is implementing rehabilitation tasks such as regeneration and improvement felling in the remaining mangrove forests. They have also begun plantation establishment in depleted areas, abandoned paddy fields, and in community forestry areas. In cooperation with international organizations, conservation and rehabilitation projects have been also carried out.

Wildlife and Nature Conservation

The British colonial government in 1918 established the first wildlife sanctuary named the Pidaung Game Sanctuary. The 1936 Wildlife Protection Act provided for the establishment of sanctuaries on land at the disposal of the government. Myanmar started systematic wildlife conservation activities in 1981 under the UNDP/FAO Nature Conservation and National Park Project. Total sanctuary cover has been steadily rising and dramatic increases have occurred during last 10 years. Logging in sanctuary areas is completely banned. The new Protection of Wildlife and Wild Plants and Conservation of Natural Areas Law replacing the old Burma Wildlife Protection Act of 1936, was enacted in 1994. The law highlights habitat maintenance and restoration, protection of endangered and rare species of both fauna and flora, establishment of new parks and naturally protected areas, and buffer zone management.

Participatory Forest Management Activities

Within the legal framework adopted in the Forest Law, the Forest Department of Myanmar issued Community Forestry Instructions (CFIs) in 1995 with the objectives to attain environmental stability and to meet the basic needs of rural communities. The CFIs highlight land allocation for community forestry on the usufruct basis and also stress the importance of local community participation in managing forests to meet their basic needs for firewood, small timber and non-wood forest products (NWFPs). Environmental conservation is also an important aspect of the CFIs. The Forest Department provides necessary assistance to local communities in the establishment of community forests. The CFIs clearly demonstrates the sharing of forest management responsibilities towards the rural communities through user groups' activities and efforts with in-kind and technical assistance from the Forest Department. It also focuses on the flow of benefits to the rural poor, participating in forest management activities.

Environmental Stresses and Impacts on Socio-Economic Sectors

Four main environmental stresses affect Myanmar: i) climate related hazards/extreme weather events; ii) habitat degradation; iii) deforestation; and iv) diminishing water resources. Environmental stresses are directly and/or indirectly associated with climate change/climate variability and affect biophysical processes that underpin a range of socio-economic sectors e.g. agriculture, water, energy, public health and natural resources.

- **Climate related hazards/extreme weather events**

Myanmar experiences six climate related hazards/extreme weather events: i) cyclones/ strong winds; ii) flood/storm surge; iii) intense rains; iv) extreme high temperatures; v) drought; and vi) sea-level rise. Drought is the most severe weather event in the country, followed by extreme day temperatures, cyclones/strong winds, and intense rain and flood/storm surge. This is based on the overall impact of drought events on local communities, including health impacts, damage to property and assets as well as loss of income and livelihoods.

- **Habitat and Land Degradation**

The root cause of land degradation in Myanmar is over-exploitation of natural resources and unsustainable land management practices. For example, illegal and uncontrolled logging has caused substantial damage to Myanmar's forests, particularly in upland areas. Over-exploitation results in soil degradation and erosion. This is further aggravated by traditional farming practices used by local farmers e.g. slash-and-burn cultivation. Poor farming practices which deplete essential minerals from soils (e.g. potassium, nitrogen, and phosphorous) has reduced land productivity. Decreased productivity and limited vegetation cover has destabilized soils and caused erosion resulting in gullies, soil loss and decreased infiltration rates. Habitat degradation in coastal areas is also prevalent in Myanmar. Large-scale destruction of coastal ecosystems (e.g. mangroves and other coastal ecosystems) has occurred as a result of increasing human populations, infrastructural developments (e.g. shrimp farming), agricultural expansion, over exploitation (timber and fuelwood), and pollution.

- **Deforestation**

Myanmar's forests have been affected by degradation, shifting cultivation, and conversion to commercial oil palm plantations (the latter is particularly relevant in the lowland forests of the Tanintharyi Region). Deforestation pressures include: i) fuelwood consumption (the principle source of energy); ii) unplanned and unrestricted agricultural expansion; iii) aquaculture (e.g. shrimp farming in the Delta region); iv) infrastructure development; and v) commercial clear cutting. Over the period 1989-1998, the annual deforestation rate in Myanmar has been estimated at 466,420 ha/annum. Furthermore, over the past two decades, Myanmar has lost >3% of its forest ecosystems. Deforestation, however, varies considerably among the regions. The central and/or more populated States and Regions show the highest losses of forest resources, the most notable being the mangrove forests in the Ayeyarwady Delta and the remaining dry forests at the northern edge of the Central Dry Zone. For example, it has been estimated that ~83% of mangroves in the Ayeyarwady Delta have been destroyed between 1924 and 1999.

- **Diminishing Water Resources**

The compounding effects of land degradation, overutilization and unfavorable agricultural practices in Myanmar have diminished water supplies for domestic, agricultural and industrial use. Degradation of vegetation cover and poor land management around Inle Lake (Myanmar's largest Lake) for example has caused severe soil erosion and sedimentation resulting in the lake becoming shallower. This has reduced the quantity of water available for use by local communities and jeopardized agricultural practices (floating gardens, fishing activities), tourism and recreational activities. The demand for water in Myanmar significantly increases during the hotter and drier parts of the year. It is expected that this demand will increase as socio-economic sectors expand, the climate gets hotter and drier and rainfall becomes more unpredictable. Under a changing climate, losses in agriculture productivity are expected as most of Myanmar's food production relies on rain-fed agriculture. Water-related impacts are likely to undermine future development and economic growth in Myanmar.

Observed Climate Variability/Change in Myanmar

The observed climate variability and change in Myanmar over the last ~six decades includes the following:

- a general increase in temperatures across the whole country (~0.08°C per decade), most notably in the northern and central regions;
- a general increase in total rainfall over most regions, however, with notable decreases occurring in certain areas (e.g. Bago Region);
- a decrease in the duration of the south-west monsoon season as a result of a late onset and early departure times; and
- increases in the occurrence and severity of extreme weather events, including; cyclones/strong winds, flood/storm surges, intense rains, extreme high temperatures, drought and sea-level rise.

Forest Resources Assessment

Planning and Statistics Division, Forest Department, under Ministry of Environmental Conservation and Forestry (MOCAF) is the organization responsible for forest resource assessment such as forest cover mapping, forestry inventory development, and inventory data processing. The first appraisal was initiated in 1957 using 1:24,000 scale aerial photography and manual interpretation. A second appraisal (1975) was assessed by using 1:1million scale color composite from 80m x 80mx MSS data, and a third appraisal (1989) was implemented with 1:500,000 scale Landsat TM data (30m x 30m resolution) and manual interpretation. The Fourth Appraisal compiled for FRA2000 in 1997 was a combination of various surveys, however, the majority was derived from digital classification of 30m x 30m Landsat TM data. The most recent inventories (FRA2005 and FRA2010) contain Landsat 7 ETM databases, some areas have been checked in the field thoroughly by using 30 meter resolution Landsat images and 4 meter resolution IKONOS images from anti-narcotic surveys (Figure 2). At present, FRA 2015 is under processing by using IRS Liss3 Landsat images (79 scenes for the whole country).

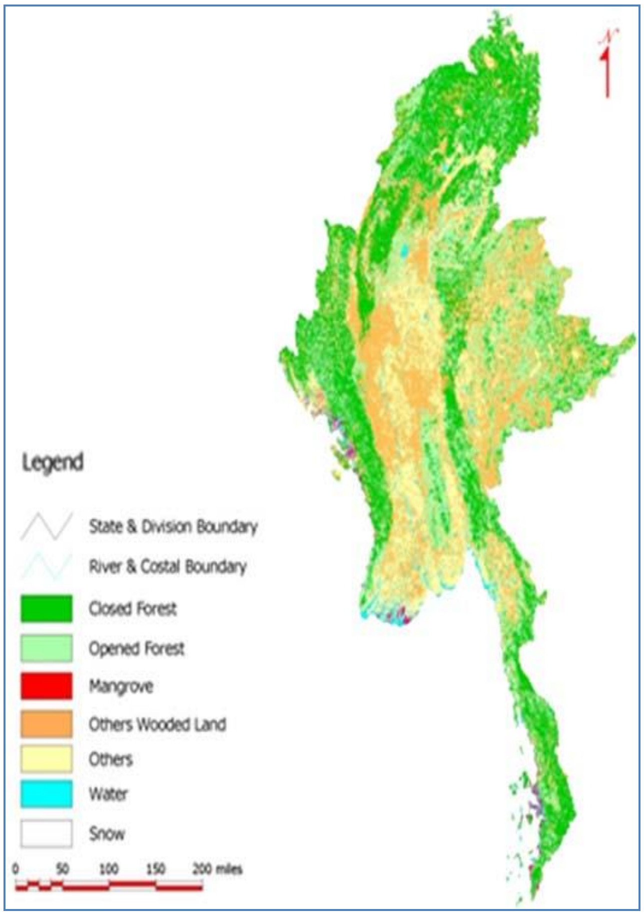

Figure 2. Forest Cover Status (FRA 2010).

The forest Department has been conducting the national forest inventory since 1981. Generally, the forest inventory is carried out in the open seasons annually (Figure 3). Although all forest products cannot be inventoried, the data on Teak and other hardwoods are being collected. In some areas the bamboos and rattans are also collected. Moreover, the natural regeneration of Teak (*Tectona grandis*), Pyinkado (*Xylia dolabriformis*) and other tree species are collected in order to assess the silvicultural condition of the forest.

The main objectives of the national forest inventory include:

- To establish permanent sample plots in the forests so that the condition of the forest and its growth can be monitored by successive measurements;
- To determine the present amount, location and quality of timber at pre-investment level;
- To understand the growing condition of bamboo species and
- To assess the silvicultural condition of the forest especially its regeneration.

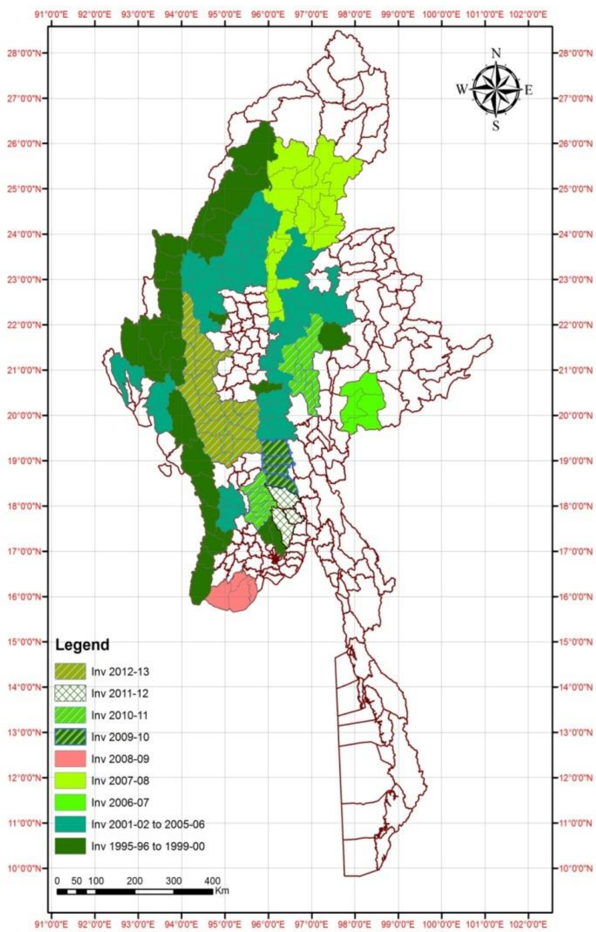

Figure 3. The area in Myanmar with forest Inventory data.

The Way Forward

The following measures have been implemented in Myanmar to ensure sustainable forest management and community-based forestry in the country:

- A Thirty-year Forest Action Plan has been developed with a focus on disaster risk reduction, sustainable forest management including natural, plantation and community forests.
- A people-centered Community Forestry approach (Community Forestry Instruction 1995) is being used in several regions including the Ayeyarwady Delta, Yangon Deltaic region and Central Dry Zone. This approach aims to promote sustainable management of natural forests through decentralization to established Forest User Groups (~30-year lease).
- Reforestation efforts have been undertaken in the Ayeyarwady Delta and Yangon Deltaic region. This includes the establishment of ~65,108 ha of plantation forests comprising mangrove and other forestry species.
- The Integrated Mangrove Rehabilitation and Management Project (Japan International Cooperation Agency [JICA] 2007-2013) is being implemented to ensure sustainable management of mangrove ecosystems and poverty alleviation in the Ayeyarwady Delta.
- Efforts to raise public awareness to forest management issues have begun throughout the Ayeyarwady Delta and Yangon Deltaic regions.

Adaptation to Climate Change

One of the most important aspects for increasing the adaptive capacity of the forest sector to climate change is using a community approach. Based on the needs identified by vulnerable communities, the following is a summary of the adaptation approaches that should be considered for effective climate change adaptation in the forest sector:

- climate-resilient forest species for reforestation and afforestation programs throughout Myanmar to increase forest regeneration and recovery under future climate conditions;
- intensified mangrove reforestation in coastal zones for coastal buffering against cyclones, flooding and storm surges;
- restoration of degraded forest areas using multi-use forest species (e.g. mango, tamarind, lead tree and cutch trees) for increasing community safety-nets and diversifying livelihoods;
- implementing fire protection and fire fighting measures (e.g. fire breaks) within forest ecosystems;
- increased public participation including the devolution of forestry management and rights to lower governmental levels as well as to local communities;

- public awareness (using signboards; radio and television) and education on the effects of climate change on forest ecosystems and economic activities;
- capacity building for improved community forestry implementation including training on seed collection, cleaning, storage, sowing, propagation and planting; and
- improved efficiency of fuelwood use by adopting technologies such as energy efficient stoves and introducing sustainable woodlots.

The above adaptation approaches have been incorporated into management plans with options for reducing the vulnerability of the forest sector and related communities to climate change impacts. Forest-based activities including reforestation, afforestation and forest conservation have been identified as the most effective and cost efficient measures to help mitigate climate change and to address climate change impacts. Even though implementation of these activities has begun across the country, there are some challenges such as the difficulty in getting real time information about disasters and some areas difficult to access.

According to the 30-year Forest Master Plan, 30% of the land area is to be set aside as reserved forests. Currently, only 24.8% the area is in reserved forests. A total of 36 Protected Area Systems (PAS) have been designated and 6 more are proposed which will constitute 6% of the land area. the Government of Myanmar is trying to increase permanent forest estates, but because of problems like encroachment, forest area is decreasing. To address these issues, the Government of Myanmar is looking into implementing REDD+ mechanisms with ITTO and UN-REDD program.

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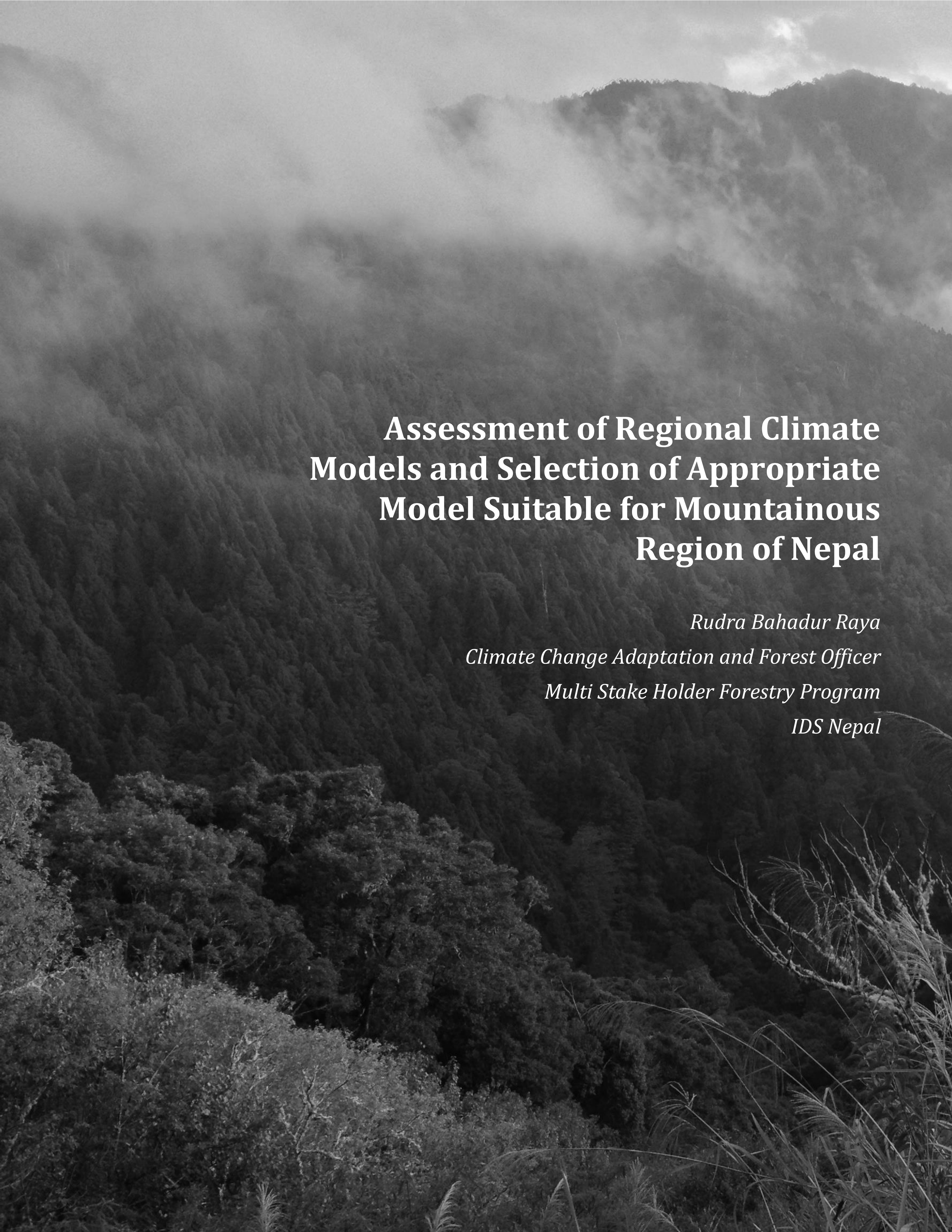

Assessment of Regional Climate Models and Selection of Appropriate Model Suitable for Mountainous Region of Nepal

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Assessment of Regional Climate Models for Application in the Mountainous Region of Nepal

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Executive summary

The Second National Communication Project is preparing a report on the research and systematic observation through consulting services. One of components of this SNC is to prepare a report on research and systematic observation as its part and one of its activities is to prepare a report on "Assessment of Regional Climate Models and Selection of Appropriate Model Suitable for Mountainous Region". The primary objective of this task is to prepare a detailed and representative description of Assessment of Regional Climate Models and Selection of Appropriate Model Suitable for Mountainous Region" for research and systematic observation in Nepal that will be included in the SNC report. The study started with a detailed review of available articles, discussion with experts and related organizations related to climate modeling. It has found a few numbers of studies on climate modeling in Nepal.

