THE STATE OF THE WORLD's

FOREST GENETIC RESOURCES

COUNTRY REPORT

PAPUA NEW GUINEA

This country report is prepared as a contribution to the FAO publication, The Report on the State of the World's Forest Genetic Resources. The content and the structure are in accordance with the recommendations and guidelines given by FAO in the document Guidelines for Preparation of Country Reports for the State of the World's Forest Genetic Resources (2010). These guidelines set out recommendations for the objective, scope and structure of the country reports. Countries were requested to consider the current state of knowledge of forest genetic diversity, including:

- Between and within species diversity
- List of priority species; their roles and values and importance
- List of threatened/endangered species
- Threats, opportunities and challenges for the conservation, use and development of forest genetic resources

These reports were submitted to FAO as official government documents. The report is presented on www. fao.org/documents as supportive and contextual information to be used in conjunction with other documentation on world forest genetic resources.

Government of Papua New Guinea

COUNTRY REPORT ON THE STATUS OF FOREST GENETIC RESOURCES IN PAPUA NEW GUINEA

Seed storage

Pinus patula seedlings

Afforestation

Araucaria hunstenii

COUNTRY REPORT ON THE STATUS OF FOREST GENETIC RESOURCES IN PAPUA NEW GUINEA

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Acronyms

ABS	- Access Benefit Sharing
ACIAR	- Australian Centre for International Agriculture Research
ACP	- Asia-Caribbean-Pacific countries
APAFRI	- Association of Pacific and Asian Forest Research Institutes
CBD	- Convention on Biological Diversity
CIFOR	- Center for International Forestry Reserach
CDM	- Clean Development Mechanism under Kyoto Protocol of UNFCCC
CSIRO	- Commonwealth, Scientific, International Research Organizations
CSO	- Clonal Seed Orchard
DEC	- Department of Environment and Conservation (PNG)
DSIP	- Development Strategy and Implementation Program
FAO	- Food and Agriculture Organization
FGR	- Forest Genetic Resources
FRA	- Forest Resources Assessment
GoPNG	- Government of Papua New Guinea
GTZ	- Gesellschaft für Technische Zusammenarbeit
ICAD	- Integrated Conservation and Development
IPR	- Intellectual Property Rights
ITTO	- International Timber Trade Organization
JANT	- Japan and New Guinea Timbers
JICA	- Japan International Corporation Agency
MTA	- Material Transfer Agreement
MTDS	- Medium Term Development Strategy
NFS	- National Forest Service
NGO	- Non Government Organizations
NTFP	- Non Timber Forest Products
NTSC	- National Tree Seed Centre
NWFP	- Non Wood Forest Products
PINBio	- PNG Institute of Biodiversity
PNG	- Papua New Guinea
PNGFA	- Papua New Guinea Forest Authority
PNGFRI	- Papua New Guinea Forest Research Institute
REDD	- Reduced Emmisson from Deforestation and Forest Degradation
SBLC	- Stettin Bay Bay Lumber Company
SPC	- South Pacific Commission
SPA	- Seed Production Areas
SPRIG	- South Pacific Regional Initiatives on Genetic Resources
SSO	- Seedling Seed Orchards
TRIPS	- Trade-Related Aspects of Intellectual Property Right
TWG	– Technical Working Group for FGR
UNFCCC	- United Nations Framework Convention on Climate Change
WMA	- Wildlife Management Area

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Executive Summary

This report provides an update on the state of Forest Genetic Resources in Papua New Guinea base on accessible information and data from government institutions and agencies and non-government organizations. The technical working group comprising of representatives from different institution were tasked to work on different chapters and submit their findings to the editorial team to collate and assemble the document. This report follows the format recommended by FAO and addresses the issues under each of the chapters. The report also includes two additional chapters; one on the impact of and challenges faced by climate change and another on the key recommendations (Chapters 9 & 10).

Papua New Guinea covers a landmass of about 46.17 million ha comprising of rugged mountains, plains, wet lands and islands. The forests cover 28.3 million ha of which about 15 million ha have been identied as production forests. Already 12.2 million ha (81%) of these production forests have or are being acquired for commercial logging, however 6.0 million ha (49%) of such forests is deemed inoperable.

The forest cover is categorized into different types of vegetations depending on the environment and species dominance. The following vegetation types recognized are; (1) Low altitude Forest on Plains and Fans, (2) Low Altitude Forest on Uplands, (3) Lower Montane Forest, (4) Montane Forest – above 3,000 m, (5) Dry seasonal Forest, (6) Littoral Forest, (7) Seral Forest, (8) Swamp Forest, (9) Mangrove, (10) Woodlands, (11) Savannah, (12) Scrub and (13) Grasslands.

The forest conservation areas in Papua New Guinea cover about 4% of the terrestrial ecosystems. The biodiversity in some of these protected areas have been inventoried for flora they conatin and management development plans formulated for each protected areas. Some of these protected areas have been assessed for the biodiversity they contain and have developed management plans for each project areas. The country has developed a strategy to shift away from an extractive economy to one that will develop and grow manufacturing, agriculture, forestry, fisheries and eco-tourism sectors, and this directive is outlined in the Vision 2050.

However the country still depends on revenue derived from timber harvested from natural forests and to date, the logged over area stands at 2.4 million ha of which 0.4 million ha has been converted to permanent alternative land uses, such as oil palm estate development projects. Forest land converted to forest plantations increased in area to 92,000 ha in 2005 however, this has slightly decreased when matured plantations were harvested. The major forest tree species planted in plantations and harvested are as follows: *Eucalyptus deglupta, Tectona grandis, Octomeles Sumatrana, Terminalia brassii, Araucaria cumminghamii, A. hunsteintii, Acacia mangium, Pinus caribaea, P. strobus, P. patula,* and *P. oocarpa*.

The state of FGRs in PNG is associated with the following environmental issues; over exploitation of natural resources, unsustainable use of FGR, destructive to natural habitat for agricultural project, introduction of invasive species, and climate change and loss of traditional knowledge of FGRs.

Institutions and agencies involved indirectly in forest genetic conservation lacks capacity to undertake appropriate strategies and methods to effectively address forest genetic conservation issues and could benefit from assistances s provided through external collaborations.

The forest genetic resource is owned by the people and with the increasing awareness on its importance, resource owners are becoming more protective over their resources and often prevent researchers undertaking work on their plants. Resource owners needs to be informed on the potential benefits that may arise from their developments and from long term research and developments conducted on them, especially when they are faced with competing offers from other developers such as mining, oil palm, logging and large scale agriculture projects.

Conversion of forest areas to other land uses threatens the rich and unique biodiversity, including the forest genetic resources in the country, especially when large pristine forests are yet to be explored and species documented. The forest resource is the livelihood of the 85% of the population, most of whom live in remote rural areas as they depend on it for their survival and daily needs. The financial returns from trees harvested also provide economic benefits, providing revenue to local resource owners, both the provincial and national levels of governments and enabling government services to flow to these isolated or remote communities. Species and habitats are being lost and destroyed through various development approaches with no system in place to regulate (monitor and report) how the forest genetic resources are being eroded from natural forests. Where agencies are undertaking awareness, there is lack of materials, especially appropriate information to deliver to the people.

The forest genetic resources are broadly covered and protected by the Environment Act 2000, Forestry Act (1991) and other internal regulations and procedures. The country does not have specific legislations on forest genetics issues in place however; this is covered within the draft legislation biodiversity currently being circulated for comments. Within the forestry sector, the effort to conserve FGR is limited to selected habitat types and species base on the requests of the landowners as this is catered for under the act.

Botanical gardens are the officially recognized sites for *ex situ* conservations unfortunately there aren't many of them in the country, these are supported by Wildlife Management Areas, National Parks, and Arboreta which harbors local floras in their natural habitats. Unfortunately these reserved sites do not received adequate financial support and therefore lack sufficient resources and capacity to effectively manage these areas.

Limited efforts have been made into *in situ* conservation of FGRs in the forest sector even though some timber species are known to be limited in their occurrence. There are no targeted forest species identified for active management in *in situ* conservation programs. The country lacks a monitoring and reporting system on genetic erosion either from *in situ* or *ex situ* conditions. The main constraint to monitoing genetic resource is lack of specific legislation, financial resources and institutional capacity.

The formal tree improvement program was initiated in PNG in 1949 with *Araucaria cunninghamii, A. hunsteinii* and *Eucalyptus deglupta.* Other improvement programs based on SSO, SPA and CSO were developed after. A program on domestication of indigenous tree species of importance to PNG was initiated in 1999 with assistance from ACIAR and it had a significant impact on the research and development activities in Forestry. The country need to

undertake further improvement on existing *ex situ* conservation stands and also develop new trials via the domestication process. It is an area that requires greater support especially for provenance, progenies, species CSOs and SSOs.

Tree breeding studies was initiated in the country from seeds collected from wild stands of *A. cunninghamii, A. hunsteinii, Acacia mangium, Terminalia brassii* and *E. deglupta*, and developed for plantation programs. The programs enabled the establishment of seed production areas (SPA) or Seed Orchards which provided quality seed sources for reforestation and afforestation programs in the country.

The main forest trees species currently developed for plantations include *Eucalyptus deglupta, A. cunninghamia, A. hunsteinii, Tectona grandis, Ochroma lagopus* and *Acacia mangium* and *A. auriculiformis*. Several commercial and lesser-known species are currently being trialed under tree improvement programmes. This improvement program is based on various research studies and trials of indigenous tree species with the support from donor agencies.

Forest plantations of commercial species such as *Tectona grandis, Pinus* species, *Ochroma lagopus,* Eucalypts species, Acacia species and Araucaria species are developed on state land specifically for timber and pulp. Seed orchards are established for the purpose of providing quality germplasm to meet domestic demands for plantations.

PNGFA is the sole supplier of germplasms (seeds) to other stakeholders especially timber companies involved in plantation development. Seeds supplied are mostly of *E. deglupta, Anthocephalus chinensis, Octomeles sumatrana* and *Acacia magium*. Forest plantations are located in the following provinces; Madang, East and West New Britain, Milne Bay, Central, Morobe, Western and Eastern Highlands.

There is a need to strengthen the awareness on forest genetic resources especially in educational programs undertaken by training institutions such as the forestry colleges and universities. Training offered at universities is at under graduate level and broadly covers basic sciences and forest science and therefore does not adequately equip graduates persuing this profession as a career. The non-government organizations do contribute to the conservation of forest genetic resources through the establishment of community wildlife management and conservation areas and do provide basic training in their project sites.

Papua New Guinea has collaborated with numerous international organizations over the years including CSIRO, FAO, UNDP, ITTO, JICA, NZAID, and regional organizations such as CIFOR, APAFRI, and on a sub-regional level with the South Pacific Commission. It was through the earlier collaborative works that provenance trials of a number of species were established forming the basis for future species improvement and development in Papua New Guinea.

Collaborative programs were initiated with the Australian Scientific Organization, (CSIRO) started in late 1950s up to the present involved seed collections for different native tree species which have potential for plantation forestry and farm fruit trees. The Japanese Government through its Technical Aid program to PNG established the PNG Forest Research Institute office complex in 1989. It also assisted the institute through the JICA experts in the establishment of seed orchards for a number of local and exotic species

ACIAR and ITTO supported long term projects in the country especially on "Species Domestication" and establishment of Permanent Sample Plots. The data and information collected from these projects paved the way forward for further research and development of other species.

The state of forest genetic diversity in the country is not well documented for many plant groups, more work is required to be done to evaluate and develop strategies to conserve and use them in a sustainable way. PNG became a signatory to CBD and other international conventions and therefore is obligated to take appropriate actions to address such commitments.

PNG is a member of WTO and is bound by the provisions of the Trade-Related Aspects of Intellectual Property Right (TRIPS) complemented by the establishment of a National Intellectual Property Office (IPPNG) under the Investment Promotion Authority (IPA). These statutory organizations provide the frameworks within which benefits arising from development of biological resources can be equitably distributed.

Within the region, PNG recognizes its undertakings made with the regional and sub-regional countries on plant genetic resources and it is taking steps to address common issues under these agreements. In particular, the "***Strategies and Action Plan for the Conservation, Management and Sustainable Use of Forest and Tree Genetic Resources in the Pacific Island Countries and Territories"*** formally endorsed by Pacific Heads of Agriculture and Forestry Services and approved by Ministers of Agriculture and Forestry at their regional meeting in Apia, Samoa in September 2008.

PNG has a draft a policy on Biosafety and Biotechnology to protect resource owners whose biological resources will be accessed for scientific research and for development of genetically modified organisms which have the potential to be commercialized. This policy would enable access to the country's biological resources and the fair and equitable distribution of benefits arising from the sustainable use of these resources

The plant resource provides a source of food, medicine and building materials in rural communities and in some urban areas. Some tree species are harvested for multiple uses such as medicine, carvings and timber and are either utilized locally or are sold in urban markets. The income generated from sale of forest genetic resources contribute significantly to both food security and poverty alleviation to rural communities although no data to support such statement.

Non Timber Forest Products (NTFPs), for example, Eaglewood or Agarwood are over exploited in an unsustainable or indiscriminate manner from the natural populations and needs to be protected. Management strategies to protect and conserve these species through *ex situ* conservation must be implemented.

There is a need for awareness, research and development to educate communities on sustainable forest management and development to deliver income generating alternatives for the smallholder farmers. Current government institutions working on improving the forest genetic resources for the local communities often lack resources to effectively implement their responsibilities

The impact of climate change on terrestrial ecosystems in PNG are becoming more and more evident as notable changes due to increasing surface and air temperatures, changes in the distribution and intensity of rainfall, alteration of hydrological regimes, changes in wind patterns and intensity, altering of fire frequencies and intensities, flooding and erosion regimes are being observed and recorded over short period of time.

The response of species and ecosystems to the impacts of climate change is noticeable, especially in forest trees where there are changes to their phenological behaviours and those of the associated fauna species.

Studies on forest trees in plantations in PNG have shown that increasing temperatures in the area over the past years have changed the soil conditions and appears to be conducive to termites and other insects thus increasing their attacks on the both plantation and natural forest trees. In areas where rapid agricultural development is occurring, large areas of forests have to be cleared to make way for agricultural crops and through this process, a number of forest plant species are either lost or reduced in numbers resulting in the erosion of the genetic bases.

I. Introduction to the country and forest sector

This Country Report was prepared by the Technical Working Group of Papaua New Guniea (PNG) Forest Genetic Resource Committee (TWG – PNGFGRC) to be submitted to FAO by end of this year, 2012. This will form part of the FAO's 2013 report on *The Status of World's Forest Genetic Resources* which would serve as a reference for future actions at the national, regional and global levels in the future.

The report is based primarily on information from internal reports available at local institutions and agencies, much of which are unpublished. Other data and relevant information were obtained from published materials available during the preparation of this report and are cknowledged in the references.

This introductory section of the report provides an overview of the historical and environmental setting of the country, the forests, their contributions to the national economy, population and the future challenges the forests, and thus the national Forest Genetic Resources (FGR) will face in the future.

II. Geological history

The island of New Guinea is the second largest in the world. It lies between 3.5^{o} and 12^{o} south of the equator in the region commonly referred to as equatorial or the `hot-wet tropics'. The island is approximately 2,500 kilometres long from east to west occupying a total area of 775,000 square kilometres. PNG occupies the eastern half of the island, just north of Australia with a total land area of approximately 46.17 million ha, of which 5.6 million ha comprises the islands, namely; New Britain, New Ireland, Bougainville and Manus as well as other 600 smaller islands **(Figure. 1**).

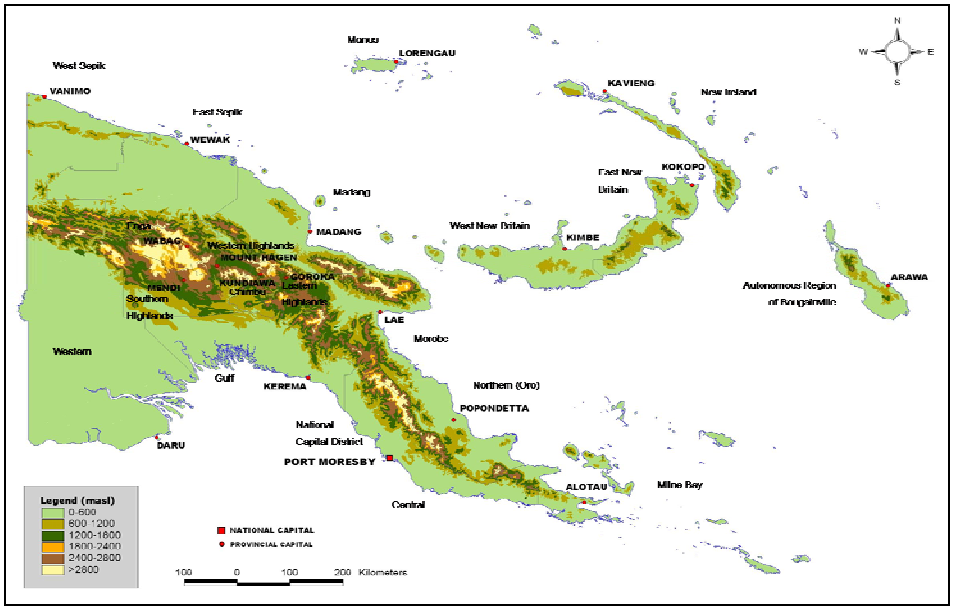

Figure 1: Map of Papua New Guinea

The country is tectonically and volcanically active with a number of large active volcanoes. Extensive mountain ranges cover much of the country, and that several of these peaks range from 2,500 to over 4000 m, with the highest peak being Mt. Wilhem (4,350 m). The rugged terrain of the country is being dissected by numerous rivers, with the Sepik River in the north (Sepik Province) and the Fly River (Western Province) in the south being the longest and largest rivers in the country. These rivers are also associated with many tributaries arising from the mountains, swamps and seasonally inundated floodplains that cover large areas of the country.

III. Climate

The average annual rainfall experienced throughout the country varies depending on the topography from the highlands to the coastal plains. It may reach up to more than 8,000 mm of rainfall annually in some higher mountainous areas to relatively low in seasonal coastal areas with 1000-1500 mm of annual rainfall. Average temperatures also vary with altitude, resulting in hot and humid tropical temperatures in the lowlands and islands and a milder temperature in the highlands. Frosts do occur above 2, 200 m.

IV. Forests

The extent of the forest areas has been declining since 1990 from 31 million ha to 28.6 million ha in 2010 (Table 1). On the other hand, areas of planted forests have increased from 63,000 ha in 1990 to 92,000 ha in 2005, but due to harvesting it decreased to 86,000 ha in 2010 as shown in Table 1 below.

Table 1. Forest characteristics and areas (*FRA 2010*)

Main forest characteristics	**Area (ha)**			
(Based on FRA 2010 Categories)	**Forest Area (000 ha)**			
	1990	**2000**	**2005**	**2010**
Primary forests	31,329.20	29,533.60	28,343.70	26,209.90
Naturally regenerated forests	131	517	1,001	2,430
Planted forest	62.8	82.4	92.3	86.1
Reforestations	na	na	na	Na
Afforestation (grassland areas)	na	na	na	Na
Total	**31,523**	**30,133**	**29,437**	**28,726**

In 2005 it was estimated that over 28.3million ha (or 61%, FAO, 210) of the total land mass constitutes the forested land. A total of 15million ha of these forested lands have been identified as productive forests, of which 12.2 million ha (81%) has or is currently acquired for commercial logging, but that 6.0million ha (40%) is deemed inoperable. Of the remaining productive forest areas, 2.4million ha has been logged and left to regenerate, while 0.4 million ha has been converted to permanent alternative land uses, such as oil palm estate

development projects. While another 1.1million ha was converted to other subsistence uses, mostly by traditional slash and burn form of agriculture (Tate, 2006).
In a recent study (Shearman, et al., 2008) it was confirmed that the extent of the forest cover is 61% of the total land area containing diverse tropical lowland and montane rainforests, swamps, dry evergreen forests and mangroves. These forests contain some of the most unique plant species, landscapes, and ecosystems in the world (Anonymous, 2010). However, the extent of the forested land has gradually declined due to increasing expansion of forest clearing through logging, large scale oil palm plantations, oil and gas and mining activities. Shearman, et al. (2008) reported that 2.92 million ha of the forested land were degraded by such activities and these disturbed forests are vulnerable to further degradation and conversion to other uses. Such threats will become increasingly obvious with the increasing population growth, extractive resource developments, food cropping and the future impacts of climate change. In regard to forest conservation and protection, less than 4% of the forested lands are currently protected under the 50 protected areas. Few of these protected areas have been inventoried of the plant species they contain or have functional plans for their management (Anonymous, 2010).

V. Forest and Economy

PNG is endowed with vast natural resources. The Government relies on these natural resources, including the forests, to enhance its economic, infrastructure and social advancements. The development of the forest resources is important as it assisted with improving the livelihoods of the vast population, most of whom live in remote and isolated communities located in some of the most isolated and rugged areas of the country. The development of the forest resources in such isolated areas provides the populatrions the much needed revenue through royalty payments, employments and sales of garden and wildlife produce with access markets through infrastructure developments and associated spin-off economic activities. Forest developments also generate revenues for local, provincial and national governments. Over the years, the development of the forest resources has contributed enormously to infrastructure and other socio-economic developments for the rural communities where such government services are eithr non-existent or very limited.

Log exports from 2001 to June, 2011 (11.5 years) amounted to some 2.7 million cubic metres from natural forests generating a total revenue of K2, 002,371,535 in FOB value. While log exports from plantations during the same period comprised 2.2 million cubic metres, earning a total revenue of K375, 347,800 in FOB (equivalent to USD 132,941,182). The major plantation tree species harvested were: *Eucalyptus deglupta, Tectona grandis, Octomeles sumatrana, Terminalia brassii, Araucaria cumminghamii, A. hunsteintii, Acacia mangium, Pinus caribaea, P. strobus, P. patula,* and *P. oocarpa*. From 1999 to 2011, the volume of finished-products from down stream-processed logs was 477,900 m^3 with an export value of USD 218, 012,979. For other processed forest products refer to **Table 2**.

Table 2. Forest products from natural and plantation trees

Forest Products	Cubic metres	Value (USD)
Sawn-timber	477,900	218,012,979
Plywood	145,670	79,760,427
Veneer	551,446	112,949,512
Furniture	1,659	1,057,848,440

Balsawood	104,767	36,496,518
Woodchips	818,244 tonnes	8,107,060

VI. Cultural Dimensions and Population

PNG is considered among the most bio-culturally diverse in the world. Its unique and diverse environments have supported many tribal groups and communities for thousands of years. These groups and tribes speak over 800 plus distinct languages. However, throughout the country two major lanuages are used; Pidgin and Hiri Motu, while English is used in business and educational.

This great bio-cultural diversity is a reflective of the extreme diverse environments as influenced by the immense variations in geology, landforms, climate and altitude. The diverse environmental conditions are well matched by the diverse cultural traditions and customs. Early settlers were estimated to have occupied the island of New Guinea some 40, 000 to 60, 000 years ago and gradually increased in numbers as well as migrating to other parts of the mainland and outer islands.

According to preliminary census for 2010, PNG's current total population is over seven million. Approximately 85% of the population lived, in rural areas. Population densities range from one person per square kilometer in the remote rural areas to over 500 people per square kilometers on some small Islands. Land shortages are increasingly common in areas where population densities are greater than 100 persons per square kilometers. The average population growth rate is about 2.7%, but this varies greatly between and within provinces, such that the higher growth rates are found in the main urban centres, while relatively lower rates are recorded in rural areas. In the highlands, this is largely due to migration into the urban areas.

