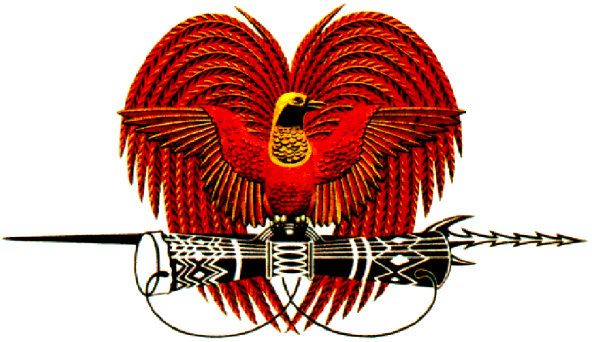


Papua New Guinea
Initial National Communication

Under the United Nations Framework Convention on Climate Change

November, 2000

P R E F A C E

Papua New Guinea (PNG) signed the United Nations Framework Convention on Climate Change (UNFCCC) at the UNCED in Rio de Janeiro, Brazil in June 1992. The UNFCCC was ratified by the Government of Papua New Guinea (GoPNG) in April 1993. The signing and ratification of the UNFCCC by the GoPNG is a testimony of our strong commitment to fulfilling our obligations to the Convention. It also signifies the concerns that PNG has about the issues pertaining to the likely impacts of climate change and sea-level rise.

One of the cornerstones of this climate Convention is the commitment by all Parties to take the necessary steps and measures to reduce greenhouse gas (GHG) emissions. This is further strengthened by the commitment of all Parties to submit to the Conference of the Parties (COP) National Communication under Articles 4 and 12 of the UNFCCC.

This document has been prepared to fulfill PNG's commitment. It contains the necessary information about the country's major sources of GHG emissions and sinks, vulnerability and adaptation options together with the necessary mitigation measures, which PNG will implement to adapt to climate change impacts and further contribute to the global efforts in reducing GHG emissions.

The GovPNG has also gone ahead in embarking on a number of new initiatives aimed at supporting our commitment to the UNFCCC. These included the establishment of a PNG Greenhouse Office to develop appropriate policies and where required, necessary legislation to address the issues relating to climate change.

Although our GHG emissions as shown in this document are relatively insignificant, we are severely affected by the impacts of climate change resulting from global warming due to increased GHG concentrations in the atmosphere. Faced with this eminent problem, PNG wants to take the lead in meeting its obligation to the UNFCCC and that we hope that those country parties whose emissions are much higher would take positive steps to do more towards reducing their GHG emissions. The direction PNG is taking is not only for meeting our commitment to the UNFCCC, but importantly to address the issues relating to the future of our social and economic developments under the prevailing environment of climate change.

I am optimistic that the programmes and projects that will eventuate from this Initial National Communication will go a long way in assisting PNG to better manage the effects of climate change more effectively, for the well being of our environment and people of which we hold so dearly.

Rt. Honourable, Sir Mekere Morauta Kt MP
Prime Minister of Papua New Guinea

F O R E W O R D

Papua New Guinea is highly vulnerable to the impacts of climate change as it encompasses more than 17,000 km of coastline and 600 islands, most of which are low lying, and has almost 2,000 coastal villages with a population of about 500,000 making it much vulnerable to sea level rise and other weather-related manifestations of climate change.

Since PNG is highly vulnerable to the impacts of climate change, the mitigation and adaptation measures highlighted in this initial National Communication are very important. They provide us the opportunity to pursue our efforts for mitigating GHG emissions and adaptive measures. Such approach would also assist us in our endeavour to promote the conservation of a unique and rich biological diversity, which has been estimated to contain between 5-7% of the global biodiversity. Further, the measures would go a long way in assisting us to implement our pending strategies for sustainable development of our natural resources.

The experiences we had during the 1997/98 prolonged drought has taught us a number of lessons, especially the vulnerability of our agricultural crops (both for food and cash), water resources and health related problems. Further, our fisheries resources, including the 2.4 million km^2 of the exclusive economic zone, although currently abundant and least less exploited, could prove susceptible to temperature and other changes. Already we are experiencing the increasing bleaching of our coral reefs as well as impacts of the rising sea levels.

Our terrestrial ecosystems are particularly diverse and complex and the impacts of climate change on them are not well understood.

I am pleased to submit this initial National Communication in fulfillment of our obligation to the UNFCCC, which have already signed and ratified.

This report has been prepared by the PNG country team on climate change with the technical assistance from SPREP and the National Tidal Facility, Flinders University, South Australia, with the financial assistance from the UNDP-GEF programme. The PNG country team comprises both the Steering and Technical Committees, drawn from various government agencies, national institutions, NGOs and the private sector.

The aim of this report is to produce document information about the country's sources of GHG emissions and sinks, vulnerability and adaptation as well as providing a number of adaptation and abatement option measures for reducing GHG emissions and adapt to changing environmental conditions resulting from climate change.

Honourable Herowa Agiwa, MP
Minister for the Environment and Conservation

CONTENTS

E D I T 0 R S

Chalapan Kaluwin
South Pacific Regional Environment Programme
Apia, Samoa

James Ashton
19 Murray Street, North Ward
Townsville, Queensland
Australia

Simon Saulei
Biology Department
School of Physical & Natural Sciences
University of Papua New Guinea
Papua New Guinea

C O N T R I B U T O R S

Martin Bonou	Department of Petroleum & Energy
Chalapan Kaluwin	South Pacific Regional Environment Programme
Philip Kaupa	National Fisheries Authority
Idau Kopi	Department of Petroleum & Energy
Kevin Luana	National Weather Service
Gabriel Luluaki	Division of Environment Science, UPNG
Samuel Maiha	National Weather Service
Gerard Natera	Office of Environment & Conservation
Job Opu	Office of Environment & Conservation
Waine Pane	Biology Department, UPNG
James Sabi	Office of Environment & Conservation
Simon Saulei	Biology Department, UPNG
Graham Sem	South Pacific Regional Environment Programme
Sobi Wape	Division of Environment Science, UPNG
Barnabas Wilmot	Office of Environment & Conservation
Maino Virobo	Office of Environment & Conservation
Katrina Solien	Office of Environment & Conservation

A C K N O W L E D G M E N T S

The government of Papua New Guinea is appreciative and supportive of the initiatives taken by the PNG country team through the Office of Environment & Conservation in bringing together experienced nationals to work in an area of common interest and national importance. The teams collective inputs, part of which are contained in this document, serve to guide the future socio-economic development of our country. Of particular, in the areas that will directly or indirectly impact on the environment's ability to accommodate the effects of climate change. The government extends its sincere gratitude to Drs Chalapan Kaluwin and Graham Sem of SPREP, Dr T. Aung of the National Tidal Facility, Flinders University, South Australia, Mr James Ashton of Townsville, Australia and UNDP-GEF for their technical and financial assistance to the PNG Climate Change Assistance Project (PNGCCAP). Presented below are the list of members of both the Steering and Technical Committees and the Project Co-ordinators.

PNGCCAP Co-ordinators:	Dr Simon Saulei	University of Papua New Guinea
	Mr Kembi Watoka	Office of Environment & Conservation
Steering Committee Chairman	Dr Wari Iamo	Office of Environment & Conservation

Technical Committee
Chairman/Project Co-ordinator: Dr Simon Saulei
Mr Kembi Watoka

Members

Steering Committee		**Technical Committee**	
Name	**Organisation***	**Name**	**Organisation**
Michael Avosa	PNGNFA	Vitus Ambia	PNGNFA
Jaru Bisa	UNDP	Godfrey Angi	OEC
Martin Bonou	DPE	Martin Bonou	DPE
Tormod Burkey	UNDP	John Fagu	Shell (PNG)
Jorgen Jensen	UNDP	Paul Lakani	NFA
Roger Kara	DPM	Philip Kaupa	NFA
Philip Kaupa	NFA	Samuel Krimbu	WEI
Sakias Tameo	DFA	Paul Lakani	NFA
Ruth Turia	PNGNFA	Kevin Luana	NWS
The late Balthasar Wayi	DAL	Kas Magari	UPNG
		John Mukiu	UOT
		Titi Nagari	OEC
		Sam Nalish	PNGFRI
		Peter Noggor	Chevron Niugini
		Joshua Novulu	UOT
		Michael Siri	DAL
		David Timi	WEI

*The full details of the organisation abbreviations are as follows: DAL – Department of Agriculture & Livestock; DFA – Department of Foreign Affairs; DPE – Department of Petroleum & Energy; DPM – Department of Planning & Monitoring; NFA – National Fisheries Authority; NWS – National Weather Service; OEC – Office of Environment & Conservation; PNGNFA – Papua New Guinea National Forest Authority; PNGFRI – Papua New Guinea Forest Research Institute; UNDP – United Nations Development Programme; UOT – University of Technology UPNG – University of Papua New Guinea;; WEI – Wau Ecology Institute.

LIST OF ABBREVIATIONS AND ACRONYMS

ARM	Atmospheric Radiation Measurement
AusAID	Australian Agency for International Development
CH_4	Methane
CLICOM	Climate Computing
CO_2	Carbon Dioxide
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DAL	Department of Agriculture & Livestock
ELCOM	Papua New Guinea Electricity Commission
EMWIN	Emergency Managers Weather Information Network
ENSO	El Nino Southern Oscillation
EU	European Union
FAO	United Nations Food and Agriculture Organisation
FIM	Forest Inventory Mapping system
GCM	General Circulation Model
GDP	Gross Domestic Product
GEF	Global Environment Facility
Gg	Gigagrams
GHG	Greenhouse Gas
GovPNG	Government of Papua New Guinea
IOC	Intergovernmental Oceanic Commission
IPCC	Intergovernmental Panel on Climate Change
JICA	Japanese International Cooperation Agency
LDS	Lutheran Development Services
LPG	Liquefied Petroleum Gas
NARI	National Agriculture Research Institute
NGO	Non Government Organisation
N_2O	Nitrous Oxide
OEC	Office of Environment & Conservation
PCB	Polychlorinated Biphenyls
PNG	Papua New Guinea
PNGBioNET	Papua New Guinea Biodiversty Network
PNGCCAP	Papua New Guinea Climate Change Assistance Project
PNGFRI	Papua New Guinea Forest Research Institute
PNGNFA	Papua New Guinea National Forest Authority
PNGNWS	Papua New Guinea National Weather Service
PNGRIS	Papua New Guinea Resource Information System
SOI	Southern Oscillation Index
SOPAC	South Pacific Applied Geoscience Commission
SPC	Secretariat of the Pacific Community
SPREP	South Pacific Regional Environment Programme
TWP	Tropical Western Pacific
UNCED	United Nations Conference on Environment and Development
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations education, Scientific and Cultural Organisation
UNFCCC	United Nations Framework Convention Climate Change
UOT	University of Technology
UPNG	University of Papua New Guinea
WMO	World Meteorological Organisation
WPWP	Western Pacific Warm Pool

E X E C U T I V E S U M M A R Y

BACKGROUND

This Initial National Communication contains a series of activities implemented by the Government of Papua New Guinea (GoPNG) in consultation with communities and non-government organisations since 1998. The Office of the Environment and Conservation (OEC) was tasked to co-ordinate the implementation of the initiative with UNDP and the appointed Co-ordinator to manage the project. National country teams comprising both the Steering and Technical Committees were established with the support of government departments, universities, and assisted by the private sector and NGOs to complete the activities and reports under the Initial Communication.

Resources were identified from the government departments including a consultant from the University of Papua New Guinea (UPNG) and support from SPREP, enabling the compilation of field studies reports for the national greenhouse gas inventory for sinks and sources and assessment of vulnerability and adaptation to climate change, variability and sea level rise. The abatement analysis was conducted, but due to insufficient and unavailable of data, only an assessment of potential mitigative measures were carried out instead.

The completion of the PNG Initial National Communication is a product of the efforts of the national country teams and guidance provided by SPREP. Financial assistance was obtained through the Global Environment Facility (GEF) administered by UNDP and implemented through the OEC. In addition, the GoPNG co-financed this activity as part of its commitment to the UNFCCC obligations.

The Initial National Communication report contains the following chapters:

1. National Circumstances
2. National Inventory of Greenhouse Gases
3. Vulnerability Assessment and Adaptation Options
4. Mitigation Options
5. Systematic Observation and Research
6. Education, Training and Awareness
7. Projections, Policies and Plans

National Circumstances

PNG is a country rich in natural resources, people and culture. It has a relatively large land mass with high mountain ranges, islands and atolls, a large scattered population and a complex system of customary land tenure. The economy is largely dominated by exports and incomes from mining and petroleum, agriculture, forestry, fishing and, to a lesser extent, construction and transport sectors. The broadly distributed access to the natural resource base provides for the basic needs of people, but not necessarily real growth per person.

The rugged terrain, unique and rich biodiversity and range of environments, cultures, languages, and the legacies of former colonial powers have heavily influenced the process of change and development. Although biodiversity is outstanding with many species unique to PNG, much of the land and habitats have been modified by erosion and land clearing, resulting mainly from traditional agriculture systems and the harvesting of timber. Commercial logging is fairly widespread throughout all regions of the country with one million hectares already logged. About one fifth of the land in PNG is subject to inundation.

As an island surrounded by the vast Pacific Ocean and the adjacent large land masses of Australia and Asia, the climate and weather pattern of PNG is heavily influenced by excess heating due to its proximity to the equator. Likewise, the biannual east–west circulation of warm air masses, weather patterns of Australia and the variable topography of the country with high mountain ranges also has an influence. In recent times, surface temperatures have increased by about half a degree Celcius since the mid 70s, while rainfall has reduced in some areas by as much as 15%. Nevertheless, there is still a relatively clear regional pattern of distribution. Sea level changes of up to 30 mm per year have been directly related to El Nino Southern Oscillation (ENSO).

National Inventory for Greenhouse Gases

The PNG Inventory for GHG has been calculated starting from 1994 using the 1996 IPCC Guidelines provided to the country teams. While this is the first attempt to complete the GHG Inventory, there were some deficiencies in data collection and its appropriate format for land use changes and forestry, waste, agriculture and livestock sectors.

Due to the unique characteristics of PNG, the application of the IPCC methodology in certain sectors created some difficulties and modification of the guidelines took place.

The GHG emissions for PNG are:

- Carbon Dioxide 1,553.57Gg
- Methane 4.27Gg
- Nitrous Oxide 12.2 Gg

The results suggest that these are relatively small per capita emissions and therefore, any reductions of these levels are practically insignificant.

The results of this work has clearly identified the need for improvement in the IPCC Guidelines, (using of emission factors), collection of data for future GHG to centralised in the most appropriate institution, more education and training on understanding the GHG interactions between forestry, land use and soils.

Vulnerability Assessment and Adaptation Options

The natural environments of the country have developed a capacity over the years to adjust to human activity and changes to the climate. However, in the past few decades, the rapidly changing climate patterns, increasing population growth and intensity and levels of uses of natural ecosystems may affect the ability of these systems to respond to such change.

PNG has already been buffeted by extreme weather and climate events such as those brought about by the El Nino in 1997/98 with further changes in temperatures and sea level rise predicted over the next 100 years. These events will lead to inundation of low lying inland and coastal areas, including the atoll islands, bleaching and loss of coastal defences. Loss of wetlands, changes to the fisheries, forestry and agriculture sectors, alteration to water resources and land use practices and impacts on health, particularly vector borne diseases such as Malaria other related water and air borne disease are also expected.

In general, the range of adaptation strategies to minimise and adjust to the impacts of climate change do not need extensive new interventions, but rather by enhancing current practices. However, the ability of the country to adapt to climate change is a function of a range of institutional, technological and cultural factors, which will need a fundamental shift attributed to the importance of sound management practices and mainstreaming of environmental considerations at planning and policy levels.

Mitigation Options for Energy, Transport, Forestry and Waste

The GHG inventory results underline the importance for the government to give priority attention for reducing the emission of greenhouse gases from the following sectors: energy, transport, forestry and waste to achieve economic and environment sustainability. The need for promoting renewable sources of energy, review current mitigation policies, create subsidies for transport systems and increase awareness and education are some important options. Table 4.1 provides a wide range of important mitigation options for the country to closely examine and develop appropriate program of actions.

Systematic Observations and Research

Reducing the uncertainty of science, impacts, adaptation and mitigation options of climate change is a challenge, especially when the country is already dealing with the presence of climate variability, sea level rise and extreme events.

The need for national research institutions in collaboration with international organisations to deal with any surprises that climate change, coupled with climate variability would impact on the economy, environment and people should be encouraged.

Education, Training and Awareness

While, literacy levels and the educational status of people is fairly low, training to increase the competency, skills and knowledge of people has been a priority for successive governments. These include using new scientific methodologies and techniques to calculate GHG emissions from sinks and sources from various sectors, assessing climate change vulnerabilities and adaptation options and raising community awareness on the impacts of climate change and variability. Training institutions from UPNG, University of Technology (UOT), University of Waikato in New Zealand, National Tidal Facility, Flinders University, South Australia and SPREP can contribute positively to capacity building in this area.

The climate change, variability and extreme events have potential impacts on the socio-economic and environmental well-being of the nation and its people. However, in the area of awareness, capacity building and human resources development to address this area in an integrated approach has not been well address and therefore, must be given priority.

Educational institutions need to incorporate climate change, variability and sea level rise into their curriculum and should be given a priority with appropriate financial support.

PROJECTIONS, POLICIES AND PLANS

The current legislative base of PNG provides for environmental planning measures and codes of practice to be included as an integral part of project planning for developments with significant environmental risk. The OEC provides policy advice and technical advisory support for the sustainable development of key sectors such as coastal and marine ecosystems, water resources, agriculture and forestry; health and fisheries, while implementation of policy measures has been devolved to the provinces. Increased efforts are needed to strengthen the capacity of local institutions and communities in dealing with climate change impacts. This will require more effective systems and networks of extracting and sharing resources and experiences within and between communities, towns and provinces.

CONCLUSION

The time to act to reduce the vulnerability of PNG is now. As such action will go a long way toward reducing the magnitude of problems that may be brought about by climate change and human activities on the environment in the future. The challenge will be to convince people of such potential impacts and start adapting and mitigating long before the anticipated impacts occur. This will require making adjustments to current development practices, whilst trading off some short term economic gains, without over capitalizing or investing in high cost or badly conceived solutions.

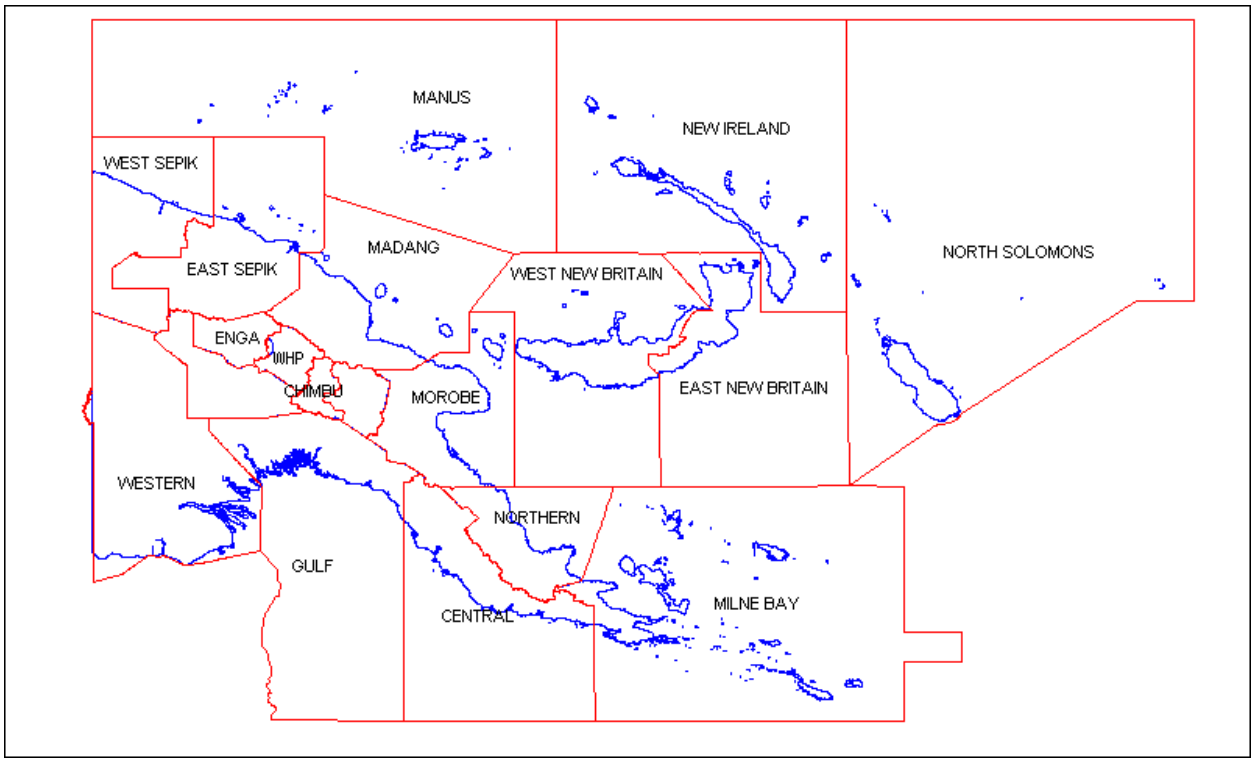
CHAPTER 1

NATIONAL CIRCUMSTANCES

BACKGROUND

Papua New Guinea occupies the eastern half of the island of New Guinea; sharing a border with the Indonesian province of West Papua (formerly Irian Jaya) to the west, Australia to the south, the Solomon Islands to the east and the Federated States of Micronesia to the north. Figure 1.1 depicts the mainland PNG and the surrounding islands demarcated into the 19 provinces.

Figure 1.1 Map of Papua New Guinea & Provinces



It has four large islands (Manus, New Ireland, New Britain and Bougainville) and some 600 smaller islands, most of which are located to the east. It is a country rich in natural resources with gold, copper, agricultural products, and recently oil and natural gas. It is also a country of considerable biodiversity, which is estimated to comprise between 5-7% of the global biodiversity and also regional variations on most cultural, geographical and developmental dimensions. However, as a small economy, sustainable development is heavily influenced by local, provincial, national and international agendas. Table 1.1 shows some key statistics of the country's national circumstances.

