INTERNATIONAL TROPICAL TIMBER ORGANIZATION

CONSULTANCY ON MULTIPURPOSE NATIONAL FOREST INVENTORY FOR SUSTAINABLE FOREST MANAGEMENT - SPECIAL CASE STUDY FOR PNG

PAPUA NEW GUINEA CASE STUDY

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1. INTRODUCTION

1.1 Background

At the request of the Government of Papua New Guinea and on the basis of the recommendations of the ITTO's Diagnosis Mission for the PNG's forestry sector (February 2007), the 42nd ITTC meeting held in Port Moresby in May 2007 approved the PP-A/42-191 which is to support PNG Forest Authority (FA) in the elaboration of a Multipurpose National Forest Inventory.

The main objective of the consultancy is to study the design and implementation of a multipurpose forest inventory at national level (i.e. assessing not only timber resources, but also, and *inter alia,* NTFPs, soils and water, carbon stocks, socio-economic and livelihood issues related to forest populations), as a tool for sustainable forest management. Using Papua New Guinea as a case study, the specific objectives are:

- identify the implications for inventory design and implementation of the information needs of policy-makers and stakeholders for forest use over and above timber harvesting,

develop an action plan, including a budget for a multipurpose national forest inventory in PNG, with due consideration given to a range of alternative inventory design options and their implications in terms of skills, cost and effectiveness for different users.

The work includes the submission, by end February 2008, of a draft report on the implications of policy-makers and stakeholders information needs for the design and implementation of a multipurpose national forest inventory; the preparation, by end June 2008, of a final draft; and the presentation of the final report with the PNG case study, at the 44th session of ITTC (Yokohama, November 2008).

The PNG case study consists of two parts :

- a general review and analysis of the current state of PNG forest resources and the implications for a multipurpose national forest assessment of the obligations of PNG in terms of information requirements as a Party to the international agreements related to sustainable forest management, conservation of biodiversity, combating deforestation and desertification, reducing greenhouse gas emissions and using the Clean Development Mechanism;

- the development of a plan for a multipurpose national forest inventory of Papua New Guinea as a tool for the sustainable management of its forest resources, and as a case study at international level, using a participatory approach and identifying the information required by the different stakeholders. Special consideration will be given to conservation of biodiversity, forest carbon budget, and forest landscape rehabilitation within a framework of sound land use planning.

More precisely, the study is to cover the following issues:

1. Implications for multipurpose forest resources assessments of the need to:

- assess rates of deforestation and forest degradation (in particular for the rehabilitation of degraded forest landscapes and for the development of sound land use planning),
- utilize forest inventories to promote improved and transparent forest governance,
- determine the conservation status of high value and/or endangered species, and
- access new and additional sources of funding, such as those potentially available for reducing greenhouse gas (GHG) emissions from deforestation and forest degradation within the framework of the UN Framework Climate Change Convention.

2. Papua New Guinea case study

- analyze and summarize the forest information base currently available in Papua New Guinea on forest cover, growing stock, regeneration and forest disturbance patterns;
- identify and define the criteria for the areas to be included in the inventory and the values to be inventoried;
- consult with stakeholders to identify ownership, tenure and access issues related to forest inventory;
- prepare a plan of action, including a budget, for a multipurpose forest inventory in Papua New Guinea, taking into account the results from international experience, identified views of stakeholders, skills availability and the scope for capacity building;
- consider a range of alternative inventory design options in the plan of action and their implications in terms of skills, cost effectiveness for different users;
- present the plan of action in a format that can be readily disaggregated into discrete sub-components for funding by a range of donors and others;
- work with two assigned local counterpart consultants during the whole period in Papua New Guinea as an aid to transfer of skills and capacity building;
- facilitate jointly a multi-stakeholder workshop to discuss findings and refine the plan of action.

The consultancy team was composed of two consultants, Jorge Malleux and Jean-Paul Lanly under a two months Special Services Agreement with the ITTO's Secretariat. After a short briefing visit at ITTO Headquarters in Yokohama (10 – 11 January 2008), the mission arrived in Port Moresby on 12 January and remained in the country until 1 February.

The mission got from FA the support needed for the realization of its commonly agreed agenda. They received an efficient cooperation from the part of the two counterpart officers appointed by the Forest Authority, Mr. Vitus Ambia, Divisional Manager of Forest Planning and Mr. Frank Agaru, Aid Coordinator, to whom they want to express their gratitude for their untiring and friendly support, as well as to Mr. Dambis D. Kaip, acting Director, Policy and Aid Coordination.

The consultants want to extend their thanks to the FA Managing Director, M. Kanawi Pouru, the Directors and staff of the FA divisions, of the Forest Resources Institute, and of the Lae Area Services Division, all officers from whom they obtained most useful information and views, as well as to the senior officers met in the other governmental agencies (particularly the Departments of National Planning and Monitoring, of Agriculture and Livestock, and of Environment and Conservation); and to the representatives of the international cooperation agencies and of the NGOs met during the mission. Finally, these acknowledgements would not be complete if they were not also addressed to Mrs. Vagi Pole for her permanent and efficient assistance during the whole duration of the mission.

1.2 Previous reports of the consultancy

1.2.1 Proceedings of the national workshop on multipurpose national forest inventory in PNG

As part of the work program of the mission, a national workshop was carried out on 29 January 2008, with the participation of Forest Authority (FA)/National Forest Service (NFS) Headquarters senior staff, 12 FA area managers and Forest Research Institute (FRI) researchers coming from different provinces. Other agencies and some NGOs were invited, but only two were represented.

For the organization of the workshop, the consultants prepared a general outline and a program which were submitted to the Forest Authority for its approval. Their original proposal envisaged a workshop of 2-days duration, one day for general presentation and discussions of the objectives, organization and implementation of a multipurpose national forest inventory in Papua New Guinea, and the second day dedicated to group work, according to main subjects/issues. The consultants also proposed that representatives of various stakeholders be invited to participate in the workshop, in order to obtain their views about the extent and detail of the needed information, like government agencies other than the Forest Authority, producers (private companies), researchers, local communities, land use planners, and others. However, the Forest Authority decided to invite mostly FA staff of Headquarters and provincial echelons, and to reduce to one day the duration of the workshop.

The limitation of participation to representatives of government agencies, essentially the Forest Authority, reduced the scope of the discussions and the number of issues raised during the meeting. However, previous meetings and discussions held by the consultants with representatives of the most important institutions and stakeholders permitted them to have a good understanding of the main difficulties regarding existing information and its accessibility, of the need for new forest resource information, and more generally of issues related to demand for forest related information from the part of the various stakeholders.

The major concern of the forest resources users is related to the actual situation and precise limits of forest land under the ownership and control of local communities: this would require a detailed cadastral map and data bank which do not exist. This is also a concern for the producers, who sign contracts (projects) with the government and communities, but frequently are entering in conflict due to wrong or inaccurate limits of forest management areas.

The actual situation of the forest resources - their composition, structure, exploitation, standing wood stocks, non timber forest products -, and the socio-economic issues at the interface between forest resources and communities are the main concerns of non governmental organizations and local people.

During the workshop, these matters were raised by the consultants, and short discussions held on them. Moreover the consultants made clear statements about the need to incorporate the social issues and relevant data in the planning and implementation of the multipurpose national forest inventory.

As a brief summary of the presentations and discussions during the workshop, some conclusions can already be drawn :

- there is a *clear and urgent need for a Multipurpose National Forest Inventory* (MNFI) covering the various components of the natural forest ecosystems: wood, non timber forest products, biodiversity, biomass, carbon stocks and wildlife, socioeconomic indicators related to people living in or near the forests, as well as those of the planted forests, including the identification of potential areas for reforestation or rehabilitation.

- there has been an important number of studies and assessments on forest resources carried out all over the country since 1960, particularly in the mid 70's with some updating in the mid 90's. However most of this information has not been organized and used to the full extent. A *thorough review and analysis of all this information* for subsequent use as background for the MNFI is needed.

- the current institutional structure of the Forest Authority seems adequate for the implementation of the MNFI. Nevertheless, there are serious limitations and constraints regarding its actual *operational capacity*, due to insufficient staff, financial resources and facilities of the National Forest Service: they will have to be increased in order to secure an efficient execution of the MNFI and the subsequent use of its results for the drafting and implementation of the National Forest Plan and for the sustainable management of PNG forest resources.

- the results of the MNFI are to be used for *national and sub-national planning*, but not at lower levels. In particular, FA should continue in addition to collect and process the data needed at the management unit level.

- the MNFI must be a permanent, continuous program incorporated in the National Forest Plan, with the necessary institutional arrangements and staff and financial resources available in a timely manner. However, the first full exercise (first cycle), to be carried out in a shorter span of time (say 5 years), will require *external economic and technical support*.

- the NFI being a multidisciplinary exercise, and considering the need to involve other governmental agencies and non governmental organizations and the other main stakeholders, in the first instance the communities which are the landowners, it is advisable to establish an *interagency coordinating committee at the highest possible level*, which could be co-chaired by the FA Managing Director and a high level representative of the National Planning and Monitoring Department.

1.2.2 Report on Information needs of decision makers and stakeholders, implications for MNFI design and implementation, review of national and international experiences

The first part of the report (chapter 2) consists of a review of the current trends regarding the demands of information put on national forest inventories by the decision makers and stakeholders, including those corresponding to the obligations of a country as Party to international conventions. The chapter starts by an analysis of the Criteria and indicators (C&I) of Sustainable Forest Management (SFM) produced under various processes, such as those of ITTO, of Tarapoto (Amazonian Countries Treaty Organization), of the African Timber Organization/ITTO and of other important initiatives in this field. The report shows that SFM as characterized by C&I has many critical implications in several information fields for the design and implementation of a mutipurpose NFI, or MNFI, notably:

- awareness and participation of the stakeholders, particularly of the local communities, is most critical, not only during the execution of a MNFI, but also during the planning process in order to assess their needs and obtain their consent during the field work, and thus avoid possible conflicts, for instance when entering private land, concessions, community land etc.;

- an economic and ecological zoning, classifying lands according to their potential is a basic task in the planning phase of a MNFI, as it allows for their realistic allocation to the different uses (agriculture, grazing, forestry, mining, ...) ;

- a good delimitation of lands for production and protection purposes, and according to ownership (public, communal or private status), is essential. A complete and detailed cadastre would be highly desirable, as it helps avoiding or resolving land tenure conflicts, thus facilitating land use planning and SFM at national and sub-national levels ;

- collection of field data on wildlife, non timber forest products (lianas, shrubs and trees for food, shelter and health care), soils and water resources is important in a MNFI, and requires the participation of various specialists, who can avail themselves of the complex and expensive logistics that characterize the execution of a forest inventory ;

- information collected and processed by a MNFI is the more useful as it is shared, disseminated and used all over the country, by decision makers, politicians, local communities, entrepreneurs, universities and research institutions. It is why a post inventory outreach plan should be one of the main outputs of a MNFI ;

- a MNFI should be a permanent process, monitoring the changes in the forest resources. Therefore, a unit dedicated to the MNFI must become a permanent component of the national forest management system. Such a unit must be staffed with good specialists and well trained employees. It should collaborate effectively with education and research institutions.

The report then compares and selects definitions of the most important terms, notably “forest”, “deforestation” and “forest degradation”, and provides technical guidelines for the estimation of deforestation and forest degradation in an MNFI. The evaluation of the secondary and degraded forest ecosystems and landscapes in a MNFI is particularly useful for designing and implementing appropriate sustainable forest management systems. Policy makers, researchers, forest practitioners and advocacy groups have tended to focus too much on large tracts of tropical primary forests, while the conservation value and the development potential of degraded and secondary forests have been neglected. If properly managed, restored or rehabilitated, degraded and secondary forests have the potential to generate significant environmental and livelihood benefits on a sustainable basis. Under certain conditions they can mitigate pressure on primary forests through their ability to produce both wood and non-wood forest products. Furthermore, they can often provide environmental services and make valuable contributions to biodiversity conservation.

The report also stresses the importance of the evaluation of biodiversity in a MNFI. It contains a matrix illustrating the implications for a MNFI of the observance of each biodiversity indicator. Special attention is given to the survey of high value and endangered species and of their regeneration. This is particularly relevant for a country like PNG, which possesses an exceptional wealth of plant and animal species, many of them endemic to the island of New Guinea.

The assessment of carbon stocks in a MNFI is particularly useful for a country signatory of the Kyoto Protocol. It must be realized, however, that their evaluation is derived indirectly (through biomass estimation) from that of the growing stock (stem volumes) of trees, obtained by application of volume equations to field measurements of DBH (diameters at breast height) and total height of the trees of the field sample. Conversion from stem volumes into whole-tree biomass is one of the notable sources of error in forest carbon inventories since most of the currently applied Biomass Expansion Factors (BEF) are not based on regionally representative biomass sampling.

Chapter 3 reviews briefly existing global forest resources assessment initiatives, as well as the following cases of multipurpose national forest inventories :

- either sponsored, and implemented with the direct guidance of FAO, like those of Costa Rica, Cameroon and The Philippines which aimed at a general appraisal of the forest situation at the country level,

- or others like those of Brazil and Venezuela (the first one in the planning phase and the second being implemented), directly financed by the respective countries. In both cases, a more complete structure exists, which can be used as a good example and reference for the PNG's study case on MNFI ;

- or else the Argentinian one, carried out with the financial support of the World Bank and completed in 2005, and which includes some interesting methodological approaches useful for future national forest inventories.

Finally, chapter 4 sketches out the situation of forests and forest management in the Asia-Pacific countries in order to illustrate the regional context within which a MNFI may be implemented in Papua New Guinea.

1.3 MNFI and forest sector development

The future development of the forest sector of wood producing countries must not be conceived any longer in mining terms. Forestry development programs will have to be based on a system of rational and integrated use of forest resources, following the SFM principles, criteria

and indicators. These, in turn, must be supported by sufficiently detailed and precise information allowing decision-makers and stakeholders to

design policies, strategies, and regulations for the conservation of forest ecosystems, securing at the same time the environmental quality and the livelihood of populations at local, national, regional and global levels.

The inventory of forest resources cannot any longer be seen only as the measurement and calculation of the stocks of timber and non timber forest products of certain forests. A multipurpose forest inventory is expected to provide reliable information on all aspects of sustainable forest management : land use changes, state of conservation of biological diversity, carbon stocks and balance, water cycle, and social and cultural elements such as cultural diversity and indigenous and local populations' knowledge.

Given these additional demands put on forest resources assessments, the forest inventory specialist (a professional or a team of professionals) should therefore not only be conversant with sampling, remote sensing and forest mensuration techniques, but also have some knowledge of other fields, such as those of biodiversity, water resources, wildlife, forest services, carbon stocks, land use changes etc. However, the contribution of other specialists or specialized institutions (universities, research agencies) would be needed, at least on a part time basis and for training. They, in turn, will benefit for their own work from the logistics facilities of the forest inventory

The fundamental objective of the multipurpose national forest inventory is to provide sufficient updated and precise information for the sustainable management of the forest resource at national and sub-national levels. Wood and non wood production is no longer the sole objective of the management of the resource. Indeed, a forest management plan should begin with a land use plan and include provisions for negotiations with other stakeholders and for conflict resolution. This requires good and detailed cartographic information, delimitation of the different areas for production, conservation and rehabilitation or restoration. Determining clear limits and information regarding forest resource ownership is also a crucial task of the NFI, particularly in the case of PNG, where about 95% of the forest belongs to the local communities, a singularity of Melanesian countries.

Sufficiently precise and accurate estimation of standing timber volume and of potential production under different management regimes is an important element of any sound forest management system. A particular issue in PNG is the differences found between the standing volume and production estimates of the Forest Authority and the actual volumes recovered and the production sustained once forest operations have started in a particular region. This is partly related to the present inventory procedures and to the FA’s capacity to review and analyze the information collected.

The PNG National Forest Plan has fundamental requirements for a production forest management planning system which are :

- establishment of a permanent and well structured institutional setup to plan, organize and implement the MNFI and to use efficiently the large amount of information generated by the national forest inventory ;

- estimation of forest areas by age classes, forest types and/or productivity classes, accessibility criteria, constraints on timber production, and by classes according to other environmental, social and economic criteria, e.g. riparian zone, priority protection, community use, ... ;

- evaluation of the social and economic relationship between local communities and the forests;

- estimation of forest timber and of other parameters, such as biomass, carbon stocks, and plant and animal biodiversity ;

- production of growth models to estimate the projected yield of timber volume or biomass over time ;

- elaboration of a data management system for integrating remote sensing/mapping, field inventory and growth modeling data, and for projecting the effects of different harvesting regimes on forest composition and structure.

Specific objectives and expected results

- The best way for setting the objectives of a MNFI during the preparation phase, and for visualizing the results to be provided by the, integration of the thematic mapping and statistical field data components within a comprehensive geographic information system (GIS), is through a list of questions that should be answered :

  - What is the extent of the different forest types in the country, by states, municipalities and local communities?

  - What is the area covered by forests and other vegetation formations and by land uses (plantations, savannas, wetlands, crops, etc..) within each zone under Special Administrative Regime?

  - What is the degree of protection for each type of forest and other vegetation formations, expressed as the ratio of the area of this type falling within the Special Administrative Regime zones to its area outside these zones ?

  - What is the degree and kind of human intervention for each forest type in the zones under Special Administrative Regime and outside these zones ?

  - What is the geographical distribution and “spatial expression” of the various forest types and vegetation formations?

- What is the average range and size distribution of patches the of different various forest types and vegetation formations and what is their degree of fragmentation ?

- What is the volume of wood and biomass available for commercial purposes of different forest tree species and groups of them and its variability for different forest types ?

- What are the endangered plant and animal species, and what are their actual degree of endangerment ?

- What are the timber products to be derived from each forest types?

- What is the level of biodiversity, the vertical stratification, plant health and regeneration of tree species of the various forest types ?

- What are the high value forests for conservation (HVFC) and their actual situation ?

- What should be the Allowable Annual Cut for timber in the various forest types by regions ?

- What are the diameter class structures for different tree species in the various forest types ?

The experience from several countries where a NFI was designed and implemented, shows that it is possible to generate and make available the above information from the first year of execution, and that all regions of a country can be covered within the span of five years. It shows also that an NFI linked to a powerful and easily searchable GIS, may be at a relatively low cost per ha considering the vast amount of information delivered. Costs obtained in Kenya, The Philippines, Venezuela and Chile for instance, were in the order of 0.1 dollar per ha. Updating the data from a NFI every 5 or 10 years provides the information needed for the improvement and strengthening of the national forest plan, for the monitoring of the forest cover, for forest management, for the knowledge of deforestation and of forest degradation and for determining the location and spatial patterns of other land uses, both in quantitative and qualitative terms, at a significantly reduced cost and complexity. It is also useful for estimating the environmental services rendered by the forests (e.g. water, and particularly fresh water, production, carbon sequestration). This information is essential for formulating policies and making the right decisions in the field of forest conservation and development. Such policies and decisions may be adapted and modified over time depending on the changing priorities assigned to the various goods and services provided by the forests.

The efficient use of the large amount of information provided by a NFI constitutes without doubt the most challenging issue to be faced once it is completed. It requires a well organized and structured institutional base, a most important condition that must be fulfilled even before the MNFI starts.

The main thrust of a national forest policy, such as that of PNG, is the management of the nation's forest resource on a sustainable basis to achieve economic growth, secure employment

with the active participation of the national entities concerned including the private sector and the civil society. The PNG Forest Authority has developed a national forest policy, a national forest corporative plan, a logging code of practice and other supportive tools to enhance sustainable forest management in the country. The MNFI is now the priority tool most urgently needed for a sustainable development of the forest sector.

To measure the progress in sustainable forest management trends, the PNG Forest Authority has adopted and applied the ITTO set of criteria and indicators of sustainable forest management of natural tropical forests at the national level. It has also developed the PNG's criteria and indicators yet to be applied at the forest management unit level.

One of the primary missions of the Papua New Guinea Forest Authority is the sustainable management of the nation's forest resources aiming at their wise use for the benefit of present and future generations to meet their economic, environmental and social needs. This is highlighted in the country's Forest Policy and in other documents forming the forest regulatory framework. Papua New Guinea's Forest Policy is based on the Fourth Goal of the Constitution which is "to ensure that the forest resources of the country are used and replenished for the collective benefit of all Papuans". It is based on the Sustainable Forest Management Principles that forest concessions are acquired under Forest Management Agreement (FMA) terms and conditions so as to ensure that the forests maintain a sustained flow of benefits to the landowners now and in the future.

2. FORESTS AND FORESTRY IN PNG

2.1 Forests and land use

2.1.1 Background

Before developing a strategy and methodology for the NFI, it is necessary to review briefly the present situation of the forest sector, in order to thrash out the most important facts, elements and constraints that should be taken into account in the design and implementation of this national task. n.

Forest Authority estimates that approximately 55 % of the total area of the country is covered by natural forests, of which 45% are considered *production forests* (for timber and other products), and 55% are for conservation, because of physical (topography and edaphic factors) and/or economic inaccessibility, or due to ecological constraints. These proportions are not necessarily agreed on and adopted by other government agencies (Departments of Agriculture and Livestock, of Environment and Conservation), and by environmental NGO' s.

Timber extraction in the production forests is the main forest priority of the government and of the private forest companies (most of them foreign owned) which are the main actors presently of the management of the forest resources. While primary forests comprise more than 2,000 tree species, of which about 200 have a timber of commercial value, more that 80% of exports

of wood products and 80% of log exports are from 5 to 8 species only. The lack of a strict control of logging, wood transport, processing and export activities makes it difficult to know in particular how much timber is actually felled, the amount of waste left in the forest and the damage caused by logging to the residual stands. This unsatisfactory situation calls for the urgent establishment of a forest monitoring system, and for the establishment of additional permanent sample plots for a precise evaluation of the post harvest stands, the number of stems, volume of commercial species, and their natural regeneration[1].

In the field of assessments of biomass and carbon stocks, forest biodiversityand water resources, in PNG, there seems to be only isolated research studies. This is in contrast with the prominent role played by PNG Government in the UN Forum on Forests and the UN Framework Convention on Climate Change, particularly with regard to carbon stocks issues and in support of the proposal for compensation of avoided deforestation and degradation. Various national agencies (Departments of National Planning and Monitoring, of Environment and Conservation, and of Agriculture and Livestock), and some NGOs are following up through the preparation of policy papers on carbon trade. The efforts of PNG in this field are likely to be accompanied by the international community, and this could mean, in turn, an important incentive for the implementation of the MNFI.

With regard to specific *forest biodiversity*, one source states that PNG forests contain some 11,000 vascular plant species, of which 90% would be endemic. Others consider the number of plant species in PNG to be higher, with some 15,000 to 20,000 species of vascular plants, but with a lower endemism rate of close to 60% (PNG Conservation Needs Assessment, 1993). Seventy six species of birds, 56 species of mammals, and 365 species of freshwater fishes, amphibians and reptiles are said to be endemic. In total, eighty four genera of animals would be endemic to PNG (ITTO' s Forest Sector Diagnostic Mission, April 2007).

Water catchments are probably to be considered the most threatened resource in view of the large scale deforestation and logged over activities in the hill and mountainous regions. Therefore, the MNFI should include a careful assessment in this field, designed and carried out in full cooperation with the national agency directly responsible for continental water resources.

Deforestation is without doubt one of the most controversial aspects related to the forest sector. Different definitions and estimations of deforestation exist. This is a problem well recognized by the Forest Authority : deforestation is often confused with forest degradation resulting from logging, and this contributes to the negative evaluation by international and national observers of the way FA is controlling forest exploitation. Since there are not clear

[1] From 1992 to 1999, ITTO' s project PD-162-91 contributed to the establishment of 72 permanent sample plots in logged over areas and to the development of a database for the information collected on these plots. Since 1995, the FRI Sustainable Forest Management program has established 55 more plots, which added to the ones established through the ITTO' s project makes a total of 127, out of which 9 are in undisturbed forests and 118 in logged over forests; as a result of accessibility problems, bad roads and broken bridges 11 have been abandoned, 18 are still inaccessible and 98 currently being measured every year.

rules or guidelines, nor control of land use changes [2], and with increasing rural populations, deforestation is also on the increase. A tend which is compounded by the customary system of land ownership.

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2.1.2 Land use for agriculture

Standard PNG topographic maps, and then land use and vegetation cover maps were prepared in the mid 70's with the support of the Australian Government. A series of 1:250,000 provincial forest maps was compiled around the same time. About 20 years later, maps of areas subject to significant logging activities and land use changes was prepared at the same scale by E.T. Hammermaster and D.F. Freyne through interpretation of 1996 Landsat TM imagery supported by ground and air surveys. These two sets of maps constitute the most reliable references for the calculation of deforestation rates during this 20-year period.

Garden sites are cleared of vegetation by hand and usually burned. Sweet potato (*Ipomoea batatas*) is the most important crop grown and consumed in PNG. It is a staple food for about 60 per cent of the rural population, including most people who live in the highlands. Nationwide, it contributes 30 per cent of calories consumed by rural people (Gibson,2001). This is about the same as the combined contribution of other important crops such as banana (*Musa* cultivars), sago (*Metroxylon sagu*), taro (*Colocasia esculenta*), Chinese taro (*Xanthosomasagittifolium*), yams (*Dioscorea* species), cassava (*Manihot esculenta*) and sugarcane (*Saccharum officinarum*). Coconuts (*Cocos nucifera*) and imported rice each contribute about 10 per cent of calories consumed by rural people. Sweet potato was adopted in the PNG highlands 300–350 years ago.

Figure No 1

Vegetable gardens, fresh vegetable crops

Figure No. 2

Gardens on steep slopes with *Casuarina* edges

[2] At present, there is neither national nor provincial-level effective land use planning since much of the land is held under customary land tenure or allocated to concessionaires whose sole primary interest is the timber resources. There is at present little interest in land use planning. (ITTO' s diagnosis forest sector mission, March 2007).

Over the past 130 years, a number of other crops have been introduced and adopted by the local agricultural systems. These include cassava, Chinese taro, potato (*Solanum tuberosum*), peanuts (*Arachishypogaea*) and numerous vegetables and fruits.

The most important domestic animal in PNG is the pig. Lowland villagers commonly keep sows and young pigs and allow them to mate with wild boars. In the highlands, pig husbandry is more intensive and pigs are enclosed or tethered. Nationally, the pig to person ratio ranges from around 0.1 to 1, and in the highlands there are about the same number of pigs as people. About 50 per cent of all sweet potato produced in the highlands is fed to pigs, typically the smaller tubers considered unsuitable for human consumption. Other common domestic animals are chickens and ducks. In some areas, hunting is an important source of food. Wild pigs, cassowaries, bandicoots and bats are common prey. Meat is not common in the daily diet and pig meat is usually eaten only on special occasions. Fish is an important food in many riverine and coastal areas. In some locations, people trade fish and other marine or river produce for sago, banana and root crops, rather than grow or harvest the crops themselves.

Around 20 per cent of rural people use land very intensively, to the point where land is cultivated continuously. In areas with moderate to very high agricultural intensity, production is maintained through the use of various land improvement practices such as composting, mounding, drainage, legume rotation, planted tree fallows and soil retention barriers. Most intensive agriculture occurs in productive environments and supports high population densities.

Expansion of the land area used for agriculture has been limited despite significant population growth. This has resulted in agricultural intensification. Common methods of intensification include the shortening of fallow periods, the extension of cropping periods and the adoption of more efficient crops such as sweet potato, cassava, Chinese taro and triploid banana. As agricultural intensity increases, so has the tendency for sweet potato to become the most important crop. Most of this intensification has occurred over the last three decades and it is still not clear how sustainable these more intensive gardens will be in the long term. The new crops and resultant changes in production systems have allowed people to maintain food production despite rapid population growth and the re-allocation of potential agricultural land to export tree crops. However, these large gains in productivity and particularly the gains associated with new crop introductions are unlikely to continue in the medium to long term. Likewise, if intensification is not accompanied by the adoption of suitable land management practices, agricultural pressure on land will lead to land degradation and reduced crop yields. Future increases in productivity will have to come from better management of land and crops.

Cash crop production has been skillfully integrated with food crop production. The most important cash crops are oil palm (*Elaeis guieensis*), Arabica coffee (*Coffea arabica*), fresh vegetables, cocoa *Theobroma cacao*), betel nut (*Areca catechu* or *Areca macrocalyx*) and copra (*Cocos nucifera*). Domestically marketed food has expanded over the past 40 years from a small base, to become a major source of cash income for both men and women. There is still considerable scope for further expansion of fresh food marketing.

The production of export tree crops such as coffee, cocoa, oil palm and copra is dominated by smallholders. While income per person is generally low, the sector has been operating consistently for over five decades. Fresh vegetables, sold domestically, are an increasingly important source of cash income for many rural people. There has also been a marked increase in small-scale secondary and tertiary business activities over the past 20 years. This is most apparent in the main towns and along major roads such as the Highlands Highway.

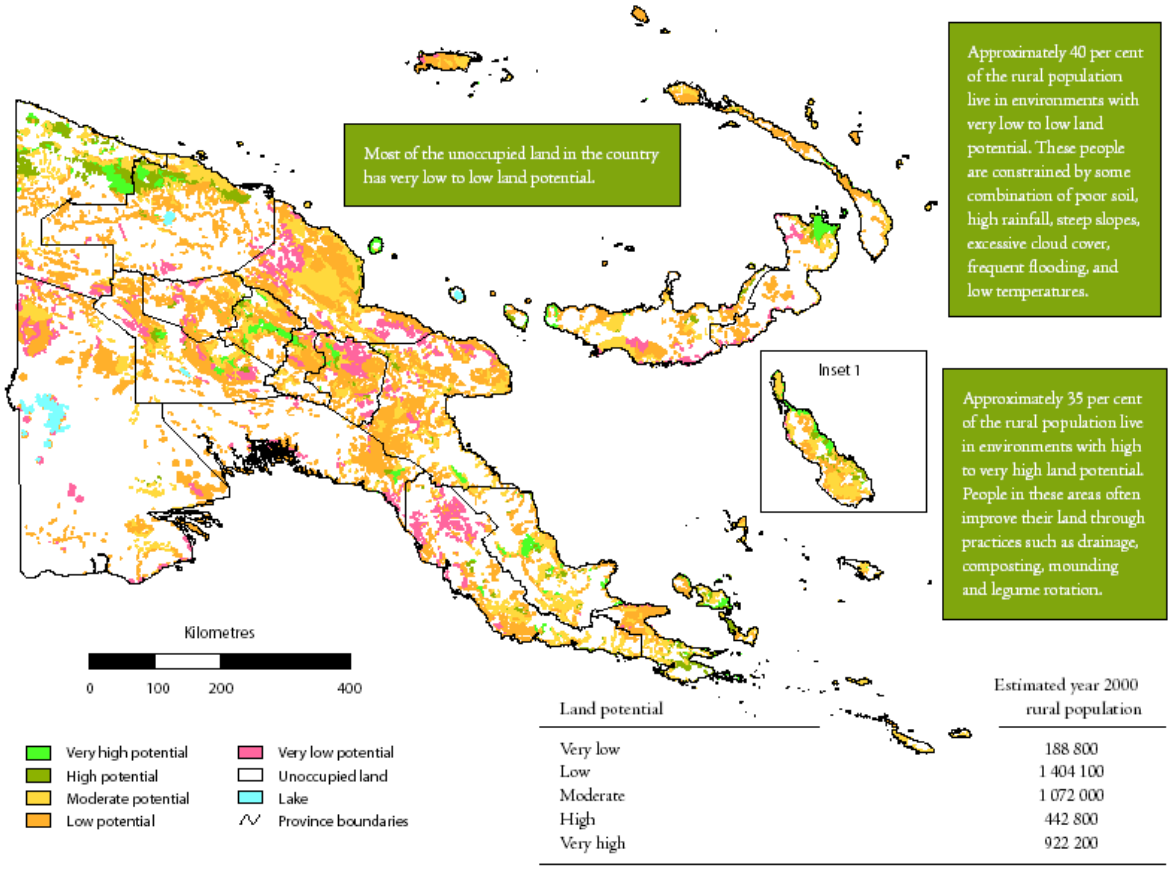
The following table provides area data on the use of land for agriculture by provinces.

Table No. 1 Use of the land for agriculture by provinces

Province	Total area (km^2)	Population 1990	Habitants per km^2 1990	Total crop land (%)	Total used land (%)	Δ (%)
Western	97,065	110,420	1	8.0	10.0	2.0
Gulf	33,847	68,122	2	11.0	12.0	1.0
Central	29,954	141,241	5	21.0	30.0	9.0
Milne Bay	14,125	158,700	11	40.0	47.0	7.0
Oro	22,510	96,239	4	19.0	22.0	3.0
Southern Highlands	25,698	317,184	12	27.0	29.0	2.0
Enga	11,839	235,561	20	31.0	37.0	7.0
Western Highlands	8,897	333,828	38	50.0	55.0	5.0
Chimbu	6,022	186,114	31	42.0	43.0	1.0
Eastern Highlands	11,006	300,515	27	50.0	53.0	3.0
Morobe	33,525	377,563	11	36.0	43.0	7.0
Madang	28,732	256,370	9	56.0	64.0	8.0
East Sepik	43,720	255,012	6	20.0	37.0	17.0
West Sepik	36,010	140,051	4	23.0	26.0	3.0
Manus	2,098	32,840	16	83.0	84.0	1.0
New Ireland	9,615	86 999	9	47.0	47.0	0.5
East New Britain	15,109	185 024	12	25.0	25.0	-
West New Britain	20,753	130,625	6	27.0	31.0	4.0
North Solomons	9,329	155,000	17	55.0	55.0	-
Total	459,854	3,567,408	(8)	25.0	30.0	5.0

The following map illustrates the distribution and density of population over the whole country.

Figure No.3 Population density distribution



Land potential	Estimated year 2000 rural population
Very low	188 800
Low	1 404 100
Moderate	1 072 000
High	442 800
Very high	922 200

2.1.3 Transport infrastructure

The road network in PNG reaches the majority of rural people. The Highlands Highway is the main arterial road in the country. It runs from Lae into the five highland provinces, and connects to Wau and Bulolo in the South, and to Madang in the Northwest. The road is used to transport cash crops such as fresh vegetables and coffee from the highlands to Lae. In return, fuel, building materials, imported food and betel nut are transported from Lae to the highlands. This road is also the supply line to the Porgera gold mine in Enga Province and to the gas and oil fields in Southern Highlands Province. Important roads also lead inland from Wewak and from Port Moresby along the coast. No road connection exists between the national capital Port Moresby and the populated areas in the highlands and on the north coast. The oil palm areas of West New Britain and Oro are well served by roads, as is the Gazelle Peninsula in East New Britain, most of New Ireland, and Bougainville.

Thousands of kilometers of minor rural roads were built between 1950 and 1970. They connect rural areas with the main road networks. Most of them were surfaced with local gravel and bridges were constructed using local timber. In the year 2000, many of these roads were in an advanced stage of deterioration. Most have lost their surfacing and, in some cases, the foundations and alignments have been destroyed. Many bridges have collapsed. In most areas, trips that once took a few hours can now take days and some roads are only passable in dry weather.

2.1.4 Land potential

Land potential has been defined using and classifying updated PNGRIS environmental data on the basis of the growth requirements for sweet potato, which is the dominant staple crop in the most part of PNG. The following factors have been used :

- annual rainfall (it affects crop growth through soil moisture availability),
- rainfall seasonality (it affects crop growth through seasonal soil moisture availability),
- temperature (it affects crop growth by influencing production rates and soil fertility cycles through the breakdown of humus; and it also sets the altitudinal limits for each crop and occasionally causes frosts which destroy crops),
- light (it affects crop growth through various triggers on plant physiological mechanisms),
- inundation (it affects crop growth and management through either destructive flooding or waterlogging),
- slope gradient (it affects crop growth and management through influences on soil erosion, drainage, nutrient leaching, solar radiation receipt and labour requirements),
- soil type (it affects crop growth and management through influences on nutrient availability, nutrient retention, rooting conditions, soil stability and water availability).

The land potential data have two limitations. Firstly, as land potential is based on data that was mapped at a 1:500 000 scale, micro- and meso- scale variation is smoothed or generalized. For example, flood-free terraces on flood plains are often narrow land units too small to be mapped at regional scales. Instead, such terrace land units would be smoothed and classified as poorly-drained flood plains. The second limitation is related to the inherent problems associated with the hard-edged classification of continuous data.

2.1.5 Agricultural pressure

Agricultural pressure is derived from the classification of land potential and agricultural intensity data. The agricultural pressure and potential classes identify land that is under-utilised and over-utilised. This is defined by mismatches between land potential and agricultural intensity. Adjustments are made to correct for the impact of cropping at different altitudes. Hanson *et al.* (2001) provide more details on the complex classification method.

