

The priority environmental concerns of Papua New Guinea

By Stephen Nicholls

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ACRONYMS

ANU	Australian National University
AusAID	Australian Agency for International Development
BIORAP	Biodiversity Rapid Assessment Project
BOD ₅	5-day Biochemical Oxygen Demand
CBO	Community-Based Organisation
CFCs	Chlorofluorocarbons
CI	Conservation International
CM	Conservation Melanesia
DAL	Department of Agriculture and Livestock
DEC	Department of Environment and Conservation
DoH	Department of Health
DoM	Department of Mining
EEZ	Exclusive Economic Zone
EFB	Empty Fruit Bunch (Oil Palm)
EIA	Environmental Impact Assessment
FCD	Foundation for Community Development
FFA	Forum Fisheries Agency
GEF	Global Environment Facility
GHU	Greenhouse Unit
GIS	Geographic Information System
HazMat	Hazardous Materials
ICAD	Integrated Conservation And Development
ICWM	Integrated Coastal and Watershed Management
ILG	Incorporated Landowner Group
IWP	International Waters Programme
MICAD	Marine Integrated Conservation And Development
MMCZ	Marine Management and Conservation Zone
MPA	Marine Protected Area
MSDS	Material Safety Data Sheet(s)
NARI	National Agricultural Research Institute
NCDC	National Capital District Commission
NFA	National Fisheries Authority
NFCAP	National Forestry and Conservation Action Programme
NGO	Non-Governmental Organisation
NRI	National Research Institute
NZODA	New Zealand Overseas Development Agency
OCM	Oceanic Fisheries Management
OLPLLG	Organic Law on Provincial and Local-Level Governments
PEC	Priority Environmental Concerns
PIC	Prior Informed Consent

PINBIO	PNG Institute of Biodiversity
PNGFA	Papua New Guinea Forest Authority
PNGRIS	Papua New Guinea Resource Inventory System
POME	Palm Oil Mill Effluent
POP	Persistent Organic Pollutant
RCF	Research and Conservation Foundation
SAP	Strategic Action Programme
SPC	Secretariat of the Pacific Community
SPREP	South Pacific Regional Environment Programme
TNC	The Nature Conservancy
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
UPNG	University of Papua New Guinea
VDT	Village Development Trust
WMA	Wildlife Management Area
WMO	World Meteorological Organisation
WWF	World Wide Fund for Nature

EXECUTIVE SUMMARY

This report discusses the major environmental threats associated with the main development sectors in the country and identifies ten principal environmental issues that encompass this range of threats. The report examines the causes of these issues, and assesses the effectiveness of the efforts (termed “responses”) that have been made so far to address these. Some underlying (“root”) causes that are common to many of these issues are identified and serve to explain, at least in part, why the responses to date have been less than entirely effective. The report then goes on to examine a number of strategies and measures that could be adopted in the future to address these ten principal environmental issues in a more effective manner by addressing these “root” causes.

The final chapter assesses the magnitude and significance of each of these principal environmental issues, taking into consideration the causal relationships and linkages that exists between them, in order to arrive at a priority ranking for each of the issues. The connection between these issues and the IWP focal areas is then discussed.

Information, comment and opinion, and other input to this report were obtained from a wide range of environment stakeholders within and outside government. The methodology included direct interviews, a questionnaire survey and a one-day workshop on “Papua New Guinea’s Priority Environmental Concerns” held for stakeholders in Port Moresby on 29th November 2002.

Papua New Guinea’s Priority Environmental Concerns are, in order of ranking:

1. Declining Water Quality in Rivers and Coastal Waters;

Although there is a lack of hard data, there is a general consensus that increasing development around the country is resulting in more solid and liquid wastes and soil sediments (from stormwaters and runoff from exposed ground surfaces) entering the rivers and coastal waters, causing deterioration in water quality. This deterioration is most evident in the increasing amounts of domestic rubbish, particularly plastics, which are now commonly seen in many rivers and along shorelines. There is also some evidence, mainly anecdotal, that increasing siltation and eutrophication (nutrient and organic enrichment) of downstream catchments and coastal waters are affecting values such as potable water quality, biodiversity and ecological productivity. The extent to which toxic materials are a significant component in this deterioration will vary from catchment to catchment, but a more accurate assessment of national conditions is limited by a lack of data.

Except for the actions of a few large corporate entities, there is little or no control over waste and surface runoff discharges. This appears to be due to a lack of public awareness of the issue and the low priority given to environmental concerns by the public, municipal and local government authorities and small to medium scale industrial enterprises. The problem is exacerbated by the inability of regulatory agencies to enforce compliance to water quality standards and discharge conditions, and a lack of environmental monitoring and management of the nation’s rivers that results in a lack of data for assessment purposes.

On the basis of the widespread and frequent occurrence of this issue, and its key role in mobilising pollutants and disseminating impacts over a wide area, this issue has been rated one in priority ranking.

2. Increasing Environmental Risks from Hazardous Materials and Wastes;

The country’s development has seen a rapid growth in the amounts and distribution of hazardous materials and wastes in recent years. This applies not only in the urban centres and development enclaves of the country, but increasingly in rural areas where environmental problems are arising from the increasing amounts of domestic and small-scale industrial wastes being produced, and the increasing pressures on traditional sanitary systems. Although the corporate operations in urban centres and development areas are generally well monitored and controlled, the monitoring and regulation of hazardous materials and wastes outside these few areas is practically negligible.