GEOGRAPHY

Papua New Guinea is a unique country in many ways. The main land has one of the most rugged terrains in the world. There is a central mountain range which is highly dissected, with the highest peak rising to 4,350 m (Mt. Wilhelm) and smaller islands include high volcanic mountains and low lying coral atolls. Types of environments range from mountain glaciers to humid tropical rainforests, swampy wetlands to pristine coral reefs. Much of the terrain is

characterized by steep gradients, fast flowing rivers, swamps, with some parts of the country subject to active volcanic activities, landslides and tidal waves.

The total land area is 465,000 km^2 and the exclusive economic zone is 2.4 million km^2. The country's Exclusive Economic Zone encompasses 17,000 kilometers of coastline and almost 2000 coastal villages, with a rural population of nearly 500,000 people. Communities in PNG have developed more than 800 languages as well as unique customs and traditions, in part due to isolation resulting from the country's rugged terrain.

Table 1.1: Summary information on Papua New Guinea National Circumstances in 1994

Criteria	**1994**
Population	3.8 million
Land area (km^2)	4673,000
GDP (US$)	860.00
GDP per capita (US$)	820.00
Share of industry in GDP (%)	40.1
Share of services in GDP (%)	33.8
Share of agriculture in GDP (%)	26.1
Land area used for agriculture purposes (hectares)	6 million
Urban population as percentage of total population	16
Livestock population	23 million
Forest area (km^2)	36,420
Life expectancy at birth (years)	55
Literacy rate	52

Ninety seven percent of the country's total land area is held by customary landowners, giving them considerable and unique rights governing extraction of resources and compensation claims. Only about 0.1% of the land area is classified as arable and 84% is forested, although much of this is inaccessible. Given the difficult terrain, the diverse cultural heritage, including a complex customary system of land tenure, the several tiers of government and the shortage of skilled manpower, environmental and climate change management is highly complex.

HISTORY

No one knows exactly when man first set foot in PNG, but evidence of his early presence has been found at a number of locations throughout the country. Archeological evidences have indicated that the early occupants of the country came some 40,000-50,000 years ago and were initially hunters and gathers until some 9,000 years ago when they settled and practiced agriculture. The communities were isolated from each other and the outside world for a number of centuries until the sixteenth century when the Europeans began their explorations and colonization programmes. No actual colonization of PNG commenced until 1884 when the Germans claimed sovereignty over the northern part of the country, and four years later the

British claimed the southern part and governed them as two separate colonies: German New Guinea and British Papua.

At the end of the First World War in 1919, Australia took over the administration of both colonies as the Trust Territories of Papua and New Guinea under the mandate of the League of Nations. In 1942 when the Second World War came to the Pacific, the Japanese took over the northern Territory of New Guinea until the end of the war when Australia again took control. Australia continued its administration of both territories until 1973 when the two territories became united and gained self-government. In 1975 Papua New Guinea gained political independence from Australia.

The overall picture of change in PNG since independence is one of a gradual broadening of a small, fragmented economy, based on natural resource production. Today, after 25 years of self rule, the major pressures being exerted on the environment are accelerated population growth and the extraction of natural resources to provide for the physical and growing needs of the country.

The progression from an economy based on complex farming and subsistence systems to a formal capitalistic economy over the last 100 years has seen rapid change throughout many parts of the country.

CLIMATE AND WEATHER

INFLUENCE OF CLIMATE AND WEATHER ON PAPUA NEW GUINEA.

The oceans and land masses surrounding the country are the key determinants of its weather and climate. Key factors, in order of significance, are:

(i) Excess heating due to incoming solar radiation at the equator where the ocean-atmosphere interactions provide the favorable moisture source for abundant precipitation typical of tropical environments.

(ii) Year to year variability of the tropical east- west or walker circulation. PNG lies at the heart of the region where the warm air rises and flows eastwards in the upper troposphere to subside in the eastern pacific high pressure system and then westwards in the surface layers across the tropical pacific ocean. In so called El Niño years this pattern is disrupted, the central and eastern pacific warm ("warm pool") and the main area of ascent associated with cloud and high rainfall moves to the central Pacific.

(iii) Location, just north of the Australian continent. Despite its tropical location and expected deep tropical weather, the south coasts of the mainland are actually dry over the period corresponding to the Southern Hemisphere winter.

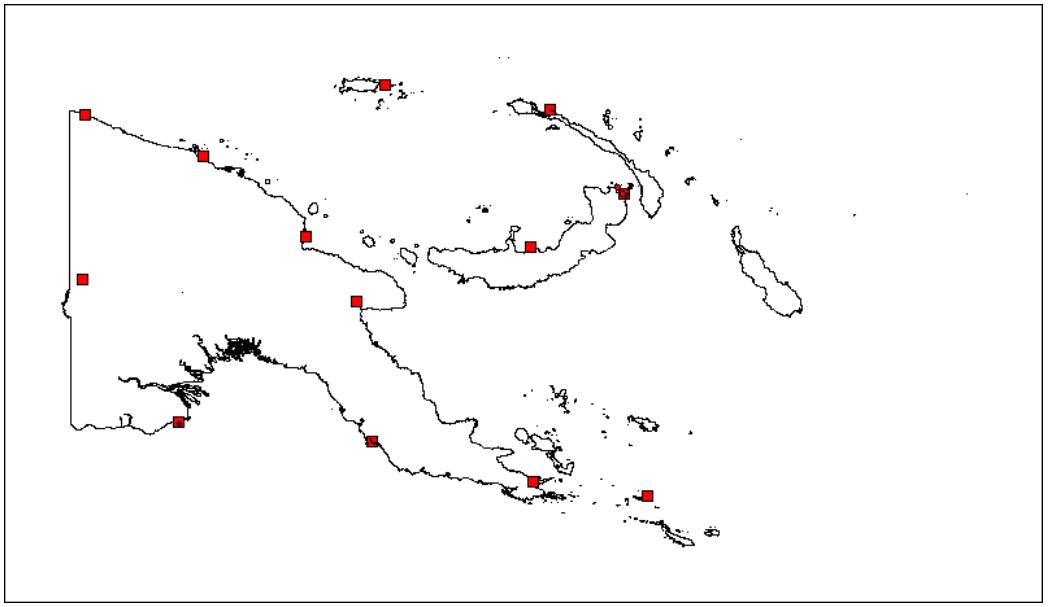
The prevailing southeast trade winds during the months June to October act as a medium for dry air movement responsible for dry conditions over this period. The influence of this southeast trade winds gradually fade towards the equator where deep tropical weather dominates. Over the remaining months from December – April, which correspond to the southern summer, the major influences are the northwest monsoons originating in Asia. This airflow transports moist humid air and provides abundant moisture over the whole country, thereby enhancing precipitation over this period. Coupled with the warm sea surfaces of the Southern Hemisphere during the period and other factors, this is also the cyclone season. In between the two seasons are months where the wind regimes are less dominant. These are referred to as transitional months, such as the

month of May immediately after the North West monsoon season and the months of October and November just preceding the North West monsoon season or just after the south east season.

(iv) Topography including the orientation of major mountain ranges. The main island of New Guinea lies in the west/east direction, while most of the ranges are aligned in a NW/SE direction. Periodic diurnal shifts in the wind direction may therefore have a real potential to alter the rainfall pattern of any given location.

The Papua New Guinea Weather Service (PNGNWS) is mandated to collect and archive data on weather, climate change, variability and sea level rise for research, predictions, marine forecasts and economic applications. There are 13 established meteorological observation stations network around the country staffed with a total of 95 professional and technical officers (plus support staff). The stations include: Port Moresby, Daru, Kiunga, Gurney (Milne Bay), Misima (Milne Bay) Nadzap (Lae), Madang, Vanimo, Momotee (Manus), Kavieng, Tokua (Rabaul), Wewak and Hoskins (see Figure 1.2 below). Port Moresby is the headquarters of the National Weather Services under the Ministry of Civil Aviation. All the data and information on weather, climate variability, change and sea level is quality controlled, and archived in the PNGNWS climate database.

Figure 1.2 National Meteorological Network (Source: NWS)



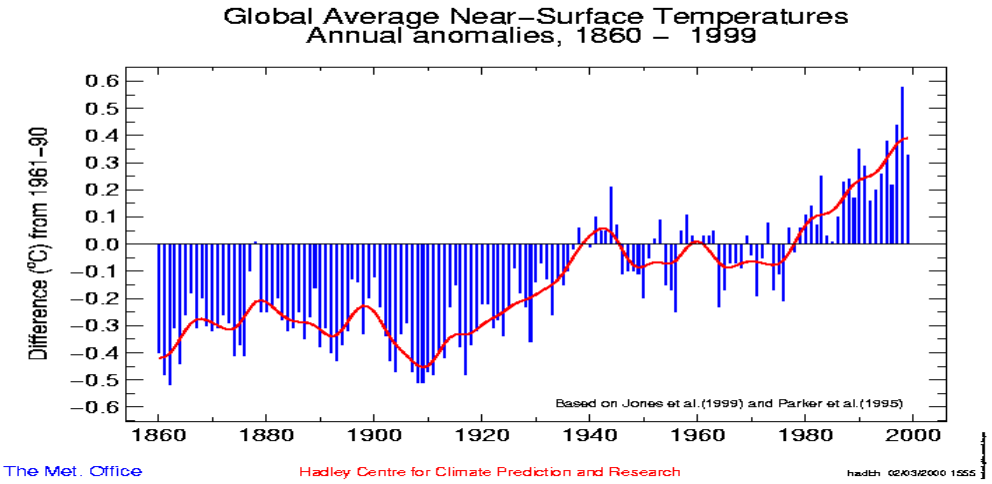
COUNTRY AND PROVINCIAL CLIMATE TRENDS

The PNGNWS existing network is 90% aviation oriented. The data and information from the network provide some understanding of the climate and weather from the atoll islands, to coastal provinces and into the hinterlands. Due to limited data from the highlands region, the temperature and precipitation patterns have been derived by extrapolating data from the southern Papuan coasts. Furthermore, there is a popular consensus that the potential climate variability and any changes in climate being sought in PNG are predominantly related to the ENSO phenomenon.

TEMPERATURE

Global average surface temperature analyses indicated that the weather and climate was changing all over the world (see Figure 1.3 IPCC, 1995), and that the issue needed more research to improve the understanding on the science of climate change, variability and sea level rise. This meant that the individual countries, like PNG needs to address this global challenge.

Figure 1.3: Global Average Surface Temperatures (Source: IPCC, 1995)



WEATHER AND CLIMATE TRENDS

TEMPERATURE

Continuous records of maximum and minimum temperature in PNG date back to 1962, although Port Moresby's records began in 1939. The earliest available continuous records of temperature in Port Moresby date back to 1945. Thereafter, other stations with continuous records began to emerge, hence the assumed country representative temperature pattern. Figures 1.4a, b and c illustrate some of these continuous recording trends in the country.

Figure 1.4a: Temperature trends in Papua New Guinea (Source: NWS)

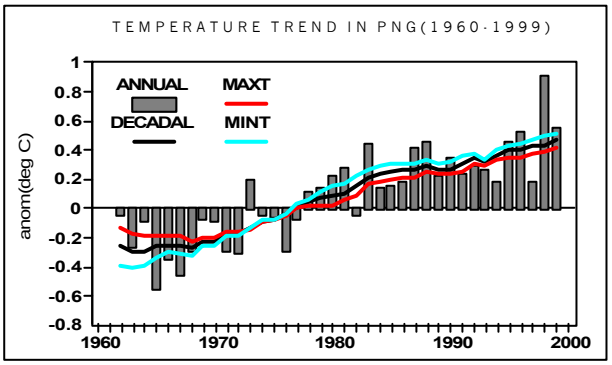


Figure 1.4b: Temperature trend in Port Moresby (Source: NWS)

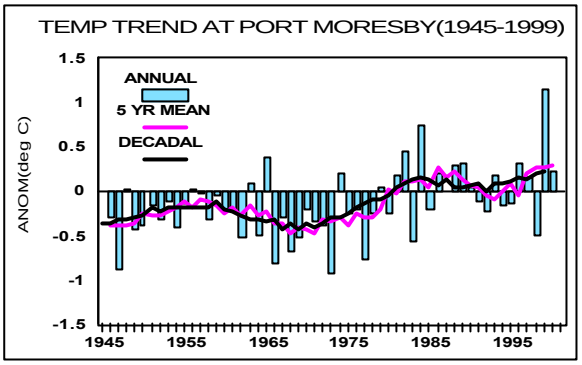
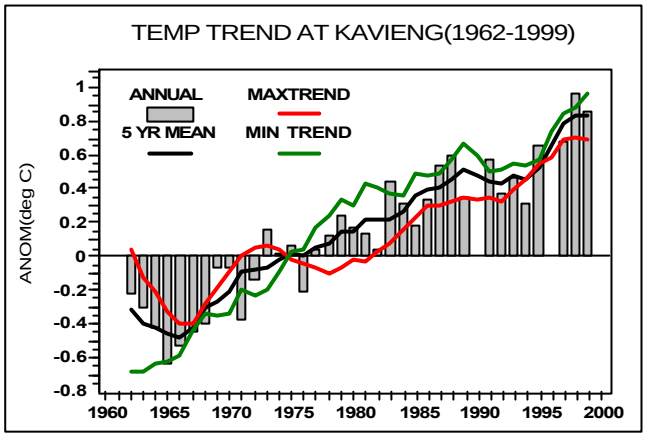


Figure 1.4c: Temperature trend in Kavieng (Source: NWS)



In general, the rate of mean near surface temperatures warming have been relatively slower over the southern relatively higher latitude region (0.25ºC) since the mid 70s compared to the tropical region (0.45ºC) as represented by the Momote trend in Manus Province. Overall observed near surface temperature trend (0.50ºC) resembles both the global and tropical Asian trend, with an overall error of +/- 0 .15ºC.

RAINFALL

The earliest records of rainfall data for PNG date back to about 1875. Four stations operated by the PNGNWS with the longest and highest quality data (PNG standard) are used in the analyses. Seasonal analysis was done to determine the seasonal trends of the south coasts, which have distinct wet and dry seasons and at the equatorial stations of Momote (Manus) and Kavieng (see Figures 1.5a,b,c and d).

Figure 1.5a. Overall Rainfall trend in Papua New Guinea since 1957 (Source: NWS)

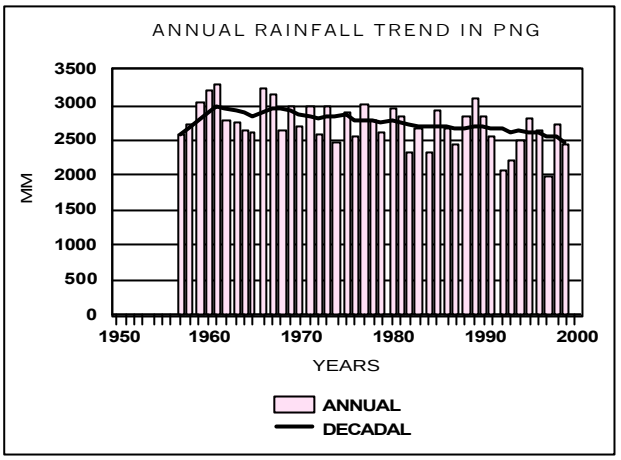


Figure 1.5b. Rainfall Trend at Port Moresby (Source: NWS)

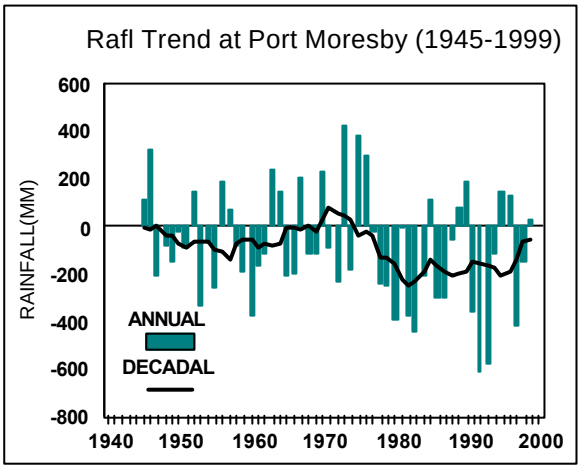


Figure 1.5c: Rainfall trend at Momote, Manus Island (Source: NWS)

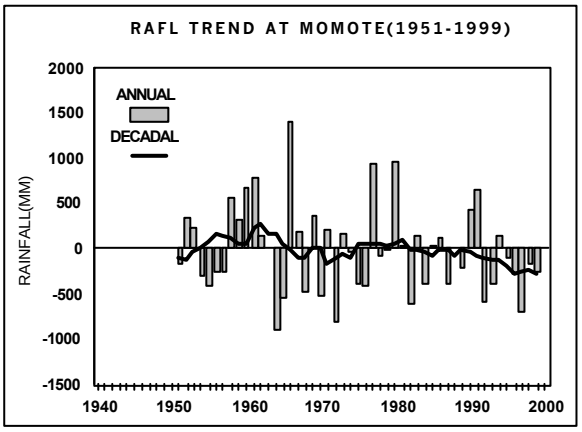
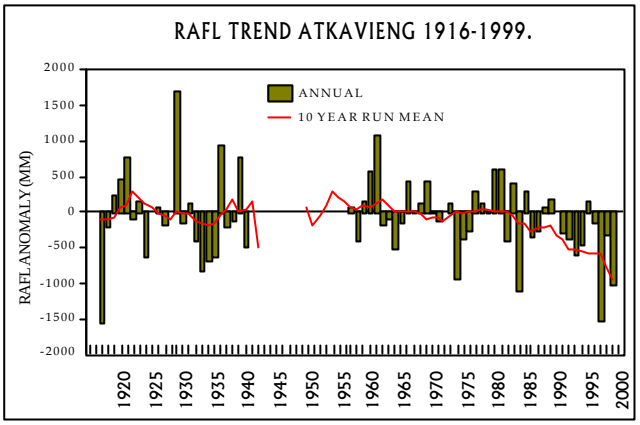


Figure 1.5d: Rainfall trend at Kavieng (Source: NWS)



Individual stations show some long-term variability. For example, the Port Moresby trend appears to indicate a possible 25-30 year rainfall variability but the length of the records doesn't allow for any definite conclusions. The overall annual precipitation trend shows significant rainfall reduction in PNG over the last 30 years and appears to disregard the variability signals inferred by individual stations.

All the individual stations consistently show decreasing rainfall trends since about the early to mid 70's, but none more so than the capital city whose rainfall has been reduced by up to 15% since 1975. However, discontinuous records have not permitted the determination of any conclusive precipitation trends in PNG in recent years.

RAINFALL VARIABILITY

Since the recordings began up to 1973, it was suggested that PNG possesses a remarkably reliable rainfall data. One measure of this was illustrated by mapping the coefficient of variation of annual rainfall for a 15-year standard period. This coefficient of variation expresses the standard deviation of annual rainfall as a percentage of the mean. The map showed that virtually the whole of the country had coefficients of less than 20% and that there was a clear regional pattern in their distribution. The central highlands and the Sepik plains had very low variability of less than 15%, while most of the island, coastal and lowland areas did not exceed 20%. The only exceptions where higher values are being experienced are observed in southeast New Britain and around Daru and eastern Papuan Islands.

The conclusions reached seemed to be related to the prevailing phase in overall rainfall pattern. A further 25 years on, it seems that there has actually been an increase in the variability. Nevertheless, the previous assertion on the remarkably reliable nature of PNG's rainfall still holds. Furthermore, it may be that the wet season rainfall could be increasing was reasonable, although the increasing phase has since ended in the mid 80's.'From current trends it may be inferred that the country is entering another increasing phase of wet season rainfall over the Port Moresby Region (see Figures 1.6a and b).

Figure 1.6a: Dry season rainfall trend at Port Moresby (Source: NWS)

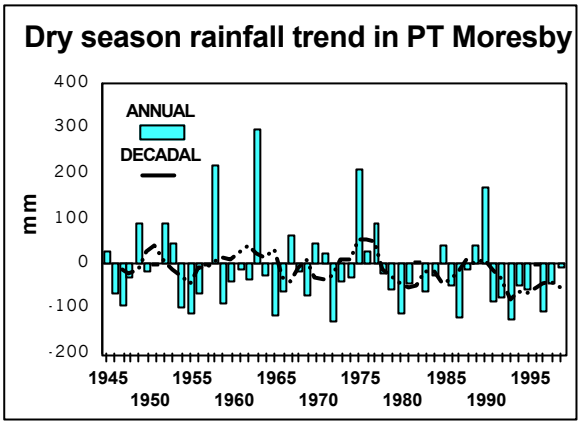
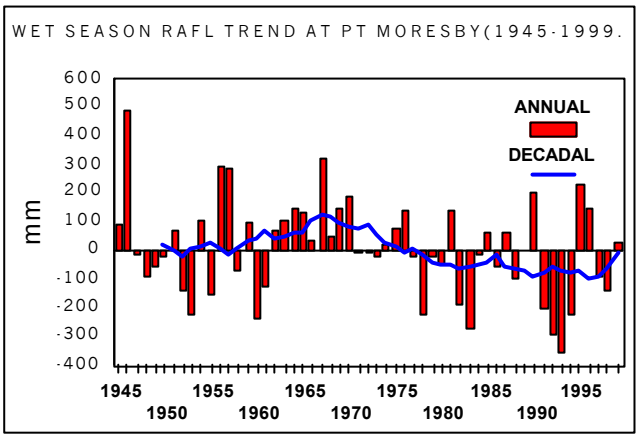


Figure 1.6b: Wet season rainfall trend at Port Moresby (Source: NWS)



SEA LEVEL RISE

A number of tide gauges installed by the Australian government are located in Manus (Lombrum Habour), East New Britain (Rabaul), Madang and Milne Bay (Alotau) Provinces and have been maintained and serviced by National Tidal Facility, in Adelaide, South Australia. Sea level trends data collected from these stations range between 5-15 years. Impacts of ENSO on relative sea level changes are significant ranging from 20-30 mm per year during the 1994/98 period.

Much of the variability in precipitation patterns in the country correlates very well with the ENSO phenomenon. Similar correlations are obvious with the short-term variations in sea level. In particular, the warming and cooling phases, which are associated with anomalous decreases and increases in sea level respectively. Observations of variations in the positive phase of dry seasonal rainfall trends showing weaker and fewer La Niña episodes infer reduced ENSO inputs into the sea level rise in PNG.