It is found from the literature review that different types of models are used in Nepal regarding climate change. The Global Climate Model was used by (McSweeney et al, 2011) showing trends in annual mean temperature. Empirical (statistical) downscaling was done by the University of Cape Town archive (A2 scenario for the 2040-2060 time period, UCT, 2012) considering around 9 models, downscaled to individual met stations for determining Monthly daily maximum temperature and monthly rainfall for the mid-century projections (A2) for different sites in the country. An analysis was done by the Nepal Agriculture Research Council (Gautam, 2008) using simulation models (DSSAT)for major crops such as rice, wheat and maize. The Water Balance Model was first used in Nepal for the Koshi Basin. MOPE used the same model for the Karnali, Narayani, Koshi and Bagmati Rivers in Nepal in order to assess the vulnerability of climate change to water resources. It was also used by Chaulagain, 2006 in Chovar in the Bagmati basin (rain-fed) and Kyangjing in the Langtang basin. NDRI/ICHARM (2012) used a Rainfall Runoff Inundation (RRI) model. Naito et al. (2000, p. 245) applied the Empirical Glacier Mass Balance Model in the Eastern Himalayas for a numerical simulation of shrinkage of the Khumbu glacier and predicted the likelihood of formation and succeeding enlargement of a glacier lake in the lower ablation area of the glacier. Similarly, Naito et al (2001, p. 315) used the same model for estimating sensitivities of some other glaciers in the Nepal Himalayas in relation to

climate change. With respect to Regional Climate Models, there have been several families of models applied in Nepal. As an example, the DHM study projects warming in all seasons in the mid-21st century (2039-2069). A new set of regional climate model runs have recently been produced as part of the DHM climate portal and the 2nd National Communication, which again has a RCM output for the A1B scenario. In 2010 the ICIMOD conducted one research on climate change impact on eastern Himalayan region of Nepal through PRECIS model on RCM framework. The study focuses mainly on analysis of contemporary trends in temperature and precipitation in the region and on analyzing the scenarios of future climate change.

From this study and analysis it is found that the appropriate climate models suitable for Nepal are DSSAT crop models, BIOME 3, PRECIS RCM, Empirical Glacier Mass Balance Model and Water Balance model.

Introduction

Climate change is a phenomenon due to emissions of greenhouse gases from fuel combustion, deforestation, urbanization and industrialization (Upreti, 1999) resulting in variations in solar energy, temperature and precipitation. Climate has changed considerably throughout the history of the earth due to change in its forcing components, whether natural or anthropogenic. The rate of global climate change during the 20th century was greater than before (IPCC, 2001a, p.45). For example, average global temperature increased by approximately 0.6 ± 0.2^{0}C during the 20th century, which was greater than in any other century in the last 1,000 years (IPCC, 2001a, p.45). The warming rate became even more pronounced during the second half of the last century, predominantly due to the increase in anthropogenic greenhouse gas concentrations in the atmosphere (IPCC, 2001a, p. 51; Graedel and Crutzen, 1993, p. 5). Many analyses show that the temperature increase in the twentieth century has been greater than in any other century during the past 1000 years (ibid). The 1990s was the warmest decade of the millennium and 1998 was the warmest year on record (IPCC, 2001a, p.173). If no action at a global level is taken to curb the rising trend, then scientists predict that the average global temperature will increase by 1.4 to 5.8ºC over the next hundred years, which may lead to consequences more drastic over the last 100,000 years (NRCS, 1995). The global average surface temperature has increased by about 0.6ºC during the twentieth century (IPCC, 2001a, p 152).

Studies show that developing countries are more vulnerable to climate change and are expected to suffer more from the adverse climatic impacts than the developed countries (IPCC, 2001a, p. 287). In a humid climate like that of Nepal, there will be changes in the spatial and temporal distribution of temperature and precipitation due to climate change, which in turn will increase both the intensity and frequency of extreme events like droughts and floods (Mahtab, 1992, p.37). Observed changes in temperature trend in recent studies shows that the temperature of Nepal is increasing. For instance, Shrestha et al. (1999) in his study for the period 1977 to 1994 indicated a consistent and continuous warming in the period at an annual rate of 0.06° C. Similarly, a study conducted by Practical Action (2009), using data for the period 1996-2005, indicated a consistent and continuous warming in maximum temperatures at an annual rate of 0.04° C. The studies also indicate that the observed warming trend in the country is spatially variable.

There are indirect effects of climate change such as sea level rise, soil moisture changes, changes in land and water conditions, changes in the frequency of fire and changes in the distribution of vector-borne diseases (ibid, p.245). Global warming is causing the melting of glaciers in the Himalayas. Changes in the snowfall pattern have been observed in the Himalayas in the past decades (IPCC, 2001b, p.553). Almost 67% of the glaciers in the Himalayas have retreated in the past decade (IPCC, 2001b, p.553). Throughout Asia one billion people could face water shortage leading to drought and land degradation by the 2050s (Christensen et al. 2007, Cruz et al. 2007). Fifteen Glacial Lake Outburst Floods (GLOF) events have been documented in Nepal (Ives, 1986, Yamada, 1998. In Asia, the principal impacts of climate change on health will be on epidemics of malaria, dengue, and other vector-borne diseases (Martens *et al*. 1999). Climate change will have a significant impact on agriculture in many parts of the world (IPCC, 1998, p.397). Increases in temperature result in a reduced growing season and a decline in productivity, particularly in South Asia (Pachauri, 1992, p.82). Mountain agriculture, practiced close to the margins of viable production, could be highly sensitive to c limate change (Carter and Pary, 1994, p.420). Risk levels of climate change often increase exponentially with altitude, therefore, small changes in the mean climate can induce large changes in agricultural risks in mountain areas (ibid, p.421). The recently observed extreme severe weather events between 2006-09 including droughts and floods have significantly affected food production in Nepal (WFP, 2009). In addition, it has been suggested that warming of more than 2.5°C could reduce global food supplies and contribute to higher food prices (UNEP & UNFCCC, 2002). International Food Policy Research Institute assessed impacts of climate change on global cereal production and concluded that the negative impact of climate change on world cereal production may vary from 0.6% to 0.9%, but in the case of South Asia, the impact could be as high as 18.2% to 22.1% (Von Braun, J., 2007). Within South Asia, the impacts are more pronounced in mountain areas than in the plain areas. It means, the impacts of the climate change are high in Nepal (Joshi et al. 2011).

Nepal signed the United Nations Framework Convention on Climate Change (UNFCCC) on 12 June 1992; it was ratified on 2 May 1994 and entered into force on 31 July 1994. As a Party to the Convention, Nepal took initiatives to identify the effects of climate change and areas that require immediate attention and assistance. Nepal had prepared the Initial National Communication with UNEP's support and shared with Parties to the UNFCCC in August 2004 as required by Article 12 of the Convention. The Initial National Communication sets out Nepal's obligatory contribution to international efforts to address Climate Change issues as a Non-Annex-I Party. It provides an overview of National Circumstances that influence Nepal's capacity to respond to the problem, and describes the Greenhouse Gas Emissions Inventory and Mitigation Options. This Communication deals on four major subjects: these are i) National Circumstances, ii) National Greenhouse Gas Emissions Inventory, iii) GHG Mitigation Options and iv) Vulnerability/Impact and Adaptations. With the continuation of step towards further implementation of the UNFCCC at a national level, the Ministry of Environment has implemented Second National Communication (SNC) project of Nepal. The project enables Nepal to present the information in a consistent, transparent, and comparable as well as flexible manner, taking into account specific national circumstances. In brief, the project aims to: a) Assist Nepal with enabling activities; necessary to undertake an improved national greenhouse gas (GHG) inventory; b) Plan for actions for the mitigation of climate change and adaptation to its potential impacts of climate change; and Prepare the country's Second National Communication (SNC) to the Conference of the Parties (COP) of the UN Framework Convention on Climate Change (UNFCCC).

Objective

The primary objective of this task is to prepare a detailed and representative description of "Assessment of Regional Climate Models and Selection of Appropriate Model Suitable for Mountainous Region" for research and systematic observation in Nepal that will be included in the SNC report.

Rationale of the study

Climate change is a serious and urgent issue and climate change is not going to be resolved in the near future. It is a real threat to the lives in the world that largely affects water resources, agriculture, coastal regions, freshwater habitats, vegetation and forests, snow cover and melting and geological processes such as landslide, desertification and floods, and has long-term effects on food security as well as in human health. It is therefore essential to comprehend the future possible scenario of climate change in terms of global warming. It is required to project the future climate change to aid policy makers in making decisions. Climate models are considered as the main tools available for developing projections of climate change in the future. In order to apply appropriate and better options for mitigation and adaptation to climate change climate modeling in various sectors like temperature, agriculture, water, glacier etc. is very crucial. Different climate models in various sectors are used in Nepal by government organizations, NGOs, academic sectors or students from different parts of the world. Nepal lacks a proper documentation of the study that has been performed on various sectors of Nepal in climate model and projections. So it is crucial to document the studies on climate modeling. With the proper documentation of the various models used in Nepal and with reference to IPCC suggested models we then can suggest the better climate model suitable for

Nepal. And most of all is one of the components of Second National Communication is to prepare a report on research and systematic observation as its part and one of its activity is to prepare a report on "Assessment of Regional Climate Models and Selection of Appropriate Model Suitable for Mountainous Region". So this study is highly required.

Scope of the study

The scope of the study includes the following:

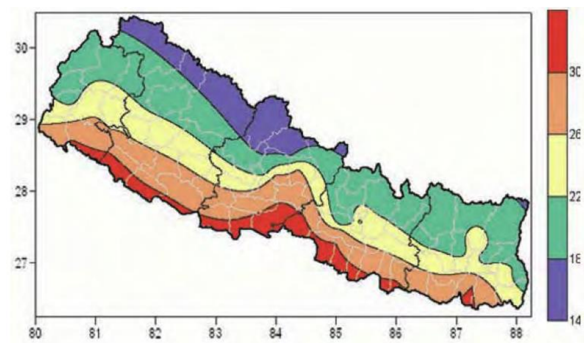
- Review of the available documents related to climate models;
- Assess the climate models that are used in Nepal to assess the climatic scenario;
- Suggest the appropriate climate model suitable for mountainous region of Nepal; and
- Based on the gathered information, prepare a final report on regional climate models and selection of appropriate model suitable for mountainous region.

Methodology

This study was based on a literature review and consultation with climate change experts and related stakeholder like research institutions, GOs, Bilateral and multilateral agencies like ADB, IFC, WB Group, INGOs and NGOs. The articles and journals were collected in electronic as well as hard copy from internet and library. The secondary information was also collected by discussion with climate change modeling experts.

Current Climate Vulnerability in Nepal

The climate of Nepal (and particularly the temperature) significantly varies across the country, due to the strong elevation gradients, from the hot Terai plains (a few hundred meters above sea level) to the cold high mountains, shown below. The highest temperatures occur during the pre-monsoon period. The lowland regions of Nepal have a warm and humid sub-tropical climate, while the high mountainous regions are cold, and remaining well below zero in the winter (PAC, 2009).



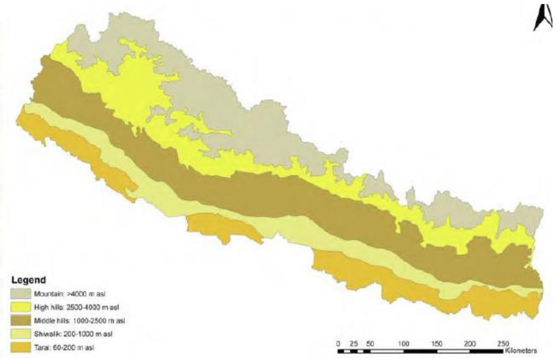
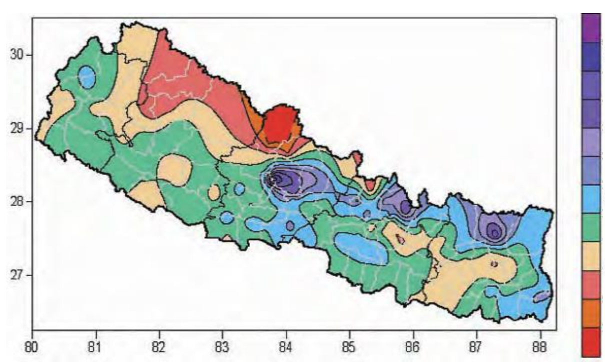


Figure 1. Spatial variation of mean maximum temperature. Source PAC, 2009,

Figure 2. Elevation. Source PAC

The mean annual rainfall in Nepal varies dramatically, by area, and perhaps more importantly, by season. The terrain and topography – notably the large mountain systems – have a major impact on rainfall patterns. Average annual rainfall is approximately 1800 mm (GON, 2010), but rainfall is dominated by the monsoon rains, from June to August/September. The monsoon rain is most abundant in the east and gradually declines as it moves towards the west (GON, 2010: PAC, 2009). High extreme rainfall is a major source of floods and landslides, as well as soil erosion and sedimentation transfer. Importantly, there is high variability in annual and seasonal rainfall between years (Baidya et al 2007; PAC, 2009).



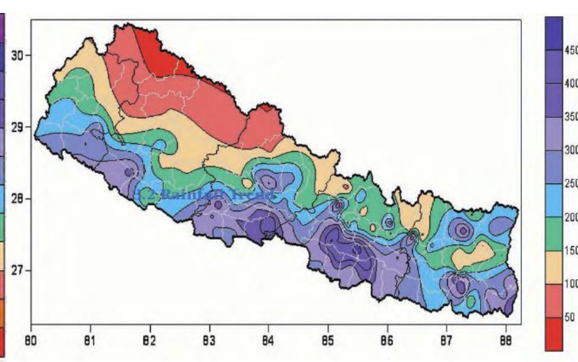


Figure 3. Annual mean rainfall. Source PAC, 2009

Figure 4. 24 hours highest rainfall (mm). Source PAC (2009)

Emerging Climate Trends

The study has reviewed the recent trends looking at observational data (including recent trend reviews; Shrestha et. al. 1999; McSweeney et al. Baidya et al 2007; Saraju et. al 2008; PAC, 2009; GoN, 2010).

The NAPA (GON, 2010) reported a trend of observed warming for Nepal (though with regional differences). More recent detailed analysis performed by Practical

Action, 2009 looking over a period of 30 years (1976-2005) reported that maximum and mean temperatures are rising. Further increases in temperature are anticipated over the next decade or so, potentially accelerating as climate change signals strongly emerge, though these increases have to be seen against the existing (and dominant) temperature gradients from altitude.

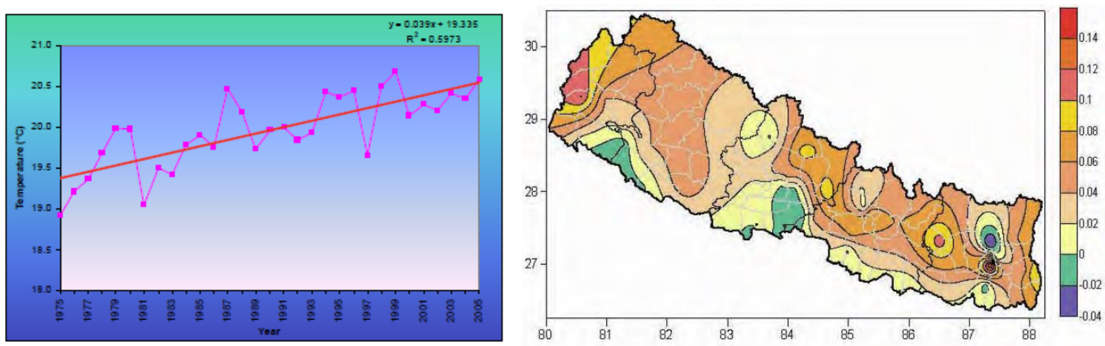


Figure 5. Annual mean temperature trend Nepal (Baidya et al (2007) and spatial pattern (PAC, 2009)

For rainfall, the situation is more unclear, and there is uncertainty. The NAPA reported that precipitation data does not show any general nationwide trends (though the UNDP country profile (McSweeney et al) reported a trend of decreasing annual precipitation). However there are number of regional precipitation trends and the NAPA reports that annual precipitation data show a general decline in pre-monsoon precipitation in far- and mid- western Nepal, with a few pockets of declining rainfall in the western, central and eastern regions. Other studies (Baidya et al 2007; Practical Action, 2009) report a change in precipitation over time during the different seasons with some regions show increases and others show decreases. Saraju et. al. (2008) found an increasing trend in the number of extreme precipitation days at the majority of the stations (but particularly for stations below 1500 metres) and highlighted the implications for landslides, flash floods and inundation.