Untreated or partially treated sewage, domestic wastes (particularly plastics), industrial wastes such as waste oils and solvents, other toxic residues and contaminated wash-waters, are frequently disposed directly into natural waters, or at inappropriate sites where they are easily carried into waters through surface runoff, flooding or groundwater seepage.

As with (1) above, a lack of public awareness and the low priority given to environmental concerns, together with the inability of regulatory agencies to monitor and enforce compliance with hazardous materials management codes and waste discharge standards, means that this issue remains an increasingly critical concern.

As the current rate of increase in hazardous materials usage and waste generation is unlikely to lessen in the coming years, there is an urgent need to take action now to address this issue before significant and more widespread environmental damage results. For this reason, this issue has been assigned second in order of priority ranking.

3. Inadequate or Unsatisfactory Water Supplies;

In the rural areas, traditional natural water supplies are coming under increasing threats from the greater demands, particularly multi-use demands, placed on them. Rising rural populations and the per capita use of water are increasing abstraction rates, whilst increasing waste and sediment loads are entering many of these waters as a result of waste disposal (see above) and development in the area.

Most of these areas are remote from government services and have little or no access to environmental advice or assistance. In the absence of this, the problem continues to grow, and until the level of environmental awareness amongst the local people themselves can be improved, the situation will continue to deteriorate with increasingly severe consequences on public health.

In many urban and peri-urban areas, recent rapid growth in population as a result of urban migration has greatly increased the demands on water supply and sanitation facilities. Although in the zoned residential areas water supply is generally reasonable, in the settlements of the peri-urban areas water supplies are usually inadequate (a few standpipes serving many households) or effectively non-existent due to a lack of maintenance and/or lack of water pressure due to too much demand. In these areas a lack of water supplies is a major contributor to various health problems.

In view of the human dimension to this issue, and its status as a basic human need that directly affects the sustainable development and livelihoods of Papua New Guineans, this issue has been assigned third in order of priority ranking. It is superseded by priorities one and two because safe and adequate water supplies can only be assured for the majority of Papua New Guineans, those living in the rural areas, if priorities one and two are addressed as a matter of priority in an effective manner.

4. Loss of Critical Habitats and Biodiversity;

Although there is much information on the flora and fauna of Papua New Guinea, and the habitats they occupy, this is widely scattered and not readily available to development proponents, regulatory agencies and decision-makers. There is a pressing need to bring this information together into a “central” reference archive that can be accessed by all who need it.

Critical habitats and biodiversity refers to those habitats and biodiversity values that are threatened by development or natural disaster and/or to which damage or loss would have a profound effect on the stability and viability of local ecosystems. Examples include many wetlands that provide vital feeding, breeding and nursery areas for many insect, fish, amphibian, reptile and bird species, mangroves and coral reefs which both provide spawning and nursery areas for many coastal and marine organisms, mature “emergent” forest trees which provide important roosting and nesting sites for many birds and provide niches for many *epiphytic* plants, notably orchids and *bromeliads*. Damage or loss of these habitats would have severe repercussions on the populations of many dependent species and disturb the dynamic balance of the food webs and other relationships that support the health and stability of the wider ecosystem.

Their damage or loss could also affect environment values that can impact directly on human developments and livelihoods. Wetlands act as important filters of surface waters, reducing turbidity and suspended solids concentrations through deposition and may reduce nutrient concentrations as these are assimilated by the wetland plants. Mangroves provide an important shoreline stabilisation function by anchoring and protecting shoreline sediments from wave and tidal erosion. Fringing coral reefs protect the coasts and shoreline from sea-swells and storm surges and provide calmer in-shore waters for coastal transport.

In a country like Papua New Guinea, where approximately 80 % of the population are dependent on maintaining the quality of their local environment to fulfil their basic needs, the importance of protecting critical habitats and the biodiversity they support goes beyond conserving the intrinsic biological value of these habitats.

Although development is putting increasing pressure on these habitats, a lack of public awareness and understanding of the risks to, and importance of these habitats is exacerbating these risks. The generally low priority given to environmental concerns and the lack of skills and resources provided to conduct effective environmental management and the monitoring of many developments in the rural sector, together with the inability of regulatory agencies to enforce compliance to acceptable practices, often results in unnecessary damage to these critical habitats.

Innovative approaches are needed, similar to those currently being conducted by several NGOs that are based on raising community awareness and local capacity building, if the principal risks to critical habitats and biodiversity are to be addressed in an effective manner.

This issue has been ranked fourth in order of priority. It is superseded by priorities one and two as declining water quality and poor management of hazardous materials and disposal of wastes are important causal factors in the loss of critical habitats.

5. Declining Coastal and Marine Resources;

There is a growing consensus of opinion that some coastal and marine resources, particularly those with an economic value such as *beche-de-mer* and some shellfish, are suffering a decline. The National Fisheries Authority has imposed catch restrictions on several harvest species, and work by several NGOs, mainly at the community level, also supports this approach.

The causes of the decline appear to be three-fold: over-harvesting of commercial species reducing target species population stocks, the use of inappropriate and/or destructive fishing methods resulting in high by-catch and damage to non-target species and habitats, and increasing pollution of coastal waters by river-borne materials and direct discharges.

Although the National Fisheries Authority has several Fishery Management Plans in place that regulate commercial operations, there is increasing concern about artisanal fishing, which is increasing as the demand for cash incomes grows. Given the widespread and often remote nature of artisanal fishing, regulation of these fisheries by the Fisheries Authority is less than effective, and several NGOs are attempting to fill this gap through community and local-government awareness and capacity building programs. These NGO programs have focussed on gathering information on the threats to habitats and stock numbers, the establishment of protected areas as stock reserves, and community education and awareness programs on appropriate fishing methods and sustainable management practices.