Tsunami and earthquakes are also important signals in the region that have influenced and impacted on sea level rise and water levels in most coastal and island provinces. The 1998 tsunami and earthquakes in the country generated large waves and storm surges that devastated the Aitape and Rabual coastal areas and islands displacing many coastal communities and causing loss of lives.

ENSO AND CLIMATE VARIABILITY

By far the most important mechanism of climate and sea level variability in Papua New Guinea is related to the ENSO phenomenon. Effects of the southern oscillation of both mean sea level pressure and the sea surface temperatures show a definite correlation between the SOI and the rainfall patterns of the southern Papuan coasts in particular. The correlation gradually fades towards the equator with equatorial regions precipitation patterns showing marked relationships only during the stronger phases of ENSO.

LA NINA

Current climate variability in PNG dry seasonal trends exhibit weakening La Niña episodes and possibly turning into weak El Niño episodes, increasing the chances of drier than normal conditions. The trend in the wet season months however, exhibits an increasing trend since about 1998, although long term data sets are needed to ascertain this assumed trend.

DROUGHT/FROSTS

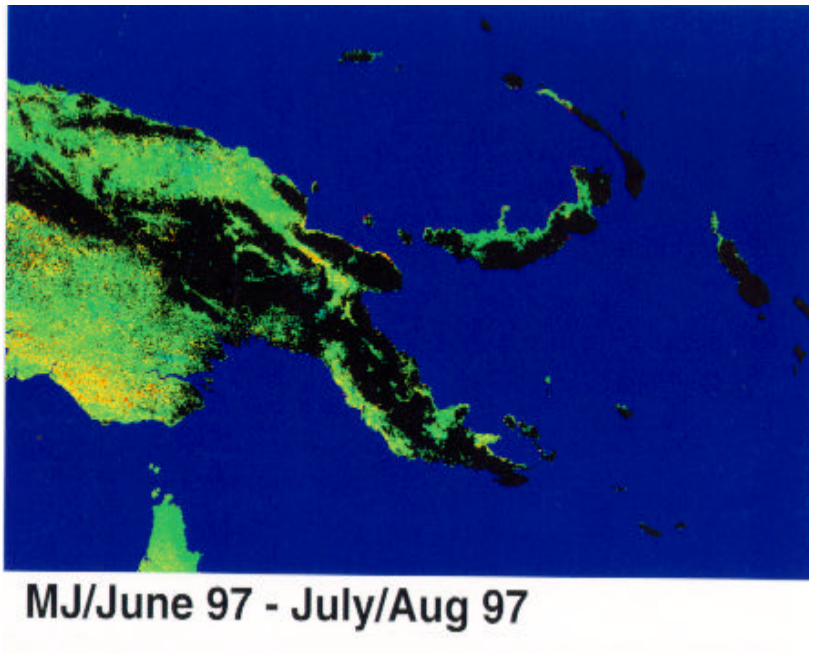
Drought and frosts are generally common occurrence in the highlands of PNG and have significant impact on the economic and environment sectors. The influence of ENSO in catalysing the development of frost and droughts in the country is quite evident as shown by the 1997/98 prolonged drought (see Figure 1.7a,b and c).

CYCLONES

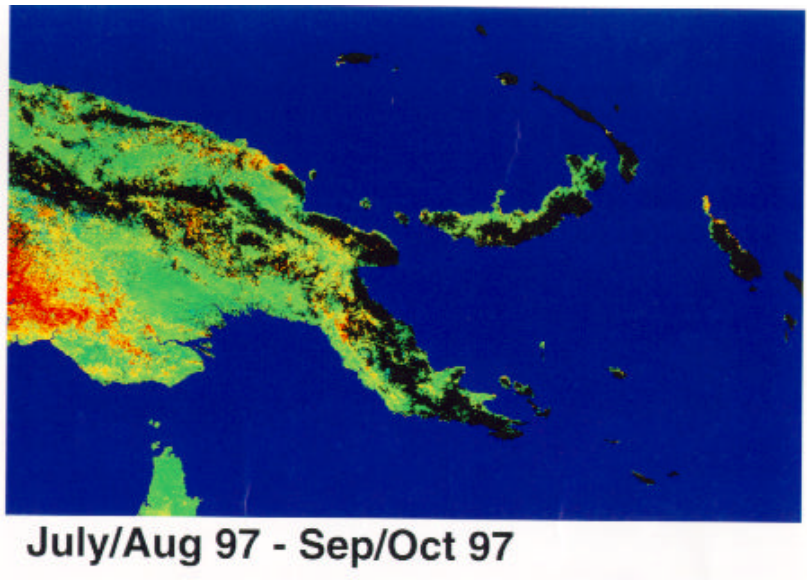
PNG lies just outside of the main Tropical Cyclone belt within the Southwest Pacific region. On average, tropical cyclones hits the country at the rate of about one cyclone per year. Despite PNG being a relatively free area from the cyclo-genesis compared to other neighboring areas in the region, there is a far higher probability of tropical cyclones forming outside and tracking into the country.

Figure 1.7a,b and c. Progressive recordings of the impact of the 1997/98 drought in PNG (Source: CSIRO)

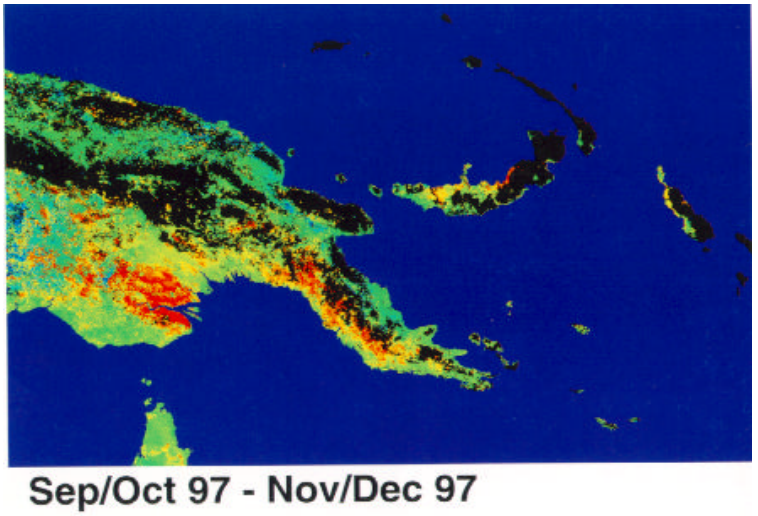
(a)



(b)



(c)



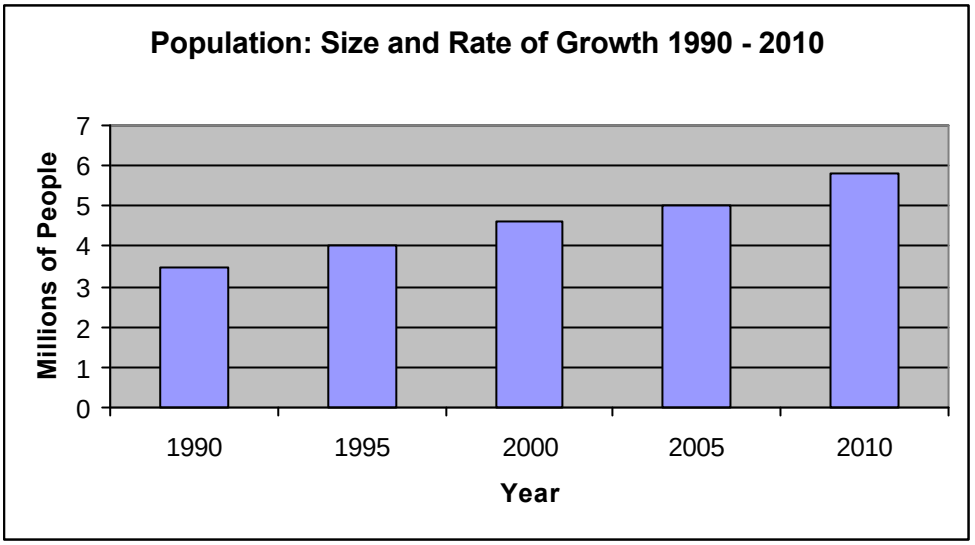
On the research front a lot more effort remains to ascertain the most appropriate conditions for cyclo -genesis within Papua New Guinea's potential prone areas. Until recently, increased probability of cyclo-genesis with cool La Nina episodes was the assumption, whilst the rationale for the late evolution in notable cases (Tropical Cyclone Aivu in May 1989) remain to be fully understood. The scenario over the previous two tropical cyclone seasons (1998/99 and 1999/00) where no tropical cyclones neither formed within nor tracked into Papua New Guinea's potential prone areas, underlines the urgent need in the country for tropical cyclone research.

POPULATION AND WELFARE

PNG has an estimated population of 3.8 million in 1994, with a population growth rate of 2.4%, and an estimated density of 8.6 persons per km^2. This relatively low population density masks pockets of high density areas, especially in the highlands and some parts of the islands provinces. At this rate of increase, the population is estimated to double every 30 years (see Figure 1.8).

The population is very young with 42% under the age of 15. According to the 1994 estimates, life expectancy is 58 years, infant mortality is 62 per 1000 live births, with an adult literacy rate of 52% and the completion rate of primary school of only 59%. However, the poverty levels in the country is considerably higher than in the neighboring Pacific countries with 35% of the population falling below the poverty line, while 94% of the poor are rural based.

Figure 1.8 Population: Size and Rate of Growth 1990 – 2010 (GovPNG)



EDUCATION AND TRAINING

High levels of literacy and strong commitment to education are solid prerequisites for mobilization of national resources. People need to have the knowledge, skills and confidence to take part in decision making. This right is embodied in the country's constitution. However, despite substantial investment in education, the educational status of the population is comparatively low.

Throughout PNG there are 2,510 community primary and 26 International Education Agency schools providing education for about 450,000 students. Secondary education is provided by 4 national high schools for a period of 2 years. Only about 50% of the primary students reached secondary schools and only about 1% of age eligible students enter grade 11. There is also a shortage of teachers and inadequate facility and financial resources. The cost of providing elementary and secondary education is three times those of other countries in the region, while that of university education is seven times higher.

Government and churches run six universities in the country. The student population of these institutions totals about 6,000 students annually. Non formal education policies have also been developed to provide support for churches, NGOs and community organizations involved in pre schools, adult literacy classes and general awareness programs. Distance education has been established for sometimes now and is providing significant contributions to non-formal education.

Training to increase the competency, skills and knowledge of the population has tended to be ad hoc, despite government policy in this area. At present, most employer agencies in the private and public sectors are required to plan, develop, conduct, monitor and evaluate their own training programs and activities.

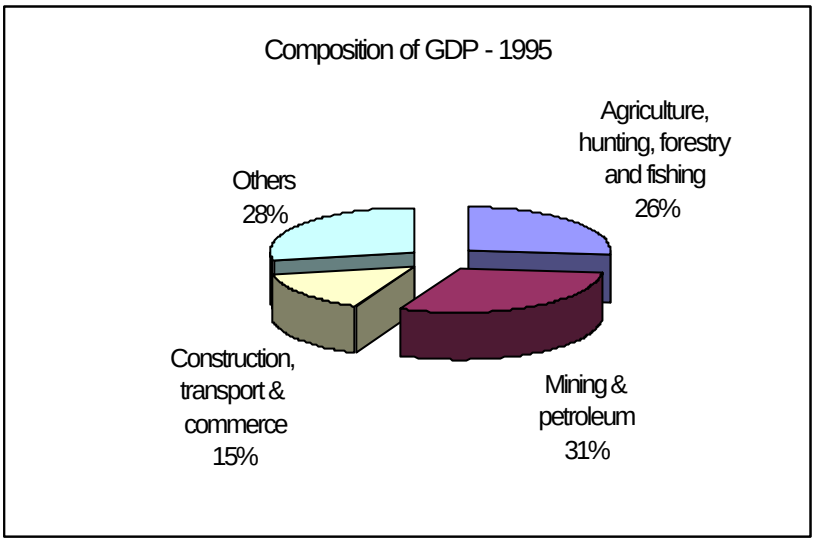
THE ECONOMY

The economy is highly dualistic in nature. On the one hand, the relatively high per capita GDP is associated with the exports and incomes generated from minerals and petroleum sectors and the contribution of aid (see figure 1.9). On the other hand, the broadly distributed access to the

natural resource base provides the basic needs of people, but not necessarily real growth per person.

Economic and social progress must be measured against the numerous constraints associated with the history and geography of the nation. Significant economic events over the past decades have placed heavy demands on economic management by the government. The steady but, moderate growth of the mid 1980s was followed by a negative growth in the early 1990s as a result of the closure of the Bougainvillea copper mine and the collapsing of the agricultural tree crop prices.

Figure 1.9: Composition of GDP by Industry in 1995 (GovPNG, 1996)



The rich natural resources, traditional culture values and generous aid have all appeared to contribute to the development of community attitudes and a socio political system, which unduly emphasize the distribution of income and wealth rather than their generation. About 85% of the population, those in the transitory phase between the subsistence and cash economy, have a per capita income of less than one third of those in the urban sector. Only 10% of the population is employed in the formal wage sector, although the potential work force is expanding at the rate of about 50,000 from school leavers each year, of which only a small proportion would be expected to find work.

From 2000 onwards, substantially increased contributions are anticipated for agriculture, forestry and fisheries sectors. Both agriculture and small micro-scale enterprise developments may provide the best prospects for large-scale employment creation in the country.

AGRICULTURE

Agriculture is the mainstay of the PNG economy, accounting for approximately 30% of GDP and around 13% of total export earnings. Land currently set aside for food and cash crop production in the country accounts for about 30% of the country's total land area. Land suitability for tree crops, arable agriculture, pasture and irrigated rice is shown in Table 12. Land currently in the food production cycle amounts to 30,000 km^2 or 6.6% of total land area.

Cash crops such as copra, coffee, cocoa, rubber and oil palm, as well as subsistence agriculture, based on root crops, sustain about 85% of the population. Surplus production is sold mainly in local markets, but also in distant, domestic markets. Large amounts of vegetables and fruits are

produced in the Highlands, but inadequate transport and marketing infrastructure limit the supply to high populated urban centers. Also, these crops are highly perishable and suffer from variable product quality, resulting in high post harvest losses.

Table 1.2: Land suitability for tree crops, arable agriculture, pasture and irrigated rice.

Land Use	Very High		Very High to High		Very High to Moderate	
	Km²	%	Km²	%	Km²	%
Tree Crops	7790	1.7	15460	3.3	66950	11.9
Arable	4960	1.1	21890	4.7	44220	9.4
Pasture	14710	3.1	29710	6.3	67290	14.3
Rice	11890	2.5	37980	8.1	61360	13.1

Around 8% of the farmers are wholly dependent on subsistence food production for survival. Subsistence agriculture accounts for about 45% of total agricultural outputs and has the potential to absorb new entrants to the labor force, provided that the social status is raised to make it more vocationally attractive.

LAND USE CHANGE

Almost 97% of land in PNG is customary land, owned either by individuals or under some form of clan ownership. Unfortunately, traditional landowners with short-term cash needs and desire for development through the sale of timber have often outweighed the long term needs for conserving their resources for future generations.

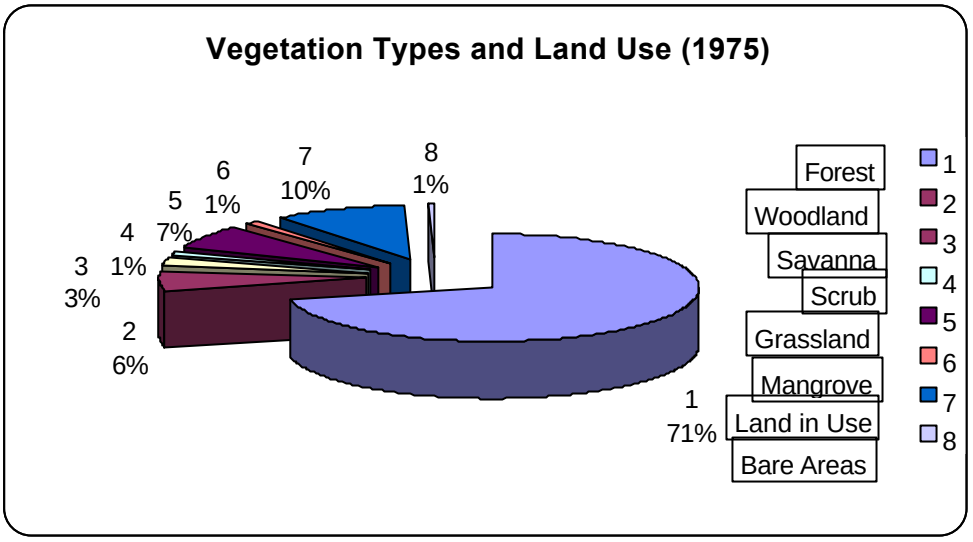
Some six million hectares are used in the rotational gardening cycle. The practice of bush fallow cultivation leads to very complex patterns of gardens and vegetation regrowths. Commonly, five to fifteen years of fallow will elapse before the regrowth is cleared for further food production. Land cleared and utilized continuously or where the period of fallow is shortened for the recovery of its previous condition may lead to soil erosion.

Of the country's total land area, approximately 470,000 km^2 or about 58% is subjected to strong or severe erosion. Further, 18% is permanently inundated or regularly flooded. Up to 200,000 hectares are cleared annually for traditional agriculture. Between 1975 and 1996, nearly 8% of the forested areas were logged, with a further 3% subjected to other forms of clearing, resulting in permanent conversion of the forested areas to other land uses.

FORESTRY

There are at least five main forest types that dominate PNG landscape. These include the lowland plains, lowland hills, lower montane forests, dry evergreen and swamp forests. Figure 1.10 provides a summary of the main types of vegetation cover and land use in 1975.

Figure 1.10: Vegetation Types and Land Use in 1975 (Source: PNGRIS)



Forest reserves cover over 36 million hectares or approximately 70% of the country's total land area. The sustainable harvest volume of available natural forest has been estimated at 3 million cubic metres per annum, assuming a 40-year cutting cycle. Commercial logging for exports is fairly widespread throughout all regions. Approximately 15 million hectares of the forests are accessible with one million hectares already logged. From 2000 onwards, the volume of log exports is forecast to be around 1.8 to 2 million cubic metres.

Forestry is largely a foreign dominated industry and sustainable yield management will require careful application and monitoring of a range of legislation and policy. Forestry operations can threaten the livelihoods of the rural residents through loss of well-developed road systems, causing soil erosion, contaminating water supplies and loss of non-timber resources. Table 1.3 provides an overview of the main factors influencing forest loss in PNG. There are also associated social problems that have emerged, despite agreements between the loggers and landowners, which typically require the loggers to pay royalties to landowners and build infrastructure such as roads, schools and rural health clinics.

FISH RESOURCES

The fisheries resources of PNG are made up of a wide variety of lagoons, reefs, deep slopes, pelagics, and bottom species. Formal employment in the fisheries sector amounts to 1000 people. However, until 1997 when it was made mandatory to complete log books, the vast bulk, both by volume and value, of fish caught in PNG waters were not landed in the country, or recorded as export, while those who catch them are not taxed on the profits they make.

Table 1.3: Main factors influencing forest loss

Forest Type	Main Factors
Mangroves and Swamp Forest	Fuelwood collection, logging, clearance, cyclones
Coastal Forest	Cash crops, portable saw mills, cyclones, introduced species
Lowland Forest	Cash crops, shifting agriculture, logging, portable sawmills, cyclones, introduced species
Semi-deciduous forest	Agriculture, fire, cyclones, introduced species
Upland Forest	Shifting agriculture, sawmills, cyclones and landslides

The export earnings from fishery products amount to about 1% of all total exports. Prawns, barramundi, lobster and high value sedimentary species dominate the commercial landings of the K12 million in annual fishery exports. The prawns, crayfish, bech-de-mer are already fished at or above sustainable levels. There are number of small-scale commercial exploitations of giant (Tridacna) clams, green snails, trochus, pearl oyster and bech-de-mer.

While fishing is widespread, much of it is used for local consumption. There are approximately 4000 part time artisinal fishermen. However, with no proper storage or readily available transport networks the immediate prospects for expanding the artisinal fishing are limited.

The majority of marine-based fisheries is located on the coast and offshore waters, while inland fisheries are mainly based on aquaculture and capture fisheries utilising more simple gear along the rivers, lakes and oxbow lakes.

Since fresh water fish diversity is relatively very low and poor, the Fisheries Authority has been prompted to embark on a programme for introducing and restocking certain areas of the fresh water bodies with exotic species to enhance stocks.

Subsistence based farming of common carp in the highlands and various inland areas of coastal provinces, like Menyamya in the Morobe Province and East New Britain. There are more than 1000 carp farmers and there is also interest in rainbow trout farming aiming at commercial venture.

Japanese International Cooperation Agency (JICA) has been very instrumental in promoting carp farming to alleviate low protein intake in the inland areas with Non-Government Organizations (NGOs) involving directly with the farmers like the Lutheran Development Services (LDS).

Tuna is the main offshore resource. Although the present annual harvest of over 250,000 tonnes is quite large, research programs have indicated that catches of three times this quantity are sustainable. Unfortunately, benefits to PNG are restricted to approximately K16 million in license fees. Additional benefits to the country would accrue if the policy to gradually localise the foreign investment proceeds, more onshore processing occurs and catches are increased to maximum sustainable levels, as specified under the UN framework Convention on Highly Migratory Fish Stocks, of which Papua New Guinea is a party.

COASTAL RESOURCES

PNG supports a plethora of coastal habitats, resources and environments including deltaic flood plains, estuaries, tidal flats, mangroves, beaches near shore environments such as bays, lagoons, sea grass beds, coral reefs and the offshore environment.

Of particular regional significance are the extensive and well developed mangrove systems. In PNG there some 37 species of mangroves belonging to 20 different genera, which are associated with the major river systems throughout the country. The most extensive of these occur along the southwest coast associated with the Fly, Kikori and Purari River systems. Apart from benefits such as opportunities for research, education, recreation and tourism development, mangroves provide a variety of products of direct use to the local people including firewood, building materials and medicines. Further, the mangrove forests are also important as major breeding grounds for fishes.