Climate Model Data and Projections for Nepal (Based on Literature Review)

The analysis of the future impacts and economic costs of climate change requires projections of future climate change, which is produced from climate models. These models use future scenarios (of socio-economic and emissions) to make projections of future changes in temperature, precipitation and other meteorological (and hydro-meteorological) variables over time. The projections are made using global climate models that operate at a high level of aggregation. However, these can be downscaled to regional levels either with statistical downscaling or with regional climate models. The review has considered the available climate model projections for Nepal. Importantly, there is a significant range of temperature across different scenarios and from different models, which cautions against the use of central trends (or reporting, e.g. with mean values). This can be seen in the figure below, which captures the range of future temperatures across different SRES scenarios and across models – showing that some models project an increase in average temperature in excess of 5 °C by 2080 (Figure 7).

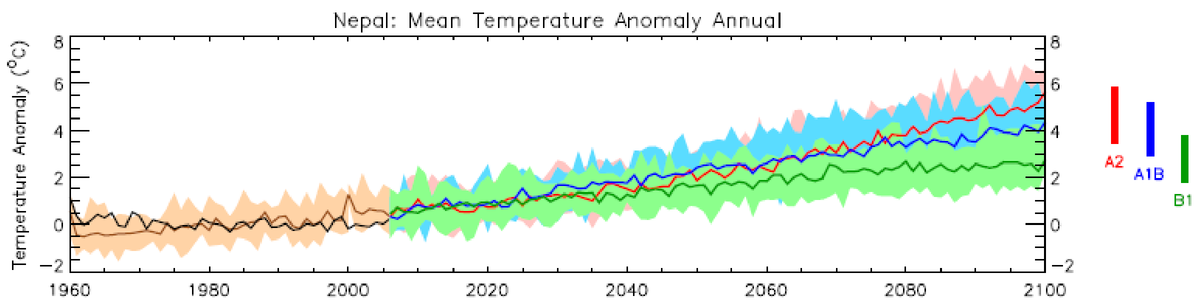


Figure 7. Trends in annual mean temperature for the recent past and projected future simulated by 15 models for each emissions scenario (McSweeney et al)

Some models project a likely increase in annual precipitation over the country, though considerable caution is needed in interpreting this finding. The increase in rainfall is primarily associated with increased rainfall during the monsoon season, and further, the models indicate increases in the proportion of total rainfall that falls in 'heavy' events. McSweeney et al (2011) report a similar variation across scenarios and model projections, indicating changes between -30% and + 100% (Figure 8).

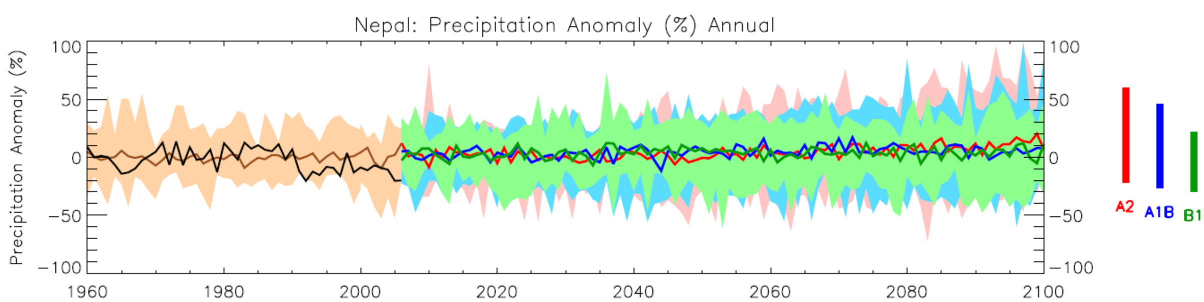


Figure 8. Trends in annual mean rainfall for the recent past and projected future simulated by 15 models for each emissions scenario % anomaly (McSweeney et al)

This is a critical finding for the study. There are a range of future emission profiles, ranging from low to high levels, and many climate models available. These give very different results, even for variables such as average temperature. For precipitation, the difference is often even in the sign of change (+/-). An important part of the review has therefore been to consider the breadth of available projections, and interpret the information, rather than reporting examples from one or two models. These differences caution against the use of Global Climate Model data, especially given the elevation and climatic zones across Nepal. However, similar differences emerge with downscaled projections.

Downscaled Projections

The study has considered two alternative approaches for producing downscaled data - empirical (statistical) downscaling and Regional Climate Model (RCM) outputs. An analysis of statistically downscaled data (derived from using station meteorological data) is presented below, from the University of Cape Town archive (A2 scenario for the 2040-2060 time period, UCT, 2012). This considers around 9 models, downscaled to individual met stations (Figure 9). The climate change projections for Kathmandu are shown in the box below (for 2040-2060 periods for the A2 scenario). These show broadly consistent trends for temperature, but very complex and uncertain projections for precipitation. The downscaled data shows even greater variation when the wide range of climatic zones in Nepal is considered. This is shown in Figure 18, which plots downscaled mid-century projections for different stations across Nepal, noting that each has a very different existing climate.

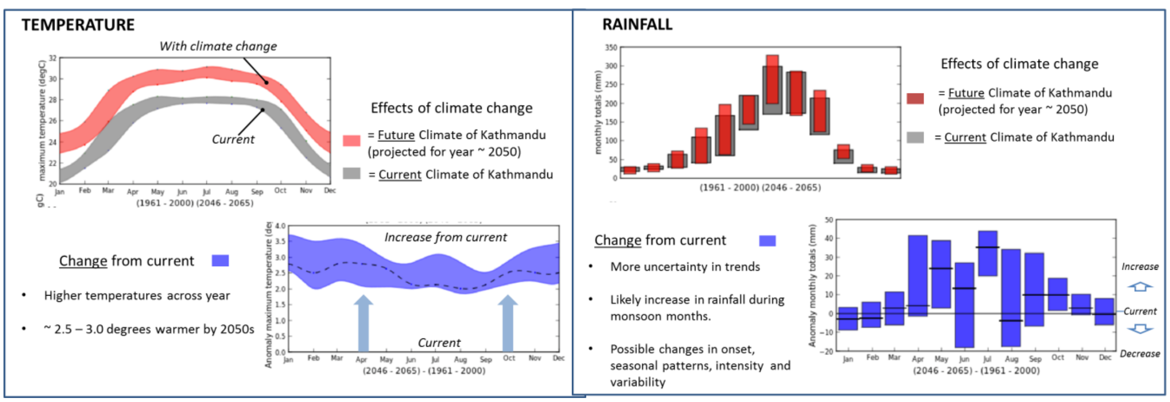


Figure 9. Temperature and Precipitation Projections for Kathmandu (A2, 2050)

Source of data: Climate Systems Analysis Group (CSAG), University of Cape Town, UCT (2012)

Figure 10 shows the monthly daily maximum temperature and monthly rainfall for the mid-century projections (A2) – for both current and future (top figures) and relative to current (bottom figures), for temperature and precipitations. While the relative changes in temperature are similar across areas, these arise on top of very different baseline climates, and will therefore have very different impacts. The changes in rainfall vary significantly by location, which leads to strong differences in the patterns of seasonal and monthly rainfall, with different precipitation trends in different parts of the country, and different levels of changes, though there is a common theme of uncertainty.

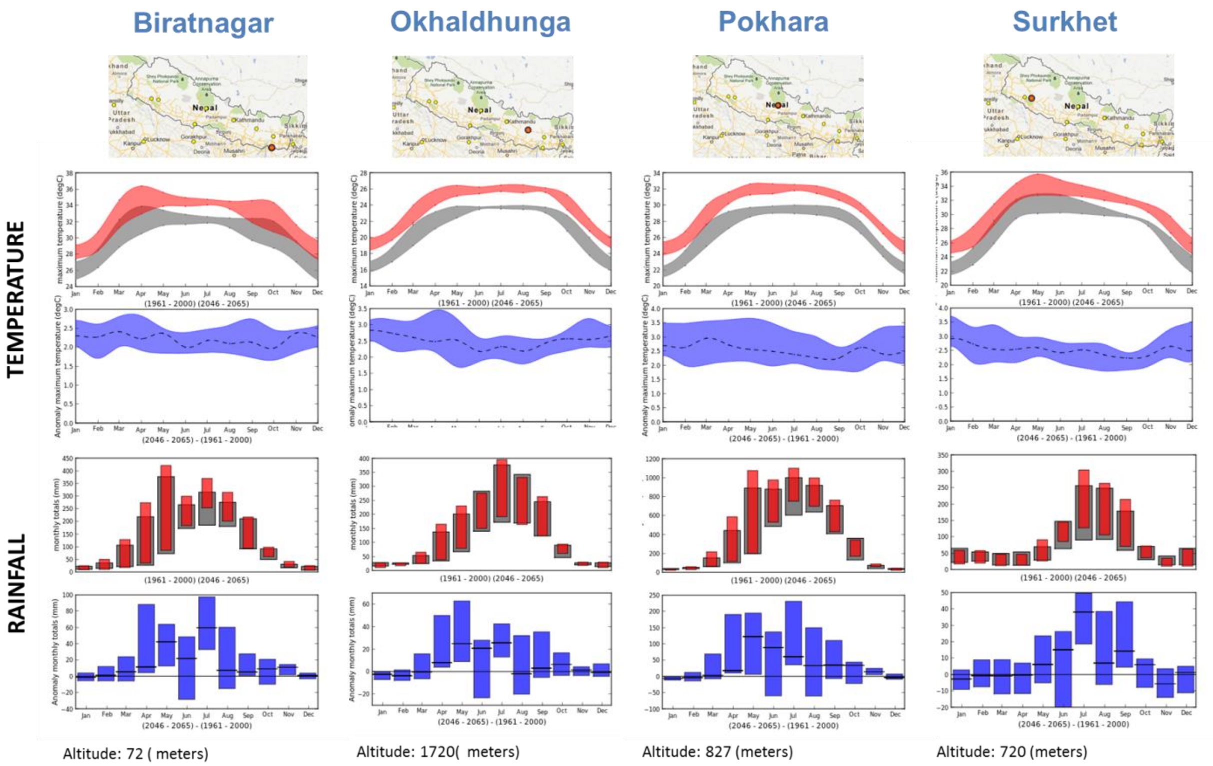


Figure 10. Monthly daily maximum temperature and monthly rainfall for the mid-century projections (A2) for different sites in the country (Source: Climate Systems Analysis Group (CSAG), University of Cape Town, UCT, 2012)

With respect to Regional Climate Models, there have been several families of models applied in Nepal (NCVST, 2009: Karmacharya et al., 2007; GCISC et al. 2009). As an example, the DHM study (Karmacharya et al., 2007) projects warming in all seasons in the mid-21st century (2039-2069) with the warming in the northern part over the high Himalayas being higher than that in the southern part, and highest in the winter and lowest in the pre-monsoon season in both the east and west Nepal. The annual mean temperature was projected to rise in the range of 1.7°C in the southern region of the country to 2.5°C in the northern region. It also projected a decrease in annual precipitation in large parts of the country, mainly in the eastern and southern Nepal (by up to -30%) but no change in precipitation over north central and north-west Nepal, and with varied seasonal changes. A new set of regional climate model runs have recently been produced as part of the DHM climate portal (which has three regional climate model outputs for the A1B scenario) and the 2nd National Communication, which again has a RCM output for the A1B scenario.

While these regional applications are very promising, it is important to highlight that while regional models may start to address the complexities of the local climate, the use of a small number of regional models does not capture model variation, i.e. it is not a substitute for multi-model ensemble analysis – indeed, it can even be counter-productive by giving apparent confidence without capturing the underlying model bias, e.g. whether the model is warmer, wetter, drier, etc..

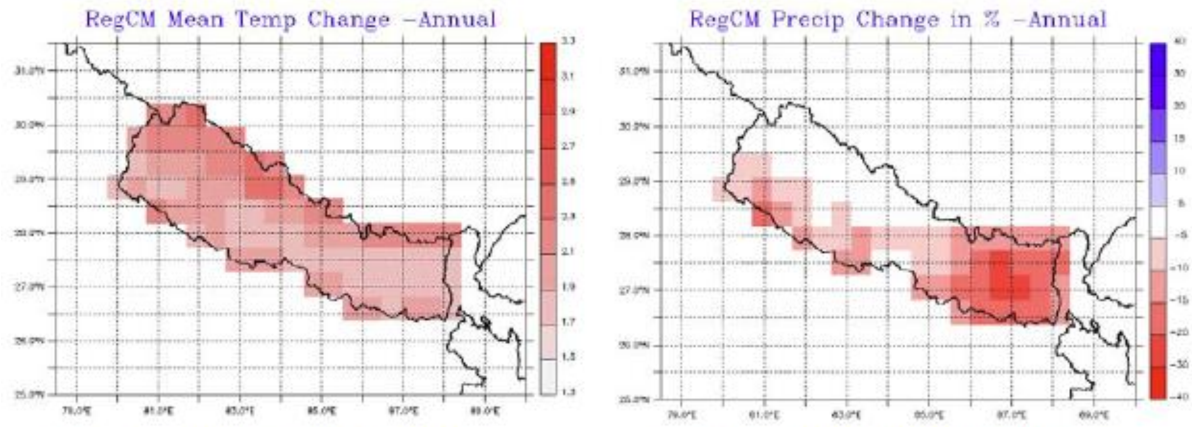


Fig. 12a: Mean annual temperature change (°C)   Fig. 12b: Mean annual precipitation change (%)

Figure 11. RCM output for Nepal. Source: Karmacharya et al., 2007

Furthermore, due to the complex topography, local variations in response to global and regional climate change, particularly for precipitation, are likely to be large and many areas may vary from the regional trend – as highlighted by McSweeney et al, there is a lack of consistency between models in representing monsoon processes. This will contribute to uncertainty in estimates of future precipitation.

Finally, there is the potential for major changes in the longer-term with the monsoon patterns of the region, with the transformation of the monsoon highlighted as one of a number of potential global tipping points (more recently referred to as tipping elements).

Overall, the projections indicate that there is high uncertainty for future rainfall, and even more so for the changes in variability and extremes, and thus broadly for water related impacts and water resources.

The review clearly highlights that for rainfall, variability and extreme events (e.g. floods and droughts), the results from the models differ significantly and there is a need to consider the outputs of a range of models, rather than a single central projection. Indeed, even if new RCM runs emerge, these will not solve the issue of future model projections, because of the range of emission scenarios and range of models, let alone the underlying evidence on some of the more complex effects of climate change on the regional climate from changes in the high mountains. It is essential to recognize this uncertainty, rather than ignoring it, and to plan robust strategies to prepare for uncertain futures, rather than using uncertainty as a reason for inaction.

In the study conducted by OECD in 2003 shows that mean annual temperature increase by an average of 1.2 C by 2030, 1.7 C by 2050 and 3 C by 2100 compared to a pre-2000 baseline. Similarly NCVST (2009) study projects the mean annual temperature to increase by 1.4o C by 2030, 2.8o C by 2060 and 4.7C by 2090. Both the studies show higher temperature increment projections for winter compared to the monsoon season. In terms of spatial distribution, the NCVST (2009) study shows a higher increment in temperature over western and central Nepal as compared to eastern Nepal for the year 2030, 2060 and 2090 with projections for western Nepal being greatest. Similar trends are projected for the frequency of hot days and nights for 2060 and 2090 (in MoE, 2010).). For precipitation GCMs project a wide range of changes, especially in monsoon: -14 to 40 % by the 2030s increasing -52 to +135 % by the 2090s (NCVST, 2009).This projection suggests that Nepal's agriculture will face many challenges over the coming decades due to climate related variability.

There are studies on the potential effects of climate change and agriculture in Nepal (Sherchand et al, 2007; Malla, 2008; Rai et al; Pokhrel and Pandey, 2011; Nayava et al 2011; Thapa and Joshi, 2010; Pant, 2011; Lama and Devkota, 2009; Bastakoti et al 2011). An analysis done by the Nepal Agriculture Research Council (Gautam, 2008) using simulation models for major crops such as rice, wheat and maize suggested that rice yields might increase under elevated CO2 and 4°C increase in the Terai (lowland)(3.4%), hills (17.9%) and mountains (36.1%). Similarly, wheat production might increase by 41.5% in the Terai, 24.4% in the hills and 21.2% in the mountains under elevated CO2, but there would be a significant decrease in production with a 4°C rise. Maize yields were expected to increase in the hills and mountains, but decreased in the Terai with 4°C rise (Sherchand et al., 2007 cit ed in Malla, 2008; Gautam, 2008). The main quantified focus to date has been on crop production and two main approaches have been used in the agricultural sector to assess future impacts (and economic costs): crop models and ricardian (econometric) analysis.

There is a significant literature that has applied crop models (agronomic models) to assess the soil-plant-atmosphere components relevant for plant growth and yield, and also look at the effects of future climate change on crop productivity (GON, 2004: Sherchand et al, 2007; Rai et al). These have found mixed results for Nepal, often with a mix of positive and negative effects depending on the degree of change, and the geographical areas considered. Many studies report an increase in crop productivity, especially at modest levels of temperature change (and especially when CO_2 fertilization effects are factored in). As an example, early DSSAT modeling in the National Communication (GON, 2004) reports that temperature rise might increase wheat output in the western region of Nepal but could lead to a decline in other regions. Rice yields were also generally anticipated to increase up to a certain temperature level. However, potential decreases in yield were reported for maize (a temperature sensitive crop) particularly in the Terai. Overall, effects have been strongly influenced by future CO_2 concentrations and CO_2 fertilization effects. Moreover, the studies and other literature highlight that the changes in productivity vary not just on temperature but on future precipitation and water availability.