While there is little hard (quantified) data on deteriorations in coastal water quality, anecdotal evidence suggests deteriorations in coastal habitats, primarily from urban coastlines where land-based discharges would be expected to have some impact on the local coastal habitats. All commentators agree there is a pressing need for further information and hard data on these parameters, particularly in regard to deteriorations in critical coastal habitats such as coral reefs and mangrove stands.

As the causes of these deteriorations will need to be addressed at their source, this will require addressing priorities one and two above, and as declining coastal and marine resources can be considered as a subset of “loss of critical habitats and biodiversity”, this issue has been assigned a ranking of fifth in order of priority.

6. Increasing Land Degradation;

Some degree of land degradation results wherever land based development occurs, and this issue while generally localised within the development area, can extend much further through its effects on downstream water quality and hydrological regimes. .

Land degradation covers a wide range of effects of varying degrees of severity, ranging from the disturbance of soil nutrient balances and fertility, to the physical loss of soils through widespread surface exposure

and erosion. Varying degrees of damage result from all land-based development but these can be minimised through the application and use of sound agronomic practices and soil conservation techniques.

However, these techniques are frequently not applied effectively, particularly in the small to medium-scale development enterprises, with the consequence that the degree of land degradation is often more severe than need be. Although there are several environmental guidelines and codes of practice which contain relevant information, these are frequently not applied either through ignorance of the guideline or reflecting the low priority given to environmental concerns. This also reflects the lack of effective enforcement of compliance by regulatory agencies mentioned previously.

Raising public awareness of the issue and wider dissemination of appropriate practices and techniques, supported by local skills training and backed up by a local compliance monitoring and/or enforcement capacity, could improve the situation considerably. However, in the current situation of scarce resources, this would have to be achieved using existing government extension services to target community-based organisations, small-holder enterprises, infrastructure construction contractors and forestry operations. This will require a concerted and coordinated effort by the Department of Environment and Conservation and other line agencies to collaborate with provincial and local government extension services to develop and deliver these capacity building programs.

The development of an inter-departmental Land Management Policy could provide a framework for establishing this collaboration and developing cross-sectoral guidelines and codes of practice, and extension training programs, to address this issue.

7. Disturbed or Unpredictable Hydrological Regimes;

Although not given a high priority, this issue was seen by some survey respondents as an issue likely to be of increasing importance as the effects of climate change become more apparent. A lack of readily available and reliable long-term hydrological data makes the accurate assessment of hydrological regimes and the accurate prediction of flood and base flow levels difficult.

Government agencies, particularly provincial governments with their planning responsibilities, should utilise every opportunity to collect and collate into provincial databases hydrological data which may be available from a variety of sources including development project monitoring. This data should also be archived at a national level so that it is available for national planning purposes, particularly in regard to such strategic issues as planning adaptive responses to climate change.

In the absence of reliable predictive capability, a precautionary approach should be adopted to designing flood control measures and setting discharge conditions (which should be based on accurate base flow assessments). This could be incorporated as one of the components in the Land Management Policy referred to above.

8. Climate Change;

Papua New Guinea has recently established a Greenhouse Unit (GHU) within the Department of Environment and Conservation. This unit has begun to address climate change issues including the identification of appropriate response measures to address the country's vulnerability to climate change and how adaptation to climate change can be achieved. The Greenhouse Unit has also identified what can be done to abate greenhouse gas emissions.

Future strategies that will be pursued by the Greenhouse Unit include:

- Promoting cross-sectoral collaboration to develop adaptive responses to address climate change in an efficient and effective manner;
- The need to integrate climate change into existing and proposed sectoral policies and strategies in order to gain more efficient and effective delivery of these adaptive responses. As a case in point, climate change concerns should be integrated into any proposed Land Management Policy.

9. Air Pollution;

Air pollution is mainly restricted to urban areas and is caused by vehicle emissions, smoke from grass and refuse burning, a few industrial emissions, and dust and other aerial particulate matter from construction

works and landfill disposal sites. Although there is a lack of data, the concentrations are believed to be low and generally well below World Health Organisation standards and other assessment criteria. However, one or two industrial emissions outside the main urban centres have been reported as sometimes emitting dense clouds of black smoke, although apart from these anecdotal reports there do not appear to be any measurements or data relating to these incidents.

In the absence of data or substantive complaints, the issue of air pollution in Papua New Guinea appears to be relatively insignificant, and therefore air pollution is not accorded a high priority at the present time.

10. Noise Pollution

Noise pollution appears to be limited to very localised incidents in urban areas and is not regarded as a significant environmental issue at the present time.

Relevance of these findings to the IWP Focal Areas:

The four IWP Focal Areas are:

- Marine protected areas;
- Sustainable coastal fisheries;
- The protection of freshwater resources; and,
- Community-based waste reduction.

The relevance of these four IWP Focal Areas to each of Papua New Guinea's Priority Environmental Concerns is summarised below. The IWP Focal Areas are highlighted in bold.

1. Declining Water Quality in Rivers and Coastal Waters

Addressing declining water quality is directly relevant to **the protection of freshwater resources** and the **sustainability of coastal fisheries**, the habitats of which are *inter alia* threatened by declining water quality. As one of the principal causes of declining water quality is the quantity of wastes entering rivers and coastal waters, **reductions in the amount of community wastes** is likely to reduce this waste load, with beneficial effects on water quality.