Agricultural pressure levels:

- *very strong* agricultural pressure (e.g. very high agricultural intensity and very low land potential)

- *strong* agricultural pressure (e.g. very high agricultural intensity and low land potential)
- *moderate* agricultural pressure (e.g. High agricultural intensity and low land potential)
- *marginal* agricultural pressure (e.g. Moderate agricultural intensity and low land potential)
- occupied land with *no* agricultural pressure (e.g. low agricultural intensity and high land potential)
- high agricultural potential (e.g. low agricultural intensity and very high land potential)
- very high agricultural potential (e.g. No agriculture and very high land potential)

Areas with strong and very strong agricultural pressure have severe land degradation problems, while areas of moderate agricultural pressure have minor land degradation problems. Areas of marginal agricultural pressure have few land degradation problems at present, but may encounter future problems if agriculture intensifies without the adoption of suitable land management practices.

It is important to note that the agricultural pressure and potential classes are static and represent conditions in the late 1990s. As the classification parameters change, such as fallow lengths or cropping periods (which determine agricultural intensity values), the pressure classes will also change.

The driving force behind such change is related to altered demographic patterns such as migration and population growth, and improved land management practices such as the adoption of soil fertility maintenance techniques. If populations increase, resulting in the intensification of agriculture, and suitable land management practices are not adopted, then agricultural pressure will increase, for example from none to marginal or from moderate to strong. However, if suitable land management practices are adopted resulting in improved land potential, without agricultural intensification, then agricultural pressure will decrease. In practice, several input parameters can change simultaneously. These sorts of combinations of conditions can be tracked through the classification process and corrected over time where necessary.

2.2 The Forest Resource

2.2.1 Forest Resource Ownership

In Papua New Guinea, forest resource ownership, like in other Melanesian countries, but unlike in the rest of the world, belongs to the customary landowners which are the tribal groups or clans. Several families constitute a clan, several clans a village, and several villages a “community”. It is estimated that 95% of the total land area of the country is customarily owned while the remaining 5% is owned either by the State (Government), private companies, religious groups belonging to the Catholic or Protestant Churches, and individuals

Table No. 2 Ownership of forests and other wooded lands

FRA 2005 categories	Area (x 1000 hectares)			
	Forest		Other wooded land	
	1990	2000	1990	2000
Private ownership	0	0	0	0
Public ownership	977	934	139	139
Other ownership (clans)	30,546	29,198	4,335	4,335
Total	31,523	30,132	4,474	4,474

Source: FAO Global Forest Resources Assessment 2005 (FRA 2005)

The forest that grows on a piece of land is by default owned by the clans which possesses that land. In order to carry out any forest related operations such as harvesting of timber or other forest product, or reforestation, extensive consultations must take place between the State agencies including the PNG Forest Authority and the landowners often referred to as the resource owners.

Most rural people live on their own land, which they own under customary title. Customary land accounts for about 97 per cent of the total land area, but governments do not formally administer this land and title documents are not issued. Some formal settlement schemes have been developed, particularly for development of cash crops such as oil palm. In that case, local people do have formal title on land and are eligible for bank loans to fund housing and cash crop development. While some settlement schemes have been successful, especially in West New Britain and Oro provinces, many others have failed due to lack of infrastructure and support for the settlers.

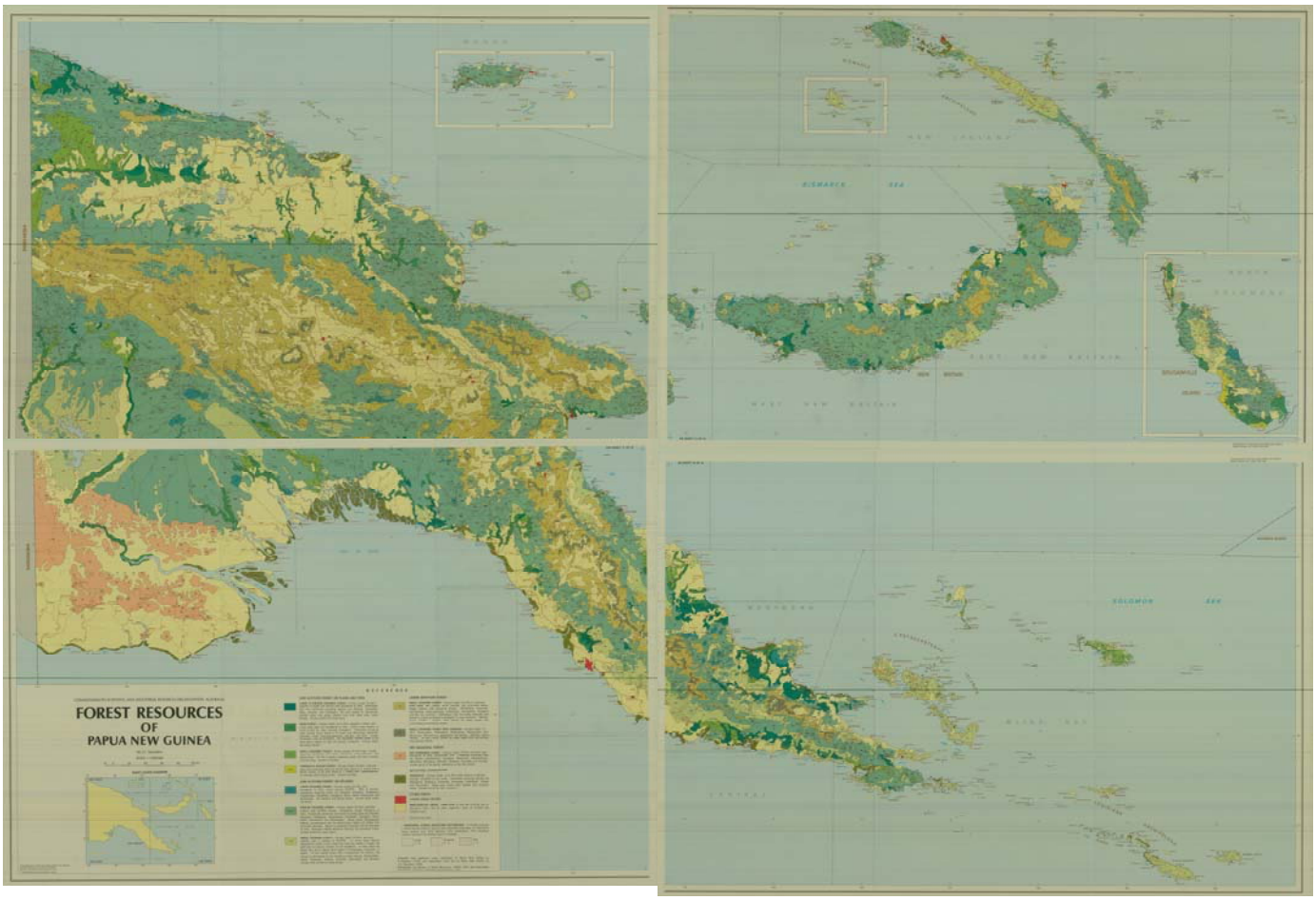
2.2.2 Vegetation Classification of PNG

Papua New Guinea is situated between 2 and 12 degrees south of the equator and thereby falls within the zone of wet and moist tropical forests. Due to its location, the country in general gets an average of 3,000mm of rainfall per year that influences the vegetation to a large extent. But, parts of the country receive less than this.

PNG's vegetation is currently classified by the PNG Forest Authority based on the structural formation of the vegetation. Six classes have been distinguished and these are: Forest, Woodland, Savannah, Scrub, Grassland, and Mangrove.

Within these 6 structural formations, 59 vegetation classes have been differentiated, as shown below in the Forest Resources Map (Sanders 1993).

Figure No. 4 Vegetation map of PNG 1993



Source: Saunders 1993

One estimate of the total number of vascular plant species is between 15,000 to 20,000, of which over 2,000 are tree species. Over 400 of these latter are utilised in one way or another, including several for harvesting for log exports and in-country processing.

Some of the main genera of commercial tree species that are exported are : *Homalium, Pometia, Calophyllum, Eucalyptus, Terminalia, Dillenia, Toona, Buchanania, Canarium, Anistoptera, Endospermum, Octomeles, Intsia, Syzygium,, Celtis, Burckella, Mastixiodendron, Dracontomelon, Canarium.*

The official national forest classification used in PNG, is presented in the chart showed below :

Forest Type	Forest sub type	Characteristics
Low altitude forest on plains and fans	*Large to medium crowned lorest* (Pl)	The canopy of this forest type is generally 30-35 m high and is irregular in both height and closure. Emergent trees often attain, and sometimes exceed, 50 m in height accentuating the unevenness of the canopy. Stem diameters gene rally range from large to small but very large stems are not uncommon. The floristic composition is very mixed with no single-species dominance. Tree species that are almost invariably present are *Pometia pinnata, Octomeles sumatrana, Ficus* spp., *Alstonia scholaris* and *Terminalia* spp. Other commonly occurring genera include *Pterocarpus, Eucalyptopsis, Artocarpus, Planchonella, Canarium, Elaeocarpus, Cryptocarya, Celtis, Dracontomelum, Dysoxylum, Syzygium, Vítex, Spondias* and *Intsia.* The proportion of deciduous trees is higher in areas with a marked dry season. This forest occurs on well to imperfectly drained alluvial plains and gently sloping, undissected fans where flooding does not occur or is short and infrequent. It is often, but not exclusively, associated with volcanic landforms. The largest areas are found on the foot slopes of Mt Lamington, the Gorapu Mountains, the north coast of New Britain and east of Marshall Lagoon
	Open lorest	This forest has an uneven canopy up to 30 m in height with many, often large, gaps revealing a lower tree stratum. Large crowned emergents often reach. 40 m, rising above a canopy comprising medium to small crowns. Large to very large stem diameters predominate. The floristic composition is very similar to the large to medium crowned forest with *Planchonia, Bischofia, Cananga, Intsia, Teysmanniodendron, Nauclea* and *Vitex* featuring among the more commonly occurring genera. Locally, *Octomeles sumatrana* may be a common emergent in frequently flooded areas. Deciduous trees are more frequent in areas with a marked dry season. The forest occurs on the lower and middle courses of the major rivers, on low levees, scrolls and plains subject to frequent short duration flooding, on back plains subject to prolonged wet-season inundation, and on fans where impeded drainage occurs. The water table remains at or near the surface for most of the year.
	Small crowned forest (Ps)	This forest type has a dense even canopy of small crowns 25-30 m in height with no emergents. Stem diameters are generally small to very small. Locally occurring dominants may be Dipterocarps, *Casuarina, Intsia* or *Campnosperma.* The forest occurs on flat to gently undulating lowland plains and fans where soils are often bouldery, gravelly and/or poorly drained. *Casuarina* colonises bouldery fans on the upper courses of major streams, forming a single species stand of trees. As the fan stabilizes, and the forest ages, mixed species invade the forest. Dipterocarp forest occurs on flat to gently undulating plains and fans, on gravelly and often poorly drained soils. *Campnosperma,* often with an understorey of sago, occurs on swampy sites. *Terminalia brassii forest : t*he forest has an even to slightly undulating canopy of large woolly crowns 30-35 m in height. The canopy is dense in a single-species stand, but may be more open when associated with *Campnosperma.* The majority of stems range from very large to medium diameter. The forest occurs on swampy fans and plains in flowing water, and sometimes along the banks of minor streams which are subject to frequent flooding. The latter occurrences are too small to be mapped, usually consisting of a single or double line of trees. The forest is confined to the island of Bougainville especially in the south and south-eastern regions

Low altitude forest on plains and fans	*Medium crowned forest* (Hm)	The canopy of this forest type is 25-30 m in height, is generally only slightly uneven and has a 60-80% crown c1osure. Except for *Arauearia,* which can reach a height of 70 m, emergents rarely exceed 40 m in height. Very large stem diameters are rare except for *Araucaria.* Floristically the forest is very mixed. Frequently occurring genera are *Pometia, Canarium, Anisoptera, Cryptocarya, Terminalia, Syzygium, Ficus, Celtis, Dysoxylum* and *Buchaniana* amongst many other commonly occurring trees. Some trees, such as *Koompassia, Dillenia, Eucalyptopsis* and the dipterocarps *Vatiea* and *Hopea,* are common to abundant in certain regions but absent from others. *Homalium* is a frequently occurring tree in New Britain, but may be rare to occasional elsewhere. Scattered *Araucaria* may be present in some are as and in others it may form dense staods. This forest type is found in a wide range of landform, slope, rack type, soil, climate and altitude up to 1400 m. Consequently the structure and floristic composition will vary widely over the full range of sites. At low altitudes, and adjacent to a plain or fan, the forest is almost identical to the large to medium crowned forest except for its topographic position. At the higher end of its altitude range the forest forms a broad ecotone and includes many trees normally found in the lower montane forest. On steep and unstable slopes, the canopy is more open, more irregular and has smaller crowns. In areas of lower annual rainfall (1200-1800 mm) and a marked dry season, the canopy contains a larger proportion of deciduous and semi-deciduous trees, and often inc1udes scrambling bamboo
	Small crowned forest (Hs)	This forest has a relatively even canopy 20-30 m in height, with a 60-80% closure and no emergents. Large stem diameters are rare, the majority of trees falling into the medium to small c1asses. The forest may be either a mixed forest which is poorly developed due to adverse site or climatic conditions, or a forest in which a small crowned tree predominates in the canopy. The mixed small crowned forest occurs on steep terrain with skeletal soils, and on low hilly to undulating terrain with poor, strongly weathered, acid clay soils. The species present in the canopy are similar to those of the medium crowned forest. In areas where there is a marked dry season, deciduous and semi-deciduous trees such as *Garuga floribunda, Brachychiton carruthersii, Intsia bijuga, Terminalia* spp., *Protium macgregorii* and *Sterculia* spp. form a significant component in the canopy. In areas subject to severe seasonal water stress, the forest is often less than 20m tall and the deciduous trees *Gyrocarpus americanus, Bombax ceiba, Albizzia* sp., *Maniltoa* sp., *Adenanthera pavonina* and *Erythrina* sp. predominate in the canopy. The species that form monospecific stands of small crowned forest are *Gymnostoma papuana, Castanopsis acuminatissima* and *Hopea papuana. Gymnostoma papuana* is typical of thin rocky soils on limestone and ultra-basic rck up to 1400 m altitude. *Castanopsis acuminatissima* dominated forest occurs on ridge crests and upper slopes up to 1900 m altitude. *Hopea papuana* dominated forest forms a thin-stemmed, tall, dense forest below 450 m altitude, mainly at the eastern end of the PNG mainland.
Lower montane forest	*Small crowned forest* (L)	This forest has an even to slightly undulating canopy 20-30 m in height. Canopy closure varies from dense to slightly open. The canopy height decreases with increasing altitude. Stem diameters are generally medium to small. However, stands of large diameter, over-mature *Nothofagus* do occur. *Araucaria* can occur in dense to scattered distribution as an emergent to 40 m in height. Frequently occurring canopy trees are *Nothofagus, Lithocarpus, Castanopsis, Syzygium, llex,* Lauraceae, Cunoniaceae, Elaeocarpaceae and conifers. *Nothofagus* can also grow gregariously on ridge crests, limestone pinnacles and doline rims, and sometimes on plateaus and upper

		slopes. The forest occurs throughout the mountain ranges in the 1400-3400 m altitude range. With increasing altitude the height of the canopy becomes lower, stem diameters and crowns smaller, and the floristic composition changes.
Lower montane forest	*Small crowned forest with conifers*	This forest has a canopy 15-25 m in height with emergent conifers. Crowns are small to very small and the canopy is dark toned on aerial photographs. Although the stems of the associated broadleaved species are generally small in diameter, the coniferous stems often exceed 50 cm diameter. *Papuacedrus, Phyllocladus, Dacryocarpus* and *Podocarpus* are the most frequent canopy and emergent trees, with Myrtaceae. Myrsinaceae. *Carpodetus* and *Drimys* common broadleaved associates in the canopy. The forest occurs in many places in the mountain ranges above 2400 m altitude.
Dry seasonal forest	*Dry evergreen forest* (D)	This forest has a fairly open canopy 20-25 m in height with emergents to 30 m and occasionally to 40 m. Stems are often low-branched and crooked. Commonly occurring trees are *Acacia, Lophostemon, Syzygium, Rhodamnia, Xanthostemon, Maranthes, Mangifera, Halfordia, Flindersia, Oreocallis* and *Grevillea.* The forest is restricted to south-west PNG in a low rainfall area (1800-2500 mm), and occurs on well to imperfectly drained, very gently undulating to low hilly terrain.
Estuarine communities	*Mangrove* (M)	This forest type covers a wide range of vegetation communities from forest to low scrub about 1 m tall. Under optimal conditions, the forest has a dense, small crowned canopy of trees up to 30 m tall. Because the mangrove species are sensitive to changes in the flooding regime and the salinity of the water, they commonly grow in distinct zones, each zone dominated by a different species or set of species. This gives a banded pattern of tones on an aerial photographs. The main mangrove tree genera include *Rhizophora, Bruguiera, Avicennia, Sonneratia, Ceriops, Lumnitzera, Xylocarpus* and *Excoecaria. Nypa* palm, included in the mangrove communities, is characteristic of areas subject to daily tidal flooding with brackish water. Mangrove communities occur on estuaries, tidal flats, and muddy shores in a tidal environment. They may grow on peat, clay, sand or coral detritus. Although found along the coast of the mainland and islands of PNG, mangrove communities attain their maximum development on the deltas of rivers draining into the Gulf of Papua.

2.2.3 Forest cover and deforestation process

Two-thirds of PNG is under forest cover. The official timber harvest is well below the estimated national sustainable timber yield. On average, each citizen has rights over about 6.4 hectares of forest. However, the majority of people still live in extreme poverty. The challenges are substantial if SFM is to be achieved.

Customary land ownership is guaranteed by the PNG Constitution and is the key factor influencing the use of the forests; 97% of the land is held as communal or clan commons. The determination of a Permanent Forest Estate (PFE) is difficult in PNG given its land ownership and tenure system. Nevertheless, ITTO estimates that the country has about 10.5 million hectares of forests that might be considered permanent ; these include 8.7 million hectares of forest over which timber rights have been acquired (production PFE), 1.7 million hectares allocated for protection and about 80,000 hectares of timber plantations[3].

The tables below provide data on the country forest cover, derived from the FAO Global Forest Resources Assessment reports (FRA 1990, 2000 and 2005) and from the Papua New Guinea country report of the Global Forest resources Assessment (FRA) 2005.

Table No. 3 Forest cover in PNG

Extent of forest and other wooded land			
FRA 2005 categories	Area (1000 hectares)		
	1990	2000	2005
Forest	31,523	30,132	29,437
Other wooded land	4,474	4,474	4,474
Forest and other wooded land	35,997	34,606	33,911
Other land	9,289	10,680	11,375
Total land area	45,286	45,286	45,286
Inland water bodies	998	998	998
Total area of country	46,284	46,284	46,284

[3] ITTO, 2006 . Status of Tropical Forest Management 2005

Source: FAO, Global Forest Resources Assessment (FRA) 2005 –
Papua New Guinea country report

Table No. 4 Forest cover according to forest types (in thousand ha)

Vegetation classes	1975	1996
Low altitudinal forest on plains and fans	3,260.8	2,875.1
Low altitude forest on uplands	17,946.8	17,171.1
Lower montane forest	8,109.9	7,745.4
Montane forest (above 3000 m)	177.4	177.4
Dry seasonal forest	1,062.9	778.6
Littoral forest	86.5	86.5
Seral forest	171.0	46.1
Swamp forest	2,250.3	1,267.3
Mangrove	601.6	550.0
Woodland	2,693.8	2,693.8
Savannah	1,190.6	1,190.6
Scrub	601.4	601.4
Grassland	3,241.1	3,241.1
Other land uses	5,015.8	7,985.5
Total PNG	46,409.9	46,409.9

Source: FAO, Global Forest Resources Assessment (FRA) 2005 –
Papua New Guinea country report

Table No. 5 Forest cover by actual use (in thousand ha)

Forest use classes	% (2005)	1990	2000	2005
Production	14.7	4,634	4,420	4,323
Future production	18.1	5,680	5,417	5,298
Reserve forest	37.1	11,665	11,125	10,880
Protection forest	1.3	410	391	383
Afforestation and Salvage forests	6.4	2,009	1,916	1,874
Other areas	22.5	7,062	6,735	6,587
Total PNG	100.0	31,460	30,005	29,345

Source: FAO, Global Forest Resources Assessment s(FRA) 2005 –
Papua New Guinea country report

Table No. 6 Forest cover by provinces (in thousand ha)

Province	Total land area	Gross forest area	
		1975	2006
Western	9,845.2	6,675.9	6,162.8
Gulf	3,480.1	2,659.5	2,457.5
Central	2,987.2	2,015.5	1,735.8
Milne Bay	1,426.4	1,080.0	909.4
Northern	2,277.2	1,726.7	1,553.8
Southern Highlands	2,574.8	2,009.1	1,875.8
Enga	1,182.4	750.4	716.6
Western Highlands	914.1	509.2	414.0
Simbu	913.4	393.9	351.5
Eastern Highlands	1,120.5	558.8	537.2
Morobe	3,393.3	2,210.0	1,963.1
Madang	2,909.5	2,115.6	1,899.5
East Sepik	4,381.3	2,103.3	2,037.2
West Sepik	3,605.4	3,236.4	2,915.7
Manus	215.0	149.5	79.9
New Ireland	961.0	792.1	432.0
East New Britain	2,045.6	1,312.6	983.9
West New Britain	1,534.4	1,815.0	853.4
North Solomons	943.3	708.3	708.3
Total PNG	46,710.1	32,821.8	28,587.4

Source: FAO, Global Forest Resources Assessment s(FRA) 2005 – Papua New Guinea country report

2.2.4 Rates of logging

The Forest Inventory Mapping (FIM) system of PNG is compiling data on forest logging. The following table below gives the forest areas logged over from 1975 to 2005 by provinces.

According to these data, 4.13 millions ha of forests have been logged over between 1975 and 2005, representing 12.6 % of the total forest area of 1975, and average logged over area countrywide annually of 138,000 ha. The extent of logged over area varies considerably according to the provinces. West New Britain, Manus, New Ireland and East New Britain have had as much as 47.5, 46.6, 45.5 and 25.0 % respectively of their forest area of 1976 logged during this 30-year period. On the other hand, Eastern Highlands and other highlands provinces, East Sepik, Western and Gulf have the lowest rates of logging. It is in these last three forest-rich provinces that pressure for logging is likely to be the most

acute. This is one important reason for giving them a priority time wise in the planning of the MNFI in order that the Forest Authority be rapidly able to master forest development.

It is interesting to note that these rates of forest logging in the provinces are not correlated to the extent of their forest cover : for instance, one of the highest logging rate is that of Manus (46.6%) which had only about 100,000 ha of forest in 1975, compared with Southern Highlands with a forest cover above 6 million ha and a logging rate of only 7.7%.

Table No. 7 Logged over areas 1975 - 2005 (in thousand ha)

Province	Land area	Forest area (1975)		Logged over area (1975-2005)	
		gross value	adjusted value		%
Western	9,845.2	6,675.9	5,626.3	513.1	7.7%
Gulf	3,480.1	2,659.5	2,4064.0	202.0	7.6%
Central	2,987.2	2,015.5	1,882.1	279.7	13.9%
Milne Bay	1,426.4	1,080.0	856.2	170.7	15.8%
Northern	2,277.2	1,726.7	1,571.4	172.9	10.0%
Southern Highlands	2,574.8	2,009.1	1,904.5	133.3	6.6%
Enga	1,182.4	750.4	723.2	33.9	4.5%
Western Highlands	914.1	509.2	453.8	95.2	18.7%
Simbu	913.4	393.9	368.2	42.5	10.8%
Eastern Highlands	1,120.5	558.8	530.5	21.7	3.9%
Morobe	3,393.3	2,210.0	2,030.2	246.9	11.2%
Madang	2,909.5	2,115.6	1,634.5	216.1	10.2%
East Sepik	4,381.3	2,103.3	1,886.7	66.1	3.1%
West Sepik	3,605.4	3,236.4	3,037.1	320.6	9.9%
Manus	215.0	149.5	105.5	69.6	46.6%
New Ireland	961.0	792.1	728.2	360.0	45.5%
East New Britain	2,045.6	1,312.6	1,223.5	328.7	25.0%
West New Britain	1,534.4	1,815.0	1,696.1	861.5	47.5%
North Solomons	943.3	708.3	566.3	0 (?)	0 (?)
Total PNG	46,710.1	32,821.8	29,231.3	4,134.4	12.6%

2.2.5 Deforestation

The compilation of total forest cover estimates of 1975, 1990, 1996, 2000 and 2005 (see section 2.2.2 above) gives an average of deforested area of 144,000 ha per year over the 30-year period from 1975 to 2005, i.e. an average annual deforestation rate (in compound interests) of 0.46%. The table below shows the results of this compilation.

Table No. 8 Deforestation rates 1975-2005 (in thousand ha)

Year	Total forest cover	Deforested area	Annually deforested area	Annual deforestation rate (%)
1975	33,667.2			
1975 -1990		2,207.2	147.15	0.451
1990	31,460.0			
1990 - 1996		762.5	127.08	0.418
1996	30,697.5			
1996 -2000		692.5	173.13	0.569
2000	30,005.0			
2000 - 2005		660.0	132.00	0.443
2005	29,345.0			
1975 -2005		4,322.2	144.07	0.457

This average deforestation rate is of the same order of magnitude as those reported by the Forest Authority to FAO. However, after checking these latter with the Manager of the FA Division of Planning, it appears that they correspond not to the area deforested every year, but to the forest area logged annually.

Deforestation rates vary significantly according to the provinces. Population density is without doubt one of the most influent causes of deforestation rates, in addition to the level of development of the local populations, and accessibility. Rural populations with very limited resources and poor livelihood conditions, are forced to clear the forests for practicing traditional shifting cultivation to eke out a subsistence. At present, it seems that this deforestation *factor* is by far the dominant one (90% ?). This may change to a certain extent in the future with the development of cash crops on a large scale, as proposed in the recently approved National Agricultural Development Plan.

The social and economic *underlying causes* (not to confuse with the factors) of deforestation are better understood by comparing the socio-economic situation of provinces with low and high deforestation rates. This is made in Annex 1 , with the presentation of the situation of two provinces with a low rate of deforestation (Western and Enga) and of two others with a high rate of deforestation (New Ireland and Manus).

The Remote Sensing Center of the University of Papua New Guinea (UPNG RSC)[4] has just completed a major study of the forest cover of the country. The RSC is a teaching and research facility, providing access to remotely sensed satellite data and GIS products on land cover and land use in the country, and services in Geographic Information Systems (GIS) and Remote Sensing to the Government of PNG and the private sector, in addition to offering GIS and Remote Sensing undergraduate courses and supervising postgraduate degrees.

The study is entitled *The State of the Forest Cover of Papua New Guinea – Mapping the extent and condition of forest cover and measuring the drivers of forest change in the period 1972-2002* [5]. It has been carried out under the leader ship of Dr. Phil Shearman with the support of the European Union, the German Development Service and the United Nations Development Programme. The involvement of the Forest Authority seems to have been, at most, negligible.

The study created a digitized land cover map from the 1972 Australian Army 1:100,000 vegetation maps (with the following classes : forest – including mangroves and swamp forest -, scrub/gardens, grassland and water)[6]; as well as a 2002 digitized land cover map using very high resolution satellite imagery (SPOT 4 and 5, Landsat ETM+) through a combination of "automated digital pattern recognition" and "expert visual interpretation", with the following simplified land cover classification : (tropical rain) forest, swamp forest, dry evergreen forest, mangrove, scrub, herbaceous swamp, grassland, non-vegetation and water. For change estimation, the number of classes was reduced to 2, forest and non-forest. Areas of forest change were detected by superimposition of the 2002 land cover map with the 1972 vegetation map.

The final report has been put on line[6] in April 2008, and prefaced by the Honorable Belden Namah, MP, Minister of Forests. The following conclusions can be singled out :

- forest change in PNG has rapidly and dangerously increased during the last decade. The rate of deforestation is much higher than the officially reported figure (150,000 ha per year, or 0.43% annual deforestation rate). The author estimates that the actual rate of *deforestation* ***plus*** *degradation* around 2002 is 1.41 % ;

- primary forest accessible to mechanized harvesting was *deforested* ***or*** *degraded* at an annual rate of 2.6% in 2001 (some 362,000 ha). *It must be noted in this respect that this figure, either in absolute or relative (percentage) terms, should not have been given as it has no internal consistency: indeed, it mixes deforestation and forest degradation, two different processes resulting in completely different*

[4] UPNG RSC website : http://gis.mortonblacketer.com.au/uPNGis/about.htm

[5] Reference : *The State of the Forest Cover of Papua New Guinea – Mapping the extent and condition of forest cover and measuring the drivers of forest change in the period 1972-2002,* by Shearman, P.L., Bryan, J.E., Ash, J., Hunnam, P., Mackey, B. and Lokes, B., University of Papua New Guinea, 2008
http://gis.mortonblacketer.com.au/uPNGis/Downloads/State%20of%20Forests%20of%20PNG.pdf

[6] The study did not use the vectorization made from the 100,000 1972-75 aerial photographs and topographic maps in the FIM system, as it has been considered that "the boundaries between forest and non-forest cover were delineated at too low a resolution for them to be used as a baseline against which processes operating on a fine local scale, such as subsistence agriculture and logging, could be measured".

consequences for the forests, and may be construed by laymen or interested groups as just deforestation. If the current trend of *deforestation and degradation* continues, 83% of the accessible primary forest of 1972 would be cleared by 2021.

- the PNG's globally important montane forest was significantly reduced through slash and burn process, specially during the drought periods.

According to the same report, the total forest cover of the whole country in 2002 was approximately 33 million of ha (32.99 million ha exactly), i.e. 71.5% of the total land area of the country. Estimation of degraded forest area being about 2.92 million ha (all considered to be in lowland rainforest), the total area of non degraded forest would be approximately 30.02 million ha (of which 15.72 million ha in lowland rainforest). The distribution of the total area of 32.99 million ha in 2002 of forest non degraded and degraded among the main forest types has been found to be the following :

- lowland rainforests cover a total area of 18.64 million ha (56.5%), of which 2.92 are considered degraded;
- lower mountain rainforests, 8,91 million ha (27.0%) ;
- upper mountain rainforests, 0.70 million ha (2.1%) ;
- swamp forests, 3.41 million ha (10.3%), mainly in the East and West Sepik, Western and Gulf provinces ;
- dry evergreen forests, 0.75 million ha (2.3%) ; and
- mangrove forests, 0.58 million ha (1.8%).

One of the many observations these area estimates by forest types suggest is that the formations on waterlogged and tidal lands, i.e. swamp forests and mangroves, and where field inventory is relatively more difficult and costly, cover a significant part of the forested land.

The figure of total forest cover reported by the Forest Authority for 2000 is 30,005,000 ha (based on images before 2000), and 29,345,000 ha for 2005. Whatever the actual figures, assessment of deforestation requires priority attention from the Forest Authority and the other concerned government agencies. The uncertainty about these figures is another reason for PNG to embark as soon as possible on a true (multipurpose) NFI. This objective of the MNFI will have to be a priority one, the more so as PNG is an active supporter of the "avoided deforestation" concept within the framework of the negotiations for a follow up to the Kyoto Protocol beyond 2012. Moreover, some forest ecosystems are threatened by increasing deforestation and high impact logging activities, both trends needing to be precisely evaluated.

To that end, the use of harmonized, internationally agreed definitions of deforestation and forest degradation is imperative. Deforested and degraded forest areas are defined as follows by the FAO-FRA protocol adopted by PNG and all other tropical countries :

- *degraded forest*: primary forest slightly to moderately disturbed within the range of common natural disturbances ;

- *degraded forest land* : forest with drastic and repeated disturbances with complete removal of the forest stand, loss of top soil, and change in microclimate;

- *deforested area*: the conversion of forest to another land-use or the long-term reduction of tree canopy cover below the 10% threshold.

Taking in consideration these definitions, it is obvious that estimates of deforested areas should not include, nor be merged with those on degraded forest as already stressed.

Methods to identify forest deforestation and degradation use high resolution satellite data. Radar data can potentially detect degradation though this application needs further development (Saatchi et al., 2007). Visual interpretation of high resolution data can detect canopy damage in some cases. Spatial patterns of log landings (patios for logging trucks and river landings) and identification of other infrastructure (e.g. roads and rivers used for transportation) has been a successful approach for identifying degradation (Asner et al., 2005).

Deforestation and forest degradation are mapped with different techniques, varying from visual interpretation to advanced image processing algorithms. For example Asner et al. (2005) developed automated algorithms to identify logging activity with Landsat data. Detection of active fires with thermal data can also indicate presence of subsequent burn scars (Roy et al., 2005). An effective solution for identifying degraded forests from proximity to infrastructure has recently been proposed to take advantage of existing observational approaches given the current limitation in knowledge on the spatial distribution of biomass (Mollicone et al., 2007). Results in the research domain have demonstrated capabilities for monitoring degradation and show promise for implementation in operational monitoring systems (e.g. Souza and Barreto, 2000; Matricardi et al., 2001; Asner et al., 2005; Souza and Roberts, 2005; Mollicone et al., 2007). Annual monitoring may be needed to capture the dynamics associated with degradation. As is the case with deforestation monitoring, the key constraint is data continuity of high resolution imagery.

More on the methods for the assessment of deforestation and forest degradation is given in section 5.1 below where the proposed area and area change assessment for Papua New Guinea is presented as part of the overall MNFI methodology.

2.3 The state of forest inventory in PNG

2.3.1 Before the mid 80's

The first natural resources survey programme in PNG was conducted by the Division of Land Research of the Australia's Commonwealth Scientific and Industrial Research Organisation (CSIRO) between 1953 and 1972 on a regional basis for the Department of Primary Industry (now Department of Agriculture and Livestock). They covered more than half of the New Guinea island part of the country plus the island of Bougainville.

Before the Independence, the Australian Army conducted an aerial survey which produced black-and-white "SKAIPIKSA" aerial photographs at the average scale of 1:120,000. The aerial photographic coverage allowed for the drawing of the 1:100,000 Topographic Survey series of maps for the entire country (using the Universal Transverse Mercator projection with the Australian Map Grid and the Australian Geodetic Datum of 1966).

The regional resources surveys used a "land form" classification system and were based on interpretation of aerial photography and reconnaissance ground sampling. They "were designed to provide rapid and large area information on the natural resources of PNG, both in inventory and map form, for the initial assessment of agricultural potential and limitations" [7].

These surveys "did not provide resource information on the whole of PNG on an individual disciplinary basis"[8], and were supplemented later on by "a research programme to determine the nature, variability and distribution of each of the natural resources for the country as a whole (which) resulted in a series of publications ... (and) maps at a scale of 1:1,000,000 ... (Geomorphology Map of PNG, Löffler 1974, Vegetation Map of PNG, Paijmans 1975). The latter two maps were based on extrapolation of the previous regional survey data using air photography, with small gaps filled with SLAR[9]. Finally, four definitive reference books were produced covering the vegetation (Paijmans 1975[10]), geomorphology (Löffler 1977), soils (Bleeker 1983) and climate (McAlpine et al. 1983) of PNG"[15].

[9] Side Looking Airborne Radar (survey and imagery).

[10] *Explanatory Notes to the Vegetation Map of Papua New Guinea*, by K. Paijmans, Land Research Series N° 35, Commonwealth Scientific and Industrial Research Organization, Australia, 1975 (with four map sheets at 1:1,000,000).

During this period, particularly in the 60's and 70's, several timber inventories were carried out prior to allocation of timber rights and for pre-investment purposes (e.g. in Ioma area in the Northern province[11]; in Central Province[12]). Forest resources information, essentially on Forest Development Areas, timber rights, permits and licenses, plantations and wood products, was presented in National Progress Reports by the Department (then Office) of Forests, and by annual editions by the same entity of the publications "Compendium of Statistics" and "Facts & Figures".

2.3.2 After the mid 80's

Phase I of the Papua New Guinea Resources information System (PNGRIS)

The consistent and comprehensive body of information on natural resources available in the early 80's was not integrated and did not allow "to relate climate to agricultural land use, or soils to forests, or to investigate the distribution of natural resources in relation to population"[15].The need was felt therefore to develop a computer system to facilitate data storage, retrieval and analysis. The work was carried out and the system installed in the PNG Department of Primary Industry, and later on in the Department of Forests, with the technical and financial assistance of CSIRO and the Australian Agency for International Development between 1981 and 1986. The system was made up of a map base showing the location of the basic spatial units (Resources Mapping Units or RMU), and of a database comprising the inventory data describing the natural resources, land use and population distribution of each RMU. This latter is "an area of land that has the same pattern of landform, geology, climate, hydrology and soils ... (which are) physical resource attributes ... (and is) time independent (i.e. unlikely to change except over the long term)"[15].