While specific clan groups tend to own the land, in many areas, outside groups are free to go and collect coastal resources. Consequently, large tracts of mangrove forests have been cut down to make gardens and used for firewood. Opening up of mangrove canopies has resulted in the establishment of short, stunted forms of some species.

Coral reefs in Papua New Guinea cover a total area of 40,000 km^2. For the most part, the coral reefs are relatively unaffected by human activities, but this largely reflects the country's dispersed and relatively isolated population as well as a lack of material development. Important anthropogenic threats to PNG reefs are considered to be unsustainable fishing, including both overexploitation and destructive practices; sediment mobilization as a result of deforestation from forestry, agriculture, and other activities, as well as population increase and urbanization. Localized threats include industrial pollution, oil spills, port development, land reclamation, and ship groundings.

NON RENEWABLE RESOURCES

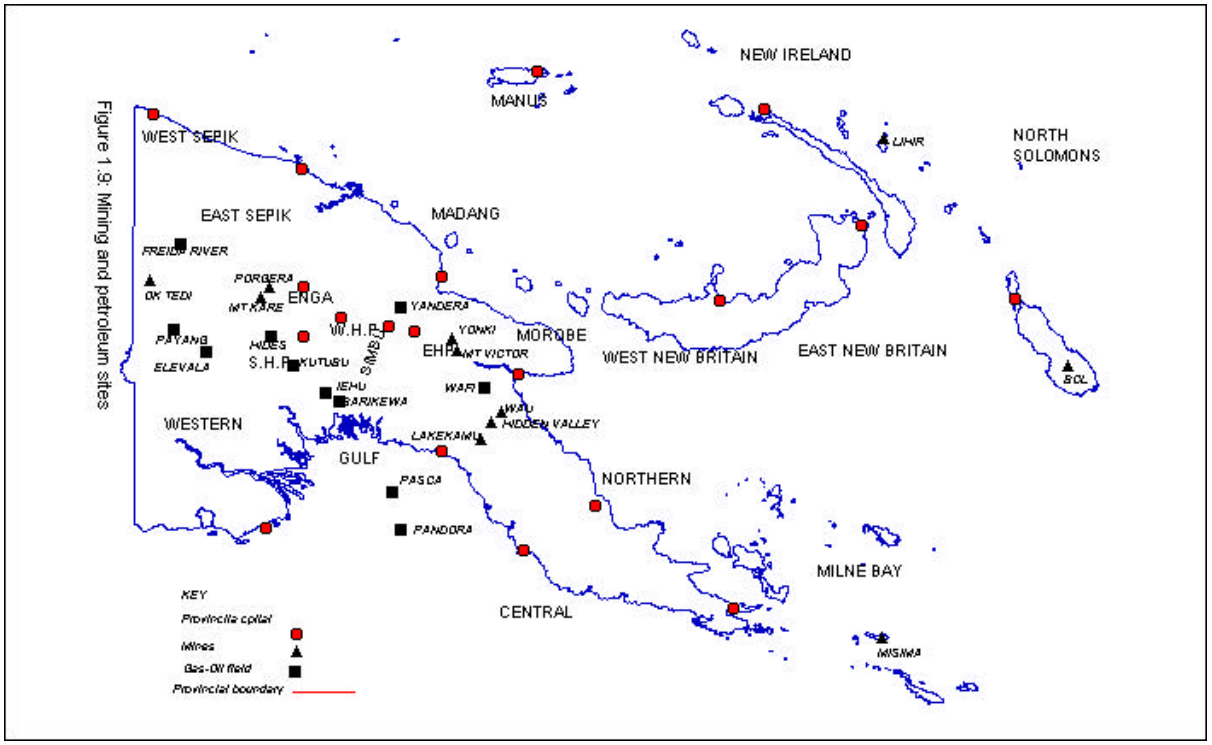
Both mining and petroleum sectors generate about K1 billion for the economy. Major mining and petroleum sites are shown in Figure 1.10. The OK Tedi Mine is the major source of PNG's mineral resources and contributes around 50% of country's total export earnings and also generates substantial internal revenue and spin off commercial activities. Previously, the production of copper and gold from the Panguna Mine on Bougainville Island and Porgera mine in Enga Province on the mainland have also contributed significantly to PNG economy and balance of trade. The mining industry, especially for gold and copper production, is expected to be the largest contributor to economic growth in the coming years.

Oil and gas industry is extremely capital intensive, a conundrum arising because of the economies of scale. From 2000 onwards, petroleum production, already at around 30 million barrels, is expected to fall over the long term, as the capacity of existing oil fields is depleted.

A number of gas projects are currently being implemented, including the pipeline to North Queensland, which will have a significant impact on Papua New Guinea's macro economy.

The provision under the Mining Act 1972, which stipulates that all gold and minerals in or under any land in the country are the property of the state is proving to be very problemic, especially when such lands are under customary ownership. Further, mining has weak links with the rest of the economy and the benefits to individual landowners and the rest of the population is not always realised.

Figure 1.11: Mining and Petroleum sites of Papua New Guinea (GovPNG, 1996)



ENERGY

Since independence, there has been little progress in the development of any real capacity in the energy sector to plan and systemically develop a stable supply of energy for the country. PNG is currently heavily dependent on fossil fuels, with petroleum products accounting for an estimated 60% of its primary energy consumption. Renewable energy, mostly hydro electricity, is estimated to contribute less than 40% of the country's energy use.

The use of fossil fuels in the country is mostly in power generation and transportation. While transportation is totally dependent on it, power generation is heavily weighted towards it too. The share of fossil fuel and renewable energy in the country's power generation is 60 and 40% respectively.

It is estimated that electricity comprises only 24 % of the total energy use in PNG. Interestingly, 46 % of this electricity is used in the capital city of Port Moresby. Annual consumption of electrical energy has rapidly increased over the years mainly due to: i) an increase in the number of customers from industrial to household sectors; and ii) an increase in average consumption per customer.

The principal use of primary energy source in the country includes the following:

i. Electricity generation

The use of hydro (run by rivers) backed up with standby diesel is commonly used in the provinces and mining sectors. In addition, co-generation (use of agricultural products; e.g. oil palm and sugar cane) are important, but are relatively small in size.

ii. Transport sector

Transport accounts for approximately 60% of all imported liquid fuels into the country for domestic consumption. Air and water transport uses approximately 20 to 10 % respectively for all transport fuels. However, road transport is a major user of imported fuels, especially petrol followed by diesel. Use of ethanol mixed with gasoline is a potential for future research.

iii. Industrial Heating/Cooling

Most electricity is used for air conditioning and refrigeration for all industrial, commercial services and government institutions. In crop drying industries, especially copra, tea and coffee there is a major swing from diesel to wood for the drying process. It has been estimated that approximately 6 million litres of diesel has been reduced in terms of importing fuels for such uses.

iv. Domestic Heating/Cooling

Electric hot water heating (solar) accounts for 40% of typical large residential users' total energy requirements. Solar generated electricity from the sun is now becoming available and affordable in the country, especially for rural and urban areas for lighting, cooking and other household applications. Wood is a principal cooking fuel for the low income households in both rural and urban areas of the provinces. Development of the charcoal industry was promising in 1981, but now has limited application in the rural areas. Kerosene consumption grew sharply in the 1970s and is still an important energy source for cooking and lighting, especially in the rural areas.

TOURISM

The tourism industry is poorly developed, even though the country offers spectacular diving sites, rainforest, ecotourism opportunities, scenery, wildlife, and a diversity of cultures. In 1993, Papua New Guinea attracted about 14,000 tourists, compared with Fiji's 300,000 tourists. Approximately, 30,000 PNG residents travel overseas as tourists annually. The main focused markets for tourism in PNG are Australia, Europe, USA and Japan. Tourism tends to be more concentrated in the urban centers, although ecotourism ventures have been set up in the more remote and isolated rural areas.

TRANSPORT

Transport services rely heavily on roads, inter island and coastal shipping for freight transport, and on air transport for long distance passenger movements. There is no railway. Developments in the transport infrastructure are largely attributed to mining and government policies.

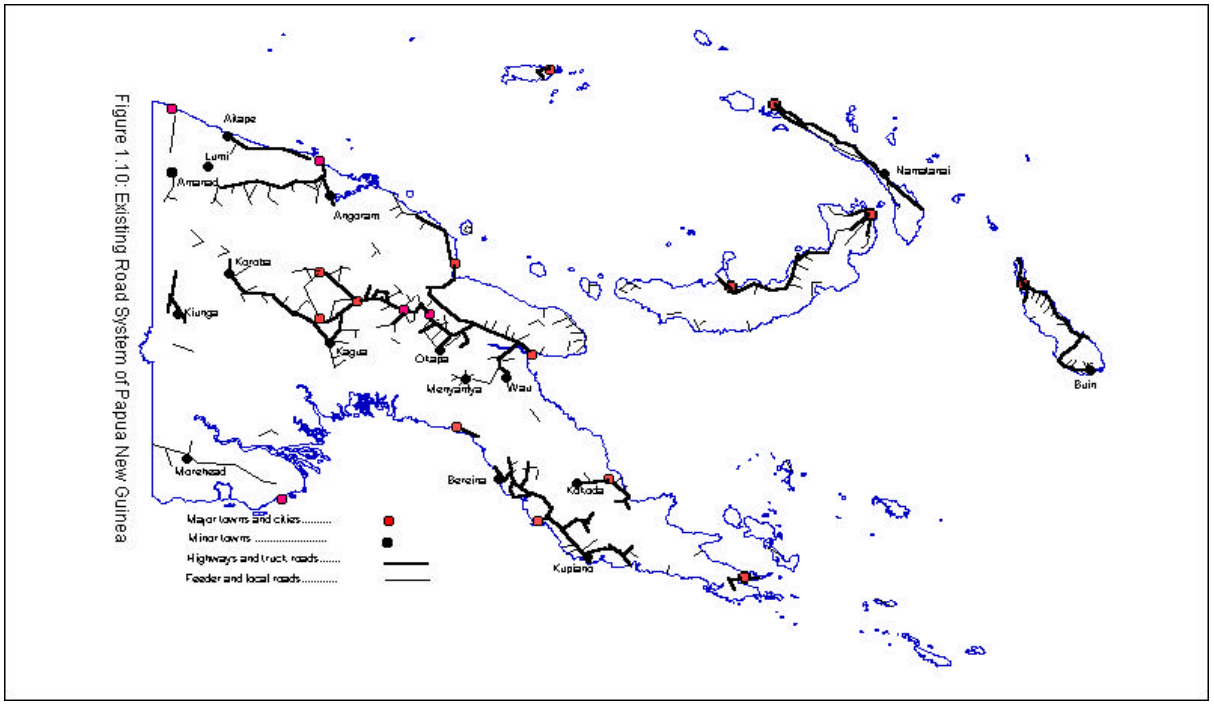
Currently, there are about 25,000 kilometers of road in the country, out of which the national and provincial roads cover about 7,000 kilometers (see Figure 1.11). For the many small, dispersed and isolated population centers, the difficult terrain has severely constrained the provision of road based services, especially to rural areas of the country. Such constraints are of major concern to the government and it's people since the opportunities for selling agriculture surpluses domestically depend crucially on access to markets, the worthiness of the roads being all weathered and costs being at reasonable levels.

BIODIVERSITY

The environments and biota of PNG are extremely rich, diverse and unique. It is estimated that the country probably harbors between 5 - 7% of the worlds' biodiversity, which is remarkable given that the land mass of Papua New Guinea is less than 1% of the worlds' total land area.

The country's biota has biogeographic similarities to West Papua, the Solomon Islands, and northern Australia. The island is large enough to host many centers of endemism with more than 6,789 endemic species of plants and animals, the largest of any Pacific island.

Figure 1.12: Existing road system of PNG.



The flora and fauna is distinctive, with predominately Indo-Malayan ties, but also showing strong Australian affinity owing to its Pleistocene land connections. On a regional level, three biogeographical provinces can be distinguished, namely: New Guinea, Bismarck Archipelago and the Solomon Islands.

Major vegetation types include coastal vegetation, mangrove forests, grasslands, swamps, Savannah, monsoon forests, lowland tropical forests, lower montane forests, upper montane forests, subalpine forests and alpine vegetation. The whole of New Guinea, of which PNG is a part, has 1,465 plant genera. Floristic diversity is highest in the lowland rainforests and decreases with increasing altitude. Globally important centers of plant diversity include the Kiunga region, Mount Wilhelm, Owen Stanley ranges and Bowutu Mountains. Of these sites, only Mount Wilhelm is within a protected area network. Most threatened plants identified to date are those endemic to the country. A summary of PNG biodiversity is provided in Table 1.4.

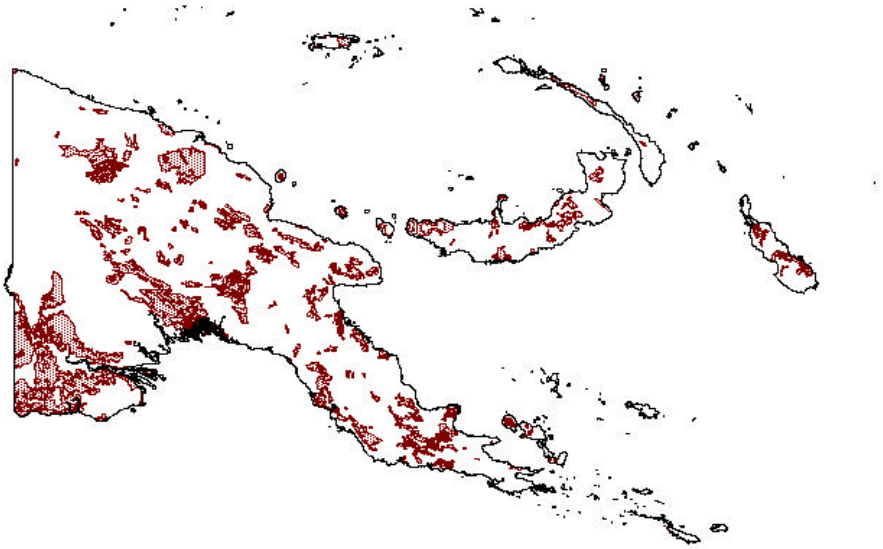
In general, the number of species of fauna diminishes with increasing altitude. However, between 500 and 1000m altitude, with variable topography and precipitation, diversity increases. Avifauna is particularly rich, with a total of 740 species recorded for PNG, of which 76 species are endemic. They include the worlds smallest and some of the worlds largest parrots, the largest pigeons, all of the world's three species of cassowaries, and more than two thirds of the known birds of paradise.

Table 1.4: Species Richness of Key Biota

Group	Status
Viruses, Bacteria and Algae	Poorly documented
Fungi	2,390 species listed
Protozoans	Terrestrial Protozoans almost entirely unstudied
Plants	Vascular plants include 15,000 to 20,000 species of ferns and flowering plants. Orchids are particularly diverse with well over 3000 species.
Invertebrates	300 species of coral identified. Very high species richness of sea pens, nudibranchs and crustacea. 300,000 species of insects estimated.
Fish	More than 3000 fishes in the region, including over 300 found in freshwater.
Amphibians	Frogs well represented with about 197 species described.
Reptiles	13 species of turtles and tortoises, approximately 195 species of lizards, 98 species of snakes and 2 species of crocodiles.
Birds	A total of 762 species of birds recorded of which 405 are endemic.
Seagrass	50 species of seagrass recorded.
Mammals	Relatively impoverished although 71 species of marsupials, 2 species of monotremes and 75 species of bats have been recorded from the New Guinea area.

The estuarine and coastal environments are endowed with dugong, whales, dolphins, birds, turtles, crocodile, fish and many invertebrate species such as molluscs, echinoderms and crustaceans. To date, about 300 species of coral and well over 3,000 species of marine fishes, have been identified. The species richness of sea pens, nudibranchs and crustaceans may be the highest in the world. By contrast, the freshwater fauna is poor, but fish, crayfish, turtles and crocodiles are important components in the lower and middle reaches of rivers and some lakes.

Figure 1.13. Biodiversity Priority Areas (Source: PNG Biorap)



Information on the rate and intensity of decline of natural resources is scanty. Many organisms, particularly marine, live in environments that are difficult to access and those organisms that have been collected have yet to be subjected to modern taxonomic analyses. Consequently, the knowledge of biodiversity in the country is limited. Recent work has also indicated that much of the country has yet to be explored in terms of the biodiversity. Figure 1.13 shows the biodiversity priority areas , which have yet to be determined.

CHAPTER 2

NATIONAL INVENTORY OF GREENHOUSE GASES

INTRODUCTION

One of the cornerstones of the UNFCCC is the commitment by all Parties to take the necessary steps and measures to reduce GHG emissions (Article 2). This is further strengthened by the commitment of all Parties to submit to the Conference of the Parties national inventories of anthropogenic emissions of GHG sources and sinks (Article 4). The main objective of the GHG inventory is to identify and evaluate the anthropogenic emissions of GHGs and to critically review and draw lessons from the initial inventory experience. Particular reference is directed towards the design, implementation and improvement of future inventories as well as interventions that may be necessary for GHG abatement over the long term.

INVENTORY PROCESS

The Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories was used to undertake the inventory and a "reference approach" was followed. It is based on the information sought from a number of sources from government, non-government and private sectors. The data were collected by a team of national experts, who have been trained on the inventory methodology. The inventory covers emissions of carbon dioxide (CO_2), Methane (CH_4) and oxides of nitrogen (N_2O) as guided by Decision 10/CP.2. The reference year for these inventories is 1994.

For PNG the inventory only covers four of the six categories of emission sources and sinks, namely, energy, industrial processes, land use and agriculture. There is no existing methodology for estimating emissions from solvents and other product use and therefore were left out of the inventory. Limited data are available for emissions and removals from land use change and forestry and waste and thus being left out of the inventory. The reported emission figures thus should be taken as “work in progress” since only three categories of emissions are reported here. Table 2.1 provides a summary of the results of the GHG inventory on the four sources of GHG emissions.

Table 2.1 Greenhouse gas inventory summary for 1994. All data are presented in gigagrams (Gg).

Greenhouse Gas Source/sink categories	**CO_2**	**CH_4**	**N_2O**
All Energy	947.57	X	X
Industrial Processes	193.0	X	X
Agriculture		4.27	12.20
Land Use Change & Forestry	413.0	X	X
Totals	**1,553.57**	**4.27**	**12.20**

The results indicate that carbon dioxide is the most dominant GHG with a calculated value of 1,553.57Gg followed by nitrous oxide with a value of 12.20 Gg and methane with 4.27Gg. However, the results also reflect an underestimation of the emissions of GHGs in PNG.

DATA GAPS

There exists serious data gaps in emissions inventory and these are discussed in this section. Not all energy sources have been accounted for in this inventory, which only covered liquid fuels. Emissions from waste, land-use change and forestry and solvents need to be included in the inventory so that comprehensive emissions total can be obtained. Agriculture emissions mainly focused on domestic livestock, but no attempt has been made to estimate emissions from soil cultivation and from burning of forests and grasslands, since there are no data from such sources or if available were not accessible.

Given these limitations with the data the inventory as presented can only be regarded as "work-in-progress". It is therefore anticipated that the next inventory for the second national communication will be much improved by addressing these data gaps. The estimation of emissions and removals from land use change and forestry will be critical due to its potential for offsetting GHG emissions from other categories of sources.

GREENHOUSE GASES

Petroleum is a major export earner for the country and at the same time PNG continues to import fossil fuel to meet its energy requirements. Natural gas reserves have been identified and large potential for its financial gains with the large emissions of carbon dioxide is expected. The main source of fuel combustion is derived from energy and transformation industries, transport, and residential sectors.

As indicated in the Table 2.1, the focus of the GHG inventory centred on Carbon Dioxide ($C0_2$), Methane (CH_4) and Nitrous Oxide (N_20).

SOURCES OF DATA

Table 2.2 provides the information on the ministries and departments, private institutions, non-government organisations which provided time, resources and data to the Climate Change Country Team to enable them to calculate the GHG gas emissions levels in each of the sectors. The data and information used to complete the PNG GHG Inventory were collected from each sector and verified before recorded.

ORGANISATION

The National Inventory has been organised into four parts corresponding to the four major source sections as described in the IPCC Guidelines (1996). Due to lack of data collected for these two major sections namely; emissions from soil cultivation (agriculture) and from burning of forests and grasslands and solvents and other product use, no emission estimates have been determined. In addition, there is no methodology available as yet to calculate the emissions from the solvents and other product use.

The IPCC Guidelines (1996) are:

Energy Activities

- Fuel combustion activities
- Fugitive emissions
- Memo items (international bunkers)

Industrial Processes

Solvent and other Products Use

Agriculture

- Enteric fermentation
- Manure management
- Agriculture soils

Land use Change and Forestry

- Managed lands
- Grassland conversion
- Managed Forestry
- Clearing Forestry

Waste

- Solid waste disposal on land
- Waste water handling.

Table 2.2 Sources of Data

Source of data	Type of data collected
Ministry of Forestry	Land-use, vegetation/forestry, maps, statistics
Ministry for Civil Aviation (National Weather Office)	Climate variability, extreme events, rainfall, models
Ministry of Mining	Statistics on mining
Ministry for Petroleum & Energy	Statistics on fossil fuels and energy
Ministry for Agriculture and Livestock	Maps on land-use, climate monitoring research, livestock and agriculture data sets
Ministry for Fisheries	Marine research programmes, fish catch data, economic information, coral reefs, marine and fisheries management policies
Office of the Environment and Conservation	Water and waste data and research. Maps of terrestrial and marine resources (biodiversity). Map info database and environmental Policies.
Ministry of Transport	Shipping and transportation database and policies. Information of use of fossil fuels by marine sectors.
University of Papua New Guinea and University of Technology	Data base on forestry and waste/pollution and research opportunities on mining, water, fisheries, forestry and modeling of scenarios.
Electricity Commission (ELCOM)	Data on types of energy used in the country, pricing and technology information.
National Forestry Institute	Data and research information on national forestry programmes. Growth rates and mitigation options identified.
World Wild Fund and Nature Conservancy (NGOs)	Data base on marine biodiversity and forestry activities and research.