2. Increasing Environmental Risks from Hazardous Materials and Wastes

The level of environmental risk from hazardous materials and wastes is increasing in communities throughout Papua New Guinea as the quantities and varieties of these materials increases. **Community-based waste reduction** programs that reduce the amounts of wastes in the local environment will lower the level of environmental risk. In riverside and coastal communities, wastes frequently enter the rivers and coastal waters, either directly or indirectly. Thus any reduction in the amounts of these wastes will also **protect the freshwater resources** and coastal habitats, which is vital to the **sustainability of coastal fisheries**.

3. Inadequate or Unsatisfactory Water Supplies

The **protection of freshwater resources** is a crucial component in any program to remedy inadequate or unsatisfactory water supplies, particularly in the rural sector. As one of the principal causes of declining freshwater quality is contamination by wastes generated within the local communities (see (1) above), **community-based waste reduction** programs would have direct relevance to improving the quality of local water supplies.

4. Loss of Critical Habitats and Biodiversity

Critical habitats and biodiversity are threatened by declining water quality, waste contamination and over-exploitation for commercial and/or subsistence purposes, amongst other risks. **Protection of freshwater resources, community-based waste reduction** programs, and the establishment of **sustainable coastal fisheries** will directly contribute towards reducing the loss of critical habitats and biodiversity in these areas. The establishment of **marine protected area(s)** will help mitigate any loss of marine habitats

and biodiversity by providing a reserve area from which recruitment to threatened or disturbed areas can occur.

5. Declining Coastal and Marine Resources

Over-exploitation of the coastal and marine resources and inappropriate harvesting methods can be addressed by an effective **sustainable coastal fisheries** program, particularly if this is augmented by the establishment of a **marine protected area**. The **protection of freshwater resources** (upstream of the coast) and **community-based waste reduction** programs can also mitigate the impacts that may be contributing to the decline of coastal and marine resources.

6. Increasing Land Degradation

One of the causes of land degradation is the contamination of soils and groundwater by wastes. A **community-based waste reduction** program would reduce the amount of contaminant material and, if accompanied by improvements in waste management practices, should result in a reduction in the rate of land degradation. As land degradation is a potential cause of degraded water resources (quality and quantity), a program addressing the **protection of freshwater resources** would need to consider the issue of land degradation in the catchment.

7. Disturbed or Unpredictable Hydrological Regimes

The **protection of freshwater resources** should include the mitigation of potential effects of disturbed or unpredictable hydrological regimes where practicable. Whilst it may not be possible to do anything practical to remedy the disturbance or unpredictability of the regime, measures could be designed and implemented to alleviate the effects. For example, flood avoidance measures such as relocation of houses and gardens, and alternative water supplies for low base flow conditions could be introduced, as well as other adaptive responses.

8. Climate Change

Given the time-scale that climate change appears to be operating at, and the current uncertainties of its specific effects at the local level, it is unlikely that community-level adaptations to climate change effects would readily fit into the current IWP community-based Focal Areas programme.

9. Air Pollution

Not directly relevant to any of the four IWP community-based Focal Areas.

10. Noise Pollution

Not directly relevant to any of the four IWP community-based Focal Areas.

Priority ranking of the four IWP Focal Areas for Papua New Guinea

Based on the linkages and relevancies identified above between the four IWP Focal Areas and the ten Priority Environmental Concerns, the priority ranking of the IWP Focal Areas in terms of their relevance and application to these concerns is, in order of priority:

1. **Community-based waste reduction;**
2. **The protection of freshwater resources;**
3. **Sustainable coastal fisheries; and of equal (third-place) ranking,**
4. **Marine protected areas.**

1.0 Introduction

1.1 The Strategic Action Programme (SAP) for International Waters of the Pacific Islands

The International Waters Programme is a 5-year program for the 14 member states of the Pacific Island Countries¹. The IWP is funded by the Global Environment Facility (GEF), implemented by the United Nations Development Programme and executed by the South Pacific Regional Environment Programme (SPREP). The Strategic Action Programme (SAP) for International Waters of the Pacific Islands was prepared in 1997 and identified its primary goal as the integrated sustainable development and management of international waters. This primary goal comprises of two complementary sub-goals.

- To assist Pacific Island countries improve regional capacity for management of trans-boundary water resources and create improved management structures to address environmental degradation and ensure the long term sustainability of ocean fisheries in the Western Pacific Warm Pool ecosystem.
- To improve the integration of environmental concerns into local, national and regional policy, and improve the water quality and the conservation of key coastal and ocean ecological areas.

The SAP defines international waters to include oceans, large marine ecosystems, enclosed or semi-enclosed seas and estuaries, rivers, lakes, groundwater systems, and wetlands with trans-boundary drainage basins or common borders. Thus for the purposes of this Programme, international waters extend from far inland to far out to sea, and include the water-related ecosystems and critical habitats associated with all these waters.

The SAP identified three priority trans-boundary concerns relating to International Waters.

- Degradation of water quality.
- Degradation of associated critical habitats.
- Unsustainable use of living and non-living resources.

The SAP, recognising that international waters in the Pacific region are subject to a number of threats that give rise to these trans-boundary concerns, focussed on the following four priorities.

- Pollution from land-based activities of marine and freshwater (including groundwater) sources.
- Issues related to the long-term sustainable use of marine and freshwater resources.
- Physical, ecological and hydrological modification of critical habitats.
- Unsustainable exploitation of living and non-living resources, particularly, although not exclusively, the unsustainable and/or inefficient exploitation of coastal and ocean fishery resources.