The development of the computer system constituted the main activity of Phase I of PNGRIS, and is presented in the publication *Handbook for Land Resource Survey Methods in Papua New Guinea*[13]. Applications to agriculture and forestry are presented respectively in the two following publications (with maps): *Agricultural Land Use of Papua New Guinea. Explanatory Notes to Map* (1993)[14], and *Forest Resources of Papua New Guinea. Explanatory Notes to Map* (1993)[22].

Phases II and III of PNGRIS and the Forest Rapid Resource Appraisal

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[11] Reference : *Appraisal of a Proposal for the Construction of an Integrated Pulp, Sawnwood and Veneer Industry in the Ioma Area,* FAO N° TA 3283, Rome, 1974.

[12] Reference : *Forest Development Study, Central Province – Papua New Guinea, Mission report : the Forest resources and Their Industrial Development*, FAO N° TCP/PNG/8801, Rome, 1979.

[13] PNGRIS Report No 1, by Basher, L.R., Trangmar, B.B., Rijkse, W.C., 1995.

[14] PNGRIS Publication no. 1, and Natural Resources Series no. 9. (+ maps, scale 1: 1,000,000), by Saunders, J.C., Commonwealth Scientific and Industrial Research Organisation for Australian International Development Assistance Bureau,1993.

In the early 90's, "developments in microcomputer technology provided the means for upgrading the system in terms of both power and user friendliness, (and) in particular ... to incorporate a computer mapping system in PNGRIS to replace the previous manually produced maps"[15].

At the same time, and in view of the significant changes in land use and the rapid development of logging activities, the need was felt of a nationwide forest resources assessment, as part of the procedures to develop national and provincial forest action plans in accordance with the recently approved Forestry Act (1991).

Again with Australian support, two projects, the PINGRIS Phases II and III, and the Forest Rapid Resource Appraisal were carried out between 1992 and 1995. The PINGRIS handbook was revised and published in 1995 (*Papua New Guinea Inventory of Natural Resources, Population Distribution and Land Use Handbook*, 2nd edition, already quoted, see footnote 1), and a forest and vegetation mapping at 1:500,000 "was incorporated in the existing PNGRIS ... which was then used to develop an interim forest inventory and resource appraisal for use in the preparation of the initial action plans[15,23].

2.3.3 The Forest Inventory Mapping System (FIM or FIMS)

A second digital mapping system for forest management covering the whole country, the Forest Inventory Mapping System (FIM or FIMS), was later on carried out at scale 1:100,000 by air photo-interpretation. Its objective was described as "to meet the longer needs for detailed comprehensive forest inventory data"[23]. However, this exercise, like all previous ones, was essentially geared to assist in the sound management of timber production from the national forest resources, and had no other priority purposes linked to other forest goods and services.

The information generated by this programme is considered to replace that produced by the Forest Rapid Resource Appraisal carried out earlier as an interim exercise. The mapping and other procedures are given *in Forest Resources and Vegetation Mapping of Papua new Guinea* by E.T. Hammermaster and J.C. Saunders[15]. In the summary statistics extracted from the FIM system[23], J. McAlpine and J. Quigley make it clear that *the resulting FIM is an information system for forest management and planning ... of national coverage ... not at a scale suitable for use at the actual operational logging level (e.g. in the production of annual logging plans for a concession) ...* (but that it) *has been designed as capable of linking to or incorporating this level of information when it becomes available.* The methodology and products of the FIM(S) are best described iby them in the following excerpts from their publication:

The FIM is centred on a forest resource and vegetation mapping prepared at scale 1:100,000 and covers the whole country. The mapping is based on an air photo-interpretation of the 1972-75 SKAIPIKSA coverage *of similar scale. This information drew on data and experience gained over the earlier long term CSIRO and Department of Forests (now National Forest Service) mapping and field survey program.*

[15] PNGRIS Publication N°4, 1995, Commonwealth Scientific and Industrial Research Organisation for Australian Government Overseas Aid Program, 1995, Canberra, 294 pp. and one map sheet.

As commercial logging activity in PNG until 1975 had been minimal, this mapping was adopted in the FIM as the baseline for forest resource information*. The 1:100,000 forest mapping was compiled on the standard PNG topographic series of the same scale ... . This mapping was* polygonized *in MapInfo version 4.5 (GIS software) using the same projection (UTM) and grid (Australian Map Grid) of the topographic maps, but adopting the later Australian Geodetic Datum of 1984 (instead of that of 1966).For ease of use, it was also compiled at 1:250,000 as a series of film overlays and these are held at the National Forest Service.*

The Forest Mapping Unit (FMU) is the basic mapping unit drawn as a polygon with a code corresponding to the vegetation/forest type (in total, 35 forest types plus 23 additional vegetation types, sometimes mixed when the vegetation patterns are spatially complex). An indication is given of the degree of disturbance. An additional broad classification is made in 42 forest zones with similar, and only indicative, species composition and gross volumes.

Other layers were added to the FIM, such as:

- limits of concession areas (Timber Rights Purchase Agreements, Forest Management Areas, Local Forest Agreements);

- extreme or serious physical limitations to logging : over 30, or 20-30 degrees of dominant slope, over 2400m altitude, karst landforms, permanently inundated areas over more than 80%, or between 50 and 80% of the land area, mangrove areas;

- limits of the different types of protected areas;

- provincial boundaries, topographic and cultural features.

Mapping of logged over areas and land use changes between 1975 and 1996

To update the 1975 mapping, a cartography of the areas subject to significant logging activity and land use change since that year was carried out using mid-1996 Landsat TM imagery at scale 1:250,000, supported by rapid ground and aerial reconnaissances[11]. It was possible to classify each FMU into undisturbed ones, logged over ones ("areas logged and left to regenerate") and deforested ones("areas logged and subsequently converted to non-forest forms of land use", and "areas cleared (but not logged commercially) and subsequently converted to non-forest forms of land use").

[11] Reference : *Land Use Change and Intensification in Papua New Guinea 1975-1996*, by J.R McAlpine and D.F Freyne, Asia Pacific Viewpoint,Volume 42, Issue 2&3, 2001, pp. 209-218

2.3.4 The 2002 Forest Cover Map Project by the University of PNG

This major study whose main methodological features and results have been briefly presented in Section 2.2.5 above will have to be carefully evaluated in order to assess whether its 2002 land cover map can be used as the "appropriate wall-to-wall map" of the MNFI at the original reference time T_0 referred to in Section 5.1 (see Chapter 5 below describing the overall methodology of the planned MNFI for PNG). In the opinion of the writers of this report, the tools and methodology used, as well as the precision of the work qualify it for this purpose.

2.3.5 PNG forest inventory systems

All operations listed in the previous section aimed essentially at mapping and estimating forest areas by types and condition classes. Only the FIM system provides indicative estimates of merchantable species composition and gross volumes ("stocking rates") for each of the 42 forest zones mapped. To determine these merchantable characteristics more precisely, particularly in the Forest Management Areas for the preparation of Forest Management Agreements, the National Forest Service has developed the Forest Inventory plots System (FIPS) based on a random sampling of two-widths strips (trees of 20-50 cm diameter counted on a 10 m wide strip, and trees > 50 cm on a 20 m wide one). The Planning Methods for Sustainable Management of Timber Stocks in Papua New Guinea project[15] (2001 - 2005) recommended that "FIPS be rewritten into a more flexible database system that allows forest planners to obtain inventory data according to different specifications", and that future field samples be recorded and linked to mapping systems". All recommendations of this project should be studied carefully when designing the MNFI, if it were only for securing a good degree of consistency between the FIPS inventories and the national one.

The same project made also useful proposals for a new system for the "tactical" timber inventories, as well as for establishing another, much needed, system for post harvest inventories. Its recommandations These recommendations too should be considered taken into account when designing the MNFI in order to have a coherent overall forest resources assessment system for sustainable forestry development in the country.

Australian Centre for International Agricultural Research (ACIAR) project (2001-2005)

An ACIAR team carried out a mission in November 2001 to review the forest inventory and planning systems and practices of PNG, and formulated a 2-year assistance project in this field [16].

[16] ACIAR project FST 98-118, FST/1998/118: Planning methods for sustainable management of timber stocks in Papua New Guinea's forest. The project was carried out in cooperation with the following institutions: PNG Forest Authority, PNG Forest research Institute (Lae), Australian Bureau of Rural Sciences (Department of Agriculture, Fisheries and Forestry), Australian National University, Queensland Forest Research Institute (Australia), Southern Cross University (Australia).

The summary report of this project has been published as an article in the Australian Department of Agriculture, Fisheries and Forestry publication[17]. The following table extracted from that article summarizes the forest inventory and planning requirements in PNG as at 2002 as they were identified by the project.

Table No.9 NFI planning in PNG-2002

Forest planning and inventory requirements in Papua New Guinea as at 2002

Planning level	Inventory / planning requirements or mandate	Standard / specification	Responsibility	Comment
National Forest Plan	Forestry Act [s.47(1)]	1% sample processed with FIPS[18], FIMS[19] and PNGRIS[20]	PNG-FA	
National Forest Inventory	Forestry Act [s.47(2)]	1 % sample, same as above	PNG-FA	Significant inventory work done but not officially called a National Forest Inventory
Provincial Plans	Forestry Act	1 % sample, same as above, compiled for each Province	Provincial Forest Officers	
Forest Management Agreement(FMA). Project Statement (Feasibility Study/tender)	Forestry Act [s. 100]	1 % sample from company plots different to above	PNG-FA	Significant inventory done but complaints that workload excessive and data not fully used
5-year Working Plan	Forestry Act [s. 101] with detailed prescriptions in the Planning, Monitoring and Control Procedures (PCMP)	1 % sample. PCMP states: *"estimate of net harvestable volume must be based at a minimum on a* 1 % *sample of the gross loggable area. Details of net harvestable volumes presented must be based on actual inventory of the areas to be logged, and not on historical data from previously logged areas"*	Company	as above
Annual Logging Plan	Forestry Act [s. 102] and PCMP	1 % as above	Company	as above

[17] Department of Agriculture, Fisheries and Forestry, 2005. Improved Strategic Forest Planning in Papua New Guinea. Bureau of Rural Sciences, Canberra

[18] Forest Inventory Plots System

[19] Forest Inventory Mapping System

[20] Papua New Guinea Resources information System

Operational set- up plan (harvesting plan)	PCMP	*At minimum consist of 10% sample of the net loggable area*	Company	Companies prefer to do a 20% sample of trees selected to be harvested. Some companies assess 100% of trees planned for harvest.

Source: ACIAR 2005. "*Improved Strategic Forest Planning in Papua New Guinea"*

Two things can be noted concerning this table: i) the exclusive focus on timber volumes and loggable areas, and ii) the standard sampling intensity fixed at 1% of the net areas inventoried, common to all levels (national, provincial, management unit, local), without any consideration given, apparently at least, to the variability of parameters and the required precision on their estimate.

2.4 Forest growing stocks and forest growth

2.4.1 Definitions

The definitions used by FAO in its last Global Forest Resources Assessment (FRA 2005) for the terms related to forest growing stocks, biomass and carbon stocks are:

Table No. 10 Definitions used by FRA-FAO (FRA 2005)

Growing stock	Volume over bark of all living trees more than X cm in diameter at breast height. Includes the stem from ground level or stump height up to a top diameter of Y cm, and may also include branches to a minimum diameter of W cm *(countries must indicate the three thresholds: X, Y, and W in cm)*
Commercial growing stock	The part of the growing stock that is considered as commercial or potentially commercial under current market conditions (and with a diameter at breast height of Z cm or more – *Z to be specified by countries*).
Biomass	Organic material both above-ground and below-ground, and both living and dead, e.g., trees, crops, grasses, tree litter, roots etc. Biomass includes the pool definition for above - and below - ground biomass.
Above-ground biomass	All living biomass above the soil including stem, stump, branches, bark, seeds and foliage.
Below-ground biomass	All living biomass of live roots. Fine roots of less than (suggested) 2mm diameter are sometimes excluded because these often cannot be distinguished empirically from soil organic matter or litter.
Dead wood biomass	All non-living woody biomass not contained in the litter, either standing, lying on the ground, or in the soil. Dead wood includes wood lying on the surface, dead roots, and stumps larger than or equal to 10 cm in diameter. All non-living woody biomass not contained in the litter, either standing, lying on the ground, or in the soil. Dead wood includes wood lying on the surface, dead roots, and stumps larger than or equal to 10 cm in diameter or any other diameter used by the country
Carbon stock	The quantity of carbon in a "pool", meaning a reservoir or system which has the capacity to accumulate or release carbon.
Carbon in above-ground biomass	Carbon in all living biomass above the soil, including stem, stump, branches, bark, seeds, and foliage.
Carbon in below-ground biomass	Carbon in all living biomass of live roots.
Carbon in	Carbon in all non-living woody biomass not contained in the litter, either standing, lying on the ground, or in the soil. Dead wood includes wood lying on the surface, dead roots, and stumps larger

dead wood biomass	than or equal to 10 cm in diameter or any other diameter used by the country.
Carbon in litter	Carbon in all non-living biomass with a diameter less than a minimum diameter chosen by the country in various states of decomposition above the mineral or organic soil. This includes the litter, fumic, and humic layers.
Soil Carbon	Organic carbon in mineral and organic soils (including peat) to a specified depth chosen by the country and applied consistently through the time series.

2.4.2 Natural forests

Growing stocks

FAO has reported in its last three last global assessments (FRA 1990, 2000 and 2005), the following estimates for the total growing stocks of forests of PNG.

Table No. 11 Total growing stock

FRA 2005 Categories	Volumes (million m^3 over bark)		
	1990	2000	2005
Growing stock	1,111	1,060	1,035
Commercial growing stock	560	536	525

Source: FAO, Global Forest Resources Assessment 2005

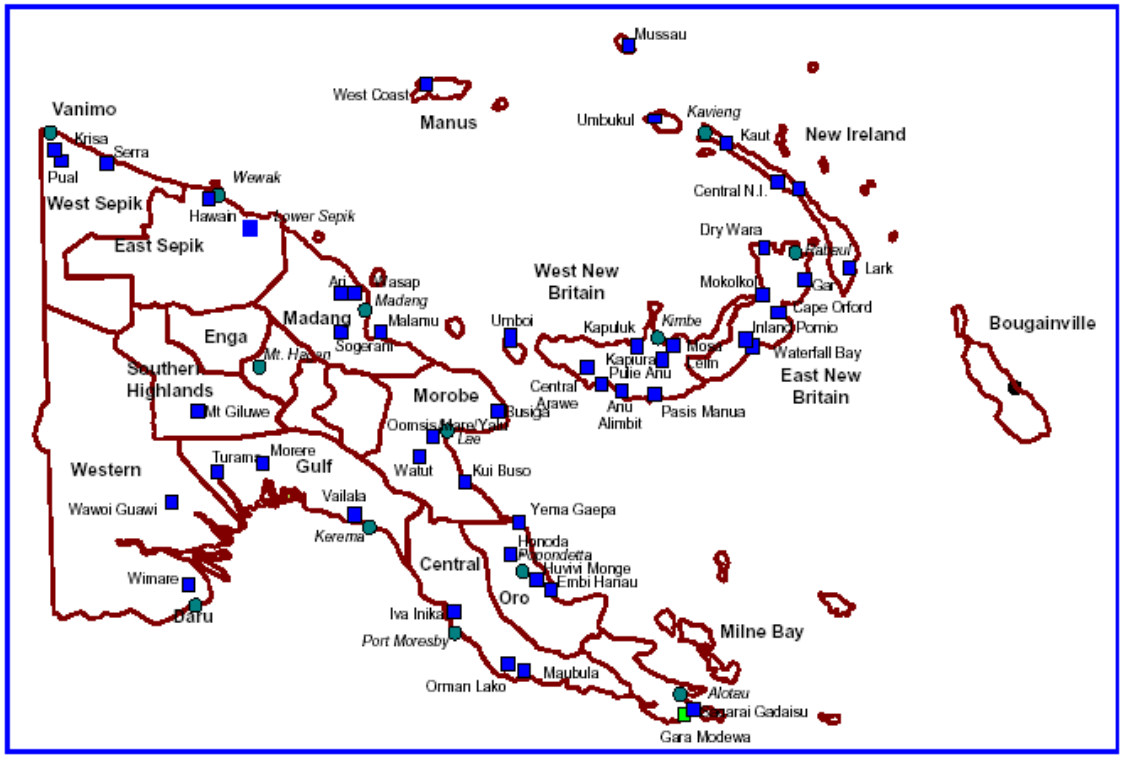
2.4.2 Permanent Sampling Plots and Forest Growth Prediction

Forest Authority, more specifically the Forest Research Institute(FRI) started establishing in 1992 a nationwide network of Permanent Sampling Plots (PSPs) under the ITTO funded Project PD 162/91Rev.1 (F) entitled "Growth and Yield of Tropical Lowland Rain Forests of PNG". The objective was to "monitor growth and yield, forest dynamics, and recovery of the forests following commercial harvesting". It initially consisted of 127 plots established in most forest types all over the mainland and the main islands (except North Solomons island, see map below). Initially, 13 of which were control plots in undisturbed forests. They have been maintained and measured by FRI. Since the network was established, "11 plots have been abandoned and 18 are inaccessible due to abandoned infrastructure (roads, bridges,...), leaving 116 potentially available and only 98 reasonably accessible"[29].

A PSP is a square of 100m x 100m, divided in 25 quadrants of 20 m x 20m. The DBH, height, crown (diameter, position, quality), location, species of all plant individuals of more than 10 cm

DBH are measured, descriptors of the plot are assessed (soils, topography, aspect, history). The trees are tagged and numbered. A manual has been drafted. The data which are compatible with international standards, are entered, stored and analyzed in a data processing system and with a growth model, PINFORM (PNG/ITTO Natural FORest Model), designed for the lowland rainforest[21]. This model "simulates the growth of a single stand with species aggregated into functional groups with similar growth rates and maximum sizes. ... (It) gives qualitatively reasonable projections of future forest structure. ... The model (has already been) used to analyze future yields associated with different harvesting regimes" [29].

Figure No. 5 Distribution of the Permanent Sample Plots in the whole country



The following table gives an indication of the variability and order of magnitude of the present value of four basic quantitative forest parameters in four PSPs, two in disturbed and two in undisturbed forest.

[21] Alder, D 1998. PINFORM: a growth model for lowland tropical forests in Papua New Guinea. Forest Research Institute, Lae. ITTO/PNG Project PD 162/91, Consultancy Report, 56 pp.

Table No. 12 Parameters observed in some PSP

Plot name	Density (stems/hectare)	Number of species	Basal area (m^2/ hectare)	Volume (m^3/hectare)
Disturbed forest				
GARAM01	436	77	22	121
Wc01 Manus	203	31	8	46
Undisturbed forest				
SAGAR03	411	58	33	227
WC05 Manus	465	50	31.5	211

The network of PSPs can serve as a most effective tool for the management of PNG forests, at least for the lowland rainforests which represent approximately two thirds of the forests on dry soils. It allows for the determination of :

- the length of cutting cycles,
- the silvicultural treatment regimes,
- the recruitment and mortality patterns of commercial tree species,
- elements for estimating carbon stocks, and
- the classification of site productivity using indicator species.

PSPs provides information to be used by the MNFI, and with the MNFI data. The implementation of the MNFI is therefore an opportunity to contribute to the maintenance of the network, and to strengthen it by :

- establishing additional plots in forest sites not represented presently and in undisturbed forests ;

- and adding measurements useful for monitoring the evolution in time of carbon stocks in disturbed forests.

2.4.3 Planted forests

The following paragraphs are extracted from the publication ODI-EU Papua New Guinea Forest Studies 3, 2007)[22] where they introduce the presentation of PNG reforestation and plantation policies.

"Plantations (in PNG) constitute a potentially important source of raw material and can reduce pressure on natural forests, by growing uniform trees that have comparative advantage in downstream processing. The productivity of plantations can be high, with, for example, Octomeles sumatrana producing up to 35 m^3/ha per year ... The plantation sector in PNG remains small. By the mid 1980`s there were 58,000 hectares of tree plantations in PNG (ITTO 2006).

[22] Overseas Development Institute. 2007. Issues and Opportunities for the Forest Sector in Papua New Guinea. Papua New Guinea Forest Studies 3.

This area has since expanded and the most recent figures show a plantation estate of 62,000 hectares (Kiki, 2006)[23]. This expansion has been entirely driven by the private sector, as the last Government plantation dates from 1985.. The main species grown are especies of Eucaliptus, Acacia and Pinus. There are about 20,000 hectares of rubber plantations and a small number of teak plantations."

"The development of the plantation sector has been slow due to the fact that the economics of such investments are not favorable. Even fast growing species take eight years before they generate their first millable logs. Cash flow and the viability of long term investment has also been limited by the traditionally high discount rates. In recent years inflation and lending rates have come down, making capital investment more attractive. Investors are still reluctant to invest in plantations and continue to have difficulty securing access to land. Oliver (2002)[24] suggests that the combined use of landgroup incorporation and lease-lease back schemes such as used in the oil palm sector may offer a way forward. At a technical level plantations are prone to disease and fire (Hunt 2002)[36]".

"In an attempt to increase plantation development, the draft National Reforestation Policy requires new logging projects to plant 500 hectares of forest per year. In addition, it intends to develop a five-year National Reforestation Program, aimed at managing existing government plantations while also establishing new commercial and community-based forest plantations. Since 1990, the PNGFA has collected a so-called reforestation levy from operators, which is to be used for reforestation and regeneration activities. Operators who can demonstrate an active plantation program are exempt from paying the charge (FRRT, 2002)[25]. Most companies seem to regard paying the levy as less costly than the implementation of a plantation program. This suggests that the levy is not achieving its objective and that it may have to be increased to a level that induces the necessary action on the part of operators. The levies are paid into a trust fund with PNG Banking Corporation and are to be used for reforestation activities. Some of these funds may have been used for payments to the provinces. Whether that has led to any reforestation is unknown. The industry suggests that the PNGFA uses "too much of the levy designated to fund silvicultural investments for administrative expenditure" (ITS Global, 2006)[26]".

"One option that needs to be explored is the extent to which PNG could make use of the Clean Development Mechanism to leverage financial support for plantation and reforestation activities by way of carbon sequestration. As of yet PNG does not have the institutional infrastructure, in the form of a Designated National Authority, to capitalize on these opportunities. While carbon sequestration may support sustainable development, biodiversity conservation and improve land

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[23] Kiki,B. 2006. Forestry facts and figures. Paper presented at the Regional seminar on forest law enforcement and governance, held at the Holiday Inn, Port Moresby, 10-11 October 2006.

[24] Oliver,N. 2002."Lease-lease back – an instrument for forestry ?"In Hunt (ed.). Production, Privatization and Preservation in Papua New Guinea Forestry, Instruments for sustainable private sector forestry series, International Institute for Environment and Development, London.pp 57-74

[25] Forest Revenue Review Team (FRRT). 2002. Review of the Forest Revenue System in Papua New Guinea. Report commissioned by the Government of Papua New Guinea.

[26] ITS Global, 2006. The economic importance of the forest sector in Ppapua New Guinea. Report fot the Rimbunan Hijau (PNG) Group.

and soil productivity, the extent to which countries are able to make use of this mechanism depends on issues such as: i) tenurial security, ii) the transaction costs involved in negotiating and implementing carbon sequestration projects, iii) overall governance in the country involved and iv) the institutional capacity available to develop an adequate legal framework (Jindal, 2006)[27]".

"The first commitment period of the Kyoto Protocol (2008 - 2012) explicitly excludes the generation of carbon credits through activities associated with the management of natural forests. A related debate on 'avoided deforestation', however, looks into the relation between carbon uptake and the sustainable management of natural forests. This debate, in which PNG is a front runner through its Rainforest Coalition with Costa Rica and others, is part of the UNFCCC negotiations on a post-Kyoto mechanism. This debate, however, is still in an embryonic stage and will become operational in 2012 at the very earliest".

Compared to the natural forest resources, Papua New Guinea's plantation resources are of only minor importance (see distribution of the plantation resources in the table below). However, if land tenure, resource ownership and other problems can be settled, there is a huge potential for plantations to provide rural employment and the basis for the development of a viable processing sector.

Currently, most of the State owned plantations are either in a state of neglect or are abandoned, although measures are being taken to provide at least basic maintenance to many of them. The one exception is the Wau-Bulolo Plantation which provides logs at a low cost to an antiquated and highly protected plywood mill. Replanting of this forest is below the sustainable level, at about 150 hectares per annum. There are three main private plantations, all operated by Japanese companies. A chipmill is already operating from harvesting of the forest resources at Gogol Plantation, with 33,559 Bone Dry Units (BDUs) of woodchips being exported from this mill in 1997. The Open Bay and Stettin Bay projects are due to come on stream within the next 4 to 5 years. Resources from these plantations are be used for wood chips also.

Table No. 13 Main forest plantations in PNG

Province	Location	Main species	Total area (ha) (Dec. 1997)
State forest plantations			
Central	Kuriva	Tectona grandis	600
Madang	Madang north coast	Eucalyptus deglupta, Acacia mangium, Terminalia brassii	900
Morobe	Wau-Bulolo	Araucaria cunninghamii, A. hunsteinii, Pinus caribaea	12,000
Milne Bay	Sagarai	A. mangium, E. deglupta, T. brassii	1,500
New Ireland	Kaut	E. deglupta, Calophyllum sp., Pterocarpus indicus	250

[27] Jindal, R. 2005. Carbon Sequestration Projects in Africa :.Potential Benefits and Challenges to Scaling Up www.earthtrends.wri.org

Eastern Highlands	Fayantina	Pinus patula	900
Eastern Highlands	Lapegu	Pinus patula	3,200
Eastern Highlands	Kainantu	Pinus patula	1,000
Western Highlands	Waghi	E. grandis, E. robusta, E. saligna, P. patula	2,100
Southern Highlands	Orere, Kui, Baino	P.patula, E. Robusta	400
Total State			22,850

Private forest plantations			
Madang	Gogol	E. deglupta, A. mangium, T. brassii	10,745
East New Britain	Open Bay	E. deglupta, T. brassii, A. mangium	12,004
East New Britain (customary, ex-State)	Kerevat	Tectona grandis, Eucalyptus deglupta, Ochroma lagopus	1,900
West New Britain	Stettin Bay	E. deglupta, T. brassii, A. mangium, Octomeles sumatrana	10,258
West New Britain	Ulamona	E. deglupta	-
Central (cust.- ex State)	Brown River	Tectona grandis	1,200
Total Private			35,107
Grand Total			57,957

Source : FAO. Asia-Pacific Forestry Sector Outlook Study : Country Report - Papua New Guinea. 1997
(Asia-Pacific Forestry Sector Outlook Study Working Paper No: APFSOS/WP/47)

2.5 Forest management

2.5.1 Forest management for development

The development of the forest resource is undertaken in accordance with the National Forest Plan, Provincial Forest Plan and the National Development Forestry Guidelines. Other supportive documents such as the Environmental Key Standards, Logging Code of Practice, Forest Management Agreement and the Project Agreement provide guidance to ensuring compliance and effective monitoring.

Project development processes for timber concession areas

Forest resources of Papua New Guinea are customary owned. The vehicle through which the government obtains timber rights is through the Forest Management Agreement (FMA). Any timber area for forestry development must in the first instance be included in the National Forest Plan as well as the respective Provincial Forest Plan.

The timber area prior to development must be surveyed to ascertain the quantity and type of resource in the area. After the completion of the acquisition process, the project is now ready for

development. A Development Option Study is conducted to ascertain the existing infrastructure and the economic potential of the timber area. Guidelines are then drawn up which are considered and approved by the Provincial Forest Management Committee and then are presented to the National Forest Board.

Once approved by the National Forest board, the project is put on tender for potential investors to express interest. Those that do it are issued project development guidelines and the Development Option Study to write up their project proposals. Interested developers prepare proposals and submit their proposal to the PNG Forest Authority for evaluation. Provincial Forest Management Committees in collaboration with the PNG Forest Authority evaluate the proposals and make recommendation to the National Forest Board for consideration and approval. The National Forest Board in turn makes recommendation to the Minister for Forests on the preferred developer.

Once the Minister makes a decision on the selection of a developer, then this latter and the state negotiation team commence negotiation. The state negotiation team is made up of representatives from the landowners, provincial government, and the National Forest Service. The result of the negotiation is the completion of the project agreement.

The project agreement is then signed between the government, developer and landowners. The developer then prepares an Environmental Plan of the timber area. Following approval of the Environmental Plan, the Minister recommends the developer to apply for the timber permit. The Minister then issues the timber permit. This is followed by the preparation and submission of a five-year working plan by the developer. Following the approval of the five-year working plan by the PNGFA managing director, the developer then has to submit a one-year development plan. Following the approval of an annual working plan, the managing director gives authorization letter to the developer to commence operations.

While the PNG government collects about 30 million US $ in log export duties each year, local communities are receiving very little in services or other government expenditures. Promised infrastructure and other ‘development’ benefits are either not provided, or are of poor quality, or else are not supported by complementary operational expenditures (either governmental or otherwise) to provide, for example, teachers for class rooms or medicines for aid posts.

Moreover, the Forest Authority and the Department of Environment and Conservation are lacking the resources needed for controlling forest operations. In most cases, forests are not being managed to maintain a sustained yield of timber, and leave the local communities soon abandoned as the logging companies move on. These latter leave behind serious environmental damage, high social costs and a bewildered and disillusioned rural population with little sustainable infrastructure and few services.

Annex 2 reproduces as an example the terms of a Forest Management Agreement between the: Forest Authority and Land Owners Groups on a given forest management area (the ASENGSENG Forest management Area).

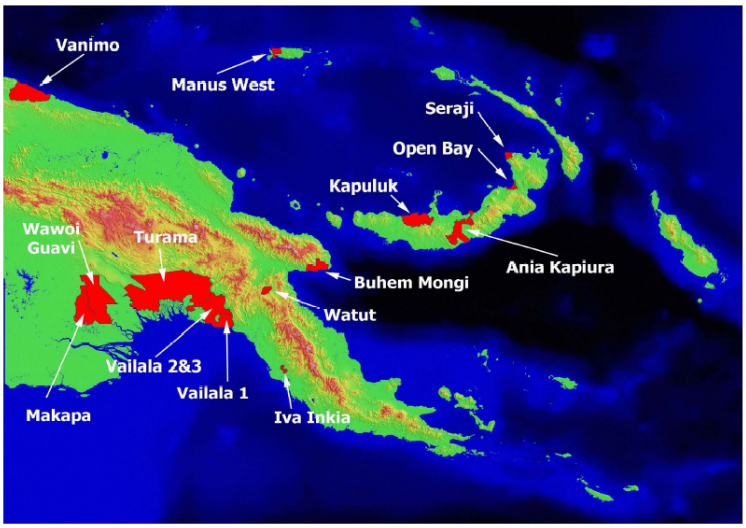
Major logging companies

There are 29 forest concessions currently in production, covering a total area of 3.5 million hectares. Privately owned companies control all commercial timber production from natural forest areas. Companies that are directly or indirectly owned or controlled by Malaysian multinational companies dominate commercial timber production. Five companies control over 80 percent of the market.

Table No. 14 Log export market shares in 2000

Company	Volume		Value	
	(1000 m^3)	% share	(1000 US$)	% share
Rimbunan Hijau	669	33.5	49,654	34.5
WKT Realty	256	13.0	20,467	14.0
Turama Forest Industries	210	10.5	14,857	10.5
Concord Pacific	151	7.5	10,993	7.5
Kerawara	149	7.5	8,035	7.5

Figure No. 6 Map showing the concentration of the main areas for logging



2.5.2 Forest management for conservation and protection

The Forest Authority, while appreciating the need to conserve and protect the nation's forest resources, is not mandated to be the lead agency for activities associated with this function. The Department of Environment and Conservation (DEC) is the Government's Lead Agency involved in Protection and Conservation of both plant and animal species.

Despite this, the Forest Authority does set aside areas for protection in its Forest Plans and, where in demand, conserve areas that have been identified as having value. Such areas are delineated and excluded from any forestry timber harvesting operations.

2.6 Population and social aspects

The 1980 National Population Census is the most reliable available source of population data for the country. The 1990 National Population Census is less reliable and is only used to determine population change between 1980 and 1990. The PNG Human Development Report (McKay *et al.*, 1999) released population growth rates for each province for the 1980 to 1990 inter-census period, which are based on urban and rural areas. This handbook is concerned only with rural areas and thus uses the work of Keig (2001), which determined provincial population growth rates for rural areas through a careful comparison of the 1980 and 1990 censuses. The figures from both sources are very similar. Estimated rural populations in the year 2000 are based on 1980 figures, which have been extrapolated based on Keig's provincial rural population growth rates between 1980 and 1990. Estimated population densities in the year 2000 are calculated in the same way. It is important to note that the district boundaries used in the 1980 and 1990 censuses were changed as a result of the 1995 Organic Law. In order to estimate populations and population densities for areas within the new districts, the 1980 census units were digitized and allocated to the new districts.

Preliminary census figures for the year 2000 show that the population of PNG was just over five million. Approximately 85 per cent of people live in rural areas. Population densities range from one habitant/km2 in the remotest inhabited areas, to over 500 habitants/km2 on some small islands. Land shortages are increasingly common in areas where population densities are greater than 100 habitants/km2. The average population growth rate was 2.7 per cent per year from 1980 to the year 2000. The total population of PNG has doubled over the last 30 years and is expected to double again in the next 30 years. Present projections indicate a population of around eight million by 2020. As a result of this rapid growth, over 40 per cent of the population are under the age of 15 years.

Population growth rates within provinces vary significantly, reflecting migration processes as well as birth and death rates. Most provinces have areas that are well above or below the

average provincial growth rate, resulting from significant in-migration or out-migration. Such areas are identified in the district summaries.

The general context characterizing the current situation of the local communities in the rural areas are the following:

- about 31% of the population lives below the international poverty line of 1USD per capita per day. The majority (about 93.5%) of the poor live in rural areas ;

- the majority of the population depends on the semi-subsistence sector, which has seen little real growth in recent decades: per capita real GDP in the nonmoving economy grew at the average rate of 0.2 % in the period 1978-1998. High percentage of the subsistence of this communities depends of the forest ;

- many communities are isolated, thus the cost of accessing goods and services or transporting goods to markets to be sold is chronically unaffordable under all but the most pressing circumstances. During field activities, it was common to experience mechanized travel costs in excess of 10 US$ each way for trips between remote communities and town centres ;

- household size averages between five and six individuals. Consequently, education and healthcare costs are high relative to the population size because they typically need to accommodate families with 3 or 4 children ;

- infrastructure is often inadequate for providing affordable access to important goods and services. Moreover, roads, bridges and public structures were often not being actively maintained or sufficiently staffed (in the case of aid posts and schools).

In the areas where forest management projects are operated by private logging enterprises under a Project Management Agreement, the limited financial returns to resource owners have substantially fallen in real terms over the last decade. Sums that are paid are not equitably distributed and rarely reach the poorest members of society. They are not applied to deliver long term benefits and are soon exhausted through a short term consumerist behavior from the part of the local people. Employment and other 'spin-off' benefits are usually taken by outside workers. In addition, salaries and employment conditions are generally very poor and have even been officially described in one project as modern day 'slavery.'

The diversity in the natural environment is matched by diverse cultural traditions. PNG is thought to have been occupied by humans for at least 40,000 years. This long-term occupation and diverse mountainous environment has resulted in the presence of over 800 distinctive local cultures and languages. There is no particular ethnic group that dominates the economic or political life. Two major *lingua franca* are spoken. The first is Pidgin, which is spoken by the majority of people. The second is Hiri Motu, which is spoken mainly around Port Moresby and elsewhere in Papua New Guinea. English is the language of administration and international communication, but Pidgin, Hiri Motu or local languages are favored in daily life.

Population growth rates vary greatly both between and within provinces. Growth rates in the main cities and towns are higher than in rural areas due to migration, the age structure of migrants and the superior health services available in urban areas. Migration is common in PNG. As with many other countries, there is a significant flow of people from rural regions to major towns and nearby semi-urban areas. There is also considerable migration to well-established rural development areas near Kimbe, Bulolo, Popondetta, Kavieng, Alotau and Kainantu. The major resource extraction locations such as Ok Tedi and Misima are also common destinations. In general, people migrate in search of wage employment and small business opportunities in the towns, more productive environments where they can grow cash crops, and better access to services and markets. Sometimes migrants return to their customary land after spending only a short amount of time away.

3. LEGAL AND INSTITUTIONAL FRAMEWORK OF THE FOREST SECTOR

3.1 Basic texts

Following the Forestry Commission of Inquiry[28] a considerable amount of new forest policy and legislation have been introduced[29]. These include:

- *National Forest Policy* : it was issued in September 1991 by the National Executive Council and covers the areas of forest management, forest industry, forest research, forest training and education, and forest organization and administration.