Land ownership in PNG is vested with the traditional customary owners, most of whom live in rural areas and they account for 85% of the total population. Ninety seven percent (97%) of the total land area is owned by these traditional customary landowners, while the state and some private individuals owned 3% of the land. In terms of forest resource ownership, the traditional owners owned 96%. The landowernership and total area according to FRA 2010 is shown in **Table 3** below.

Table 3. Forest ownership and area (*FRA 2010*)

Forest Ownership	**Area (ha)**			
FRA 2010 Categories	**Forest Area (000 ha)**			
	1990	**2000**	**2005**	**2010**
Public forests	946	904	883	883
Private forests (Owned by indigenous / tribal communities)	30,577	29,229	28,554	28,554
Other forests	0	0	0	0
Total	**31,523**	**30,133**	**29,437**	**29,437**

VII. Challenges for the Future

In the forseeable future, managing the forest genetic resources will be dictated by increasing population growth and its impacts on the forest resources resulting from the demands for increased socio-economic developments. Thus, influencing the policy directives such as those illustrated in the National Government's Medium Term Development Strategy (MTDS) 2010-2015, the Development Strategy and Implementation Program (DSIP) 2015 – 2030 and the Vision 2050. At the same time, the challenges of the pending impacts of climate change and the desire for increasing acreage for biodiversity conservation are some issues that the forestry sector will have to address in the years to come.

The Government's strategic direction as outlined in the Vision 2050 document provides challenges to shift away from an economy dominated by extractive resource sectors to one that will develop and grow manufacturing, agriculture, forestry, fisheries and eco-tourism sectors. Of the seven pillars of Vision 2050, two (2) provide clear directions for sustainable development in forestry and timber industry and therefore the FGR, especially from:

- Wealth creation, natural resources and growth nodes; and ,
- Environment sustainability and climate change.

Under the strategic direction of wealth creation there are three (3) implications for socio-economic growth through forestry and these are:

- Eliminating the export of round logs by 2010;
- Ensuring downstream processing of all logs on shore; and,
- Developing forestry plantations in suitable areas, with landowners' participation.

This country report presents a compilation of historical and updates of information and data relating to the status of the country's forest genetic resources. It is important to note that this report has not exhausted all available data and information. However, it is much more comprehensive than other previous reports and therefore it is a good source for future reference. Moreover, the challenges encountered during the time of compilation and drafting of this report are included in the key issues and recommendations.

Chapter 1: The Current State of the Forest Genetic Resources in Papua New Guinea

1.1 Introduction

Quantifying changes in forests ecosystems in the tropics is important because of the role forests play in the conservation of biodiversity, food web and the carbon cycle. PNG has one of the world's remaining forest areas of tropical forests.

The forest comprises of many types and are categorized into thirteen main vegetation types; (1) Low altitude Forest on Plains and Fans, (2) Low Altitude Forest on Uplands, (3) Lower Montane Forest, (4) Montane Forest – above 3,000 m, (5) Dry seasonal Forest, (6) Littoral Forest, (7) Seral Forest, (8) Swamp Forest, (9) Mangrove, (10) Woodlands, (11) Savannah, (12) Scrub and (13) Grasslands (FAO 2010). Within these vegetation types there are different forest types comprising of localized forest communities. Much of the rich and diverse flora species are yet to be discovered in their natural habitats. A small fraction of the native tree species have been identified and domesticated in large scale plantations include; *Araucaria hunsteinii, A. cunninghamii, Acacia mangium, Acacia crassicarpa, Eucalyptus degluta and E. pellita.*

The development of forest genetic resources in Papua New Guinea is dictated by the development of natural forests resources especially harvesting of large forests to meet the demand of local and international markets. The Papua New Guinea Forest Authority (PNGFA) is the government regulating agency that manages the country's natural forest resources and forest plantations. In natural forest resource areas, the forest resource areas are acquired from the local communities and developed by investors. The developers are allowed to harvest only commercial trees above certain diameter. The main timber trees harvested from these resource areas are listed in **Table 4**.

The forest plantations in PNG have been developed using local tree species and a few exotic species. The early forest extension programs for the community to engage in woodlot and community forestry farming received mixed results in the communities, due to low demand for timber and fuelwood and the fact that the economic return are not realized immediately compared to other crops. Some of the species in plantations include; *Eucalyptus deglupta* (Kamarere), *Tectona grandis* (Teak), *Ochroma lagopus* (Balsa), *Pinus carabaea, Araucaria cunninghamii* (hoop pine), and *Araucaria hunsteinii* (klinkii pine).

Some of these species have been selected and trialed in different sites in the country with the purpose of selecting the best site for large scale development of each species. Research and species improvement programs for these species are continuing.

Large scale clearance of natural forest areas for commercial development and other landuses continues to impact and erode the forest genetic resources in the country. The loss of undocumented forest genetic resources is a challenge for the country because it must maximize the benefits derived from the remaining plant recources.

Given the importance of forest genetic resources to the communities, PNG is cureently working on policy directives for sustainable forest management (SFM) of natural forests to intergrate climate change initiatives (REDD+) and at the same time increase forestry plantation.

1.2 Diversity within and between forest main ecosystems

The vegetation types in the country are classified into thirteen catergories; (1) Low altitude Forest on Plains and Fans, (2) Low Altitude Forest on Uplands, (3) Lower Montane Forest, (4) Montane Forest – above 3,000 m, (5) Dry seasonal Forest, (6) Littoral Forest, (7) Seral Forest, (8) Swamp Forest, (9) Mangrove, (10) Woodlands, (11) Savannah, (12) Scrub and (13) Grasslands (FAO 2010). The major features of these vegetation types are listed in **Table 3** and also discuss below.

Low Altitude Forest on Plains and Fans which cover an area of 2,875.1 million hectares comprise of three forest types. These are; large to Medium Crowned Forest (**PI**), the Open Forest (**Po**) and the Small Crowned Forest (**Ps**). The tree species found in the **PI** forests include; *Pometia pinnata, Octomeles sumatrana, Ficus spp. Alstonia scholaris* and *Terminalia spp.* Other domninant genera include; *Pterocarpus, Artocarpus, Planchonella, Canarium, Elaeocarpus, Cryptocarya, Celtis, Dracontomelum, Dysoxylum, Syzygium, Vitex, Spondias* and *Intsia.* Tree genera found in the **Po** forests include; *Planchonia, Bischofia, Cananga, Intsia, Teysmanniodendron, Nauclea* and *Vitex.* Same genera found in Po forests can also be located in the Small Crown Forests.

Low Altitude Forests on Uplands has three main forest types and covers an area of about 17,171.1 million hectares. These forest types are catergorised as; Large Crowned Forest (**HI**), Medium Crowned Forest (**Hm**) and Small Crowned Forest (**Hs**) forest types. Tree species found in the **Hl** forest are usually of mixed species composition, frequent canopy trees such as *Pometia, Canarium, Anisoptera, Cryptocarya, Terminalia, Syzygium, Ficus, Celtis, Dysoxylum* and *Buchanania.* In the **Hm** forest type which is below 500 m altitude, the frequent species found are those that also occur in **HI** forest type including; *Koompasia, Dillenia, Eucalyptopsis,* and dipterocarps. Genera *Hopea* and *Vatica* are abundant in most of these forest types but absent in others.

Above 500 m altitude, abundant genera found are *Magnolia (Elmerrillia), Flindersia, Castanopsis, Lithocarpus, Syzygium, Cryptocarya, Litsea, Cinnamomum, Galbulimima, Dryadodaphne, Garcinia, Neuburgia, Pouteria, Planchonella, Platea, Sterculia, Elaeocarpus* and *Sloanea*. Scattered trees and small stands of *Araucaria* may reach 70 meters in height. The **Hm** forest is further categorized into three sub-classes comprising of Medium crowned forest, *Araucaria is* a common genus (**HmAr**), Medium crowned damaged forest (**Hmd**) and Medium crowned forest with an even canopy (**Hme**). Similar tree genera are found in **Hs** as well as **Hm** forest. **Hs** forest type is further sub-classed into *Small Crowned Forest with an even canopy (**Hse**), Small Crowned Forest with Araucaria common (**HsAr**), Small Crowned Forest with Castanopsis (H**sCa**), Small Crowned Forest with Casuarina papuana (HsCp), Small Crowned Forest with Nothofagus (**HsN**) and Small Crowned Forest with Rhus taitensis (**HsRt**).*

Lower Montane Forest category constitutes of the Small Crowned Forest (**L**) and the Small Crowned forest with Conifers (**Lc**) cover a total area of 7,745.4 million hectares whilst the Montane Forest (Mo) above 3,000 m occupies about 177,400 hectares.

The other forest types include; Dry Seasonal Forest (**D**) 778,600 ha, Littoral Forest (**B**) 86,500 ha, Seral Forest (**F**) 46,100 ha, Swamp Forest (**Fsw**) 1,267.3 million hectares, Mangrove (**M**) 550,000 hectares, Woodlands (**W**) 2,693.8 million hectares, Savannah (**Sa**) 1,190.6 million hectares, Scrub forests (**Sc**) 601,400 hectares and Grassland (**G**) 3,241.1 million hectares. The remaining 7,985.5 million hectares is covered by other land uses (FAO 2010, Hammermaster and Saunders 1995).

The common genera in the **L** forests are *Lithocarpus, Castanopsis, Alphitonia, Astronia, Caldcluvia, Casearia, Cinnamomum, Cryptocarya, Litsea, Dryadodaphne, Elaeocarpus, Sloanea, Elmerrillia, Galbulimima, Garcinia, Gordonia, Neuburgia, Platea, Planchonella, Schizomeria, Mischocarpus, Syzygium,* and *Podocarpus* (conifers). With increasing altitude the species composition gradually changes, common high altitude genera are; *Ascarina, Claoxylon, Euodia, Halfordia, Ilex, Nothofagus, Pygeum, Quintinia, Timonius, Weinmannia, Xanthmyrtus, Zanthoxylum, Podocarpus, Dacrycarpus, Phyllocladus* and *Libocedrus.* The genera found in the Lc are conifers; *Libocedrus, Phyllocladus, Dacrycarpus* and *Podocarpus*. Broadleaf genera comprises of; *Ascarina, Claoxylon, Melicope (Euodia), Halfordia, Ilex, Pygeum, Quintinia, Timonius, Weinmannia, Xanthomyrtus* and *Zanthoxylum*.

There are other categories of small crowned forest which include; Small Crowned Forest dominated by genus *Araucaria* (LAr), Small Crowned Forest of mainly *Nothofagus* (LN), Very Small Crowned Forest (Ls), Very Small Crowned Forest of *Casuarina papuana* (LsCp) and Very Small Crowned Forest (LsN) dominated by *Nothofagus* species.

The Montane Forest (Mo) above 3,000 m (Mo) covers is dominanted by species in the following genera; *Carpodetus, Drimys, Eurya, Olearia, Quintinia, Schefflera, Syzygium* and *Xanthomyrtus* including conifers.

The common tree genera in Dry Seasonal Forest (D) and Littoral Forest (B) include; *Pterocarpus, Terminalia, Planchonia* and *Nauclea*. Towards the coastline, the forest conapy generally reduces and merges into low forest communities containing *Calophyllum, Barringtonia, Pongamia* and *Hibiscus.*

Table 3. Major forest type categories and main tree species *(FRA 2000).*

Major forest types	Area (000 ha)	Main species for each type	
		Trees	**Other species if applicable**
Large to medium crowned forest (Pl)	798.2	*Pometia pinnata, Octomeles sumatrana, Ficus* spp *Alstonia scholaris & Terminalia* spp, *Pterocarpus indicus, Artocarpus atilis, Planchonella* spp., *Canarium* spp., *Elaeocarpus sphaericus, Cryptocarya* spp., *Celtis* spp., *Dysoxylum* spp., *Dracontomelon dao, Syzygium* spp., *Vitex cofasus, Spondias dulcis& Intsia bijuga*	*Calamus hullrungii, calamus steenisii,, Orania* sp, *Glubia costata, Flagillaria indica, Alpinia* sp, *Pothos* sp, *cyathea* sp,
Open crowned forest (Po)	1,252.10	*Planchonia spp., Bischofia, Cananga, Intsia, Teysmanniodendron, Nauclea & Vitex*	*Alpinia* sp, *Calamus, Cisus* sp, *Tetrastigma, Merremia* sp.
Small crowned forest (Ps)	824.8	Similar species as in Po above	ditto
Large crowned forest (Hl)	320.7	*Pometia, Canarium, Anisoptera, Cryptocarya, Terminalia, Syzygium, Ficus, Celtis, Dysoxylum, & Buchanania*	*Flagilaria indica, Calamus* sp, *Alpinia* spp, *Cyathea, Tectaria* sp,
Medium crowned forest (Hm)	13,839.40	Similar species as in Hl above and other; *Koompasia, Dillenia, Hopea, Vatica, Elmerrillia, Flindersia, Castanopsis, Lithocarpus, Cryptocarya, Litsea, Cinnamomum, Galbulimima, Elaeocarpus, Dryadodaphne, Garcinia, Neuburgia, Planchonella, Sterculia & SLoanea*	*Ammomun* sp,. *Plueranthodium* sp, *Dicksonia* sp, *Riedelia* sp,
Small crowned forest (Hs)	3,011.00	Similar species as in Hm above	ditto
Small crowned forest (L)	7,303.60	*Lithocarpus, Castanopsis, Alphitonia, Astronia, Caldcluvia, Cinnamomum, Cryptocarya, Litsea, Dryadodaphne, Elaeocarpus, SLoanea, Elmerrillia, Galbulimima, Gordonia, Garcinia, Neuburgia, Planchonella, Schizomeria, Syzygium & Podocarpus*	*Bulbophylum* sp *Dendrobium* sp, *Cyathea* sp, *Dicksonia* sp, *Natus, Riedelia* sp
Small crowned forest with conifers (Lc)	441.8	*Libocerus, Phyllocladus, Dacrycarpus & Podocarpus*	*Cyathea* sp, *Dicksonia* sp, *Natus, Riedelia* sp
Montane Forest (above	177.4	*Dacrycarpus, Podocarpus, Phyllocladus, Drimys, Libocedrus, Eurya, Carpodetus, Qlearia, Quintinia, Schefflera, Syzygium & Xanthomyrtus*	Same as above

3000m) (Mo)			
Dry seasonal forest (D)	778.6	*Acacia, Tristania, Syzygium, Rhodamnia, Xanthostemon, Maranthes, Mangifera, Halfordia, Flindersia, Oreocallis, Grevillea*	*Livistonia papuana,*
Littoral Forest (B)	86.5	*Pterocarpus, Terminalia, Planchonia, Nauclea, Calophyllum, Barringtonia, Pongamia, Hibiscus, Casuarina equisetifolia, Melaleuca leucadendron*	
Seral Forest (F)	46.1	*Octomeles, Artocarpus, Casuarina grandis, Eucalyptus deglupta, Terminalia brassii*	
Swamp Forest (Fsw)	1,267.30	*Campnosperma, Melaleuca, Terminalia, Syzygium, Nauclea, Myristica*	*Cyprus* sp, *Pandanus* sp, *Frecynatia* sp,
Mangrove (M)	550	*Avicennia marina, Sonneratia caseolaris, Rhizophora, Bruguiera, Camptostemon, Heritiera, Xylocarpus,*	Palms and Pandans
Woodlands (W)	2,693.80	*Carallia, Nauclea, Melaleuca, Acacia,*	*Livistonia* sp,
Savannah (Sa)	1,190.60	*Eucalyptus; E. alba, E. confertiflora, E. papuana, E. tereticornis, Melaleuca, Tristania, Acacia, Xanthostemon,*	*Themeda australis, Heteropogon contortus, Sehima nervosum, Sorghum nitidum, Arundinella setosa, Capillipedium parviflorum,*
Scrubs	601.4	*Hibiscus tiliaceus, Desmodium umbellatum, Pemphis acidula, Allophylus cobbe, Messerschmidia, Eriachne, Libocedrus, Quintinia, Eurya, Rhododendron,*	
Grassland	3,241.10	Na	
Other land uses	7,985.50	Na	

1.3 Local Forest Types and Global Ecological Zones

According to the Forest Types and Ecological zones breakdown used in FRA 2000, the forest vegetation types in PNG fall into the Tropical zone with all months without frost. Frost does occur periodically in the higher mountains above 3000 m and do extend below at times however are a typical of the normal climatic pattern.

As shown in Table 3a, the sub-alpine and Upper Montane forest falls into the TM category (Tropical Mountain systems) and the Lowlands, Dry seasonal, Coastal and Wetlands forests falls into the Tropical rain forests zone (TAr).

Table 3a. Forest types and ecological zones *(FRA 2000)*

EZ Level 1 – Domain			EZ Level 2 - Global Ecological Zone
Ecological Zone	**Sub-Zone**	**Forest Type**	**GEZ Code**
Alpine	Sub-Alpine	Alpine grassland, Subalpine grassland and Alpine shrubland	TM
Montane	Upper Montane, Mid Montane and Lower Montane	Very small crowned forest (Mo),Montane Scrubland and Montane s	TM
Lowlands	Low altltitude plains and fans	Large to medium crowned forest (Pl), Open forest (Po) and Small crowned forest (Ps)	TAr
	Low altitudes on uplands	Large crowned forest (Hl), Medium crowned forest (Hm), Medium crowned forest with Araucaria common (HmAr), Medium crowned depapurate/ damaged forest (Hmd), Medium crowned forest with even canopy (Hme), Small crowned forest (Hs), Small crowned forest (Hs), Small crowned forest with *Araucaria* (HsAr), Small crowned forest with *Castanopsis* (HsCa), Small crowned forest with *Casuarina papuana* (HsCp), Small crowned forest with *Nothofagus* (HsN) and Small crowned forest with *Rhus taitensis* (HsRt)	TAr
Dry Seasonal	Savannah	Savannah (Sa), Savannah with gallery forest (Saf) and Savannah with *Melaleuca leucadendron* (SaMI),	TAr
Coastal	Littoral / Mangroves	Mangrove Fores Communities	TAr
Wetlands	Swamp	Mixed swamp forest (Fsw), Swamp forest with *Campnosperma* (FswC), Swamp forest with *Melaleuca leucadendron* (FswMl) and Swamp forest with *Terminalia*	TAr

		brassii (FswTb), Swamp grassland (Gsw)	
Serial	Riverine	Riverine mixed successions (Fri), Riverine successions with *Casuarina grandis* (FriCg), Riverine successions with *Eucalyptus deglupta* (FriK), Riverine successions with *Terminalia brassii* (FriTb), Riverine successions dominated by woodland(Wri), Riverine succession dominated by grass (Gri)	TAr

1.4 Main value of forest genetic resources

The main value of forest genetic resources in PNG is its cultural value. The majority of the people live in rural communities and isolated villages depend on the forest resources for their daily needs, the basic needs being for building shelter and food. This is futher discussed in Chapter 8.

In terms of economic value, PNG depends on its forest resources to develop and bring government services to isolated and remote communities. The government does not have the capital to build roads into non-economic areas and depend on investors to develop resources such as timber in order for roads to be built.

At present none of these major timber tree species are threatened, however there have been concerns by the civil society regarding over harvesting of some of the premium tree species such as *Instia bijuga* and *I. palembanica* (kwila), *Pterocarpus indicus* (Rosewood), *Vitex* spp. (Garamut) and *Diospyros* spp. (Ebony). A management plan regarding the sustainable harvest of these species has been developed and is yet to be endorsed for implementation throughout the country.

Other non timber forest products harvested from natural forests susch as rattan, eaglewood and massoy are subjected to specific management protocols aim at sustaining their populations in the wild. PNGFA has developed a management plan for managing eaglewood and it is developing similar plans for the other forest products.

In additions to these economic and cultural valued species, there are other introduced species that have become established into the landscape and have become invasive (*Piper aduuncum* and *Spathodea campanulata*) and are a threat to the the natural forests (**Table 4**).

Table 4. Priority species based on commercial value, vulnerability and invasiveness

Priority Species	**Tree (T) or Other (O**	**Native (N) or Exotic (E)**	**Reason for Priority**
Scientific Names			
Acacia crassicarpa	T	N	Economic
Acacia mangium	T	N	Economic
Araucaria cunninhammii	T	N	Economic
Araucaria hunsteni	T	N	Economic
Eucalyptus deglupta	T	N	Economic
Eucalyptus pellita	T	N	Economic
Intsia bijuga	T	N	Economic
Ochroma lagopus	T	E	Economic
Pinus caribaea	T	E	Economic
Pometia pinnata	T	N	Economic
Tectona grandis	T	E	Economic
Terminalia brassii	T	N	Economic
Gyrinops ledermanii	T	N	Economic/ Threaten
Aquilaria moluccana	T	N	Economic/ Threaten
Santalum macgregorii	T	N	Economic/ Threaten
Cryptocarya massoy	T	N	Economic/ Threaten
Spathodea campanulata	T	E	Invasive
Piper aducum	T	E	Invasive

The forest plantations comprise mostly of local species and these are managed and harvested upon maturity of the trees. Some of the tree species used in plantations include; *Eucalyptus deglupta* (Kamarere), *Tectona grandis* (Teak), *Ochroma lagopus* (Balsa), *Pinus caribaea, Araucaria cunninghamii* (Hoop), *Araucaria hunsteinii* (Klinkii), etc.

1.5 Factors influencing the state of forest genetics in Papua New Guinea

There are many other factors influencing forest genetics in the country. Log harvest is regarded as a major contributor to forest genetic variations in terms of both flora and fauna existence. Most of the trees harvested for log exports are from the natural forest (**Table 5**) with no reliable data available for how much hectares are managed for these tree species. **Table 5a** provides a total export value for these species over the last 10 years. Some of these species do have other values and uses in the communities.

Table 5. Forest tree species used in Papua New Guinea

Species (Scientific name)	Trade Name	Native (N) or Exotic (E)	Current Uses (code)	Type of management	Area managed (ha)
Araucaria cunninghamii	Klinkii	N	1, 2	Plantation	>4000
Araucaria hunsteini	hoop	N	1, 2, 3	Plantation	
Acacia mangium	Acacia	N		Plantation	2000
Acacia crassicarpa	Acacia	N		Plantation	
Alstonia scholaris	Cheesewood White	N	1	Natural forest	na
Aglaia culculata	Amoora	N	1	Natural forest	na
Anisoptera thurifera	Mersawa [PNG]	N	1	Natural forest	na
Buchanana mollis	Pink Satinwood	N	1	Natural forest	na
Burkella sp.	Burckella	N	1	Natural forest	na
Calophyllum inophyllum	Calophyllum	N	1, 3	Natural forest	na
Campnosperma brevipetiolata	Campnosperma	N	1, 3, 4, 5	Natural forest	na
Canarium indicum	Canarium Red	N	1, 4	Natural forest	na
Canarium oleosum	Canarium Grey	N	1	Natural forest	na
Celtis latifolia	Celtis Hard	N	1	Natural forest	na
Celtis philipiensis	Celtis Light	N	1	Natural forest	na
Cryptocaria sp.	Cryptocarya [Medang]	N	1, 4	Natural forest	na
Dillenia papuana	Dillenia	N	1	Natural forest	na
Dracontomelon dao	Walnut PNG	N	1, 3, 4	Natural forest	na
Dysoxylum sp.	Dysox	N	1	Natural forest	na
Magnolia tsiampacca	Elmerrillia [Beech Wau]	N	1	Natural forest	na
Endospermum medullosum	Basswood PNG	N	1	Natural forest	na
Eucalyptus deglupta	Kamarere	N	1, 2, 4,	Natural forest, plantation	na
Garcinia sp.	Kandis	N	1	Natural forest	na
Homalium foetidum	Malas	N	1, 3	Natural forest	na

Instia bijuga/palembanica	Kwila	N	1	Natural forest	na
Litea sp.	Litsea [Medang]	N	1	Natural forest	na
Maranthes corymbosa	Plum Busu	N	1	Natural forest	na
Mastixiodendron pachyclados	Garo Garo	N	1	Natural forest	na
Ochroma lagopus	Balsa	E	1, 2	Plantation	43,000
Octomeles sumatrana	Erima	N	1	Natural forest	na
Palaquium warburgianum	Cedar Pencil	N	1	Natural forest	na
Pometia pinnata	Taun	N	1, 3, 4	Natural forest	na
Pterygota sp.	Oak White Tulip	N	1	Natural forest	na
Syzygium spp.	Gum Water	N	1, 4	Natural forest	na
Tectona gradis	Teak	E	1	Plantation	3,627
Terminalia spp.	Terminalia	N	1, 4	Natural forest	na

The tree species listed in **Table 5a** are categorized as commercial tree species. The value provided based on the FOB prices from 2001 to 2011. It can be noted from the total value that the extraction of these resources contributes quiet significantly to the country's economy.