The DHM/APN (Sherchand et al, 2007) study also applied DSSAT. It reports that CO_2 concentration increases (in the absence of other effects) would increase crop production (due to fertilization effects). However, varied effects were found across the three crop types and three physiographic regions (Terai, Hill and Mountain) when temperature and rainfall trends were factored into the analysis. For rice, there were broad increases in yields projected across the temperature and rainfall changes, though with a lower relative increase with higher temperature changes in the Terai. For wheat, yields were more varied, with some reductions in yield in the Terai when temperature was factored into account, but favorable changes reported in the mountains. For maize, projected yields declined in the Terai and Hill regions with higher temperatures (though led to positive effects in the Mountains). However, it also highlighted that many of the crops are particularly vulnerable to variability and droughts in key stages of development (particularly pre-monsoon). Overall, the projections were reported to show that Nepal could move from a nation of marginal surplus under a baseline normal scenario to a case where supply and demand only just balanced under the climatic change scenario (assuming no adaptation). Rai et al, using the DSSAT model, looked at rice in Nepal and reported that modest temperature increases (minimum temperature) have positive effects, but above 2°C negative impacts start to arise.

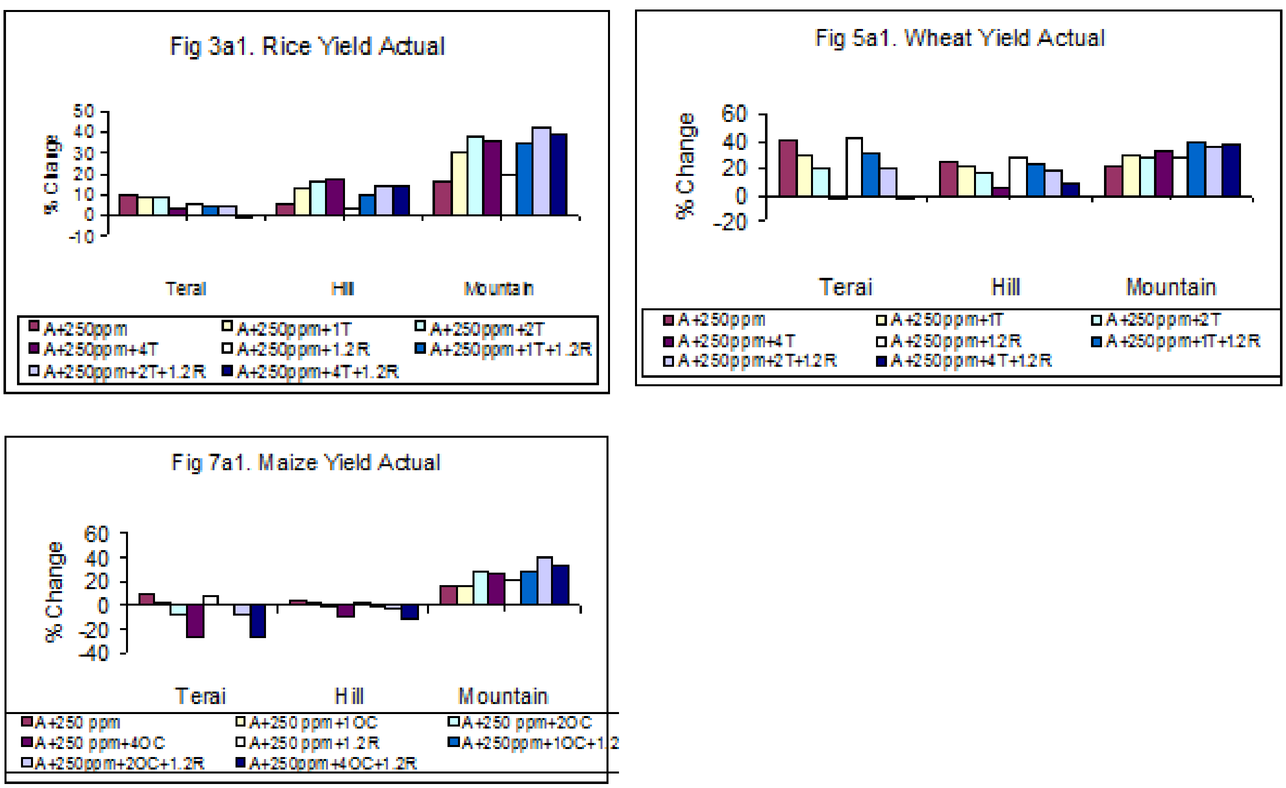


Figure 12. Rice, wheat and maize yield at different altitude regimes as influenced by climatic variability. Source Sherchand et al (2007)

There have also been some Ricardian modeling studies, which consider the long-term productivity of land, and consider different influences on land value or farm net revenues, including climatic differences, using cross-sectional data. These can look at how future climate conditions affect these land values or farm net revenues. Thapa and Joshi (2010) apply such a Ricardian approach to Nepal. This identifies existing relationships between net farm income and climate variables. The findings show that these variables have significant impacts on the net farm value per hectare.

There is relatively less information available on the potential effects of climate change on livestock. The studies and reviews available (Pokhrel and Pandey, 2011, Sherpa, et al. 2009) indicative a combination of possible effects, either from direct impacts (heat stress) or from indirect effects associated with vector borne disease, impacts on pasture or forage production, climate variability and water availability or hazards risks, and highlight potential increases in production costs and/or declining productivity. The studies identify that yaks might be particularly vulnerable to climate change, due to the fact they are acclimatized to colder temperature, and are sensitive to high temperatures, with effects potentially exacerbated by herding practices.

The Water Balance Model

WatBal model was developed by Yates (1994, p.1) for climate impact assessment of river basin runoff. It was first used in Nepal within the US country study programme for the Koshi Basin (Gurung, 1997, p.33). MOPE (2004, p.98) used the same model for the Karnali, Narayani, Koshi and Bagmati Rivers in Nepal in order to assess the vulnerability of climate change to water resources. Potential evapo-transpiration was calculated separately using the Penman-Monteith equation (Allen et al., 1998, p.65) and applied as input data in the model. In order to assess the climate change impacts on river runoff, (Chaulagain, 2006) the model was calibrated and validated for two hydrological stations 1. Chovar in the Bagmati basin (rain-fed) and 2. Kyangjing in the Langtang basin (snow-fed). This was sdone in order to estimate the sensitivity of river runoff to temperature and precipitation changes. The result showed that the runoff had a negative correlation with temperature change but a positive correlation with precipitation change. There will be a 7.5% decrease in annual runoff with a 5ºC rise in the temperature assuming no change in precipitation. Similarly, a 10% decrease in the precipitation and a 5ºC rise in the temperature may result in a 17.4% decrease in the river runoff of the Bagmati River at Chovar. He also performed the runoff modelling with *WatBal* model for the glacier-fed Langtang Khola. A sensitivity analysis for the Langtang Khola was carried out for the temperature changes from $+1^0$C to $+5^0$C and the precipitation changes from -10% to +10%. The result showed a 0.6% decrease in annual runoff with a 5ºC rise in the temperature assuming no change in the precipitation. Similarly, a 10% increase in the precipitation and a 5ºC rise in the temperature may result in only a 1.9% increase in the annual runoff of the Langtang Khola. The runoff of the Langtang

Khola was less sensitive to temperature rise than that of the Bagmati River (see Table 5.4). This was because of the existence of the melt-water component in the runoff of the Langtang Khola, which masks the effect of decreasing runoff due to warming by providing additional runoff from glacier-melt.

In terms of rainfall and river discharge, in line with the climate models, there are strong differences by season and high uncertainty across the models that translate into projections of water availability. These are further exacerbated due to the complexity of the Nepalese monsoon (thus even downscaled models have high uncertainty of future trends). Some studies (e.g. GoN, 2004) report potential increases in river discharge associated with increased monsoon rainfall, also noting that the increase in extreme precipitation would be a factor in increasing flood risks. NDRI/ICHARM (2012), using a Rainfall Runoff Inundation (RRI) model, project that precipitation frequency will increase in the near future due to climate change, with an increase in intensity that will increase extreme (flood) events in the lower West Rapti River Basin, leading to increased household damage and agricultural losses. Importantly, they identified that the most affected villages from increased risks are also the areas which are most socio-economically disadvantaged.

Sharma and Shakya (2006) assessed potential changes from emerging climate change trends in the Bagmati River basin, which is interesting due to the current water supply deficit. The study reported a trend of reduced mean yearly flow and monsoon season flow in the Bagmati River, and highlighted the effects of continued trends on hydro-power production. The study also reported that the magnitude of floods is decreasing but the frequency and duration are increasing. There are also possible issues of increasing demand and reduced supply water (e.g. Downing et al, 2012) between India and Nepal, and that given underlying demand trends, any changes from future climate change could be important. Such studies show the importance of local information and conditions, and analysis really needs to be undertaken at the catchment level, and to consider subsequent impacts and economic costs, this needs to extend to the analysis of demand as well as supply and availability, though previous applications of water management models (e.g. in the Tinau) have found the variability in the mountain context makes such assessments very uncertain.

Empirical Glacier Mass Balance Model was originally developed by Y. Ageta in 1983 using the observational data in 1978 and 1979 to calculate the mass balance of Glacier AX010 in the Nepal Himalayas (Kadota and Ageta, 1992, p.2). The general assumptions for the model application are as follow (Ageta and Kadota, 1992, p.90):

- A rise in temperature does not affect precipitation and other climatic factors.
- The amount of precipitation on the glaciers is independent of altitude and uniform for the whole glacier area under study.

- The temperature changes with an adiabatic lapse rate of -0.6°C per 100 m of altitude.

This model received a wide acceptance to estimate the glacier mass balance in the Nepal Himalayas. Naito et al. (2000, p. 245) applied this model in the Eastern Himalayas for a numerical simulation of shrinkage of the Khumbu glacier and predicted the likelihood of formation and succeeding enlargement of a glacier lake in the lower ablation area of the glacier. Similarly, Naito et al.(2001, p. 315) used the same model for estimating sensitivities of some other glaciers in the Nepal Himalayas in relation to climate change. This analysis has revealed that the glaciers in the Nepal Himalayas, which are mostly summer-accumulation type, are more sensitive to temperature change than other glaciers in the world. Likewise, Kadota et al. (1997, p. 246) used this model to monitor and predict the shrinkage of a small glacier in the Nepal Himalayas and concluded that the shrinkage would accelerate in the years to come.

Dam breach model

A dam breach model developed by the National Weather Services (NWS-BREACH) was used to simulate the outburst hydrographs of Lake Imja Tsho. The inputs required by this model include the geometry and some geotechnical parameters of the moraine dam, the lake area, and the lake depth information. The geometric data of the Dig Tsho moraine dam were taken from the DEM. Since geotechnical parameters for the lakes were not available, parameters from the Tsho Rolpa were used (DHM 1996). This substitution is justified because of the many similarities between the two cases. Geometric data of the moraine dam of Lake Imja Tsho was based on information from a detailed survey conducted by Japanese scientists (Watanabe 1995) and the lake area-depth information was based on the bathymetric data of the lake (GEN 2001). After the GLOF hydrograph was derived from the NWS-BREACH model, the nature of flood propagation in the downstream was derived from hydrodynamic modelling. For this, the geometric and hydraulic data from HEC GeoRAS was exported to HEC-RAS, a single dimensional hydrodynamic model developed by the US Army Corps of Engineers, Hydrologic Engineering Center (HEC) (USACE 2004). A flow hydrograph, derived from NWS-BREACH, was given as the upstream boundary. The attenuation of Lake Imja Tsho GLOF is much dampened. The peak discharge of 5400 m^3s^{-1} at the outlet of the lake is sustained for a considerable distance. Many closely spaced peaks are found throughout the river reaches. Higher flooding depths occur at the narrower river sections. Such narrow sections can be found at the gorges downstream of Tengboche and upstream of Namche Bazar, and at the confluence of the Dudh Koshi and Bhote Koshi. The spatial distribution of the flood was analysed by preparing inundation maps for the high flood level along the river. The inundation maps reveal the spatial extent of the flooding as well as the depth of the flooding along the river reach (Table 4.3). This table helps estimate the arrival time of the flood – information that can be useful in preparing to reduce the GLOF risk.

Regional Climate Model

A regional climate model (RCM) is a high resolution climate model that covers a limited area of the globe, typically 5,000 km x 5,000 km, with a typical horizontal resolution of 50 km. RCMs are based on physical laws represented by mathematical equations that are solved using a three-dimensional grid. Hence RCMs are comprehensive physical models, usually including the atmosphere and land surface components of the climate system, and containing representations of the important processes within the climate system (e.g., cloud, radiation, rainfall, soil hydrology). Many of these physical processes take place on much smaller spatial scales than the model grid and cannot be modeled and resolved explicitly. Their effects are taken into account using parameterizations, by which the process is represented by relationships between the area or time averaged effect of such sub-grid scale processes and the large scale flow.

Given that RCMs are limited area models they need to be driven at their boundaries by time-dependent larges cale fields (e.g., wind, temperature, water vapour and surface pressure). These fields are provided either by analyses of observations or by GCM integrations in a buffer area that is not considered when analysing the results of the RCM (Jones *et al.*,1995).

PRECIS Model

PRECIS is a regional modeling system that can be run over any area of the globe on a relatively inexpensive, fast PC to provide regional climate information for impacts studies. The idea of constructing a flexible regional modeling system originated from the growing demand of many countries for regional-scale climate projections. Only a few modeling centers in the world have been developing RCMs and using them to generate projections over specific areas as this task required a considerable amount of effort from an experienced climate modeler and large computing power. Both these factors effectively excluded many developing countries from producing climate change projections and scenarios. The Hadley Centre has configured the third-generation Hadley Centre RCM so that it is easy to set up. This, along with software to allow display and processing of the data produced by the RCM, forms PRECIS.

Use of PRECIS RCM model in Nepal

In 2010 the ICIMOD conducted one research on climate change impact on eastern Himalayan region of Nepal through PRECIS model on RCM framework. The study focuses mainly on analysis of contemporary trends in temperature and precipitation in the region and on analysing the scenarios of future climate change. The Climate Research Unit's Times Series' (CRU TS 2.0) data (New et al. 2002) were used to analyse temperature and precipitation trends. The eastern Himalayas were divided into three elevation zones: below 1,000, 1,000 to 4,000; and above 4,000 metres and area-averaged trends were derived for these regions for the period from 1970-2000. The period from 1970-2000 was chosen because after the 1970s the global and regional temperature records show monotonous rising trends, whereas before this period the trends generally descend (Jones and Mann 2004; Shrestha et al.1999). The spatial distribution of trends in annual and seasonal temperature is illustrated in Figure 2: it is clear that major parts of the region are undergoing warming trends. Annual mean temperature is increasing at the rate of 0.01°C/yr or more. In general, for annual and seasonal trends there is a diagonal zone with a southwest to northeast trend with relatively less (0 to 0.02°C/yr) or no warming. This zone encompasses the Yunnan Province of China, part of the Kachin State of Myanmar, and the northeastern states of India and Assam. The area to the upper left of this zone, which includes eastern Nepal and eastern Tibet, shows relatively greater warming trends (>0.02°C/yr). The warming in the winter (December, January and February; DJF) is much greater, about 0.015°C/yr more than the annual trends and more widespread by comparison. The diagonal zone of less warming is significantly small and limited to Yunnan and Arunachal Pradesh.

Conclusion

It is found from the literature review that different types of models are used in Nepal regarding climate change. Global Climate Model was used by (McSweeney et al, 2011) showing trends in annual mean temperature for the recent past and projected future simulated by 15 models for each emissions scenario (%) anomaly and trends in annual mean rainfall for the recent past and projected future simulated by 15 models for each emissions scenario % anomaly.

Empirical (statistical) downscaling (An analysis of statistically downscaled data derived from using station meteorological data) was done by the University of Cape Town archive (A2 scenario for the 2040-2060 time period, UCT, 2012) considering around 9 models, downscaled to individual met stations for determining Monthly daily maximum temperature and monthly rainfall for the mid-century projections (A2) for different sites in the country.

With respect to Regional Climate Models, there have been several families of models applied in Nepal (NCVST, 2009: Karmacharya et al., 2007; GCISC et al. 2009). As an example, the DHM study (Karmacharya et al., 2007) projects warming in all seasons in the mid-21st century (2039-2069). A new set of regional climate model runs have recently been produced as part of the DHM climate portal (which has three regional climate model outputs for the A1B scenario) and the 2nd National Communication, which again has a RCM output for the A1B scenario. In 2010 the ICIMOD also conducted a research on climate change impact on eastern Himalayan region of

Nepal through PRECIS model on RCM framework. The study focuses mainly on analysis of contemporary trends in temperature and precipitation in the region and on analysing the scenarios of future climate change.

An analysis was done by the Nepal Agriculture Research Council (Gautam, 2008) using simulation models for major crops such as rice, wheat and maize. The main quantified focus to date has been on crop production and two main approaches have been used in the agricultural sector to assess future impacts (and economic costs): crop models and ricardian (econometric) analysis. There is a significant literature that has applied crop models (agronomic models) to assess the soil-plant-atmosphere components relevant for plant growth and yield, and also look at the effects of future climate change on crop productivity (GON, 2004: Sherchand et al, 2007; Rai et al) as an example DSSAT modeling.

The Water Balance Model – *WatBal* was first used in Nepal within the US country study programme for the Koshi Basin (Gurung, 1997, p.33). MOPE (2004, p.98) used the same model for the Karnali, Narayani, Koshi and Bagmati Rivers in Nepal in order to assess the vulnerability of climate change to water resources. It was also used by Chaulagain, 2006 in Chovar in the Bagmati basin (rain-fed) and Kyangjing in the Langtang basin.

NDRI/ICHARM (2012) used a Rainfall Runoff Inundation (RRI) model, which projected that precipitation frequency will increase in the near future due to climate change, with an increase in intensity that will increase extreme (flood) events in the lower West Rapti River Basin, leading to increased household damage and agricultural losses.

Naito et al. (2000, p. 245) applied Empirical Glacier Mass Balance Model model in the Eastern Himalayas for a numerical simulation of shrinkage of the Khumbu glacier and predicted the likelihood of formation and succeeding enlargement of a glacier lake in the lower ablation area of the glacier. Similarly, Naito et al (2001, p. 315) used the same model for estimating sensitivities of some other glaciers in the Nepal Himalayas in relation to climate change.