- *Forestry Act,* 1991 : it was gazetted in June 1992 as a direct result of the Commission of Inquiry, and provided for the establishment of the new and autonomous Forest Authority to replace the old Department of Forests. The Act provides for much tighter controls in the acquisition and allocation of land for forest development.

- *Forest Regulation No. 15,* 1992 : it was introduced to enable registration of forest industry participants and consultants under the Act.

- *Forestry (Amendment) Act*, 1993 : it was certified in April 1993 and provided for a clear administrative function of the National Forest Board, and of the National Forest Service through the Managing Director and the Provincial Forest Management Committees.

- *National Forest Development Guidelines,* 1993 : they were issued by the Minister for Forests and endorsed by the National Executive Council in September 1993. The Guidelines establish essentially an implementation guide for aspects covered in the new Forest Act, especially in terms of sustainable production, domestic processing, forest revenue, training and education, review of existing projects, forest resource acquisition and allocation, and sustainable development.

- *National Forest Plan* : under the Forestry Act of 1991 (as amended), the Forest Authority has been required to prepare a National Forest Plan to provide a detailed statement of how the national and provincial governments intend to manage and utilize the country's forest

[28] The exact title of this body was "Commission of Inquiry into Aspects of the Timber Industry", or "Barnett Commission" after the name of the judge who presided it. Established in 1987, and concluding its work in 1989, it "revealed an imbalance of power between the Minister for Forests and the Department of Forests, ... an imbalance of power between the (national) Department of Forests and the provincial Division of Forests, ... and a high level of corruption" in this sector, particularly "amongst parliamentary ministers" (Overseas Development Institute. 2007. Issues and Opportunities for the Forest Sector in Papua New Guinea. Papua New Guinea Forest Studies 1).

[29] The text of this section is borrowed from the page "Forest laws of PNG" on the Internet site of the Forest Authority (http://www.forestry.gov.pg), and from the 1997 FAO document Asia-Pacific Forestry Sector Outlook Study : Country Report - Papua New Guinea. (Asia-Pacific Forestry Sector Outlook Study Working Paper No: APFSOS/WP/47).

resources. The National Forest Development Program (NFDP) under the Plan is now under implementation.

- *Logging Code of Practice,*1996 : it was finalized in February 1996 and tabled in Parliament in July 1996. This PNG code is inconsistent with the Regional Code proposed at the 1995 Suva Heads of Forestry Meeting but is more specific to PNG operating conditions. It has been mandatory as of July, 1997.

- *The 1996 Forestry Regulations* : they cover all facets of the industry procedures and control, and were approved by the National Executive Council in 1996, and finalized to be finalized soon after with some changes. These Regulations provide the legal status for the implementation of many of the requirements specified under the Forestry Act 1991 (as amended).

- *Forestry (Amendment no. 2) Act,* 1996 : it was passed by Parliament and certified on the 11 October 1996. The major amendment relates to the membership to the Board to still have eight members, including the representatives of a National Resource Owners Association and the Association of Foresters of PNG.

- Since the Forestry Act was first enacted in 1991, it has been amended four times : the first one in 1993, then in 1996, 2000 and 2005.

The PNGFA five-year Corporate Plan 2007-2012

During the launching of the Corporate Plan, the then Minister for Forests, Honorable Patrick Pruaitch stated that the forestry sector contributed to the economic well-being of the rural population, established infrastructures such as roads and bridges, and provided employment and community services such as schools, health facilities, communications and transport services that otherwise had never existed in many of our rural areas; the above contributions had been very significant to the nation's building in the last 30 years of independence, and this could continue into the future if PNG forest resources, being renewable, were wisely used and managed in a sustainable manner. In the medium term the country continuing to face economic, environmental, social issues and challenges as a developing nation, forestry would continue its role as a key player in the nation's development programs. He added:

"The plan intends to make the Forest Authority more efficient and responsive to its core business and its clients.... Strategic policy and operational areas that will be strengthened include: Corporate planning and management; field services in the provinces and project areas; forest development through plantations and management of logged-over areas in partnership with landowners; strategic research programs that will achieve sustainable forest management; and Corporate response to collaborate with private sector and other agencies on environment and climate change initiatives". The Corporate Plan provides the strategic overview and directions for the next five years and will be continually reviewed to ensure that it is in line with the government's development policies and the needs of the country, particularly the resource owners. In attendance to witness

the occasion were members of Parliament, Heads of the diplomatic corps and Heads of government departments and statutory bodies as well as National Forest Service staff."

The Corporate Plan also complements and attempts to translate the government's 2005-2010 Medium Term Development Strategy, which aims to improve the national economy through increased export income, hence enabling the government to improve infrastructure, social services, and reduce poverty levels particularly in the rural areas.

The Corporate Plan reaffirms :

- the core objectives and functions of the Authority as laid down in the Forestry Act 1991 and amended from time to time ;

- the development and management strategies relating to resource management, forest industry development, forest research, forestry training and development, and forest administration, that are enshrined in the 1991 National Forest Policy.

It gives also a sense of direction to the activities and strategies that the Authority will pursue in order to support and implement the government's economic and social development agenda through medium term development strategies.

In presenting the Corporate Plan, Mr. Kanawi Pouru, Managing Director of the National Forest Service, added that the Forest Authority's mission is "to secure forest resources (natural and plantation) and facilitate their utilization on a sustainable basis, for the social and economic benefit of the people of PNG. ... In this plan, the functions and core business of PNGFA will continue to focus on resource acquisition, allocation, development, and management of the natural forest resources as long as the resource owners are willing to transfer timber rights to the State for commercial forestry operations". However, "given the changing trends in future resource security, government development policies, global timber trade, and the impacts of climate change, the core business of the Forest Authority need revisiting and adjustments".

"In that respect, the following fields of action will be given close attention: forest plantation development, particularly by increasing plantable areas within the vicinity of existing plantation areas; management of logged over areas ; downstream processing ; forest research will be more focused and result oriented ; and forest administration working towards an autonomous regulatory/commercial organization. Given the aforementioned, it will be a challenging time ahead for the Authority, but the Corporate Plan will provide the way along which PNGFA may focus its limited resources to achieve its set objectives. The Plan will also ensure that the Authority meets its obligations under the Forestry Act, and provides a way forward to develop partnerships among PNGFA's stakeholders, including government agencies, the private sector, and resource owners, in participating in the sustainable development and management of the country's resources".

3.2 Present institutional set up

3.2.1 Policy formulation in progress[49]

- Downstream Processing Policy

  Successive governments have been emphasizing onshore processing of forest products, but the forest industry continues to be log export oriented. To ensure wise utilization of the nation's forest resource, and to increase value of forest products as well as technological transfer, the PNGFA issued a National Policy on Downstream Processing of Forest products. In 2005, it produced a revised version which was to be submitted (at the end of 1986) to the National Executive Council for its consideration and approval for use. The policy once finalized and implemented shall contribute significantly towards the government's export driven economic recovery strategy.

- Reforestation Policy

  Though there is still much uncertainty on the deforestation rate in Papua New Guinea (one reason for an urgent implementation of a MNFI)[30], one thing is sure, the rate is relatively high, without accounting for the reduction of the growing stock through forest degradation. Papua New Guinea is a signatory to the Kyoto Protocol for carbon sequestration and its Clean Development Mechanism. Hence, the need for reforestation in Papua New Guinea is very crucial. The Ministry fir forests issued in September 2005 a draft National Reforestation Policy to meet future timber demand both domestically and for export as well as to fulfill the government's commitment to the Clean Development Mechanism. The policy is to be submitted to the National Executive Council.

- Eco–Forestry Policy

  - Most, if not all major timber operators in the country, are foreign owned given the capital intensive nature of forestry businesses. To ensure resource owner participation in the development of their timber resource, the European Union funded the Eco-Forestry Project. The project has three components, i.e. a field component; a marketing component and a policy component.

  The Ministry for Forests issued in 2004 a National Eco-Forestry Policy to create a conducive environment for landowner participation and wise utilization of the forest resource. After gauging views from various stakeholders through regional workshops, the policy is to go before the National Executive Council for its consideration and approval.

[30] The 2008 UPNG Remote Sensing Center study claims that it was 0.77% annually around 2002 : 0,0077x 32,986,000 ha i.e. 254,000 ha per year.

3.2.2 Subjects for future policy consideration

- Forest Research Policy

  The recent review of the forest research programs carried out by the Forest Research Institute (FRI) recommended that a policy on forest research be formulated. The policy will aim to redirect limited resources (financial and manpower) to conduct applied forest research and dissemination of results.

- Non – Timber Forest Products (NTFP)

  In addition to the timber species, the flora of PNG contains many species of non timber forest products most of which have commercial importance. This includes rattan, sandalwood, eaglewood, medicinal plants, resins etc. Smuggling of eaglewood and sandalwood is prevalent in the Western, Gulf and Sepik provinces. Forest Authority is considering formulating a policy on non–timber forest products.

- Forest Industry Overview

- The forest industry is one of the few industries that operate in remote areas of Papua New Guinea. As such the industry creates the few opportunities for rural communities to enter the formal workforce and improve their standard of living using money earned as wages. Forest companies create basic infrastructure such as roads, bridges, schools and health centers. In the absence of government support, the presence of the forestry industry in rural areas is usually seen as a proxy for government with communities becoming entirely dependent on the forestry operations to act as the government body and the business entity to provide service to the community.

- Financial contribution of the forestry sector

  PNG's real Gross Domestic Product (GDP) was about K 8,084.4 million[31] in 2005. The contribution to this real GDP from the agriculture, forestry and fishing sector was estimated at K 3,114.6 million or 38.5 percent. Using the relative values of exports generated by the forestry sector in 2005, this suggests that forestry's contribution to real GDP in 2005 was as high as K 742.2 million or 9.2 percent of total real GDP.

- Contribution of the forestry sector to central government revenue

  In addition to royalty payments made directly to landowner groups and the provision of services in remote areas, the forestry industry also makes substantial contributions to state revenues in the form of both income tax payments and log export tax payments. Log export tax payments alone in 2005 were K 130 million which equates to 2.4 percent of total central government revenue (excluding receipts from borrowings).

[31] Using the 2007 rate of conversion, this is equivalent to some 3,150 million US$

- Contribution of the forestry sector to exports

  The forest industry has mainly been log export oriented. About 2 million m^3 of tropical logs are exported annually making PNG the world's second largest exporter of tropical logs after Malaysia. In 2005, the export of forest products represented 4.7 percent or K 476.3 million of the value of all exports from PNG (K 10,147.5 million) making forest products the largest non-mineral export from PNG in terms of value.

- Contribution of the forestry sector to employment

  The forestry sector employs directly about 7,000 people with half working in logging operations and the other half employed in other activities such as veneer processing, timber processing, carpentry, supporting workshop/engineering services.

- Downstream processing

  For the last several years, downstream processing of forest products in PNG has been the fastest growing manufacturing sector of the economy. Log exports have declined by over 33 percent since the Asian currency crisis of 1997, and declined again in 2004 compared to 2003; this at a time when other exporting countries are increasing production and exports. On the other hand, exports of downstream processing products have increased by over 200 percent since 1997 (in US$ value) and by almost 10 percent in 2004 compared to 2003.

80 percent of log exports go to just China/Hong Kong, Korea and Japan. China is the principal market for logs from PNG; it imported over 1.0 million m^3 of logs from PNG in 2002, a figure rising to 1.7 million m^3 in 2005 – accounting for 74.6 percent of PNG's log exports. The major markets for processed and semi-finished products are Australia, New Zealand and various South Pacific countries. Veneer is predominantly exported to China and South Korea.

3.2.3 Forest Authority

The PNG's Forest Authority (FA) has the adequate structure and organization for the planning and implementation of the MNFI as shown by its organizational chart and its territorial infrastructure. However, the full accomplishment of the mission of the FA, for the adequate and efficient administration of the forest resources is actually far from being ideal, in view of the evident and dramatic lack of resources affecting the majority of the different components of the whole institutional structure. The economical crisis affecting the institution is impacting on the efficiency of the administration, either in the control and monitoring of the use of the forest resources as well as of the flow and commercialization of forest products, which should be covered by the National Forest Service through its Divisions of Planning and Mapping, Forest Management, Field Services and of Resources Development.

The implementation of a MNFI and its full implementation in the field and in the office, is a sizable national task that can be achieved with a important economical support, but it will require

an increase in staffing and budget allocation, and, most importantly, the collaboration of other concerned government agencies. In this respect, serious efforts are needed to improve the channels of communication and coordination with these agencies, particularly with the Departments of National Planning and Monitoring, of Agriculture and Livestock, and of Environment and Conservation. Moreover, external resources will be needed for the first cycle of the MNFI, particularly for the purchase of equipment and supplies (e.g. remote sensing imagery) and for staff training.

The units of the Forest Authority more related to the planning and implementation of the MNFI are the Divisions of Forest Planning, of Field Services and of Forest Management, and the Papua New Guinea Forest Research Institute. All three divisions report to the Managing Director's Office and are directly responsible for the delivery and administration of the core functions and strategies stipulated under the Forestry Act 1991 (as amended).

Forest Planning Division

This division has three branches: Acquisition, Planning and Mapping. Its main functions are to:

- develop, coordinate and revise Provincial Forest Plans and the National Forest Plan and ensure that these plans are consistent with the National Forest Development Guidelines and with the principles of sustainable forest management ;

- *plan and implement forest inventories in both new and existing forest concessions; provide advice and information on forest inventory to clients; and update inventory information on the species and stand densities of different forest types in PNG ;*

- implement the acquisition of priority forest resources as per the National Forest Plan under the Forest Management Agreements (see section 2.5.1 above) ;

- conduct landowner awareness at the project sites and assist landowner groups with the incorporation of land groups, a pre-requisite to the formalization of FMA ;

- provide cartographic services to FA clients in the form of maps and other spatial information; and

- provide printing services to FA and its clients.

Within the whole FA structure, this Division is the most directly concerned with forest inventory activities. Its mapping unit seems adequately organized for basic tasks related to drawing, visual photo interpretation, but has a limited capacity for digital interpretation, scanning and printing. Though the Division is currently short of staff and financial resources for the fulfillment of its tasks, it should be the one responsible for the technical aspects and the coordination of the logistic activities of the MNFI. However, the current forest inventory activities are essentially related to FMA projects. They are executed before the allocation of any area for logging, and are carried out and financed by the FA. Timber logging companies generally complain about the

overestimation of commercial volumes provided by these inventories. Whatever is the truth[32], there is scope for a more elaborate methodology of volume estimation (field sampling techniques, volume equations, ...).

Field Services Division

Established in 2000, the Division has the highest number of staff, with only five based at the FA Headquarters in Port Moresby (the Divisional Manager, the Principal Field Services Officer, a Field Services Officer, the Chief Scaler, and an assistant). The great majority of the staff is located in the provinces. Three of the four regional offices in the country, those of the Southern, Momase and New Guinea Islands regions, come under this Division. The Highlands region reports to the Forest Management Division because they are heavily involved in tree planting with no large scale natural forest logging operations. The National Forest Service has 19 provincial offices – one per province - with a provincial forest officer reporting to the respective regional area manager. Project supervisors based in the project sites (concessions in activity) report to their respective provincial forest officer.

The participation of the field staff of this division, with the adequate technical and logistic support, in the implementation of the MNFI is highly desirable.

Forest Management Division

Forest Management Division has three Branches, namely Plantation Management, Natural Forest Management and the Highlands Regional Office. Each Branch reports directly to the Divisional Manager through their respective managers. Bulolo-Wau plantation (Morobe province) is considered a separate entity and reports to the Divisional Manager through the Plantation Division Manager. The Division also manages the National Tree Seed Center located in Bulolo. This center is responsible for the collection, maintenance and distribution of tree seeds from various seed production areas to support the Division's objectives in forest plantation management and community forestry projects.

The Division's primary responsibility is to create and manage State-owned timber plantations and to rehabilitate natural forests.

One of the most important contributions of the Division of Forest Management to MNFI could be to provide in the preparation phase the existing information regarding the state of forest plantations and natural forests in close coordination with the Division of Planning.

The Papua New Guinea Forest Research Institute (FRI)

[32] One cannot help realizing that this criticism usually addressed by concessionaires to national forest services is consistent with their interests.

The FRI and the Universities (University of PNG, University of Technology) and Colleges (Forest and Timber Colleges) can also play an important role in the design and implementation of MNFI and provide a substantial support to it.

FRI is the research arm of the Forest Authority of which it is an integral part. It is mandated to conduct forest research in line with the National Forest Policy (1990), and the Forestry Act 1991 provides the legal framework for it. Approximately 60 researchers and support staff work in FRI. The institute has four program areas, namely Natural Forest Management, Planted Forests, Forest Biology, and Forest Products. Its mission statement specifies that its objective is to provide a scientific basis for the management of Papua New Guinea's forest resources.

The ITTO' s Diagnostic Mission states: "it was soon evident that the scope of research undertaken at present is narrow. The institution would certainly need significant funding and logistical support to take advantage of its good facilities and technically trained staff. It would also need a revised research policy and financing to address new and emerging forestry issues, such as forest policy, forest economics, … community forestry, non-timber forest products, biological diversity conservation, and payment for ecological services (PEF) among many other topics the institute could usefully address. The PNGFRI has great potential to be transformed into a regional class research resource". This coincides fully with the perception of this mission, after it has visited the FRI in Lae where it is based.

Provincial and local levels

a) The Provincial Forest Management Committees

The Provincial Forest Management Committees (PFMC's) assist the provincial governments in preparing forest plans and development programs, recommending the selection of operators and preparing the allocation of Timber Permits. There are indications that PFMCs are not implementing their mandate as stated in the law, due to their lack of capacity, and to the fact that they are not vested with enough power in the provincial and local governments.

To achieve easier and more efficient participation of the provincial and local levels within the structure of the FA and of other government agencies, it would be necessary to elaborate clearer and more complete guidelines at these levels, and to increase means of the PFMCs in order for them to provide logistic and technical support. The MNFI could provide the opportunity to establish a national network for forest information collection and exchange, which would support the MNFI, either during the implementation of the first cycle or during the subsequent stages.

b) Local communities

The local communities own more than 95% of the total land area. There is uncertainty on the extension and boundaries of the forest land belonging to a given clan[33]. The boundaries of the

[33] According to the traditional social structure of PNG' s population, the basic nucleus of the society being the family (generally from 5 to 7 members), a group of several families forming a clan, several clans composing a village and

land owned by a clan are somehow unclear due to the reluctance of the clans or communities to delineate their property fearing that the State could it from them. However, they use often natural limits such as ridges, streams and other land features easily recognizable.

Communities are thus, in principle, those to allocate forest resources either for production or protection. Indeed, they can decide by themselves the use of the land according to their traditions and needs. As a result, prior awareness and consultation with local communities must take place in a participatory way before any field activity of the MNFI is carried out in their area in order to avoid the conflicting situation faced in some cases by private logging companies[34] .

In this context, mention has to be made of the relevant contribution by the ongoing ITTO funded project entitled "Sustainable Management of Tropical Forest Resources through Stakeholder Agreements in Traditionally Owned Areas of Papua New Guinea" [PD 324 Rev. 3 (F)]. The experience and results derived from this project would be quite useful for the MNFI.

The MNFI must be a permanent, continuous program incorporated in the National Forest Plan, with the necessary institutional arrangements and staff and financial resources available in a timely manner. However, the first full exercise (first cycle), to be carried out in a shorter span of time (say 5 years), will require external economic and technical support.

3.2.4 Other organizations

Department of National Planning and Monitoring (DNPM)

In the great majority of countries, under a similar or different title, this multi-disciplinary and, in fact, really inter-departemental, ... Department concentrates large responsibilities. It is generally associated with, or even integrated into either the Prime Minister Office, or the Ministry of Finance. In PNG, it is under the Minister for Finance, National Planning and Monitoring, and it is presented as the Department which "implements and enforces the government's development policies and strategies",. That confers it an important say in the planning and implementation of development programs and projects in all sectors, and thus considerable influence and power. It is represented in the Board of public agencies, and therefore seats in the National Forest Board,

several villages belonging to one community. The more common denomination for a local population is community with its own authority and rules.

[34] There are additional controversies and misgivings about the extension of some FMAs beyond their geographic boundaries and the process of renewal of some agreements after they expire. The way by which the government, including the PNGFA, deals with such issues appears to be non-transparent and non-participatory. Many FMAs have been the subject of litigation over the validity and extension of licenses; and, even, the constitutionality of 1991 Forestry Act with respect to these matters has been challenged. (ITTO' s forest sector diagnosis mission report, March 2007). While logging does bring short-term cash incomes to the local landowners, these resources are rapidly dissipated and, in general not the source of lasting benefits. In addition, communities suffer from the environmental impact generated by some damaging logging practices.

at the highest level of "". Among its many important functions, it has that of evaluating performance and achievements of public institutions and programs[35].

It is for all these various reasons, and also because the group of DNPM representatives who met with Mr. Frank Agaru and the consultants in the Department Headquarters reacted most positively to the concept of MNFI, that the consultants consider quite justified that the Departmental head, or one of his/her Assistant Secretaries, co-chair with the FA Managing Director the High Level National Steering Committee proposed for the MNFI.

Department of Agriculture and Livestock (DAL)

History in all countries, but at different periods, has witnessed the competition for land between agriculture on one hand, and forests and forestry on the other. In most industrialized countries, forests are now re-growing on land which was cleared for agriculture and grazing in past centuries. In most tropical countries, like in PNG, the expansion of the different forms of agriculture and grazing (traditional shifting cultivation, industrial or small scale cash cropping, "ranching", etc.) continues.

A constant dialogue between forest managers and agronomists is necessary. This means, in PNG, at national and provincial level, between FA and DAL, and between their regional and provincial echelons. There is no doubt that more forest clearing for agriculture will take place in the country in the short and medium terms. In January of this year, DAL has issued the "National Agriculture Development Plan 2007-2016" whose projections, if achieved, will mean the clearance of large tracts of forest.. For the good of both agriculture and forestry, it is important that these clearings take place on lands where the type of agriculture considered are sustainable, and are integrated in a sound approach of land capability assessment and land use planning.

Moreover, some outputs of the MNFI, such as data on soils and water data, will serve not only forest conservation and development, but also a truly sustainable agricultural development, the more so as the agriculture component of PNGRIS seems to be at a standstill.

Again, for these reasons and others, a close cooperation between FA and DAL, in the design and implementation of the MNFI, in Port Moresby and the provincial capitals as well as in the field, is considered highly desirable. It is also why the consultants are recommending that DAL be represented in the High Level National Steering Committee[36].

Department of Environment and Conservation (DEC)

[35] DNPM published in 2007 the first annual report of the Permanent Management Framework for the Medium Term Development Strategy (2005-2010). This very interesting and informative work notes, for instance, in the Chapter "Environment" a negative trend in the "number of logs discovered on vessels not declared for export", but an encouraging one on "log shipments inspected for which discrepancies were reported".

[36] They would be even tempted to propose, though it is not in their mandate, to have the Head of DAL as a member of the National Forest Board, since agriculture is by far the most important consumer of forested lands.

The Head of DEC has been a member of the National Forest Board since its inception. The approval of DEC is required for all major development projects. Most services provided by the forests are of an environmental nature, particularly, but not only, conservation of biodiversity (ecosystems, species, intra-specific variability), protection of soils and water, and carbon budgets. DEC has no territorial echelons and have essentially a policy and regulatory role. Like other Departments, it is in dire need of data in its field of competence, particularly on the area distribution of particular forest ecosystems and of endangered plant and animal species, all information useful for the design and management of the national network of protected areas (at present essentially on paper).

The existing cooperation between FA and DEC will naturally extend to encompass MNFI design and implementation. Obviously, DEC should be represented in the High Level National Steering Committee for the MNF. Its interested staff should be given the possibility to contribute at the field level, making use of the inventory logistics.

Universities and other education institutions

There is no doubt that MNFI management should seek the cooperation of the *University of Papua New Guinea* in Port Moresby, and most particularly, of its Remote Sensing Center. The major forest cover study which it has recently issued should be evaluated carefully to verify that it can serve as the (2002) baseline for by the MNFI, whose results would be compared with those of interpretations of future high resolution satellite imagery for area change assessment (see Section 5.2 below). Having read carefully the report and discussed with the leading scientist, the consultants, while disagreeing with the authors on an important point of presentation of the results[37], consider the study of high value and a most serious baseline candidate. They cannot believe that this considerable work carried out with public funding in a PNG public institution could not be used for the benefit of the PNG's MNFI. And they propose that UPNG be represented in the High Level National Steering Committee.

The Forestry Faculty of the *University of Technology* in Lae has forest inventory as a subject matter in its curriculum. Its teaching staff could contribute to the design and implementation of training courses to be organized for the professionals in charge of the field work within the framework of the MNFI. Similarly, the Timber and Forestry Training College , also in Lae, could participate in the training of inventory staff with particular reference to species identification and the making of botanical samples, possibly in cooperation with the Forest research institute.

Other organizations

The consultants had interesting exchanges with the national managers of two Non Governmental Organizations working with local communities in forest development and conservation, the *Village Development Trust* in Lae, and *The Nature Conservancy* (TNC) in Port Moresby. There is no doubt in their minds that the experience and knowledge of such

[37] Deforestation and forest degradation estimates are systematically combined, though the two processes are essentially different in nature and consequences on the forest ecosystems.

organizations in working in a participatory manner with forest communities could be used with advantage by the MNFI, particularly, but not only, with regard to the socio-economic part of the field inventory. A representative of the community of eco-development NGOs should be member of the High Level National Steering Committee.

Last, but not least, is the *Forest Industries Association*. Its members have an interest in a traditional NFI, though they probably would like it to be strictly limited, for their own planning purposes, to those forest areas on dry soils not yet logged. The additional information to be collected by a MNFI, is likely to be of little or no interest for them, the more so as they may fear that it could slow down the "useful" work. FIA is represented in the National Forest Board, and should also be represented in the High Level National Steering Committee, as the association of an important category of stakeholders.

4. THE MNFI STRATEGY AND PLANNING

4.1 Proposed Institutional arrangements

The main challenge of MNFI is dual : first, to implement it in a satisfactory manner and in time, and, second, once it has been achieved and the considerable amount of data processed, to have a correct and efficient use of the results in order to improve the whole forest system of production and conservation of the forest resources. This requires not only a strong team in data collection and processing, but also a strong institution capable to use this information for building up a national sustainable forest management plan, which is the essential important goal of the whole exercise.

4.1.1 General coordination and administration of the MNFI

Within the institutional structure, the Forest Authority, an *executive unit* must have the responsibility of the practical implementation of the MNFI. The NFI being a multidisciplinary exercise, and considering the need to involve other governmental agencies and non governmental organizations and the other main stakeholders, in the first instance the communities which are the landowners, it is advisable to establish an interagency *High Level National Steering Committee* (see section 4.1.2 below).

Considering that almost all forest resources belong to the local communities, a close contact must be maintained by the Forest Authority with their representatives for coordination in the preparation phase and as the work progresses. The conclusions and recommendations of the ongoing ITTO supported project "Sustainable Management of Tropical Forest Resources through Stakeholder Agreements in Traditionally Owned Areas of Papua New Guinea" [PD 324 Rev. 3 (F)] should be taken into account in the preparation and implementation phases of the MNFI. The active participation of local communities members should be sought through an awareness plan and an intensive outreach program (Radio, TV and simple documentation), particularly in the preparation phase, as well as in the participation in the field teams of community members from different parts of the country. Their association should have a permanent seat on the National Steering Committee in order for the local communities to be kept informed and to be able to participate fully in the preparation and implementation of the MNFI.

4.1.2 The High Level National Steering Committee

The mission of this Committee should be threefold:

- general guidance and supervision,
- political and economical support to the MNFI,
- facilitation of interagency cooperation and coordination.

The Forest Authority Managing Director and the Head (or one of his/her assistants) of the Department of National Planning and Monitoring will co-chair the Committee, and ensure the full participation of the other members. The coordination mechanism between the institutions is delegated to an *Executive*

Director who is to liaise with the Executive Unit. The Committee should meet regularly, say every quarter, at least in the preparation phase.

The permanent member institutions represented in the Committee would be : Forest Authority (Co-Chair), Department of National Planning and Monitoring (Co-Chair), Department of Agriculture and Livestock, Department of Environment and Conservation, (one) Provincial Forest Management Committee, the National association of local communities, PNG's University , and the Forest Industries Association. Financial and scientific support institutions should be invited to participate, such as sponsor agencies, the Forest Research Institute, the Timber and Forestry Training College, and the University of Technology.

4.1.3 The MNFI Executive Unit

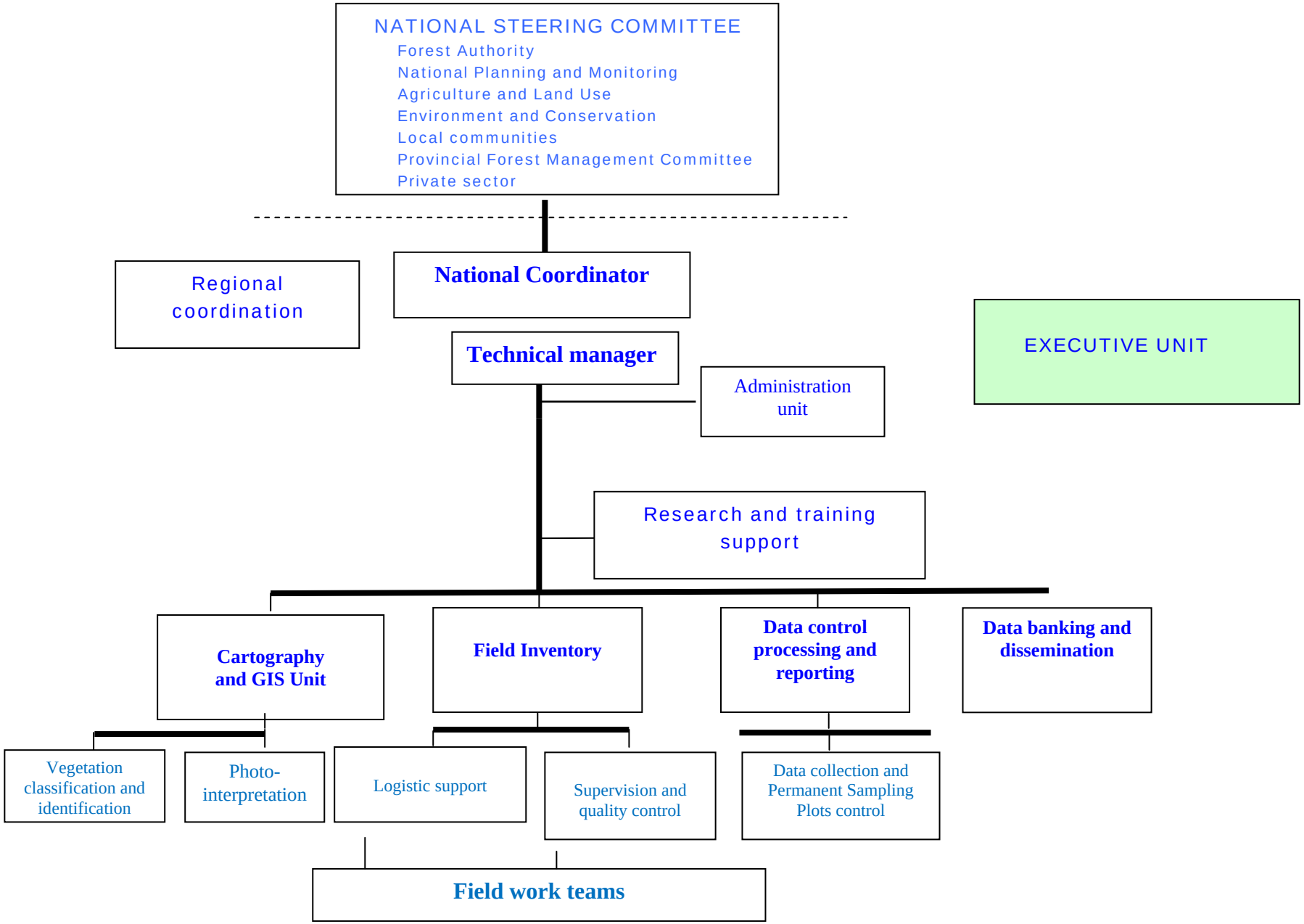
This body, which could be called the Central National Forest Inventory Unit would be part of the FA (attached to the Forest Planning Division). Its mission is to coordinate and support the practical execution of the NFI, providing the detailed methodology and support for the field work, carrying out data collection and processing, and generating updated information (statistical and geo-referenced) on the distribution, quantity, characteristics of forests and other vegetation types, and of their changes over time under a comprehensive approach integrating the various forest goods and services(including that of reservoirs of biodiversity).

4.1.4 Organizational chart

The preparation phase can be carried out by an organization relatively simple, limited to the executive unit, led by a National coordinator assisted by a Technical manager (Deputy coordinator), with the support of the regional units of the Forest Authority, and of national and international consultants. However, the implementation phase of the first cycle requires a reinforced structure in order to ensure perform efficiently and meet the targets on time. In the subsequent cycles, the work will be reduced, and it will be possible to return to a simplified structure.

The figure below shows the proposed organizational chart for the preparatory phase. This scheme seeks to achieve high-level political support (National Steering Committee) bringing as Co-Chairman the Head of the Department of National Planning and Monitoring or one of his/her assistants), and senior representatives of other Governmental and Non Governmental Organizations. The Executive Unit of the National Forest Inventory will be established in the FA Division of Forest Planning and headed by a national coordinator and deputy coordinator, two senior professionals of high profile. It will include several units and sub-units, each of them responsible for part of the work. The concrete involvement of participating organizations would be coordinated through an Interagency Working Group. The Technical Manager and the professionals in charge of units the of Cartography and GIS, of field sampling inventory, of data control, processing and reporting, should be nominated after a selection process and employed full time, while that of raining and of data banking and dissemination could be staffed by professionals hired part time.

Figure No.7 Organizational chart for the Multipurpose National Forest Inventory in Papua New Guinea



Information users

The Forest Authority will use the MNFI results for the elaboration and implementation of the National Forest Development plan, to be updated every 5 years, and for decisions regarding the efficient administration of the forest resources. Its regional echelons will use the information to determine the annual allowable cuts by forest types within specific zones, as well as for the master plans for the conservation and management of forest resources at the regional level

The Department of National Planning and Monitoring will have at its disposal information useful for formulating the national and regional land use plans, and the national development plans, with the possibility of estimating more precisely the actual and potential contribution of the forest resource to the country's economy.

The Universities, technical schools and research institutions will be able to access and use a large amount of information for teaching and scientific purposes, including flora and fauna specimens, and data on distribution and evolution of forest ecosystems and species. They will have information material for studies on deforestation and forest degradation, carbon sequestration and climate change, and on many other subjects.

Finally, private forest enterprises, both logging and wood processing companies, will have access to a updated information about timber resources of the country, which will facilitate decisions on investment and trade.

4.2 Strategy

a) Space elements

- Level : national and sub-national (provincial), not lower ;
- geographic distribution of work over the duration of a cycle : the field work should be carried out at the same time in 3 to 5 zones simultaneously by as many teams (see also 5.5 c) ;
- case of small islands : how to cater for their relatively large number is an issue to be addressed (those smaller than Manus, which is a province on its own, number approximately 470 as shown on the 1:2,000,000 scale "International Travel Map" of PNG, ranging from comparatively large ones to atolls).

b) Time elements

- The MNFI system should be made up of *continuous series of cycles* : increasingly, national forest inventories are carried out on a continuous basis, in order to assume their monitoring function ;
- *duration of cycles* : 5 to 10 years, depending on many factors (cycles of continuous national forest inventories have generally this range of duration); in the case of PNG, given the long time elapsed since the last nationwide inventory, and the coming into force in 2013 of the successor to the Kyoto Protocol, it is recommended that the first cycle lasts only 5 years;
- *seasonal aspects* of field work: during the peak of the rainy season, a part at least of the field staff should be assigned office duties, such as data checking and capture ;
- different *phases* of a cycle (see section e) below).

c) Data to be collected

- *Numbers of trees* above 10 cm DBH by species and 10cm diameter classes, by forest types in all forests ;

- standing and commercial *volumes* with more detail in production forest areas ;
- *volume increments*, using the data provided by FRI from its Permanent Sample Plots ;
- *biomass and carbon stocks* (derived from above volume estimates and soil assessments) ;
- *biodiversity* : plant and animal species occurrence – on small quadrats for the plants of the grass and undergrowth layers -, identification of rare and endangered species, special ecosystems assessment, all this being intensified in potential conservation zones ;
- *water* (surface water, water points, springs, ponds, turbidity, ...) ;
- *soils*, using simple methods such as the "rapid visual soil assessment technique" ;
- *deforestation* and land use changes, *forest degradation* and related aspects will be assessed everywhere ;
- *socioeconomic assessments*, carried out through household surveys and Rapid Rural Appraisal methods.