Table 5a. Main commercial tree species harvested in PNG over the last 10 years (2001 - 2011).

#	Trade names	Scientific names	Volume (m^3)	FOB(kina)
1	Taun	*Pometia pinnata*	3,162,450	262,798,694
2	Malas	*Homalium foetidum*	1,980,684	131,813,332
3	Calophyllum	*Calophyllum inophyllum*	1,923,931	156,102,067
4	Kamarere	*Eucalyptus deglupta*	1,584,806	87,751,595
5	Kwila	*Instia bijuga/palembanica*	1,398,067	245,213,460
6	Terminalia	*Terminalia spp.*	1,363,167	88,916,028
7	Mersawa [PNG]	*Anisoptera thurifera*	996,856	92,091,719
8	Cedar Pencil	*Palaquium warburgianum*	870,222	71,701,455
9	Dillenia	*Dillenia papuana*	823,508	52,999,002
10	Canarium Red	*Canarium indicum*	816,766	53,794,242
11	Pink Satinwood	*Buchanana mollis*	686,661	40,137,417
12	Erima	*Octomeles sumatrana*	647,397	41,108,416
13	Gum Water	*Syzygium spp.*	614,071	36,905,460
14	Basswood PNG	*Endospermum medullosum*	558,538	34,734,150
15	Garo Garo	*Mastixiodendron pachyclados*	533,851	32,833,694

16	Burckella	*Burkella sp.*	502,734	33,304,645
17	Walnut PNG	*Dracontomelon dao*	430,794	27,991,668
18	Celtis Light	*Celtis philipiensis*	375,744	22,394,106
19	Canarium Grey	*Canarium oleosum*	316,351	20,901,878
20	Plum Busu	*Maranthes corymbosa*	303,980	17,777,740
21	Campnosperma	*Campnosperma brevipetiolata*	298,344	18,079,094
22	Oak White Tulip	*Pterygota sp.*	297,574	17,708,788
23	Litsea [Medang]	*Litea sp.*	268,907	16,193,052
24	Dysox	*Dysoxylum sp.*	264,163	16,036,278
25	Cryptocarya [Medang]	*Cryptocaria sp.*	253,098	15,175,773
26	Celtis Hard	*Celtis latifolia*	250,170	15,217,170
27	Kandis	*Garcinia sp.*	233,604	13,826,851
28	Amoora [Pacific Maple]	*Amoora sp.*	229,445	14,266,144
29	Elmerrillia [Beech Wau]	*Magnonlia tsiampacca*	226,618	14,018,853
30	Cheesewood White	*Alstonia scholaris*	222,163	13,319,798
			22,434,664	**1,705,112,569**

1.6 Managed Forests for Environmental Services

Whilst there are many species with potential for provision of various environmental services, only selected species have been utilized for limited uses only. **Table 6** provides some examples of species used in the country. Some parts of the country are very unstable due to the rugged terrain and do experiences landslides during high rainfall periods. Along the highways that pass through these areas, *Paraserianthes fulcataria* and bamboo clumps (*Bambusa vulgaris*) are planted to provide stabilitity and control erosion of surface soil materials.

In selected swamp areas, trees have been planted to assist drain the soil and the areas are now available for other economic crops. In the Surinki area in the highlands of PNG the swamp area was planted with *E. depluta* and in the Markham swamp, *Terminalia brassii* was planted to improve the area. The Sirunki area is now available for other cash and food crops.

Most of the trees and woody plant species are managed in a concession timber area or Forest Management Area (FMA). Trees at 50 cm DBH and over are selectively logged while the forests are left intact with all trees below 50 cm DBH, woody species, palms and ferns. Some of the trees and woody species are listed in **Table 6** are also retained in buffer zones in logged over areas to reduce soil erosin entering river systems.

Table 6. Main tree and other woody plant species managed for environmental services

Species (Scientific names)	Native (N) or Exotic (E)	Environmental Services or Social Value (refer to code)
Anisoptera thirifera	N	3
Anisoptera thirifera	N	3
Bambusa vulgaris	N	*Site stabilization and erosion control*
Eucalyptus pellita	N	Grassland rehabilitation
Eucayptus deglupta	N	*Reclaimation of swampland*
Gyrinops caudata	N	3,6
Gyrinops ledermanii	N	3, 6
Luceaena spp.	E	2,1
Paraserianthes falcutaria	N	*Site stabilization and erosion control*
Pometia pinnata	N	1
Terminalia brassii	N	*Reclaimation of swampland*

There are species which have been over harvested for their economic value such as *Aquilaria filaria, Gyrinops ledermanii*, and more recently *Cryptocarya massoy*. These trees are harvested and sold to overseas markets. The occurance of these species and others listed in **Table 7** are localized in some areas of the country. Often these localities are in isolated areas where access is difficult and government services are limited or lacking.

A few of these species are being threatened by mining due to loss of their habitat such as *Methrosideros* sp on the Bulldog road in the Hidden Valley mining area in the Morobe Province.

Table 7. List of tree and other woody species considered threaten in all or part of their range

Species (scientific name)	Area (ha) of natural distribution	Average number of trees per ha	Proportion of species natural distribution in country	Distribution in country (W, L, R)	Type of threat (1-15)	Threat Category		
						High	Medium	Low
Agathis alba	na	na	100	L	1		✓	
Aquilaria filaria	na	na	50	L	1		✓	
Araucaria cunninghamii	na	na	100	L	1		✓	
Araucaria hunsteini	na	na	100	L	1		✓	
Disopyros spp	na	na	100	L	1,3,7	✓		
Gyrinops ledermanii	na	na	100	L	1. 3, 7	✓		
Lamiodendron brassii	na	na	100	L	1,2		✓	
Manilkara sp	na	<1	100	L	1		✓	
Maranthes corymbosa	na	<1	100	L	1		✓	
Methrosideros sp	na	na	100	L	1,2,7		✓	
Santalum macgregorii	na	na	100	L	1,3,7	✓		

Seeds of commercial tree species mention in **Table 8** are collected from CSOs, SSOs, SPAs, and progenies plantings. The germplasm (seeds, seedlings from forest floor, truncheons) of some tree species are collected from natural populations in the wild for *ex situ* conservation stands or multiplication of planting stocks by stem cuttings. These tree species are classified as non-timber forest product and access to plant materials of these species are often difficult.

The genetic variability studies on the adaptive characters and molecular characteristics are yet to be undertaken for most commercial tree species due to lack of skills and availability of facilities. The only genetic variability achieved for most plantation species is the morphological traits directly measured on field sites.

Table 8. Quantity of seed produced from documented sources

Species Scientific name	Native (N) or Exotic (E)	Total quantity of seed used (kg)	Quantity of seed from documented sources	Quantity of seed tested provenances	Quantity that is genetically improved
Acacia crassicarpa	N	100-150	30	na	na
Acacia mangium	N	200-300	100	na	na
Araucaria cunninhammii	N	500	20-50	na	na
Araucaria hunsteni	N	600-700	30	na	na
Eucalyptus deglupta	N	5	2	na	na
Eucalyptus pellita	N	17	6	na	na
Tectona grandis	E	100	50	30	30

1.7 Future Needs and Priorities

The following are some of the issues required by the Medium Term Development Strategies (MTDS), the Development Strategy and Implementation Programs (DSIP) and the Vision 2050 to be addressed by the regulating agency and other stakeholders in the country.

1. Revise the existing Forestry Policy & other forestry legislations to strengthen conservation and reforestation/re-afforestation programs.

2. PNGFA to develop a National Reforestation Programme to meet the required acerage by 2030. At the same time timber projects that are located in isolated areas should develop and establish an effective program to improve the forest composition in logged over areas.

3. Establish understanding under joint venture agreements with land owners to secure land to develop Seed Orchards, establish species trials of indigenous species and large scale reforestation and afforestation projects due to lack of land.

4. More research into the domestication of indigenous tree species for plantation development, enrichment plantings etc., should be carried out in the future with adequate manpower and financial resources.

5. Develop Management Plans for high value premium indigenous tree species. Develop conservation strategies to conserve genetic - resources for useful indigenous tree species. Encourage and support such work in other countries and to establish guidelines based on scientifically agreeable criteria, economic, environmental and social aspects.

6. Develop technical guidelines for the establishment and management of *ex situ* and *in situ* conservation stands. The guidelines to ensure there is complimentarity between *in situ* and *ex situ* conservation so both should be carried out in parallel as an integral part of genetic resources conservation programmes aimed at improving the use of genetic material. Need to establish *in situ* stands of target tree species through development of *ex situ* conservation strategies in PNG to conserve the natural genetic resources.

7. Need to document work done with *in situ* and *ex situ* conservation strategies including work on exotic and indigenous species. Capture of representative germplasm for conservation, research and development purposes, in PNG for *ex situ* and *in situ* stands including species trials and provenance trials.

8. The *in situ* system, through conservation of the ecosystems, is considered as the fundamental requirement for conservation of Biodiversity of tropical forests while *ex situ* was considered complimentary to *in situ* and seen as more relevant in cases where *in situ* conservation of ecosystems proved impractical or impossible.

9. No institute should be the sole caretaker of the responsibility for conservation because rural agriculture in all its forms and the commercial forestry in terms of harvesting and marketing are responsible for the magnitude of deforestation resulting in collapse of forests in PNG, degradation of land, environment, genetic resources and biodiversity.

Chapter 2: The State of *in situ* Genetic Conservation

2.1 Species in actively managed *in situ* conservation programmes.

The target species of interests actively managed under *in situ* conservation programs have been those species of instrumental various. The primary category is the traditional values, for example, for both construction (e.g. timber) and non-timber species (e.g. bamboos). This has been extended with an integration of modern economic interests on sustainable harvests of traditional commercial species (e.g. timber and paper pulp production) and investments on ecosystem services (e.g. carbon sequestration). Against this backdrop the intrinsic values of forest biodiversity is not often articulated in the conservation management programs in the first instance.

There is no targeted forest species listed for active managed *in situ* conservation programs according to the current species conservation or protection laws. This is in stark contrast to the given national policies and its entailed legal framework to take into account 'plants and trees' within the fundamental provisions of the National Constitution with reference to the Fourth Goal on *Natural Resources and Environment*, and by virtue of S98 of the *Organic Law on Provincial Governments and Local-Level Governments* 1995 (OLPGLLG, 1995). The OLPGLLG (1995) defines a natural resource to include "minerals, petroleum, gas, marine products, water, timber (including forest products), fauna, flora and any other product determined by law to be a natural resource". The definition within its general objective includes the entire forest biological diversity (biodiversity).

This grave situation of a lack of a national law to offer protection to 'flora' is denoted by the National Executive Council (NEC) Decision No. 262/98 in which one of the required major undertakings by the Department of Environment and Conservation (DEC) and the Papua New Guinea Institute of Biodiversity (PINBio) is to facilitate and develop a law to protect 'flora' in order to mirror the *Fauna (Protection and Control) Act* 1966. This requirement for a 'flora protection' or a 'fauna and flora' legal regime has not been achieved to date.

In essence there is no list of targeted species by a relevant national conservation law and includes those relating to forest genetic resources. The current conservation policies and programs include the entire forest biodiversity within the ambits of current *in situ* conservation objectives and management.

- Forest Genetic resources inventories and surveys
- Conservation of forest genetic resource within and outside of protected areas
- Sustainable forest management on ecosystem management for forest genetic resources within and outside of protected areas
- Activities on *in situ* conservation areas
- Criteria for *in situ* genetic conservation identification
- Use and transfer of germplasm
- Assessment of major needs for *in situ* conservation

2.2 Categories of *in situ* conservation areas or protection

There are basically two types of conservation areas in PNG under the dual managed systems of modern laws and innovations, and traditional or customary laws. The two categories are provided in **Table 10a** below. The categories under modern innovations and customary laws are referred to as Informal protected areas. The modern innovations include protected areas developed under commitments through Conservation Deeds, Integrated Conservation and Development Projects (ICADs or ICDPs) and Locally Managed Marine Areas (LMMAs).

Table 10a. Types of protected areas in PNG

	Formal		Informal
1	Wildlife Management Area	1	Conservation Deed Areas
2	Sanctuary	2	Customary conservation araeas
3	National Park	3	Integrated Conservation and Development Projects (ICDP or ICAD) or Areas of Interest (AOI)
4	Historic Reserve	4	Locally Managed marine Areas (LMMAs)
5	Memorial Park		
6	Provincial Park		
7	Protected Area		
8	District Park		
	Conservation Areas		
1	Local-Level Government Conservation Area		
2	Fishing exclusion or control zones		
3	Ramsar Site		
4	World Heritage Site		

Note that under Forest Management Agreement (FMA) 10% of the accessible forests are also protected as conservation areas, apart from those inaccessible areas within the concession.

The categories of *in situ* protected areas established by current laws are shown in **Table 10b** below.

Table 10b. Categories of protected areas in PNG

	Protected Area	Legislation
1	Conservation Area	*Conservation Areas Act* 1978
2	Marine Protected Area	*Fisheries Management Bill* 2005
3	Wildlife Management Area (WMA)	*Fauna (Protection and Control) Act,* 1966
4	National Parks	*National Parks Act* 1980
5	Protection Forest	*Madang Forest Protection Bill* 2007 and *Eastern Highlands Forest Protection and Management Bill* 2008
6	Reserves	*Fauna (Protection and Control) Act* 1966, *Mining Act* 1992 and *Oil and Gas Act* 1998
7	Protected Areas	*Fauna (Protection and Control) Act* 1966
8	Sanctuaries	*Fauna (Protection and Control) Act* 1966
9	Provincial Parks	*Organic Law on Provincial Governments and Local-Level Governments* 1995 (OLPGLLPG)
10	Locally Managed Marine Areas (LMMAs)	*Motu Koita Assembly Act* 2007, *Talasea Marine Environment Management Law* 2004, *Bialla Marine Environment Management Law* 2004, *Hoskins Marine Environment Management Law* 2004
11	Local Conservation Area	*Almami Environment Conservation Law* 2003
12	Botanical and Zoological Gardens	*National Parks Act* 1980
13	Memorial Parks	*National Parks Act* 1980, OLPGLLG (1995)

A general distribution of the types or categories of protected areas by their area coverage is provided in **Table 10c** below. The total size of area coverage is placed at 1,642,826 ha (see Chatterton et. al., 2006).

Table 10c. Distribution of formal protected areas by type and area

Type	**No**	**Area**	**%**	%
(Category)		**(ha)**		(Rounded)
Wildlife Management Area	26	1,539,119	93.6873	94
Sanctuary	5	75,271	4.5818	5
Protected Area	2	20,245	1.2323	1
National Park	7	7,959	0.4845	0.5
Provincial Park	2	177	0.0108	0.01
Reserve	3	49	0.003	0.003
Memorial Park	3	5	0.0003	0.0003
Total	**48**	**1,642,825**	**100**	100

A number of anomalies from the current data and information are however apparent and need attention. An example of this is that the number of WMAs should be 35 and not 26 (as shown in **Table 10c** above) and should equate to a total of 52 sites in PNG according to **Table 10d** and **Figure 2**. It is noted that even with the increase of the number of the protected area sites the total area remains the same.

Table 10d. The 52 protected areas in PNG

PA. ID	Name	Marine/ Terrestrial	Province	Area (ha)
1	Bagiai WMA	Marine/ Terrestrial	Madang	13,760
2	Baiyer River Sanctuary	Terrestrial	Western Highlands	64
3	Balek Wildlife Sanctuary	Terrestrial	Madang	470
4	Baniara Island WMA	Marine/ Terrestrial	Milne Bay	37
5	Cape Wom Memorial Park	Terrestrial	East Sepik	105
6	Crater Mountain WMA	Terrestrial	Chimbu, Eastern Highlands, Gulf	270,000
7	Crown Island Wildlife Sanctuary	Marine/ Terrestrial	Madang	58,969
8	Garu WMA	Terrestrial	West New Britain	8,700
9	Hombareta WMA	Terrestrial	Oro	130
10	Hunstein Range WMA	Terrestrial	East Sepik	220,000
11	Iomare WMA	Terrestrial	Central	3,827
12	Jimi Valley National Park	Terrestrial	Western Highlands	4,180
13	Kamiali WMA	Marine/ Terrestrial	Oro	65,541
14	Kavakuna Caves	Terrestrial	East New Britain	Undefined
15	Klampun WMA	Terrestrial	East New Britain	5,200
16	Kokoda Historical Track Reserve	Terrestrial	Oro	Undefined
17	Kokoda Memorial Park	Terrestrial	Oro	200
18	Lake Kutubu WMA	Terrestrial	Southern Highlands	241
19	Lake Lavu WMA	Terrestrial	Milne Bay	2,640
20	Lihir Island WMA	Marine/ Terrestrial	New Ireland	20,208
21	Loroko National Park	Terrestrial	West New Britain	100,00
22	Maza WMA	Marine/ Terrestrial	Western	184,230
23	McAdam National Park	Terrestrial	Morobe	1,821
24	Moitaka Wildlife Sanctuary	Terrestrial	National Capital District	44
25	Mojirau WMA	Terrestrial	East Sepik	5,079
26	Mt Gahavisuka Provincial Park	Terrestrial	Eastern Highlands	77
27	Mt Kaindi WMA	Terrestrial	Morobe	1,503
28	Mt Susu National	Terrestrial	Morobe	1,503

	Reserve Park			
29	Mt Wilhelm National Reserve	Terrestrial	Western Highlands [Chimbu?]	817
30	Namanatabu Reserve	Terrestrial	Central	27
31	Nanuk Islands Reserve	Terrestrial [/Marine?]	East New Britain	12
32	N'Drolowa WMA	Marine/ Terrestrial	Manus	5,850
33	Neiru (Aird) Hills WMA	Terrestrial	Gulf	4
34	Nuserang WMA	Terrestrial	Morobe	22
35	Oi Mada Wara WMA	Terrestrial	Milne Bay	22,840
36	Paga Hill National Park Scenic Reserve	Terrestrial	National Capital District	17
37	Pirung WMA	Marine/ Terrestrial	North Solomons [ARB]	43,200
38	Pokili WMA	Terrestrial	West New Britain	9,840
39	Ranba WMA	Marine/ Terrestrial	Madang	41,922
40	Ranba Wildlife Sanctuary	Terrestrial	Madang	15,724
41	Sawataetae WMA	Terrestrial	Milne Bay	700
42	Siwi-Utame WMA	Terrestrial	Southern Highlands	12,540
43	Talele Islands National Park Reserve	Marine/ Terrestrial	East New Britain	12
44	Tavalo WMA	Marine/ Terrestrial	East New Britain	2,000
45	Tonda WMA	Terrestrial	Western	590,000
46	Varirata National Park	Terrestrial	Central	1,063
47	Wewak Peace Park	Terrestrial	East Sepik	1.9
48	Zo-oimaga WMA	Terrestrial	Central	1,510
49	Tab WMA	Marine/ Terrestrial	Madang	964
50	Tabad WMA	Marine/ Terrestrial	Madang	16
51	Sinub WMA	Marine/ Terrestrial	Madang	17
52	Laugum WMA	Marine/ Terrestrial	Madang	73

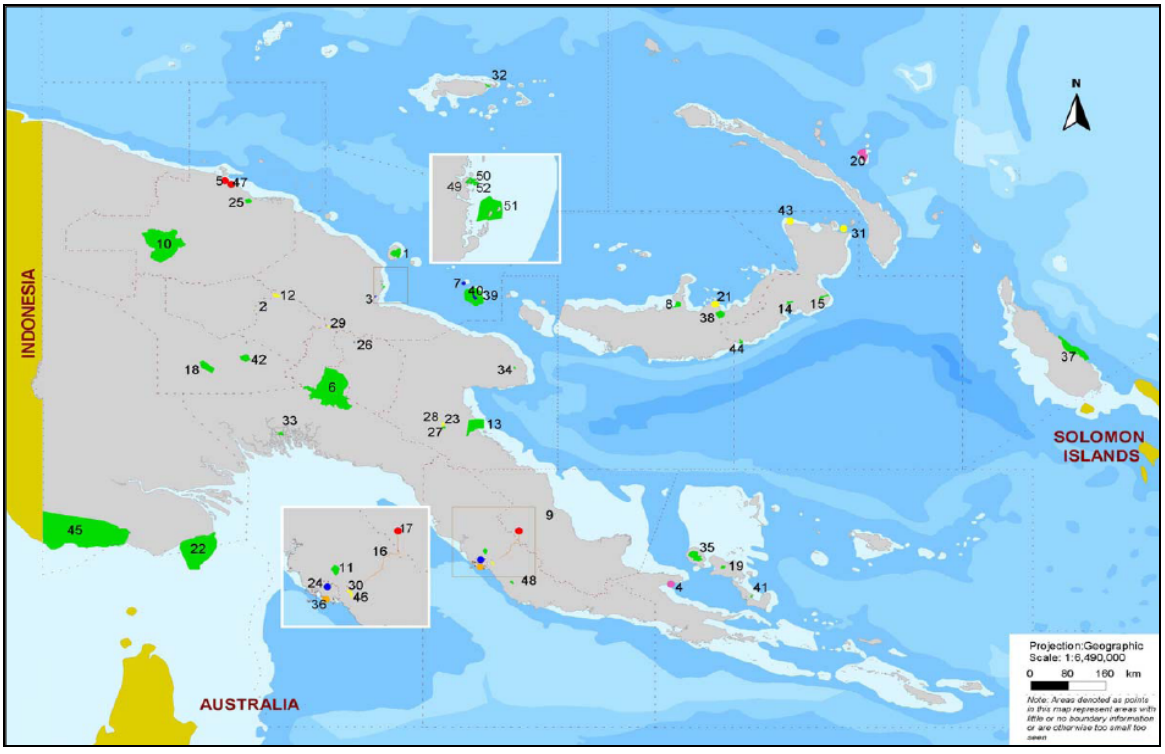

Figure 2: Map of the 52 Protected Areas in PNG

An updated data and information from recent publications with the notable ones being Chatterton et. al. (2006) and Shearman et. al, (2008) have provided an improved coverage of protected areas with emphasis on the apparent inadequate effectiveness of conservation management in PNG and a bleak outlook on the future of forest conservation in PNG.. These works however are also prone to some fundamental errors as shown in a simple contrast in **Annex 1**. One of the noted data of concern is the total area coverage expressed in Chatterton et. al. (2006) is 1,642,826 ha while Shearman et. al. (2008) gives a total of 1,294,969 ha.