The conclusion of ICIMOD research shows that the area-averaged seasonal and annual biases and sensitivities of the HadRM2 and PRECIS simulated mean temperatures over the Eastern Himalayan region. Both models indicate cooler climates than those of the observed data during all seasons and annual periods. Further, both models show the greatest bias during winter (DJF) and the least during pre-monsoon (March, April and May; MAM) over the region. Comparing Tables 2 and 3, the biases in the PRECIS simulation are greater than those in the HadRM2 simulation by 0.8°C in DJF and 0.1°C in MAM. Whereas, the biases in the HadRM2 simulation are greater than those in the PRECIS simulations by 0.5°C in summer (JJA) and 0.7°C in the post-monsoon (September, October and November; SON) period. It may thus be concluded, in general, that over the Eastern Himalayan region the performance of HadRM2 is better during winter and that of PRECIS is better during the summer and post- monsoon (SON) seasons. During the pre-monsoon (MAM) and annual periods, both models perform more or less uniformly.(*Devkota l. et. Al, ICIMOD, 2010).*

Recommendations

Due to complex geographical structure, data availability and based on literature review the PRECIS model with RCM framework is suitable for climate change impact study in Nepal. The PRECIS model is suitable because it can be run on a personal computer (PC) and can be applied to any area of the globe to generate detailed climate change projections. PRECIS has a horizontal resolution of 0.4425° latitude by 0.4425° longitude with 19 levels in the atmosphere and four levels in the soil. The present version of PRECIS has an option to downscale to a horizontal resolution of 25 km with A1B scenario. Other appropriate models that are suggested for Nepal include the following:

- In Agriculture DSSAT crop models (agronomic models) to assess the soil-plant-atmosphere components relevant for plant growth and yield, and the effects of future climate change on crop productivity.
- There are models (BIOME 3, FAO) to project the extent and nature of future ecosystem changes in the geographical distribution of species, and these models can be effective partially to quantify effects of climate change in a country like Nepal where adequate data are not available.
- Empirical Glacier Mass Balance Model to calculate the mass balance
- Water Balance model for climate impact assessment of river basin runoff

Acronyms

ADB	Asian Development Bank
APN	Asia Pacific Network
COP	Conference of Party
DHM	Department of Hydrology and meteorology
DSSAT	Decision Support system for Agro technology Transfer
GLOF	Glacier lake Outburst Floods
ICIMOD	International Centre for Integrated Mountain Development
IFC	International Finance Cooperation

IPCC	Intergovernmental Panel on Climate Chang
MOPE	Ministry of Population and Environment
NAPA	National Adaptation Program for Action
NARC	Nepal Agriculture Research Council
NDRI	Nepal Development Research institute
OECD	Organization for Economic Cooperation Development
PRCIS	Providing Regional Climate for Impact Studies
RCM	Regional Climate Model
RRI	Rainfall Runoff Inundation
SNC	Second National Communication
UNDP	United Nation Development program
UNEP	United Nation Environment Program
UNFCC	United Nation Framework Convention on Climate Change
WFP	World Food Program

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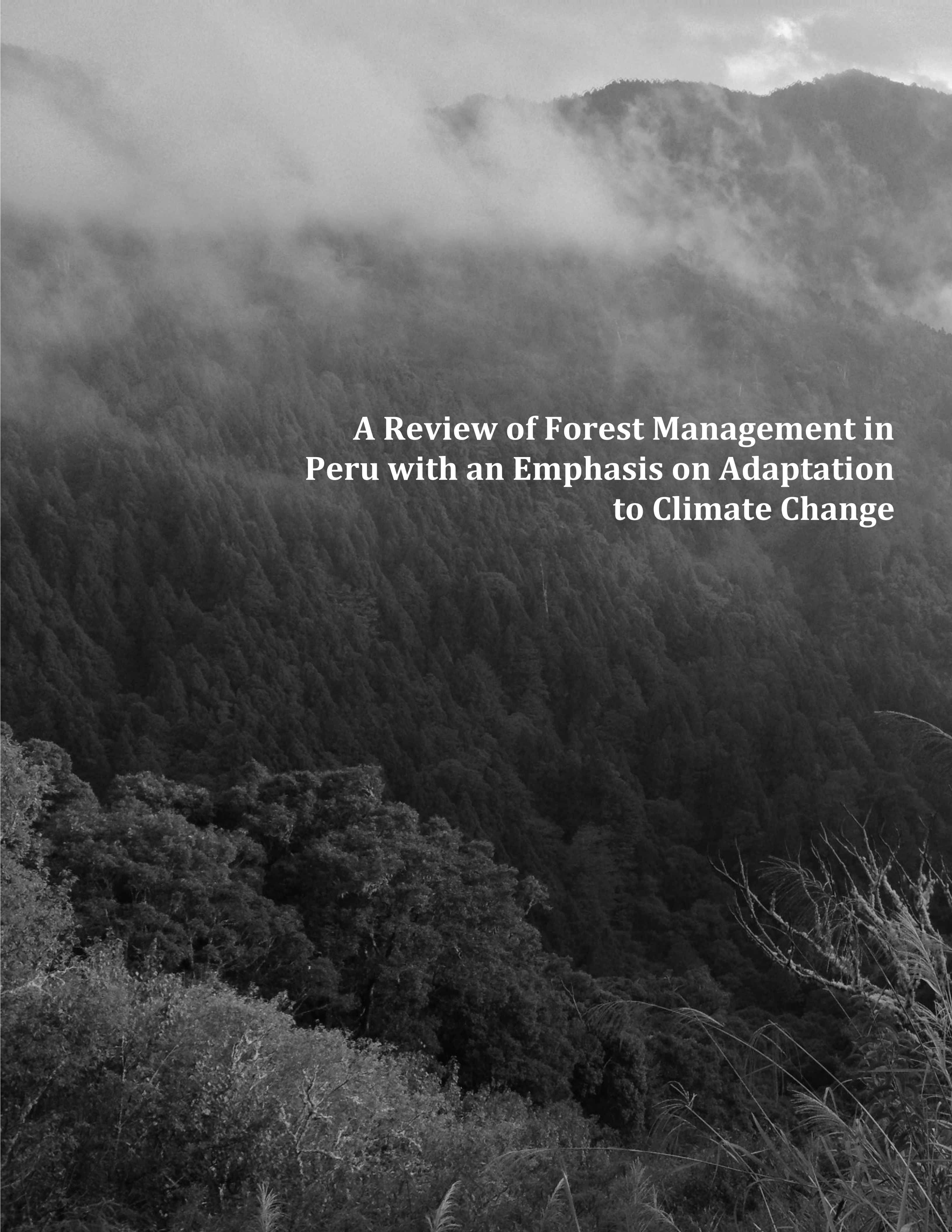

A Review of Forest Management in Peru with an Emphasis on Adaptation to Climate Change

A Review of Forest Management in Peru with an Emphasis on Adaptation to Climate Change

Forest Management in Peru

There are a wide variety of natural resources in Peru with a forested area of 69 million ha (Coast = 4.6%, Highland = 1.3% and Jungle = 94.1%). The Ministry of Agriculture - MINAG, through the General Directorate of Forestry and Wildlife - DGFFS, is the lead agency for ensuring the proper management of forests and forest resources and wildlife for the national benefit of society and the environment. The DGFFS consists Technical Administrations of Forestry and Wildlife - ATFFS, who are responsible for the management and control activities forest wildlife in the area under its jurisdiction-wide Peruvian territory. It also formed by the following directorates:

- Promotion Directorate of Forestry and Wildlife - DPFFS. - Proposes, coordinates and monitors standards, guidelines, policies, programs and projects. Establishes guidelines for responsible forest management and advocacy, etc.
- Management Directorate of Forestry and Wildlife - DGEFFS. – Attends to administrative procedures (export permits, registrations, etc.)
- Information and Control Directorate of Forestry and Wildlife - DICFFS. - Manages the National Information System for Forestry and Wildlife. Generates and consolidates information forestry, among others.

Forest Resources

Peru has the second largest area of Amazonian forests in Latin America with a high potential for mitigation of climate change (Figure 1). It is an important source of natural resources and environmental services. Forestry is important in Peru as it owns 13% of the Amazonian rainforest and has over 70 million ha of forest (MINAM, 2009). Peruvian forests are incredibly diverse with as many as 2,500 different plant species per hectare, as well as a great diversity of tree species, as reflected in the forests of Misahana y Yanamono (Loreto region) with 300 species of trees per hectare.

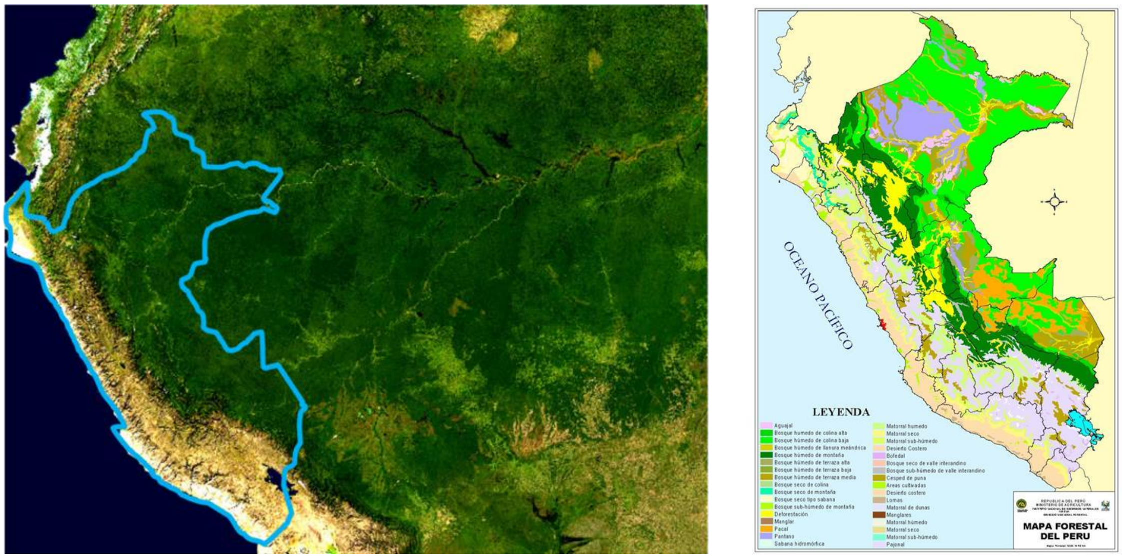

Figure 1. The area of Peru overlaid on a satellite image of the eastern Amazon region (left) and a map of the forest types within Peru (right).

Deforestation

The factors leading to deforestation in Peru include: slash and burn agriculture, wood extraction, grazing of livestock, large-scale agriculture and forest plantations, clearing to grow cocoa, construction of illegal airstrips, and road and infrastructure development in the Amazon. These are compounded by the increased demand for land and resources due to population growth (PCM, 2008).

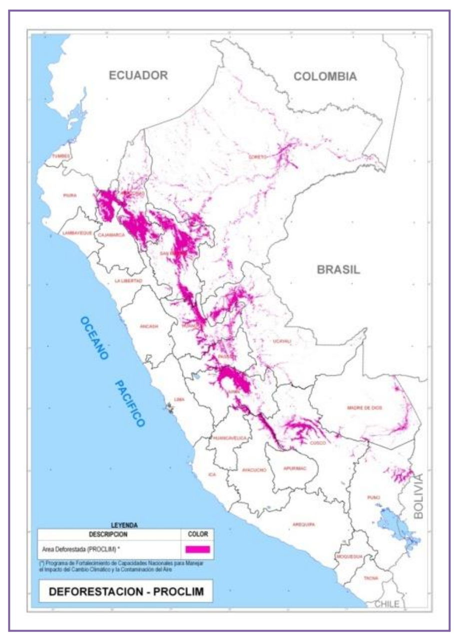

Figure 2. Map of deforestation in Peru.

The largest areas deforested are: Amazonas, Loreto and San Martin (Figure 2). Currently, the Peruvian government, through the Ministry of Environment, has developed two initiatives to reduce deforestation; The first, entitled the Special Project Preserving Together, is designed to preserve at least 10.5 million ha of Amazon forest in five years, located on lands titled to indigenous communities. The second entitled the National Initiative for Conservation of Forests is designed to stop deforestation voluntarily through the conservation sustainable 54 million ha of forests. In addition there is a large amount of land available for reforestation initiatives (Figure 3).

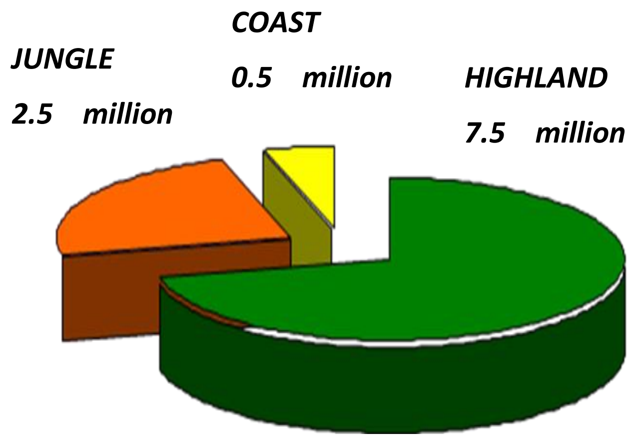

Figure 3. Lands suitable for reforestation (10.5 million ha) by type.

Action Plans for Adaptation to Climate Change

National Climate Change Strategy

The overall objective of the National Climate Change Strategy is to reduce the adverse impacts of climate change through integrated studies of vulnerability and adaptation, and to identify vulnerable areas and sectors in the country, where adaptation projects should be targeted. Another key objective is to control emissions of local pollutants and greenhouse gases (GHG), through renewable energy programs and energy efficiency in various sectors.

National Communication of Peru to the Convention United Nations

Peru is a country party to the UN Framework Convention on Climate Change (UNFCCC) since 1992 and the Kyoto Protocol since 2002, and thus aligns with the objective of the Convention to "stabilize the concentration of greenhouse gases in the atmosphere and avoid reaching a level of dangerous anthropogenic interference ". Through its Second National Communication, Peru fulfilled its commitment to inform the parties of its emissions of greenhouse gases (GHG) and to outline the measures taken or envisaged to implement the Convention. The Peruvian government decided that this effort should be accompanied by a solid and ambitious international commitment. The diverse nature of climate change and the geographical, social, political and cultural center of Peru requires the participation of diverse and multiple actors.

Data Sources and tools for Addressing Climate Change

National Inventory of Greenhouse Gases - GHG

The reporting of GHG emissions is a major requirement of the National Communication mandatory for signatories to the UN Framework Convention on Climate Change and the Kyoto Protocol. A GHG emissions inventory is a database that lists, by source, the amount of greenhouse gases emitted into the atmosphere in for a certain time period (EPA, 2009). For Peru, the detailed quantification and analysis of the results of the inventory is critical to guide and promote national efforts to mitigate emissions towards the overall goal of combating climate change. Nationally, this information allows the development of regulations to guide the economic and social sectors, encourage alternative energy sources and establish policies that ensure the continuation of a process of sustainable development that is better adapted to the demands of climate change. The national GHG inventory data refers to the year 2000 and is expressed in the units of CO_2 equivalents (CO2e). The inventory is also compared against figures from the inventory of 1994, corresponding to the First National Communication. The main sources of national emissions are classified by category and presented in relation to the increases in GDP and population during the period. It also provides information with respect to uncertainties to provide quality control and quality assurance of the data.

The national inventory shows a growth in emissions of 21% from the year 2000 to 1994. During this period Peru's GDP increased by 23% and the population increased by 10.7%, leading to a per capita emission increase of 2.5 tCO_2e. Globally, Peru in the year 2000 represented to 0.4% of total emissions. Compared to the first inventory in 1994, Peru showed progress in institutionalizing monitoring actions of emissions, coordinating among stakeholders, improving the methods of collection and storage of information.

Remote sensing was employed to improve the precision of the analysis of Land Use Change and forestry – LULUCF. The LULUCF sector represents the largest source of emissions in Peru coming mainly from deforestation in the Peruvian Amazon: 47.5% of the total. Power generation (21.2%) was the next largest source followed by industrial processes (18.9%).

A proposal has been put forward through the National GHG Inventory process to improve the quality of the data, including the determination of activity levels and the development of emission factors. It also aims to optimize methodologies, uncertainty quantification, quality control, and to improve mechanisms for data collection and institutional coordination, particularly in the LULUCF. This process involves capacity building activities, development and technology transfer, and coordination aimed at building the still nascent inventory development effort to contribute to the overall management of climate change.

Mitigation and Adaptation to Climate Change in Peru in the Forestry Sector

Peru has pursued projects under the Clean Development Mechanism and the mechanism for Reducing Emissions from Deforestation and Forest Degradation in developing countries, including conservation, sustainable forest management and enhancement of forest carbon stocks (REDD +).

The main focus of the mitigation strategy has been to implement policies in the public sector to restore and maintain forest ecosystems. However, this will require additional technical and financial support both nationally and internationally.

Since 2001 there have been efforts to create and strengthen institutional capacities with support from the Clean Development Mechanism (CDM). In 2003, the government approved the National Strategy for CDM in order to identify potential investment in mitigation projects and to develop national policies for Peru's participation in the CDM.

Between 2001 and December 2009, MINAM approved 39 CDM projects, of which 21 have already been registered by the CDM including 6 that have generated income from the sale of Certified Emission Reductions (CERs). Together, the projects represent a reduction greater than 67 million tons of CO_2e. The most common project types include hydropower (61%), followed by fuel switching projects (13%) and solid waste (11%). Peru is considered one of the most attractive countries for investment in CDM projects worldwide.