Inventory of forest plantations and assessment of potential areas for afforestation and reforestation will be specifically designed.

d) Funding strategy

External funding may be sought for separate components of the first cycle of the MNFI (preparation and training, remote sensing and mapping, forest plantation inventory, ...) with corresponding project documents adapted to different international financing sources, possibly in a phased approach.

Concomitantly, the government should give some signals of political will, such as :

- establishing a high-level national steering committee for the MNFI,
- allocating minimum resources for the preparation phase (see e) below), and
- organizing current available information useful for the MNFI.

e) Phases of the cycle

1) Preparation phase (9 to 12 months)

This phase includes the following components:

- Establishment of the institutional setup (see also below under this heading), including:
  - the management structure inside the FA,
  - nomination and/or recruitment of the permanent staff assigned to the project,
  - designation of the focal points in the participating agencies,
  - establishment of the high level interagency coordinating committee.

  All these measures can be prepared and/or acted on by the FA ahead of the actual start of the MNFI.

- Refinement of the MNFI methodology, on the basis of an assessment of the feasible response (in terms of reporting areas and precision) to the needs expressed by the various stakeholders and in consultation with them.

- Pilot field exercise: a full testing exercise on a reduced area should be implemented for the assessment of the proposed methodology.

- Detailed planning of the MNFI, using the PERT system or any other type of "critical path" analysis, again in consultation with the various stakeholders, taking into account their involvement and contribution in the implementation of the overall exercise.

- Organization of existing information : this is an essential activity. In practice, no NFI "starts from scratch", there is plenty of information available in qualitative, pictorial, numerical and digital forms, at various levels, recent or less recent, which can be utilized with advantage by an NFI in various ways and for various purposes: stratification and use for ratio/regression estimates for the field (sampling) inventory (to make it more efficient), previous taxonomic work and botanical collections for species identification, previous soil sampling and vegetation mapping, … .This is particularly the case of PNG.

- Acquisition of equipment and supplies, with particular reference to the ordering and purchase of a complete coverage of high resolution satellite imagery in digital format (the last complete high resolution satellite imagery coverage used for wall-to-wall forest mapping corresponds in average to the year 2002).

- First period of staff training, particularly of those involved in the interpretation of remote sensing imagery and digitized mapping, and of those responsible for the field work at regional and provincial levels (taxonomy, sample plot localization, forest mensuration, soil surveys, socioeconomic surveys, ...).

2) Interpretation of remote sensing imagery and mapping

This phase may overlap to some extent with the preparation phase, and includes :

- Development of the various classifications (forest types and other vegetation categories, land use classes, soil types, terrain conditions, …) in consultation with the specialists and users concerned.

- Semi-automated interpretation of the satellite imagery and mapping on different layers of the various classifications agreed on, at a scale of 1:100,000 to 1:250,000, supplemented by the necessary "ground truthing".

This work should start sufficiently ahead of the field sampling in every region/province to allow for the stratification of the field (sampling) inventory. Imagery interpretation and mapping, on one hand, and field work, on the other, should progress more or less at the same pace.

3) Field sampling

Distribution of the field sample

There are various ways of distributing the field sample in space and time.

- Given the increased efficiency provided by stratification (reduced cost for the same precision
on given forest variables, or increased precision on given forest variables for the same cost), it is generally considered that the sampling should be *stratified by forest types* once

these latter have been mapped (and their areas measured) by interpretation of remote sensing imagery.

- Then, there is the issue of the *distribution over time* (over the duration of the cycle) of the whole nationwide sample : either $1/n^{th}$ of the sample (n years being the duration of the cycle) is done every year, or the sampling is concentrated in $1/n^{th}$ of the country every year. The first approach allows for the provision of results for the whole country from the end of the first year, but is more expensive for obvious logistic reasons (particularly in the case of Papua New Guinea). It is the one used by Sweden and more recently by France. The second method is less expensive, but provides valid estimates for the whole country only when the cycle is over, and not before.

  A sort of intermediate approach is proposed here, i.e. that field sampling be carried out simultaneously in different regions/important provinces (like Western Province in the Southern Region) and continued on a province by province basis over the duration of the cycle. This would mean, as an average, one province per year during the first cycle (five years, of which approximately four of field sampling). Within each region, it is proposed to start by the province where results are most in demand.

- Finally, there is the question of the *type of sampling*:

  - one-stage or two-stage sampling[1] ?
  - (at every stage) randomly selected or systematically distributed area wise?
  - same or different intensity in each province and/or in each forest type ?
  - variation of intensity by number of samples or size of the samples ?

For many reasons, it is proposed that the sampling be one stage, and that the sampling units be systematic and not at random.

- <u>Field sampling units</u>

  The sampling unit (in a one-stage sample, or the secondary unit in a two-stage sample), should be a composite "tract", made of a cluster of circular or rectangular plots and subplots of different sizes for the assessment of :

  - land use/land cover/vegetation/forest occurrence,
  - regenerative capacity of the forest,
  - non timber forest products,
  - numbers of trees > 10cm DBH,
  - volumes of boles > 50cm per quality classes,
  - plant occurrence in the undergrowth and grass layers,

  <u>plus</u> a rapid visual soil assessment (surface condition, depth, texture, structural condition, porosity, color, drainage, pH, . …), with one soil sample by tract;

[1] There is a two-stage sampling when the sampling units (said to be "primary units") are not surveyed completely, but are themselves divided in smaller units, only a sample of them ("secondary units") being surveyed in each of the selected "primary units".

plus, within concentric circles around the center of the tract, a socioeconomic survey from a given number of households, observations of water bodies and water quality, and of wildlife occurrence.

The mission's conclusion on the question of field sampling is to suggest, within each region (or each province), the use of a stratified systematic sampling design (by main forest types) using preferably a grid of "tracts" of round geographic coordinates whose spacing will depend on the percentage error acceptable (e.g. ± 20 % at 0.95 probability level) on key variables, such as:

- number of trees (all species or all commercial species together) with DBH > 10 cm per hectare of forest in the region/province (either all types of forests, or, separately, undisturbed productive forests, logged over forests, protection forests);
- total carbon or biomass content of the forest vegetation in the region or province[2].

4.3 Planning

4.3.1 General considerations

The information provided and analyzed in chapter 2 on the present state of forest resources, and on the socioeconomic context, with regard in particular to local communities and agricultural development, call for a careful planning of the MNFI. The main elements to be considered are:

- the high dependence of the rural population (80% of the total population of the country) on forest goods and services: this requires a complete appraisal of the diversity, amount and value of goods and services for local communities ;

- more than 95% of the natural forests belong to the local communities (landowners), and any access to this resource (even for inventory or research), should be previously negotiated with them;

- the increasing interest and pressure of the private companies, mainly foreign ones, for obtaining logging agreements in natural forests under the system adopted in the 1996's forest policy and national forest plan ;

- the lack of reliable and updated information regarding the current state of PNG forests (after the of considerable efforts made by FA and other PNG agencies with the support of Australian cooperation during the period 1975-1996) is a serious handicap for the forest sector : a full

[2] Many useful forest inventory references exist, particularly on the subject of field sampling, among which the *Manual of Forest Inventory with Special Reference to Tropical Forests* (FAO Forestry Paper n° 27, Rome, 1981). On multiple forest resources assessments, the FAO's Support to National Forest Monitoring and Assessment program has elaborated useful handbooks, such as the one entitled *Integrated Natural Resources Assessment – Kenya – Field Manual*, 7th edition, FAO, Rome/Nairobi, 2007, and the more recent one, of a more general scope entitled *National Forest Monitoring and Assessment – Manual for integrated field data collection*, FAO, Rome (2008). Finally, there are recent examples of national forest inventories whose scope goes beyond the sole objective of timber management, such as those carried out in Argentina (with World Bank funding), in Bolivia (with ITTO's assistance), and in Venezuela (with FAO's support).

assessment of PNG forest resources is badly needed for sound land use planning and for sustainable forest management;

- the increasing need for reliable information expressed by the various stakeholders, and for PNG to fulfill its obligations as a Party to various international agreements and conventions.

A MNFI being a complex endeavor in both technical and logistic terms, its implementation requires a solid institutional foundation with an adequate structure and skilled staff. However what is at least as important is *the efficient use of the information collected and processed by the MNFI*, the main objective of which is to provide the reliable information needed for the implementation of the national forest development plan[2]. This is clearly stated in the National Forest Plan elaborated by the FA and recapped by the 2007 ITTO Diagnostic Mission ("conduct a national forest inventory as soon as possible; a multidisciplinary team of foresters, environmentalists, conservationists to be involved in a National Forest Inventory every 5 to 10 years as per recommended in the PNG Forest Policy"). It would be useless to have or implement a refined and complete MNFI, if the government agencies and, more generally, the stakeholders are not well prepared to utilize the information provided at the right time and in the most efficient way.

The need for a national forest inventory in PNG is mentioned in the Forestry Act, and in the National Forest Plan, elaborated and approved in 1996, but not yet fully implemented, due to several constraints, most of them related to the lack of economic resources and the apparently low priority given by the government to the forest sector, despite the existence of a well elaborated legal and institutional frame.

Timber extraction in the production forests is the main forest priority of the government authorities and private companies which are responsible for the management of the forest resources. While primary forests comprise more than 2,000 tree species, of which about 200 have a timber of commercial value, more that 80% of exports of wood products and 80% of log exports are from 5 to 8 species only. The lack of a strict control of logging, wood transport, processing and export activities makes it difficult to know in particular how much timber is actually felled, the amount of waste left in the forest and the damage caused by logging to the residual stands. This unsatisfactory situation calls for the urgent establishment of a monitoring system in the forest, and of additional permanent sample plots for the accurate measurement of standing volume, natural regeneration, and actual commercial volume by species[38].

In the field of assessments of forest biodiversity, water resources, biomass and carbon stocks in PNG, there seems to be only isolated research studies. This is in contrast with the prominent role played by PNG Government in the UN Forum on Forests and the UN Framework Convention on Climate Change, particularly with regard to carbon stocks issues and in support of the proposal for compensation of avoided deforestation and degradation. Various national agencies (Departments of National Planning and Monitoring, of Environment and Conservation, and of Agriculture and Livestock), and some NGOs are following up through the preparation of policy papers on carbon

[38] From 1992 to 1999, IITO' s project PD-162-91 contributed to the establishment of 72 permanent sample plots in logged over areas and to the development of a database for the information collected on these plots. Since 1995, the FRI Sustainable Forest Management program has established 55 more plots, which added to the ones established through the ITTO' s project makes a total of 127, out of which 9 in undisturbed forest and 118 on logged over forest. As a result of accessibility problems, bad roads and broken bridges, 11 have been abandoned, 18 are still inaccessible and 98 currently being measured every year.

trade. The efforts of PNG in this field are likely to be accompanied by the international community, and this could mean, in turn, an important support to the implementation of the MNFI.

Water catchments are probably to be considered the most threatened resource in view of the large scale deforestation and logged over activities in the hill and mountainous regions. Therefore, the MNFI should include a careful assessment in this field, which should be designed and carried out in full cooperation with the national agency directly responsible for continental water resources.

Deforestation is without doubt one of the most controversial aspects related to the forest sector. Different definitions and estimations of deforestation exist. This is a problem well recognized by the Forest Authority : deforestation is often confused with forest degradation resulting from logging, and this contributes to the negative evaluation by international and national observers of the way FA is controlling forest utilization. Since there are not clear rules or guidelines, nor control of land use changes[39], and with increasing populations, deforestation is also on the increase. This is compounded by the customary system of land ownership.

After a quick appraisal of the institutional and physical contexts of the forest sector in PNG, on the basis of the information provided by the many persons and institutions contacted, taking into consideration several experiences of multipurpose forest inventory and of integrated national forest resources assessment in different tropical countries, the following strategy has been prepared the implementation of the MNFI.

Figure No. 8 Schematic organization of the information to be collected and assessed

[39] At present, there is neither national nor provincial level land use planning being practiced, nor much interest in land use planning, since much of the land is held under customary ownership and tenure, or allocated to concessionaires whose primary interest is only the timber resources (ITTO' s diagnosis forest sector mission, March 2007).

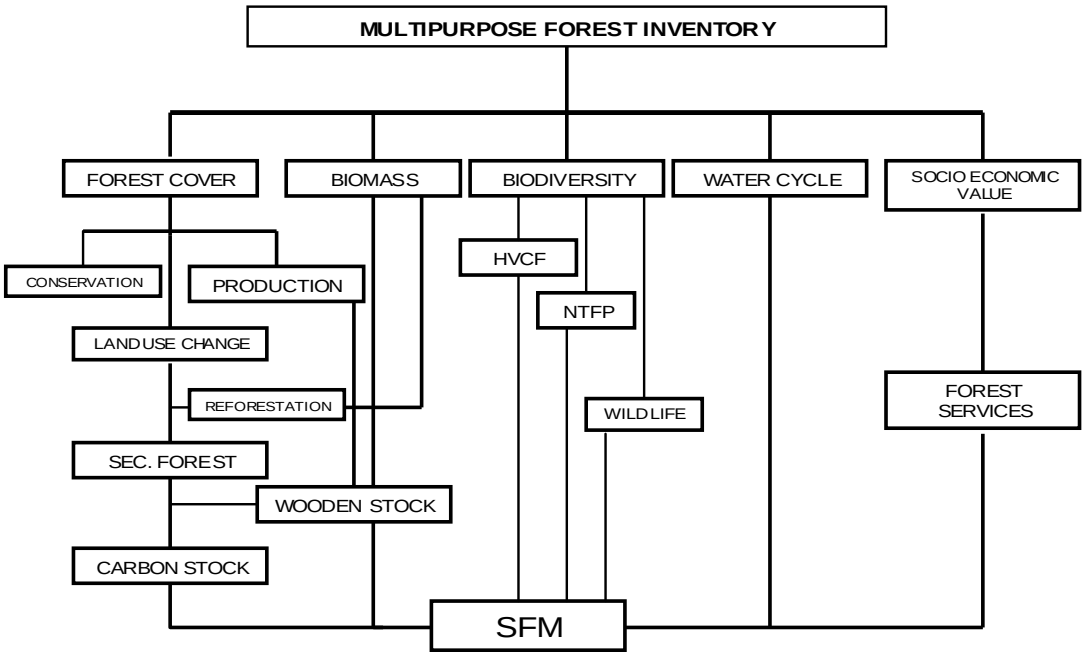

MULTIPURPOSE FOREST INVENTORY
FOREST COVER
BIOMASS
BIODIVERSITY
WATER CYCLE
SOCIO ECONOMIC VALUE
CONSERVATION
PRODUCTION
HVCF
NTFP
LAND USE CHANGE
REFORESTATION
WILDLIFE
FOREST SERVICES
SEC. FOREST
WOODEN STOCK
CARBON STOCK
SFM

Table No. 15 General approach for data collection by main components

Variable	Extent	Detail
FOREST COVER	National and regional vegetation maps	Scale 1/250,000 differentiation by eco-floristic characteristics, density and height, deforestation, regeneration and reforestation rates
BIOMASS	Total aerial biomass, timber volume, carbon stocks	By forest types, species and DBH classes, commercial and potential use . Numbers of trees above 10 cm, by species and 10cm diameter classes by forest types in all forests Standing and commercial volumes with more detail in production forest areas Volume increments, using the data provided by FRI from its Permanent Sample Plots Biomass and carbon stocks (derived from above volume estimates and soil assessments)
BIODIVERSITY	General description and assessment of flora and fauna	Abundance, frequency and value of importance, high conservation value forest types and species, endangered species . Plant and animal species occurrence – on small quadrats for the plants of the grass and undergrowth layers -, identification of rare and endangered species, special ecosystems assessment, all this being intensified in potential conservation zones
WATER	Main water sources and catchments accounted	Permanent and periodic flows of water, level of pollution of waters (surface water, water points, springs, ponds, turbidity, ...) Soils, using simplified methods such as the “rapid visual soil assessment technique”
SOCIO – ECOMOMIC	Relationship between people livelihood and the forest resource	Use and consumption of forest products, importance in economy of local communities Deforestation and land use changes, forest degradation and related aspects will be assessed everywhere Socio-economic assessments, carried out through household surveys and Rapid Rural Appraisal methods

4.3.2 Assessment of importance and priorities of the main variables (information fields)

As a part of the work program of the mission, a national workshop was carried out on 29 January 2009, with the participation of FA HQs senior staff, 12 FA area managers and FRI researchers coming from different provinces, A matrix had been distributed at the second session to the workshop participants for them to indicate the priority they assign to 12 fields of information in each of the 19 provinces. Results of the exercise were analyzed for two provinces (Morobe and Central provinces) for which there were respectively

A total of 1019 observations were collected through the matrix of qualification, full filled by 30 participants on the workshop, however given the case that some participants did not have any knowledge or experience regarding some particular province, it was decided that he (them) should n't full fill the information for these provinces.

The results of this exercise shows that there are important differences in the importance or priority between the information fields when applied to the provinces, which could permit to the NFI planners to give more or less emphasis or priority to this parameters according to the provinces.

In general the information fields of total forest cover, production forest, forest degradation and areas for reforestations, seems to be on the top of the priorities for the whole staff of the FA, when the scoring is screamed between H, M and L priorities, the highest score was done to the water catchments and areas for reforestation, followed by total forest cover areas and degradation forest.

Table No. 16 Score by information field and level of importance (H,M,L)

	SUB-TOTAL	SUB-TOTAL	SUB-TOTAL	TOTAL
Information fields	H	M	L	T
Total natural forest cover	36	39	17	92
Production forest	31	39	28	98
Protection forest	22	20	41	83
Forest degradation	35	39	19	93
Biodiversity (flora)	34	33	14	81
Biomass and carbon stock	29	42	15	86
Water catchments	44	26	11	81
Wildlife	32	33	13	78
Expansion of shifting cultivation	39	17	22	78
Expansion of cash crops	32	31	21	84
Area for reforestation	44	27	15	86
Area for rehabilitation	24	28	27	79
TOTAL	402	374	243	1019

Table No. 17 Resulting level of importance by information fields

Priority	Information field
I	Natural forest cover, Production forest, Forest degradation, Biodiversity, Water catchments, Deforestation, Area for reforestation
II	Biomass and carbon sequestration, Wildlife, Areas for rehabilitation, Expansion of cash crops
III	Protection forest

Table No. 18 Qualification score by provinces and information fields given by the workshop participants

Regions	Southern Region					Highlands region					Northern Region				Islands Region				
Provinces	Western	Gulf	Central	Milne Bay	Oro	Southern	Enga	Western	Chimbu	Eastern	West sepik	East Sepik	Madang	Morobe	Manus	West New Britain	East New Britain	New Ireland	Northern Solomon
forest cover	12	4	0	0	1	3	0	0	0	0	3	1	0	2	4	5	0	1	3
Production forest	12	1	0	0	0	4	0	0	0	0	3	0	1	0	2	6	0	2	3
Protection forest	12	1	0	0	0	2	1	0	0	1	1	0	1	0	0	3	0	0	2
Forest degradation	4	0	0	0	1	5	3	1	8	3	2	0	0	2	2	3	0	1	1
Biodiversity (flora)	12	4	0	0	2	5	1	0	3	0	1	0	0	2	2	1	0	1	1
Biomass and carbon stock	9	4	0	0	0	3	0	1	0	1	2	0	0	2	3	4	0	0	3
Water catchments	13	2	0	0	2	5	6	1	5	4	2	0	0	2	0	1	0	1	3
Wildlife	10	2	0	0	1	5	3	0	0	2	2	0	0	2	0	3	2	0	2
Expansion of shifting cultivation	4	0	0	0	1	8	5	2	5	4	1	0	0	2	0	4	2	1	0
Expansion of cash crops	3	0	0	0	2	7	5	2	4	3	0	0	0	0	0	5	0	1	0
Area for reforestation	14	2	0	0	3	3	5	3	2	5	1	0	0	2	1	2	0	1	0
Area for rehabilitation	2	0	0	0	0	5	5	2	4	2	2	0	0	2	0	0	0	0	1
TOTAL	107	20	0	0	13	55	34	12	31	25	20	1	2	18	14	37	4	9	19

Table No. 19 Specific weight by assigned priorities

Regions	Southern Region					Highlands region					Northern Region				Islands Region				
Provinces	Western	Gulf	Central	Milne Bay	Oro	Southern	Enga	Western	Chimbu	Eastern	West sepik	East Sepik	Madang	Morobe	Manus	West New Britain	East New Britain	New Ireland	Northern Solomon
forest cover	3	3	1	1	2	2	1	1	1	1	3	3	1	3	3	3	3	3	3
Production forest	3	1	1	1	1	2	1	1	1	1	3	1	3	1	3	3	3	3	3
Protection forest	3	1	1	1	1	2	1	1	1	1	2	1	3	1	1	2	3	1	2
Forest degradation	1	1	1	1	2	3	2	2	3	3	2	1	1	3	3	2	3	3	1
Biodiversity (flora)	3	3	1	1	3	3	1	1	2	1	2	1	1	3	3	1	3	3	1
Biomass and carbon stock	2	3	1	1	1	2	1	1	1	1	2	1	1	3	3	3	3	1	3
Water catchments	3	2	1	1	3	3	3	2	3	3	2	1	1	3	1	1	3	3	3
Wildlife	3	2	1	1	2	3	2	1	1	2	2	1	1	3	1	2	3	1	2
Expansion of shifting cultivation	1	3	1	1	2	3	1	3	3	3	2	1	1	3	1	3	3	3	1
Expansion of cash crops	1	3	1	1	3	3	1	3	3	2	1	1	1	1	1	3	1	3	1
Area for reforestation	3	2	1	1	3	2	1	3	1	3	2	1	1	3	1	1	1	3	1
Area for rehabilitation	3	3	1	1	1	3	1	3	3	2	1	1	1	3	1	1	1	1	1
TOTAL	29	27	12	12	24	31	16	22	23	23	24	14	16	30	22	25	30	28	22

Green = 3, Yellow= 2, Red = 1

Table No. 20 Scores by provinces using a weighted index by information field

Regions		Southern Region					Highlands region					Northern Region				Islands Region				
Provinces	Index	Western	Gulf	Central	Milne Bay	Oro	Southern	Enga	Western	Chimbu	Eastern	West sepik	East Sepik	Madang	Morobe	Manus	West New Britain	East New Britain	New Ireland	Northern Solomon
forest cover	3	9	9	3	3	6	6	3	3	3	3	9	9	3	9	9	9	9	9	9
Production forest	3	9	3	3	3	3	6	3	3	3	3	9	3	9	3	9	9	9	9	9
Protection forest	1	3	3	3	1	1	2	1	1	1	1	2	1	3	1	1	2	9	3	6
Forest degradation	3	3	1	1	3	6	9	6	6	9	9	6	3	3	9	9	6	3	3	1
Biodiversity	3	9	9	3	3	9	9	3	3	6	3	6	3	3	9	9	3	9	9	3
Biomass and carbon stock	2	4	6	2	2	2	4	2	2	2	2	4	2	2	6	6	6	6	2	6
Water catchments	3	9	6	3	3	9	9	9	6	9	9	6	3	3	9	3	3	9	9	9
Wildlife	2	6	6	3	2	4	6	4	2	2	4	4	2	2	6	2	4	9	3	6
shifting cultivation	3	3	3	1	3	6	9	3	9	9	9	6	3	3	9	3	9	3	3	1
Cash crops	2	2	3	1	2	6	6	2	6	6	4	2	2	2	2	2	6	1	3	1
reforestation	3	9	6	3	3	9	6	3	9	3	9	6	3	3	9	3	3	3	9	3
rehabilitation	2	6	9	3	2	2	6	2	6	6	4	2	2	2	6	2	2	3	3	3
TOTAL		72	64	29	30	63	78	41	56	59	60	62	36	38	78	58	62	73	65	57

4.3.3 Resulting priorities by region and provinces

Table no. 21 Priorities for the inventory, by regions and provinces

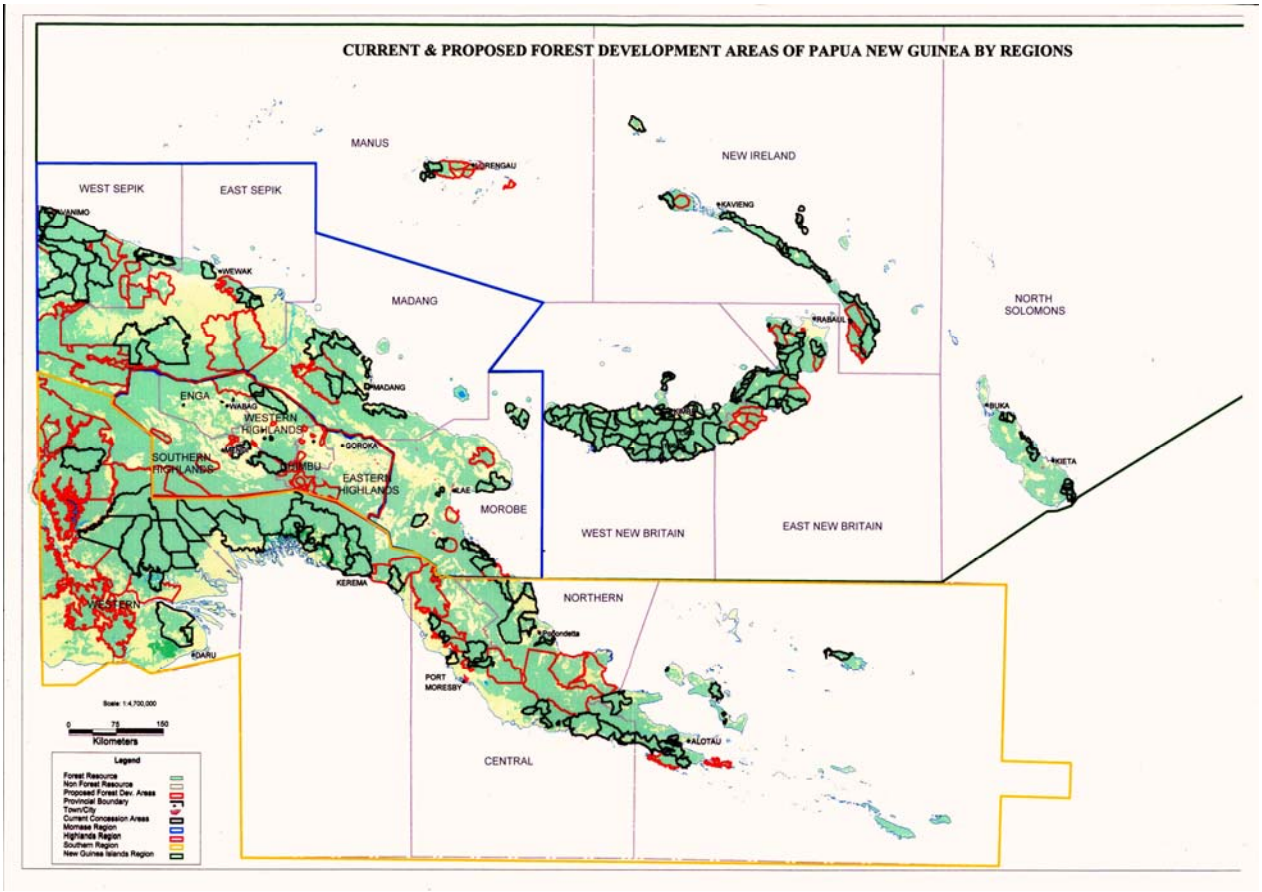
REGION	PRIORITY I	PRIORITY II	PRIORITY III
SOUTHERN	WESTERN, GULF, ORO		CENTRAL, MILNE BAY
HIGHLANDS	SOUTHERN	WESTERRN, CHIMBU, EASTERN	ENGA
NORTHERN	MOROBE	WEST SEPIK	EAST SEPIK, MADANG
ISELAND	WEST NEW BRITAIN, EAST NEW BRITAIN, NEW ISELAND	MANUS, NORTHERN SALOMON	

The priorities by provinces as a result of the importance or priority assigned to each of the information fields, offer an important information for the spatial and time strategy to be applied for the field work, in such a way that if the total duration of the first cycle of the MNFI is five years, the provinces which are classified as priority one (I), may be considered for the first period of the forest inventory, i.e the two first years ; the provinces with priority two (II) will be inventoried during the second period of the inventory, i.e years 3 and 4 ; and the provinces with priority three (III) will be inventoried during the last year.

Table No. 22 List of PNG provinces

1. Central	11. Morobe
2. Chimbu (Simbu)	12. New Ireland
3. Eastern Highlands	13. Northern (Oro Province)
4. East New Britain	14. Bougainville (North Solomons)
5. East Sepik	15. Southern Highlands
6. Enga	16. Western Province (Fly)
7. Gulf	17. Western Highlands
8. Madang	18. West New Britain
9. Manus	19. West Sepik (Sandaun)
10. Milne Bay	

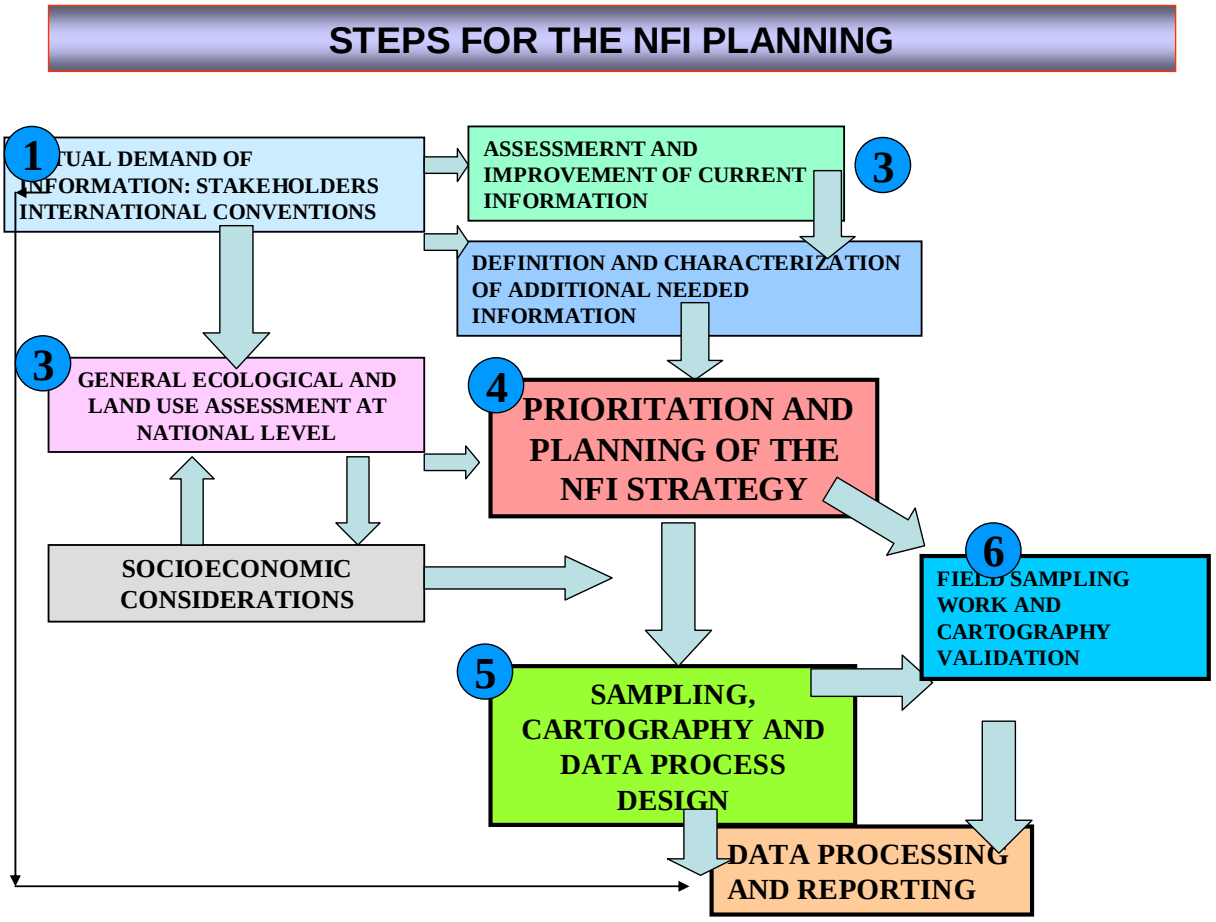
Figure No. 9 Map with the enumeration of the provinces



4.3.4 Phasing and planning

The main steps for the planning are summarized in the following chart :

Figure No. 10 Planning steps flow chart



5. METHODOLOGY

5.1 Assessment of areas and area changes and mapping

5.1.1 Deforestation and forest degradation assessment

Distinction between deforestation and forest degradation

The confusion that reigns between the two notions of deforestation and forest degradation has all too often been kept alive, or unconsciously made. In order to avoid any ambiguity, we have to recall the following elements

- *deforestation*: this involves a decrease in the area covered by forest. However, it must be complemented by a definition of the term "forest", and, most importantly, cannot be defined without adding a reference to the use (or allocation) of the piece of land considered. In point of fact, there exist certain forms of forest utilization – and priority objectives of forest management – that clear temporarily the forest cover while guaranteeing its maintenance. This is the case of clear cutting of areas where forest will regenerate itself or be regenerated, or of the final cut in an even-aged forest silvicultural treatment once natural regeneration has been assured. In other words, there is no deforestation if there is a guarantee of continuity in maintaining the forest cover;

- *forest degradation*: this does not involve a reduction of the forest area, but rather a quality decrease in its condition, this being related to one or a number of different forest ecosystem components (vegetation layer, fauna, soil, …), to the interactions between these components, and more generally to its functioning. The estimation of degradation can be hampered by a number of difficulties that are notably caused by:

  – the different choices of the initial state of reference: "climax" or its numerous substitutes, the forest condition which corresponds to the silvicultural model that was adopted, …;

  – the criteria (with their indicators) one favours: health and vitality, species diversity, the production capacity of market or non-market goods and services;

  - depending upon whether we limit ourselves to the present date, or whether we consider that the present state is only transitory and leads to a satisfactory, or even improved, later state.

The ambiguities of the term degradation, and the difficulties of estimating it, are additional reasons for clearly differentiating between deforestation and forest degradation.

Definitions of "forest", "deforestation" and "forest degradation"

Definitions depend on the objectives assigned to them, the tools used to estimate their extent, the institutions using them and the time at which they were formulated. In the end, we shall have to restrict to only one definition for each term for sake of clarity and consistency. FAO[40] lists the most important

[1] "Definitional issues related to reducing emissions from deforestation in developing countries" Forests and Climate Change Working Paper 5.

internationally agreed definitions, a short list of them being :

- for forest :

- *"a minimum area of land of 0.05-1.0 hectares with tree crown cover (or equivalent stocking level) of more than 10-30 per cent with trees having the potential to reach a minimum height of 2-5 metres at maturity in situ"* (including closed and open forests, young natural stands and all plantations which have yet to reach the crown density threshold, temporarily unstocked areas expected to revert to forest) (UNFCCC, 2001, "Marrakech accord");

- *"a land area of more than 0.5 ha, with a tree canopy cover of more than 10 percent, which is not primarily under agriculture or other specific non-forest land use"* (UNEP/CBD,2001);

- *"land spanning more than 0.5 hectares with trees higher than 5 metres and a canopy cover of more than 10 percent, or trees able to reach these thresholds in situ. It does not include land that is predominantly under agriculture or urban use"* (FAO,2006).

- for <u>deforestation</u> :

  - "*the direct human-induced conversion of forested land to non-forested land*" (UNFCCC, 2001, Decision 11/CP.7 , "Marrakech accord");

  - *"the conversion of forest to another land use, or the long-term reduction of the tree canopy cover below the minimum 10 percent threshold"*: this definition is used, inter alia, in the FAO's Global Forest Resources Assessment Programme ;

- for <u>forest degradation</u>:

  - *"a reduction of canopy cover or stocking within the forest"* (FAO,2000) ;

  - *"a secondary forest that has lost, through human activities, the structure, function, species composition or productivity* normally associated with a natural forest type expected on that site" (UNEP/CBD, 2001) ;

  - *"changes within the forest which negatively affect the structure or function of the stand or site, and thereby lower the capacity to supply products and/or services"* (FAO, 2001 and 2006) ;

  - "*a direct human-induced loss of forest values (particularly carbon), likely to be characterized by a reduction of tree crown cover"* (excluding reduction of crown cover resulting from the normal cycle of forest management operations)*"* (ITTO, 2005) ;

  - "*the direct human-induced average rate of carbon stock loss between 10% to 30% of carbon stock per hectare and year during 3 to 8 consecutive year., and to the extent that loss does not qualify as deforestation"* (UNFCCC, 2007).