In short, the data and information on protected areas need more attention to make all the information to be consistent from the various reviews and analysis and the current review on the protected area policy being undertaken by Department of Environment and Conservation (DEC, 2012).

2.3 Actions taken to sustain and improve inventories of forest genetic resources in *in situ* collections

The major national forest program is referenced to the 1991-1995 National Forestry Conservation Action Program (NFCAP) under the auspices of the World Bank led Structural Adjustment Program (SAP). The noted relevant outcomes from the NFCAP included the protected areas rehabilitation (WWF and DEC, 1992), conservation needs assessment (Beehler, 1994), conservation areas strengthening program proposal (DEC, 1995) and integrated conservation and development initiatives (e.g. Stuart and Sekhran 1996, Saulei and Ellis 1997, McCallum and Sekhran 1996, Ellis 1999). The additional noted interventions since the NFCAP include the biodiversity data management (DEC, 1997), biodiversity rapid assessment modelling (BioRap) (Margules et. al. 1999), initiatives on protected areas

required under the commitments of the CBD (1992) and International Union Conservation Networks (IUCN) include the effectiveness of protected areas management (Chatterton et. al. 2006), national biodiversity strategy and action plan (DEC 2006, DEC 2007), strengthening conservation capacity program (Pringel, 2011), investments and sustainable financing (Genolagani et. al. 2008, Saulei 2008, Kula 2008, Mogina 2008, Kwa 2008), status of forests and rates of forest change (Shearman et. al. 2008) and community-based forest and coastal conservation and resource management (UNDP and DEC, 2009). The major undertaking by DEC at present is on the development of a national protected area policy (DEC, 2012).

Within the context of sustained *in situ* collections in protected areas there is very limited and /or lack of collections. A number of field researches are undertaken only on selected sites for example, the Varirata National Park by the University of Papua New Guinea (UPNG) academic programs which has included phenological studies.

An important program of relevance is within the national forest concession procedures of the Forest Management Agreement (FMA) requirements in which 10 percent is set aside for 'conservation' purposes. This set aside is still being debated as to whether portions of production areas could be included or this is confined to only 'environmental constraints' areas. The noted activity here is on species inventories which are not readily available.

The basic issues for noting include: preliminary inventories are undertaken but no detail follow-up inventories or surveys; lack of knowledge on total forest genetic species from all areas; knowledge on presence and absence of species are primarily based on casual observations; and no continuation of surveys in protected areas.

2.4 Actions taken for promoting *in situ* conservation

There is willingness by all the stakeholders in promoting *in situ* biodiversity conservation in PNG. The Non-Governmental Organizations (NGOs) and various research and education institutions in partnership with local resource owners and communities have been at the helm of various promotional programs and development of protected areas.

The promotion and development efforts for protected areas have been jeopardized by the standing 2005 'moratorium' on establishment of protected areas in the same areas for forest concessions or in competing for potential areas.

The largest and a more effective outlook on promotion for forests conservation in PNG has been with the potential of new investments under the global initiatives on investments through mitigation measures. With the onset of the Kyoto Protocol in 1997 and PNG's ratification in 2000 the PINBio initiated various activities under its Clean Development Mechanism (CDM). The alternate option under the auspices of the *United Nations Framework Convention on Climate Change* (UNFCCC-1992) by PNG through the Coalition of Rainforest Nations (C*f*RN) initiatives on reducing emissions from degradation and deforestation (REDD) engulfed the PNG forest sector since 2005. This provided the catalyst for reviewing the public policy on forest biodiversity and protected areas.

The debate on the core issues of forest conservation through the protected area management regimes needs attention. That is, which of the 'REDD' versions is PNG going to opt for in terms of:

- REDD - no conservation and therefore no protected areas;
- REDD+ - dubious inclusion of conservation and therefore application of protected areas is uncertain; and
- REDD++ - inclusion of conservation and therefore protected areas is the core management regime, but is currently outside of the UNFCCC working terms of an international regulatory market. A response to this dilemma has prompted the PNG NGOs and partners' initiative to propose a Payment for Ecosystem Services model (Expert Working Group, 2011).

It appears that since the 2005 moratorium imposed by DEC the pro-active promotions and development activities for the establishment of protected areas in PNG have been reduced significantly. One of the noted results is the down-graded programs of international conservation-based NGOs in PNG.

An additional note on promotion is that the mainstream education curricula from the primary to the secondary and national high schools do not articulate the value of protected areas. The current programs are focused on detrimental environmental impacts and general conservation perceptions. It is the academic and related programs by universities and NGOs that appear to be doing promotional activities from the classrooms.

It is noted in the earlier sections that the most recent Government support in promoting *in situ* conservation in PNG is by DEC at present seeking contributions from stakeholders on the development of the national protected area policy.

2.5 Constraints to improving *in situ* conservation in the country

There are many constraints faced in improving conservation efforts in the country which are common to all countries. Here in Papua New Guinea the following are noted to be major obstacles:

- Lack of funding to support and sustained initiatives taken by various organisations
- Lack of resources especially trained personnel
- Lack of logistical support for field operations

2.6 Priorities for future *in situ* conservation actions

The priorities for conservations actions in PNG has been addressed at various levels and through different programmed and strategies in the past however, it has always been difficult to secure long term commitment from the government and other stakeholders. There is a need to re-visit these outcomes and determine if they can be revived.

There is a need to enhance capacity of institutions and agencies directly involve in conservation activities and other related programmes, especially in biodiversity explorations. Such assistance could be done through external collaborations with adequate resources to impelement these biodiversity explorations.

2.7 Capacity-building needs and priorities for *in situ* conservation actions

The Forest Genetic Resource is own by the people and with the increasing awareness on its importance communities are protective of their resources. However, there is a need to assist people to make inform decisions when faced with competing offer from other developers such as mining, logging, oil palm and large scale agriculture projects.

Such awareness can be approach by all agencies and stakeholders working with the communities. Lack of materials especially information is also a problem and will need to be addressed to enable an effective awareness to the communities.

2.8 Research priorities to support *in situ* conservation

PNG Forest Research Institute has a number of continuing research activities that involve in the documentation of the flora of the country and covers issues that support the *in situ* conservation objectives. PNGFRI does collaborate with DEC and other conservation organizations involved in conservation efforts in the country.

The priorities for conservation activities are based on the objectives of each organization and the communities they work with.

2.9 Policy development to support *in situ* conservation actions

The DEC is the leading agency in and it is currently circulating a national policy on Protected Areas which will address many of the priority areas.

Chapter 3: The State of *ex situ* Forest Genetic Resource Conservation

3.1 Introduction

The PNGFRI which was established in 1989 under the funding by Japanese government through its international development agency (JICA) has continued to further develop the *ex situ* genetic conservation stands that were established in 1949 by the then Silvicultural Research and Forest management Research branches located in Bulolo and Madang respectively under the PNG Forest Department (now PNGFA). Currently, the PNGFA has several arboreta, state forest reserves, botanical gardens, a Nation Tree Seed Centre (NTSC), nurseries and National Forest Service (NFS) offices situated in 20 provinces throughout the country. NFS is responsible for reforestation, afforestion and logging operations in each province and report directly to PNGFA. Although, 97 percent of the land is customary land, which means genetic resources are belong to the people, the PNGFRI still access FGRs in national parks and on customary land after negotiating with the resource owners.

The conservation of natural forests is important, providing *in situ* conservation and sources of propagules (e.g. seeds) for future rehabilitation of the degraded forests. The value of these areas is therefore incalculable. The Institute also ensures *ex situ* conservation of PNG native and exotic forest species continue to evolve.

The *ex situ* genetic conservation program of native species aims to serve as the genetic bank for the variability existing among and within the populations of forest tree species for present and future uses to meet economic, social and environmental needs. The objectives of the program also include the study of the genetic structure, silvicultural behaviour, heredity of traits of economic interest and improved seed production for reforestation, afforestation and degraded sites created by bushfires or logging activities.

3.2 Plantation development

Plantation development in PNG commenced in 1949 based on native species such as *Araucaria cunninghamii* (hoop pine), *A. hunsteinii* (klinkii pine), *Eucalyptus deglupta* (Kamarere) and *Terminalia brassii* in logged over areas. In 1995, afforestation had begun in PNG at Brown River, Central Province using the exotic species, *Tectona grandis* (Teak). Since then, plantation development expanded to other parts of the country. To date, a total of 62, 277 ha of various commercial plantation species were developed in the country. Plantation tree species currently used are *Araucaria cunninghamii, A. hunsteinii, Eucalyptus deglupta, Terminalia brassii, Tectona grandis, Acacia mangium, A. auriculiformis, Agathis alba (Kauri), Anthocephalus kadamba, A. chinensis, Eucalyptus grandis, E. robusta, E. pellita, Ochroma lagopus (Balsa), Pinus caribae, P. patula, P. strobus and P.oocarpa.*

As plantation development commenced and began to expand, the PNGFA realized that in order to keep pace with the expansion program, reliable seed sources are required to provide and support this increasing development programs. This leads to seed collection from the natural stands and subsequently the establishment of *ex situ* genetic conservation of major

plantation species. These *ex situ* genetic conservation stands provide improve propagules (seeds, seedlings) to support the plantation development in the country.

3.3 Trials of native and exotic tree species

The development of native and exotic tree species had begun in the late 1960s. The objectives of establishing statistical and replicated trial plots were and still are to collect data on the growth performances to analysis for determining the next breeding strategies of a particular tree species. Locations of these *ex situ* stands are situated at 700 m.a.s.l (higher altitude - Highlands) and at 50-100 m.a.s.l (lower altitudes in the Southern and New Guinea Islands region) of the country. The types of research carried out in these research sites are silviculture treatments (spacing, thinning, pruning, growth & yield), tree improvement, establishment of seedling and clonal orchards, and species screening.

The *Pinus* species introduced in the highlands were *P. strobus, P. caribaea, P. patula,* and *P. ocarpa*, while for afforestation programs, *Aaucaria cunninghamii, Eucalyptus grandis, E. robusta*, *E. saligna* and *E. grandis* were advocated and used. These species have adopted successfully and currently they are the major plantation species in the highlands of PNG. *Tectona grandis* (Teak) which was trailed in the southern region of the country also proved to be a successful species which has now being a major timber species planted nationwide. Recently, additional species such as *Switenia macrophyla* (Mahogony), *Gyrinops ledermanii* (Eaglewood) and *Santalum macgregorii* (Sandalwood) were introduced for breeding and improvement studies and the results are still being analysed, while further research are being conducted focusing mainly on native high altitude species.

In the late 1960s, native species namely, *Eucalyptus deglupta, Terminalia brassii, Anthocephalus chinensis, Pometia pinnata* (Taun), *Dracontomelon dao* (Walnut), *Calophyllum europhyllum (Calophyllum), Araucaria cunninghamii* and *Pterocarpus indicus* (Rosewood) and two exotic species: *Ochroma lagopus* (Balsa) and *Tectona grandis* (Teak) were introduced and trialed in East New Britain (New Guinea Islands) at the same time *Pometia pinnata (form pinnata), Pometia pinnata form glabulos, Eucalyptus deglupta, Anthoceplus kadamba, Intsia bijuga, Tectona grandis, Terminalia brassii* and *Castanospermum australe* (black bean – naturalized species) were trial in West New Britain.

3.4 Means of germplasm conservation

The single method of germplasm collection and conservation is by seeds. Seeds collected from ‘plus trees’ from the wild or from SSOs, CSOs or SPAs are stored at the NTSC. Other germplasm materials such as pollen and plant tissues are not handled or processed by PNGFRI as there were no suitable facilities to cater for these, but these types of materials will be implemented in the future once acquisition of such facilities are established at PNGFRI and can be used or exchange within the country or to overseas partners.

3.5 Infrastructure capacity for *ex situ* conservation

The NTSC has facilities for storing quantity of seeds to cater for research, plantation development in the country and to export at the request of overseas partners or companies. Nevertheless, the NTSC facilities need expansion in line with the government priorities in reforestation and afforestation programmes in the country. Improvement of germplasm via breeding programs undertaken by PNGFRI for commercial species such as *Araucaria cunninghamii, A. hunsteinii, Pinus carribeae, Pinus oocarpa, Pinus patula, Tectona grandis, Ochroma lagopus, Eucalyptus deglupta, Eucalyptus pellita, Acacia mangium*, and *A. carssicarpa* will need to be enhanced. These are clonal germplasm bank including Seed Production Areas (SPAs) of commercial and non-commercial species providing quantity and quality germplasm for plantation development in the country as well as supply to overseas partners.

3.6 *Ex situ* conservation stands

A number of *ex situ* conservation stands have been established by PNGFA through PNGFRI since early 1980s. The first CSOs established were for *Araucaria hunsteinii, A. cunninghamii, Tectona grandis, Eucalyptus deglupta,* and *Pinus caribea* (**Table 11a**) which are being used for providing quality and quantity seeds for reforestation and afforestation plantation development programs in the country.

Table 11a. Area of *ex situ* conservation stands

No.	Trial Type	Scientific Name	Area (ha)
1	CSO	*Araucaria hunsteinii*	1
2	CSO	*Araucaria cunninghamii*	1
3	CSO	*Acacia mangium*	0.32
4	CSO	*Acacia crassicarpa*	0.68
5	CSO	*Pinus caribea*	1
6	CSO	*Eucalyptus deglupta*	0.28
7	CSO	*Tectona grandis*	2
8	Species	*Acacia crassicarpa*	0.5
9	SPA	*Acacia mangium*	0.65
10	Species	*Eucalyptus pellita*	1.4
12	Species	*Intia bijuga*	0.6
14	Progeny	*Tectona grandis*	0.8
15	Provenance	*Agathis robusta*	2.4
16	Provenance	*Calophyllum euryphyllum*	0.8
17	Genetic/Progeny	*Calophyllum euryphyllum*	1.34
18	Provenance	*Pometia pinnata*	0.92
19	Provenance	*Dracontomelon dao*	0.5

Figure 3. Procedures of seed collection in Clonal Seed Orchards (CSOs)

3.7 Arboreta and botanic gardens

Arboreta and botanical gardens were established to serve the purpose of conserving the rare, and endangered plant species or species under threat from over exploitation, research and educational purposes, and access to plant materials for breeding programs. Early arboreta and botanical gardens established in the country dated back to 1949 and are listed below (**Table 11b)**.

Table 11b. Arboreta and botanical gardens

Location	**Description of uses**
National Botanical Garden-Lae	Conserve rare, endangered or important indigenous plant species including exotic species and for research purposes. Similarly for researchers and Educational purposes, most staff and students of forestry training.
Oomsis Forestry Station near Lae	Indigenous and exotic species. Notably for *Shorea*, *Anthocehalu*s and teak plantings
Bulolo Forestry College	Two arboreta comprising indigenous species used for teaching botany
Bulolo Forestry Station	Conserving indigenous and exotic species, include valuable planting of *Agathis spathulata*, representatives of hoop pine provenance, a source of obtaining hybrid seed.
Bulolo National Seed Production Area	NSPA contains clonal and seedling seed orchards of various species, including demonstration lots of indigenous and exotic species. There are 119 accessions

	planted in this area and 49 species are represented.
Wau Ecology Institute	Conserving natural, planted vegetation and a botanical reserve and a refuge for birds
Dami Forest Station-West New Britain	Indigenous tree species established include *Anthocephalus chinensis, Pometia pinnata, Intsia bijuga, Eucalyptus deglupta* and Black bean
Keravat Forest Station-East New Britain	Contains both exotic and indigenous species
Kagamuga Forest Station	This arboretum contains many species of Australian Eucalyptus species and *Pinus* species located in Western Highland.
Gahavizuka Provincial Park, Goroka, Eastern Highlands	Natural occurring and planted indigenous tree species, mainly high altitude species such as *Castanopsis* and *Nothofagus* species.
National Capital Botanic Gardens-Port Moresby	Conserving various plant species for educational, research, recreation activities, and visits by general public

Given the importance of arboreta and botanical gardens, expansion and introduction of additional new species are needed. Many of the plant species need labeling to serve its purpose as educational and research arboreta that are accessible to students and researchers within the country and visitors from abroad.

3.8 Use and transfer of germlasms

All germplasm of important commercial tree species in the country are been managed and controlled by PNGFA through the PNGFRI. For access, formal requests for germplasm from industries, NGOs and individuals have to be directed to the director's office at PNGFRI. The director of the institute will then endorse the supply of germplasm upon receiving the request (letter) and forwards it to the Planted Forest Programme which executes the request and the germplasm is processed and delivered. Currently, most requests for germplasm are for plantation development, community forestry, woodlot establishment, interested farmers or tree growers.

3.9 Documentation and characterization

There are number of different forms and characteristics used in the selection and domestication of tree species. There are specific forms to use in the field, laboratory and nursery such as those used for seed tree selection and description, seed collection and seed viability and germination which are entered into the seed data base. Field trial establishments are recorded in a registry. The characteristics being recorded include the tree physical attributes (diameter, height, bole length, crown weight, seeding production), environmental conditions (temperature, humidity, rainfall, soil types), and laboratory conditions and requirements (temperature, experiment type, purpose), and field trial documentation (trial types, location, objectives, management and measurement plans, thinning schedule).

3.10 Maintenance of *ex situ* stands

Maintenance and continuous management of these existing *ex situ* conservation stands by PNGFA is important as they currently support plantation development program in the country.

3.10.1 Seed source for plantation

Most of the seedlings raised for plantation development in the country are from seeds. Thus, quarterly maintenance of these seed stands are usually required to ensure that such trees are not competing with the undergrowth for nutrients to maintain vigorous growth. Flowering and fruiting studies are also carried out at the same time. This helps to determine if there is any change in the annual seed production.

3.10.2 Clonal propagation

Continuous management of these *ex situ* conservation stands (CSOs, SSOs, provenance, progenies) would promote good healthy seed trees to harvest scions from them for vegetative propagtion activities. The clones produced from vegetative propagation techniques such as grafting and stem cuttings would enable **P**NGFRI to establish new clonal seed orchards to avoid fire risk, illegal harvesting of seed trees and promote seeds production as ageing of old seed trees in *ex situ* conservation stands are approaching their over maturity age and their annual seed production is reduced.

Figure 4. Source of germplasm conservation stands

3.11 Promotion of *ex situ* stands for conservation

Promoting *ex situ* conservation nationally has been through PNGFA and private companies' involvement in terms of plantation development, selection of best trees in the plantation for further breeding studies, domestication of commercial trees, and establishment of SPAs and CSOs.

3.12 Private sector involvement in *ex situ* conservation

Private companies such as Stetin Bay Lumber Company (SBLC), JANT and Open Bay Timbers (OBT) to name a few, have been involved over the years in developing large scale forest plantations, utilizing improved and certified seeds from improved source supplied by PNGFRI. In turn, these companies also conduct selections of the best seed trees within their plantations to supplement those received from NTSC. Furthermore, the seedlings they raised from these seed trees are used to establish their own seedling seed orchards (SSOs) to sustain their plantation development and timber production. Seedlings or seeds collected from wild are also included in these SSOs by the companies to increase its genetic pool.

3.13 State involvement in *ex situ* conservation

The government of PNG (GoPNG) through PNGFA has increased plantation development programs over the years by promoting reforestation and afforestation programs. Seedlings raised for these reforestation and afforestaion development programs were sourced from *ex situ* conservation stands (CSOs, SSOs) established by PNGFRI. Recent provenance trials of commercial tree species developed under the domestication project funded by ACIAR in collaboration with PNGFRI will soon be converted into SPAs. The best provenances indentified after data analysis would be subjected to vegetative propagation activities (grafting or cuttings) for CSOs establishment.

The breeding improvement of theses *ex situ* conservation stands are important to provide improve seeds for large scale reforestation programs in the country and in no doubt address the GoPNG's Vision 2050 requirements, which directed that the size of plantations be increased by another 80,000 ha by 2030. This is a challenge for PNGFRI to fast track the improvements of its provenance and progenies trials to add to the existing *ex situ* conservation stands so that it can produce adequate seeds to meet the government's requirements.

Table 11. *Ex situ* conservation

Species		Field collections				Germplasm bank			
Scientific name	Native (N) or Exotic (E)	Collections, provenance or progeny tests, arboreta or conservation stands		Clonal banks		In vitro		Seed banks	
		No. Stands	No.acc	No. banks	No. clones	No. banks	No. acc	No. Banks	No. acc
Tectona garndis	E	>40	15	1	29	-	-	3	na
Araucaria hunsteinii	N	>30	20	1	20	-	-	na	Na
Araucaria cunninghamii	N	>20	10	1	20	-	-	na	na
Acacia crassicarpa	N	35	>15	1	>15	-	-	na	na
Acacia mangium	N	55	35	1	>15	-	-	2	2
Eucalyptus deglupta	N	20	12	2	15	-	-	na	na

3.14 Constraints for improving *ex situ* conservation stands

The major obstacles for further breeding improvement and expansion of *ex situ* conservation in the country are; lack of maintenance to old facilities and addition of new facilities, funding, shortage of skills manpower, land availability, and lack of knowledge and understanding the importance of *ex situ* conservation on the part of local communities in the country.

3.14.1 Lack of improved facilities

The only National Tree Seed Centre (NTSC) in the country was built in 1987 with assistance from New Zealand Aid. The main functions of the Centre are to process seeds after collection, carry out seed germination testing, seed packaging and labeling, storage and supply whenever requested. The facilities (e.g. seed cleaning and processing area) or equipment (e.g. main storage units) are 24 years old and often are not functioning well to full capacity to enhance seed viability and longevity. There is an urgent need for a complete rehabilitation and expansion of the NTSC to meet the increasing high demand for germplasm from both within the country and abroad.

Apart from the NTSC, seed and tissue culture laboratories within the PNGFRI building complex were built when PNGFRI became established in 1989. These laboratories need

urgent upgrading or complete rehabilitation, including replacements of malfuncting old equipment to support research activities concerning germplasm (seeds experiments, tissue culture) that have been continually planned annually by the institute.

3.14.2 Lack of funding

Funds allocation annually from the national government is inadequate to carry out field studies and germplasm collection throughout the country. In addition, maintenance of *ex situ* conservation areas (provenance, progenies, species, CSOs, SSOs), further breeding improvements of these *ex situ* stands (e.g. selection of best individuals from the provenance trials) and measurement of these trialed plantings are always delayed due to short falls in funding allocated to PNGFA from the government.

Hindrance to improving of *ex situ* conservation associated with lack of funds has affected the progress of breeding improvement programs. There are number of external funded projects such as Australian Centre for International Agriculture Research (ACIAR), JICA and FAO who have been collaborating with PNGFA in the development of *ex situ* conservation in the country, but the problems encountered with such donor funded projects is that, they are here only for short term (approx. 2-3 years) and often their project objectives do not fall well with those of PNGFRI. Further, the objectives of most external funded projects implemented so far, cover a wider and varied research activities to be achieved in such a shot period of time. Some of these research activities were never completed as the project has to winds up due to limited time under the project cycle. After the completion of the planned research activities (e.g. provenance or progeny trials), these are then transferred to PNGFA to manage, but due to lack of funds allocated annually from the national government, the maintenance, measurement, thinning, and selection of best trees for vegetative propagation are not continued as scheduled. Consequently, distorted data for provenance, progenies or species trials can be produced for trial documentation and unfortunately a number of these trials can be terminated without achieving their main goal, i.e. converting such trials to seed stand or sources.