Although Peru is not a big emitter in absolute terms, it has comparable emissions to countries with higher GDP and is working to decouple its economic growth trajectory from the growth trend of emissions. Mitigation efforts within Peru can provide economic and social benefits to help offset the costs of reducing emissions. Short-term efforts will be focused on increasing energy efficiency through hydropower generation and to other sources of renewable and clean energy. In the medium-term work within the forestry sector will help to reduce the costs of mitigation efforts including: reducing deforestation and forest degradation and increasing forest area through reforestation. These efforts will have benefits with respect to the conservation of biological diversity, and will help to maintain the flow of ecosystem services that improve the quality of life in forest dependent communities.

Challenges in Forestry

The following challenges must be addressed to improve forest management in Peru:

- Encourage private investment in conservation and the sustainable use of forests.
- Adopt regulations on payments for ecosystem services.
- Channeling international financial resources to implement the National Initiative for Forest Conservation and Preserving Special Project Together.
- Minimize the potential for harmful incentives that could promote further deforestation.
- Develop and evaluate potential deforestation baseline scenarios at the sub-national level.
- Generate capacity among all stakeholders, especially among forest-dependent indigenous communities.
- Update existing inventory data to better account for deforested and degraded land throughout the country.

In relation to REDD +:

- Clarify the legal and institutional framework for the implementation of REDD + schemes.
- Design a system for equitable distribution of the benefits to be gained as a result of the establishment of REDD + schemes.
- Define the rights of ownership or grant of environmental services.
- Increase access to financing and technology to design and implement appropriate procedures for measurement, reporting and verification.
- Conduct studies of forest opportunity costs (regional) to determine the value of the benefits that would ensure their protection.
- Build models to evaluate the impacts of different activities on deforestation, degradation and loss of carbon stocks.
- Improve access to reliable regional baseline deforestation scenarios and build references to generate possible future scenarios.
- Establish an institutional framework that includes a system of measurement, reporting and verification of forest with clear competences.
- Determination of standards or tax laws related to economic benefits (cash income) obtained as a result of the implementation of REDD + mechanisms.

Ongoing Work in Forest Inventory Development

Forest Inventories in Permanent Production Forests (Department for the Promotion of Forestry and Wildlife)

The Department for the Protection of Forestry and Wildlife, in conjunction with respective regional governments, has begun development of forest inventories in permanent production forests where forest concessions were implemented (2002-2004). Inventories are being developed using the ARC GIS platform.

National Inventory of Forests and Sustainable Forest Management Peru on Climate Change (MINAG-MINAM-FAO) (GCP/GLO/194/MUL)

This inventory is being developed jointly by the Ministry of Agriculture, Ministry of Environment and FAO. It aims to improve the ecological, social and economic forests and natural resources, and increase its benefits to rural livelihoods and their role in mitigating and adapting to climate change in Peru. The platform Open Foris developed by the FAO is being used for the collection and processing of data (Figure 4).

Figure 4. A screenshot showing the user interface for the Open Foris software.

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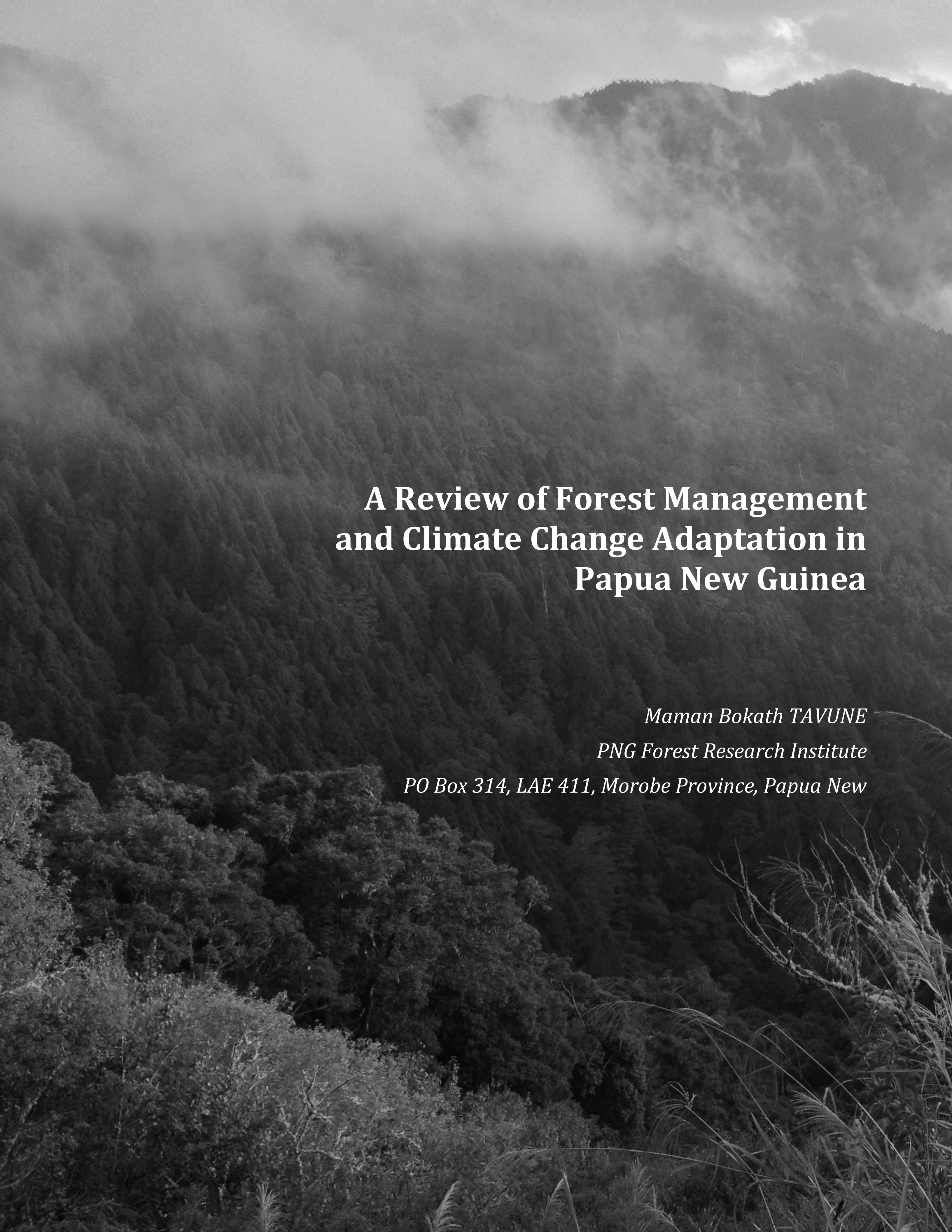

A Review of Forest Management and Climate Change Adaptation in Papua New Guinea

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Abstract

The PNG Forest Authority as mandated by the government oversees Forest management in Papua New Guinea (PNG). The total landmass of PNG is 46.3 million ha of which 62.6% (29.437m ha) is forested. All forestry operations by PNGFA are governed by specific policies and guidelines. The foundation for the forestry policies is the 4th goal of the National Constitution: "…to ensure that the forest resources of the country are used and replenished for collective benefit of all Papua New Guineans for current and future generations." Forest adaptation initiatives associated with extreme climate events are governed by a policy framework for action for 2009 to 2015. Impacts of climate change on forest ecosystems, social and economical values are clearly described. Efforts are taken to assess vulnerabilities of identified impacts of climate extremities. Likewise, local communities and other key stakeholders have initiated adaptation measures.

Key words:

Forest management, PNG Forest Authority, climate change, climate extremities, vulnerability, adaptation

Forest Management in Papua New Guinea

The Papua New Guinea (PNG) Forest Authority (PNGFA) manages the vast tropical forests and forest resources of PNG as mandated by the government. PNGFA's mission statement is in harmony with the country's constitution and aims to *"Promote management and wise utilization of the forest resources of Papua New Guinea as a renewable asset for the wellbeing of present and future generations."* As the custodian of the forests and forest resources, PNGFA is responsible for managing and developing the nation's tropical natural forest and state-owned forest plantations and for negotiation of timber industries activities as well as other forest related activities in the country.

Forests and forest resources of PNG

The total landmass of PNG is 46.3 million ha of which 63% (29M ha)was classified as forested area as of 2010 (FAO, 2010). The total land cover is broadly classified as shown in Figure 1. The productive forestlands of PNG are rich with some of the world's highest quality tropical hard woods and other forest products that are a major revenue source for the country[1]. The forest resources of PNG are unique and very diverse in terms of flora and fauna, some of which are found nowhere else on earth. PNG's vegetation is classified based on the structural formation of the vegetation. Six broad classes have been distinguished as follow; Forests, Woodland, Savannah, Scrub, Grassland, Mangroves. Within these 6 structural formations, 59 vegetation classes have been differentiated.

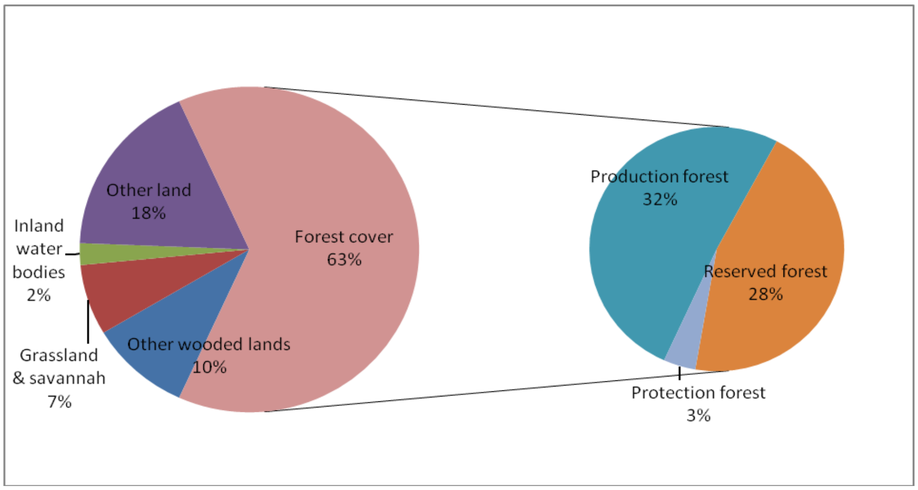

Figure 1: Land coverage of PNG. Source: FAO, 2010

Geographically, the independent state of PNG is located on the eastern end of the Island of New Guinea and lies between 141.0° and 154.9° eastern longitudes and between 2.2° and 11.7° south latitudes (Figure 2). PNG has a population of about 6.1 million people with over 800 distinct languages and over 1000 ethnic tribal groups. Moreover, over 85% of the country's population live in rural areas and depend on the forests for their sources of food, medicine, clothing, shelter, water and for almost all their daily needs.

[1] PNG FA 2007 – 2012 Corporate Plan

Figure 2: Map of New Guinea showing the Independent state of Papua New Guinea.

Over the last 20 years (1990-2010), the forested areas of PNG have decreased by around 9.37% (3 million ha; FAO, 2010). Elsewhere, Shearman *et al* (2008) also reported 1.41% of PNG's forests being deforested or degraded between 1972 and 2002. The major causes of deforestation and forest degradation have been logging and subsistence agriculture. Figure 3 shows the different drivers of deforestation and forest degradation.

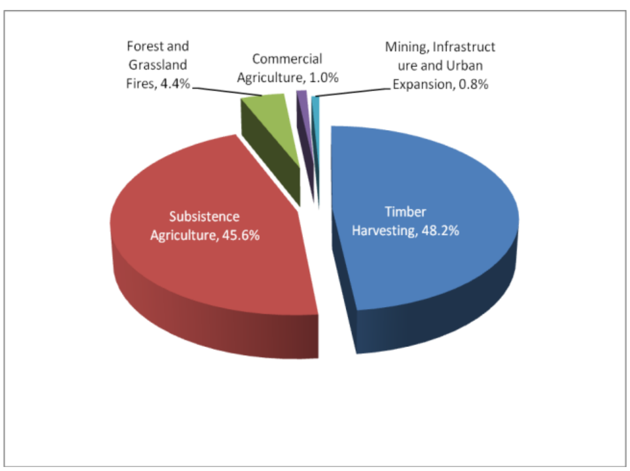

Figure 3: Pie chart showing different drivers of deforestation and forest degradation in PNG. Source: FAO, 2010.

Forest Policies

Forest resources within PNG are managed by the PNGFA. Its operations are governed by the following policies and guidelines: National Forest Policy 1991, Forestry Act 1991 (as amended), PNG Forest Authority Corporate Plan, The National Forest Development Guidelines 2009, Forest Regulations, National Forest Plans (19 Provincial Forest Plans)[2], PNG Logging Code of Practice, 24 Key Standards, and the Forestry and Climate Change Framework for Action 2009-2015. The main policy target [i.e. National Forest Policy 1991] was approved in 1990 and published in 1991. There are two main objectives of this Policy: (i) management and protection of the nation's forest resources as a renewable natural asset, and (ii) Utilization of the nation's forest resources to achieve economic growth, employment creation, greater Papua New Guinean participation in industry and increased viable onshore processing. There are four other supportive objectives of the 1991 Forestry Policy that are consistent with the government's strategies, especially in the sustainable development framework (e.g. MTDS[3]; LTDS[4] and PNG Vision 2050). The foundation for the forestry policies is the fourth goal of the Constitution and that is, *"to ensure that the forest resources of the country are used and replenished for the collective benefit of all Papua New Guineans now and for future generation."*

Framework of Planning System

The National Forest Plan provides a detailed statement on how the government intends to manage, develop and utilize the national forest resources. The forestry plan outlines a program of forest acquisition and the identification of areas that are considered to be suitable for commercial logging. Areas suitable for logging are acquired by the State under a Forest Management Agreement (FMA) between the landowner's representative, identified under an Incorporated Land Group (ILG), and the PNG Forest Authority. Operations of all major timber concession areas are processed and operated in accordance with the National Forest Plan and the respective Provincial Forest Plans and regulated by the Forestry Act.

Forest resource development is undertaken in accordance with the National Forest Plan, Provincial Forest Plan and the National Forestry Development Guidelines. Timber harvesting operations are guided by the 'PNG Logging Code of Practice' and the '24 Key Standards' .

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[2] National Forest Plan comprises following documents: Development Guidelines for Forestry Sub-Sector; Forest Classification in each Province; Allowable cut by Province; Schedule for forest development in each province; National Forest Development Programme.

[3] Medium Term Development Strategy

[4] Long Term Development Strategy

Environmental Protection System

Environmental management is one of the eleven listed strategies under the Forest Management Policy. According to forestry policy, all forest resource developers are required to submit an environmental plan for each approved project. The environmental plan must be consistent with the Environmental Planning Act. Guidelines specific to forestry projects are regulated and issued by the Department of Environment and Conservation. Areas approved for conservation are restricted from any forms of development, except where specific permission is given by the Minister for Environment and Conservation under a relevant clause of the Environmental legislation. The Environmental Key Standards and Logging Code of Practice are supportive documents that provide guidance to ensuring compliance and effective monitoring of logging operation and the environment. However, there is need for climate change, variability and sea level rise policy as it is important for the country. Further, there is also a need for a review of the current National Action Plan for Adaptation of vulnerable forest ecosystems for PNG to compliment the broad framework 2009-2015.

Action Plan For Climate Change Adaptation

The PNG Forest Authority has recognized that it cannot achieve its commitment to sustainable development and as a national government agency without the support of other relevant agencies and partner support. Within this context a framework for action, *"Forestry and Climate Change Framework for Acton for 2009-2015",* outlines the broad priorities for the government. The framework provides a strategic platform not only for use by policy and decision makers, but also for the development and strengthening of national, provincial and community partners for implementation of initiatives. The framework is consistent with the timeframes of PNG's national development strategies[5] and other international obligations[6]. Significantly, it addresses the issues of forestry and climate change that require a national multi-stakeholder approach. The vision of this framework has been defined as follows: *"…Papua New Guinean people, their forests, environment and livelihoods are resilient to the risks and impacts of climate change"*. The goal is: *"to ensure that Papua New Guinea people build their capacity to be resilient to the risks and impacts of climate change through implementing adaptation measures; contributing to mitigation of greenhouse gas (GHG) emissions; improving decision making and good governance; improving understanding of climate change and its effects; promoting education and awareness; and developing and strengthening partnerships and cooperation"*.

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[5] E.g. Medium Term Development Strategies (MTDS) and Millennium Development Goals (MDGs)

[6] E.g. Kyoto Protocol, the Johannesburg Plan of Implementation and subsequent work program of the UN Commission on Sustainable Development.

Implementing Climate Change Adaptation Measures

Increasing resilience with respect to climate change through adaptation has been identified as a key priority for all provinces and communities. The government has acknowledged that PNG is already witnessing the adverse effects of climate change. The New Guinea Islands, highlands and coastal areas of the country, in particular believe their very survival is threatened. The ecological fragility, economic vulnerability and the remoteness of PNG inhibit its ability to recover from extreme weather and climatic events. National adaptation policies and measures need to be integrated into sustainable development strategies and plans. PNG will encourage adaptation measures based on the precautionary approach and principles of risk management with a focus on improving the livelihoods of its people. Such an approach will require the implementation of resilience building measures that have multiple benefits including disaster risk reduction.

Expected Outcomes by 2015

The following outcomes are expected by 2015:

- Adaptation measures to climate change developed and implemented at all levels.
- ARCDM and REDD^{+} projects on forestry initiatives facilitated and developed with adaptation funds or from government and donor funding.
- Highly vulnerable forestry priority areas identified through site-specific baseline data, collection and interpretation and adaptive actions developed.
- Integrated approaches to adaptation embedded in national sustainable development plans and budgeting process.
- Research and development into forest types and climate impacts.
- Restoration and rehabilitation: forest enrichment and plantation development with soil protecting species in highly degraded areas.
- Main streaming of climate change into Forest Management Plans and policies.
- Methodologies and research initiatives incorporated and streamlined into school curriculum.
- Integrated food and wood production (agroforestry) for environmental, economic and social services that improve local communities' capacity to cope with adverse climatic events.
- Improved and effective coastal mangrove and littoral forest management to minimize effects of heavy storms and rising sea level on coastal communities.
- Improved and effective urban forestry management to maintain and improve shade cover to keep towns and cities in PNG cooler.