Much work and debate has taken place on the evaluation and comparison of these definitions of forest degradation, and it is not the place here to rehash all what has been said and written on the subject (see in particular the Intergovernmental Panel on Climate Change reports, and the UNFCC Subsidiary Body for Scientific and Technological Advice session proceedings from 2001 onwards, as well as the FAO Working Paper mentioned above). As we can see from this sample of internationally agreed definitions, degradation is much dependent on the category of users, i.e. on the component or function of the forest

ecosystems. It is even more complicated: for climate change specialists, a reduction of the canopy may translate a past release of carbon in the atmosphere, and thus an aggravation of the greenhouse effect (a negative development well reflected by the term "degradation"), and, at the same time, an increased absorption of the atmospheric CO_2 and of the role of forest as a carbon sink (a positive development).

For these three terms, the definitions used by FAO and likely to be used for the next round (2010) of its Forest Resources Assessment Programme, are those which seem the most adaptable to the variety of objectives of a MNFI and to the several reporting requirements on forests of countries to the agreements and international organizations they are party to or part of (mainly UNFCCC, CBD, ITTA, FAO and its FRA Programme). The Summary Report of the Technical Meeting of the National Correspondents to the Global Forest Resources Assessment (FRA 2010) held in Rome in March 2008, highlights, among others, the following points:

- FRA serves as an harmonization framework for the forest reporting streamlining role of the Collaborative Partnership on Forests of the UN Forum on Forests and its Global Objectives on Forests;

- FRA data are used by ITTO for updating its indicators on the status of tropical forest management;

- FRA 2010 (including its global remote sensing survey) are to be the main data source for assessing progress towards the 2010 Biodiversity Target of the CBD.

Taking all these elements into account, the definitions proposed as most appropriate for a MNFI will be:

- forest: *"a minimum area of land of 0.05-1.0 hectares with tree crown cover (or equivalent stocking level) of more than 10-30 per cent with trees having the potential to reach a minimum height of 2-5 metres at maturity in situ"*;

- deforestation: *"the conversion of forest to another land use, or the long-term reduction of the tree canopy cover below the minimum 10 percent threshold"*;

- forest degradation: *"a reduction of canopy cover or stocking within the forest"* [41].

Deforestation and forest degradation are characteristics of change over a period of time, and they can be assessed by comparison of the estimated extent (for deforestation) and the estimated conditions (for degradation) of a given forest area at the beginning and at the end of that period. The comparison of estimates at both occasions is valid of course insofar as definitions of concepts and classifications used at both times are the same. Hence, the importance of selecting the most relevant definitions and classifications at the beginning of a MNFI process.

Whereas deforestation corresponds to a simple alternative– e.g. there was forest (the way it is defined) on that particular' location at the beginning of the period, and there is no forest on the same spot at the end of the period, a phenomenon which can be measured by a binary variable (1 and then 0) - , forest degradation has different forms and degrees of gravity, even using the simple definition proposed above. So, we shall consider separately both phenomena.

[41] The 2000 FAO definition is considered to be more operational than the more recent ones used by the Organization, insofar as it can be more easily used both in the field and on remote sensing imagery.

5.1.1.1 Assessment of deforestation

It is proposed that deforestation be based exclusively on semi-automated interpretation – i.e. supported by ground truthing - of remotely sensed (satellite and airborne sensors) and/or recorded (flight reconnaissances) data at the beginning and end of the period under review. This period should be of the order of 7 to 15 years.

Several procedures to estimate deforestation exist within the framework of a MNFI, depending on the availability of maps and remotely sensed data (i.e. aerial photography or high resolution satellite data) 7 to I5 years back and at approximately the time of the inventory (but not more than 2 years before it). Maps and remotely sensed data may be, or may have been, drawn, interpreted or simply ordered by non forest organizations, either public, private or non governmental. Given the high costs of remote sensing products and of their interpretation, as well as that of aerial flights, forestry agencies in charge of MNFI must take all possible opportunities to organize and use existing data. It is also assumed that planimetric maps at, say, 1 to 200,000 scale, exist.

Tables 17 and 18 summarize different situations, options and corresponding actions related to the beginning of the period (T_0 time, i.e. 7 to 15 years from the start of the first cycle of the MNPI), and to the end of the period of deforestation estimation (T_1 time, start of the first cycle of the MNFI).

Deforestation being a clearly defined change of land use/land cover as well as a relatively simple phenomenon (compared in particular to forest degradation), there is no significant difference in the methods for estimating it between a conventional inventory and a MNFI, except concerning the principal criterion (criteria) used in both types of inventory for the classification of areas in forest types. Whatever this criterion(a), there should be sufficient evidence that the remote sensing imagery and tools used have proved effective in distinguishing the forest classes built upon them, both experimentally and on a large scale. In a MNFI, the number of criteria on which to base the interpretation classification is likely to be larger, and, the classification more refined and complex. However, the designer should not forget a well-known classification axiom: the more numerous and smaller the classes, the less precise and accurate the corresponding estimates. It would be an illusion to consider that increasing the complexity will result necessarily in the quality of the MNFI area estimates.

Two words of caution must accompany the recall of this latter principle. First, there has always been a tendency of the remote sensing community to oversell the capacity of remote sensing tools, though probably less now than it used to be the case in the early stages of satellite sensing. A lot of ground truthing remains indispensable, particularly for those new variables to be estimated in a MNFI (ecosystem and species occurrence, soil characteristics, ...). Second, this principle applies, other things being equal, to all estimation fields and all components of a MNFI: the desire to cover in the inventory the largest scope possible of forest goods and services should not go at the expense of the production of reliable results of acceptable precision and accuracy.

As far as PNG is concerned, the situation is the one described in the left column of table 1, i.e. the *country has already at its disposal a complete remote sensing coverage* (using the European high – resolution earth observation satellite SPOT 4) whose average date of imagery is 2002 ("T_0" baseline); *and a complete wall-to-wall vegetation map* drawn from it by the Remote Sensing Centre (RSC) of the University of Papua New Guinea (personal communications from A. dell'Ariccia and P. Shearman, January 2008). And a comparison has already been made by this Centre, thanks to a considerable work of vectorisation transfer, between this map and a former one dating back 1975 and revised by J.A.

Bellamy and J.R. Mc Alpine[42]. The results of this latter exercise have been published[43]. It is essential that cooperation with the University of PNG should be sought by the management of the MNFI, not only for the use of this most relevant baseline information, but also for the assessment of the "T_1" baseline (around 2009-2010)[44].

[42] "PNG Inventory of Natural Resources, Population Distribution and Land Use Handbook", 2nd edition , compiled by J.A. Bellamy and J.R. Mc Alpine, PNG Resources Information System (PNGRIS) publication n°6, Port Moresby, 1995.

[43] See sections 2.2.5 and 2.3.4, and footnotes 6,7 and 13.

[44] In a press release dated 9 June 2006, Earth Data International announced that it had been awarded by the Australian Government (under a MoU with the PNG government) a 16 million US$ contract for the use of its *GeoSAR airborne radar mapping system* (dual-band – including a X-band for vegetation cover - interferometric synthetic aperture radar) over 318,000 km^2 of PNG territory (about 70% of total area of the country, and 80% of its continental part). The survey was to be completed in 2007, and various maps would be produced within the span of four to five years. The capabilities of the system were presented in a rather inflated way, as able to serve as a basis for development choices, such as ... how to sustain forests while harvesting lumber (sic).No information was obtained on this operation either from the governmental institutions consulted, or from the Australian Embassy.

Table 23 : Situations, options and corresponding actions related to the beginning of the period of deforestation estimation (time T_0)

Time	Situations	Complete RS* coverage at T_0 available		Complete RS coverage at T_0 not available		
		Appropriate W-to-W** forest map available	Appropriate W-to-W forest map not available			
T_0 = T_1 – 7 to 15 years	Options			Acquire complete coverage at T_0	Acquire a systematic or other objective sample (from partial coverage, if possible)	Organize aerial survey (or reconnaissance air survey) by systematic line sampling
	Actions	No interpretation and mapping work needed (forest area estimates available at T_0)	Semi-automatic interpretation of RS imagery, W-to-W forest mapping and area estimation at T_0	Semi-automatic interpretation of RS imagery, W-to-W forest mapping and area estimation at T_0	Semi-automatic interpretation of sampled RS imagery, forest area estimation at T_0 by sampling	Semi-automatic interpretation of sampled RS imagery (or use of reconnaissance records), forest area estimation at T_0 by sampling

Table 24 : Options and corresponding actions related to the end of the period of deforestation estimation (first phase of first cycle of MNFI – time T_1)

Time				
T_1	Options	Acquire complete RS coverage at T_1	Acquire a systematic or other objective sample from complete RS coverage at T_1	Organize aerial survey (or air reconnaissance) by systematic line sampling
	Actions	Semi-automatic interpretation of RS imagery (for W-to-W forest map and area estimates at T_1) Compare estimates with T_0 area estimates	Semi-automatic interpretation of sampled RS imagery (for area estimation by sampling at T_1) Compare estimates with T_0 area estimates	Semi-automatic interpretation of sampled RS imagery (for area estimation by sampling at T_1) Compare estimates with T_0 area estimates
		NB: Field inventory can use a stratified sampling design, since the extent and location of the various forest classes (strata) are exactly known	NB: Field inventory cannot use a stratified sampling design, since the extent and location of the various forest classes (strata) are not exactly known.	

* RS : Remote Sensing (all types of sensors and platforms)
** W-to-W : Wall-to-Wall (i.e. complete map/mapping)

However, this situation may not be the one applying to PNG if the classification used by RSC for its land cover is not considered appropriate for the MNFI. In this case, a new interpretation work would have to be carried out to characterize the situation around 2002 (T_0, average date of the remote sensing coverage obtained by the RSC), before the same classification is applied to a new remote sensing coverage at the beginning of the first cycle of MNFI (T_1).

Another reason for not using the RSC land cover map could be that the University of Papua New Guinea is not prepared to release it for the implementation of the MNFI. This situation is mentioned here because lack of exchange of data between PNG Departments and public bodies has been stressed by several high ranking civil servants and aid cooperation representatives interviewed by the consultants, authors of this report. However, these latter refuse to envisage such a situation, the MNFI being a multidisciplinary endeavour undertaken for the service of the country as a whole[45].

5.1.1.2 Assessment of forest degradation

At the 23rd Conference of Parties to the UNFCCC (Bali, 3-14 December 2007), some scientists, while recognizing that estimation of emissions from forest degradation required more sophisticated and expensive methods and necessitated more ground-based measurement than deforestation, highlighted that new tools existed. Three categories, at least, can be identified.

a) Specially designed automated processing systems for high resolution (optical and near infrared) satellite data, such as the Carnegie Landsat Analysis System (CLAS) for forest disturbance assessment, e.g. to detect logging activities. It has been used in Brazil [46], Peru and the island of Borneo. It uses data from Landsat satellites, including the Enhanced Thematic Mapper data. Though there is uncertainty about the future of the Landsat programme, it may be reasonable to consider that processing systems would be applied to other similar types of satellite data (e.g. those of the SPOT satellites, or the forthcoming France's Very High Resolution panchromatic and multispectral Earth observation satellite PLEIADES) and will produce results useful for the assessment of forest disturbances.

b) High resolution radar sensors on satellites, such as the PALSAR (*Phased Array L-Band Synthetic Aperture Radar*) system on the Japanese ALOS (Advanced Land Observing Satellite) satellite[47]. The sensitivity to canopy structure of this system could prove useful for assessing forest degradation defined as indicated in paragraph 1.1.2 ("a reduction of canopy cover or stocking within the forest"). ALOS satellite was launched in 2006 and is expected to be operational for ten years or more. The whole system can provide "wall-to-wall high resolution image data that is acquired over short time frames and not impeded by cloud cover"[7]. It can be presumed that acquisition of the imagery will be

[45] To combat the damaging effect of such a "compartmentalization", it is proposed to establish a high level interagency coordinating committee (see).

[46] Source: "Selective Logging in the Brazilian Amazon" by Gregory P. Asner et al., *Science,* 21 October 2005: Vol. 310. no. 5747, pp. 480 - 482

[47] Source: "New Eyes in the Sky: Cloud-Free Tropical Forest Monitoring for REDD with the Japanese Advanced Land Observing Satellite (ALOS)" by Josef Kellndorfer et al. , The Woods Hole Research Center, United Nations Framework Convention on Climate Change (UNFCCC) Conference of the Parties (COP), 13th session, Bali, 3-14 December 2007

less expensive than in the case of the second system. However, its potential for assessing forest degradation is still to be ascertained as experimentation has just started in various tropical zones (Xingu Basin and Mato Grosso, in Brazil, Gabon and Equatorial Guinea in Central Africa, and Bali in Indonesia[7]). Other satellites with similar very high (metric) resolution radar systems are launched or to be launched soon, such as the Germany's TerraSAR-X, the Canada's Radarsat-2, or the Italy's COSMO-SKYMED within the framework of the French-Italian ORFEO system.

c) New airborne systems, such as the combination of a laser-based system (LIDAR) for topographic mapping and of the Visible/Infrared Imaging Spectrometer (AVIRIS)[48] for hyperspectral imagery. This device has been used apparently successfully in Brazil to identify and delineate selectively logged forest, which means that it allows for the classification and mapping of forest vegetation according to canopy cover. Since it requires a specific aerial survey to cover the country embarking on a MNFI, it is likely to be more expensive.

These various types of new remote sensing tools, some of them still to be fully tested for their application to the assessment of tropical forest degradation, may prove useful in a MNFI. However, their use will need, like all other thematic remote sensing applications, to be calibrated and supplemented by *ground truth* collected through the *field inventory* component and, possibly, *aerial reconnaissances*.

For MNFI systems to be started in the coming years, as could be the one in PNG, it is unlikely that T_0 estimates (i.e. estimates several years before the starting time T_1 of the MNFI) will be available, as forest degradation assessment methods on extended areas, using remote sensors on aerial or satellite platforms, are for most of them under experimentation or yet to be experimented. Forest degradation between T_0 and T_1 is therefore not likely to be feasible, except on a sampling basis by revisiting sample plots or lines of a previous inventory, if at all possible [49]. A similar table for forest degradation as Table 1 above for estimating forest cover at T_0 in the case of deforestation has therefore no relevance for the MNFI to be started in the coming years. As for table 2, its equivalent for the assessment of forest degradation would present the various actions to be taken for estimating the state of forest cover at the starting time T_1 of the MNFI depending on the assessment methods used.

In the case of PNG, it is suggested that either an automated processing system for high resolution (optical and near infrared) satellite data (such as the CLAS system), or a system using high resolution radar sensors on satellites (such as the PALSAR/ALOS one) be used. If, for financial or other reasons, one such satellite-based system could not be considered, then the more conventional use of large scale (infrared) colour photographs on parallel strips, or even the good old system of aerial reconnaissance by observation along parallel sample lines could be used at T_1 , and repeated at T_2 and subsequent times.

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[48] "This optical sensor that delivers calibrated images of the spectral radiance in 224 contiguous spectral channels with wavelengths from 400 to 2500 nanometers" ... and serves " to identify, measure, and monitor constituents of the earth's surface and atmosphere based on molecular absorption and particle scattering signatures".

[49] It could be argued that PSPs established for growth and yield estimation in some countries (such as PNG, where about 100 plots are being regularly measured) could be used to estimate forest degradation. However, because of their limited number, and of the fact that they do not generally constitute an unbiased nationwide sample, only very broad indications, without statistical value, can be inferred on forest degradation from these.

5.2 Acquiring information on high value and endangered species

In its decision 3 (XLII) "Multipurpose forest inventory as a tool for sustainable forest management" from which this study originates, the international tropical timber council noted that an accurate and up-to-date multipurpose forest inventory is essential to securing sustainable forest management ... in addition to *securing a sustainable timber supply and up-to-date information on the status of high value species*. the expression underlined is seen in relation to *timber production*, and may be extended to *other valuable non timber forest products* (NTFP); and can be referred to a large extent to *indigenous plant species* (high value non indigenous (i.e.) species are considered in the plantation inventory).

In contrast, the concept of *endangered species* relates more directly to the overall concern about the possible loss and the need for conservation for *plant* and *animal species* as part of the world's *biological diversity*. the adjective "endangered" is used in the annex to the decision instead of "threatened", as it seems that this latter word serves to encompass, at least in the IUCN definition, the whole range of situations: "least concern", "near threatened", "vulnerable", endangered", "critically endangered", "extinct in the wild" and "extinct" (see "list of categories and criteria" - version 3.1, 2001, of the IUCN red list of threatened species").

A limit should be set to the numbers and forest types plant and animal species to be identified and recorded within the framework of an MNFI. It is suggested here that this latter should be concerned essentially, if not only, by the *seed(-reproducing) plants* (i.e. excluding mosses, mushrooms, ferns and lichens); and by *terrestrial vertebrates*[50], excluding sea fish species, i.e. mammals, birds, reptiles and fresh and brackish water fish[51]. scientists interested in species not covered by an MNFI (the non vascular and the spore- reproducing plants, worms, insects and other arthropods, ...) may like to use the logistics of a MNFI and join survey teams (as "embedded staff") to make their own observations.

For a MNFI to provide more information on high value (timber and NTFP) species constitutes a logical extension of the scope of conventional forest inventories carried out mainly or exclusively for assessing the productive functions of the forests; whereas collecting and processing data on endangered plant and animal species represents a clear departure from these inventories. this is why these two objectives of a MNFI will be treated separately.

Identification of species of tropical forest ecosystems from remote sensing imagery is generally not feasible, except for tree species in very specific cases, such as:

- when using very large scale colour (or infrared colour) aerial photography, or
- when species form pure forest stands: mangroves, rear mangroves, palm tree stands, other types of permanently or temporarily inundated riparian forests, tropical pine (or other coniferous species) forests, *Gilbertiodendron dewevrei* stands in the Congo basin, ..., or else,

[50] With the possible exception of some edible invertebrates such as some insects (e.g. caterpillars) as NTFP products.
[51] Concerning this latter category, if included, special survey procedures exist, such as those applied in Australia. See "Monitoring our freshwater fish - An overview" - Queensland government's Department of Primary industries and fisheries, 2006 (http://www2.dpi.qld.gov.au/fisheriesmonitoringprogram/11123.html#whymonitor)

- when species, though not forming a pure stand, are sufficiently dense and visible in the canopy by the characteristics and, possibly, phenology of their crowns. this is the case, for instance, of the dominant trees of the "cuipo" species (*Cavanillesia platanifolia*) in the Darien province of panama: their easy recognition even on small scale aerial photography is allows for a separation (stratification) between dry soil forests between those with or without this species.

As a general rule, it can be considered that the occurrence and condition of given tropical tree species, not to speak of shrub and grass species, can only be assessed through field inventory. however, whenever recognition of some specimens (generally the biggest trees) of a given species can be made in a reliable and cost effective manner, it is recommended to use it as a first stage (e.g. stratification of the field sampling) of the assessment of this and other species as a way to reduce the amount and intensity of the field work.

Information on high value species in a MNFI

During the preparation phase, a nationwide *list* of high value forest plant species for timber and non timber forest products should be drawn carefully. it should include as much as possible potentially valuable species, i.e. those which have a market likely to develop in the coming years. Regarding this latter point, a country like PNG possesses several non timber forest species whose products she does not use for exportation yet, but which are commercialised and exported by other countries: this is the case of the nut producing trees of *barringtonia procera* (cut nut or pao), *canarium indicum* (galip nuts) or *pandanus julianettii* (karuka nuts)[52].

Field inventory of these species should not be limited to the exploitable or mature specimens, but should also consider the state and potential of their *regeneration*. in the case of timber species, or of NTFP tree species of high value, this can be done by counting and measuring seedlings, saplings, poles (DBH ≤ 10cm), and small trees (11cm ≤ DBH ≤ minimum exploitable diameter) in plots smaller than those used for the trees of exploitable sizes. For the latter, algorithms would have to be devised, if they do not yet exist, to convert field data in estimated production outputs (in PNG, for instance, conversion in quantities of essential oil from the bark of the trees of massoy (*Cryptomeria massoy*) or lawag (*Cinnamomum spp.*). in addition, special enumeration and measurement techniques would have to be devised for the inventory of certain NTFP species which are not trees, such as orchids in the case of PNG.

For some time already, conventional national or large scale forest inventories have collected and processed data on the regeneration of high value species, at least in the pole and tree classes below the minimum exploitability diameter. but those which have also included the enumeration of seedlings and saplings are few. One of the oldest, and which remains a very good example, is the one designed in Venezuela by Bernard Rollet as FAO expert in a forest development project in the Venezuelan Guyana in the late 60's [53] . Another example is the project of integrated natural resources assessment in Kenya, carried out with the support of the FAO/Netherlands partnership program. The field manual of

[52] The timber species "yellow Terminalia" (*Terminalia kaernbachii*) could be used more for the production of okari nuts.

[53] «Estudio de preinversión para el desarollo forestal de la Guyana Venezolana», SF:82/VEN 5 , FAO, 1970, Rome

this project proposes sampling units in the form of square tracts, made of recording units of different size - rectangular plots, themselves divided in rectangular subplots, and finally circular plots of a small radius (a few meters) -, the smaller the recording units, the smaller the size of the vegetation elements, from large trees to seedlings and annual plants.

Some high value non timber species are not tree ones, but smaller plants (some, like species of orchids, may be epiphytes of trees). Their inventory should be considered in the same way as for the regeneration seedlings, saplings and poles of high value timber species, i.e. be enumerated in subplots of the sampling units. the recording of physical variables on the same subplots, such as soil characteristics, topography, aspect and light intensity, will permit to draw correlations between species occurrence/frequency and these variables, and thus facilitate research work for their eventual domestication.

As far as PNG is concerned, a rapid investigation in the statistics of production, processing and export of logs and wood products allows for the drawing of the short list given in first table below, which will have to be corrected and complemented with the concerned stakeholders. these latter may like to add to the short list of timber species the white and red planchonella (*Planchonella spp*., Sapotaceae), the taun (or obahu, *Pometia pinnata*, Sapindaceae), some Terminalia (*Terminalia spp*., Combretaceae), the paldao (or walnut, *Dracontomelum dao*, Anacardiaceae), or else nyatoh (*Burckella obovata,* Sapotaceae) which have also, or have had a high value at a time. The same holds true for NTFP species, for which a short list has also been attempted (see second table below). Indeed, these lists should include not only species which might have been highly valued in the past (and may now be threatened), but also new marketable species, or species likely to become marketable in the near future. forest species marketability changes over time[54], and such a list cannot be considered final once and for all. It should be left unchanged during the whole duration of a cycle of a MNFI, but should certainly be reviewed for the next cycle, taking into account the changes which have occurred in the trade of timber and non timber products.

[54] Exports of rattans from PNG developed fast in the mid 90's when exports of raw rattan were banned in Indonesia, Malaysia and the Philippines ("Non-Wood Forest Products in 15 Countries Of Tropical Asia : An Overview", edited by P. Vantomme, A. Markkula and R. N. Leslie, FAO, Bangkok, 2002, quoting "*Non-wood forest products of Papua New Guinea", by* P.B.L Shrivastava,. FAO, Bangkok , 1995 .

Table No.; 25 Some high value timber species in PNG

Latin name	Family	Common name	Other common names
Pterocarpus indicus	Leguminoseae	new guinea rosewood	amboyna, burmese rosewood, narra, paduk (africa), red sandalwood
Intsia bijuga, i. patanbanica	Leguminoseae	kwila, merbau	borneo teak, moluccan ironwood
Toona ciliata (syn. cedrela australis), Toona sureni	Meliaceae	red cedar	australian red cedar, kalantas
Anisoptera thurifera	Dipterocarpaceae	mersawa	(can exist in pure stands)
Calophyllum spp.	Guttiferae	callophyllum	alexandrian laurel, borneo mahogany, beach callophyllum
Palaquium spp.	Sapotaceae	pencil cedar	
Pericopsis mooniana	Leguminoseae		nandu wood, nedun tree
Alstonia scholaris	Apocynaceae	blackboard tree	milkwood pine, white cheesewood
Aglia cucullata	Meliaceae	pacific maple	
Gonystylus spp.	Dipterocarpaceae	ramin	

Table No. 26 Some high value (plant) NTFP species in PNG (excluding food species)

Latin name	Family	Name and type of non wood forest products
Barringtonia procera	Lecythidaceae	Cut nut (or pao)
Canarium indicum	Burseraceae	Galip nut
Myristica argentea	Myristicaceae	Papua nutmeg (or pace)
Terminalia kearnbachii	Combretaceae	Okari nut
Gyrinops ledermannii	Thymelaeaceae	Eaglewood - Oil (for perfume and incense) - Other names: agarwood, gaharu, aloeswood
Santalum macgregorii	Santalaceae	Sandalwood – Handicrafts
Cryptocaria massoy	Lauraceae	Massoia bark oil (for ointment, and flavour in the food industry)
Agathis spp.	Araucariaceae	(Manila) copal gum (for naval stores)
Calamus spp., Korthalsia spp. Daemonorops spp.	Arecaceae	Rattans
Acanthephippium spp. Aerides spp. , etc...	Orchidaceae	Orchids (estimated number of orchid species in New Guinea is considered to be more than 3,200)

Information on endangered species in a MNFI

There is no question that the reference database on endangered animal and plant species is the IUCN Red List of Threatened Species. It is a commendable global programme which offers a good basis for a large number of users worldwide. Like all world databases which have to be maintained by a central nucleus of experts (whose work may or may not be tutored by an international group[55]) managing and sorting out a large flow of information of varied quality, it is subject to criticisms from scientists who are

[55] In the case of the Red List , the work is directed by the IUCN Species Survival Commission and its many Specialist Groups and Task Forces.

specialized in certain animal or plant families/genera in a given country/region. It is why the designers of a MNFI should always consult with these specialists to possibly amend the status given in the Red List, before drawing the final list of endangered species to be identified and counted.

As already mentioned in section 1.3.1, we shall consider that information on endangered species, alike that on high value species, is collected in the field inventory (which holds true generally always except in the case of adult specimens of a very limited number of tree species).

The attention to be afforded to a given threatened species may depend on the degree of its "endangerment". If a plant species belongs to the "critically endangered" category, its seedlings (and, if relevant, its saplings and poles) would have to be counted in a larger number of subplots, or in subplots of larger size, than those of less threatened species.

The solution is less clear in the case of animals. The occurrence of "critically endangered" fauna species may have to be recorded systematically along the whole axis of the sampling unit ("tract"), and possibly also outside (for instance, along the path to the sampling unit); whereas the occurrence of animals of less threatened, and hence more frequent, species may be observed only on part of the whole axis of the tract.

The case of threatened species influences strongly the type of field sampling, more specifically whether it should be randomly or systematically distributed geographically. It has been a permanent dilemma for forest inventory experts[56] to have to choose between the scientific strictness of a randomly selected sample (with the possibility of an unbiased estimation of the sampling errors) and the many practical advantages of a systematic sample. For the same sampling intensity, the sort of "scanning effect" of a systematic sample, especially if the grid is a square one and the sampling units are "tracts" of a certain size, is a way to detect more effectively the whole of all rare species.

For that reason, and many others linked to the many objectives of an MNFI additional to those of a conventional forest inventory (e.g. assessment of forest soils), the adoption of a systematic field sampling design is strongly recommended.

In a given country, the list of plant and animal forest species which qualify as threatened (from "near threatened" to "critically threatened") is not a short one. Limiting the field enumeration to the specimens of the high value and endangered plant species would constitute a risk of error and a loss of information (since species presently considered as not having a high value, or not being endangered, may fall in one or both of these two categories later on. Therefore, the following procedure is proposed for plant species:

- to count trees of DBH ≥ 10 cm of all species by diameter classes in the whole field sample (and take the corresponding measures needed for volume and carbon estimation), irrespective of whether they are of endangered or high value species, or of none of these categories: this sort of exercise was carried out already in the 60's for pre-investment studies of pulpwood projects in natural forests, for instance in West and Central Africa (Edea project in Cameroon, Okango project in Gabon, San Pedro project in Côte-d'Ivoire);

[56] It is less so, in fact not at all, for the geologists and soil specialists who give preference to systematic survey designs.

- to count poles, saplings and seedlings of endangered and high value tree species, as well as the shrub, suffrutescent and grass specimens of all other plant species, in subplots of different area of the sampling units depending on the size and degree of "endangerment" (see also section 1.3.2 above).

For animal species, the length of sampling unit axis along which observation (possibly by sex and young /adult classes) will be carried out

Electronic processing of the enumeration and measurement data contained in the field inventory forms will allow for their treatment by plant (or animal) species of the three categories, i.e. high value, endangered and all other species.

A basic prerequisite for the good quality of a tropical forest inventory, and particularly of a MNFI which is to produce a good image of forest biodiversity, is the available capability for species identification. In tropical countries, not all seed-reproducing plant species, and even terrestrial invertebrates. In some countries with a high rate of endemism like Papua New Guinea, the proportion of unknown species is significant. This poses a real problem for the implementation of a MNFI. Several general guidelines should be followed to secure the reliability of the inventory data, such as:

- having a thorough advance training of the plant and animal spotters of the field inventory teams; this training should include the preparation of botanical and zoological samples for forwarding to the concerned national or overseas scientific institutes for identification ;

- having one experienced botanist and one experienced zoologist working in each territorial echelon of the MNFI: these specialists may react quickly on requests related to species known by them but not by the field teams, without having to send the samples for identification to a central institution; and serve as intermediates between this latter and the field teams.

As far as endangered species of Papua New Guinea are concerned, the preparation phase will have to:

- prepare a cooperation agreement with the Papua New Guinea National Herbarium (in Lae), institution which is benefiting of the achievements of the project of repatriation of electronic accession data to the Papua New Guinea National Herbarium[57];

[57] The project "aims to develop a low-maintenance, cost-effective internet-accessible herbarium accession database (*PNGplants*) for use by the Papua New Guinea National Herbarium. Initially, the database has been populated by the repatriation of replicate electronic data of the Lae herbarium held at the following four major Australian herbaria: Australian National Herbarium (CANB), Queensland Herbarium (BRI), National Herbarium of Victoria (MEL) and the National Herbarium of New South Wales (NSW). The independent electronic records held at LAE will be accessible via the *Plants of Papua New Guinea* website, an extension of the *Australia's Virtual Herbarium* (AVH) initiative. This consortium of herbaria has agreed to repatriate the electronic data of about 130,000 records from Papua New Guinea. LAE will become a joint contributor to the AVH project, together with the other major Australian Herbaria. Data will be used for the mapping of species distributions; analysis of areas of endemism, species richness, and ecological preferences; environmental management decisions; and analysis of botanical exploration within Papua New Guinea. This project is supported by the Global Biodiversity Information Facility (GBIF).

- conduct a thorough study of the IUCN Red List and other relevant documentation, such as the *Guide to Trees of Papua New Guinea,* by Barry J. Conn & Kipiro Q. Damas[58] ;

- organize a special training programme aimed at the plant and animal spotters of the field teams.

5.3 Field sampling

The choice of statistical sampling technique to be used in an inventory depends on three key elements: population size, the accuracy required and costs mean that its implementation. In the case of IFN, which covers large areas should be considered in addition, objectives, the periodic repetition of measurements and time of execution, so that the design selected frame in a flexible plan that allows incorporate changes showing the characteristics of national development.

Your planning should take into account the conditions prevailing in the country, both economic Now, as the market prospects and the need to modify land uses. It must provide that the amount of data and intensity of sampling may vary according to the extension of the state and plans based on management tools and the National Forest Policy, to inflict some areas of forest management. Finally, the sampling design must meet the expectations of information requiring different government agencies that used in their programs and projects.

5.3.1 Calculation of the sampling size

To determine the sample size, the following elements were considered:

a) Sampling error : any forest inventory requires the prior implementation of a pilot survey for the determination of the variability (or coefficient of variation, C_v) of the main parameters to be estimated. Most NFI are planned for a 10-15% sampling error (some times 20%) at 0.95 probability level (i.e. approximately twice the standard error) for the total growing stock above 20-30cm DBH over the area of reference (reporting unit). In the case of PNG, a 10% sampling error on this parameter, all species together above 25 cm DBH, for the whole country is proposed. This level of error applies also to commercial volume, biomass and carbon stock.

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[58] Several other important studies exist on PNG's biodiversity which should be consulted during the preparation phase, e.g.:
- *Papua New Guinea Conservation Needs Assessment Vol. 1. Biodiversity Support Program*, by Alcorn, J. B. (ed), 1993., Government of PNG, Department of Environment and Conservation. Corporate Press Inc., Landover, Maryland
. *Papua New Guinea Conservation Needs Assessment Vol. 2. Biodiversity Support Program*, by Beehler, B. M. (ed), 1993, Government of PNG, Department of Environment and Conservation. Corporate Press Inc., Landover, Maryland.
- *A Biodiversity conservation plan for Papua New Guinea based on biodiversity trade-offs analysis*, by Faith, D. P., Margules, C. R. and Walker, P. A., 2001b, Pacific Conservation Biology.

b) Variability : unfortunately, in the case of PNG this information is not readily available. Growing stock parameters of mixed tropical rainforests have generally high coefficients of variation,

depending of course on the size of the sampling unit – a higher number of small units is needed for a required sampling error than in the case of larger units -, and on the forest type considered.

b) Size and shape of the sampling unit : many studies all over the tropics show that a suitable size of sampling unit is a rectangle of 10 m x 250 m. Various tests on the sampling unit size show that it is at the same time efficient and representative.

c) Area of work (reporting unit): the total country's forest area.

d) Precision : the precision requirement on a key parameter is between 10 and 15% at 0.95 probability level.

The following example shows how the coefficient of variation (C_v) of a given parameter and the sampling error varies for a number n of them, according to the size of the sampling unit (a), this size varying from a minimum area of 2,500 m^2 (10mx250 m) and a maximum one of 20,000 m^2 (8x 2500 m^2).

n = number of SU is fix (40) , a varies from 2,500 m^2 to 20,000 m^2.

Table No. 27 Example of the variability of the population according to the size of the sampling unit

n	a (m^2)	S	C_v (%)	S_x	S_x x t (%)
40	2,500	5.68	40.47	0.898	12.95
40	5,000	9.80	33.56	1.549	10.71
40	7,500	11.6	26.37	1.83	8.26
40	10,000	13.79	22.69	2.18	7.23
40	15,000	20.15	20.45	3.17	6.64
40	20,000	25.85	20.20	4.08	6.45
	1				

Where S_x is the standard error ; t = t of Student (= 2 approx. at 0.95 probability level)

In the next table, n varies from 9 to 260 but the size, and a remains constant at 250 m^2.

Table No. 28 Example of the variability according to the variation on n

n	**a** (m^2)	**S**	C_v **(%)**	S_x	S_x x t **(%)**
9	250	7.48	45.21	2.49	34.7
15	250	7.71	45.13	1.99	25.03
40	250	5.68	40.57	0.89	12.95
104	250	8.13	47.15	0.79	9.24
168	250	7.33	45.17	0.565	6.62
260	250	7.90	48.8	0.49	5.93

S_x is the standard error ; t = t of Student (= 2 approx. at 0.95 probability level)

According to this example, the conclusion is that, for a sampling error (S_x% x t) of 10 %, and a C_v of 47%, we need 104 samples of 250 m^2, or 40 sampling units of 500 m^2

In view of the lack of information regarding the variability of the parameters for the whole PNG forest or by forest types, the C_v (%) corresponding to a given parameter (e.g. growing stock all species above 25cm DBH) for each forest type is given, conservatively, a value guaranteeing that the number of sampling units used will result the maximum allowable sampling error related to the average of the standing volume by ha for all forest types together. Using a sampling unit of 10,000 m^2 (1 ha), composed of 4 recording units of 10x250 m (2,500 m^2), the estimated C_V (%) for each forest type is shown in the following table

Table No. 29 Calculation of the coefficient of variation, according to the weighted-stratified method

FOREST TYPE	CALCULATION OF THE STRATIFIED CV FOR THE WHOLE FOREST				
National classes	Area 1000ha	%	Pj	CV%*	Pj*CV%
Low altitudinal forest on plains and fans	2,875.10	8.61	0.0861	100	8.61
Low Altitude Foresta on Uplands	17,171.10	51.42	0.5142	100	51.42
Lower montane Forest	7,745.40	23.20	0.2320	100	23.20
Montane Forest (above 3000 m)	177.4	0.53	0.0053	70	0.37
Dry Seasonal Forest	778.6	2.33	0.0233	75	1.75
Littoral Forest	86.5	0.26	0.0026	120	0.31
Sral Forest	46.1	0.14	0.0014	120	0.17
Swamp Forest	1,267.30	3.80	0.0380	60	2.28
Mangrove	550	1.65	0.0165	60	0.99
Woodlands	2,693.80	8.07	0.0807	120	9.68
	33,391.30	100.00	1.0000	**Total CV%**	**98.77**

* Estimate according to the general characteristics of each forest type.

The weighted average for a stratified population gives a coefficient of variation (C_V) of 98.77%, or approximately 100%, and the allowable sampling error is fixed at 10% at 0.95 probability level, using sampling units of 4 x 2,500 m2 (10,000 m2).