It is therefore critical that the duration of an external funded project can be negotiated during the planning stages of the project between the representatives of the external collaborator and PNGFA, especially for future projects focusing on the domestication of important tree species in PNG. The reasons for negotiating longer period of project, for instance, 5 to 10 year maximum would be ideal. One such proposed activity for future development of *ex situ* stands would be that of seed collection of 20 potential plantation species to establish large provenance trials on a secured state land. Such trials would form a secure genetic base comprising 20 species and that during the 5-10-year period, assessments and selections could be made for best provenance for further breeding activities.

3.14.3 Shortage of trained personnel

Currently, there are a limited number of trained personnel (plant breeders) under the Tree Breeding and Improvement Unit at PNGFRI. This has affected the continuous implementation of breeding and improvement of targeted species in the country. Thus, increasing the number of staff for this research unit is needed so various research activities relating to *ex situ* conservation of selected species can be achieved.

3.14.4 Land availability

Since 97% of the land is a customary owned and that only 3% is state or privately owned, land availability is a constraint for establishment of new *ex situ* conservation areas. Proper arrangements or agreements between the landowners and the state is required so that the landowners can participate in the development, ownership, and security of the *ex situ* conservation areas are secured. Such arrangements would allow free access by PNGFA to collect germplasm from the CSOs, SSOs, provenance and species planting areas for supply or further breeding improvement activities.

3.14.5 Need for awareness on *ex situ* conservation

FGRs in their natural stands in the country are customarily owned by the traditional owners who are the rightfully owners under the constitution. Accesses to FGRs in the wild have to be plainly explained to the resource owners, especially in respect to the purpose and importance of collecting germplasm on their forest land and why it is importance for them to conserve the FGRs.

Currently, little awareness and education on the importance of accessing FGRs from the wild for domestication process at its initial stage have been conducted for the benefit of the resource owners. There is an urgent need for awareness and education in this regard so that some progress can be done on the preservation of the remaining genetic resource base for all the valuable species. Importantly, PNGFA or any external funded project has to involve the resource owners to participate in the *ex situ* conservation stand development or domestication process of those selected species.

3.15 Priorities for future *ex situ* conservation actions

A major review is planned to assess the current status of *ex situ* conservation of each major and/or potential plantation species. This will assist in determining what needs are required for each species in terms of next breeding strategy to be carried out on them. Meanwhile, it is suggested that emphasis would be made on the following priority areas for immediate actions;

i) Provenance seed collections for commercial and valued lesser-known tree species from their natural habitat
ii) Selection of ‘Plus trees’ or seed trees in the wild or from the existing *ex situ* conservation planting areas
iii) Establishment of bigger clone banks comprising various species in a central location and duplication of ageing CSOs.
iv) Upgrading of seed storage facilities both at the NTSC laboratory and at the PNGFRI
v) Upgrading of tissue laboratory at the PNGFRI
vi) Access and report on current additional seed production areas (SPAs)
vii) Increase and promote vegetative propagation activities (cuttings, grafting, budding etc;) for CSOs development of important tree species

After discussion with various National Forest Service (NFS) offices in selected provinces, two land areas (one in the lowland and another in the higher altitude) of 200 ha have been identified on state own land. Clearance and mapping of these areas will be undertaken soon by PNGFRI staff. These secured areas would be used for establishing and centralizing all the seed production of various commercial tree species.

3.16 Capacity building needs and priorities for *ex situ* conservation actions

Defined below are the immediate requirements and priority actions to be addressed in the future for further breeding improvement studies on the existing *ex situ* conservation stands, establishment of new *ex situ* stands of tree species of commercial value, improve research facilities, and increase the number of staff to continue developing the *ex situ* conservation activities in the country.

- Increase research staff in the Tree Breeding and Improvement Unit at PNGFRI
- Upgrade tissue and seed laboratories at PNGFRI
- In-house training of staff in tissue culture techniques including use of equipment in the laboratories
- Expansion and replacement of old seed storage facilities at NTSC
- Conduct a nationwide domestication process to collect germplasm (seed, seedlings) of commercial and lesser-known valued species from the wild for the purpose of establishing provenance testing trials
- Clonal propagation of naturally selected best provenance tree species in the country
- Establish centralized seed production areas both in the lowland and high altitude areas

In addition, managing any further improvements of the existing *ex situ* conservation stands and development of new trials through the domestication process should be a priority. Sustainability of *ex situ* conservation stands such as provenance, progenies, species, CSOs, and SSOs, and subsequent breeding work need to be adequately funded from the government and other sources must be sustainable over a long period of time. Such adequate funds can go a long way in enabling the expansion and upgrading of facilities and training of staff to promote *ex situ* conservation in the country. Since PNGFA may not achieve all the *ex situ* conservation development programs, it is therefore highly recommended that collaboration with external donor for funding should be pursued.

Chapter 4: The State of Use and Sustainable Management of Forest Genetic Resources

4.1 Introduction

The use of genetically improved planting materials commenced in the country with the introduction of the improved seedlots of exotic species such as the *Tectona grandis, Pinus caribaea, P. strobus, P. oocarpa, P. patula, P.merkusii, Ochroma lagopus, Eucalyptus grandis, E. robusta, E. saligna* and *E. deglupta*. The germplasm (seeds) were collected by researchers from their native habitats and supplied to PNG for research purposes or for plantation development purposes. PNG was also involved in the sharing or supply of indigenous tree species germplasm with other countries. The exchange of germplasm between PNG and overseas partners had made it possible for tree breeding and improvement activities to commence on particular tree species that have been selected. For instance, the first tree seeds collected from the wild stands in the country for breeding studies, plantation programs and supply upon request to overseas partners were *A. cunninghamii, A. hunsteinii, Acacia mangium, Terminalia brassii* and *E. deglupta*. The collection of seeds from these tree species enabled the establishment of seed production areas (SPA) or CSO which provided quality seed sources for reforestation and afforestation programs in the country.

4.2 Seeds transferred internationally

As indicated in **Table 12**, the reproductive plant parts that have been exchanged internationally are from seeds. While the transfers of vegetative parts to international partners have not been progressed to date due to lack of proper facilities to process, store, pack and deliver. Apart from lack of proper facilities, lack of technical skills is also a hinderance to the handling of vegetative materials (e.g. pollens grains) for export. Seeds shared with overseas collaborators or partners were purposely for research or plantation projects.

Table 12. Seeds transferred internationally

Species		**Quantity of seed (kg)**			**No. of vegetative propagules**		**No. of seedlings**		**Purposes**
	Native (N) or Exotic (E)	**Import**	**Export**		**Import**	**Export**	**Import**	**Export**	
Acacia mangium	N	0	370	Australia	0	0	0	0	research
Acacia crassicarpa	N	0	441	Australia	0	0	0	0	research
Araucaria hunsteinii	N	0	2.5	Australia	0	0	0	0	research
Araucaria cunninghamii	N	0	1	Australia	0	0	0	0	research
Intsia bijuga	N	0	1	Australia	0	0	0	0	research
Albizia falcataria	N	0	20	Australia	0	0	0	0	research
Eucalyptus deglupta	N	0	0.9	Australia	0	0	0	0	research
Araucaria hunsteinii	N	0	1	New Zealand	0	0	0	0	research
Araucaria cunninghamii	N	0	1	New Zealand	0	0	0	0	research
Araucaria hunsteinii	N	0	300	Bruneii	0	0	0	0	plantation
Araucaria hunsteinii	N	0	40	Costa Rica	0	0	0	0	plantation
Acacia mangium	N	0	na	Indonesia	0	0	0	0	plantation
Albizia falcataria	N	0	50	Singapore	0	0	0	0	plantation

Acacia mangium	N	0	na	Singapore	0	0	0	0	plantation
Araucaria hunsteinii	N	0	na	Singapore	0	0	0	0	plantation
Eucalyptus deglupta	N	0	2.3	Solomon Island	0	0	0	0	plantation
Araucaria hunsteinii	N	0	na	USA	0	0	0	0	research
Acacia mangium	N	0	na	USA	0	0	0	0	research
Acacia crassicarpa	N	0	na	USA	0	0	0	0	research
Eucalyptus deglupta	N	0	0.2	USA	0	0	0	0	research
Albizia falcataria	N	0	na	USA	0	0	0	0	research
Tectona grandis	E	7	na	China	0	0	0	0	research
Tectona grandis	E	5	na	Costa Rica	0	0	0	0	research
Tectona grandis	E	6	na	Lao	0	0	0	0	research
Tectona grandis	E	4	na	Thailand	0	0	0	0	research

4.3 Forest species presently subject to tree improvement programmes

Over the years PNGFRI has been actively involved in conducting trials and carrying out breeding improvements on plantation species which also include those that have multipurpose uses and those currently being classified as NTFP (**Table 13**). As in the past, most of the current activities are focused on exotic species, such as the *Pinus* spp and teak. Work on species identification as being of multiple uses is concentrated mainly on the native species. In addition, trials are also being continued for the existing plantation species with the purpose of increasing their growths and timber quality (**Table 14**).

Table 13. Forest species presently subject to tree improvement programmes

Species (Scientific names)	Native (N) or exotic (E)	Improvement programme objective				
		Timber	Pulp	Fuelwood (FW)	MP	NTFP
Agathis robusta	N	✓				
Calophyllum euryphyllum	N	✓				✓
Eucalyptus deglupta	N	✓		✓		
Eucalyptus grandis	E	✓		✓		
Eucalyptus pellita	N	✓				
Gyrinops ledermanii	N					✓
Ochroma lagopus	E	✓				
Pinus carribeae	E	✓				
Pinus oocarpa	E	✓				
Pinus patula	E	✓				
Pometia pinnata	N	✓		✓	✓	
Santallum magregorii	N					✓
Tectona grandis	E	✓				

4.4 Tree improvement trials

Tree improvement programme was initiated in the late 1970s with *Araucaria hunsteinii*, *Araucaria cunninghamii*, and *Pinus* species, to name a few (**Table 14).** This improvement program was based on a series of consultancies or collaborative research initiatives to assist, as well as work on progenies, seedling seed orchards (SSOs), seed production areas (SPAs) and 'Plus Trees' selection from plantations and the natural stands. In 1998, a collaborative research on 'PNG's Indigenous Tree Species Domestication Project' between PNGFRI and ACIAR started and eventually improved technical skills, knowledge, germplasm collection, nursery protocols, field statistical designs, establishment, and documentation of *ex situ* conservation trials. This external funded project has proven to be successful as evident from the increased number of improved trials ever since.

Table 14. Tree improvement trials

Species		Plus trees	Provenance trials		Progenies trials		Clonal testing and development			
Scientific name	**Native (N) or exotic**	**Number**	**No. of trials**	**No. of prov.**	**No. of trials**	**No. of families**	**No. of tests**	**No. of clones tested**	**No. of clones selected**	**No. of clones used**
Pinus carribeae	E						4	15		15
Pinus oocarpa	E				2	18				
Pinus patula	E				2	12				
Tectona grandis	E						1			29
Tectona grandis	E				1	18				
Ochroma lagopus	E				3	128				
Eucalyptus grandis	E				1	32				
Agathis robusta	N				4	32				
Eucalyptus deglupta	N						1			18
Eucalyptus deglupta	N				1	18				

4.5 Seed orchards

The first improved seed orchards established were; *Pinius* species, *Araucaria hunsteinii*, *Araucaria cunninghamii*, and *Eucalyptus deglupta* (**Table 15**). Tree improvement work on these species, has to date, have reached two generations (F1and F2). Currently, there are no breeding activities undertaken by FRI to select 'the best clones' (10 clones) to establish generation 2 for the majority of the species. The "best" 10 clones for 3rd generation and 'superior' 10 clones for 4th generation would be used for planting. Seeds supply for planting at present are from the 1st and 2nd generations from the tree improvement seed orchards.

Table 15. Seed orchards

Species (Scientific names)	**Seed orchards**		
	Number	**Generation**	**Area (ha)**
Pinus oocarpa	2	F1	2
Pinus patula	2	F1	2
Tectona grandis	1	F2	0.6
Ochroma lagopus	2	F1	1
Ochroma lagopus	1	F2	1.3
Eucalyptus grandis	1	F1	2
Agathis robusta	1	F1	1
Eucalyptus deglupta	1	F1	0.7

4.6 Types of reproductive materials

The main reproductive plant materials used in PNG are seeds and vegetative parts (e.g. scions, truncheons – see **Figure 5**). The seeds collected are classified into 3 categories based on its germination rates. Category 1 are those with >20% germinabilility, category 2, 30-70%, and category 3, 30% germination rate regardless of where they are sourced from (either from CSO, SSO, or SPA). The use of these improved germplasm in the country is very limited, only used by Forest Authority in its plantation programs. There was very little motivation or no action on the part of the Forest Authority to encourage local communities and farmers to use such improved germplasm. However, this trend is now being addressed through a donor (ACIAR) funded balsa and teak projects in East New Britain Province, which assisted local tree farmers through training and awareness about the importance of improved germplasm and training on the use of such materials for establishing their woodlots or plantations.

Figure 5. Seeds and vegetative materials collected for *ex situ* conservation

Reproductive plant materials from the improved seed stands are seeds or vegetative plant materials which after collection and processed are stored and later exchanged with overseas and local partners. These are also used in reforestation and afforestation projects (**Table 16**).

Table 16. Types of reproductive material available

Species	**Types of material**	**Available for national request**		**Available for international requests**	
		commercial	**research**	**commercial**	**research**
Pinus spp.	seeds and scion	√	√	√	√
Eucalyptus deglupta	seeds and scion	√	√	√	√
Eucalyptus pellita	seeds and scion	√	√	√	√
Tectona grandis	seeds and scion	√	√	√	√
Ochroma lagopus	Seeds	√	√		

Further, there are no community participation in tree breeding programs in PNG, although some of the projects were established on customary land since the late 1980s. The problem encountered under this arrangement was that of having access to germplasm (seeds or vegetative plant materials) due to disagreement with the customary landowners. As a consequence, all SPA, SSO and CSO have to be established on state land. Establishing forest plantations on state land also provides security and accessibility for data and germplasm collection. At present all the seed production stands are established by PNGFA and or in collaboration with donor partners. The ownership of these reproductive materials or germplasm from these CSOs, SPA and SPA is vested with PNGFA.

4.7 Information system for tree breeding improvement projects

All information concerning seed collections from the wild or "plus trees" from plantations, seed processing, storage, germination test, nursery practices and research trial establishments are well documented and stored in a filing system at PNGFRI. It includes silviculture treatments, species, provenance, family, progenies, SSOs, SPAs, CSO and demonstration trials dated back to 1956.

In 2008, PNGFRI with the assistance from CSIRO created a 'Planted Forest Trial Register' enabling all information of the trials to be entered into a registry. All information for new research trials and on-going breeding improvement on existing research trials are updated once field data is made available.

4.8 Commercial use of the genetic resources and management.

The transfer of germplasm (seeds and vegetative materials) is managed by PNGFA. Germplasm (seeds) exchanged between PNGFA and private companies in the country such as Stettin Bay Lumber (SBLC), Open Bay Timbers, and Japan New Guinea Timber (JANT) who used such materials for forest plantation development.

The main tree species used by SBLC for its planations are; *E. deglupta*, *Anthocephalus chinensis, Octomeles sumatrana* and *Acacia magium* purposely for sawn timber production to meet the increasing demands both from local and as well as overseas buyers. JANT has concentrated on the development of *E.deglupta, Terminalia brassii, Anthocephalus chinensis* and *Acacia mangium* for the production of woodchips, while, Open Bay Timbers manages huge acerages of *E. deglupta* for production of sawn timber. Apart from these two companies, the PNGFA is also enaged in establishing plantations to provide timber for existing processing plants. In Madang, PNGFA with the assistance from NZ Aid established plantations of *E. deglupta* and *Acacia mangium* to supply JANT for chip wood production. Moreover, large plantations of Araucarias and pines established at Bulolo and Wau areas of Morobe Province supply raw materials to PNG Forest Products for plywood and veneer, while *E. deglupta* and *Terminalia brassii* were established at Ulabo, Milne Bay Province and *Tectona grandis* in Kuriva, Central Province were also established and managed by PNGFA.

PNGFA also has a number of smaller planations located in both the highlands and lowlands which used tree species adapted for conditions prevalling in those areas. A list of major plantation, the species used, products and locations is provided below (**Table 16a**)

Table 16a. Major plantation species in PNG

Location	altitude	Species	Utilization purposes
Bulolo	High	*Araucaria cunninghamii*	Veneer and Sawn timber
Bulolo	High	*Araucaria hunsteinii*	
Bulolo, Highlands region	High	*Pinus caribaea*	sawn timber, poles and post
Brown River, Kuriva	Low	*Tectona grandis*	sawn timber
Waghi Swamps, Western Highlands	High	*Eucalyptus grandis, E. robusta*	sawn timber, fuelwood
Highlands Region	High	*Pinus* species	sawn timber, rehabilitation of grassland
Madang	Low	*Acacia mangium, E. deglupta*	Woodchips
New Britain	Low	*Tectona grandis, E. deglupta*	sawn timber

4.9 Future improvement on genetic resources and conservation

All SPAs, SSOs, Species trials, and CSOs in the country are managed by PNGFA/PNGFRI. Various management strategies can be applied to improve and conserve the genetic resource such as;

1. Maintenance and expansion of seed storage facilities at NTSC
2. Renovation of Tissue culture laboratory at PNGFRI to propagate tree species that are difficult to collect seeds from in the natural forest
3. Maintain existing arboretum and establish additional arboretums in the country
4. Establishment and conservation of large scale seed production and conservation areas
5. PNGFA to collaborate with private companies, NGOs, and landowners in conservation of FGR's initiatives.

4.9.1 Control pollination

Control pollination technique is a breeding strategy aim at cross-breeding two species through pollen transfer. Early control pollination was carried out on *Araucaria cunninghamii*, *Eucalyptus deglupta*, *E. pellita* and *Pinus merkussii*. Unfortunately, research has not continued due to lack of national expertise and availability of suitable facilities and equipment (e.g. to store pollen gains for future use). In 2005, a cross-pollination experiment facilitated by ACIAR project was conducted between *E. deglupta* and *E. pellita* at PNGFRI. Although, the experiment itself did not succeed, the staff members who took part in implementing the project were able to learn the techniques involved as it was focused on training of PNGFRI staff.

4.9.2 Vegetative propagation (cutting)

Vegetative propagation techniques applied by PNGFRI for further breeding of important species are grafting and cuttings. Grafting techniques includes top cleft, bud grafting and patch grafting. These grafting techniques were employed to establish CSOs in selected part of the country both on state land and customary or private lands. The top cleft grafting covers mostly *Pinus caribaea, P. strobus, P.patula, P.oocarpa* and *P. merkusii* for the establishment of CSOs in PNG. This grafting technique was unsuccessful for *Araucaria cunninghamii, A. hunsteinii,* and *Agathis alba*. Budding technique was used in *Tectona grandis* but failed. Cuttings of *Pometia piñata, Calophyllum eruphyllum,* Eaglewood, Sandalwood, *Dracontomelon dao, Endospermum medullosum, Eucalyptus deglupta, Araucaria cunninghamii, Araucaria hunsteinii, Eucalyptus pellita, Instia bijuga, Endospermum medullosum,* and *Homalium foetidum* were successful.

More leafy stem cutting trials on large scale using the above mentioned species have been planned for the next five years from 2012 -2017 while new species will come on board for trialing. Exotic species included for cutting studies are *P. caribaea, P. merkusii, P.oocarpa, P. patula* and *P. strobus*. There were some successes, which should be trialed on bigger scale for mass propagation for planting stocks. Those species that indicate success in rooting of cuttings will be trialed on experimental plantations in the country.

4.9.3 Centralisation of seed production area for all species

To further foster PNGFA's efforts in producing quality and quantity of seeds of commercial tree species, approximately, 200 ha of state land has been identified for the development of a new and bigger seed production area. One of the sites would be located at the lowlands and the other at the higher altitude. Currently, PNGFA through PNGFRI has only small areas for seed production (seed orchards) and in some cases these areas are too small to be classified as seed orchards, but rather more like woodlots.

It is in such large areas that experiments can be conducted on hybridization, open pollination, phenology (flowering and fruiting), annual seed production per clone and harvest of vegetative plant materials for vegetative propagation for further cloning activities, apart from being only use for seed production.

a. Lowlands

For the lowland site, Open Bay has been identified in 2012 to cater for all selected lowland major plantation species including the potential species identified such as *Pometia pinnata, Eucalyptus pellita, Homalium foetidum, Endospermum medullosum, Anisoptera thurifera, Dracontomelon dao, Calophyllum eruphyllum, Intsia bijuga* and *Eleocarpus* spp. and will be developed and managed by PNGFRI.

b. High altitude

This particular site is located in Bulolo (800 m.a.s.l) to cater for plantation species adopted for high altitude including the potential species such as *Nothofagus perryii, Castononpsis accuminitisima* and the *Magnolia tsiampacca (*Wau Beech).

The FGRs have been sustainably utilized and managed to further improve their quality and increase their quantity to promote planting development programs. Most native species, particularly commercial tree species, have undergone breeding improvements, but majority of them including lesser-known species have not been studied due to lack of resources and support from successive governments over the years.

Chapter 5: The State of National Capacities in Research, Education, Training and Legislation and their Mechanisms for coordination of information for forest genetics resources

5.1 Introduction

This chapter provides an overview of the capacities of the institutions in the country, both government and non-government institutions that are actively undertaking research, education and training programs that are related directly or indirectly to forest genetic resources in PNG. The capability of institutions varies greatly both in terms of infrastructures and resources, which in turns dictates the type and quality of programs offered, hence the needs for interventions are proposed from a national perspective.

5.2 Policy & legislations

The country's forest genetics resources is governed and regulated by the legal frame work of National Forestry Act (1991) and subsequent amendments, the national Forest Policy (1991), Environmental Act (2000), and the Agricultural legislations. The Forest Policy broadly covers all forest resources but requires appropriate management strategies to be undertaken to develop, manage and regulate specific forest resources that are not adequately catered for within the established management procedures.

5.3 National policy on forest genetic resources

PNG does not have a specific policy on forest genetic resources however, it manages its forest genetic resources under various policies and regulations within the Ministries of Forests, Agriculture and Livestock and Environment and conservation. These government agencies have divisions or sections within their organizations that manages, regulate, undertaken research on and develops forest genetic resources and materials.

As mentioned above, PNGFRI manages all plant genetic materials relating to timber productions and NARI manages all plant materials relating to food crops, nuts and other non-woody species. These materials are managed based on the internal procedures and protocols of each institution.

5.4 National capacities in research

The PNG Forest Authority and the Department of Agriculture and Livestock have research Institutions within their organizations which undertake research on forests and agricultural crops for economic development and sustainable utilization. The PNGFA undertake research on tree species improvement and development through the Forest Research Institute (PNGFRI) and the National Agriculture Research Institute (NARI) undertakes research on agricultural crops. These institutions have demonstrations plots and field trials of various forest and crops genetic resources at different locations and sites in the country. These

demonstration plots are used as sources for seed collections and planting materials for distribution to famers. Results and other information obtained from research activities are disseminated to the farmers through community awareness, workshops and community extension programs.

There are other institutions established in the country to undertaken research on specific economic crops such as Cocoa and Coconut, Coffee and spices. These institutions focus on the research, management and dissemination of research results of these specific crops to their farmer groups.