UNCERTAINTY AND LIMITATIONS OF EMISSION ESTIMATES.

The uncertainties and limitations as per IPCC Guidelines will be covered in this chapter.

EMISSIONS

ENERGY

Carbon dioxide emissions for PNG were mostly derived from the liquid fossil fuel-petroleum. Table 2.3 shows $C0_2$ emission from the main liquid types.

Table 2.3. Sectoral $C0_2$ (Gg) emission based on fuel types

Fuel Type	Carbon Dioxide emission (Gg $C0_2$)
Crude Oil	0.00
Orimulsion	0.00
Natural Gas liquids	0.03
Gasoline	138.20
Jet Kerosene	0.00
Other Kerosene	120.00
Gas/Diesel Oil	575.67
Residual fuel oil	0.00
LPG	7.44
Lubricants	0.00
Other oil	105.39
Total	**947.57**

The total amount of GHG for the energy sector was 947.57Gg from carbon dioxide ($C0_2$) representing approximately 61% of total GHG emissions. Of these liquid fuels gas, diesil, oil and gasiline and other Kerosene, are major sources of carbon dioxide emissions in PNG.

POWER GENERATION.

PNG has become increasingly dependent on commercial energy in the past decades. Commercial energy consumption (especially petroleum products) grew from 44% in 1970s to 62% in 1980 and continues to grow at a steady rate. The increase in oil consumption was due mainly to use of oil for power generation and continuous operation of the gas turbines in Port Moresby. However, the planned gas project between Australia and PNG to commence after 2002 and a gas line to Port Moresby for industrial use/power generation may have significant reduction on oil consumption for power generation in the country

TRANSPORT

During 1981 transport accounted for 59% of all imported liquid fuels into the country for domestic consumption. Air and water transport used 20% and 11% respectively for all transport

fuels. It has been estimated that these figures have risen to 25 % and 15% for both sectors. Road transport is the major user of imported fuels, especially. Petrol is the major source of imported fuel used by road transport followed by diesel.

Attempts to collect data from the responsible ministries and line departments proved difficult.

MEMO ITEMS

INTERNATIONAL BUNKERS

International bunkering for the GHG from international marine and aviation is important for the country to note and understand for future international reporting. Two major suppliers and distributers of gas/diesel/jet gas in the country; Shell (PNG) and Mobil, have access to these important data and information. However, these have not been included in this national calculation.

AGRICULTURE

Agriculture is the main economic backbone of PNG accounting for 13% of total export earnings. Land currently set aside for food and cash crop production in the country accounts for about 30% of the total land area. Land suitability for tree crops, arable agriculture, pasture and irrigated rice is important (see Table 1.2). Land currently under food production cycle amounts to 30,000 km^2 or 6.6% of total land area.

Cash crops such as copra, coffee, cocoa, rubber and oil palm, as well as subsistence agriculture, based on root crops, sustain about 85% of the population. Large amounts of vegetables and fruits are produced in the Highlands, but inadequate transport and marketing infrastructure limit the supply to the larger populace urban centers. These crops are highly perishable and suffer from variable product quality, and high post harvest losses.

Around 8 % of the farmers are wholly dependent on subsistence food production for survival. Subsistence agriculture accounts for about 45% of total agricultural output and has the potential to absorb new entrants to the labor force, providing that the social status is raised to make it more vocationally attractive.

Livestock mainly pigs, cattle, poultry, goats, horses and sheep are raised in the country mainly for national and domestic use mainly. There are more than four large private companies involved in poultry ventures. The Department of Agriculture's National Agriculture Research Institute (NARI) and FAO are the main institutions involved in agricultural research initiatives in the country.

Methane levels are relatively low compared to some countries of similar size in the Pacific region. The results in Table 2.4 show emissions of methane from the range of animals farmed in the country. The Climate Team believes that the total CH_4 emissions are of low value, but this do not reflection a true picture of the PNG's potential. Some difficulties were encountered in collecting data from the most important departments, this included the data not being centralised. Many institutions around the country were involved in data collections, but the information were not in the correct format for the GHG Inventory studies.

Table 2.4: Methane emission from Livestock

Livestock type	Population (000s)	Emission Factor Manure Fermentation	Emission from Manure Management	CH_4 Emission(Gg) Total
Poultry	20	0.018	0.361.0	0.0004
Dairy cattle	0.589	33	19.40	0.06
sheep	3.116	0.21	0.65	0.02
Non-dairy	62.88	7	440.16	3.77
Swine	19.072	20	381.44	0.4
Total				**4.27**

LAND USE CHANGE

Almost 97% of PNG is customary land, owned either by individuals or under some form of clan ownership. Thus for any economic activities to be sustained must involve some form of partnership with traditional landowners. Approximately 6 million hectares are used in the rotational gardening cycle. The practice of bush fallow cultivation leads to very complex patterns of gardens and vegetation regrowths. Commonly, five to fifteen years of fallow will elapse before the regrowth is cleared for further food production. Land cleared and utilized continuously has lead to soil degradation.

Fifty-eight percent of the total area of the country is subject to strong or severe erosion. Further, 18% is permanently inundated or regularly flooded. Up to 200,000 hectares are cleared annually for traditional agriculture systems. Between 1975 and 1996, nearly 8% of the forest areas were logged with a further 3% being subjected to other forms of clearing, resulting in permanent conversion of the forested areas to other land uses.

The determination of the GHG emission from landuse changes is not fully understood in the country, especially for evaluating nitrogen and methane gas emissions interactions between land/soil and forestry or agriculture. More work is required to adequately cover this area for the next national communication.

FORESTRY

There are at least five main forest types that dominate PNG's landscape. These include lowland plains, lowland hills, lower montane forests, dry evergreen and swamp forests. Figure 1.10 provides a summary of the main types of vegetation cover and land use in 1975. Approximately 75% of the country is forested, of which more than half is on steep land.

Forest reserves cover over 36 million hectares or approximately 70% of the country's total land area. The sustainable harvest volume of available natural forest has been estimated at 3 million cubic metres per annum, assuming a 40-year cutting cycle. Approximately 15 million hectares of the forests are accessible with one million hectares already logged. From 2000 onwards, the volume of log exports is forecast to be in the vicinity of 1.8 to 2 million cubic metres.

Forestry operations can threaten the livelihoods of the rural residents through loss of well developed road systems, causing soil erosion and contaminating water supplies, as well as loss of non timber resources (see Figure 1.10).

During the 60's and 70s major forest research activities were focussed on managed forest programmes, especially for potential plantation species. To date relatively little forest plantation research has been carried out due mainly to financial constraints and the shift on emphasis towards natural forest management.

Approximately 59,000 ha plantation forest has been established in the country, of which 33% comprises of exotic species-principally *Pinus* and *Eucaplytus*. Of these, the government owns 11,000 ha, mainly the coniferous plantations at Wau and Bulolo areas in the Morobe Province.

Table 2.5 provides an assessment of the Carbon uptake from the changes in the plantation sector. The total Carbon uptake is calculated at 112,546.68 ktc, with an estimated annual removal of 413. 0 Gg.

Table 2.5: Carbon uptake by forests.

Plantations	Area (kha)	Annual Growth Rate (tdm/ha)	Annual Biomass Increment (ktdm)	Carbon Fraction of Dry Matter	Total Carbon Uptake Increment (ktc)
Acacia spp	1.699	15	25.49	0.5	12.24
Eucalyptus spp.	4.61	14.5	66.85	0.5	33.42
Tectona grandis	3.052	8	24.42	0.5	12.21
Pinus spp.	6.536	11.5	75.16	0.5	37.58
Pinus caribaea	-	10	-		-
Mixed Hardwoods	1.527	6.8	10.38	0.5	5.19
Mixed Fast Growing Hardwoods	10.56	12.5	132.00	0.5	66.00
Mixed Softwoods	6.545	14.5	94.90	0.5	47.45
Other Forests (Moist)	32002.7	6.8	217,618.36	0.5	108,809.18
Other Forests (Seasonal)	1062.9	6.8	7,227.72	0.5	3,618.86
Other Forests (Dry)					
Total	**33084.232**				**112,546.68**

WASTE

Traditionally and culturally, the people have strong ties with their coastal environments. Poor waste disposal (solid, liquid and hazardous) practices definitely have negative impacts on both freshwater and coastal marine environments affecting public health, ecosystems and the economy of the country. Greater efforts and resources are required at national, provincial and individual levels to better manage waste disposal and to minimise the impacts on the fragile environment of the country.

CURRENT WASTE MANAGEMENT PRACTICE

Generally, there has been a lack of sound waste management in areas of solid, liquid and hazardous wastes in PNG due to a number of factors including problems with legislation, policies, infrastructure, planning, public awareness, and both human and financial resources to implement sound waste management practices throughout the country.

Methane emission originates from several sources, including anaerobic decomposition of organic wastes in solid waste sites, in sludge and residual solid by products. Calculation of methane emission from solid and liquid waste sites proved to be difficult, mainly through lack of data and its format. The sections below will briefly discuss the constraints and data gaps in determining the levels of methane and nitrous oxide emissions.

i. Solid Wastes

Solid waste management problems have escalated over the past few decades as a result of population growth and rural populations shifting to urban centres seeking improved life style, employment and educational opportunities. This has further overloaded existing waste disposal systems that were already struggling to cope in the first place. Also the type and volume of wastes generated in the country have become more abundant and complex as demands for imported canned, plastic-wrapped, or bottled goods have increased. The dumping of wastes from mining activities into the rivers and the ocean has also increased substantially.

The search for environmentally safe and socially acceptable areas for disposal of wastes is an unending problem faced by all the towns and villages. No one wants a dump located in his or her "backyard". All too often mangrove areas, oceans, rivers and/or beaches become landfills by default. For example in Port Moresby city, two landfill sites at 6 Mile and Baruni cater for daily domestic waste generated from a population of more than 300,000 people. It is estimated that the average daily waste from the commercial, domestic and industrial varied between 0.21- 0.4Kg per person per day, of which 53% is biodegradable.

Due to the lack of data available from the private sector and related government departments, quantification of total emission of methane from solid waste has not been possible.

ii. Hazardous Wastes

Hazardous or special wastes are dangerous to the people and have harmful effects on the environment, such as shallow groundwater lenses and marine resources. Thus special care and practices are required to deal with these types of waste, which include the following: batteries (vehicle, and small household), waste oil, pesticides, medical waste, paint and solvent, industrial waste (timber treatment and processing, mining processing), transformers (PCB), and septic tank cleanings.

Ideally, these wastes should be collected, stored and removed from the country for safe disposal or recycling overseas. However there are substantial costs and logistical problems in this approach. Export of wastes must be in accordance with the requirements of the Basel Convention (Convention on the Control of Trans-boundary Movements of Hazardous Wastes and their Disposal) and the Waigani Convention (Convention to Ban the Importation into Forum Island Countries Hazardous and Radioactive Waste and to Control the Trans-boundary Movement and Management of Hazardous Wastes within the South Pacific Region).

There are three aspects to the management of hazardous wastes in the country. Firstly there is the problem of dealing with accumulations of waste or unwanted chemicals or hazardous materials which are in storage in the absence of any organised disposal programme. Secondly there are the situations where contamination of soil or groundwater has occurred. This may be due to accidental spillage and leakage of stored chemicals or deliberate burying in an attempt to dispose of such materials. These first two situations are in large part, the legacy of unsatisfactory waste and hazardous material management in the past.

The third aspect of hazardous waste and chemicals management is to take a more positive view and to ensure procedures and structures are in place to ensure that no more waste accumulations or contaminated sites are allowed to develop as a result of current activities. Unfortunately, the "out of sight/out of mind" approach has generally been taken. For example, the burning of medical waste is commonly practised in country.

iii. Liquid Wastes

Unfortunately there is a lack of sufficient available data to assess typical characteristics of wastewater produced in the country.

Based on the country's estimated population using various methods of treatment an estimated concentrations for each characteristic, such as biological oxygen demand, nitrogen content and phosphorous are calculated as follows: 5,665.0; 3,106.0 and 374.0 tons per year respectively. The country's wastewater treatment plants indicated that industrial wastes were not allowed into their collection systems. Major industries in the country include edible oils, oil export and production, oil palm production, agricultural and livestock processing, sugar refining, fish canning and beer brewing. Most industrial operations provide some sort of treatment and disposal systems, but again there is little information available, plus a lack of discharge monitoring system. Potential economic opportunities exist with expanding industrial growth. This growth comes with increased industrial waste types and volumes that will have to be dealt with to protect the environment. More control over discharges will therefore need to be exercised by government authorities to minimise adverse effects to the environment.

Mining activities in PNG all produce wastewater that is potentially dangerous to the environment if not treated appropriately. Each mining operation should have its own treatment facilities and must be continually monitored.

Calculation of nitrous oxide emissions from human and animal waste management systems has not been possible.

CONCLUSION

There is still a lot of gap in data from the following sectors; land use, livestock, agriculture, bunker fuels calculations and waste.

Although reduction of the emission will not impact the average person, significant savings on economic, environment and health of the country would be gained if the government and private sectors changed their attitudes as well as policies to seriously place renewable energy as priority program of actions. A range of mitigation options is discussed under mitigation in chapter 4.

CHAPTER 3

VULNERABILITY ASSESSMENT AND ADAPTATION OPTIONS

INTRODUCTION

The natural environment throughout PNG is extremely fragile and highly vulnerable to both natural and human impacts. During the last 50 years or so, increasing pressures on the resources are intensifying the country's exposure to extreme events such as natural hazards like cyclones, droughts, earthquakes and tsunamis. In addition to these threats and pressures to the environments of PNG are the expected changes that may arise from climate change and climate variability, which will likely further exacerbate these impacts and deplete the resources that are most essential for basic life support systems.

Vulnerability assessment is needed to identify the degree of future risks induced by climate change, variability and sea level rise on the vulnerable areas of the economy and to help determine how to respond to these threats. One form of response is adaptation which aims to adjust or cope with the changes brought about by climate change.

CLIMATE CHANGE AND SEA LEVEL RISE SCENARIOS

RISING VULNERABILITY TO EXTREME WEATHER AND CLIMATE VARIABILITY.

Climate change could pose problems in the future for the GoPNG as impacts from weather and climate extreme events, which are now being experienced. For example, the 1978, 1981/1982 and 1997/1998 El Nino events significantly devastated the country's economy.

From current baseline data and information about the country's weather, climate trends and inter-annual variations in sea level rise, the following is the summary:

Both the temperature and precipitation trends in PNG resemble the global and regional trends respectively;

The increases in the mean near surface temperatures especially over the last 25 years appear to be above the global mean (see Figure 3.1);

The increase in the mean minimum temperatures has been greater than that of the mean maximum temperatures since 1970;

The detection of climate change is still uncertain as it is based on the current data sets which have a short period of observations;

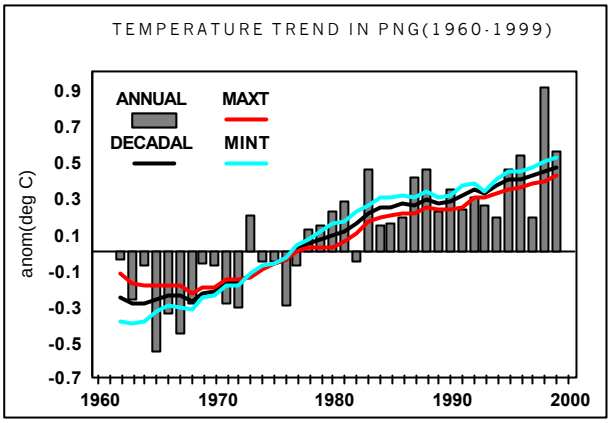
The dry seasonal patterns exhibit weakening La Niña impacts during dry season and that the weakening is eventually influencing the weak dry conditions. This implies longer decadal phases of dry conditions;

There's an obvious need for a widespread climate network to effectively monitor climatic variables unique to this part of the world. This may include careful observation of the northwest monsoonal flows necessary for the detection of the onset of the El Niño episodes;

There is already a relative sea level rise around the country, but this is strongly influenced by El Nino and La Nina signals (see Photographs 1.1 – 1.3).

There has bean an increase of 0.5ºC in the mean near-surface temperatures, but since the mid 1970's, much of the increase could be attributed to the rapid increase in minimum temperatures rather than the traditional maximum temperatures.

Figure 3.1: Temperature Trends (Source: NWS)



TEMPERATURE AND RAINFALL SCENARIOS

Some works are underway to develop the specific climate change and sea level rise scenarios for the country, but these are not available. However, the IPCC has developed two general circulation models (GCMs) which are applicable to PNG's conditions as shown in Table 3.1. The scenarios ask "what if" question about the effects of climate change and sea level rise and how sensitive the country would respond to the changes.

Table 3.1: Temperature and Rainfall Scenarios

GCM pattern	2020 Temp. ^{o}C	Rainfall %	2050 Temp. ^{o}C	Rainfall %	2100 Temp. ^{o}C	Rainfall %
HADCM2	**0.6**	**0.4**	**1.2**	**2.2**	**0.8**	**1.5**
CSIRO9M2	**5.1**	**0.1**	**10.3**	**18.9**	**-0.1**	**-0.2**

This table shows the IPCC 'best guess' (middle) and 'worst (high emission) case' scenarios of the projected temperature and sea level rise. Both models suggest future temperature rise of between 0.4^{o}C to 2.2^{o}C and indicate that there could be significant temperature increases.

From the current work in the Pacific and data sets from the country, there may be high rainfall intensity events and prolonged droughts. The dominance of El Nino- Southern Oscillations (ENSO) events recently being experienced in the country (1997/98) and the Pacific region could influence the modeling results.

Sea Level Rise Scenarios

The sea level rise scenario calculations for PNG are based on the IPCC Second Assessment Report as data sets from regional relative sea level rise, local effects, ocean circulation, salinity, wind and pressure patterns are not available.

Photograph 1.1. Rising sea level causing denudation of coastal vegetation and loss of land for island communities (Source: S. Saulei)

Table 3.2 is determined from the best guess and high estimates of GHG emissions. The figures give an indication of what might happen over the next century based on the middle and worse scenarios of sea level changes. These are consistent with the temperature projections. Both results show significant increase in global sea level rise over the next century. However, for the Pacific region and PNG with short data sets from the monitoring stations, the influence of ocean dynamics, local noise signals, atmospheric pressures, and ENSO may effect the relative sea level rise results.

Table 3.2. Sea level rise scenarios

Scenarios	2020	2050	2100
IS92a (best guess)	**80mm**	**200mm**	**490mm**
IS92e (high)	**160mm**	**400mm**	**940mm**

VULNERABILITY

COASTAL AND MARINE ENVIRONMENTS

PNG coastline, coastal villages and rural coastal population are vulnerable to sea level rise and other weather-related manifestations of climate change. The main impacts will be inundation of coastal wetlands and foreshore areas, bleaching of corals, which will weaken the coral reefs as barrier protection systems. Loss of wetlands, freshwater sources due to seawater intrusion, and lands may eventually lead to displacement of communities, resulting in aggrivated future social problems.

Photograph 1. 2. Beach erosion resulting from sea level rise (Source: S. Saulei)

INUNDATION

The permanent or periodic inundation of deltaic flood plains, swamps, and low-lying areas could affect up to 50% of the Papuan Coastlines, and 10% of the northern shorelines (for a 1m sea level rise – IPCC's highest estimate). This may result in damage to mangroves and swamp forest ecosystems, as well as human productive systems. More than 90% of the coastlines of Gulf and Western Provinces are likely to be impacted. Flooding is also expected to affect the lower Sepik-Ramu region. Approximately 4500 kilometers out of a total of 17100 kilometers of shoreline are expected to be moderately to severely inundated, affecting up to 30% of Papua New Guinea's population. In addition, there is a danger that some very low-lying islands, including barrier islands, will be completely submerged. Evidences of this are already occurring, especially in the outer lying atoll islands of Mortlock, Tasman and the Duke of York Islands.

Flooding is likely to cause a loss of coastal infrastructure, including roads, such as parts of the Magi and Hiritano Highways, marine installations, and urban centers, such as the coastal settlements of Hanuabada, Vabukori, and Koki in Port Moresby. Large parts of Lae's industrial and residential areas, and other low-lying towns, such as Kieta, Kimbe, Madang and parts of Rabaul are likely to be affected. The replacement, mitigation, and additional maintenance costs imposed by such changes are likely to be quite substantial.

BLEACHING AND LOSS OF COASTAL DEFENSES

A large proportion of Papua New Guinea's shoreline is protected by both barrier and fringing coral reefs. Coral reefs are known to be sensitive to increases in surface ocean temperatures, which cause die back and bleaching from the loss of zooxanthellae (the algae that sustains them). Elevated sea surface temperatures, associated with coral bleaching and ENSO activity have been observed on a number of occasions and at various locations throughout the country.

The inundation of reefs, combined with increased surface water temperatures and possible sedimentation and increased turbidity from shoreline erosion could also contribute to reef mortality. Unhealthy coral reefs that have been dynamited, over-fished or poisoned are known to be less able to maintain normal rates of growth, and thus, are more likely to drown. The loss of vital sea-wall barriers that are provided by barrier reefs and mangrove communities may heighten the impacts of coastal flooding. As breakwaters, coral reefs provide a vital wave energy dissipation function and their loss would result in increased coastal erosion.

WETLAND LOSS

The distribution and zonation of mangroves is mostly influenced by salinity, tidal fluctuations and drainage patterns. Secondary influences include temperature, land relief and shelter from storm surges and big waves. Salination of mangrove systems could occur given that they prefer a salinity level, which is equal to or close to that of seawater. Similarly, increased storminess may also change the zonation through accresive or erosive action of the waves. The loss of mangrove system integrity will have adverse effects on subsistence welfare of the local villagers living in or near such mangrove areas.

Photograph 1..3 Salination effect on mangrove forest causing dieback (Source: J. Aruga)

The distribution of tropical seagrasses is also affected by variation in water temperatures (which should be warmer than 20^{o}C) and water movement.

LAND LOSS

Competition for limited resources, and restrictions imposed on out-migration and settlement by Papua New Guinea's system of land tenure are likely to lead to a number of social pressures and potential conflicts over land. Areas where population and land-use pressures are already high,

and where land degradation is a current problem are likely to suffer from additional degradation and loss of productivity. This will retard the ability of human communities in such areas to respond to other ecological stresses.