Each of these imminent threats affects each of the trans-boundary concerns, and requires integrated measures to address the concerns effectively. The SAP found that the ultimate root cause underlying these imminent threats related to deficiencies in management, in which it identified two subsets: governance and understanding. The governance subset is characterised by the need for mechanisms to integrate environmental concerns, development planning, and decision-making. The understanding subset is characterised by the need to achieve an awareness of the international waters environment through education and participation, which in turn will allow the successful development and implementation of measures to protect international waters.

In order to address the root causes of degradation of international waters, the SAP proposes targeted actions that will be carried out in two complementary component areas.

- Integrated Coastal and Watershed Management (ICWM).
- Oceanic Fisheries Management (OCM).

By using these approaches, the SAP aims to facilitate the transition from sectoral to integrated management of International Waters in the 14 participating member states.

The ICWM approach will focus on four Activity Areas.

- Better water quality.

- Sustainable fisheries.
- Effective marine protected areas.
- Improved waste management.

The OCM approach will also focus on four Activity Areas.

- Sustainable ocean fisheries.
- Improved national and regional management capability;
- Stock and by-catch monitoring and research.
- Enhanced national and regional management links.

Each component area will include a number of Targeted Actions to achieve.

- Management/institutional strengthening.
- Capacity-building/institutional strengthening.
- Awareness/education.
- Research/information for decision-making.
- Investment.

The program objectives and activities identified under the IWP are described more fully in the Project Document signed by SPREP and UNDP in February 2000.

1.2 The Implementation of the International Waters Programme

The IWP has two main components.

Oceanic Component

The main objective of the oceanic component is “to enable conservation and sustainable yield of ocean living resources”, and will focus on the management and conservation of tuna fish stocks in the western central Pacific (contiguous with the Western Pacific Warm Pool ecosystem). This component aims to strengthen existing efforts by the 14 member states to secure long-term sustainable benefits from the tuna resource in the western central Pacific. The existing efforts will be strengthened by the establishment of stronger collaborative mechanisms between the states to improve the sustainable management and conservation of the western central Pacific tuna resource.

This will be done through a coordinated program involving the Secretariat of the Pacific Community (SPC) and the Forum Fisheries Agency (FFA). This program will provide information on:

- **Current exploitation of the tuna resource in the western central Pacific.**
- **Existing environmental condition in this area of the Pacific.**
- **Options for improving the sustainable benefits from the exploitation of this resource.**

The main focus during the early stages of this program will be to establish new collaborative arrangements between the participating countries for the management of the region’s tuna resource.

In Papua New Guinea the National Fisheries Authority is the Lead Agency for the implementation of this component of the IWP.

Coastal Component

The main objective of the coastal component is to “address root causes of the degradation of international waters in coastal regions” through a programme focused on improved **Integrated Coastal and Watershed Management (ICWM)**.

This component will focus on the **Priority Environmental Concerns** identified for the region during the Strategic Action Programme.

- **Marine and freshwater quality.**
- **Habitat and community modification and degradation.**
- **Unsustainable use of living marine resources.**

This will be achieved through the implementation of 14 small-scale, community-based, pilot projects (one in each participating member state) that address sustainable resource management and conservation issues in the coastal zone. This component envisions the establishment of improved local community

capacity and processes for the design and implementation of sustainable resource management and conservation programs in the Pacific Islands region. One of the key approaches that will be pursued, reflecting the community-based focus of these pilot projects, will be to encourage the active participation of all the stakeholders in the design and implementation of each pilot project.

These pilot projects will focus on four **Focal Areas** that reflect the four priority regional environmental concerns that were identified in the SAP.

- **Marine protected areas;**
- **Sustainable coastal fisheries;**
- **Protection of freshwater resources;**
- **Community-based waste reduction.**

Each project will be based on a “learning by doing” approach that will aim to strengthen capacity at the community level and provide valuable lessons on best practice and appropriate methodologies for sustainable resource management and conservation that offer the greatest potential for replication across the region. Thus it is hoped that the lessons learnt during the implementation of each pilot project may allow the project to be replicated in larger follow-up projects in other areas and other member states.

In Papua New Guinea, the Department of Environment and Conservation is the Lead Agency for the coastal component of the IWP.

1.3 The Purpose and Structure of this Report

This report is the first stage in the selection of a pilot project for the coastal component of the IWP in Papua New Guinea and presents an overview of the priority environmental concerns in the country. The purpose of this report is to assist in the selection of one or more of the IWP Focal Areas under which a pilot project will be implemented.

The Introduction gives a brief description of the IWP Strategic Action Programme that identifies the programme parameters and describes how the programme design was formulated around these key parameters. It describes in more detail the two main components of the IWP, the Oceanic Component and the Coastal Component, and the intended outcomes of each.

Chapter 2 provides a general overview of the environment of Papua New Guinea, and goes on to describe in more detail the specific themes covered: rainfall and temperatures, geomorphology and soils, people and the land, constraints on rural development, terrestrial vegetation, inland waters, coastal and marine environments, and biodiversity.

Chapter 3 examines the principal threats to the environments of Papua New Guinea across five main development sectors: agriculture, forestry, mining and petroleum, fisheries, and public health.

Chapter 4 reviews the recent changes to environmental regulation, and the status of conservation legislation in Papua New Guinea.

Chapter 5 summarises the principal environmental issues and problems facing Papua New Guinea at the present time and analyses the immediate and underlying “root” causes that have given rise to these problems. The chapter also reviews the remedial efforts that have been carried out to date to address these causes, and the extent to which these remedies have been effective.