The academic institutions carry out limited research trials however they do utilizes research trials and projects sites that are established by research institutions and agencies. In the forestry, students are taken to the field and shown the procedures and processes for tree species selection from natural populations, plantations and silviculture techniques for management purposes. PNGFA has selected native high-valued species and developed them for large scale plantations. For example in Madang Province, *Eucalyptus deglupta* and *Acacia mangium* are planted on a large scale for wood chip production. The students visit this project area and wood chip processing facility regularly as part of their curricula. Other plantations in country are also visited by the students as part of their curriculum.

Research undertaken at PNGFRI focuses on species improvement for plantations, selection of species for rehabilitation of degraded sites, rare and endangered species and management of low diverse forest areas.

PNGFRI manages and maintained Seed Orchards of selected species including *Eucalyptus deglupta, E. pelita, Acacia mangium, A. crassicarpa, Araucaria hunsteinii, A. cunninghamii and Pinus carebaea* in Bulolo and other sites in the country. Seeds from improved progenies are collected and supplied to the industry for plantation establishment.

Research is also undertaken on the physical and chemical properties of these species and other non-timber forest species.

Similar works have been done in the agriculture sector through the National Agriculture Research Institute, which among other programs, has a specific programs and activities focusing conservation and characterizations of germplasms of agricultural food crops in the country.

5.5 National capacities in education and training

Training in forest and forestry management, and terrestrial biology is provided at the undergraduate level by three universities in the country; the University of Technology (UOT) University of Papua New Guinea (UPNG) and the University of Natural Resources and Environment (UNRE).

The training offered at each institution vary according to the objectives of the training provided, for instance, the training provided at the University of Natural Resources and Environment focus more on agriculture and community livelihoods, the University of Technology focused on forest management and those offered at the University of Papua New Guinea focused more on theoretical and biological processes.

The University of Technology provides most of the training in forestry and forest management through the department of Forestry. The school has two forestry campuses outside the main campus at Taraka; the Bulolo University College which caters for second and third year students and the Timber and Training College which caters for technical and operational courses on downstream processing.

The University of Papua New Guinea provides broad approach training within the discipline of biological sciences. Some of the relevant courses covered includes; Organism diversity, structure & function; Ecological processes; Terrestrial ecosystems & management; Evolutionary processes; Introduction to genetics & evolution; Plant diversity; and Principles & practice of taxonomy. Graduates from this program are working in forestry, horticulture (fruit and vegetable crops), government institutions, industry and non-government organizations' especially in environmental monitoring and biodiversity and conservation projects.

The University of Natural Resources and Environment provides training in agricultural sciences covering plants and animals and has a number of campuses in the country. Graduates from UNRE are employed by the agriculture and other resource industries providing management and technical skills to these sectors.

Table 17. Institutions engaged in field and laboratory work related to FGR for conservation

Name of institution	Type of institution	Activities or programs	Contact information
PNG Forest Authority – Forest Research Institute	government	Permanent Sample Plots Botanical Gardens, Seed Orchards, Species trials, establishments of germplasm, clonal and tissue culture, Seed banks.	Managing Director, P. O. Box 5055, Boroko, National Capital District, PNG. Email: enquiries@pngfa.gov.pg
Department of Environment and Conservation	government	Protected Areas and Wild management Area	Director, Dept. of Environment and Conservation, P. O. Box, 6601, Boroko, National Capital District, PNG
World Wildlife Fund	NGO	Wildlife management Areas	Director, P.O. Box 8280, Boroko, NCD, PNG
New Guinea Binatang Research Centre	NGO	Permanent Research Plot	Director, PO Box 604, Madang, Madang Province, PNG
The Nature Conservancy	NGO	Local Conservation area	The Director, P.O. Box 2750, Boroko, National Capital District, PNG
JANT	Industry	Commercial plantation	The Manager, P.O. Box 714, Madang, Madang Province, PNG
Stettin Bay Lumber Company	Industry	Commercial plantation	The Manger, P.O. Box 182, Kimbe, West New Britain Province, PNG
Open Bay Timber Company	Industry	Commercial plantation	The Manager, P.O. Box 1929, Rabaul, East New Britain Province, PNG

5.6 Institutional capacities

The capacities of the institutions in the country vary depending on their core activities however, most government institutions have well established facilities and resources to support research activities in forest genetic resources than non-government institutions both in terms of research and development and outreach to communities.

5.6.1 Government institutions

The PNGFA-FRI was formerly established in 1989 with core research programs in traditional aspects of forests and forestry. The institute has four research prorams and is supported by a finance and administration team. It has established research plots for major species inventories and undertaken research work on other potential species. The institute has an office complex comprising of a herbarium, botanic garden with nursery facilities, research laboratories, a seed center and research sites in the field. The information and data generated are published in the research bulletin and peer review journals as well as stored in electronic databases. A few of these databases are available locally and online.

The National Agriculture Research Institute is a well-established institution more research sites and up to date research facilities.

5.6.2 Non-government institutions

There are non government institutions in PNG with active research programs in biological research activities. The NGO institutions include New Guinea Binatang Research Center (BRC) and The Nature Conservancy (TNC) based in Madang Province, the PNG Institute of Biological Research (PNGIBR), Wildlife Conservation Society (PNG), Research and Conservation Foundation (RCF) based in Goroka in the Eastern Highlands Province, the World Wilflife Fund (WWF) based in Port Moresby, National Capital District. These institutions carry out research on the diversity of the fauna and flora in the country however not specifically on forest genetic resources.

The BRC have established a 50 ha forest plot in Madang which will be come a permanent research site for the future and some of the issues on conservation of forest genetic resources will be addressed through research works that will be undertaken in this site.

The non-government institutions in PNG focus on community issues and broad environmental issues affecting the local communities. Their research activities are short term and specific to their areas of interests. Some of the non-government institutions do provide training opportunities to young graduates and may offer training opportunities to young people in conservation of forest genetic resources in the future.

The NGOs provide training for local communities to assist in research data gathering and in the process gained some knowledge about conservating forest resources.

Table 18. Needs for developing forest genetic resource legislation

Needs	Level of Priority			
	Not applicable	Low	Medium	High
Improve forest genetic resources legislation				√
Improve reporting requirements				√
Consider sanction for non-compliance			√	
Create forest genetic resources targeted regulations			√	
Enhance cooperation between forest genetic resources national authorities				√
Create a permanent national commission for conservation and management of forest genetic resources			√	
Other (Please specify				

5.7 Interventions

There is a need for increased support and resources to facilitate for a nationwide program on forest genetics resources to involve all stakeholders. The level of basic support available at the national and private institutions varies and will require an assessment to determine needs and requirements.

5.7.1 Government institutions

With the government institutions the most obvious area requiring support are in strengthening capacity for long term research into potential local species. It is estimated that there are over 400 tree species harvested and exported to overseas markets. The price fetched from these species is considered to be below the potential value due to lack of knowledge about the properties of these species.

Tree Breeding and Improvement strategies are in place however needs strengthening and further development to advance on the current selected genotypes. There is a need to increase the number of research plots and in different environmental conditions.

The documentation of record for Management Procedures for Forest Genetics Resources will need to be put in place and maintain to enable future evaluations and analysis of the field trials. Training is required for field officers to enable them to manage these projects.

There is also a need to consider establishing large scale forest genetics reserves or arboretum focusing on economic species and rare species in natural forests,

A number of private companies have developed their own plantations and will require seed from quality sources. Seeds Orchards needs to be maintained to supply quality seeds for these plantations.

5.7.2 Regional and global levels

Where there are species common to countries within a region, it is suggested a regional database on those species be maintained at a regional center and supported by all countries concerned. The level of awareness on forest genetic resources is non existence and only surfaces when a unique species is discovered. Therefore, this level of awareness must be raised to a level where it is generally understood among all stakeholders who are the main users of these resources. **Table 19** below sums up the views on the level of awareness on forest genetics recources in the country.

Table 19. Awareness raising needs

Needs	**Level of Priority**			
	Not applicable	**Low**	**Medium**	**High**
Prepare targeted forest genetic resources information				√
Prepare targeted forest genetic resources communication strategy				√
Improve access to forest genetic resource information				√
Enhance forest genetic resources training and education			√	
Improve understanding of benefits and values of forest genetic resources				√

Chapter 6: The State of Regional and International Collaboration

Papua New Guinea has collaborated with numerous international organizations over the years including FAO and International Timber Trade Organization (ITTO), regional organizations such as CIFOR and Asia-Pacific Association of Forest Research Institutes (APAFRI) and on a sub-regional level with SPC. Collaborations were also enhanced through bilateral aids from Australia through CSIRO and ACIAR, Japan through JICA and New Zealand through its NZAid.

6.1 International networks

Collaboration with FAO in forestry was initiated in PNG in the 1970s through the international provenance trial programs for pines, *Pinus oocarpa* and later, the *Eucalyptus deglupta* which were tested for possible adoption into forest plantation in the country with particular emphases on growth performances. This was followed by trialing of various species of *Leucaena* species with the Department of Agriculture and Livestock (DAL). It uses the species for enhancing soil fertility, fodder and shade for tree crops such as cocoa and coffee and recently for vanilla farming. FAO also assisted with the *Cassuarina* (*C. equisetifolia, C. oligodon* and *C. papuana*) provenance trials.

Collaborations with ITTO was focused on the establishment of teak plantations on degraded areas such as the savanna grasslands and the initiation of permanent sampling plots in logged over areas in 1994 aimed at monitoring forest recovery following forest harvesting – monitoring of regenerating growth performance through time. The data from this project have now become an important driver for intervention approach for determining forest carbon sequestration and storage under the UNFCCC REDD programs.

The Australian centre for International Agriculture Research (ACIAR) collaborations with PNG involved mostly the research activities relating to forests,trees and community involvement. ACIAR collaboration projects include domestication of indigenous species of PNG and germplasm of indigenous species, fuelwood species, teak (*Tectona grandis*) and balsa (*Ochroma lagopus*) projects.

More recently, CIFOR through ACP-EU sponsorship allows funds for a number of forest research projects as well as training conducted through the African, Caribbean and Pacific regions.

Forest mapping, inventory and land utilization were made possible through the collaborative efforts with CSIRO and JICA.

APAFRI, a regional association of Forest Research Institutes in Asia and Pacific was set up purposely for networking amongst the Institutions in the region.

6.2 International collaborative programs in the country

Collaborative programs were initiated with the Australian Scientific Organization, CSIRO started in late 1950s up to the present involved seed collections for different native tree species such as the Acacias or wattles (*A. mangium, A. araucaliformis, A. aulococarpa, A. crassicarpa*), Eucalypts or Kamarere (*E. deglupta, E. pellita*), *Toona sureni* and *Flindersia* sp. which have potential for plantation forestry and farm fruit trees. Extraction of oil from Astrommytes as a potential community project based in Lower Fly District of Western Province was initiated by CSIRO in early 2000 and though supported by the local communities who operated the stilts and earned revenue from the sales of the oil, the project did not last long due to local disputes and by 2006 ceased to exist. CSIRO also established a number of teak and eucalypt species trials at different altitudinal gradients from the lowlands to the highlands.

The Japanese Government through its Technical Aid program to PNG established the PNG Forest Research Institute office complex in 1989. It also assisted the institute through the JICA experts in the establishment of seed orchards for teak (*Tectona grandis*), wattle (*Acacia mangium*), eucalypt (*Eucalyptus deglupta*), hoop (*Araucaria hunstetii*) and klinkii (*A. cunninghamii*) pine seed orchards.

At a regional level, PNGFA has close collaborations with the South Pacific Commission (SPC) through various regional programs sponsored by Australia, New Zealand and some European countries (e.g., SPRIG, GTZ) such as the Domestication of native tree species including Basswood (*Endospermum mollucana*), Rosewood (*Pterocarpus indicus*), Pencil Cedar (*Toona sureni*) and mahagony (*Swetnia macrophylla*), tree propagation, sharing of information and training in relevant areas of forest research, management and marketing of timber products.

Apart from such international collaboration, the PNGFA has also collaborated in both research and training with national and international NGOs such as WWF, The Nature Conservancy (TNC), Wildlife Conservation Society (WCS), New Guinea Binatang Research Centre and national NGOs such as the community based organizations in various locations throughout the country. Most of the local collaborations involved conservation of forest projects, assessments of the distribution of some economic non timber forest products (NTFP) such as agarwood (*Gyrinops* and *Aquilaria* spp), massoy (*Cryptocarya massoy*) and sandalwood (*Santalum macgregorii*).

FAO assisted with agarwood in the assessment and documentation of its distribution throughout the country and inoculation of fungus trials for increased oil production formation in the wood.

The New Zealand Government through its aid agency (NZAID) funded the establishment of the National Tree Seed Centre at Bulolo where all seeds collected from both exotic and indigenous tree species both from natural and plantation (seeds orchards) are processed and stored for sales, exchanges and plantation requirements.

Recently the private sector is coming into the FGR picture. Since 2011 two joint venture companies in collaboration with the PNG Forest Research Institute have invested into a biomass energy project in which they have already established 12 ha of their target 25,000 ha plantation. Currently they are planting *Eucalyptus pellita* and *Acacias* and at the same time

testing other native species for two critical factors; coppiceability of the species and high energy outputs for their gasifiers which they will established in March 2013. Apart from their seed requirements for their plantations, the joint venture companies are also venturing into the establishment of clonal bank for species they are interested in and already they have started work on *E. pelitta* and very soon will start work on other species.

6.3 Needs and priorities for strengthen international networks

PNG is associated with and has benefited well from its collaboration with international organizations in the regional and globally as mentioned above. The status of forest genetic resources, dependency of communities on it and its contributions to sustainability at the local level needs to be fully appreciated by collaborating partners so that future collaborations can be drawn up at the Technical Aid Corporation level. This will provide significant long term benefits to the communities especially with development of infrastructures and provisions of technical experts over a longer period compared to short term projects.

Of the many international institutions that have collaborated with national institutions and agencies PNG over the years, **Table 21** provide a list of some of those that have worked with PNG Forest Authority.

Table 21. Main activities carried through the networks and their outputs

Network Name	Activities*	Genus/Species Involved (scientific names)
ACIAR	Establishment of Native Species for Provenance and Progeny Trials (Species Domestication)	*Pometia Pinnata, Calophyllum europhylum, Dracontomelon dao, Santalum macgregorii, Endospermum medullosum, Elmeralia papuana, Terminalia complenata, Athocephalus chinensis,*
CSIRO	Species trials and Seed Orchards establishment	*Acacia mangium, Acacia auricaliformis, Acacia aulococarpa, Acacia crassicarpa, Eucalyptus deglupta, Ecalyptus pellita, Toona sureni* and *Flindersia* sp.
FAO	Provenance trials and field surveys	*Pinus oocarpa, Eucalytptus deglupta, Leucaena, Casuarina equisetifolia, C. oligodon C. papuana, Gyrinops ledermanii, Aquilaria mollucana*
ITTO	Afforestation in grasslands	*Tectona grandis*
SPC	Domestication of native species	*Endospermum mollucana, Pterocarpus indicus, Toona sureni, Swietenia macrophylla*

JICA	Seed collection, species trials and establishment of seedling seed orchards	*Tectona grandis, Eucalyptus pellita, Pterocarpus indicus, Intsia bijuga, Pometia pinnata, Caralia, Nothofagus peryi, Acaia mangium, Eucalyptus deglupta, Araucaria cunninghamii, Araucaria hunstenii,*
CIFOR	*In situ* conservation of dipterocarps	*Anisopthera thurifera*
NZAID	Provision of infrastructure support	*Establishment of a nataional seed centre storage facility*
SPRIG	Domestication of native species	*Endospermum mollucana, Pterocarpus indicus, Toona sureni, Swietenia macrophylla*
GTZ	Domestication of native species	*Endospermum mollucana, Pterocarpus indicus, Toona sureni, Swetnia macrophylla*

6.4 International programmes

In 2003 the ACIAR provided funding and collaborated with the Forest Research Institute on a project titled "Species Domestication" to evaluate native species with potential for plantation development. The project selected 10 (ten) native tree species from natural populations in different parts of the country and established trial plots in the Morobe Province. The data and information collected from this research were very valuable and useful to our research on species development for the following reasons:

- previous species trials were established for demonstration purposes only,
- the project provided a systematic approach to evaluating and establishing trials which allows for scientific and statistical analysis of the growth data,
- it provided training for staff and enable them to document data from past trials by setting up an register database for the institute for *ex situ* conservation trials and allows for future trials to be properly design, document and store data ,
- the database now allows for data and other relevant information to be easily access, and,
- under the project, staff and other stakeholders including NGO organization were trained and also had opportunities to be trained internally and outside of the country

6.5 International agencies and main results of these programmes.

The ACIAR funded projects include:

1. Species Domestication project - establishment of provenance and progeny trials for native species for future research
2. Tree Germplasm Improvement and Selection - Re-establishment of aged *ex situ* conservation clonal seed orchards (*Eucalpytus deglupta, Tectona grandis*)

3. Tree Germplasm Improvement for Teak in PNG - Collection of vegetative plant materials from plus trees from plantations in the country and this will enable PNGFRI to provide seeds and vegetative materials for establishing larger and better plantation of teak in the country
4. Floriculture - Establishment of horticultural germplasms at the institute

6.6 Financial support to forest genetic resources

Financial support for forest genetic resource projects at the institute were broadly based covering all aspests from species selection to seed collection, seedling seed orchards, progeny trials, clonal seed orchards to seed production areas.

6.7 Needs and priorities for future international collaboration

The state of forest genetic diversity in the country is unknown for many plant groups and there is a greater need for more work to be done to understand, evaluate and develop strategies for utilization of potential species. Whilst effort is being made to conserve forest areas in the country the pressure for other land uses such as logging, agriculture, mining and subsistence farming continues to add pressure on natural forests and therefore more and more species are becoming threaten and on the verge of extinction as a result of loosing their habitat.

This highlights the need of the country to take necessary actions s to develop strategies and manuals for species selection from wild populations and establish them in safer habitats for future research and development. In this regard, international collaborations could achieve this for the benefit of our country and the region.

There are potential species for development for niche markets and the two hardwood species with great potentials are *Pometia pinnata* and *Homalium foetidum*. These species are widely distributed in the lowland forests and can become major tree crops in the future.

Within the institute, the laboratories require upgrading and provision with modern research equipments and supplies. There is a need for more external training for staff especially research and technical staff.

Access to forest genetic materials in the country has been a problem and requires better policing by responsible institutions. The country has been working on a regional Material Transfer Agreement (MTA) however, this has yet to be sign off on by member countries in the region.

The following are needs and priorities of the country for international collaboration in forest genetic resources and these are summarized in **Table 20** below.

1. Documentation, evaluation and identification of major plant groups in the country and conservation of vulnerable species groups and habitats. The expected outcome would be to develop strategies and manuals for species selection from wild populations and establish them in safer habitats for future research and development.

2. Identification of potential niche markets for native species of high value will increase the conservation status of such species hence there is a need for such research. Such research should focus on the development of selected hardwood species with great potentials such as *Pometia pinnata* and *Homalium foetidum* which are widely distributed in the lowland forests and can become major tree crops in the future.

3. Technical training in the area of species conservation and development is lacking and needs to be incorporated into collaborative program activities.

Table 20. Needs for international collaboration and networking

Needs	Level of Priority			
	Not applicable	**Low**	**Medium**	**High**
Understanding the state of diversity.				√
Enhancing in situ conservation and management			√	
Enhancing *ex situ* conservation and management				√
Enhancing use of forest genetic resources			√	
Enhancing research				√
Enhancing education and training			√	
Enhancing legislation				√
Enhancing information management and early warning systems for forest genetic resources,			√	
Enhancing public awareness			√	
Any other priorities for				

6.8 International agreements

Papua New Guinea has adapted a number of international agreements both at the regional and global level. The impact of such agreements, treaties and conventions on sustainable uses of forest genetic resources various depending on the local uses and utilization. In the last two years, the export of forest products generated from *Gyrinops ledermanii* and exported to overseas markets was banned due to its listing on Appendix II of CITES, and this ban was only lifted after a management plan was developed to manage harvesting of trees from wild populations.

Chapter 7: Access to Forest Genetic Resources and Sharing of Benefits arising from their Use

7.1 Introduction

The distribution of forest tree germplasm plays an important role in the development and conservation of productive forestry sector in many countries, especially those dependent on exotic tree species. PNG, through its National Tree Seed Centre (NTSC) situated in Bulolo, Lae, Morobe Province, supply adequate seeds of both indigenous and exotic tree species domestically, regionally and/or internationally upon request. Many indigenous and exotic tree genera and species in PNG are economically important in the Oceania region as well as to Southeast Asian countries. Given the diverse indigenous tree species and their various end uses, timber trees and non-timber forest product (NTFP) species warranted for further improvement studies and may drive the desire from researchers from neighbouring countries to access the germplasm. Examples of these tree species are elaborated on below:

7.2 Indigenous species:

- Kamarere (*Eucalyptus deglupta*) is a major timber tree of lowland rainforests and highly demanded for its germplasm.

- Eucalypts (*Eucalyptus* spp.) are commercial timber tree species of lowland rainforests in PNG.

- Acacia (*Acacia* spp.) are native to southern parts of PNG, Australia and neighbouring Indonesia and some Pacific island nations (Midgley et al. 2003). *Acacia* spp. have been domesticated for a variety of uses including paper pulp, fuelwood, tannin, animal forage and land rehabilitation projects.

- Klinkii pine (*Araucaria hunsteinii*) and Hoop pine (*Araucaria cunninghamii*) are a commercial timber trees as well as plywood manufacturing which supply domestic markets and overseas markets in New Zealand and Australia.

- Eaglewood (*Gyrinops* and *Aquilaria* spp.) is probably the world's most valuable NTFP in the island of New Guinea including PNG, Indonesia, Malaysia, Thailand, Bangladesh, Vietnam and India. Known for centuries for its fragrance which is used in perfumery industries, religious ceremonies and medicines.

- Sandalwood (*Santalum macgregorii*) is native to PNG, while other species are found in other Pacific Island nations (notably, Vanuatu, Fiji) and Australia. Share a similar uses and status as Eaglewood, a NTFP which is known for its fragrance.

7.3 Exotic species:

- Teak (*Tectona grandis*) is a major timber tree in PNG and important for plantations in their native countries like India, Myanmar, Thailand, Indonesia and Burma.

- Pinus (*Pinus* spp.) are high value-timber trees in PNG and are well established in the Highlands Provinces of PNG. The trees are harvested for plywood, poles use in building constructions and for electricity poles in rural areas of the country.

In PNG, forest genetics materials, mainly forest tree germplasm began to leave PNG's shores in late 1970's through donor-support programme agreements. The seed collection expeditions involved researchers under the donor-support projects and personnel from local authorities. Access to tree germplasm at a customary landowner level is normally through verbal agreements reached following discussions with the owners without signing of any written agreements or exchanges of genetic resources between government agencies without irregularities being raised for unscrupulous practices involved in the exploitation of materials for commercial purposes (Whimp and Busse 2000). In recent times, political and public demand increases to regulate the movement of all kinds of genetic materials. This is vital for protecting the national assets, promoting conservation and plant improvement programs via breeding studies.

PNG is a party to a number of important international agreements relating to plant genetic resources in general and the mechanisms developed pertaining to their material exchanges. Like other countries, PNG also has experienced examples of issues encountered in exchange of native forest genetics resources (FGRs). Presented below are briefs about such international agreements that PNG has signed and committed to implement their requirements.