There is a strong inverse correlation between the levels of socio-economic development of the coastal provinces of PNG and the extent to which they will be affected. Several provinces are expected to be most affected by sea level rise such as Western, Gulf, West and East Sepik, Manus, New Ireland, Bougainvillea and Milne Bay, many are least developed. The communities in a number of these provinces could suffer the greatest loss of land and other socio-economic disruptions. In addition, issues of resettlement will be compounded because of the strong inherent customary land tenure system. In instances where resettlement is an option, the financial and cultural (dislocation) costs are likely to be high.

FISHERIES

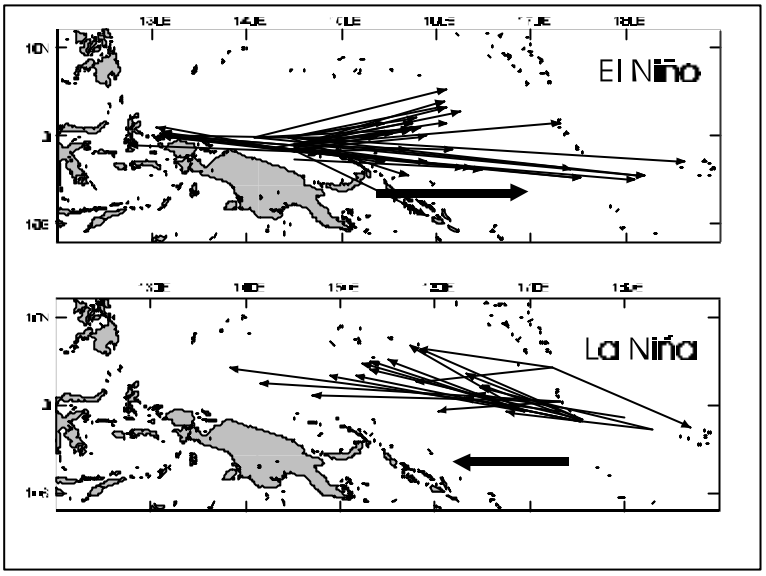
The levels of fishing effort and fish behavior are directly affected by the weather and sea surface temperatures. However, the impacts will be complicated by the presence of anthropogenic factors. Climate change will have the greatest effect on fisheries that are already stressed, for example, through overexploitation and over capacity. Most of these impacts can be identified, but not readily quantified or predicted.

Many breeding grounds for commercially important fish and shellfish are located in shallow waters near the coasts and within mangrove systems. Barramundi, crabs, prawns and other species are dependent on mangroves for their development during various stages of their life cycle. Therefore, any loss of mangrove ecosystems has potential severe consequences on artisinal and commercial fisheries.

Changes in the incidence of ciguaratera fish poisoning, have been related to sea surface temperature increases and reef disturbance. If ciguaratera becomes a persistent problem in an area, people may modify their diet or decrease their protein intake, thus indirectly affecting their budget, lifestyle and health.

The distribution of tuna fisheries is affected by the location of the Western Pacific Warm Pool (WPWP) where Papua New Guinea is situated, an area of warm surface waters (more than 28^{o}C) that produces virtually all of the tuna caught by purse seine. During El Niño years the WPWP can be displaced eastward into the central Pacific by nearly 4,000 km (see Figure 3.2 below). In addition to this geographical displacement, El Niño also influences the abundance of tuna. El Niño years tend to result in higher than average abundance of skipjack, while La Niña years generally result in higher abundance of yellowfin tuna and albacore in the subsequent months.

Figure 3.2. Tuna Fisheries and Climate Variability



BIODIVERSITY

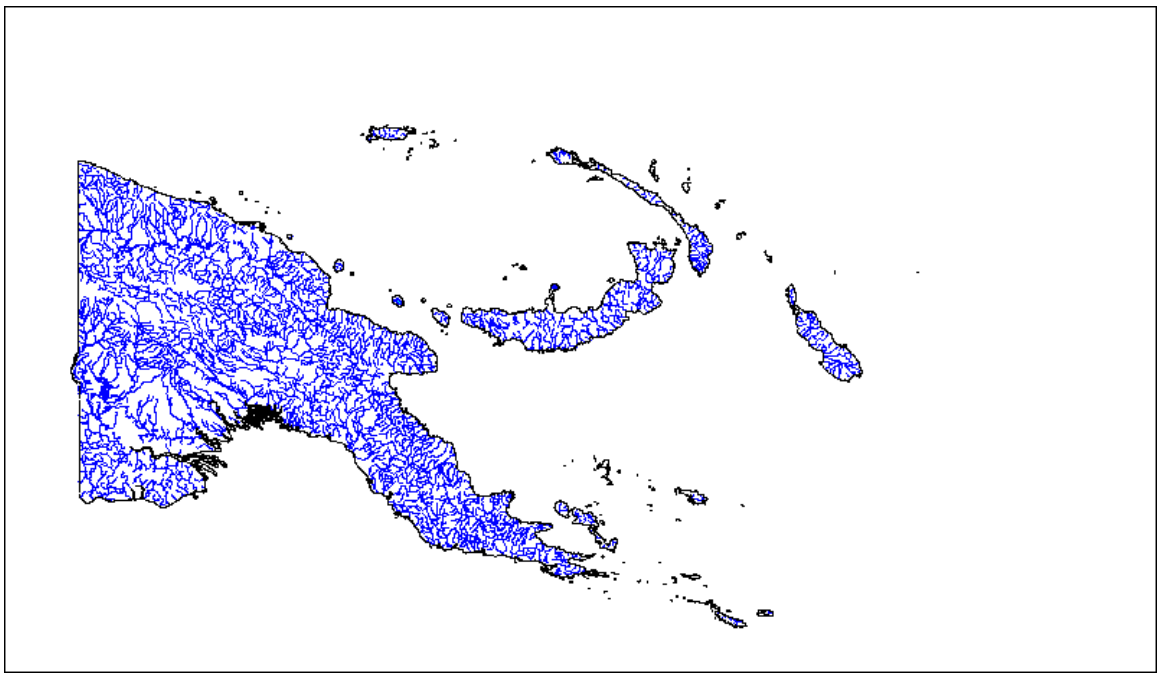
The viability of the natural environment is already under constant threat from current patterns of development, consumption, urbanization, infrastructural development and population growth. The vulnerability of biota and their environments are discussed elsewhere in this communication. Any changes to the natural systems will greatly affect the country's unique and very rich biodiversity. For example, aspects of the life histories such as length of hibernation, preferred niches, etc. of various biota may be different from that in the absence of climate change, but to what extent is unclear.

WATER RESOURCES

Water is a resource with which PNG is richly endowed (see Figure 3.3). The majority of the major river systems are located in the western end of the country and have a flow of rate of some $5000m^3/s$ annually, and similarly receive rainfall greater than 3000 mm per annum. These major river systems dominate the inland hydrological cycle in mainland Papua New Guinea.

The water resources have been gradually depleted due to rapid industrial and resources development, population pressure, forestry and agriculture expansion. Increased emissions of greenhouse gases pose a strong possibility of rapidly depleting the water resources availability, owing to fluctuations in rainfall behavioral patterns and evapo-transpiration potential.

Figure 3.3. Major river systems in Papua New Guinea



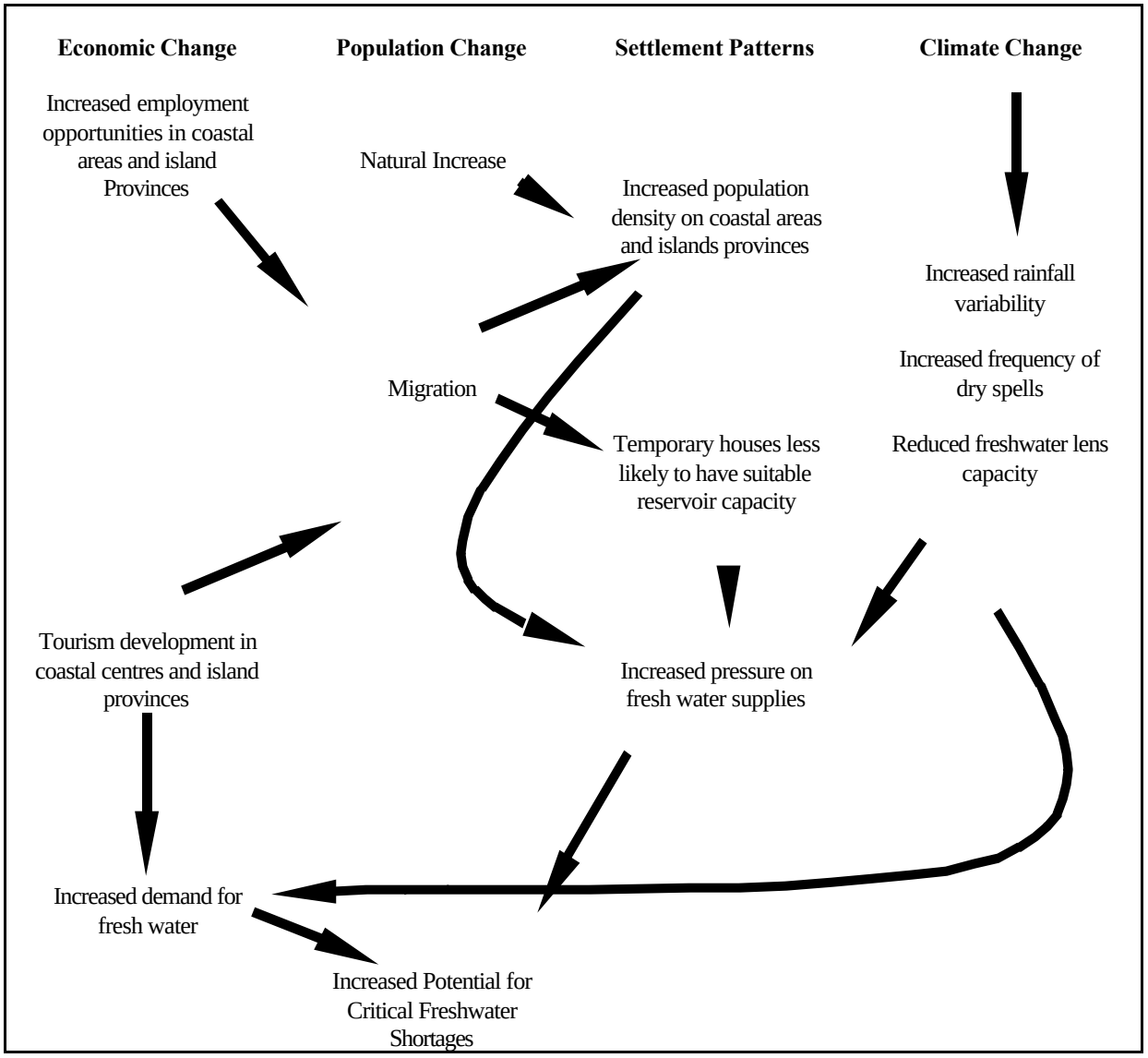
Vulnerability to water resources is induced by changes in climatic conditions such as increases in temperature, rises in sea level and depletion in carbon dioxide gas. For example, increased CO_2 concentration would reduce stomatal conductance in many plants, implying a reduction in transpiration although the effects vary considerable between species. These changes are likely to upset the overall normal water availability, water balance and hydrological cycle.

CONTAMINATION OF FRESHWATER LENS

More than 200 low-lying islands and coral atolls throughout PNG support small human settlements. These communities rely on ground water lenses for supply of fresh water, both for human consumption and for gardening. These lenses are likely to be affected by salt-water intrusion because of rising sea levels and leakage during storm surges, thus causing a shortage of fresh water. The photograph 1.3 shows the manifestation of sea level rise and loss of freshwater in one of the affected islands in PNG. The complexity of effects of climate change on water supplies not only because of the various geophysical factors (sea level rise, precipitation, changing island morphology) but also because of a range of socio-economic processes is shown in Figure 3.4.

Photograph 1.3 Loss of Freshwater due to saltwater intrusion (Source: S. Saulei)

Figure 3.4 Possible climate change effects on water supplies in Papua New Guinea.



HEALTH

Most Papua New Guineans live, on average, to the age of 56, which is the lowest in the South Pacific region. The leading causes of death for all ages are pneumonia, prenatal problems, malaria, meningitis, tuberculosis and diarrhea. A mere 20% of rural people have access to safe water and sanitation services, contributing to water borne disease and making PNG most vulnerable to cholera outbreaks. In terms of health risks, women, children and the old among the village-based population are more susceptible than the stronger male population.

The impacts of climate change on health can be classified into three categories:

(i) Direct impacts on human safety: where storms can damage and destroy health centers and related infrastructure, thereby disrupting essential health services. For example, severe cyclones have destroyed services in the areas of Milne Bay province with marginal areas of Northern and Central Provinces also affected to some degree.

(ii) Nutritional related disease arising from malnutrition and food shortages, especially where subsistence crops and fisheries are affected. For example, prolonged heavy rains and flooding in low-lying areas or wetlands of the Western and Sepik provinces as well as many parts of the country has resulted in mass migration inland, or away from the affected areas. Since these areas are full of swamps and no proper land for agriculture, people mostly depend on sago and fish as their major source of food. These people would be at a greater risk as a result of climate change simply because they are incapable of working on the land.

(iii) Indirect effects such as increases in the incidence of vector borne and other diseases where intense droughts and cyclones disrupt water supplies and sanitation systems. Malaria is associated with a broad range of habitat, an optimum temperature above 22^{o}C and an altitude of less than 670 meters (see Figure 3.4). Vulnerable areas are the Kikori and Sepik plains, Star Mountains and some parts of New Britain.

Malaria could be exacerbated by sea level rise. It could cause people to relocate, while the change in temperature and increased rainfall could result in water contamination, shifting the mosquito vector and farming problems. In addition, climate change indirectly increases the severity of disease by reducing agricultural production, which can lead to malnutrition.

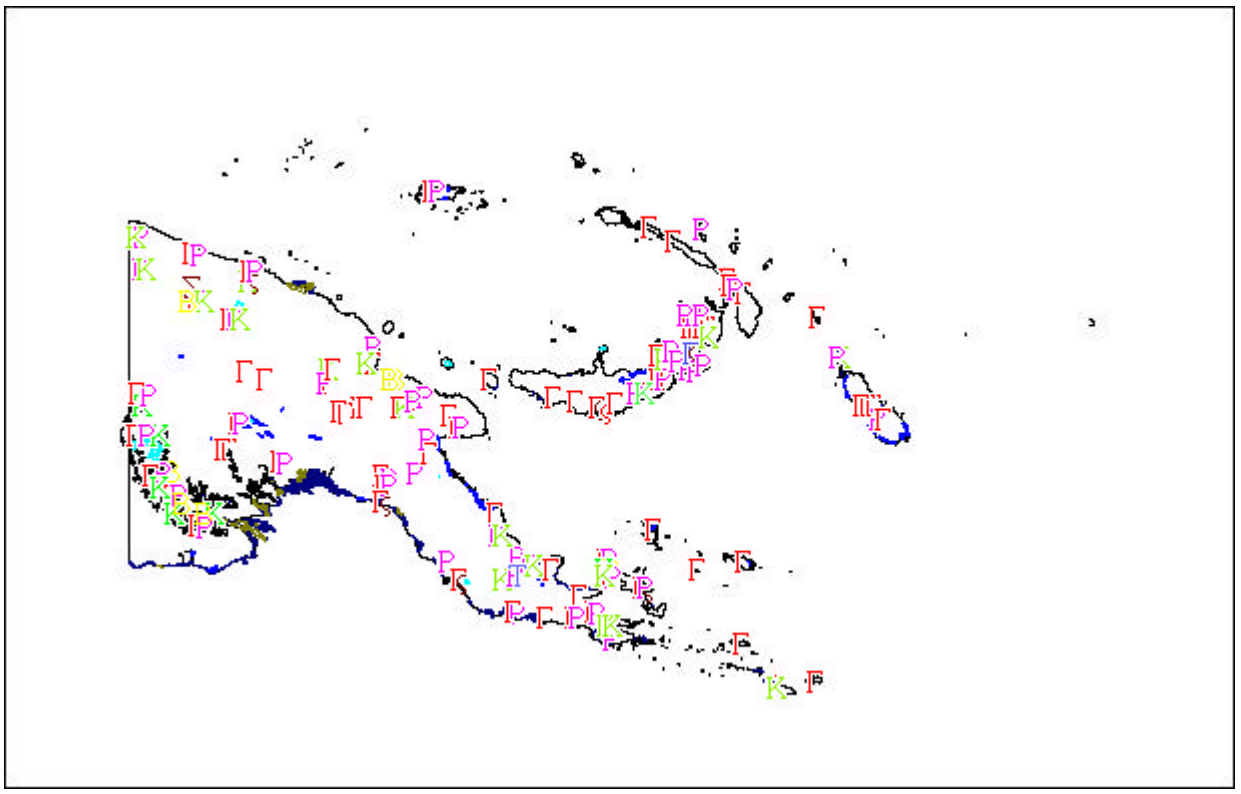
LAND USE CHANGE, AGRICULTURE AND FORESTRY

Land Use Change

Although forestry is of major economic value to the country, excessive logging in agricultural areas has a major environmental impact and has the potential to affect agriculture. Should this happen, there would be increased danger of erosion of fertile land, lowering of the water table in underground reserves, and exposure of river banks to flooding/overflowing during monsoonal rains.

The problem of land clearing will be exacerbated if prices for export crops such as tea, coffee, cocoa and copra are depressed as farmers will be tempted either to intensify cropping practice or clear more land. Available forested lands will be subjected to increased deforestation to cater for the increase in population. There would not be enough land for cultivation and further more, no land rights to available land. The people would also need to adapt to new methods of farming such as on mountain slopes and valleys, however, these methods of farming could also have negative implications on crops. Farming in valleys would expose crops to frost damage during drought periods. In addition, the complex traditional land tenure system that exists in PNG will make it more difficult to achieve coordinated changes in land usage that may become necessary due to climate change and sea level rise.

Figure 3.4: Malaria trends and possible habitats (source Natera, 1999).



LEGEND: ***Coloured habitats***: Light Blue – Lake; Hash Blue: Differentiated Swamp; Hash Dark Blue: Blocked Swamp; Dotted Yellow: Esturines; Cris-cross Blue: Mangrove Swamp. ***Coloured Letters***: F – Anopheles farauti; P – A. punctulatus; K – A. koliensis; W – A. karwari; S – A. subpictus; B – A. bancroffii

AGRICULTURE

Agriculture production is very sensitive to climate and climate variability. Crop yields are influenced by inter-annual variations in weather, nutrient status of soils and temperature. Climate change will affect soils primarily through changes in soil moisture, soil temperature and soil organic matter content.

The vulnerability of crops to climate change may either be increased or diminished by future technological changes. If technological advances narrow the optimal range of input conditions for agricultural production (e.g. need for high levels of fertilizer), and if climate change results in increased variability such as increases in frequency of droughts as well, production risks may also be expected to increase.

The direct effect of increased temperature generally decreases photosynthesis at temperatures above 25°C for tropical crops like sweet potato, cassava, taro and yams. In PNG (high island country), rising temperature will raise the upper altitude limits at which tropical crops can be cultivated. Higher temperatures will affect agricultural productivity, whereby farmers will be subjected to heat stress due to high temperature and humidity.

Other effects of rising temperatures include:

- rapid post-harvest deterioration of crops;
- greater rate of water loss through evaporation, especially in limestone areas, leading to greater occurrences of droughts in low-lying areas, and a decline in soil fertility;
- flooding of low lying areas if accompanied by higher rainfall. Soils will suffer greater leaching and loss of fertility and the humid conditions will favor increased incubation of agricultural pests and diseases;
- shorter time for crops to mature, hence smaller produce and thus, a lower overall yield.

Carbon dioxide will have the greatest potential effect on agricultural yields, especially for major tropical C3 plants that depend on carbon dioxide for photosynthesis, like sweet potato, cassava, taro and yams. Experiments based on doubling of CO_2 concentrations have confirmed that "CO_2 fertilization" can increase mean yield of C3 crops by 30%. These tropical plants are a staple diet to PNG subsistence farming population. With more carbon dioxide in the atmosphere, the rate of photosynthesis in these plants will increase. Although this may be of benefit to these tropical tuber crops, increased carbon dioxide would also enhance weed growth, which could adversely affect yields.

FORESTRY

Natural forests are disappearing through shifting agriculture at a rate of between 200,000-250,000 ha annually, logging by some 60,000ha and other forms of developments (infrastructure, large-scale commercial agriculture, settlements, etc.). At present, the extent of plantation forestry covers only about 59,000ha, while treated natural forests only accounts for about 6,600ha compared to the rate of forest removals. At this rate of removals and replacements, it becomes very obvious that the current estimated acreage of productive forests (ca. 14 million ha) would not last further than 50-60 years.

Changes in temperature may affect the formation of cloud forests, which occupy a very narrow geographical and climatological niche. A slight shift in temperature or precipitation patterns could cause this zone to shift upwards enough to be eliminated.

ADAPTIVE MEASURES

INTRODUCTION

The capacity to adapt to climate variability and climate change is affected by a range of institutional, technological and cultural features. There needs to be a fundamental shift in the importance given to sound environmental management with a mainstreaming of environmental considerations at planning and policy levels. There is probably a role here for large international organizations (e.g., UNDP, EU) to assist however, various past efforts in this regard have been less than successful.

Careful thoughts should also be given to the level of implementation of any intervention. That is, whether it is site specific or at a generic level, or whether it should be from the bottom up or top down, or whether it is culturally acceptable, or whether the timing is right and what costs and benefits will these bring. Table 3.4 below summarises the range of adaptation measures in each of the sectors.