Information for Chapters 2, 3, 4 and 5 was drawn from literature searches, the findings of various environment and conservation projects conducted in Papua New Guinea over the last 10 years, and face-to-face discussions with a wide range of in-country stakeholders. These discussions provided valuable insights into the current environmental situation in Papua New Guinea as these stakeholders, all of whom are actively involved in the environment and conservation sector in Papua New Guinea, were drawn from Government, Non-Government Organisations and the private sector, and represented a wide range of opinion and perspective. At the end of each discussion, the stakeholder was asked to complete a Stakeholder Survey Questionnaire (see Annex 1) and return the completed questionnaire to the National Coordinator, IWP, or the author.

A draft report was prepared at this stage that was distributed to all the stakeholders in advance of the IWP Stakeholders’ Consultative Workshop, which discussed the findings of the draft report and attempted

to prioritise the environmental concerns that had been identified.

Chapter 6 considers the options identified by the survey respondents, at the Consultative Workshop and in the discussions with stakeholders, to improve the effectiveness of future remedial efforts that aim to address the causes of the principal environmental issues and problems.

Chapter 7 concludes this report with an assessment of the relative magnitude and significance of these principal environmental issues and problems, and ranks these in order of priority.

2. The Environment of Papua New Guinea

2.1 General Overview

Papua New Guinea has a population of 5.1 million (PNG National Census 2000), and 80 % of this population (approximately 4 million people) live a traditional rural subsistence lifestyle that is supported by the biological richness and diversity of the forests, inland waters and coastal seas.

In recent years the sustainable capacity of these ecosystems to continue to support the country's rural population has come under threat as the country's rapidly growing population, which has averaged an annual growth rate of 3.5 % over the last 10 years (Saulei et al. 2002), imposes greater demands on these natural resources.

These demands stem from the underlying expectation of all Papua New Guineans that development will bring an improved quality of life with improved welfare services (health and education) and increasing opportunities for personal income generation and the economic benefits these would bring. At the core of these demands is the exploitation of natural resources for revenue generation, both by government and by the local people, particularly in rural areas that lack employment opportunities. In the absence of well-developed commercial and employment sectors, government has to rely on taxes and royalties from the exploitation of its natural resources as a principal source of revenue.

Much of the mainland and the central areas of the larger islands is extremely rugged and inaccessible. With few roads and navigable rivers, many of these areas remain sparsely populated and isolated from government services and development opportunities. Like its larger neighbour to the south, much of the population is concentrated in the coastal regions, although dense populations are located in parts of the highlands around the central plateau, and along some of the major (navigable) rivers in both the highlands and lowland areas. Thus, although the country has a land area of a little over 460,000 square kilometres, large parts of this remain sparsely populated and inaccessible to development. Those areas of land that are accessible and suitable for development show a rapidly growing population, which is pushing the limits of natural resource sustainability in these areas.

Papua New Guinea has a remarkable range of natural environments, ranging from alpine ranges and mountain tops rising to 4,400 metres above sea-level, through montane forests on volcanic or karst pavements, to hot and humid lowland rainforests, savannahs and swamps that may extend for hundreds of kilometres along the wide coastal plains. The range of marine environments include some of the world's most diverse coral reefs and mangrove forests, as well as a wide variety of productive deltaic and coastal wetlands that harbour some of the most diverse ecosystems on the planet.

2.2 Rainfall and Temperatures

Rainfall, altitude, soil type and the history of disturbance (natural and anthropogenic) are the four main factors that influence the diversity of habitats and vegetation.

Rainfall ranges from 950 mm per annum in some lowland areas, notably around Port Moresby, to as high as 10,000 mm per annum in parts of the highlands region. Generally rainfall varies between 2,500 mm and 3,500 mm per annum, although large areas of the highlands receive in excess of 4,000 mm per annum. In most areas there is little seasonality in the rainfall, although there is in some of the drier areas, such as around Port Moresby.

Temperatures in lowland areas are more or less constant throughout the year, at around 30°C, whilst temperatures of 25°C or less are common in many highland areas. This combination of high temperatures and rainfall, particularly in the lowland areas, results in high levels of air humidity and only moderate rates of evaporation.

Periodic droughts and frosts affect the vegetation, as do the periodic large fires that sweep through the savannah, woodland and grassland systems that occur in many parts of the country. These fires may have anthropogenic causes or natural causes such as lightning strikes or volcanism.

2.3 Geomorphology and Soils

The rugged relief and mountainous terrain of much of Papua New Guinea, with elevations ranging from sea level to over 4,400 metres in relatively short distances, provides a very wide variety of environmental conditions which supports the remarkable diversity of habitats and species that occur in the country. Habitat and species variation with altitude is much greater in the tropics than in the temperate regions, as there is less climatic overlap between low- and high-elevation sites in the tropics compared to those in temperate areas, resulting in a greater variety of distinct habitat types within a given altitude range.

The high rainfall characteristic of much of the rugged upland and highland areas gives rise to many landslips and mudslides, which temporarily bury or dislocate the vegetation, often exposing large areas of soil and rock, and resulting in temporarily severe siltation of downstream watercourses.

Papua New Guinea is located on the Pacific's "Ring of Fire" and is geologically active. Associated with this geological activity are volcanoes, earthquakes, *tsunami*, landslips and mudslides, which have profound effects on the local population, habitats, and downstream areas. Relatively minor eruptions are commonplace along parts of the north coast of the mainland and in parts of the islands' region, most notably in East New Britain. Although such volcanic activity has a devastating effect on the flora and fauna in the immediate impact zone, aerial fallout of mineral-rich dusts, surface lava flows and ash add considerable amounts of biologically active salts and nutrients into the local soils and water. This is an important factor contributing to the fertility of soils in many areas.