Implementation Strategy

PNGFA recognizes that the implementation of this framework, its forestry policy, MTDS, LTDS, the PNG MDGs Strategy, and the PNG Vision 2050 are mutually reinforcing. This will require more focused and substantially increased efforts by PNGFA, the PNG Government and by the rest of the international community. These efforts are based on the recognition that PNG has primary responsibility for its own development strategies. The PNGFA, with the necessary support from its donor partners and the international community, will seek to implement actions identified in the national framework with the support of the landowners and their communities, as necessary. Harmonized implementation of this five-year framework is essential.

Monitoring Framework

Evaluating progress towards the vision, goal, principles, outcomes and priority activities of this framework will be undertaken following the establishment of an appropriate baseline and mechanism. UN organizations, NGOs and the private sector will, where necessary, provide support for regional and international reporting. Targets and indicators will be established within the action plan linked to the framework and set at the appropriate levels. A mid-term review of the framework is currently being done (2013) to determine its overall success. Key stakeholders will meet biennially to review progress on the implementation of this framework and its action plan. This will require the PNGFA, Office of Climate Change and Development (OCCD), the Government, local communities, and NGOs to identify progress towards achieving and implementing the principles contained in this framework, and to identify emerging gaps requiring priority action and adjustment of priorities in the future.

Key Issues and Management Options for Addressing Climate Change

Climate Change Predictions

Surface temperatures in PNG are projected to increase by 2-4 °C (IPCC, 2007) combination with decreases in precipitation. These projected changes will likely lead to significant increases in the frequency and intensity of extreme climatic events, e.g. El Nino and La Nina. The IPCC Fourth Assessment Report (FAR) provides and reaffirms strong evidence that global, regional and national changes due to climate change, variability and sea level rise are caused by human and natural activities (IPCC, 2007).

Current Impacts of Climate Change

Climate change in PNG is real and its impacts on terrestrial ecosystems are becoming more evident including the following observations: increasing surface and air temperatures, changes in distribution and intensity of rainfalls, alteration of hydrological regimes, changes in wind patterns and intensity, altering fire frequencies and intensities, flooding and erosion regimes and changes in frequency and intensity of extreme weather events (Saulei, S., *et al.* 2011).

The impacts of climate change in PNG are quite clear. The consequences of extreme climatic conditions with in the forestry sector are projected to include the following (also see Table 1):

- Prolonged and intense droughts and increased fire frequency and intensity: e.g. in 1997-98 PNG experienced severe droughts resulting in extensive forest fires and loss of big areas of both natural and plantation forests.
- Increased temperatures leading to reduction in soil moisture, changed soil physical structures, increased seedling mortality: (e.g. Bulolo forest plantation – reduction in tree growth and termite attack as being reported).
- Changes in the phenology, seed quality and physiology of trees due to increased temperatures.
- Invasive weeds: Increased occurrence of weeds and invasives such as exotic plants and animals which are not known to occur in the area before.
- Insects and pathogens: e.g. increase termite attack on trees as in Bulolo plantation, termite attacks were found to be related to the vulnerability of trees exposed to increasing temperatures and changed soil physical conditions (Saulei *et al,* 2011).
- Natural forest mortality: Increased frequency of drought mortality leading to substantial socio-economic impacts
- Increased frequency of pests and diseases: trees that are stressed due to injuries sustain during logging are more vulnerable to any form of insect and pathogenic attacks. Exposure to new extreme micro-climatic conditions e.g. as observed at Asengseng, (Saulei *et al* .unpl.) may only promote pest and diseases and thus tree mortality.
- Flooding, landslips and erosion: Increased frequency of extreme precipitation events resulting in flooding, soil erosion, landslips and increased seedling mortality (esp. in plantation).
- Sea level rise –Trees are dying along low lying coastal areas and on low lying atolls, e.g. along an inlet at Jacquinot Bay, Pomio, resulting from the effects of rising sea level or subsiding land enabling the sea to submerse the area. Mangroves are also dying in some areas (e.g. Aromot Island) due to lack of substrate which have been eroded over past years. Hence, islanders plant more mangroves to protect their islands behind constructed sea walls following mangrove zonal arrangements along the coastline.
- Food and freshwater security: Rise in sea level has allowed sea water to move inland through surface wash and intrusion through the soil thus affecting freshwater sources and food crop yields e.g. Siasi Island, Duke of York Islands (Saulei, et al., 2010; Saulei & Nagari, 1998) and outlying islands and atolls.

Table 1. A summary of the elements of climatic vulnerability and their impacts.

Exposure & Sensitivity	Impacts
Increase temperature	Changes to soil physical characteristics including moisture holding capacity; increase vulnerability of plant matter susceptible to fire; change in phenological behavior of trees.
Increase in extreme events	Droughts, floods; landslips, soil erosion, soil compaction due to flushing out actions of flowing water
Increases in forest fires	Reduction in wood supplies; follow up infestations by insects and pathogens
Increases in insect, fungal, etc. outbreaks	Reduction in wood supply both in terms of quantity and quality
Changes in forest productivity	Changes to wood supply and carbon sequestration
Shifts in species composition	Changes to technology and markets; changes to other values
Genetic erosion through selection and breeding especially for species selected for seed orchards	Reduction of resilience or adaptation mechanisms to impacts of climate change

Source: Saulei, S. et al. 2011

Like the rest of the world PNG must begin to reduce their levels of emissions by developing and applying national climate change and mitigation policies:

1. The impacts of climate change is extended to oceans, extreme temperatures and wind patterns,
2. Volcanoes and its aerosols in PNG continually contribute to offsetting some warming,
    - PNG GHG levels/concentrations continue to increase due to the Petroleum, Gas and Mining activities, Forestry, waste, energy and technology contributions,
    - Risk assessment and monitoring on climate change, variability and extreme events in PNG should be a priority.

Projected Impacts of Climate Change in PNG

The following are important potential projections in the climate change; variability and sea level rise in PNG:

- The level of GHG in the atmosphere will continue to increase in the next 100 years as developing countries like PNG will contribute to meet its economic and social aspirations through the development of natural resources of oil/gas, forest and landuse change;
- Melting of ice caps and thermal expansion of the oceans are the main factors contributing to the sea level rise in PNG and the pacific region. Provinces such as Bougainville, Manus, East Sepik, Milne Bay, Central, Gulf, Western, East New Britain and others with their outlying small islands will be further impacted;
- Climatic data for PNG and pacific region are still scarce and there is an urgent need for better modeling for future projections is essential;
- Most global models project that there will be an increase in the frequency and intensity of tropical cyclones;
- Climate change and variability will impact the whole country but will be most heavily felt in the New Guinea Islands, Milne Bay, Gulf, Central, Sepik Provinces, and Fly provinces.
- EL Nino and La Nina signals will continue to increase in frequency and intensity with impacts on the entire country on food and freshwater security.
- Highland provinces will be impacted severely by the increased frequency of drought events especially for populated areas.

Such information is vital to help guide the development of effect forest management policies and strategies with respect to climate change adaptation.

Protecting forest resources and enhancing social, economic and environmental values

Table 2 Summary of some of the methods and approaches to protect forest resources in PNG.

Key Issues /Main Challenges from Climate Change	**What should be done to protect forest and enhance its social, economic and environmental values**
Droughts/ forest fires	Reduce non-climatic threats to forest ecosystem & its biodiversity such as timber harvesting, hunting, burning, gardening. Set up climate (weather) monitoring systems at strategic locations e.g. near forest plantation, and warning signs or fire indicator to warn people to be wary and not ignite fire; Improve capacity to combat fires (fire fighting)/ impose tough penalties on arsonists.
Natural forest mortality	Conserve intact ecosystems, avoid habitat fragmentation and create biological corridors; rehabilitation of affected areas; determine cause of

	mortality through research; weigh out adaptation options & implementation (Action Plan).
Plantation mortality	Follow strict nursery practices, improve seedling handling and planting techniques, and management during early stages after planting. Conserve and promote genetically diverse tree populations with genetic potential to acclimatize to climate change; *ex situ* conservation or relocation of vulnerable plantation tree species. Maintain natural processes (e.g., migration, predation, pollination, seed dispersal) in the plantations which are necessary for ecosystem function;
Reduced tree growth	Assessment of potential genetic erosion within species of plantation trees be addressed so that work on characteristic selection be considered and make way for possible backcrossing to be conducted (Saulei, S,. *et al.* unpl.)
Increase incidences of pests and diseases/ invasive species	Determine the species, their points of entry and population size of major insect and pathogenic infestations causing forest trees mortality and establish strategies for eradicating and monitoring them over a period of time (Saulei, S,. *et al.* unpl.)
Degradation of areas	Rehabilitation of degraded and exposed areas by planting trees that would meet the set objectives, e.g. SRC[7] trees for firewood/ posts/ charcoal production or commercial timber trees for timber/ post; Carbon sequestration, etc.
Sea level rise	Building sea walls; Protection of shoreline by planting mangroves and other non-mangal trees where mangroves cannot grow.
Freshwater security	Enhance water storage and conservation; improve management of forest watershed areas & water-use efficiency.
Food security	Promote Agroforestry (MPTS[8]) through inter-planting of food crops with trees.
Capacity building	Build capacity for research, planning and implementation of adaptive measure. Conduct

[7] SRC–Short Rotation Coppicing trees

[8] MPTS-Multi-Purpose Tree Species

	awareness to villages so they are able to make inform decisions.

Review of Available Tools and Methods

Data analysis and modeling application

Forestry inventory data and other non-climatic data including socio-economic data collated for vulnerability and adaptation baseline studies on impacts of climate change are analyze by PNGFA. Modeling applications using baseline data for climate change impacts is rare. Climatic data analysis and modeling application used by PNGFA are sourced from IPCC's Assessment Reports and other sources (e.g. PNG National Weather Service).

Data Sources

Models depend on quality data and information. PNGFA conducts vulnerability and adaptation assessments, including other forestry research and inventories to collate useful baseline data and information. They are also building capacity for GIS & remote sensing tools to provide up to date forest data/ information as well as for monitoring changes in forest cover. Climatic data for PNG and the Pacific region are scarce and there is a need for better modeling for future projections (Saulei, 2011). Climate data and information are collated by PNG National Weather Service and PNG Maritime Authority, but there are more data and information that can be sourced from published reports by IPCC (e.g. FAR4, IPCC 2007).

Decision-support tools

Forest adaptation and vulnerability assessment on climatic extremities is quite a new area of research for the PNGFA. The availability of different tools and methods to use is not a limitation. There are many tools and methods available (UNFCCC, 2005). PNGFA uses tools that are suitable to achieve set goals and objectives of a particular assessment and also based on its capabilities to use them. Generic methods and tools used in recent vulnerability and adaptation assessments in PNG include: cognitive mapping, expert judgment (see Giupponi et al, 2008 and Locatelli, B., *et al.,* 2008) and Rapid Vulnerability & Adaptation Assessment methods (Santoso, 2007). These three methods are detailed briefly as follows:

- ***Cognitive mapping*** (or concept mapping or mental model) - is a structured process that enables researchers to produce a map of the concepts or ideas behind a topic of discussions and to describe how these ideas are interrelated. It assists the researchers to define problems and structure their mental model. For the vulnerability and adaptation (V&A) assessment, cognitive mapping can start with identifying the different elements relating to vulnerability. The second step involves clustering of the identified elements into groups or initiating events, intermediate events, outcome and consequences. The third step aims at representing casual links between the elements and the last step consists of explanations of these links.

- ***Expert judgment*** – a method used for eliciting informed opinions from experts of a specific topic (see Meyer and Booker, 1991). It is a useful method when resources are limited for conducting an in-depth analysis of scientific literature, collecting data or modeling.

- ***Rapid Vulnerability & Adaptation Assessment*** – a method for designing national strategies and plans of adaptation to climate change and climate variability. With respect to the V&A assessments, a number of coastal and small island communities in PNG were assessed using the rapid assessment method designed for use in Indonesia (Santoso, 2007) with particular emphasis on the following parameters: *Exposure; Sensitivity*, and the *Adaptation* capacity in regard to transport, communication, finance, manpower and health for the island communities (Saulei, S,. 2011).

Modeling of impacts of climate change on forests and other ecosystems for vulnerability and adaptation is very limited in PNG. Much of what has been done by PNGFA are mainly depend on site-specific baseline studies and assessments to determining impacts of climate change and vulnerability issues and determining adaptation options.

New techniques learned from previous trainings and their application

There has been no training attended by the author in the past specifically focusing on vulnerability and adaptation in light of climate change. However, PNGFA does conduct workshops on climate change issues and through such workshops, issues of vulnerability and adaptation have been extensively discussed and new ideas are shared. Further, there are volumes of literature available that provide information on climate change and related subjects that are easily accessible via the internet.

Forest adaptation strategies under different potential climate change scenarios and forests management scenarios

National adaptation policies and measures reflecting the whole of country approach need to be mainstreamed into national sustainable development strategies and plans. A national plan of adaptation needs to be prepared to reduce the adverse effects of climate change (Santosa, H. 2007). The plan is best to be mainstreamed and incorporated into national long-term development strategy (Prabowo, 2006). Forest adaptation strategies should be tailored to address identified site-specific potential climate change scenarios and to suit specific forest management scenarios, taking into consideration existing forest policies and forest development plans of the country (PNG).

The extent of vulnerability to climate change and climate variability of forests ecosystems in PNG is not fully understood. There are few vulnerability and adaptation baseline assessments done in PNG (e.g. Saulei, S & Nagari, T., 1998; Saulei, S., *et al*. 2010; Saulei, S., *et al.* 2011). Currently, adaptation strategies resulting from thorough vulnerability assessments are very few, and much less at the national level. Some reasons for the lack of vulnerability assessments are due to the fact that research on Vulnerability and Adaptation (V&A) started only recently after restructuring of PNGFA and establishment of the REDD and Climate Change Branch and Species Vulnerability & Adaptation Unit of PNGFA in 2009. Capacity to undertake such activities are also being considered for further development and improvement.

Looking Ahead

The following challenges and opportunities have been identified with respect to climate change adaptation:

Challenges

- Capacity: In terms of personals and financial resources to vigorously pursue vulnerability and adaptation baseline studies and initiatives, especially in vulnerable ecosystems.
- Capacity building is vital to enable developing countries such as PNG to develop adaptation programs and strategies.
- Uncertainties in institutional arrangements in terms of infrastructure, capacity building, policy and new practices to carry out Vulnerability and Adaptation (V&A) initiatives.

Opportunities

- Policies and measures are currently in place.
- There is strong leadership and coordination of V&A related activities.
- Institutional arrangement is currently in place.

“Adaptation is an essential pillar of any comprehensive policy response to climate change. Learning by doing can enhance our understanding of the adaptation process and build the knowledge base to facilitate effective adaptation actions.” – UNFCCC

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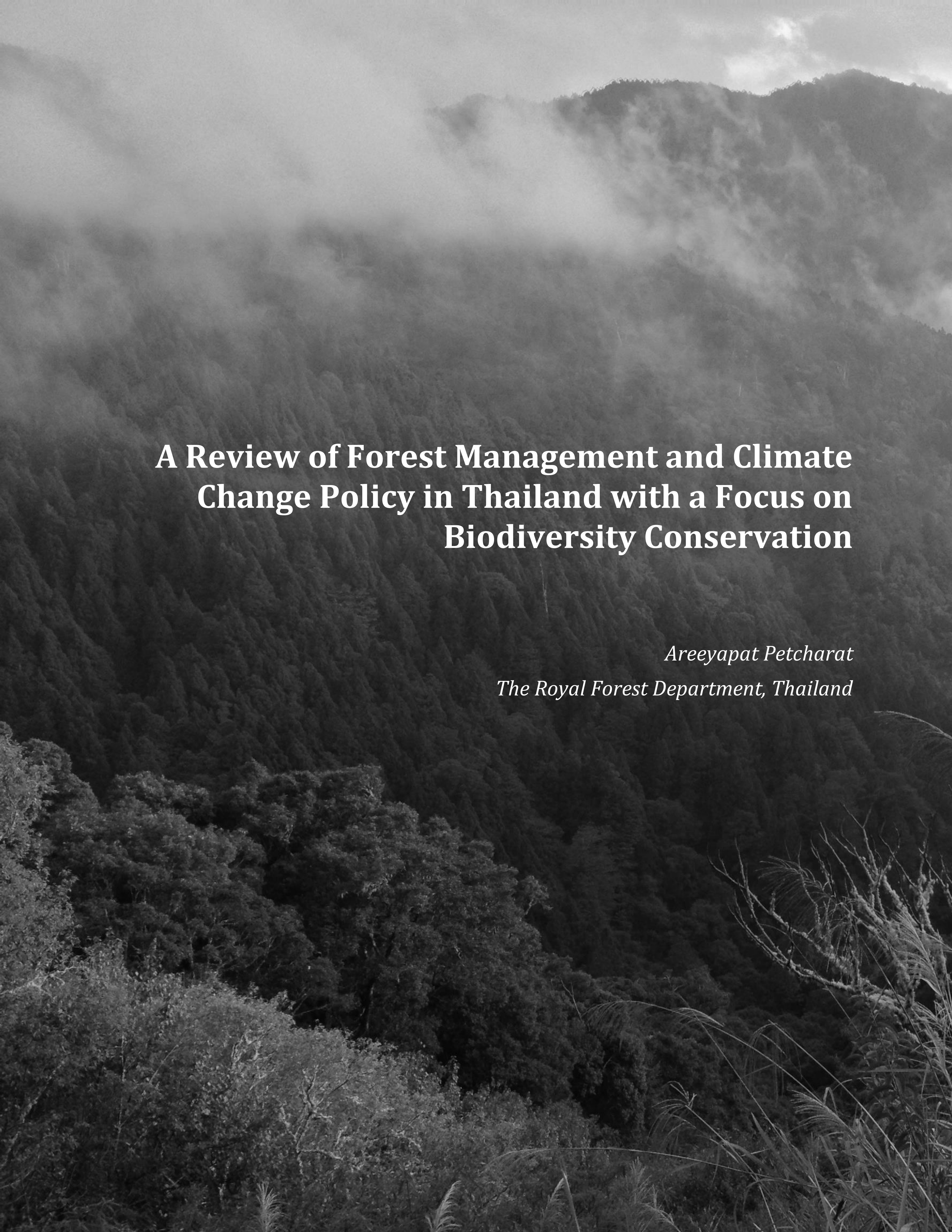

A Review of Forest Management and Climate Change Policy in Thailand with a Focus on Biodiversity Conservation

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Introduction

As the result of the increase in greenhouse gas concentrations in the atmosphere, it is concluded that the temperature of the earth will increase by several degrees over the next century (Houghton et al. 1992). If the atmospheric concentrations of greenhouse gases continue to rise, climate change is highly likely. Implications of climate change include: the sea level rise, changes in agricultural production, changes in runoff and water supply, and shifts in the location of forests and other terrestrial vegetation towards the poles and to higher elevations (Tegart et al. 1990; Smith et al. 1995). Many countries are vulnerable to adverse effects of climate change such as sea-level rise, the persistence of droughts, and increases in the frequency and intensity of forest fires. In Thailand, for example, temperatures have increased by 0.10 °C to 0.18 °C per decade over the past five decades of observation. Its rainfall has been decreasing over the past three to five decades. It is predicted that extreme events, including prolonged floods and drought, landslides, and strong storm surges will become more frequent and more damaging. Changes in rainfall patterns and the frequency and intensity of rainfall have affected the quantity and quality of water resources of several watersheds. Jesdapipat (2008) reported that rainfall patterns have become highly irregular and the dry season has grown longer and hotter. FAO (2012) also states that climate change has posed challenges for forests and forest-dependent people. It is a dynamic and complex issue that increases uncertainty about what future forests will look like (CCFM 2012). Therefore, it is significant to seek innovative ways to adapt sustainable forest management policies and practices for a changing climate.