Table 3.4 Adaptation measures

Coastal and Marine Environments	
Mechanism	**Constraints and Opportunities**
Coastal management policy and planning	Maintenance of the integrity of the natural systems and their buffers is important in the face of climate change. Government policy needs to take account of the potential impacts of likely changes in sea level, the need to avoid development in areas prone to inundation or accelerated erosion and the need to ensure the safety of people. The adverse effects of natural hazards are particularly important at provincial government level because the hazards usually have localized effects. Local authorities have a stake in avoiding, minimizing, and mitigating the costs and effects of natural hazards.
Integrated Coastal Management	Integrated coastal management is needed as a long-term approach. However, in the PNG context, truly integrated institutional approaches are unlikely in the foreseeable future, but these are not needed. What is needed is institutional coordination horizontally (across sectors) and vertically (local - provincial – national), that can be achieved at relatively low cost and with minimal institutional restructuring.
Community based monitoring and management	There is essentially no routine monitoring of PNG's marine environment, except for private programs operated by mines. Academic institutions and research stations have initiated a few monitoring efforts but these are not directly linked to management efforts. The few examples of successful management interventions to ensure sustainable use of PNG's coral reef resources generally involve community-based initiatives such as codes of practice or voluntary efforts by local industry groups. The level of a project's physical presence on site should match community commitment.
Integrated research	Recommendations for integrated research in ecosystem need to focus on finding out the distribution and structure of species and ecosystem; storm events to help understand ecosystem engineering and site rehabilitation; identification of human use patterns; cultivation and management of mangroves and testing of village based ecosystem care units and; identification of sources of income from traditional shell fishing to shell crafting.
Building capacity in provincial and national government agencies	PNG has generally adequate environmental legislation but very low, and declining, capacity to implement it. The environmental planning and management capacity of relevant national and provincial government agencies is extremely limited, hampered by the nation's political and economic instability and a seemingly endless process of institutional reorganization. For example, the OEC was recently downgraded from a cabinet department, and staff cut by 50%. Even before this the department suffered from critical shortages of human and financial resources. The management of threats such as urban development, watershed degradation, large-scale industrial development, and commercial fishing urgently require technical staff and institutional capacity in provincial and national government agencies. Capacity building is hampered by cultural obligations

	and work demands, inefficient bureaucracies and funding constraints.
Hard and soft measures	Structural measures such as sea walls and groins are costly and provide few benefits other than protection of erosion and safeguarding of assets only on a short term basis. Sea walls may also increase problems downstream. Therefore, structural options should be screened for their compatibility with community aspirations. Soft options involving revegetation to stabilize the shoreline are less costly but need constant maintenance. They may also be easily affected by increased storminess and wave action. Set back areas also help control development.

Fisheries	
Mechanism	**Constraints and Opportunities**
Adaptive management	Adaptation strategies should be aimed at acquiring a capacity to respond to unexpected changes in the environment by quickly changing fishery management approaches.
Develop aquaculture	Aquaculture helps to relax the gap between demand and supply and will reduce the pressure on wild stockings.
Reduce post harvest losses	New technology may help reduce by-catch and maintain fish quality.
Stronger regional collaboration for management and research	For tuna fisheries, PNG needs to continue it's strong involvement in the establishment of multilateral agreements with distant water fishing nations. Poor resolution of climate models are not able to predict changes at the scale of fish recruitment. Data on the spatial and temporal distribution patterns of tuna can help fish management authorities adjust their management practices.
Data collection systems	Aside from data on a few fisheries stocks, existing information on the marine environment to establish any form of baseline against which trends might be identified as a basis for management is almost completely inadequate. Nearly all work has consisted of "one off" studies at one or a very few sites, and there is virtually no information about spatial and temporal variability. Some basic information about the coastal biota (e.g., species lists) has been provided by work at the UPNG and various research stations, but it is very limited both geographically and taxonomically.
Fish and marine reserves	A conservation needs assessment has identified 30 priority areas for conservation of critical habitats. This includes stock enhancement of inland fisheries. A number of marine reserves are currently being proposed in Milne Bay and highlands provinces.

Agriculture, Land Use Change and Forestry	
Mechanism	**Constraints and Opportunities**
Micro credit and small business expansion.	Traditional agriculture in PNG is based on a rotational bush fallow system, which is highly productive and generally sustainable, providing population pressure does not force the use of too short a rotation period. However, in order for households to maintain food and nutritional security throughout the year, they must have access to sources of income through on-farm or off-farm activities. This requires both a supportive policy and planning system at the national level, effective extension services and access to credit and business opportunities.
Research into new plant varieties, crop rotation, use of irrigation, altered nutrient levels and plantation forestry alternatives.	Research is needed to find out more about adaptive measures that exist such as breeding and genetic programs; protection systems such as fire, insects and diseases; the regeneration potential of natural forests whether intact or logged; suitable plantation site and species selections; and suitability of indigenous species.
Sustainable natural forest management	One of the most contentious issues that the forest authority needs to address is how can it expand its programme on forest replacement and implement its policy on sustainable natural forest management when it is faced with the dilemma that the land and the forests on it are owned by the customary owners who may have other uses for their land and forests.
New technologies	The introduction of new and/or improved codes of practice, reduced impact logging, the provision of better information about timber stands, and the upgrading of the resource management capacity of the forestry professionals, technicians and field supervisors are key elements in the process of achieving sustainable forest management. Strategies for future farming developments through the introduction of sustainable subsistence crops and the introduction of new farming methods and practices are needed.
Capacity Building	Capacity building initiatives should be focused on piloting innovative extension systems, improving and integrating farming technologies, strengthening agricultural data collection and planning and expanding micro credit and small business training facilities.
Woodlot establishment, agroforesty and tree planting supported by active forestry extension.	These practices could be carried out where there is a shortage of wood and wood products for domestic consumption. In Port Moresby, there is an ongoing mangrove reforestation programme with villagers on the Motuan coast.

Biodiversity	
Mechanism	**Constraints and Opportunities**
Slow biological invasions	Aquatic plants such as the Water Hyancith and Salvinia have been major problems in the Sepik River and elsewhere but there is no comprehensive monitoring programme on distribution, population sizes, rates of change, environmental impacts and effectiveness of control measures.
Strengthen and enforce policies that protect critical habitats	Many initiatives at protecting critical habitats on a sustainable basis have tended to become academic and research orientated exercises, which are far removed in terms of providing the tangible benefits to landowners and the community at large.
Research into the local effects of climate variability and change on species	Models of the distribution of species or species associations could be related to the drivers of climate change. Monitoring of specific plots may also allow human and climate change impacts to be differentiated.
Increase awareness of visitors and the public concerning the value of species and biodiversity	The government's priorities are to ensure resource owners play a more meaningful role in planning and implementation of development and conservation activities by improving their understanding of the environmental and social impacts of different land use options and helping them achieve higher sustainable incomes.
Maintain gene pools through a system of connected protected areas	Knowledge of native species is minimal but could be useful in the future to redistribute and maximize gene pools. Reintroduction's of species are possible but not to the full range of species that once existed.
Strategic policy	The National Biodiversity Strategic Action Programme initiative, developed out of the Convention on Biodiversity, will provide the framework for an integrated strategy for the country. The OEC will need considerable strengthening if it is to oversee the coordination and implementation of this strategy. Landowner issues may also need to be resolved.

Water Resources	
Mechanism	**Constraints and Opportunities**
Invest in new water technologies, particularly for recycled water.	A lot of waste-water is being discharged into ponds and lagoons during the dry and wet seasons all year around.
Encourage integrated water management approaches	Changes in hydrological characteristics are likely to lead to changes in the aquatic and wetland ecosystems and increase demands for irrigation from the agricultural sector. Integrated water resource management under a 'no regrets' response option requires intensive investment but it has the potential to draw independent water users under one governing agency.
Incorporate climate change into water management legislation	Ensure that Climate Change and variability is incorporated in various Environmental and Conservation Acts, but focusing on water and including monitoring, data collection and management of the water resources.
Transfer of new technology to assist with water projects/ activities	Project developers have been encouraged to upgrade capability and capacity building for water quality monitoring and assist in the acquisition of upgraded resources to enhance national technologies. One example is the ALERT flow forecasting and warning soft and hardware systems currently employed by the OK Tedi Mining Limited for dredging and navigation for warning of its ore shipment. Although the system is generally functioning

	well, it is expensive to maintain. This system has been recommended for use in other applications such as Bumbu catchment flood preparedness and warning system in Lae, Sepik flood propagation for navigation, and modernization of Laloki River water and power supply systems.
Improve resources information and monitoring	PNG has comprehensive information on 90% of the river systems in the country with a representative rainfall network. Additional information includes water volumes and quality, (selective) attributes of resource development and developers, commercial entities and other small scale projects. Research into new technologies is underway to improve information collection and data transfer on water resource management methodology, water hazard warning and forecasting and improvement of analysis techniques. Keeping up with technology developments is a high priority for PNG. Recent use of satellite data transmission technology and remote sensing has reduced costs drastically in a short time of application, and resulted in real time data transfer with reasonable precision. The whole system is highly sophisticated and requires well trained personnel to install and operate. With the assistance received from international agencies involved in water management, engineering and resource development, a primary baseline database has been established for PNG. This further implies that information transfer and exchange with other Pacific and Southeast Asian countries will commence by the end of year 2000. This includes attending specific training and job attachment programs.
Develop alternative water sources such as rainfall catchment devices as well as saltwater and brackish water desalination plants	Severe shortage of water in the small islands, atolls of New Guinea island provinces and the Central province in particular has forced an emergence of basic water acquisition technologies. Tanks have been designed to withstand salt, durability, compatibility for transportation and ease of assembly on site. This concept is inexpensive in the long term and requires no maintenance, training or management skills. Desalination plants is one of the options currently considered. Very few are in operation because of high capital and running costs. Establishment, operation and maintenance is very expensive and requires very skilled personnel. Equipment and initial labor have to be source abroad while training has to be provided for the local communities on the maintenance and management of the entire establishment.
Water conservation measures including leakage control	Licenses for large water uses could help discourage water wastage. Improved plumbing, communal tanks and stand pipes could help reduce wastage.
Water carting	Carting water to rural areas, squatter settlements and communities from a main supply system is a new concept. Specially designed vehicles are used to cart approximately 1000 or more liters of water and travel more than 100 km (1 hour) to dislodge its contents into 100 to 1000 liter tanks for each household. Water carting is only suitable over a short distance and time and is recommended for use in severe dry seasons only.
Runoff and precipitation retention	Open retention basins are a practical option given the very rugged nature of this country. Direct precipitation, excess streamflow and overland runoff can be trapped in retention basins and stored for an indefinite period of time for any future use.

Training	Local on job training and work attachment are not costly but simultaneously beneficial, and is the fundamental basis of information and knowledge acquisition and transfer. Because of the very unique nature of this profession in PNG job related training is not readily available in most of the technical and tertiary institutions in the country. Advance postgraduate training on engineering hydrology, water resources management and water biochemistry are held abroad.
Redistribution of water resources	Temporal and spatial inter basin water transfer is one viable option but requires capital investment. The basic concept is to abstract a certain portion (variable) of water from a main river system or where there is abundance of water resources, and transfer it to a receiving basin where its source is inadequate to meet all demands from it's a normal river runoff and underground sources. Inter basin water transfer due to extensive spatial coverage and lacking treatment is recommended for irrigation and hydropower generation, and should be applicable during the dry weather periods only.

Health	
Mechanism	**Constraints and Opportunities**
Control vector borne diseases	Requirements to control vector borne disease such as malaria include: identify location and elevation of habitats for the various species of malaria, compile and monitor the occurrence of diseases and identify vulnerable areas and people resistant to a particular strain.
Reduction in heat stress through infrastructure improvement including adoption and enforcement of more stringent building codes	Health care infrastructure needs to be upgraded but support for these measures will place a large burden on public expenditures.
Comprehensive disaster management programmes	Areas vulnerable to tsunami, landslides and cyclones have already been identified. However, erosion risk will also be affected by tectonicity and mass movement of the earth's crust. More detailed surveying and mapping of such areas is required.
Preventative health care through public awareness programmes	
Improve medical services	The government is in the process of decentralizing the country's health system from the national to the provincial and district levels to enable more cost effective and coordinated delivery of services. Training and capacity building initiatives have been launched to enhance management skills within the health sector. International aid programmes are also in place to provide technical support to improve it's pharmaceutical supply system, cold chain logistics, blood bank system and public health laboratories. These programmes will also concentrate on vaccine preventable diseases, diahorrea control, acute respiratory diseases and tuberculosis, with much of the funds directed to rural areas.
Improve quarantine services	

CONCLUSION

Climate change, variability and sea level rise are important issues, which affect the development and environment of PNG. The adaptation strategies to minimise impacts do not need extensive new interventions, but rather the enhancement of current practices. The development choices made today and mistakes magnified in the face of climate change will be felt by future generations. The resilience of economic, social and environmental systems is expected to decrease and the country may feel the full magnitude of climate change impacts.

In PNG, the most vulnerable would be the village-based population, which depend on subsistence farming for their livelihood and means of cash income. Those who are dependent on farming, fishing or forestry would see their livelihoods degraded by the changes in rainfall patterns, degraded soils, forests and fishing grounds. They would find it more difficult to change over to new crops and farming practices and methods, adopt effective irrigation methods, acquire cultivable land for continued farming and adopt better fishing methods.

The time to act to reduce the vulnerability of the country is now. Appropriate actions will have to be implemented as these will go a long way toward reducing the magnitude of the damages brought about by climate change and human activities on the environment in the future. The challenge will be to determine how to make some adjustments to the current path of development, whilst still achieving economic gains without investing in high cost or badly conceived solutions.

CHAPTER 4

MITIGATION OPTIONS - ENERGY, TRANSPORT, FORESTRY AND WASTE

INTRODUCTION

The energy, transport and forestry sectors are important as the economic backbone of the country. The different types of waste (solid, liquid and hazardous) as by-products of different sectors, including energy, transport and forestry, require urgent attention to reduce the emissions of GHG. For the people of PNG to seriously mitigate the impacts of climate change and variability so that their actions have long term environment and economic sustainability; identification of range of mitigation and adaptation options especially the "non-regrets" types should be given priority.

In Papua New Guinea, the options to use forests as a major sink is quite obvious, with large tracts of forests still intact and the potential for establishing reforestation and afforestation needs to be explored. The use of intact forests for mitigation GHG emissions would also enhance PNG's approaches to conserving its unique and very rich biological diversity. Similarly, the options for use of biomass, biogas, hydro-power, etc., from the available resources in the country needs to be considered.

Presented below in Table 4.1are some important mitigation options in the energy, forestry, transport and waste that have been identified. However, no analysis of mitigation option measures were not done due to lack of data. Some activities/programmes are currently being implemented to reduce GHG emissions and to cope with the climate change and extreme variability signals. The government (provincial), landowners and private groups ought to assess the potential of these mitigation options and develop them as programmes for the country.

Table 4.1: Energy, Transport, Forestry and Waste Mitigation Options.

Energy Mitigation Options	
Mechanism	**Constraints and Opportunities**
Promote the widespread use of renewable energy and the efficient use of conventional energy.	The provincial/national governments need to explore new and efficient technology to replace conventional ones. In addition, research is needed into the renewable energy such wind, solar power, more hydro schemes, and biofuels. Use of the Kyoto Protocol and its initiatives to support renewable energy and transfer of technology in country.
Encourage agencies involved in agriculture, fisheries, trade and industry to develop programmes that address fuel import replacement.	Most people are unaware of the economic implications of fuel importation. Thus there is a need for more research, education and public awareness to look at alternatives to energy fuel. Exploiting natural energy resources like gas, oil, solar, wood, ethanol and wind to reduce fuel important quota. Other options include the introduction of a carbon tax on imported fuel.
Incentives such as duty free privileges, tariffs and tax exemptions for pioneering industries	The Petroleum and Energy Ministry need to address these types of incentives. Incentives are needed which allow private sectors and village communities to be able to afford new energy efficient technologies.
Facilitate the development of Emission GHG Factors	There are difficulties in calculating the GHG levels in the country for the GHG Inventory. To make the inventory as comprehensive as possible, there is a need for research to determine the emission factors for forestry and land use/agriculture.
Lowering energy consumption through demand-side management energy efficiency and conservation programmes	This has been carried out in other countries but it may be useful for PNG to apply energy auditing, green labeling in home appliance/offices, tax refunds and consumer education. This will impact on the current policies and measures.
Policy/regulations to incorporate climate change and Variability	Currently there is no climate change policy included in energy policies. Because of future climate change impacts on energy sectors, the policy needs to reflect this issue. E.g. Develop national oil contingency plan
Information and Awareness on Renewable energies	There is lack of information on renewable energy, labeling schemes and efficient audits. The need for public awareness and training programmes is essential for the energy sector. Use of regional organizations for training and capacity building.
Data centralized for future GHG Inventories	During the GHG Inventory exercise, the data for both energy and transport sectors were not readily accessible or in the right format. Many of the industries and government departments were not aware of the importance of the UNFCCC treaty and its linkages to their sectors. Consideration should be given to centralizing the data or making them available on a distributed network.
Equipment and/ Technology supply	Affordable and efficient appliances, with supplies and parts being difficult to obtain is a constant problem. This would be rectified with monitoring and proper procedures are put in place.

Transport- Mechanism	Constraints and opportunities
Transport sectors need to introduce Tax incentives to all petroleum and size of vehicles	To reduce as much emission and $C0_2$ level, transport sectors will need to create initiatives such as carbon tax on all petroleum; tax vehicles according to size and give exemption to non- fuel consuming transport system.
Need to create subsidies for public transport systems	With so many vehicles already in crowded towns, the attraction for subsidies to public transport, use of efficient cars and non-fuels consuming transport system must be encouraged.
Policy and regulations	With the already increased air pollution and increasing emission level, new policies/regulations must be introduced for engine sizes and ban vehicles with high emission levels.
Technology and Equipment Transfer	For large towns in the country and the pressure on finance and creating air pollution in the country, public transport vehicles must encouraged to benefit all.
Training and education and awareness	Generally the people are not aware of the importance of transport sector and fuel consumption and air pollution. There needs to be more public education, training and awareness on this sector

Forestry- Mechanism	Constraints and Opportunities.
Introduction of Tax incentives	The country's forest is an important resource and needs to be better managed at the community and provincial level. In order to continue with better practices, new initiatives like creating tax concessions to forest sectors or sell emission offset rights are needed.
Subsidies for Forestry sectors	The communities and landowners own large forestry areas but lack finance and research capacity to better manage their resources. The need for research organizations and government to assist in providing free seedlings and support to improve their roads is necessary.
Policy and Regulation	It was realised that during the GHG Inventory exercise, the Forestry department was not aware of the importance of the UNFCCC/Kyoto protocol and how national policies has not reflected any obligations of these treaties. In order to benefit from these treaties, the forest policies need to account for climate changes programmes.
Research and Development	The results from the GHG Inventory for Forestry revealed some problems on lack of data in forest types, inappropriate data format, inappropriate emission factor used in GHG calculations, and data on carbon dioxide and nitrous oxides interactions between soils and forestry were important but not readily available. The need for urgent research to address these areas to up date the next Initial National Communication is a priority.

Integrated Forestry Management Approach (Agro-forest Management)	Land and forest disputes between landowners/Provincial governments and outsiders is a hindrance to management of forestry initiatives. Initiatives under Integrated Forest Management or Agro-forest Management can benefit small provinces and communities with limited land area. In addition, forestry and land management approaches should targeted to reducing emission of GHGs.
Carbon Sequestration Initiatives	Due to financial constraints a lot of mono-plantations in the country are slowly diminishing. Under the UNFCCC/Kyoto protocol and its financial mechanism the country could stand to benefit in the long term. Those provinces with much land and plantations (pines, teak, mahogany trees) should look into carbon sequestration initiatives. With large mangrove areas along the coast of most provinces, special efforts to develop the programme is essential for adaptation and mitigation measures.

Waste – Mitigation Options	
Mechanism	**Constraints and Opportunities**
Raise priority of waste management In PNG	The government, its provincial governments and private companies need to be involved to effectively address these issues.
Revise waste management legislation and guidelines, particularly for hazardous waste	There are two aspects to the management of hazardous wastes in the country. Firstly, there is the problem of dealing with accumulations of waste or unwanted chemicals or hazardous materials, which are in storage in the absence of any organized disposal programme. Secondly, there are the situations where contamination of soil or groundwater has occurred. This may be due to accidental spillage and leakage of stored chemicals or deliberate burying in an attempt to dispose of material. Special care and practices are required to deal with wastes such as batteries (vehicle, and small household), waste oil, pesticides, medical waste, paint and solvent, industrial waste (timber treatment and processing, mining processing), transformers (PCB) and septic tank cleanings.
Strengthen environmental monitoring and enforcement	Most industries in the country have some sort of treatment and disposal systems, but there is little information available, particularly discharge monitoring. Government authorities need to have more control over discharges to minimise adverse effects to the environment.
Improve waste conservation infrastructure	Capital intensive; would require outside funding and technical expertise to implement.
Initiate education on recycling, composting and waste reduction programs	Wastes should be collected, stored and removed from the country for safe disposal or recycling overseas. However there are substantial costs and logistical problems in this approach.
Identify waste site areas	The search for environmentally safe and socially acceptable areas to dispose of wastes is an unending problem faced by all the towns and villages. No one wants a dump located in his or her "backyard". All too often mangrove areas, oceans, rivers and/or

	beaches become landfills by default. Export of wastes should be in accordance with international conventions.
Education, Training and awareness	Waste is priority issue for the country and its towns and villages, especially cleanness and health reasons. The importance of public awareness, training and education for the whole country must be given priority.
Integrated Waste Management	The different types of waste (solid, liquid and hazardous) introduced into the towns and villages are long term concern. Any waste management programmes implemented should be integrated with other sectors like water, coastal, agriculture and environmental ones. Reduction of emissions of GHG in the waste areas is any important component of the plan.

CONCLUSION

There are a range of mitigation options but these are not necessarily currently realised by government, industry or communities. Mitigation options need not be capital intensive but can involve low impact and low cost technologies or management practices not too different from those currently in use.

CHAPTER 5

SYSTEMATIC OBSERVATION AND RESEARCH

INTRODUCTION

The GoPNG and it's scientists have realised the importance of climate change and are now coordinating and implementing programmes/activities to improve their understanding of the science, impacts and adaptation measures of climate change and variability. The country is also committed to implementing its obligations, which often have a strong research or information component under the following international treaties: United Nations Framework Convention for Climate Change (UNFCCC) and the Kyoto Protocol, Convention of the World Meteorological Organization, the Vienna Convention and Montreal Protocol, and the Convention to Combat Desertification and Agenda 21. The implementation of these treaties is usually at the national level in partnership with other bilateral and international organizations.