7.4 International agreements

PNG is a member and signatory to various international agreements for protection, conservation, management of fauna and flora, and exchange of FGRs. These agreements, protocols, regulartory mechanisms and standards have been developed and agreed upon have significance impacts on forest reproductive materials and how they are used in both their origins and foreign countries.

7.4.1 Convention on Biological Diversity (CBD)

PNG became a signatory to CBD in 1992 and in February 2001 it ratified it, thus being recognised as a member of the CBD. The major objectives of the CBD are for the conservation of biodiversity, the sustainable use of genetic resources and the fair and equitable sharing of benefits derived from their uses. It also includes access to genetic resources and transfer of appropriate technologies and funding. The practical implications of such access and benefits sharing are subjected to continuing dialogue and work programmes among nations to agree on a workable mechanism to enable them to share and benefits from their respective genetic resources in a sustainable manner.

7.4.2 International undertakings on plant genetic resources

IU was the first international agreement to deal with plant genetic resources. It was adopted at the 1983 FAO Conference as an instrument to promote international cooperation in issues associated with accessing plant genetic resources, including forest and tree genetic resources. This agreement is currently being revised so that it can be consistent with CBD as there has been inequity in the sharing of benefits from the exchange, use and development of plant genetic resources (Bragdon 2000). The Pacific Sub-regional Plan of Action for Conservation and Management of Forest Genetic Resources under this agreement was endorsed by the Pacific Heads of Forestry in May 2000 (Anon 2000). This "Strategies and Action Plan for the Conservation, Management and Sustainable Use of Forest and Tree Genetic Resources in the Pacific Island Countries and Territories (PICTs, 2007-2015) was formally drafted and endorsed by Pacific Heads of Agriculture and Forestry Services and approved by Ministers of Agriculture and Forestry at their regional meeting in Apia, Samoa in September 2008. The Action Plan presently serves as a framework for planning and implementing the conservation, management and sustainable use of forest and tree genetic resources within the PICTs. One of the major recommendations in the Action Plan is for the establishment of a regional tree seed centre now being established by SPC to facilitate the exchange of tree germplasm among PICTs. In 2010, a workshop was organised in direct response to the recommendation of the 2009 Heads of Forestry Meeting 'that PICTs contribute and participate in the process of developing the " State of the World's Forest Genetic Resources Report" to be presented to the fourteenth session of the FAO Commission on Genetic Resources for Food and Agriculture in 2013. This country report basically is part of PNG's commitment to this recommendation.

7.4.3 Intellectual property, the World Trade Organisation and the TRIPs agreement

Intellectual property rights (IPR) is a legal recognition bestowed on inventors to prevent others from applying their inventions, designs or other formulations of any plant genetic resource for a specific time. The World Trade Organisation (WTO) oversees trade issues and the signing of agreement on intellectual property. WTO agreement on Trade-Related Aspects of Intellectual Property Right (TRIPS) is legal binding in recognition of national property rights systems, and so considering them under international rules. Three Pacific Island nations; Papua New Guinea, Fiji and Solomon Islands are members of the WTO and are bound by the provisions of TRIPS. In the addition, PNG has as of 2003 or so established a National Intellectual Property Office (IPPNG) under the Investment Promotion Authority (IPA).

7.4.4 Plant varietal rights

This aspect of CBD on IP on plant variety rights has yet to be developed and of which the IP-PNG office and the Departments of Agriculture & Livestock and Environment and Conservation together with the National Agriculture Research Institute are currently addressing.

The TRIPS agreement requires WTO members to provide protection of plant varieties. These plant varieties are achieved through plant breeding efforts, and their diversity are protected including the rights and interest of local communities responsible for promoting and maintaining diversity. Developing countries in the Asia-Pacific region have developed their own systems of protection to comply with the provisions of TRIPS as well as trying to to meet their obligations under the CBD.

7.4.5 Access benefit sharing and international law

Access benefit sharing (ABS) is an important concept that has to be implemented by Pacific Island nations. It is a process and involves the usage of many different concepts that will assist in policy formulation concerning the plant diversity. In 2004, PNG Institute of Biodiversity (PINBio) introduced the first report on ABS by Dr. Kwa, the 'Kwa Report' or 'document'. The report provides comprehensive details of current conventions, acts, procedures, institutions, etc, that are dealing with specific areas of ABS and biodiversity. The report provides recommendations, invaluable information about some general and specific laws and acts that have implications to biodiversity and related-areas or specific issues and challenges that PNG has to address. The report also outline a possible 'Biodiversity Law and Policy in PNG' that would be useful for developing the ABS framework. (Review on PNG's FGRs, 2006).

Globally, attempts have been made to have access to biological materials, knowledge and skills to improve the living conditions of disadvantaged communities who are also the traditional owners of the genetic resources owners. This has resulted in the formulation and adoption of CBD in 1992. ABS has been defined in certain significant international treaties, including the following; (i) United Nations Convention on the Law of the Sea (UNCLOS); (ii) International Treaty on Plant Genetic Resources for Food and Agriculture (ITGFA); (iii) Agreement on Trade Related Aspects of Intellectual Property Rights (TRIPS). The considerations of the provisions under these international agreements are essential as they relate to ABS and therefore have bearing on the national ABS regulatory framework.

7.5 Policies on aspects of biodiversity

Although currently there is no specific national policy or law on biodiversity, the fourth goal of the National Constitution clearly state that;

> *"We declare out fourth goal to be Papua New Guinea's natural resources and environment to be conserved and used for the collective benefit of us all, and be replenished for the benefit of future generations*".

and which is further enforced under the five key principles of the environment policy for the;

1. Development must be economical, social and ecological;
2. Wise use of non-renewable resources;
3. Recognition of the ability of the environment to produce renewable resources;
4. Safeguard and wise management of wildlife and their habitat in the development process; and
5. Planning to be applied to human settlement and urbanization.

However, these five principles do not include any provision that address the issues relating to sharing of benefits arising from the exploitation of biodiversity, in particular the FGRs. In addition, the 1991 Forest Policy also does not provide clear directives for accessing forest and tree genetic resources and benefit sharing associated to their uses. The draft of Eco-forestry policy in 2003 also does not clarify issues (Review on PNG's FGRs, 2006).

7.6 Policies on ABS

Issues relating to ABS has been separated in general discussion on biodiversity due to its complexity. ABS involves issues of accessing, obtaining prior Informed Consent (PIC) resource owners, benefits sharing and also the IPR. In 2005, a draft Biosafety and Biotechnology policy was formulated. The policy was formulated to protect resource owners whose biological resources will be accessed for scientific research and for development of genetically modified organisms which have the potential to be commercialized. This policy would enable access to the country's biological resources and the fair and equitable distribution of benefits arising from the sustainable use of these resources (Review on PNG's FGRs, 2006).

7.7 National Tree Seed Centre

The NTSC is one of the research components under the Planted Forest Programme at PNG Forest Research Institute (PNGFRI). NTSC plays a vital role in the seed collection, seed processing, testing, storage, distribution and exchange of FGRs, especially tree germplasm. It performs seed collection of plantation tree species such as Klinkii pine (*Araucaria hunsteinii*), Hope pine (*Araucaria cunninghamii*), Teak (*Tectona grandis*) and Kamarere (*Eucalyptus deglupta*) including Acacias (*Acaccia* spp.), Taun (*Pometia pinnata*), Kwila (*Intsia bijugua*) and Rosewood (*Pterocarpus indicus*) as well as other native and exotic tree species.

PNG has over the years contributed significantly in the export of tree germplasm. Since 2003, the NTSC supplied well over 800 kilograms of tree seeds to overseas clients and generated PNGK917, 755.20 (source, NTSC). This excludes the amount earn annually from the sale of indigenous or exotic seeds sold to the private companies, individuals and landowners through illegal practices without proper monitoring and records reaching PNGFA.

7.8 Seed sources

PNGFA through PNGFRI has established a number of clonal seed orchards (CSOs) of important tree species such as *Pinus caribeae*, *Eucalyptus deglupta*, *Acacia araucaliformis*, *A. crassicarpa*, *Araucaria cunninghamii*, *Araucaria hunsteinii*, and *Tectona grandis* and Seed Production Areas (SPAs) for *Tectona grandis* and *Acacia mangium* among other tree species. Some seedlots used in these CSOs were sourced from overseas, mostly exotics, for instance, plant materials of Teak (*Tectona grandis*) from Thailand and India.

Quality seeds are collected during each seeding season by PNGFRI's NTSC from these CSOs and SPAs to distribute upon request to National Forest Service (NFS) in each 20 provinces in

the country for reforestation and reafforestation programs. However, over the years NFS through its tree plantation programs identify and select their candidate seed trees to harvest seeds from to supplement those received from PNGFRI's NTSC. Seeds are also sold or supply to private companies engage in growing sustainable tree species of economical importance such as Balsa and *Acacia mangium*, the two sustainable tree crops for over 15 years.

7.9 Access to indigenous tree germplasm from the natural forests.

PNG has a very complex system of ownership of the forest and tree genetic resources. Whatever plant species including tree species are owned by the traditional owners and has to be acquired by the state. The procedures involved the national government through the PNGFA and channelled through the National Forest Services (NFS) in each province, local level governments, incorporated land groups (ILGs) (landowners), and individual clan members. The State holds property rights only over state owned tree plantations established on state owned lands and on land areas that have been acquired such as those for national parks and other state own conservation areas.

For any access to native flora in PNG advice has to be sought from NFS office in that particular province or provincial forestry office to liaise and negotitate with landowners for entry into landowner's forests or for gaining access to native forest genetic resources. The ownership of the FGRs in PNG has not been changed in the past and therefore will continue for unforseen future. However, the FGRs owners are keen in participating in any research or sharing of germplasm if proper awareness or explanation is provided aimed at educating the people on the aims and the importance of seed collection expeditions into the forests and the potential benefits that the owners can gain in the case of further research and development (concerning the comercialisation of FGRs, in particular the tree germplasm).

For PNGFRI to plan for seed collections expeditions, the institute through the NTSC has to liaise with NFS. The NFS through its established contacts can negotiate with the resource owners to access the tree germplasm materials. The payment for collecting the tree germpalsm is required to ensure there is common understanding and harmony among the two parties. It is a token of appreciation in using or having access to the FGRs on a customary land and in turn facilitate for future collections of tree germplasm in the area.

7.10 Materials Transfer Agreements (MTAs)

To date, there is no formal mechanism formulated to ensure that PNG via PNGFA would gain access to information on the performance of these genetic resources once they are planted, and subsequent generation of germplasm which had undergone certain tree improvement programs which have been undertaken by the recipient(s). Since 1987, PNG via PNG NTSC has been using only the seed consignment document for the export of PNG native tree seed. This is an issue not seriously taken into account in the last 25 years and PNGFA needs to address it by formulating a MTA to accompany all consignments of PNG native tree seed exported to overseas clients, or exchange under a donor-support programme agreement. In addition, a comprehensive MTA should be developed if exchange of FGRs involves vegetative plant materials such as pollen, shoots, or plant tissues for *in vitro* propagation in a foreign country. However, steps have been taken to formulate and

implement MTA this year (2012), first with the South Pacific Commision through its Regional Seed Centre and also with a local company: Ramu Agro-Industries Limited.

7.11 Seed exchanged under a donor-support programmes

There are several examples of native tree seeds exported under the donor-support programme agreements between PNGFA and a number of overseas clients dating back to the late 1970's. These include seed collection expeditions carried out by Australian Tree Seed Centre (ATSC, part of CSIRO's Division of Forestry) in collaboration with local authorities in PNG. Seeds of *Eucalyptus pellita* and Acacias (*Acacia* spp.) were collected during these seed collection expeditions from late 1970's to 1980's mainly in Western Province, PNG (Vercoe and McDonald 1990). In addition, *Acacia mangium* seed collections for international provenance trials were coordinated by CSIRO and FAO in the early 1980s (Doran and Skeleton 1982). It was reported that after the analysis of *Acacia mangium* provenance variation among the seedlots collected, two provenances from PNG were consistently the best performers in terms of growth traits (Hardwood and Williams 1991). However, the issue that PNG has not resolved is that of accessing information and/or improved germplasm of *A. mangium* from CSIRO. This may be due to the fact that there was no legal binding agreement signed by PNGFA and CSIRO to facilitate for access to germplasm pertaining to sharing of its benefits after years of undergoing tree improvement treatments overseas. Further, this may also be due to the arrangements under a donor-support programme agreement between PNGFA and CSIRO. There was also no MTA agreement between PNGFA and CSIRO as there was none in existence that has been developed by PNGFA.

7.12 Obstacles arising from accessing and sharing of FGRs

For the last 25 years there are no mechanisms that have been formulated for accessing information or genetic material once planted and progress through stages of tree breeding improvements by the recipient(s) in neighbouring Pacific Island nations or other countries in the world. PNG government through the PNGFA has to develop policies, legislations or regulatory quality standards to benefit the exporter (origin of native genetic resources) and the recipient client in sharing benefits arising out of the use of forest genetic resources, in particular, tree germplasm.

In overcoming these setbacks, the Forest Policy and Planning as well as PNGFRI Directorates of PNGFA have to formulate policies associate to exchange and benefit sharing arising from improvement of FGRs between PNG and overseas clients. This has to involve large-scale consultation involving various government organisations, private tree germplasm dealers, companies, NGOs, and landowner organisations prior to developing a comprehensive regulations or mechanisms to accommodate the issue relating to benefit-sharing of tree germplasm of both exotic and native trees.

Chapter 8: The Contribution of Forest Genetic Resources to Food Security, poverty Alleviation and sustainable Development

8.1 Introduction

The utilization of plant resources is a cultural heritage of the people in Papua New Guinea and the rural communities lived off the land and forests. Forest resources in local forest areas are closely guarded and protected by communities because they depend on them for hunting for their protein and collect materials to build their shelters, canoes, food, medicine and other necessities.

The diversity of forest plant resources used by people varies from area to area depending on the physical nature of their surroundings and on the types of plants available in their communities. Some plant species are widely distributed and their uses are similar in most communities, while in other areas, the plant species they used may be very localised. Plant uses in communities have been documented for a number of communities however, such documentations are limited to specific disciplines such agriculture, medicines or anthropological studies.

The plants resources used by local communities contribute directly and indirectly to food security, poverty alleviation and sustainable development. The plant species covered in this chapter exclude those tree species being harvested by logging companies and exported either as round logs or sawn timber.

8.2 Contribution of forest genetic resources to food security

Forest genetic resources provide a source of food, medicine and building materials for the rural communities. The forest plants provide essential food minerals and vitamins for a balanced diet and good health. Fruit tree species such as *Terminalia kaenbarkii* (okari nuts), *Canarium indicum, Barringtonia edulis*, and *Pometia pinnata* are sources of healthy protein, whilst *Metroxylon sagu* is a major source of carbohydrate (Kambuou, 1995). Some of these tree species are also harvested for timber such those just highlighted above. There is potential for sustainable and dual production of such species, but research and application of agroforestry approaches have only just begun and the full potential is yet to be realised. As efforts continue, effective forestry and environmental policies that incorporate issues on land ownership are also needed for sustainable forest management.

Some species are harvested and sold for export to overseas market such as eaglewood and sandalwood. In the recent times, the barks of massoy trees have been harvested from natural forests and exported overseas.Estimating the contributions of minor forest products to communities would be difficult due to lack of broad-based information systems for tracking the combined value of the many products that make up the various non-timber forest products industries. While high valued species fetch more values, their benefits are shared to fewer members compared to the diverse NTFPs which are harvested and sold by more people amongst the various communities throughout the country. Their economic and cultural values

when considered in aggregate, makes management for NTFPs an important component of sustainable forest management and the conservation of biological and cultural diversity.

Other forest products found in the forests include gums, seeds, essential oils, tannins, nuts, vegetables, fruits and mushrooms (Papua New Guinea Forest Studies 1, Overseas Development Institute). **Table 22** provides a checklist of forest genetic resource species used by local communities.

Table 22. Forest genetic resources used for food security and sold to generate income

Scientific Name	Common Name	Indigenous (I) or Introduced (E)	Parts of plants used for food	Product sold for Income
Annona muricata	Soursop	E	Fruits	Fruit, Foliage
Annona reticulate	Castard apple	E	Fruits	Fruits
Areca catechu	Beetle nut	I		Fruits
Arenga microcarpa	Limbun	i		Slabs
Artocarpus altilis	Breadfruit	I	Fruits, Seeds	Fruits, Seeds
Baccaurea papuana	Mabewa	I	Fruits	Fruits
Bambusa spp	Bamboo	I	Young shoots	Stems
Calamus sp	Rattan	I	Rattan	Rattan
Calava	Clover	E	Foliage	Foliage
Canarium indicum	Galip	I	Nuts	Nuts, Timber
Cinnamomum	Cinamon	I	Bark	Bark
Citrus limon	Lemon	I	Fruits	Fruts, Foliage
Cocoa nucifera	Coconut	I	Nuts	Nuts, Juice, Timber, Fronds,
Coffea arabica	Coffee	E	Roasted beans	Beans
Dracontomelon dao	Mon	I	Fruits	Fruits, Timber
Ficus copiosa	Fig	I	Fruits	Fruits
Ficus damaropsis	Fig	I	Young leaves	Young leaves
Ficus wassa,	Fig	I	Fruits, Young leaves	Fruits, Young leaves
Garcinia mangostana	Mangosteen	E	Fruits	Fruits

Gluta papuana	Hekakaro	I	Fruits	Fruits & Resin
Gnetum gnemon	Tulip	I	Fruits & Foliage	Fruits & Foliage
Inocarpus fagifer	Chestnut	I	Seeds	Seeds, Timber
Lentinusedodes & other mushroom spp.	Mushroom	I	Fruiting Body	Fruit body
Macadamia integrifolia	Macadamia nut	E	Nuts	Nuts
Mangifera minor	Mango	I	Fruits	Fruits
Mangifera odoratum	Mango	I	Fruits	Fruits
Metroxylon sagu	Sago	I	Starch	Starch, Fronds
Myristica fragrance	Nutmeg	E	Spice	Nuts
Nephelium lappaceum	Rhambutan	E	Fruits	Fruits
Nephelium mutabie	Pulasan	E	Fruits	Fruits
Pandanus spp.	Marita, Karuka	I	Fruits	Fruits, Leaves
Pangium edulis	Paluk	I	Seeds	Seeds & Timber
Piper methysticum	Kava	I	Roots	Roots, Foliage,
Piper nigrum	Black pepper	E	Seeds	Seeds
Pometia pinnata	Taun	I	Fruits	Fruits, Timber
Spondias dulcis	Jungle fruit	I	Fruits	Fruits, Timber
Sygygium buetnerianum	Watergum	I	Fruits	Fruits, Timber
Terminalia kaernbachii	Talis	I	Seeds	Seeds, Timber, Tannins
Theobroma cacao	Cocoa	E		Seeds

8.3 Contribution of forest genetic resources towards poverty alleviation through utilization

The Forest Genetic Resources contribute significantly to both food security and poverty alleviation to rural communities, although data is lacking to evaluate their impact on the living standards of the communities. The contribution from each product varies depending on resource management, stock abundance and market demands.

However, experience has shown that where market demands are high for a specific commodity, the harvesting of that commodity also increases and often, uncontrolable. The recent media release of unscrupulous cutting of *Cryptocarya massoy* for bark extraction is

one example. This prompted the PNG Forest Authority to put notice in the two daily papers to halt the harvest of this species and for Forest Industry Participants who has stored stocks in their possession to sell off. Another example is *Gyrinops ledermanii* (Eaglewood) which was over harvested and therefore was placed under CITES as an endangered species and harvesting is banned.

Sustainable management of forest tree species through conservation will allow for research on beneficial characteristics, especially for those species showing potential as sources of food and medicine as well as timber. Promotion of such species through awareness and managed production particularly at the localized small-scale will help contribute towards income generation to help alleviate poverty at the smallholder farmer level.

Endemic forest species such as galip (*Canarium indicum*.) and taun (*Pometia pinnata*) provide nuts and fruit for income generation and can be harvested in the long term for building materials or revenue.

The emerging galip industry in East New Britain Province is an example where mixed cropping stands of galip and cocoa are proving to be successful. Spice trees (Cinnamon), perfume wood (eagle wood) and ebony are some species that also have the potential as alternative cash crops or sources for income generation. Research into grafting and multiplication of such species and/or varieties is needed.

8.4 Priorities in developing forest resources to sustaining poverty in communities

The benefits from extractive non-renewable resource projects in rural communities do not benefit the vast majority within the vicinity of these projects. The increasing population adds additional pressure on the distribution of financial benefits (Poesi and Damba, 2000). Constrained livelihood with low income generation opportunities threatens sustainable community development. The agriculture industry may currently be the main sector for employment and income generation, but an enhanced and sustainable forest industry can help contribute toward improving the daily livelihoods of the majority of the population (Jeffery, 2012).

Research and development components are needed to educate communities through awareness on sustainable forest management and development, which can deliver income generating alternatives for the smallholder farmers (Jeffery, 2012). Subsequently, the approach may have a negative influence on the dependency for large-scale commercial logging.

The environment influences and in particular, climate or weather patterns in an area of concern as it does have an impact on some commercial timber species. Deforestation and forest degradation and thus the alteration of the environment without heed of the natural topography or geography can be detrimental to the community when extreme weather conditions occur and there is a need to undertake species specific research to address such concerns.

8.5 Institutional capacity

Current government institutions working on improving the forest genetic resources for the local communities include the PNG Forest Authority, the Department of Agriculture at the national level and the provincial division offices of the Provincial Governments. These offices often lack resources to effectively implement their responsibilities such as delivering tree seedlings to the farmers.

8.6 Interventions

Harvesting of non timber forest species from natural populations is a cultural way of life for most of the rural communities and unfortunately, some species have been over harvested in their range. The few species that have been over harvested in the last 10 years include *Aquilaria filarial* and *Gyrinops ledermanii*. These are eaglewood species only occur in some parts of the country. A management plan was developed to manage this species in the wild and this will require a lot of resources to establish, especially the monitoring plots and baseline for each of the producing areas.

A national management plan is also required for other NTFP species that are harvested in the wild for economic and cultural needs.

8.7 Long term management strategies for minor forest products

As concerns continued to increase about potential ecological impacts arising from NTFP harvesting and that the market demands for some of these products become more apparent, urgent appropriate management strategies must be put in place and should should include:

- establishing and securing fair market value for the Forest genetic resource collected to ensure fair compensation to the State
- provision for an adequate mechanism oversight and management of harvest techniques or harvest impacts on various NTFP
- provision for sufficient information, documentation, and categorization of collector in order to facilitate understanding, networking, information exchange and involving various collector and corresponding harvest impacts
- address potential for collection of rare or endangered species that are subspecies or closely related species of certain NTFPs

The sustainable management of individual species of NTFPs must become more specific to individual species over time and should involve:

- categorization and stratification of NTFP on the basis of ecological importance (and/or risk) and market demand coupled with the population inventories, identification of collectors and establishing current harvest rates; and,
- the development of management guidelines, procedures, and regulatory and monitoring processes on a species by species basis.

8.8 Regional and global levels

On the regional front, there is a need for member countries to assist each other in improving the development of *Santalum album* and *Santalum yasi* as these species have the potential to contribute to poverty alleviation in a significant way.

Chapter 9: The Challenges to the Future of National Forest Genetic Forest Genetic Resources

9.1 Introduction

In this chapter a number of challenges are raised and discussed ranging from the impacts of climate change and threats resulting from the country's rapid economic development through extractions of natural resources and the potential future demands on the forest land and resources that will be exerted by the rapidly growing population growth.