Soils range from old alluvium deposits to newly formed soils as a result of recent volcanism. In most areas the soils are generally fertile, of moderate depth and exhibit a relatively robust structure that supports a high level of organic production. Disturbance to vegetation occurs frequently from both natural and anthropogenic causes.

2.4 People and the land

The vast majority of the country's rural population follows a traditional lifestyle based on subsistence agriculture (gardening), hunting and fishing, and gathering a wide range of edible, medicinal, cultural and construction materials from their local environment (forest, woodland, wetlands, etc. environments). In areas accessible to provincial or district centres, these goods and produce may be traded or sold in order to purchase materials unavailable in their local environment such as rice, tea, kerosene, pharmaceuticals, tools and clothes.

The close ties of the people with their land continue today as they have done for thousands of years in a culture where family ownership of land is a fundamental component of the socio-economic structure and the way it operates. Ninety-seven percent of the country's land is under customary land tenure (Sowe et al 2002), whereby land is passed down through the family, mainly by patrilineal descent, although matrilineal descent does occur in some areas of the country.

Natural resource developments in Papua New Guinea must obtain agreement from the landowners upon whose land the development will occur. In situations where many landowning families are involved, the process of agreement, the distribution and sharing of royalties and other benefits, and the resolution of contentious issues arising during the course of the development, is facilitated through the formation of Incorporated Landowner Groups (ILGs) representing all the land-owning families involved.

2.5 Constraints on Rural Development

One of the ubiquitous constraints to trade and development throughout Papua New Guinea is the problems of transport and access, particularly to some of the more remote areas of the mainland such as parts of Western Province and Morobe Province. In these areas, travel times of two or more days are commonplace between the more remote villages and the district administration centre, where medical aid, communications and transport connections to the rest of the country can be found. Many of the more remote communities have no, or very limited access to produce markets. Consequently they suffer major economic disadvantages in terms of access to a cash income that can be used to obtain the basic needs, such as pharmaceuticals, tools and clothes, which are unavailable from their local environment. These

disadvantages are further compounded by the inability of these remote areas to attract teachers, nurses and other professionals who could develop the human capacity in such areas to become more self-sufficient and perhaps develop innovative solutions to the constraints imposed by their isolation.

The difficulties in communication and transport make it equally hard for government services (health, education, policing, environmental monitoring and enforcement) to reach these more remote communities. This results in these communities suffering disadvantages and hardships through lack of basic government services, most notably education, health and law and order.

Remoteness also makes it much harder for government to monitor and police (regulate and enforce) any natural resource or infrastructure developments undertaken in these areas. Many of the country's larger extractive industry and other natural resource development projects are located in the more remote areas. A recurring theme amongst capacity building and institutional strengthening development projects in the environment sector has been the question of how to get a more effective environmental monitoring and enforcement presence on the ground in the more remote areas of Papua New Guinea.

Financial constraints on government preclude the deployment of government environmental officers at the district and provincial centres, of which there are about 100 in the country. Even if this were feasible, in many instances this would still require two or more days of travel to get to the development site before the monitoring / enforcement could even begin.

An alternative that has been considered in the commercial logging industry is the positioning of an independent government monitor / regulator at each major project site. However, the independence and thus the efficacy of these positions were frequently compromised, as communications, logistics and travel were usually only possible at the behest of the operator in these remote areas. Consequently the opportunities for taking coercive, or even punitive action to enforce compliance with regulations were limited as the over-riding requirement to continue the job was to remain on good terms with the operator who was the sole provider of all communications and logistics.

Another alternative approach involves raising the environmental awareness of local people so that they are capable of recognising environmental threats and impacts and taking appropriate action to prevent such threats from eventuating or to mitigate the impacts. At the village level it would be feasible to improve the quality and reliability of water supplies and sanitation practices, and the methods of dealing with domestic solid wastes, by conducting environmental awareness programmes for the local people, preferably in the local language and through a local Community Based Organisation.

Whether this approach could be taken a stage further, to develop environmental monitoring and reporting skills amongst the local people, so that they could become the "eyes and ears" of the environmental regulatory framework remains to be seen. However, even if such an approach could be successfully implemented at the village level, the issue of notification to the appropriate authority and the enforcement of preventative or remedial measures remain outstanding issues to be resolved.

2.6 Terrestrial Vegetation

Forest cover is the dominant vegetation in Papua New Guinea. Forests cover 360,000 km² (78 %) out of a total land area of about 460,000 km² (Sekran and Miller 1994). These forests are characterised by very high tree species diversity when compared to other tropical forests around the world, reflecting the wide range of climatic, geographical and geological conditions that occur in the country. This species richness is the principal reason why Papua New Guinea figures so highly on the world's biodiversity ratings. This large number of different tree species provides a wide range of diverse forest habitats for other flora and fauna (with the notable exception of mammals, which for a variety of reasons are only poorly represented in the wildlife of Papua New Guinea).

Within the forest habitats of Papua New Guinea, diverse assemblages of animals, plants and micro-organisms have developed that are unique to these warm, humid, shaded environments. However, most of these remain poorly studied and largely unknown to science (Sekran and Miller 1994). As a biological and genetic resource they are largely unexplored, yet because of their considerable differences to most of the explored and researched natural world, they have the potential to deliver genetic source material and other bio-resources that cannot be obtained anywhere else. The unknown but potentially immense value

of this unique diversity is one of the primary reasons for protecting and conserving Papua New Guinea's natural heritage of tropical rain forest.