PNG is fully involved in the activities and programmes of the following organizations:

- Intergovernmental Panel for Climate Change
- World Climate Program of WMO
- UNFCCC/Kyoto Protocol financed through GEF
- Montreal Protocol programmes
- United Nations Environment Program
- UNESCO/Intergovernmental Oceanic Commission (IOC)
- United Nations Biodiversity Convention

These are well established organizations and institutions who are committed to improving the understanding of the science of climate change and variability. Funding from the GEF has enhanced studies and increased capacity building to address the issues such as the GHG Inventory, impacts, vulnerability and adaptation and mitigation options.

DATA COLLECTION, SYSTEMATIC OBSERVATIONS AND INSTITUTIONS.

The PNGNWS has a national responsibility for climate and weather forecasting. The basic and essential functions of a National Meteorological Service can be summarized as follows:

- To plan, implement, operate and maintain surface and upper air observing networks over its territory;
- To provide and maintain systems for the collection, and quality control of observational data and their processing in support of meteorological research, the provision of real time weather and climate services, and assembly of a national climate record;
- To advance meteorological science and the development and improvement of its operations and services through supporting research and development;
- To provide a range of weather information, forecast and warning services to the community at large, usually through the mass media;
- To provide a range of sector-specific operational meteorological services through the mass media and through other channels to major user groups such as agriculture, shipping, aviation and national defense;
- To keep and maintain a national climate archives and the provisions for climate data and climate monitoring and prediction services;
- To provide advice on meteorological and climatological matters to other government agencies and to its national community;

- To fulfill its obligations under regional and international conventions such as the SPREP Convention, the Convention of the World Meteorological Organization, the United Nations Framework Convention on Climate Change, the Vienna Convention, and the Convention to Combat Desertification and Agenda 21.

The PNGNWS has been the main institution involved in researching climate and weather. However, with the recent interest at the international level on climate change and variability and its potential impacts on the country's economy and its people, there is now a strong shift by the institutions to work with all national and international organization to address this issue. The following institutions are involved in research in climate change, variability and sea level rise issues.

BILATERAL, REGIONAL AND INTERNATIONAL

Some of the partners involved in climate related research in the PNG include, the World Meteorological Organization (WMO), South Pacific Regional Environment Programme (SPREP), South Pacific Applied Geoscience Commission (SOPAC), Secretariat of the Pacific Community (SPC), Australian Government (AusAID and Bureau of Meteorology), Israel Government on impacts of agriculture and the USA (Energy Department).

NATIONAL INSTITUTIONS

The following government department and non-government organizations are involved in related research on climate change matters:

OEC, Department of Energy and Petroleum, UPNG, UOT, National Forestry Institute (PNGFRI), Transport Department, PNGNFA, NARI, National Fisheries Authority, Nature Conservancy, Foundation of the South Pacific, World Wildlife Fund and Greenpeace.

RESEARCH PROGRAMMES

PNG network of meteorological stations in the country involves other partners in collecting, arching and managing the data and information on climate change, variability and weather. There are number of important research programmes in the short to long term being undertaken in the country. These have been established and coordinated in the following areas:

METEOROLOGICAL SERVICES SYSTEMATIC AND OBSERVATIONAL NETWORKS

The PNGNWS has about 95 professional and technical staff to manage its programmes in 13 meteorological centers around the country. It is from these centres that data are continuously collected, collated, archived and disseminated throughout the country, regional and international bodies, especially the WMO. Plans to increase the number of meteorological stations are underway. It recently re-commissioned its upper air program in Port Moresby, in addition to the Momote Upper Air Program operated by the TWP/ARM programme in Manus.The surface observing programme continues to operate with support from satellite imaging system to provide low-resolution data both for general and aviation weather forecasting purposes. An EMWIN system provides alternative access to a range of weather information for national and international presentation. Climate services, in which almost all available professionally trained meteorologists are involved, is well developed and coupled to the CLImate COMputing (CLICOM) applications.

The institutions involved in implementing and co-ordinating two international research programmes with PNG are:

i) Measurement of GHG signals in the oceans/seas in the country and the Pacific region, in detecting sea level rise, funded by Australian government since 1999;
ii) Measurement of solar radiation in the ocean, clouds and the islands of the Pacific, financed by USA Department of Energy since 1996.

These programmes are addressing the global climate change issues and data is made available to IPCC process and international communities, especially in improving their climate change models and scenarios.

The main users of meteorological services are the general public, the media, aviation, marine, disaster management (severe weather, including drought), agriculture, forestry, mining, petroleum, energy, water resources and tourism sectors.

INFORMATION GAPS

- Lack of quality data and collection
- Early storm surges warnings
- Early predictions of El Nino and La Nina signals

SPECIFIC CAPACITY NEEDS

- Education and awareness
- Training and technology upgrades
- Network and data transfer capabilities

DISASTER MANAGEMENT

The country is very vulnerable to the effects of climate change and natural and man made hazards, such as cyclones, storm surges, high abnormal sea tides, floods, fire, mining activities and droughts. These events are very much linked to the climate change impacts on the country and its people and are now being an area of priority for the government to address. A national Disaster Management plan is in place to enable correct response options to be executed.

To enable resilience and adaptation strategies to be implemented, the following information gaps and capacity needs have been identified as 'no regrets' approach to deal with disasters.

INFORMATION GAPS.

- Lack of information on vulnerable areas/sites
- Lack of information on the ocean circulation and tides
- Lack of information on water/rivers and drainage systems

SPECIFIC CAPACITY NEEDS.

- Lack of early warning systems
- More education and awareness
- Training on new technology
- Training of human resources

AGRICULTURE AND LAND USE

Both the PNGNWS and the Agricultural Ministry are developing adaptation options and research to address the climate change, variability and natural disasters in the country. The National Agriculture Research Institute (NARI) based in Lae, Morobe Province is the leading research institution involved in improving the quality and production of crops (coffee, tea, coconuts, cocoa), livestock, soil erosion and farming systems. Current studies include research into cultivators of vegetables and root crops (sweet potatoes) which have increased tolerance for drought and climate variability, waterlogged conditions, pests and resistance to disease. NARI has also mapped out the country in different agro-ecological zones, which is useful for future adoptation under climate change.

The following are some information gaps and capacity needs identified in this sector.

INFORMATION GAPS

- Lack of data on new cultivators
- No emission factors determined
- Lack of data on crops to address natural disasters response options
- Lack of GHG gases impacts on crops production

CAPACITY GAPS

- Lack of appropriate technology/tools
- Public awareness and training

FISHERIES AND MARINE RESOURCES

PNG has a declared Fishing Zone of some 2.3 million square kilometers. Large volumes of fresh water runoffs, which are saturated with high nutrient loads, makes its way to offshore areas where upwelling dramatically increases the productivity of the ecosystem. This zone supports large fish populations ranging from tuna, sharks and mixed reef fishes.

Research on the impacts of climate change and variability combined with production of high nutrients on tuna and coral reef ecosystems are being carried out by OEC, UPNG, Secretariat of the Pacific Community (SPC), and the Institute for Research and Development (New Caledonia). Meteorological and oceanographic data could be linked to model different scenarios to help better understand and manage the fishery resource and its dynamics (see Figure 5.1).

The following are some information gaps and capacity needs identified in this sector:

DATA GAPS

- Lack of data on national fishing effort and yields
- Lack of understanding of the fishing impacts on habitats
- Lack of understanding of food relationships and impacts of climate change.

CAPACITY NEEDS

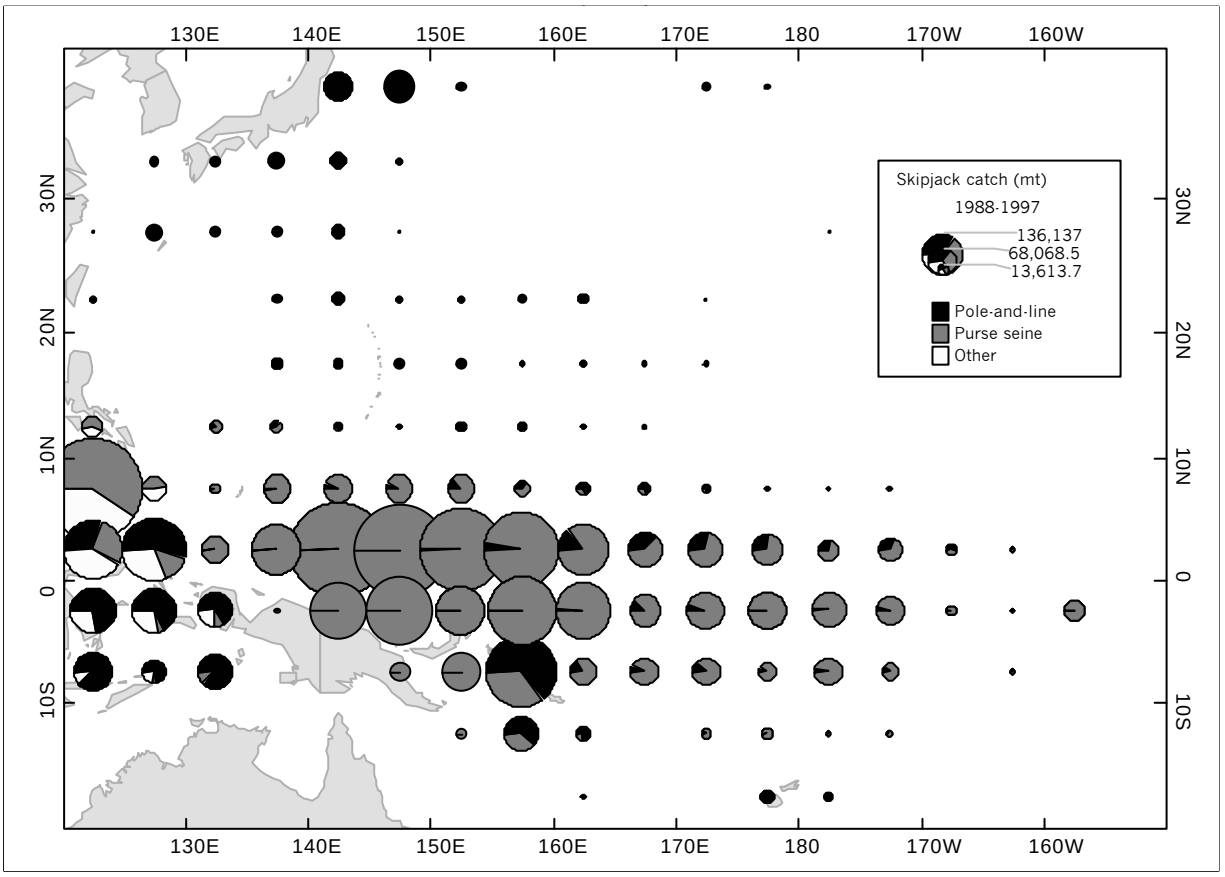
- Education and awareness
- Training of human resources
- Fisheries courses at tertiary levels
- Lack of financial resources to continue with research programmes

FORESTRY

The forest types in PNG, especially the lowland rainforests are different in many ways and much diverse from other forests in the country. In addition, there are different types of forest found in the highlands, coastal areas and the island provinces of the country. The impacts of climate change and variability on the forestry in the country has now being investigated after the 1997/98 El Nino coupled with the long drought. The forest in provinces of the New Guinea islands were affected the most during this period.

The Forestry Ministry through its Research Institute in Lae (PNGFRI), Morobe Province, (UPNG) and the (UOT) are the main institutions in the country under going research in the Forestry sectors. Their research includes identification of new species of trees/plants, cross breeding, re-vegetation of old mine sites and collection and archiving of data in a central location.

Figure 5.1 Skipjack catch during the El Nino period and how climate change and variability can influence the productivity and catch (Source: SP Fisheries Forum).



In addressing the climate change and improving the GHG inventory calculations, the OEC and the UPNG are in the process of determining the emission factor for Forestry in the country funded UNDP and GEF.

There are number of information gaps and capacity needs identified under this sector.

INFORMATION GAPS

- Lack of data on growth rates of the forest
- Lack of quality data in calculating $C0_2$ emissions and sinks from the forest.

- Lack of data on forestry and soil types.

CAPACITY NEEDS

- Training of human resources
- Education and awareness

FUTURE RESEARCH

More targeted research is needed to address the science, impacts, adaptation and mitigation of climate change and should include:

- Determination of emission factors is assisting the calculations of GHG inventory
- Effects of $C0_2$ fertilization on crops growth, development and productivity
- Calculations of sinks and sources from the forestry, land use change and agriculture
- Identifying traditional adaptation options
- Renewable energy sources
- Better understanding of EL Nino impacts on the country's economic sectors
- Relationship with fish catch and climate change and variability
- Relationship of oceans, solar radiation and clouds
- GHG signals in the oceans and sea level rise
- Impacts of climate change on cultural and traditional aspects
- Effects of Ozone and climate change of human health
- Development of Integrated coastal area management
- Relations between climate change and coral bleaching
- Technology transfer
- Soft and hard adaptation options

CONCLUSION

There are critical information gaps and uncertainties, which must be addressed in order to better understand and properly apply vulnerability and adaptive measures in PNG. A network of climate change observation systems have been established around the country, but these may not be enough to fully appreciate the scenarios under climate change, climatic variability and sea level rise in the next 5 to 50 years. Even in the international arena, there are relatively few resources being devoted to relevant empirical research and observations, which could be applied to the PNG circumstances.

Climate change, variability and sea level should be the priority areas of interest for PNG. However for this to occur, human resources and capacity building is needed to facilitate the understanding of the science, impacts and adaptation options on climate change, particularly for policy development and planning.

CHAPTER 6

EDUCATION, TRAINING AND AWARENESS

INTRODUCTION

In 1990 and 1995, scientists from the IPCC worked on ways to reduce or minimise the uncertainties in differentiating between the greenhouse energy signals and natural climate variability; the magnitudes of the potential impacts of sea level rise. They determined that climate change is serious and action must be taken now (even where all the data are not available) in order to manage the risks.

Since 1989, the PNG Prime Minister and his colleagues from the Forum Island Countries also agreed that sea level rise and climate change is one of the priority issues affecting the coastal areas and atoll nations of the region. However, they also recognize that the national capacity to deal with these problems whilst stimulating economic development are limited by traditional land management systems, unique population dynamics, the complexity and vulnerability of islands' ecosystems, limited natural resource bases, and heavy reliance on foreign aid. Having ratified the UNFCCC and signed the Kyoto protocol, the country will need resources to fulfill its international obligations. At the national level, education, training of human resources and public awareness programmes/activities will set the platform for the government to address the climate change and achieve sustainability in the long term.

Through the efforts of the UPNG in 1989, a Climate Change Coordination Group consisting of representatives from government ministries was formed to advise the government on the climate change and sea level issues. The OEC was then given the responsibility to the coordinate all programmes and activities on the issue.

Since then, the tertiary institutions and some Government Ministries (especially, Foreign Affairs, Civil Aviation and OEC) are generally aware of the climate change and variability activities. These institutions have made some attempts to educate, train and raise awareness on the issues as part of their programmes with some major constraints especially with financial and human resources support. Further, these institutions have commenced working on policy to address the issues of climate change and sea level rise.

While limited training, education and awareness are conducted in the government offices and the tertiary institutions, the majority of the population of the country have little knowledge of climate change and variability, its implication and consequences to them and the country as a whole. Therefore special efforts will need to be made through education and awareness to ensure that the people are aware of the impacts of climate change and variability to be able to adapt to these situations.

ACTIVITIES

From 1991,the country has been able to attract bilateral and regional climate change funding to implement their education, training and public awareness activities through several initiatives including:

- The South Pacific Sea Level and Climate Monitoring Project funded by the Australian government
- The Atmospheric Radiation Measurement Project, funded by USA
- World Meteorological Organization
- Australian Bureau of Meteorology

- Climate and Agricultural Project funded by Israel
- South Pacific Regional Environment Program.

Through these projects and programmes, the government has made some efforts to include climate change in some provinces (Manus and Central) and national educational curriculum. Some activities include: school visits, public displays, training primary and secondary teachers on climate change modules, public campaign, daily climate and updates, newsletters, media and public awareness in schools.

The UPNG and PNGNWS are the two main institutions which offer formal education training courses to address the climate change and sea level rise.

INFORMAL EDUCATION

To raise awareness on the climate change and variability is a challenge in the country where illiteracy rate is very high, and informal education activities will be the most effective method of discussing and creating interest and awareness. This should include the following activities:

- Use of Television programmes
- Weekly articles on newspaper
- Mitigation and adaptation awareness campaign in private and village communities
- Use of University students to annually raise awareness in the provinces and villages
- NGOs to promote and raise awareness through community discussions.
- Annual international occasions such as World Environment Day and the World Water Day

While formal and informal education and training are being implemented, the number and role of NGOs in the country is an important vehicle to raise awareness on the climate change and variability. Partnerships with the government (especially provincial), schools and NGOs are important to share and disseminate information on climate change, variability and sea level rise and its consequences on the lives of the people.

CONCLUSION

The current knowledge and understanding of climate change, variability and sea level rise poses tremendous challenges to the country's environment, economy and the comfort of its people in the long term. Improving the understanding and communicating of the science, impacts, adaptation and mitigation of climate change and variability through the education, training and awareness will facilitate appropriate policy developments in this area. One way to do this is to set up a sustainable development network that links NGO and community based initiatives around the country. Such as awareness raising, needs assessment, project planning, leadership skills, etc., to provide better access to resources and information.

CHAPTER 7

PROJECTIONS, POLICIES AND PLANS

INTRODUCTION

The environmental legislation of PNG provides for environmental planning measures to be included as an integral component of project planning for developments with significant environmental risk. Specific areas covered by the legislation include mechanisms for licensing of contaminants discharged into the environment as well as planning and regulating the use of water resources. An Environmental Bill, still in draft form, provides statutory tools, procedures and processes to enable local and provincial governments to formulate by that are within the object of the Act. Environmental codes of practice and guidelines provide a means to define practices for specific sectors, including hydrocarbon storage, oil palm processing, roads and bridges, landfill and sewage.

With the redirection of funding to the provinces, government organisations responsible for the environment such as OEC now only retain the responsibility for policy and technical advisory support. Like all other government agencies, the OEC has been restructured and its activities streamlined, incorporating ways and means of increasing revenue.

POLICY DEVELOPMENT GOALS IN THE AREA OF CLIMATE CHANGE

COASTAL AND MARINE AREAS

- Protection of critical ecosystems
- Protection of towns and assets
- Land use policies
- Control of erosion

WATER RESOURCES

- Water resource management
- Catchment management
- Alternative water supply
- Flood control

AGRICULTURE AND FORESTRY

- Community sustainability programmes (e.g. in involving landowners with spin-off and non core activities)
- Sustainable production systems
- Research
- Land Use policies

HEALTH

- Control of diseases, particularly vector borne diseases such as malaria and cholera
- Poverty reduction

FISHERIES

- Stronger regional collaboration
- Modeling and research
- Fleet management
- Development of a fishing industry that is internationally competitive, generates employment, expands local food supplies and reduces imports.

TRENDS AND POLICY MEASURES

FUTURE POPULATION TRENDS

- Increasing population density, especially in urban areas, Highlands, East Sepik and East New Britain Provinces as well as some other coastal areas, flood prone areas and marginal lands.
- Greater social demand for services such as health, education and job creation
- Land area per person will continue to decrease, especially in urban centers
- Increasing infrastructure
- Changes in demographic profile with a large youthful population base, more alienated from traditional structures, with different standard of living expectations.

POLICY MEASURES

- Reduce population growth and maintain it at a sustainable level and assess requirements for future levels of public service and infrastructure.
- Increase spacing between birth to realize health and welfare benefits to women and children
- Conduct public information and awareness campaigns, improved primary care services, increased counseling and improved contraception.

FUTURE ECONOMIC TRENDS

- Subsistence agriculture will continue to be important
- Continued dependence on natural resources and foreign aid.
- Growing indebtedness likely to increase pressure on natural assets
- Revenue base insufficient to meet planned expenditure
- Possible higher returns from offshore pelagic fish stocks.

POLICY MEASURES

- Organic Law which will bring about greater decentralization of powers, resources and responsibilities to the Provincial and Local Levels of governments.

FUTURE ENVIRONMENTAL TRENDS

- Environmental degradation in densely populated areas
- Increase in deforestation
- Increase in problems of waste disposal
- Lack of adherence to sustainable parameters in natural resource use leading to increases in rural impoverishment.

POLICY MEASURES

- Increased outsourcing of conservation initiatives and some responsibilities to NGOs and local communities.
- Strengthening of the OEC through training of staff, review of the various Acts, design of policy guidelines for environmental monitoring and legislation and enforcement processes.
- Development of specific policies such as the National Environment and Conservation policy, NGO - OEC Partnership policy, which aims to guide cooperation between the two parties in order to maximize benefits to landowners. The National Biodiversity Strategic Action Plan and PNGBioNET research programmes, which are aimed at protecting and using plants and animals on an ecologically sustainable basis should be promoted and supported.
- Enactment of the Environment Bill.
- Introduction of a moratorium on all new forestry licenses, extensions and conversions and to review all existing licenses, that logging practices are carried out in a sustainable way and that all landowners get their fair share of benefits from resource use.

FUTURE SOCIO-CULTURAL TRENDS

- Highly skewed income distribution and social problems, especially in urban areas
- Increase in preference to imported foods
- Increases in non-communicable diseases with nutritional and lifestyle changes

POLICY MEASURES

- Future application of social impact assessment

CONCLUSION

In light of predicted impacts of climate change such as the flooding of low-lying islands and lowland areas, the possible increase in frequency and intensity of strong tropical cyclones, heavy rainfalls, etc., the following political and economical strategies should be taken into considerations, not only within the country, but also within the Pacific region:

- Increase efforts to strengthen the abilities of local institutions and communities to effectively deal with climate change impacts, including other social and economic development issues;

- Increase in the amount of responsibility and degree of authority given to regional and international institutions, and key national communities which are in a better position or are more capable of administering the affairs of island communities that are more likely to suffer social and economic impacts brought about by climate change;

- Increase efforts to develop more effective systems of extracting and sharing resources and experiences within and between island states at all levels. This is especially important in the provision of basic services for people who may migrate away from low-lying islands and lowland areas, which would be at higher risk from the impacts of sea level rise.