The impacts of changing climatic conditions are becoming more and more evident, especially on most vulnerable areas such as the low-lying coastal areas, small islands, along major river systems and in the highlands where most populations live and also where major forest types are found. With increasing temperatures and rainfall together with the unpredictable climatic conditions that affects the timing of food crop harvesting and plantings, communities are experiencing failures in crop yields and thus the sustainability of their livelihoods.

Papua New Guinea's rapid economic development in particular the developments of forest, mineral, oil and gas resources together with the associated infrastructure as well as the increasing population and its demands on land for food, cash crops and health and education has greatly impacted on the availability of arable land and the forests that occupy them. In addition, the push for the establishment of more forest plantations as envisaged in the Vision 2050 meant that a number of native species that are currently not being domesticated or if already domesticated, have yet to be farmed on a large scale. The exotic tree species which at present are few, are being used in large scale forestry plantations, such as the pines (Pinus species) and the Australian eucalypts which might be expanded in the future, especially in the highlands and Bulolo areas.

In the process of extracting the minerals, oil and gas, the establishment of roads, bridges, settlements, shifting and large scale commercial agriculture and other infrastructure and harvesting of commercial forest trees and development of large scale forest plantations, forests and tree populations will be affected through destruction and isolation, thus reducing the populations to survive or if they survive would have limited capacity to persist within the natural environment.

9.2 Climate change and its impacts on forests and forest genetic resources

Climate change is real and its impacts on terrestrial ecosystems are becoming more and more evident, especially with the increasing surface and air temperatures, changes in the distribution and intensity of rainfall, alteration of hydrological regimes, changes in wind patterns and intensity, altering of fire frequencies and intensities, flooding and erosion regimes and in the changes of the frequency and intensity of extreme weather events. It is anticipated that surface temperatures are to increase by 2 – 4oC (IPCC, 2007), while decreases in precipitation will likely lead to a significant reduction of rainfall and that there will be increases in the frequencies and intensities of extreme climatic events (e.g. El Nino and La Nina). Thus, the consequences such incidences of extreme climate could result in

droughts, fires, invasive weeds, insect and pathogens, flooding, landslips and erosions on terrestrial systems and sea level rise along the coast.

Further, the physical changes in terrestrial ecosystems resulting from climatic changes would involve the distribution of microclimates, appearances of novel microclimates and disappearance of certain microclimates, timing, distribution and availability of pollinators, dispersers, etc., habitat distribution and losses of certain habitat types.

In response to such climatic impacts, tree species and forest communities may adopt a number of mechanisms to cope with the impacts by changing their phenology, physiology or behavior, evolve, migrate or even becoming extinction. In the past, most species have responded to such changing climates by migrating to new areas and evolved over a longer period of time coinciding with suitable climates. However, the current rate of climatic change appears to be faster than the species' ability to evolve or migrate. Further, the changes in species composition would also alter interactions among different species in regard to the following interactions: predator – prey relations, changes in inter-species competition and changes in host-plant relationships. Creation of new habitats or extinction of species on habitats which are no longer conducive for them to occupy may result in the invasion and spread of invasive species to occupy new niches that have been developed as a consequence of such changes.

In addition, human induced changes to tree genetics such as through selections and breeding that select certain required traits for promotion of growth and form will render such trees, especially those used in plantations become isolated and more vulnerable to the impacts of climate change.

Further, isolation of tree populations from development activities and from natural isolation through geographical barriers and/or to the nature of their population distributions also renders such population to become vulnerable to the dramatic changes to climatic conditions.

This paper describes these challenges that need to be considered in the application of traditional forestry practices through the applications of some of the suggested mitigative and adaptive measures to minimize the impacts of climate change.

9.3 Impacts on forest physical environment

The impacts of climate change on the physical environment of the forest ecosystems will include the following:

- Increase surface and air temperatures which will affect the soil texture and moisture, the rate of evapo-transpiration and the metabolic activities of insects and pathogens as well as creating a more arid environment conducive to drought and forest fire.

- Changes in the distribution and intensity of rainfall will alter the distribution of species and forest ecosystems, erosion, flooding and landslips. The decreases in precipitation and patterns coupled with increasing temperatures and occurrences of extreme climate conditions such as El Nino and La Nina will promote incidences of droughts and fires and in turn affect the follow up effects (which may be direct or

indirect) on the incidences of pests and diseases and invasions of altered habitats by invasives and/or extinction of species not adaptable to such climatic changes.

- Altering hydrological regimes as dictated by rainfall patterns and intensities
- Changes in wind patterns and intensity will affect leaf moisture balance and on exposed soils, the soil moisture.
- Alter fire, flooding and erosion regimes
- Changes in frequency and intensity of extreme weather events

Such physical impacts arising from changing climatic conditions would in turn alter the distribution of forest microclimates, appearances of novel forest microclimates as well as the disappearance of certain microclimates, the timing, distribution and availability of pollinators, dispersers, etc., habitat distribution and possible loss of certain forest habitat types.

9.4 Species most vulnerable to the impacts of climate change

The responses of species and ecosystem to the impacts of climate change may involve the following four potential responses:

- Acclimation to new environmental conditions
- Adapted changes to their phenological and physiological behavior
- Evolve, but over a relatively short may find it too difficult and eventually become extinct
- Migration – they may involve the species adapting some mechanism to assist them to escape into other area through some dispersal mechanism such as having winged seeds or the dispersal agents adopting some means of dispersing the seeds/fruits in distant areas.
- Extinction – may become feasible if all other options for species to adapt and become resilient to changing climatic conditions are not adopted.

In the past, most species have responded to changing climates by migrating to new areas where conditions are more suitable for them, while others evolved to adapt to such changed conditions over a longer period of time coinciding with suitable climates. However, the current rate of climate change may be faster than the species' ability to evolve or migrate.

Further, those species already threatened by no-climatic threats (e.g., hunting, deforestation), Species occurring at top of mountains or higher altitudes and with narrow range of distribution, Populations that occur at the upper limits of their distributions, Species with limited dispersal capability, Species that occur in habitats isolated and/or fragmentations due to human actions such as logging, selective breeding, infrastructure development, etc. from others,

excluding possibility for migration, Species with low reproductive rates or small genetic base would reduce ability to adapt and maintain their persistence in the areas/sites of their original habitats.

9.5 Species responses to altered climatic conditions

In response, the species may have to alter their relationships with others and in particular the following relationship:

- Predator – prey relations
- Changes in inter-species competition
- Changes in host-plant relationships
- Spread of invasive species
- Increased insect and pathogen infestations

In respect to insects and pathogens, Petzoldt and Seaman (2011) indicated in their analyses on climate change effects on insects and pathogens that any increase in temperature has potential impacts on both the host plants and their pests. For plants, the impacts would be related to changes in their physiology to adapt to changing environmental conditions in their flowering and fruiting behaviours or in terms of adopting high resistance to diseases. However, as shown by a number of researchers (see Petzoldt and Seaman, 2011), such resistance may be overcome more quickly by more rapid disease cycles, resulting in a greater chance of pathogens evolving to overcome host plant resistance.

In a recent study of the Bulolo Plantationsin Morobe Province by researchers from PNGFA Forest Research Institute (Saulei, 2011) and the Asengseng Timber Concession area in West New Britain Province (Saulei, et.al, 2012) have shown that increasing temperatures in the area over the past years have changed the soil conditions as well as the rate of termite and other insects' attacks on the both plantation and natural forest trees. Much of the insect attacks were related to the vulnerability of trees to exposures to increasing temperatures and changed micro-climatic and soil conditions.

Further, insects and pathogens that were normally found in intact forest environment are also affected by this edge effect in that they and the environment of their habitats are also exposed. These changes also alter their behavior and in some cases found themselves free from any of their original control regulators such as their natural predators. Increasing temperatures may change their modes of sexual and feeding behaviors or for those that a host specific, they may change their host to other ones or become generalist depending on what is available to them as food or residential sources.

Apart from injuries, many of these trees appeared to die due to the "edge effect"- a phenomenon found common amongst trees which have not experienced any exposures to extreme environmental conditions than to what they have been adapted to inhabit (i.e., in an intact closed forest environment) as observed at Asengseng Timber Concession area (Saulei, et.al, 2012). In this case, many of these trees have not experienced exposures to high and direct effects of increased sunlight, temperature, wind, high direct precipitation, low humidity, dry and low soil moisture. Further, in order for these trees to become adaptive to such extremities, time is a factor, so that over time they can acclimatize themselves to such changes and therefore be able to survive. This may not be the case for these trees in the area. As a consequence, the trees became over stressed and thus become vulnerable to any form of

insect and pathogenic attacks. Many of these insects and pathogens can sense which trees are under stress through chemo-hormonal emissions which insects and pathogens can detect. Similarly, insects and pathogens are also affected and they can become prevalent, decline in populations or even migrate to new hospitable forests when exposed to extreme environmental conditions like those experienced under forests that have been cleared. Their persistent on site will depend very much on both the availability of food sources and conducive surrounding environmental conditions.

9.6 Adaptation strategies for conserving forests genetic resource in a changing climate

The key strategy advocated by the UNFCCC for minimising and adapting to the impacts of climate change for forests and their genetic resources is that of adaptation

Protect as much areas of different intact forest type ecosystems and natural habitats as possible

Healthy, intact forest ecosystems will be more resilient (or less vulnerable) to climate change because they:

- Harbour large and viable populations of plant species which are unlikely to go extinct during extreme events
- Serve as sources of individuals and genes to colonize new areas
- Have genetically diverse plant populations with the genetic potential to acclimatize to climate change
- Maintain natural processes (e.g., migration, predation, seed dispersal) which are necessary for forest ecosystem function
- Reduce other (non-climate) threats to biodiversity (e.g., hunting, fires, etc.)
- Avoid fragmentation of different forest type ecosystems and natural habitats
- Where possible, maintain or re-establish landscape connectivity to allow movement of species
- Promote sustainable agriculture and forestry as a means of conserving forests in fragmented landscapes
- For species that are particularly vulnerable to climate change, *ex situ* conservation or translocation may be necessary

Climate change is the greatest and most severe threat to forests in the long-term and therefore must be clearly defined and addresses in a national policy.

Forest carbon projects (CDM and REDD) designed under these strategies can assist efforts towards reducing Green House Gas (GHG) emissions, increase the extent of forest cover, increase conservation areas from 2% to 20% and also add value to biodiversity by protecting, restoring critical habitats and assisting to maintaining landscape connectivity.

9.7 The impacts of increasing economic and population growth

As mentioned in the introductory part of this chapter, PNG is under going rapid economic growth resulting from the extraction of its mineral, oil and gas as well as forest resources. At the same time, its population growth rate has shown and almost three fold increase since the 1980s. This rapid economic growth has meant that large areas of forests have to be cleared to make way such projects as well as for expanding the large scale agriculture projects under the Special Agriculture Business Leases (SABLs) for cash crops such as oil palm and rubber, which over a short period of time (one year) has covered over five (5) million hectares of natural intact forests. In the process of forest clearance, a number of species are either lost or reduce in numbers resulting in the erosion of the genetic bases for a number of populations and in the long run may become isolated and probably become extinct. Further, some forest patches are left either as buffers of some sort or due to their inaccessibility cannot be used. Such isolated populations without any connectivity (corridor) with other populations for allowing movements of genes between populations would also become more vulnerable to the impacts of climate change and eventually go extinct.

Established plantations can also have the same process of genetic erosion resulting from selection and progressive breeding where only a number certain morphological characteristics of the trees are selected and promoted for used in plantations. Further selections and breeding done on the first generation would then result in eroding the genetic base of the species and with no further mixing of this genetic base with similar species outside the plantation would eventually result in extinction of the species due to lack of a broad genetic base that would allow resilience to increasing changing climatic conditions.

9.8 Policy change and directives

Changes in the policy and directives can have a major impact on current and future strategies for conservation and sustainability of the forest and Forest Genetic resources. The policy directives for PNGFA to reduce and eventually stop exports of logs implies that all logs harvested from the forest concession areas meant that downstream processing has to be established. At the same time, because of decreasing size of the natural forest, an increase in plantations has to be implemented and this has been directed by the government's Medium Term Development Strategy (MTDS), Development Strategy and Implementation Program (DSIP) and Vision 2050.

The government's strategic direction outlined in the Vision 2050 document clearly provides a major challenge for the country to shift from being heavily dependent on extractive non-renewable resources such as mining and energy sectors to more reliance on developing the renewable resource sectors such as man-power, agriculture, forestry, fisheries and eco-tourism. In regard to the forestry sector, the Vision 2050 provides two pillars or strategic focus areas for the sector and these are:

- wealth creation, natural resources and growth node; and,
- environmental sustainability and climate change

Under the strategic directive for wealth creation there are three (3) statements that form the basis for the socio-economic growth through forestry:

- elimination of export of round logs by 2010;
- ensuring downstream processing of all logs onshore; and,
- developing forestry plantations in suitable areas, with landowners'participation.

The strategic directive for environmental sustainability and climate change also has three (3) statements which have implications to forestry and timber industry:

- reduce greenhouse gas emissions by 90% to 1990 level;
- establish a sustainable development policy in all sectors, especially forestry, agriculture, mining, energy and oceans by 2015;
- conserve the high biodiversity which represents 5-7% of the world's biodiversity.

The MTD Plan 2011-12015 further articulates these government's directives by focusing on improving the forest policy and regulations for the next five years and calls for a review of all existing policies.

This change of policy directives is confronted with a major constraint and that is the land accessibility which the state does not own, but rather owned by the traditional customary owners. To address this issue, the state and its forestry agency need to establish a mechanism where by the agency can form a partnership with the landowning groups in developing forest plantations. Alternatively, the state can empower the land owning groups through the provisions of both technical and financial support to develop their own forest resources as well as establishing their own forest plantations. At the same time such provisions should also be applied to downstream processing and value adding products that will be exported to international markets. Further, assistance should be provided to land owner enterpreners venturing into international markets to meet both quality and standard requirements of such markets.

Chapter 10 Key Issues and Recommendations

10.1 Issues

During the preparation of this report, a number of issues were encountered which slows down the progress of preparing this report. Firstly, from the onset in getting the process moving, especially in organizing the structure of the coordination and validation of the document, the people selected to be involved, though initially agreed to take part did not commit themselves to participate, so other people have to be slotted in their place.

In setting up the process for getting this FGR country report off the ground, a National FGR Committee was established with a chairperson. This was followed by a stakeholders workshop held in Port Moresby, and it was at this workshop that Nine Technical Working Groups (TWGs) were established together with the members. Each of the TWG had a Team Leader who was responsible to conduct meetings, collected data and information and lead the group in drafting their respective chapter. Very few of these team leaders actually took the lead in drafting and submitting the draft and similarly, very few members of the TWG drafting team ever contributed.

Other major constraints to producing this report include the following:

- Unavailability of data and information – many of the documents, data and information are not available because they are scattered or individuals and agencies owning them are not willing to provide

- Uncommitted government agencies – a number of related government agencies are either not interested or do not have the time and not committed to fulfill their undertakings for this report.

- Accessing and developing land for FGR – as mentioned above, land is owned by traditional customary owners and to access and develop them need new approaches and acquisition is not permitted.

- Appropriate comprehensive national policy and legislation for forestry, environment and conservation is lacking and urgently required to minimize the issue of fragmented and uncoordinated approach.

- Lack of concrete forest land use plans for implementation immediately after logging operations ceased.

- Policy on Bio-safety and ABS, although already in place (as a draft) needs to be reviewed and approved for implementation

- Streamlining of FGR into government economic development strategy, especially in Forestry and agriculture.

- Lack of extension work to conduct awareness and education, importantly at community level for FGR, climate change and conservation.

- Collaboration with other government agencies, education and research institutions and NGOs for implementation of FGR policy and Programs.

It is therefore, strongly recommended that the above key issues be addressed, especially by those key government agencies reposible for conserving, managing and developing FGR, such as: Agriculture, Environment & Conservation and Forestry.

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Annex 1: Protected Areas in Papua New Guinea

Protected Areas in PNG established by national laws as at 2007

(Sources: Chatterton et. al. 2006, Shearman et. al. 2008, Kwa 2008)

	Protected Area	Year	Province	Area (ha)[1]	Area (ha)[2]	Legislation
1	McAdam National Park	22/2/62	Morobe		2,117	*National Parks Act* 1980
2	Baiyer River Wildlife Sanctuary	13/1/68	Western Highlands	64		*Fauna (Protection and Control) Act* 1966
3	Wewak Peace Memorial Park	24/4/69	Eastern Highlands	2		*National Parks Act* 1980
4	Varirata National Park	18/12/69	Central		1,033	*National Parks Act* 1980
5	Cape Wom Historical Site National Park	18/10/73	East Sepik	2		*National Parks Act* 1980
6	Nanuk Provincial Park	6/12/73	East New Britain	12	36	*National Parks Act* 1980
7	Tonda Wildlife Management Area	6/2/75	Western	590,000	608,505	*Fauna (Protection and Control) Act* 1966
8	Baniara Island Protected Area	13/2/75	Milne Bay	37		*Fauna (Protection and Control) Act* 1966
9	Pokili Wildlife Management Area	26/6/75	West New Britain		11,952	*Fauna (Protection and Control) Act* 1966
10	Garu Wildlife Management Area	9/12/76	West New Britain		7,798	*Fauna (Protection and Control) Act* 1966
11	Siwi-Utame Wildlife Management Area	27/1/77	Southern Highlands	12,540	12,528	*Fauna (Protection and Control) Act* 1966
12	Bagiai Wildlife Management Area	27/1/77	Madang	13,760	17,001	*Fauna (Protection and Control) Act* 1966
13	Ranba (Long Island) Wildlife Management Area	30/6/77	Madang		13,612	*Fauna (Protection and Control) Act* 1966
14	Sawataetae Wildlife Management Area	30/6/77	Milne Bay	700	790	*Fauna (Protection and Control) Act* 1966
15	Talele Nature Reserve	26/7/77	East New Britain	12		*Fauna (Protection and Control) Act* 1966
16	Balek Wildlife Sanctuary	4/8/77	Madang	470	577	*Fauna (Protection and Control) Act* 1966
17	Crown Island Wildlife Sanctuary	4/8/77	Madang	58,969	1,395	*Fauna (Protection and Control) Act* 1966
18	Ranba (Long Island) Wildlife Sanctuary	4/8/77	Madang	57,646		*Fauna (Protection and Control) Act* 1966
19	Tavalo Wildlife Management Area	13/11/77	West New Britain		926	*Fauna (Protection and Control) Act* 1966
20	Mojirau Wildlife Management Area	22/6/78	East Sepik		6,826	*Fauna (Protection and Control) Act* 1966
21	Maza Wildlife Management Area[3]	21/12/78	Western	184,230		*Fauna (Protection and Control) Act* 1966
22	Namanatabu Reserve	15/3/79	Central	27	55	*Fauna (Protection and Control) Act* 1966
23	Lake Lavu Wildlife Management Area	5/3/81	Milne Bay		2,711	*Fauna (Protection and Control) Act* 1966
24	Zo-oimaga Wildlife Management Area	15/3/81	Central		942	*Fauna (Protection and Control) Act* 1966
25	Horse Shoe Reef Wildlife Management Area[4]	9/7/81	Central			*Fauna (Protection and Control) Act* 1966
26	Oi Mada Wara Wildlife Management Area	6/8/81	Milne Bay	22,840	22,984	*Fauna (Protection and Control) Act* 1966
27	Kokoda Memorial Park	24/9/84	Oro	1		*National Parks Act* 1980
	Kokoda Historical Reserve		Oro	10		
28	N'drolowa Wildlife Management Area	28/3/85	Manus		5,690	*Fauna (Protection and Control) Act* 1966
29	Pirung Wildlife Management Area	25/5/85	AR Bougainville	43,200		*Fauna (Protection and Control) Act* 1966
30	Nuserang Wildlife Management Area	9/10/86	Morobe	22	1,024	*Fauna (Protection and Control) Act* 1966

[1] Chatterton et. al. 2006
[2] Shearman et. al. 2008
[3] Exclusively marine
[4] Exclusively marine

31	Paga Hill National Park Scenic Reserve	10/9/87	National Capital	27		*National Parks Act* 1980
32	Iomare Wildlife Management Area	24/12/87	Central		3,943	*Fauna (Protection and Control) Act* 1966
33	Neiru (Aird Hills) Wildlife Management Area	24/12/87	Gulf		2,414	*Fauna (Protection and Control) Act* 1966
34	Mt. Gahavisuka Provincial Park	27/7/89	Eastern Highlands	77	199	*National Parks Act* 1980
35	Moitaka Wildlife Sanctuary	27/7/89	National Capital	44		*Fauna (Protection and Control) Act* 1966
36	Mt. Kaindi Wildlife Management Area	15/3/90	Morobe		866	*Fauna (Protection and Control) Act* 1966
	Mt. Susu National Park		Morobe	49	119	
37	Mt. Wilhelm National Park	17/5/90	Simbu	817	703	National Parks Act 1980
	Mt. Wilhelm National Reserve		Western Highlands	817		
38	Lihir Island Wildlife Management Area	6/6/91	New Ireland	20,208	19,973	*Fauna (Protection and Control) Act* 1966
39	Loroko National Park	10/10/91	West New Britain	100		*National Parks Act* 1980
40	Jimi (Ruti) Valley National Park	31/10/91	Western Highlands			*National Parks Act* 1980
41	Lake Kutubu Wildlife Management Area	25/6/92	Southern Highlands	24,100	21,322	*Fauna (Protection and Control) Act* 1966
42	Crater Mountain Wildlife Management Area	25/11/93	Eastern Highlands-Simbu-Gulf	270,000	269,020	*Fauna (Protection and Control) Act* 1966
43	Kamiali Wildlife Management Area	19/9/96	Morobe	65,541	28,353	*Fauna (Protection and Control) Act* 1966
44	Hombareta Wildlife Management Area	6/3/97	Oro	130	149	*Fauna (Protection and Control) Act* 1966
45	Kavakuna Caves Wildlife Management Area	22/4/97	East New Britain			*Fauna (Protection and Control) Act* 1966
46	Hunstein Range Wildlife Management Area	13/11/97	East Sepik	220,000	219,929	*Fauna (Protection and Control) Act* 1966
47	Klampun Wildlife Management Area	4/9/03	East New Britain		5,121	*Fauna (Protection and Control) Act* 1966
48	Laugum Island Marine Wildlife Management Area	26/1/06	Madang			*Fauna (Protection and Control) Act* 1966
49	Sinub Island Marine Wildlife Management Area	26/1/06	Madang			*Fauna (Protection and Control) Act* 1966
50	Tab Island Marine Wildlife Management Area	26/1/06	Madang			*Fauna (Protection and Control) Act* 1966
51	Tabab Island Marine Wildlife Management Area	26/1/06	Madang			*Fauna (Protection and Control) Act* 1966
52	Libano-Arisai Wildlife Management Area		Southern Highlands			*Fauna (Protection and Control) Act* 1966
53	Libano-Hose Wildlife Management Area		Southern Highlands			*Fauna (Protection and Control) Act* 1966
	Jimi Valley National Park		Western Highlands	4,180		*National Parks Act* 1980
	Jimi Valley Wildlife Management Area		Western Highlands		4,360	
	Kavakuna Caves		West New Britain			
	Managalas Pleteau		Oro			
	Tonda Extension		Western			
	Kau Wildlife Management Area		Madang	77		Traditional/customary law
	TOTAL			1,642,826	1,294,969	