The calculation of n is as follows : $n = [t \times C_V / S_x]^2$
where :

C_V= coefficient of variation = 100%
t = t of Student = 2 approximately)
S_x = sampling error = 10%

Therefore, n will be equal to : $n = [2 \times 100/10]^2 = 400$

The minimum number of sampling units required for a sampling error equal or lower than 10% is 400 which has to be distributed proportionally to the area of each forest type. The following table shows the number of sampling units to be distributed over each of this vegetation types

Table No. 30 Calculation of the number of sampling units according to the proportionality of each forest type (N_j)

FOREST TYPE	Proportional N by forest type			
National classes	Area 1000ha	%	Pj	Nj
Low altitudinal forest on plains and fans	2,875.10	8.61	0.0861	**34.44**
Low Altitude Foresta on Uplands	17,171.10	51.42	0.5142	**205.70**
Lower montane Forest	7,745.40	23.20	0.2320	**92.78**
Montane Forest (above 3000 m)	177.4	0.53	0.0053	**2.13**
Dry Seasonal Forest	778.6	2.33	0.0233	**9.33**
Littoral Forest	86.5	0.26	0.0026	**1.04**
Sral Forest	46.1	0.14	0.0014	**0.55**
Swamp Forest	1,267.30	3.80	0.0380	**15.18**
Mangrove	550	1.65	0.0165	**6.59**
Woodlands	2,693.80	8.07	0.0807	**32.27**
	33,391.30	100.00	1.0000	**400.00**

Pj = proportional area of the forest type, Nj = number of sampling units per forest type

According to this result, the forest types with the major number of samples are the low altitude forest (205), lower montane forest (93), them the other forest types like low altitudinal forest on plain (34) and woodland (32), the other forest types, due to its very low area, have got a small number of samples,.

Considering that the 400 sampling units are systematically distributed on the whole country proportionally to the area of each forest type, some forest types will not be sufficiently sampled for obtaining reliable information about standing volume, biomass and particularly biodiversity; consequently a further adjustment has to be done in order to ensure that very forest type receives a minimum number of sampling units for the collection of a consistent set of statistically acceptable and reliable information . The minimum number of samples required for a consistent statistical analysis being around 25, the necessary adjustment has been calculated and the results are shown in the table, below.

Table No. 31 number of sampling units by forest types

FOREST TYPE	N	
National classes	Nj calcutated	Nj Adjusted
Low altitudinal forest on plains a	34.44	35
Low Altitude Foresta on Uplands	205.70	205
Lower montane Forest	92.78	92
Montane Forest (above 3000 m)	2.13	25
Dry Seasonal Forest	9.33	25
Littoral Forest	1.04	25
Sral Forest	0.55	25
Swamp Forest	15.18	25
Mangrove	6.59	25
Woodlands	32.27	35
	400.00	517

According to this readjustment, the new total number of SU will be: n = 517

5.3 .2 Sampling allocation

Considering that the actual total area of forest in PNG is approximately 33 million ha, and the area by the total number n (517) of sampling units, the surface of a block corresponding to a sampling unit will be of 62,000 hectares, equivalent to a square of 25x25 km (625 km^2), each block being “represented” by a sampling unit.

In order to systematically distribute the samples, a grid of 25x25 km should be placed over the whole country (46,000,000 ha) giving a total of 742 squares, out of which only 517 will be controlled in the field for the MNFI (because more than 13 million of hectares are classified as agriculture crops and grass land, water surfaces and other non forest land).

MODEL OF 25X25 KM GRID OVER THE WHOLE TERRITORY

The distribution of the 517 sampling units will be done according to the following two-step procedure

- first step: consists of Block 25 km x 25 km.

- second step: The second level is a unit of 10,000 m2 composed of four recording units of 2500 m2 . in a squares of 1x 1 km

Additionally the center (nadir) of each sampling unit, will be used for socioeconomic and environmental observations, as it will be explained ahead

Figure No. 11 Samplig grid for the whole country

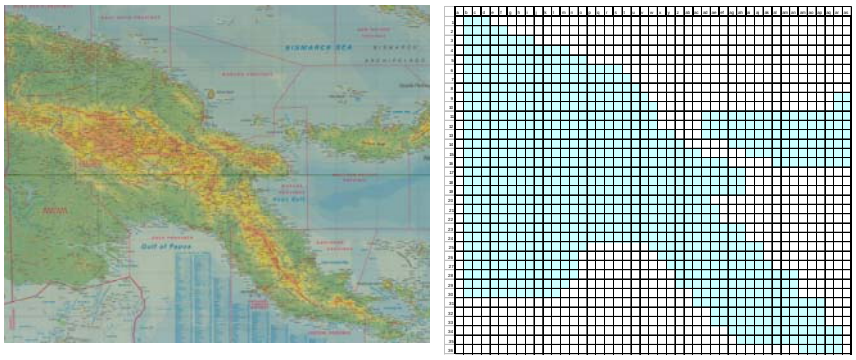


Figure No. 12 Sampling units allocation in a grid of 25x25 Km

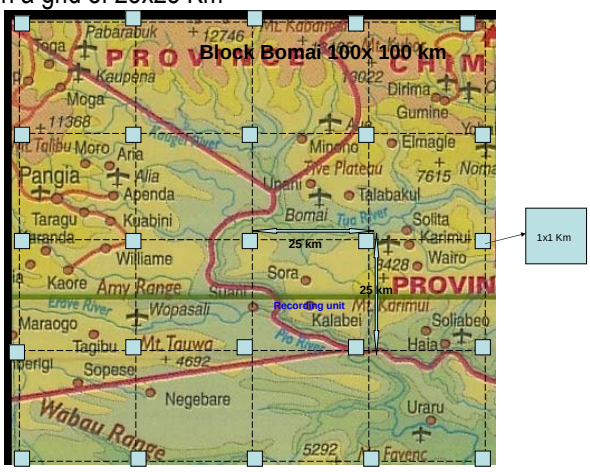


Fig. No. 13 Detail of sampling allocation grid

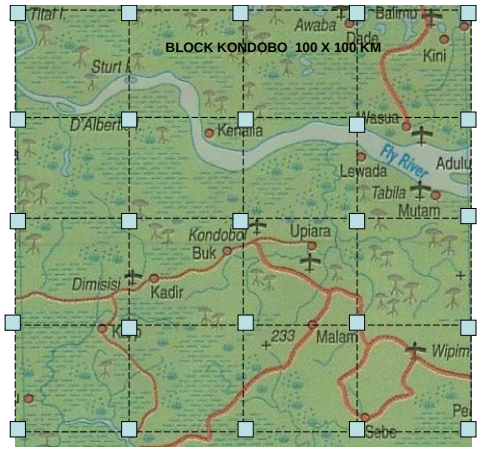


Figure No 14 Details of one block

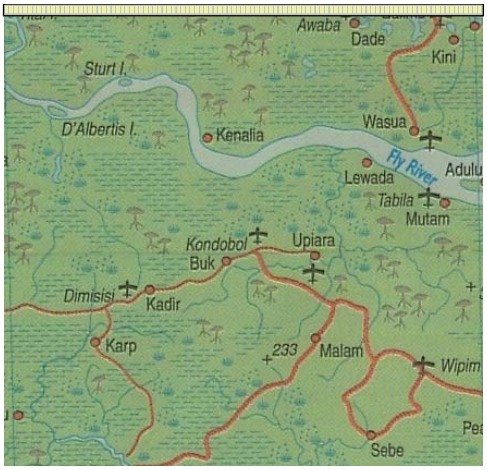


Figure No. 15 Details of the Recording unit

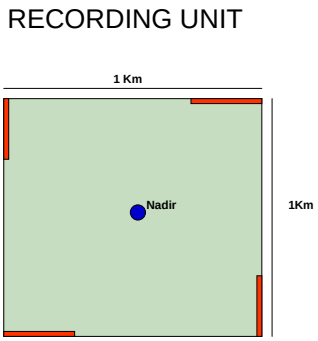
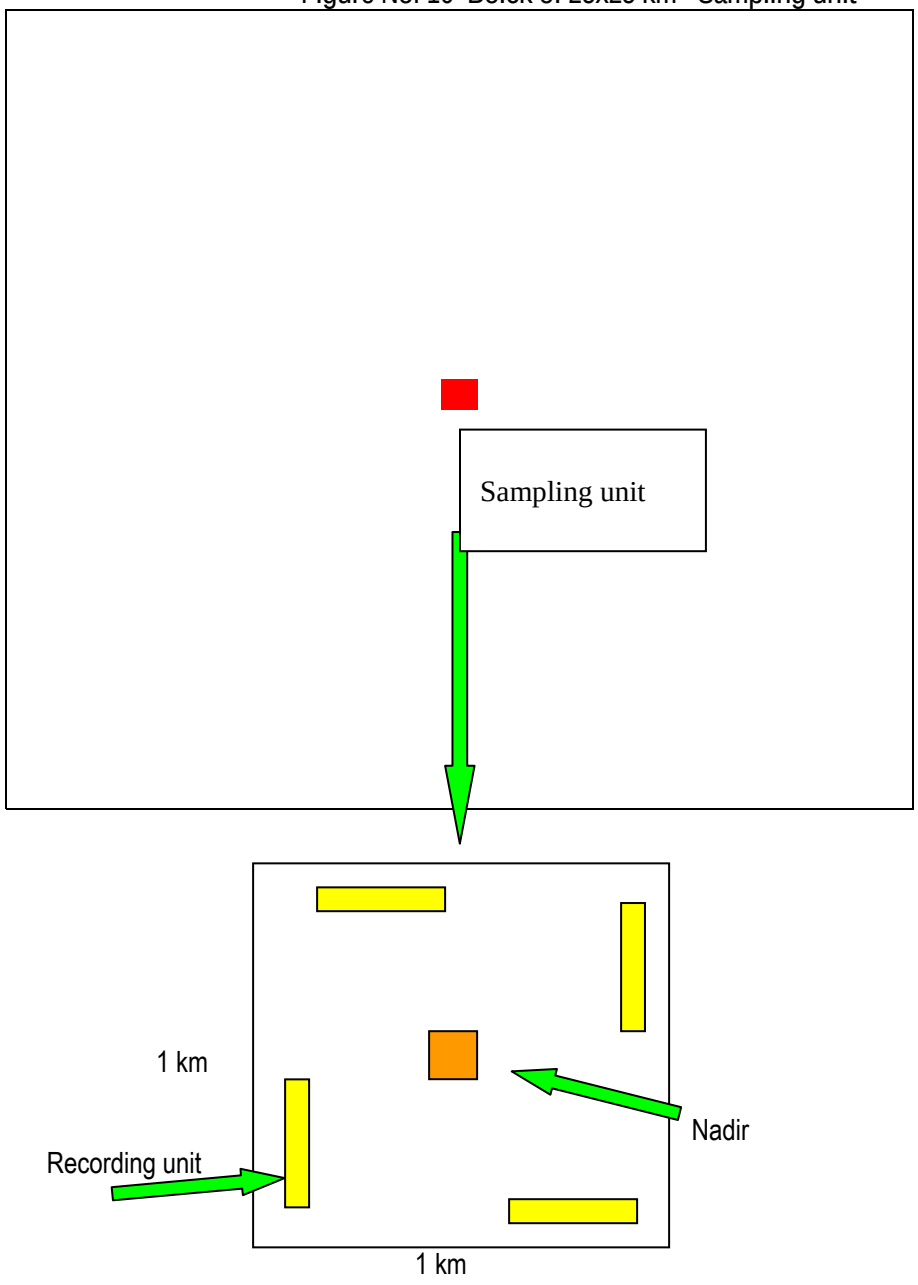


Figure No. 16 Bolck of 25x25 km= Sampling unit



The recording unit or plot is rectangular of 10 x 250 m and subdivided into 5 parcels of 10 mx 50 m, among them one will be randomly selected for small trees and non timber products control, within this parcel a sub parcel of 10 x 10 m will be controlled for natural regenerations and seedlings.

Figure No. 17 Sampling and sub sampling units

The nadir is just the center of the sampling unit as a geographic reference for socioeconomic and environmental information collection

Table No. 32 Recording data

Level	Type of information	Detail	Variables
Block of 25 x 25 km	Forest vegetation types physiographic conditions and general land features	Using aerial photographs and satellite imagery, classify the vegetation type, deforestation and, secondary forest and agriculture land, grass land	Land cover and land use maps at 1/50,000 for field control and 1/250,000 for the whole country ensemble
Sampling Unit (1 x 1 km), around the nadir point	Socioeconomic conditions, state of the forest, NTFP, wild life	Observations about the state of the forest, human activities, accessibility, water sources, wild life occurrences and non timber forest products	Natural forest, logged forest, degraded forest, fire, deforestation. forest plantation, agricultural crops, water sources and quality of water. Livelihood conditions, population activities and density, accessibility, use of wood and NTFP products
Recording unit	Standing trees measurements for commercial volume	Trees above 25 cm DBH: specie, diameter, total height, commercial height, health and quality of the tree	Diameter (DBH), stem height, commercial height, quality of logs (each 4 m), main branches health of the tree,
Parcel of 10x 50 m	Small trees for carbon stocks control	Small trees, between 10 to 25 cm DBH: specie, diameter, total height, health and quality of the tree	Diameter (DBH) and stem length, NTFP presence abundance and frequency
Sub parcel of 10x 10 m	Natural regeneration	Counting trees below 10 DBH and seedlings: specie, total height	Number of seedlings and , herbs and epiphytes

5.4 Variables

Table No. 33 Relationship and importance of the different variables for the MNFI objectives

	TIMBER	BIODIVERSITY	CARBON	SOCIO
VARIABLES				
Trees	XXX	XXX	XXX	XX
Palm trees	X	XXX	XX	XXX
Bamboos	X	XXX	XX	XX
Herbs-lianas		XXX	X	XXX
Epiphytes		XXX	X	X
Wildlife		XX		XXX
Soil		X	XX	XX
Water volume		XX		XX
Water quality		XX		XXX

Table No 34 . Parameters need for each objective

	LOGGING	BIODIVERSITY	CARBON	SOCIO
VARIABLES				
Trees	Specie, commercial Volume, quality of logs, distribution	Specie, Number, frequency, abundance and health	Biomass	Frequency abundance
Palm trees	Volume, distribution	Specie, Number, frequency, abundance and health	Biomass	Frequency abundance
Bamboos	Volume, distribution	Specie, Number, frequency, abundance and health	Biomass	Frequency abundance
Herbs-lianas		Specie, Number, frequency, abundance and health		Frequency abundance
Epiphytes		Specie, Number, frequency, abundance and health		Frequency abundance
Wildlife		Specie, Number, frequency, abundance and health		Frequency abundance
Soil		Quality	Organic material	Quality
Water volume		Flow		Flow
Water quality		Pollution state		Pollution state

5.5 Permanent Sample Plots and monitoring system

The opportunity given by the MNFI, to visit almost every corner of the country, using a costly logistical organization must be used in order to improve the permanent sample plots network:

- controlling the present PSPs in different localities and forest types,
- establishing an additional number of PSPs, seeking for a real representativeness of the different forest types/forest ecosystems.

According to this premise, a minimum number of new PSPs should be established, assuming that an adequate representation of each forest type should be a minimum of 3 PSP and a maximum of 12, the following table give the total PSP to be established

Table No. 35 Allocation of PSP by forest type

FOREST TYPE	
National classes	PSP
Low altitudinal forest on plains and fans	**6**
Low Altitude Foresta on Uplands	**12**
Lower montane Forest	**9**
Montane Forest (above 3000 m)	**3**
Dry Seasonal Forest	**3**
Littoral Forest	**3**
Sral Forest	**3**
Swamp Forest	**3**
Mangrove	**3**
Woodlands	**6**
TOTAL	**51**

The total number of PSPs to be established is 51, that means approximately 10% of the total sampling units

The allocation of this PSP will be decided during the execution of the MNFI, taking in consideration:

a) representative areas of each forest type,
b) accessibility,
c) guarantee of their permanence for at least 50 years

In this PSPs, the same type of information taken on the previously established PSP must be recorded every two years.

The establishment of the PSPs will be done in the nadir point of each selected sampling unit, according to the criteria above indicated

5.6 Recording forms

FIELD FORM 1

Figure No. 18 sampling unit/ recording unit

MULTIPPURPOSE NATIONAL FOREST INVENTORY - PAPUA NEW GUINEA																		
F1	REGION		Date				Forest Type			Soil		Water		Nadir coordinates	
	PROVINCE		Team Leader				Land Use			Deep		Flow		N	
	BLOCK		Hour entry				Fisiography			Text		Qual.		S	
	SAMPLING UNIT		Hour Out				Accesibility			Drain		Use		E	
	RECORDING UNIT						Human presence							W	
	Tree		Stem				Logs (quality)				branches						Observations: nadir point	
N. of tre	Local Name 1	Local name 2	DBH	DBH2	HT	HC	Log1	Log2	Log3	Log4	D1	L1	D2	L2	D3	L3	Human activities	
001																		
002																		
003																		
004																		
005																		
006																		
007																		
008																		
009																		
010																		
011																	Wild life	
012																		
013																		
014																		
015																		
016																		
017																		
018																		
019																		
020																		
021																	NTFP	
022																		
023																		
024																		
025																		

FIELD FORM 2

Figure No. 19 PARCEL 10X50 m

MULTIPPURPOSE NATIONAL FOREST INVENTORY - PAPUA NEW GUINEA							
F2	BLOCK		Date		Forest type		
	SAMPLING UNIT		Team Leader		Density		
	RECORDING UNIT		Hour entry		Intervention		
	PARCEL 10X50		Hour Out				

Trees < 25 cm > 10 cm DBH								NTFP			
No	Local Name	DBH	Canopy	HT	HC	Qual.	Health	No	Name	Use	Abundance
001								1			
002								2			
003								3			
004								4			
005								5			
006								6			
007								7			
008								8			
009								9			
010								10			
011								11			
012								12			
013								13			
014								14			
015								15			
016								16			
017								17			
018								18			
019								19			
020								20			
021								21			
022								22			
023								23			
024								24			
025								25			

FIELD FORM 3

Figure No. 20 SUB PARCEL 10x10 m

MULTIPPURPOSE NATIONAL FOREST INVENTORY - PAPUA NEW GUINEA								
F3	SAMPLING UNIT			Date				
	RECORDING UNIT			Team leader				
	PARCEL 10X50			Hour entry				
	SUB PARCEL 10X10			Hour Out				

Trees < 10 cm DBH > 1 m TH			NATURAL REGENERATION			HERBS & EPIPHYTES		
No	Local Name	Quant.	No	Local name	Quant.	No	Local name	Use
001			1			1		
002			2			2		
003			3			3		
004			4			4		
005			5			5		
006			6			6		
007			7			7		
008			8			8		
009			9			9		
010			10			10		
011			11			11		
012			12			12		
013			13			13		
014			14			14		
015			15			15		
016			16			16		
017			17			17		
018			18			18		
019			19			19		
020			20			20		
021			21			21		
022			22			22		
023			23			23		
024			24			24		
025			25			25		

FIELD FORM 4

Figure No. 21 SOCIOECONOMIC INFORMATION

MULTIPPURPOSE NATIONAL FOREST INVENTORY - PAPUA NEW GUINEA					
F4	BLOCK		Date		
	SAMPLING UNIT		Team leader		
			District		
			Tribe		

POPULATION						
Tribe		No	Health	R&W	language	Observations
	Male					
	Female					
	Children					

LIVELIHOOD CONDITIONS			
		Qual.	REMARKS (quantity, quality, species….)
001	Housing material		
002	Housing State		
003	Sanitary conditions		
004	School existence		
005	Acces		
006	Main economic activity		
007	Agriculture crops		
008	Forestry		
009	Lifestock		
010			

FORESTRY							
	Activity	Fr.	Species	Quant.	Distance	Buy	Price
001	Fire wood collection						
002	Wood harvesting/housing						
004	Logging						
005		Date	Species	Vol	$/m3	Benefits	
	F agreement						

5.6 Field inventory crews

The field inventory crews (FIC) will be integrated by local people in each region and province, and their composition should be of 8 members, taking into account the amount of information to be collected on the various land uses and the division of tasks among individuals. One or two members of the field teams (temporary assistants) will be hired locally and act as guides in the field. The number of crews will vary according to the number of blocks or sampling units to be controlled in each region, taking in consideration that each crew will spend one full week per SU.

The total number of SU to be controlled is 500 and the total time to be expended for the field work should be about 4 years during the dry season it gives a total of 12 months of full time field work, consequently 41 SU which has to be programmed per month, taking in consideration that a maximum of 6 teams will be organized per region (4), a total of 21 months of full field work will be necessary to accomplish the whole task.

The team should include habitants specialized in the concerned key disciplines: forestry; agriculture, crop and livestock, botanic, soil and water, sociology and wildlife, however One forester (trees, forest types, natural regeneration, NTFP, water), one agronomist (soils and water, agriculture, livestock), one biologist (wildlife, botany), and one sociologist. The other 4 habitants will be charged as cutters and logistic support In general team members must be experienced in tree, shrub and herbaceous species identification (using local and/or scientific names).

The responsibilities of each team member must be clearly defined and their tasks are proposed as follows:

- The team leader is responsible for organizing all the phases of the fieldwork, from the preparation to the data collection. He/she has the responsibility of contacting and maintaining good relationships with the community and the informants and monitoring and ensuring timely progress in the fieldwork. He/she will specifically:
  - Prepare the fieldwork: carry out the bibliographic research and gather required secondary data, field forms and maps at appropriate scales;
  - Plan the work for the team;
  - Establish contact and introduce the survey objectives and work plan to local authorities, local technical officers (forestry, agriculture, land, community development), and request their assistance to inform local communities and identify key informants, guides and assistants;
  - Administer the location and access of tracts and plots;
  - Take care of team logistics: obtain information and organise accommodation facilities and food (meals; cooking facilities); recruit local assistants; organize access to the tracts;
  - Plan /organise the interviews together with those team members assigned to undertake interviews;
  - Be responsible for ensuring accurate filling in of recording forms and taking notes and applying cross-checking procedures to insure reliable data;
  - Organize daily meetings after fieldwork in order to sum up the day's activities and plan the next day;
  - Make a report of the tract summarizing the data collection process.

  - Organize and ensure fieldwork safety (first aid kit, support of local authority/armed guards if required, reduce risk from wildlife).
  - Maintain good team spirit.
- The assistant of the team leader will:
  - Help the team leader to carry out his/her tasks;
  - Ensure easy access to the tract with a guide very familiar with the area;
  - Take necessary measurements and observations;
  - Make sure that the equipment of the team is always complete and operational;
  - Supervise and orient the temporary assistants;
  - Assist the team leader in the making of the tract report.
  - Take over if the team leader falls sick.
- The technical field team members/enumerators will carry out the field measurements and interviews.
- The temporary assistants (4), who are recruited locally, should be assigned the following tasks, according to their skills and knowledge of local species, language and practices:
  - Help to measure distances ;
  - Provide the common/local name of tree, plants, and wildlife species;
  - Inform about access to the tract;
  - Open ways to facilitate access and visibility to technicians;
  - Provide information about the various natural resources uses and management (forest, soil, water, crop, livestock);
  - Carry the equipment.

Training of the teams on the survey methodology should be undertaken in theoretical and practical sessions in the beginning of the fieldwork where techniques of different land measurements, tally of data and techniques of interviews will be explained and practised.

The names and addresses of the team members must be written down in field form F1b.

Sampling Unit	SOCIO ECONOMIC	PLOT	ENVIROMENT	SUB PLOT	TREE	NTFP
BLOCK	DistHospital	Plot_ID	Water courses: perm.seasonal,dry	Sub Plot_ID	Tree_ID	Species
SUB BLOCK	DistSchool	Lat_0m	Water quality: G, F, B	LandUse	TreeCode	Products
ADM1 (Region)	DistSettlement	Long_0m	LandTenure	Width	DBHCm	Frequency
ADM2 (Province)	DistMarket	Lat_125m	Wildlife ocurrences	Length	HeightDapM	Amount
ADM3 (District)	PopulationDynamics	Long_125m	Fire	Designation/ProtectionStatus	TotalHeightM	State
ADM4 (Locality)	PopulationMainActivity	Lat_250m	FireArea	CanopyCover	ComercialHeightM	observations
TopoMapNo	PopulationOnSite	Long_250m	* EnvironmentProblem	CanopyPattern	MeasureType	
TopoMapName	PopulationSince	StartDate	Aspect	StandStructure	Health	
PhotoNo	LivelyhoodTrend	EndDate	Slope	ManagementPlan	HealthDegreeAttack	
LatCentPoint	SettlementHistory	Worktime	Relief	Disturbances	Obervation	
LonCentPoint	Topography	StartPointDescription	SoilTexture	TimberExploit	TimberQuality	
AltitudeCentPoint	ForestFragmentation	PermanentMark	SoilMoisture	Stumps (diameter?)	observations	
StartDate	Hunting	DisplacementPermanentMark	OrganicMatter	* Silviculture		
EndDate	Walking traks	BearingPermanentMark	Observations	StandOrigin		
AccessTime	Flora collection	LatPermanentMark	observations	observations		
GlobalEcologicalZone	Traditional use	LongPermanentMark				
LatLeavingRoad	Observations	observations				
LongLeavingRoad						
DistAllWeatherRoad						
DistSeasonalRoad						
* Crew						
* Informant						

5.7 Data processing

The data processing system, called "Information System for the National Forest Inventory" (ISNFI), should allow the capture and storage in a database the field measurements of forest trees and other components of the forest, such as measurements of soil, other vegetation types, forest products, forest composition, level of intervention, etc..

These data, using a data processing, generates information on the current state of the forest, in terms of statistics on numbers of individuals, basal area and existing volumes by species, groups of species, by DBH categories, at the forest type and sampling unit .

Likewise, the system might generate information on the qualitative variables associated with the other components of the forest, such as soil types, canopy density, density of undergrowth, stratification and composition of the forest, other forest products (resin, fruits, seeds, etc..)

5.2.8 Outputs

According to the MNFI planning the different products to be obtained after the field work and data processing, should be ordered by components, aiming to provide enough details for timber, biodiversity, carbon stocks and socio economic issues, as it is shown in the following table

Table No. 36 products by component

COMPONENT	PRODUCTS	DETAIL
FOREST COVER	1. Forest maps 2. Area and vegetation description by forest type, regions and provinces	1 National: 1/1,000,000 1 Regional: 1/250,000 2 Province: 1/100,000
STANDING VOLUME	3. Average standing volume per forest type 4. Average volume commercial volume by forest type, hectare and DBH classes 5. Quality of commercial volume in % 6. Average of commercial volume by most value species, by forest type, ha and DBH classes	1. Volume by 20 cm DBH classes 2. Correlations between Height and DBH 3. Quality classes: Excellent, very good, good, fair, bad
BIOMASS	7. Biomass above ground for trees above 25 cm DBH 8. Biomass above ground for trees between 10 to 25 cm DBH 9. Estimate volume of organic material on the ground, by forest types	1. Stem biomass in Cubic meters and Tons by forest types 2. Branches biomass in cubic meters and tons. 3. Tons of organic material by forest types
BIODIVERSITY	10. Presence, abundance and frequency of trees, shrubs, wild life, epiphytes 11. Health of the vegetation	1. Number of trees and other individuals. 2. Index of importance by specie 3. Relationship between forest type and species 4. Endangered and HVC species
CARBON	12. Carbon stocks by forest types, national, regional and provincial	Amount of C derived from biomass above and under ground
SOCIOECONOMIC	13. State of the population and their relationship with the forest 14. Livelihood condition	Statistics about population and forest resources use and income

6.0 ALTERNATIVE INVENTORY DESIGN OPTIONS

A multipurpose national forest inventory, as the same title indicates, is a integrate and integral assessment of the whole forest resource from a particular country, however it is true that every country have some particularities like extension, accessibility, forest ecosystems, uses and stakeholders, priorities, available economic resources etc. which have to take in consideration for the elaboration of the proposal of MNFI, nevertheless the opportunities to think in different alternatives or options for design are narrow, if the whole concept and extend of the MNFI has to be applied, and a minimal accuracy and reliability have been to maintain for the necessary consistence and confidence, in this context one can only seek for the technical alternatives, like sampling design, zoning priorities, range of accuracy and timing or phasing, the following matrix can explain better this approach:.

Table No. 37 Assessment of the options

OPTIONS	CHARACTERISTICS	ADVANTAGES	DISAVANTAGES
Sampling design	In general systematic sampling design is used and recommended for NFI, however a combination of systematic and random distribution of the samples can help in particular conditions	There are several methods of sampling that could be adopted for different conditions of the forest and the terrain. Sampling units allocation, shapes, sizes are flexible for designing and implementing, some are more complicate than others but in any case the result accuracy is the most important indicator	Playing with sampling designs is easy and often attractive for foresters, nevertheless they must be consistent, and reliable according to the objective of the NFI. The main problem or disadvantage of the modification of the sampling or their replicability or their capacity for integration with other data makes some time unviable the use of some designs.
Zoning priorities	Not all the forest types, forest zones of sub-national areas have always the same importance or priority, that depends of their accessibility and potential either for production or protection, the internal and external demand etc.	Given priorities to some particular zones of the forest ecosystem, should be a standard way of planning either for NFI and National forest planning, it helps for better rationalization of time and monetary resources	The potential of the zones are exposed to variations according to the national or state government policy, consequently that might change along the time (in some cases short periods)

Accuracy	For tropical countries A maximum allowable sampling error foreseen for a NFI is 20%, and the lowest one is 10% , so a range of accuracy could rage between this two levels .	Information from MNFI are not necessarily used for management plans of specific areas of forest or forest land, but depends very much of the accuracy required or demanded by the, any how the cost difference between stakeholders, 10% and 20% sampling error are nor in the same proportion, consequently to choose the highest accuracy or the lowest sampling error could be advisable in more of the cases. However in some case the detail, emphasis or accuracy in some variables or parameters could be adjusted	When the level of accuracy is determined and decided, there are not return or opportunities to modify it once the field work is in process or already done, unless additional high costs.
Timing	A MNFI should provide updated information which has to be used for national forest planning and national forest management plans, which in general are elaborated or updated every 5 years, in some cases 10 years	Instead of the theoretical need of updating the information of the forest resource every 5 years, which is frequently not affordable by most of tropical countries, there are other ways how to update information using less costly alternatives.	5 years period cycles for MNFI seems to be too short for tropical countries in view of the high cost of its implementation. The first MNFI could be executed in 3 or 5 years (depending of the available funds and size of the country) but to accelerate too much the execution of the inventory could jeopardize the quality of the work and data.

In the light of this short analysis about the characteristics, advantages and disadvantages of the different options, the more advisable options or alternatives for NFI design could be the following:

Sampling method: should be the more simple and accessible one both for field data collection, data processing and release of results, in this case it is recommended to adopt or use sampling systems already developed and validate in other regions or countries, in that consideration only two options could be experimented:

- Systematic grid with a fixed density using one stage sampling design
- Systematic grid with a fixed density of sampling using two stages sampling design in clusters, that could help for scaling down the total cost and facilitate the logistics

Zoning priorities: In case of lack of funds for the whole MNFI, it could be advisable to break down the total area of the country in a few priority zones, where the priority I will be executed immediately, the priority II should be implemented in the mid time if the economic, security and accessibility condition permitted, priority III could be left for longer time.

Accuracy : there is a limit for the accuracy, which shouldn't be above 20% standard error for the average standing volume, however instead of modifying the standard error level, which is preferable to maintain at the lowest allowable level (10%), one alternative could be the adjustment of the details in the field data collection, which is one of the main sources of the cost of the inventory. The opinion of the consultants is that the lowest SE and the maximum detail should be kept in the MNFI, because this results in the highest cost benefit.

Timing: It will depend very much of the available economic resources but a too long period of executing the whole process less benefits will be obtained from the MNFI.

In conclusion the simplest but effective sampling design, the highest accuracy, the zoning prioritizing and the shortest time of implementing the MNFI must be the golden rule for the planning and implementation the whole process.

7. TIMING AND COSTS FOR THE MNFI IN PNG

As it was previously stated the MNFI is planned in four different phases: i) preparatory, ii)implementation-field work, iii) data processing reporting and dissemination and, iv) further monitoring

7.1 Timing planning PREPARATORY PHASE

ACTIVITIES	1	2	3	4	5	6	7	8	9	10	11	12	13	14	RESPONSIBLE	MEANS
1) Establishment of the institutional setup															National Forest Council	Protocol of interagency agreement, Prime Minister Decree
2) Develop the basic design of inventory including the classification system of vegetation, sampling system and ground data collection.															Division of Planning	International Consultants (ITTO)
3) Organization of existing information															Division of Planning and Cartography	Ad Hoc Team of Foresters collecting Available information, reports, maps and research documents
4) Develop an easily accessible database containing bibliographic information available on forest resources.															Dvision of Planning PNG's University	National and international consultants
5) To conduct workshops and courses, for the incorporation of experiences and perspectives and to train staff in the procedures of inventory.															Division of……. Technical institute of Forest (ale)	Elaboration of manuals, sillabus and guidelines by the PNG's Univ
6) Acquisition of equipment and supplies															Division of planning Procurement division	List of materials and equipment requiered Identify and select supllers
7) To conduct a pilot inventory, full exercise .															Division of planing	Selection of the adequate (representative area for the exercise) all field teams trained and equiped
8) Refinement of the MNFI methodology															Division of planning	Results and eveluation of the field exercise
9) Detailed planning of the MNFI															Division of Planning	Elaboration of the final manuals and guidelines
10) Second period of staff training															Division of……. Technical institute of Forest (ale)	Special training program elaborated and funded

7.2 PLANNING SHEET FOR THE IMPLEMENTATION PHASE, BY QUARTERS

ACTIVITIES	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15 16	17	18 19	20	RESPONSIBLE	MEANS
1) Generate updated mapping of vegetation 1:250.000 scale for the whole country, with emphasis on forests, based on Landsat TM satellite imagery 7, and radar images, to allow the identification and delineation of the maximum details for forest inventory and general management plans of different regions.																			Cartography and GIS Unit	Full set of Satellite Imagery at 1/250,000 scale. Full equipped lab. For GIS
2) Incorporate the mapping to a geographic information system (GIS), also incorporating the following layers of information: administrative boundaries (States, Municipalities and Parishes); area under Special Administrative Regime; roads; hydrography; contour every 200 meters and taxonomy.																			Cartography-GIS and data processing units	International consultant , GIS system operating
3) Field data collection quantitatively estimate the main non-timber and wood products, vertical structure, degree of intervention and diversity of forest wood components through a sampling: size, volume, density, frequency, abundance and the establishment of permanent sampling plots																			Sampling and data processing unit, field teams and provincial administrations	5-6 Field teams trained and equipped
4) Develop software to enter, validate, process, store, manage, consult and deploy database Geographic GIS that will be generated with the inventory, integrating information mapping and sampling plots.																			Sampling and data processing Unit	National and international consultants
5) Develop GIS applications that provide access to amicably in the database inventory to generate statistics, crossing information with other databases that exist and to be developed in future, and make it accessible via the Web .																			Cartography-GIS , sampling and data processing units	International and national consultants
6) To develop the necessary training equipment at vocational and technical inventory, as well as various government officials and users in different States, for implementation, consulting and use of the database inventory.																			Research and training support unit	Training program and training material. Including trainers2

7.3 DATA PROCESSING AND DISEMINATION OF INFORMATION

7) To develop activities to disseminate the information through the Executive for the different stakeholders and relevant institutions. Consolidate the National Forest Inventory database developed																					Data Bank and information Unit	Outreach information system and materials
8) Providing information to the Bureau of Planning of the Directorate of the Forest Authority, as an input for the National Forest Development Plan and the programme of Forest Statistics																					Data Bank and information Unit	Periodical reports
9) To administer the database of inventory, to keep it operational and accessible, organizing distribution and marketing																					Data Bank and information Unit	Permanent data processing team

7.4 MONITORING AND PLANNING FOR THE UPDATE (FOLLOW UP) AFTER THE FIRST MNFI

ACTIVITIES	RESPONSIBLE	MEANS					
1) Develop GIS applications to help update and monitor changes in the coverage of forests and other land uses, as referenced on its existing components and are to be developed in future, and make it accessible via the Web.	Sampling and Data Processing unit. Cartography Unit, Data Bank and information Unit	Updated software, high level professional team					
2) Develop mapping using new images to detect changes in the coverage of forests and other land uses. It is considered updating a region per year, coinciding with the regions covered by the annual inventory in the implementation phase.	Cartography Unit	New set of satellite imagery					
3) Control, monitor , maintain the permanent sample plots, process collected information	Sampling and Data Processing Unit	Permanent field teams					
3) Manage and maintain operational database into a GIS format.	Data Bank and information Unit	Updated hardware and software equipment					
4) Identify opportunities for the development of new studies, projects, crossing information seeking collaboration and partnership with relevant institutions and organizations	Research support Unit	Research team					

7.2 Cost estimation

The estimation of the cost of the MNFI, has been done considering the following components:

7.2.1 Field work, Personnel, Equipment, Travel and transportation expenses, Operational expenses

Table No. 38 summary of the field work cost

Team members	Salary (per month) in USD $	Total per month In USD$
Team leader	2400	2400
Technicians (3)	2000	6000
Labors (4)	600	2400
Total per month	Total	10,800
125 months of team		1,350,000

Table No. 39 Summary of the Equipment cost

Item	Quantity	Cost per unit USD $	Total Cost
Compasses	30	70	2,100
Calipers	30	50	1,500
Tents	18	240	4,320
Diameter tapes	36	40	1,440
GPS	12	400	4,800
Digital camera	6	400	2,400
PC	12	1,500	18,000
Lap top	6	2,500	15,000
Satellite images	50	2,500	125,000
Cars (4x4)	5	40,000	200,000
Scanners	3	5,000	15,000
Plotters	3	15, 000	45,000
Printers	6	500	3,000
Software	4	5,000	20,000
TOTAL			457,560

Table No. 40 Summary of the Personnel, travel and operational expenses

Item	Total estimated
Senior staff Project Director. And Tech. director)	528,000
International consultants	310,000
Other staff but the field staff	541200
Domestic travel	245,440
International travel	16,600
Operational expenses	221,000
TOTAL	1,638,800

Table No. 41 Total cost per component

COMPONENT	USD $	%
PERSONNEL-STAFF	1069,200	29.14
INTERNATIONAL CONSULTANTS	310,000	8.45
FIELD WORK	1350,000	36.79
EQUIPMENT	457,560	12.47
TRAVEL AND TRANSPORT COSTS	262,040	7.14
OPERATIONAL EXPENSES	221,000	6.02
TOTAL	3,669,800	
AVERAGE COST PER HECTARE *	0.115	

* Considering 32 million hectares of forest and forest land

0.115 USD$ per hectare as a first approximation of the total cost of the MNFI, is an average comparable with the cost of other NFI, for instance Argentina, Cameroon and Venezuela have average costs of 0.1 USD$, per hectare. This cost can varies in more or less 10% after the adjustments to be done as a consequence of the full pilot exercise in the field, during the preparatory phase of the MNFI.