This report presents a brief introduction of forest management in Thailand and summarizes the issue of forest policies designed to address the adverse effects of climate change. It also suggests changes to help resolve some of the main challenges associated with climate change and key issues in protecting forests from these threats in sustainable manner. Moreover, a case study of biodiversity conservation under a changing climate, including data analysis and modeling for climate change adaptation is examined in this report. Additionally, challenges and opportunities are presented in the last section.

Overview of Forest Management in Thailand

Land area and forest cover

Thailand has a total land area of approximately 53 million ha. In 1961, the total forest area of the country was about 27 million ha covering over 53.3 percent of the country. As a result of the forestland encroachment, the forest area declined to 25.3 percent in 1998. Since 2000 onwards the annual rate of deforestation has been about 63,000 hectares per year. Subsequently, in 2006, the country has 16.8 million ha of forests, representing 33 percent of the country's area. With regard to the 1985 National Forest Policy, 40 percent of the country area shall be kept under forest: 25 percent of the country area for protected forest and 15 percent of the country area for production forest. Since the government banned all logging in natural forests in 1989 the area of existing forests reported in 2010 was 33.09 percent. Therefore, about 7 million ha of forests is needed to achieve the nation target (FAO 2001; FAO 2009).

Policy framework for forest management

Thailand has enacted several forest policies over the past few decades including: the National Economic and Social Development Plan, the National Forest Policy, and the Constitution. These are summarized below:

The National Economic and Social Development Plan (NESDP)

The 1961 First National Economic and Social Development Plan (NESDP) aimed to protect 50 percent of Thailand's areas as forests. The second NESDP (1967) reduced the area to be protected to 40 percent. Finally, the first formal National Forest Policy was "announced" in 1985, - emphasizing economic or production forests and conservation or protected forests. It divided the 40 percent of land under forests into 25 percent for economic forests and 15 percent for conservation forests. The seventh NESDP (1992-1996), following the imposition of the logging ban, reversed the allocations to 25 percent of conservation forests and 15 percent of economic forests to emphasize conservation objective (FAO 2001). At present, Thailand is implementing the 11th Plan (2012-2016) with reflects the importance of the environment to production and consumption patterns, and its important mission in cooperating in the management of natural resources and biodiversity to ensure their richness.

The National Forest Policy

In 1985 the National Forest Policy was proposed with a target of keeping 40 percent of the country area as forested areas, 25 percent of the country area for protected forest and 15 percent of the country area for production forest. The policy also identifies the need for partnerships between the public and private sectors and encourages local community participation and close cooperation with the private sector. However, the policy was silent about the root causes of deforestation and poverty reduction in forest areas and it did not involve rural people (FAO 2009).

The Constitution

It is believed that the 1997 Constitution has been the most important political development in Thailand. The Constitution recognizes the right and roles of Thai people to participate in national policy formulation regarding resources and environmental development and conservation. It has been the most significant recent political development in Thailand clearly noting the right of societies in managing natural resources (FA0 2009).

Legal framework for forest management

The Government of Thailand has established **laws** toward the protection and conservation of forest areas. The five main Forestry Acts formulated regarding to forest protection and conservation include (FAO 2009):

- Forest Act, B.E. 2448 (1941) concerns logging operations and non-wood forest product collection, transportation of timber and non-timber products and sawnwood production as well as forest clearing.
- National Park Act, B.E. 2504 (1961) covers the determination of National Park land, the National Park Committee, and protection and maintenance of National Parks.
- National Forest Reserve Act, B.E. 2507 (1964) includes the determination of National Reserved Forest, control and maintenance of the National Reserved Forests.
- Wildlife Conservation and Protection Act, B.E. 2535 (1992) establishes provisions for national wildlife preservation, establishment of a Protection Committee and identification of 15 species of reserved wildlife.
- Forest Plantation Act, B.E. 2535 (1992) covers the determination of reforestation and land registration of private reforestation rights, ownership and exemption from royalty on forest products from reforested areas.

Forest Management Responsibility and Strategies

In the past ownership and control of all forests belonged to the Royal Forest Department (RFD). From 2002, these responsibilities were transferred to three departments, which are: the Royal Forest Department (RFD) who is responsible for forests outside protected areas; the National Parks, Wildlife and Plant Conservation (DNP), being responsible for forests assigned as protected areas; and the

Department of Marine and Coastal Resources and Environment (MNRE), managing coastal flora and fauna, including mangrove forests.

The present forest management approach has had three main interventions:

- *Expansion of designated protected areas,*
- *Expansion of the forest resource base by plantation to substitute wood supplies from natural forest,*
- *Development of community forestry.*

Expansion of designated protected areas

Thailand has set a target to have 25 percent of the country's total land area as protected areas. Since the enactment of the National Park Act in 1961 the areas under legal protection have expanded rapidly and they presently cover about 17 percent of the total nation area. The protected area system consists of national parks, wildlife sanctuaries or local government-controlled forest parks, no-hunting areas, botanical gardens and arboreta. They are under the control of the DNP. National forest reserves managed by the RFD are also part of the system. The forest reserves have less strict rules than sites with protected area status. In 2009, there were 1,221 National Forest Reserves spreading over 23.4 million ha. However, most protected areas and national forest reserves have people living in them and all have people living nearby who harvest timber and non-wood forest products. Resource harvesting in protected areas is not allowed under current legislation except by permission of the Director General. Therefore, Thailand still needs to develop a more efficient natural resource and environmental management mechanisms such as integrated management of protected areas and conflict management, based on a system for good governance.

Expansion of the forest resource base by plantation

Although reforestation in Thailand started in 1906, the reforestation program gradually expanded after 1961. Native teak has been the most favoured species for commercial plantation. During 1994-1996 an area of about 800,000 hectares was planted with forest trees. From 1994 to 2001, the government had launched farm forestry program to respond to the deteriorated wood supply situation. However, the planted area only covered 169,400 ha. The total extent of planted forests in 2000 was estimated at 2.81 million ha (FAO 2009).

Community forestry

Community forestry is a significant tool for forest management in Thailand. To address the country's rampant deforestation problem, the Thai government officially recognized community forestry as a tool for sustainable forest management. In 1991, the government began drafting a Community Forest Bill to guide the formalization of community engagement in forest management. Since then several versions have been drafted but approval has been on hold due to difficulty in reaching a consensus among politicians and stakeholders. Unfortunately, for two decades the bill has been debated, rejected, and then rescinded. The major point of contention has been over local people's forest use rights within protected areas. Although Thailand's Constitution, which guides the country's laws and policies, clearly empowers communities to actively engage in natural resource management, protection and use, the National Park Act of 1961, which prohibits use of timber and non-timber forest products, works against community forestry. Thus, support for community forestry varies even within the Ministry of Natural Resources and Environment. The evidence of this is that the RFD, responsible for all forests outside protected area, has long supported community forest whereas the DNP, responsible for protected-area forests, has largely worked to prevent community forestry in protected areas. However, community forestry proponents-including the RFD, NGOs, and Thailand's emerging community forestry networks-continue to make progress. As of 2010, the RFD had formally recognized and registered about 7,000 community forests, all outside of protected areas, and it is actively seeking to register more. A major recent initiative has been the development of community forestry networks with a range of members, from the sub-district administrative unit and district levels through to the Community Assembly, which operates nationally. These networks are proving to be an important vehicle in which to share lessons learned and practical experience for setting up and managing sites. The emerging issues of climate change mitigation and adaptation are also gaining the attention of the community forestry movement in Thailand (RECOFTC 2011).

Forest Policies/Action Plans for Climate Change Adaptation

Since 2000, research work has been conducted on the impacts of climate change in Thailand. The research has provided a broad picture of the effects of climate change in Thailand. It has shown that rainfall all across the regions in the country has the potential to increase by about 10-20 percent. The rainy season will not change much, although the weather will tend to be warmer due to an increase in maximum and minimum temperatures by 2 degrees Celsius. Moreover, natural disasters, especially droughts and floods, have become increasingly common in the country (Ministry of Natural Resources and Environment 2011).

In Thailand, the process of understanding vulnerability and adaptation options with respect to climate change has begun including the development the Initial National Communication (INC) and its submission to the United Nations Framework

Convention on Climate Change (UNFCCC) in 2000. Subsequently, the proposal for Second National Communication (SNC) was prepared in 2005 and approved in 2006. Furthermore, Thailand's National Strategy on Climate Change, 2008-2012, gives top priority to climate change impact, vulnerability and adaptation. Over the past decade Thailand has made substantial efforts to expand technical knowledge concerning climate change and to integrate the results into the process of sustainable national development. To address commitments under the UNFCCC and the Kyoto Protocol, Thailand has continuously promoted energy conservation and implemented measures to accelerate use of alternative fuels to support GHG reduction efforts. Since 2000, substantial efforts to expand forest areas have been carried out in the form of conserved forests, reforestation and rehabilitation of deforested areas, and expansion of community forest and commercial forest. Reforested areas have increased by more than 64,000 ha (Ministry of Natural Resources and Environment 2011).

Key Issues/ Changes to be Resolved Main Challenges from Climate Change

It is believed that climate change presents enormous threats for forests and people who depend on forest resources. In the forest sector, mitigation strategies include: reducing emission from deforestation, reducing emissions from forest degradation, and increasing the capacity of forests to act as carbon sinks (FAO 2012). There are many possibilities to reduce the risks and vulnerabilities associated with climate change through adaptation CCFM (2012). Smith and Lenhart (1996) suggested a number of adaptation strategies for managing forests. These include:

- Enhance forest seed banks. Seed collections should represent the variety of genotypes that exist for each species.
- Encourage diverse management practices including the planting of appropriate tree species with greater resistance to heat and drought in the southern range of managed forest boundaries. The mix of different timber-harvesting strategies may be used to promote forest diversity.
- Establish flexible criteria for intervention. Policies that establish flexible criteria for the use of existing forest intervention management practices should be in place. The use of management practices such as salvage harvests, silvicultural management, insect and fire control, and restoration activities should be allowed to change as conditions change. Such policies apply to current forest management but should also consider how the structure of the forest might change because of climate change.
- Reduce habitat fragmentation and promote development of migration corridors. Geographic fragmentation may threaten the ability of forests and forest species to migrate or adapt to changing climate. Currently, the health of many forests is stressed by existing fragmentation. Forest fragmentation may be reduced through incentive programs for multiple-use management that balances preservation and use within a single parcel or through the negotiation of conservation easements that protect geographically important land parcels from development.

In addition, the implementation of adaptation as a component of Sustainable Forest Management or SFM should be a priority in Thailand. Since 1961, Thailand's five-year national economic and social development plans have provided a framework for sustainable management. The Enhancement and Promotion of the National Environment Quality Act (B.E. 2535) has also been promulgated in order to ensure the country's economic and environmental development processes. Some issues that need to be addressed to ensure the sustainability of forests and community resilience in the face of changing climatic conditions are:

- Fnancial incentives, (e.g. through REDD+) could provide critical support for communities to manage forest sustainably. Although local communities have a long and tradition and strong interest in sustainable forest management, poverty makes it difficult for communities to resist alternative land uses.
- Support is required to develop environmentally and socially sustainable strategies. This includes technical guidance and financial support for initiatives which can help reduce pressure on forests.

The Brief History on Forest Inventory in Thailand

National forest inventories in Thailand were started in 1953 using the Profile Sample Plot method. Then, the Camp-Unit System was applied in 1955 and was used by the FAO to conduct forest inventory in the northern part of Thailand between 1961 and 1962. The RFD also set a plan to conduct the forest inventories in all provinces by using the same method. However, only 80% of the plan was accomplished in 1976. From 1982-1986, the RFD used the Unit System, also called "Intensive Forest Inventory", to conduct the inventory programs in the northern part of the country. From 2002, Thailand has used continuous national monitoring of forest resources to measure plants, including herbs, moss and lichen, and other forest crops such as bamboo, rattan, and climbers, as well as soils and coarse woody debris. Remote sensing has been used as survey method since 1973 to support National Forest Inventory. It was used to identify forest types and boundaries, and to estimate forest cover. To develop the sampling design Hotspots (Thematic) were used for precision. The design was systematic, and it covered all types of forests. Inventories have been of stratified using forest types, ecological zones and others. Moreover, ground sampling has been used to install a network of permanent sampling plots to quantify the overall baseline amount, to track changes in various forest resources, and to improve forest resources mapping (e.g., the non-timber forest products that cannot be easily detected on satellite imagery) (FAO 2007).

Biodiversity Conservation under a Changing Climate

Biodiversity and Climate Change

Habitat loss and fragmentation are well understood as significant threats to biodiversity. In recent years, it is substantially understood that climate change has the potential to dramatically affect biodiversity. Although there is considerable uncertainty in how species and ecosystems will respond to climate changes, global climate change is already having significant effect on biodiversity (Commonwealth of Massachusetts 2010). There are two types of action need to be taken to address the challenge of climate change and biodiversity conservation. The first is mitigation to reduce emissions of greenhouse gases, the root cause of climate change. The second type of action is adaptation, which means increasing the ability of natural systems to absorb and respond to change. To mitigate climate change it is important to limit the increase in concentration of green house gases in the atmosphere. Ecosystems and their biodiversity have a role to pay in securing the substantial carbon stocks held within the earth's atmosphere. It is also important to find ways to increase the ecosystems and their biodiversity resistance to current and future climate change (UNEP 2013).

Biodiversity Conservation under a Changing Climate: A Case study from Ban Sam Kla, Lumpang Province, Thailand

Background

Ban Samkha Village is located in Mae Jang National Forest Reserve in Lumpang Province, one of the northern provinces of Thailand. Multiple gradient plains surrounded by hills and Mae Jang National Forest Reserve dominates the landscape of Ban Samkha village. The village's 152 households engage in traditional rotational rice production, located two to four kilometers outside the village. Villagers have longstanding practices of community forest and recognize livelihood dependence on surrounding natural resources.

Roles of the community in climate change mitigation and adaptation

Some mitigation and adaptation actions that the community has used to conserve biological diversity in Mae Chang Forest Reserve, with the collaboration of the RFD and NGOs, will be presented as follows.

Mitigation actions

- Reforestation and rehabilitation of deforested areas. The community has participated in reforestation and forest rehabilitation for several years. The community, the RFD, private sectors, and NGOs have been working in collaboration to promote biodiversity conservation by using the strategy of community forest management and or social forestry which is an approach based on people's participation in forest management.
- Reduce crop residue burning. It is noted that the reduction of burning crop residue provides environmental benefits, not only for mitigating greenhouse gas but also preventing road accidents and undesirable health effects.

Adaptation actions

- The community participation in water management and wildfire prevention. These actions include the construction of check dams, fire break, usage of the applied technology. The risk of wild fire has been reduced through controlled burns and thinning (e.g., removal of excessive vegetation and dead fuels through thinning).
- The community participation in developing biodiversity data bases systems which can be served as tools for planning and management.
- Collaborating across Mae Jang Forest Reserve areas to create habitat linkages. This allows species migration between areas.

Challenges and Opportunities

Climate change poses a number of challenges to SFM in the country, especially in terms of deciding how best to plan and adapt for an uncertain future. New approaches to SFM are being developed, and forest managers are seeking innovative tools to support decision-making in a changing climate. Well managed forests can also contribute to combating climate change through: sequestering carbon through new forests; substituting energy derived from fossil fuels; avoiding emissions from forest loss and degradation. These strategies include: multi-purpose resource management, minimizing conflict to building partnerships, public participation and international collaboration. Moreover, it is important to evaluate the long-term impacts of climate change and determine what the community might do now and in the future to respond to the effect of climate change on forests. In addition, research and development related to climate change, by the inter-organizational collaboration and cooperation will strengthen the capacity of the forest sector to adapt to climate change. Finally, it is vital to promote good governance in national administration at all levels in order to achieve development that is sustainable. Community forestry is one of the relevant measures to achieve forest governance that has 8 major characteristics: participatory, consensus oriented, accountable, transparent, responsive, effective and efficient, equitable and inclusive and follows the rule of law.

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