Table No. 42 Cost by activities and phases

1. PREPARATORY PHASE	USD$
1.1 Establishment of the institutional setup	196,800
1.2 Develop the basic design of inventory including the classification system of vegetation, sampling system and ground data collection.	128,600
1.3 Organization of existing information	50,400
1.4 Develop a database containing bibliographic information available on forest resources.	36,400
1.5 Organize and conduct workshops and courses, for the incorporation of experiences and perspectives and to train staff in the procedures of inventory.	70,800
1.6 Acquisition of field and office equipment and supplies *	454,400
1.7 Develp a pilot inventory, full exercise .	87,600
1.8 Refinement of the MNFI methodology	49,600
1.9 Detailed planning of the MNFI	49,400
1.10 Second period of staff training	12,000
TOTAL PHASE 1	1,136,000
2. IMPLEMENTATION PHASE	
2.1 Generate updated mapping of vegetation 1:250.000 scale for the whole country,	813,200
2.2 Merging thematic geographic information system (GIS), with administrative boundaries (States, Municipalities and Parishes); area under Special Administrative Regime; roads; hydrography; contour lines.	61,400
2.3 Revision and improvement of the MNFI guidelines and manual	9,600
2.4 Field data collection non-timber and wood products, vertical structure, degree of intervention and diversity of forest wood components through a sampling	984,000
2.5 Develop software to enter, validate, process, store, manage, consult and deploy database Geographic GIS that will be generated with the inventory, integrating information mapping and sampling plots.	25,000
2.6 Development of GIS applications that provide access to the database inventory and crossing information with other databases that exist and to be developed in future, and make it accessible via the Web .	34,400
2.7 Develop training at vocational and technical inventory level for government officials and users	23,800
2.8 Develop activities to disseminate the National Forest Inventory data and results for the different stakeholders and relevant institutions.	32,000
2.9 Adequate the NFI data for the immediate use of the Forest Authority, as an input for the National Forest Development Plan and the programme of Forest Statistics	61,600
2.10 To administer the database of inventory, to keep it operational and accessible, organizing distribution and marketing	25,200

TOTAL PHASE 2	2,070,200
3. POST INVENTORY PHASE	
3.1) Develop GIS applications for updating and monitor changes in the coverage of forests and land uses,	116,800
3.2) Develop mapping using new images to detect changes in the coverage of forests and other land uses.	134,800
3.3 Control, monitor , maintain the permanent sample plots, process collected information	120,800
3.4 Manage and maintain operational database into a GIS format.	54,400
3.5 Identify opportunities for the development of new studies, projects,	36,800
TOTAL PHASE 3	463,600
TOTAL BUDGET	3,669,800

Table No. 43 Summary of the total budget

PHASE	COST IN USD$
PREPARATORY PHASE	1,136,000
IMPLEMENTATION PHASE	2,070,200
POST MONITORING PHASE	463,600
TOTAL	3,669,800

Table No. 40

DETAILED BUDGET FOR THE MULTIPURPOSE NATIONAL FOREST INVENTORY IN PNG

Budget line code	ACTIVITIES	Quant.	$ USD	Total	Year 1	Year 2	Year 3	Year 4	Year 5	TOTAL
	1. PREPARATORY PHASE		Unidad						0	-
	1.1 Establishment of the institutional setup									-
10.10	Project coordinator	12.00	5,000	60,000	60,000					60,000
10.20	Technical director	12.00	6,000	72,000	72,000					72,000
10.30	Local experts	2.00	2,400	4,800	4,800					4,800
10.40	Technical assistants			-	-					-
10.50	International consultant	3.00	14,000	42,000	42,000					42,000
20.10	Sub-contracts			-	-					-
30.10	Domestic travel	20.00	500	10,000	10,000					10,000
30.20	International Travel	2.00	2,500	5,000	5,000					5,000
40.10	Equipment			600	600					600
50.10	Materials			2,400	2,400					2,400
60.10	Operational expenses and miscellaneous				-					-
100.00	Total			196,800	196,800					196,800
	1.2 Develop the basic design of inventory including the classification system of vegetation, sampling system and ground data collection.								-	-
10.10	Project director				-				-	-
10.20	Technical director				-				-	-
10.30	Local experts				-					-
10.40	Technical assistants	6.00	4,000	24,000	24,000					24,000
10.50	International consultant	3.00	14,000	42,000	42,000					42,000

20.10	Sub-contracts			20,000	20,000					20,000
30.10	Domestic travel	6.00	500	3,000	3,000					3,000
30.20	International Travel			-	-					-
40.10	Equipment			30,000	30,000					30,000
50.10	Materials			6,000	6,000					6,000
60.10	Operational expenses and miscellaneous			3,600	3,600					3,600
100.00	Total			128,600	128,600					128,600
	1.3 Organization of existing information									-
10.10	Project director				-					-
10.20	Technical director				-					-
10.30	Local experts	4.00	2,400	9,600	9,600					9,600
10.40	Technical assistants			-	-					-
10.50	International consultant	2.00	14,000	28,000	28,000					28,000
20.10	Sub-contracts			-	-					-
30.10	Domestic travel			-	-					-
30.20	International Travel			-	-					-
40.10	Equipment			12,000	12,000					12,000
50.10	Materials			800	800					800
60.10	Operational expenses and miscellaneous				-					-
100.00	Total			50,400	50,400					50,400
	1.4 Develop an easily accessible database containing bibliographic information available on forest resources.									-
10.10	Project director				-					-
10.20	Technical director				-					-
10.30	Local experts	4.00	2,400	9,600	9,600					9,600
10.40	Technical assistants	6.00	1,800	10,800	10,800					10,800
10.50	International consultant	0.50	14,000	7,000	7,000					7,000

30.10	Sub-contracts			-	-					-
30.20	Domestic travel	6.00	500	3,000	3,000					3,000
40.10	International Travel			-	-					-
50.10	Equipment			4,800	4,800					4,800
60.10	Materials			1,200	1,200					1,200
100.00	Operational expenses and miscellaneous			36,400	36,400					36,400
	1.5 Organize and conduct workshops and courses, for the incorporation of experiences and perspectives and to train staff in the procedures of inventory.									-
10.10	Project director				-					-
10.20	Technical director				-					-
10.30	Local experts	8.00	2,400	19,200	19,200					19,200
10.40	Technical assistants	8.00	1,200	9,600	9,600					9,600
10.50	International consultant			-	-					-
20.10	Sub-contracts			-	-					-
30.10	Domestic travel	48.00	500	24,000	24,000					24,000
30.20	International Travel			-	-					-
40.10	Equipment			12,000	12,000					12,000
50.10	Materials			3,600	3,600					3,600
60.10	Operational expenses and miscellaneous			2,400	2,400					2,400
100.00	Total			70,800	70,800					70,800
	1.6 Acquisition of field and office equipment and supplies									-
10.10	Project director									-
10.20	Technical director				-					-
10.30	Local experts	4.00	2,400	9,600	9,600					9,600
10.40	Technical assistants	4.00	1,200	4,800	4,800					4,800
10.50	International consultant			-	-					-

20.10	Sub-contracts			-	-					-
30.10	Domestic travel	8.00	500	4,000	4,000					4,000
30.20	International Travel			-	-					-
40.10	Equipment			200,000	200,000					200,000
50.10	Materials			24,000	24,000					24,000
60.10	Operational expenses and miscellaneous			12,000	12,000					12,000
100.00	Total			254,400	254,400					254,400
	1.7 Develop a pilot inventory, full exercise .									-
10.10	Project director				-					-
10.20	Technical director				-					-
10.30	Local experts	4.00	2,400	9,600	9,600					9,600
10.40	Technical assistants	24.00	1,200	28,800	28,800					28,800
10.50	International	2.00	14,000	28,000	28,000					28,000
20.10	Sub-contracts			-	-					-
30.10	Domestic travel	36.00	500	18,000	18,000					18,000
30.20	International Travel				-					-
40.10	Equipment				-					-
50.10	Materials			1,200	1,200					1,200
60.10	Operational expenses and miscellaneous			2,000	2,000					2,000
100.00	Total			87,600	87,600					87,600
	1.8 Refinement of the MNFI methodology									-
10.10	Project director			-	-					-
10.20	Technical director			-	-					-
10.30	Local experts	4.00	2,400	9,600	9,600					9,600
10.40	Technical assistants	8.00	800	6,400	6,400					6,400
10.50	International consultant	2.00	14,000	28,000	28,000					28,000
20.10	Sub-contracts			-	-					-
30.10	Domestic travel	4.00	500	2,000	2,000					2,000

30.20	International Travel				-					-
40.10	Equipment				-					-
50.10	Materials			1,200	1,200					1,200
60.10	Operational expenses and miscellaneous			2,400	2,400					2,400
100.00	Total			49,600	49,600					49,600
	1.9 Detailed planning of the MNFI									-
10.10	Project director				-					-
10.20	Technical director				-					-
10.30	Local experts	8.00	2,400	19,200	19,200					19,200
10.40	Technical assistants	8.00	1,200	9,600	9,600					9,600
10.50	International consultant	1.00	14,000	14,000	14,000					14,000
20.10	Sub-contracts			-	-					-
20.10	Domestic travel	6.00	500	3,000	3,000					3,000
30.10	International Travel			-	-					-
30.20	Equipment			-	-					-
40.10	Materials				-					-
50.10	Operational expenses and miscellaneous			2,400	2,400					2,400
60.10	Gastos de operación y misceláneos			1,200	1,200					1,200
100.00	Total			49,400	49,400					49,400
	1.10 Second period of staff training									-
10.10	Project director			-	-					-
10.20	Technical director			-	-					-
10.30	Local experts	6.00	2,400	7,200	7,200					7,200
10.40	Technical assistants	6.00	1,200		-					-
10.50	International consultant				-					-
20.10	Sub-contracts				-					-
30.10	Domestic travel				-					-
30.20	International Travel				-					-

40.10	Equipment				-					-
50.10	Materials			3,600	3,600					3,600
60.10	Operational expenses and miscellaneous			1,200	1,200					1,200
100.00	Total			12,000	12,000					12,000

	2. IMPLEMENTATION PHASE								-	-
	2.1 Generate updated mapping of vegetation 1:250.000 scale for the whole country,								-	-
10.10	Project director	48.00	5,000	240,000		60,000	60,000	60,000	60,000	240,000
10.20	Technical director	48.00	6,000	288,000		72,000	72,000	72,000	72,000	288,000
10.30	Local experts	12.00	2,400	28,800		28,800				28,800
10.40	Technical assistants	12.00	1,200	14,400		14,400				14,400
10.50	International consultant	1.00	14,000	14,000		14,000				14,000
20.10	Sub-contracts			120,000		120,000				120,000
30.10	Domestic travel	6.00	500	3,000		3,000				3,000
30.20	International Travel		2,500	-		-				-
40.10	Equipment			3,000		3,000				3,000
50.10	Materials			6,000		6,000				6,000
60.10	Operational expenses and miscellaneous			96,000		96,000				96,000
100.00	Total			813,200		417,200	132,000	132,000	132,000	813,200
	2.2 Merging thematic geographic information system (GIS), with administrative boundaries (States, Municipalities and Parishes); area under Special Administrative Regime; roads; hydrographic; contour lines.								-	-
10.10	Project director								-	-
10.20	Technical director								-	-
10.30	Local experts	4.00	2,400	9,600		9,600				9,600

10.40	Technical assistants	6.00	1,200	7,200		7,200				7,200
10.50	International consultant	1.00	14,000	14,000		14,000				14,000
20.10	Sub-contracts			24,000		24,000				24,000
30.10	Domestic travel	6.00	500	3,000		3,000				3,000
30.20	International Travel			-		-				-
40.10	Equipment					-				-
50.10	Materials					-				-
60.10	Operational expenses and miscellaneous			3,600		3,600				3,600
100.00	Total			61,400		61,400				61,400
	2.3 Revision and improvement of the MNFI guidelines and manual									-
10.10	Project director									-
10.20	Technical director									-
10.30	Local experts	2.00	2,400	4,800		4,800				4,800
10.40	Technical assistants	2.00	1,200	2,400		2,400				2,400
10.50	International consultant					-				-
20.10	Sub-contracts					-				-
30.10	Domestic travel					-				-
30.20	International Travel					-				-
40.10	Equipment					-				-
50.10	Materials			1,200		1,200				1,200
60.10	Operational expenses and miscellaneous			1,200		1,200				1,200
100.00	Total			9,600		9,600				9,600

	2.4 Field data collection quantitatively estimate the main non-timber and wood products, vertical structure, degree of intervention and diversity of forest wood components through a sampling: size, volume, density, frequency, abundance and the establishment of permanent sampling plots									-
10.10	Project director									-
10.20	Technical director									-
10.30	Local experts	120.00	2,400	288,000		72,000	72,000	72,000	72,000	288,000
10.40	Technical assistants	360.00	1,200	432,000		108,000	108,000	108,000	108,000	432,000
10.50	International consultant	8.00	14,000	112,000		28,000	28,000	28,000	28,000	112,000
20.10	Sub-contracts			24,000		6,000	6,000	6,000	6,000	24,000
30.10	Domestic travel	80.00	500	40,000		10,000	10,000	10,000	10,000	40,000
30.20	International Travel	4.00	4,000	16,000		4,000	4,000	4,000	4,000	16,000
40.10	Equipment			24,000		12,000		12,000		24,000
50.10	Materials			12,000		3,000	3,000	3,000	3,000	12,000
60.10	Operational expenses and miscellaneous			36,000		9,000	9,000	9,000	9,000	36,000
100.00	Total			984,000		252,000	240,000	252,000	240,000	984,000
	2.5) Develop software to enter, validate, process, store, manage, consult and deploy database Geographic GIS that will be generated with the inventory, integrating information mapping and sampling plots.									-
10.10	Project director									-
10.20	Technical director									-

10.30	Local experts	4.00	2,400	9,600			9,600			9,600
10.40	Technical assistants	4.00	1,200	4,800			4,800			4,800
10.50	International consultant	0.50	14,000	7,000			7,000			7,000
20.10	Sub-contracts			-			-			-
30.10	Domestic travel			-			-			-
30.20	International Travel			-			-			-
40.10	Equipment			2,400			2,400			2,400
50.10	Materials						-			-
60.10	Operational expenses and miscellaneous			1,200			1,200			1,200
100.00	Total			25,000			25,000			25,000
	2.6) Development of GIS applications that provide access to the database inventory and crossing information with other databases that exist and to be developed in future, and make it accessible via the Web .									-
10.10	Project director									-
10.20	Technical director									-
10.30	Local experts	6.00	2,400	14,400			14,400			14,400
10.40	Technical assistants	4.00	1,200	4,800			4,800			4,800
10.50	International consultant	1.00	14,000	14,000			14,000			14,000
20.10	Sub-contracts			-			-			-
30.10	Domestic travel			-			-			-
30.20	International Travel			-			-			-
40.10	Equipment			-			-			-
50.10	Materials						-			-
60.10	Operational expenses and miscellaneous			1,200			1,200			1,200

100.00	Total			34,400			34,400			34,400
	2.7 Develop training at vocational and technical inventory level for government officials and users in different States,									-
10.10	Project director									-
10.20	Technical director									-
10.30	Local experts	4.00	2,400	9,600			9,600			9,600
10.40	Technical assistants	8.00	800	6,400			6,400			6,400
10.50	International consultant			-			-			-
20.10	Sub-contracts			-			-			-
30.10	Domestic travel	6.00	500	3,000			3,000			3,000
30.20	International Travel			-			-			-
40.10	Equipment						-			-
50.10	Materials			3,600			3,600			3,600
60.10	Operational expenses and miscellaneous			1,200			1,200			1,200
100.00	Total			23,800			23,800			23,800
	2.8 Develop activities to disseminate the National Forest Inventory data and results for the different stakeholders and relevant institutions.									-
10.10	Project director									-
10.20	Technical director									-
10.30	Local experts	4.00	2,400	9,600			3,200	3,200	3,200	9,600
10.40	Technical assistants			-						-
10.50	International consultant	1.00	14,000	14,000			14,000			14,000
20.10	Sub-contracts			-						-

30.10	Domestic travel			-						-
30.20	Internationals Travel			-						-
40.10	Equipment									-
50.10	Materials			4,800			1,600	1,600	1,600	4,800
60.10	Operational expenses and miscellaneous			3,600			1,200	1,200	1,200	3,600
100.00	Total			32,000	-	-	20,000	6,000	6,000	32,000
	2.9 Adequate the NFI data for the immediate use of the Forest Authority, as an input for the National Forest Development Plan and the programme of Forest Statistics									-
10.10	Project director									-
10.30	Technical director									-
10.30	Local experts	4.00	2,400	9,600				4,800	4,800	9,600
10.40	Technical assistants	8.00	1,200	9,600				4,800	4,800	9,600
10.40	International consultant			-						-
10.50	Sub-contracts	2.00	20,000	40,000				20,000	20,000	40,000
20.10	Domestic travel			-						-
30.10	International Travel			-						-
30.20	Equipment									-
40.10	Materials									-
50.10	Operational expenses and miscellaneous									-
60.10	Gastos de operación y misceláneos			2,400				1,200	1,200	2,400
100.00	Total			61,600						61,600
	2.10 To administer the database of inventory, to keep it operational and accessible, organizing distribution and marketing									-
10.10	Project director									-

10.20	Technical director									-
10.30	Local experts	6.00	2,400	14,400				7,200	7,200	14,400
10.40	Technical assistants	6.00	1,200	7,200				3,600	3,600	7,200
10.50	International consultant			-						-
20.10	Sub-contracts			-						-
30.10	Domestic travel			-						-
30.20	International Travel			-						-
40.10	Equipment									-
50.10	Materials			3,600				1,800	1,800	3,600
60.10	Operational expenses and miscellaneous									-
100.00	Total			25,200						25,200
									-	-

	3. POST INVENTORY PHASE								-	-
	3.1) Develop GIS applications for updating and monitor changes in the coverage of forests and other land uses,								-	-
10.10	Project director	6.00	5,000	30,000					-	30,000
10.20	Technical director	6.00	6,000	36,000					-	36,000
10.30	Local experts	4.00	2,400	9,600					-	9,600
10.40	Technical assistants	2.00	1,200	2,400					-	2,400
10.50	International consultant	2.00	14,000	28,000					-	28,000
20.10	Sub-contracts			-					-	-
30.10	Domestic travel	12.00	500	6,000					-	6,000
30.20	International Travel			-					-	-
40.10	Equipment								-	-
50.10	Materials			2,400					-	2,400
60.10	Operational expenses and miscellaneous			2,400					-	2,400
100.00	Total			116,800					-	116,800
	3.2) Develop mapping using new images to detect changes in the coverage of forests and other land uses.								-	-
10.10	Project director								-	-
10.20	Technical director								-	-
10.30	Local experts	8.00	2,400	19,200						19,200
10.40	Technical assistants	8.00	1,200	9,600						9,600
10.50	International consultant	1.00	14,000	14,000						14,000

20.10	Sub-contracts			-						-
30.10	Domestic travel			-						-
40.10	International Travel			-						-
50.10	Equipment			80,000						80,000
60.10	Materials			12,000						12,000
100.00	Operational expenses and miscellaneous			134,800						134,800
									-	-
	3.3 Control, monitor , maintain the permanent sample plots, process collected information								-	-
10.10	Project director								-	-
10.20	Technical director									-
10.30	Local experts	12.00	2,400	28,800						28,800
10.40	Technical assistants	24.00	1,200	28,800						28,800
10.50	International consultant	1.00	14,000	14,000						14,000
20.10	Sub-contracts			36,000						36,000
30.10	Domestic travel	12.00	500	6,000						6,000
30.20	International Travel			-						-
40.10	Equipment									-
50.10	Materials			6,000						6,000
60.10	Operational expenses and miscellaneous			1,200						1,200
100.00	Total			120,800						120,800
									-	-
	3.4 Manage and maintain operational database into a GIS format.								-	-

10.10	Project director								-	-
10.20	Technical director									
10.30	Local experts	12.00	2,400	28,800				14,400	14,400	28,800
10.40	Technical assistants	6.00	1,200	7,200				3,600	3,600	7,200
10.50	International consultant	1.00	14,000	14,000				14,000		14,000
20.10	Sub-contracts									-
30.10	Domestic travel	12.00	500							-
30.20	International Travel									-
40.10	Equipment									-
50.10	Materials			1,200				600	600	1,200
60.10	Operational expenses and miscellaneous			3,200				1,600	1,600	3,200
100.00	Total			54,400	-	-	-	34,200	20,200	54,400
	RESULTADO 3.2									
	3.5 Identify opportunities for the development of new studies, projects,								-	-
10.10	Project director			-						
10.20	Technical director			-						
10.30	Local experts	4.00	2,400	9,600					9,600	9,600
10.40	Technical assistants			-					-	-
10.50	International consultant	1.00	14,000	14,000					14,000	14,000
20.10	Sub-contracts			-					-	-
30.10	Domestic travel	6.00	500	3,000					3,000	3,000
30.20	International Travel	2.00	4,000	8,000					8,000	8,000
40.10	Equipment								-	-
50.10	Materials			1,000					1,000	1,000

60.10	Operational expenses and miscellaneous			1,200					1,200	1,200
100.00	Total			36,800					36,800	36,800

TOTAL BUDGET OF THE MULTIPURPOSE NATIONAL INVENTORY IN PAPUA NEW GUINEA

				TOTAL	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	
	TOTAL ANNUAL BUDGET			3,469,800	936,000	740,200	475,200	424,200	435,000	3,469,800
	Actual forest cover area in hectares									**28,587,360**
	Average cost per hectare ($ USD)									**0.1214**

Annex 1

Comparison of the demographic, social and economic situation of provinces with a low and high rates of deforestation

Provinces with a low rate of deforestation (Western and Enga)

The estimated rural population of Western province was 106,000 habitants in 2000, or 3% of the national rural population. The provincial rural population growth rate is 2.2% per year. The highest population densities are on the southern coastal plains between the Oriomo and Pahoturi rivers where there are 26 habitants/km^2. The East Awin Refugee Relocation Area (EARRA), east of Kiunga, has 20 habitants/km^2. All other areas in the province have low population densities of less than 10 habitants/km^2. There is significant out-migration from the Hindenburg Range, the areas around Bolovip and Olsobip, the upper Murray Valley, the Nomad area and from the Gama Valley

People around Lake Murray and along the Fly River earn moderate incomes from the sale of crocodile skins, fish and fresh food. Those north of Kiunga, around Morehead and along the south coast between the Oriomo and Pahoturi rivers have low incomes derived from the sale of betel nut, fresh food and rubber. Most other people in the province earn very low incomes from minor sales of fresh food, betel nut, animal skins, fish, crocodiles and rubber. The Ok Tedi mine provides various sources of income to people in the province. Those in the mine impact area receive income from royalties and wage employment. Many of the Ok speaking people who live in the mountains north of Tabubil receive remittances from relatives working at the mine. More recently the impact area has been extended and people along the Ok Tedi and Fly rivers below the mine site have received compensation payments for damage caused by mine tailings deposited in the river system. People in the Nomad, Balimo, Morehead, Wipim and Kondubol areas have few non-agricultural sources of income.

The estimated rural population of Enga province was 405,000 habitants in 2000, or 10% of the national rural population. The provincial population growth rate is the highest in the country at 4.6% per year. However, there are some doubts over the accuracy of the 1990 census data. Population densities are highest in the Lai, Ambum and Tsak valleys with 360 habitants/km^2. The upper Lagaip Valley has 210 habitants/km^2, while the swamp fringes near Kandep have around 170 habitants/km^2. Areas near Kompiam and Porgera have densities of 60 habitants/km^2, while the rest of the province has only 24 habitants/km^2. More than half of the area of the province is mountains devoid of people. The Porgera area, upper Lagaip Valley, Ambum Valley and Lai Valley have significant in-migration of people looking for better access to services, more productive environments and wage employment.

Enga is a poor province. Incomes range between very low and moderate. Agriculture provides the main source of cash income through sales of coffee, fresh food and firewood. Most of the coffee is grown around Wabag, Wapenamanda and Kompiam in areas below 2100 m, which is the upper altitudinal limit of Arabica coffee. People in the higher areas around Kandep and Laiagam sell small amounts of potato and firewood. People in the north of the province are very poor and have few cash-

earning opportunities. Royalties and wage employment are provided by the Porgera gold mine and are the only major sources of non-agricultural income in the province. This income is very high but only benefits people living close to the mines.

Provinces with a high rate of deforestation (New Ireland and Manus)

1. The estimated rural population of New Ireland province is 133,000, which is 3% of the national rural population. The provincial rural population growth rate is very high at 4% per year. The highest population densities of 162 habitants/km^2 are on the East Islands, off Lavongai, and on the Tingwon Islands. Mahur and Masahet islands, in the Lihir Group, and Boang Island, in the Tanga Group, have similar densities. The coastal plains of Lavongai, Lihir and Malendok islands and the Anir Islands have moderate densities of 47 habitants/km^2, while most of New Ireland has 30 habitants/km^2. All remaining areas in the province have low population densities. Areas around Kavieng and Namatanai have significant in-migration.

On most of New Ireland, and on the coastal areas of Lavongai and Dyaul islands, incomes are high and are derived from the sale of copra, cocoa, oil palm, betel nut, fish and fresh food. People on the Lelet Plateau earn high incomes from the sale of fresh food. People in the inland areas of Lavongai Island earn moderate incomes from the sale of betel nut, fresh food and tobacco. Incomes are low in the very south of New Ireland and on the island groups, and are derived from minor sales of cocoa, copra, fish, fresh food and betel nut. Many sources of non-agricultural income exist on the northeast coast of New Ireland. People run small businesses, Passenger Motor Vehicles and trade stores, and gain wage employment from both businesses and plantations. A limited number of people on the southeast coast receive wages from cocoa and oil palm plantations. People on Lihir Island receive significant income in the form of wages and royalties from the gold mining operations.

2. The estimated rural population of Manus province was 37,000 habitants in 2000, which is 1% of the national rural population. The provincial rural population growth rate is high at 3% per year. The highest population densities are on the small islands off the north coast of Manus (Harengan, Arowe, Sori, Ponam, Andra, Hus, Oneta, Pityilu, Hawei and Ndrilo islands) and off the south coast (Mbuke, Johnston, Ndrova and Tilianu islands) where there is an average of 500 habitants/km^2. Bipi, Sisi and Pahi islands to the west of Manus have densities of 250 habitants/km^2, while Baluan, Pam and Nauna islands to the south have 125 habitants/km^2. The remote Aua-Wuvulu, Ninigo, Hermit and Kaniet island groups have densities of 65 habitants/km^2, while Rambutyo, Tong, Pak and Los Negros islands to the east of Manus have 25 habitants/km^2. Manus Island itself has relatively low densities, 25 habitants/km^2 in the east and 7 habitants/km^2 in the west, and contains the majority of the provincial population.

Most people in the Manus province have moderate to high incomes derived from the sale of copra, betel nut, fresh food, fish and cocoa. People closer to markets in Lorengau tend to have higher incomes. People in the Aua-Wuvulu, Ninigo, Hermit and Kaniet island groups earn low incomes from minor sales of copra. The major source of non-agricultural income in the province is remittances from relatives working in urban centres elsewhere in PNG. People from Manus Province have a long history of gaining advanced education, working elsewhere and sending their children to school.

Annex 2

Example of a Forest Management Agreement

The example is the one of the ASENGSENG Forest Management Area.

The Land Owners groups concerned are : BILANGI, WIWUN, WATOK, SUSUHUK, TELPON, SULUK, SUMOLO, ARUNUK, WUNGPI, TEKEPIO, KEREL, YAWONG, MAES, LAND GROUP, TUNGIN, SAIU, TETEME, KALANG, ASAHI.

The clauses of the FMA are the following :

1. Area

1.1 The area covered by this Agreement is the ASENGSENG Forest Management Area, described in Schedule 2

2. Term

2.1 The term of this Agreement is for a period of 50 years commencing on the date set out in Schedule 1[†] .

2.2 At the end of each 20 year period during the Agreement, the parties to this Agreement may agree in writing to extend the term of this Agreement by a further twenty years.

2.3 An extension under Sub-clause 2.2 may be made subject to such changes in the terms and conditions of this Agreement as the parties agree in writing.

2.4 Where some but not all of the Land Groups agree to an extension under Sub-clause 2.2, the term of the Agreement will be extended accordingly only in respect of the land areas* of the Land Groups that have agreed to the extension.

2. Volume

3.1 The estimated volume and species composition of the merchantable timber in the Forest Management Area is as specified in Schedule 4.

4. Ownership of Timber

4.1 Each Land Group declares that :

(a) its members are customary owners of the land areas[*] identified as their land in Schedule 2 item 3;
(b) it is entitled under custom to authorise the Authority to deal with timber on that land; and
(c) no other person has any right or interest in the timber or other forest produce on the land.

4.2 A Land Group shall indemnify[#] the Authority against any loss or damage suffered by the Authority as a consequence of any part of a declaration made under Sub-clause 4.1 being false.

[†] Timber Permits will be for shorter periods than the Forest Management Agreement, but a 50 year term is required to ensure that the forest can be managed sustainably.
[*] This expression is defined in Clause 19.

4.3 Subject to the terms and conditions in this agreement, the timber rights in respect of the Forest Management Area are vested in the Authority for the term of this Agreement. The Authority may assign timber rights to a forest industry participant in accordance with the terms and conditions of a timber permit or authority for the duration of that permit or authority, subject to the conditions contained within it. The term of a timber permit or authority may not extend beyond the term of this Agreement.

4.4 A timber permit must not authorize the harvesting of excluded forest products set out in Schedule 5, trees and forest products which are marked under Sub-clause 8.3(a), or timber which is located in cultural areas, burial grounds and gardens identified in accordance with Sub-clause 8.3(b).

4.5 Property in timber within the Forest Management Area shall remain with the customary owners of the land in which it grew or is growing, until it has been felled by a forest industry participant, at which point in time property will transfer to the forest industry participant, subject to the payment of royalties.

4.6 Although the property in timber remains with the customary owners until it is felled, those customary owners have no power to terminate this Agreement except in accordance with Clause 16. The Land Groups undertake that they will make sure that the owners of the timber abide by the terms of this Agreement, and will not interfere with the carrying out of this Agreement

4.7 The Land Groups must not allow any other person to acquire an interest in the timber which the Authority or a forest industry participant may be entitled to take under this

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[#] This means that the Land Group will pay any legal costs against the Authority which arise from a false declaration about ownership of land or timber.

PROTECTED AREAS IN PAPUA NEW GUINEA

(Information provided from Department of Environment and Conservation, February 2008)

	NAME	TYPE	PROVINCE	AREA (HA)
1	Tonda WMA	WMA	Western	590,000
2	Crater Mountain WMA	WMA	Chimbu, Eastern Highlands,Gulf	270,000
3	Hunstein Range WMA	WMA	East Sepik	220,000
4	Maza WMA	WMA	Western	184,230
5	Kamiali WMA	WMA	Morobe	65,541
6	Crown Island Wildlife Sanctuary	S	Madang	58,969
7	Pirung WMA	WMA	North Solomons	43,200
8	Ranba WMA + Sanctuary	WMA	Madang	57,646
9	Lake Kutubu WMA	WMA	Southern Highlands	24,100
10	Oi Mada Wara WMA	WMA	Milne Bay	22,840
11	Lihir Island	PA	New Ireland	20,208
12	Bagiai WMA	WMA	Madang	13,760
13	Siwi-Utame WMA	WMA	Southern Highlands	12,540
14	Pokili WMA	WMA	West New Britain	9,840
15	Garu WMA	WMA	West New Britain	8,700
16	Ndrolowa WMA	WMA	Manus	5,850
17	Klampun WMA	WMA	East New Britain	5,200
18	Mojirau WMA	WMA	East Sepik	5,079
19	Jimi Valley National Park	NP	Western Highlands	4,180
20	Neiru (Aird Hills) WMA	WMA	Gulf	3,984
21	Iomare WMA	WMA	Central	3,828
22	Lake Lavu WMA	WMA	Milne Bay	2,640
23	Tavalo WMA	WMA	East New Britain	2,000
24	Mc Adams National Park	NP	Morobe	1,821
25	Zo-oimaga WMA	WMA	Central	1,510
26	Mt Kaindi WMA	WMA	Morobe	1,503
27	Variarata Nat. Park	NP	Central	1,063
28	Mt Wilhelm National Reserve	NP	Western Highlands	817
29	Sawataetae WMA	WMA	Milne Bay	700
30	Balek Wildlife Sanctuary	S	Madang	470
31	Hombareta WMA	WMA	Oro	130
32	Loroko National Park	NP	West New Britain	100
33	Mt Gahavisuka Pro. Park	PP	Eastern Highlands	77
34	Baiyer River Sanctuary	S	Western Highlands	64
35	Mt Susu National Reserve Par	NP	Morobe	49
36	Moitaka Wildlife Sanctuary	S	National Capital District	44
37	Baniara Island WMA	PA	Milne Bay	37
38	Namanatabu Reserve	R	Central	27
39	Nuraseng WMA	WMA	Morobe	22
40	Paga Hill Nat. Park Scenic R	NP	National Capital District	17
41	Nanuk Island Reserve	R	East New Britain	12
42	Talele Is. Nat. Park Reserve	NP	East New Britain	12
43	Kokoda Historical Reserve	R	Oro	10
44	Cape Wom Memorial Park	MP	East Sepik	2
45	Wewak Peace Memorial Park	MP	East Sepik	2
46	Kokoda Memorial Park	MP	Oro	1
47	Kavakuna Caves	WMA	East New Britain	

	NAME	TYPE	PROVINCE	AREA (HA)
48	Sinub Island	WMA	Madang	
49	Laugum Island	WMA	Madang	72.95
50	Tab Island	WMA	Madang	984.30
51	Tabad Island	WMA	Madang	16.30
52	Kau Wildlife Area	Informal	Madang	
	Managalas Plateau	Proposed	Oro	
	Tonda Extension	Proposed	Western	
	Sulamesi - Mt Bosavi	Proposed	Southern Highlands	
	Wereaver-Baro	Proposed	Western	
	Suki-Aramba	Proposed	Western	
	Simbine	Proposed	Madang	
	Me'ha	Proposed	East Sepik	
	Uma	Proposed	East Sepik	
	Libano-Hose	Proposed	Southern Highlands	
	Libano-Arisai	Proposed	Southern Highlands	
	Wiad	Proposed	Madang	
	Milne Bay Marine	Proposed	Milne bay	
	YUS Conservation Area	Proposed	Morobe	
			TOTAL	**1,643,898.55**

List of tables and figures

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