The twelve categories of vegetation described below are classified according to zonal types, primarily based on altitude and rainfall. This classification system is based on Johns (1977, 1993) as used by the Conservation Needs Assessment (Saulei and Beehler 1993). Much of the following material is taken from the Papua New Guinea Country Study On Biological Diversity edited by Sekhran and Miller (1994). The vegetation categories are presented in approximate order of altitude, with coastal habitats (such as mangrove forest) at the start, continuing through lowland and middle-altitude vegetation to the alpine habitats of the highland summits and ridge-tops.

Coastal Vegetation:

This vegetation occurs on the succession of well-drained ridges and slopes aligned parallel to beaches that are relatively common in many coastal areas of Papua New Guinea. The vegetation ranges from the pioneering herb and grass beach communities occupying the harshest environments closest to the beach, through the beach scrub communities, which occur behind the pioneers, to the inland mixed forest, which occupies the well-drained ridges and slopes.

The pioneering communities consist mainly of beach grasses and ground-hugging plants that are adapted to the typically poorer sandy soils adjacent to the beach. These species characteristically propagate by vegetative growth, often exhibiting adaptations to water stress such as the thick leaf surfaces of the herbaceous plants and long thin leaves (reducing the leaf's surface area) of the grasses. Behind these the stunted saline-resistant beach scrub communities gradually give way to the inland mixed forests that occupy the somewhat richer and more structured soils of the ridges and slopes behind the coastal strip.

Mangrove Forest:

These coastal and estuarine (around the river mouths and along the shores of estuaries) tidal forests are typically inundated daily by salt or brackish water. They are widespread and extensive in the deltas of many of the rivers that drain the southern side of Papua New Guinea, notably the Fly, Kikori and Purari Rivers, and many of the smaller rivers that drain the southern slopes of the Owen Stanley Range and discharge along the coast of Central Province.

Mangrove trees have a very close-knit and extensive network of robust and binding aerial roots which trap and hold the tidal mud and river sediments brought down into the tidal reaches during flood events. This combination of the close-knit network of aerial roots and the deep layers of organically rich sediment that have accumulated between them provides a unique and highly varied habitat for a remarkably diverse aquatic and semi-aquatic coastal marine community.

Species diversity ranges from the myriad small invertebrates that inhabit the many surface niches on the aerial roots and other tidal zone surfaces, to the numerous open-water fish and larger invertebrate species for which these tidal mangrove habitats are the principle nursery areas for the young and larvae.

The microbial communities on the surface of, and within, the mud sediments are also a key component of the wider coastal ecosystem. These communities decompose much of the water borne organic debris and detritus which settles out in the quieter waters amongst the aerial root networks of the mangrove trees. This debris and detritus comes in every day on the tide, and periodically from inland catchment areas following high river flows which carry their sediment loads into these tidal reaches. The high concentrations and richness of this organic matter result in high levels of productivity and nutrient recycling within mangrove forest areas, and importantly, the retaining of these within the tidal and shoreline communities, arresting their loss off-shore.

Anthropogenic Grassland:

This vegetation covers much of the dry hilly country along the north-east coast, and is the main vegetation in many populated highlands valleys. In most cases these grasslands are artificially maintained by man-made fires, without which they would probably revert to woodland.

Swamp Vegetation:

Swamps are areas of ground that are inundated for part, or most, of the year. Swamp vegetation varies considerably in species composition and community structure depending on the varying regimes and

patterns of inundation, and on the soils and vegetation of the surrounding catchment, which supply much of the sediment and organic matter that makes up the swamp bed.

Although of highly varied composition, the trees are characteristically more widely separated than they would be on drier ground resulting in a more broken and open canopy, beneath which an under-storey of broadleaf species such as palms and *Pandanus* typically occurs. Swamp grasses and reeds form the dominant species in the herbaceous layer, which also exhibits considerable variation in composition between different swamp regimes and catchments.

Savannah:

Mixed savannah, found in the monsoonal south-west of Papua New Guinea, varies in composition and structure according to the local relief, drainage and frequency of burning. The dominant tree species include *Eucalyptus*, *Albizzia* and *Melaleuca*. This vegetation also occurs on waterlogged plains and some dry hill slopes up to 500 metres at locations elsewhere in Papua New Guinea.

Monsoon Forest:

This forest type occurs mostly in areas near the coast with an annual rainfall of less than 2,500 mm., and a prolonged dry season such as occurs in the areas to the northwest of Port Moresby, some parts of Western Province and the Safia-Pongani region in the southeast of the country. The dominant tree species include *Bombax*, *Erythrina*, *Tetrameles*, *Albizzia*, *Acacia* and *Mangifera*. In some areas, such as around Port Moresby, the monsoon forest grades into savannah woodland with *Eucalyptus*, *Albizzia* and *Melaleuca* trees.

Lowland Tropical Rainforest:

This forest type occupies much of lowland Papua New Guinea that lies below 1,000 metres and receives more than 2,500 mm rainfall per annum. It is probably the richest vegetation type for plant diversity in PNG (Saulei & Beehler, 1993), and although it covers large areas of the country, it is probably also the least studied forest type. This type of forest is separated into two sub-categories:

- Lowland Wet Forest, below 500 metres with more than 3,500 mm rainfall per annum;
- Lowland Humid Forest, occurring below 1,000 metres with between 2,500 and 3,500 mm rainfall per annum.

Lower Montane Forest:

Occurring between 1,000 and 2,000 metres elevation, this common forest type is quite variable in composition and structure. Typically dominant tree species include *Araucaria* and *Castanopsis* species, but different dominant species do occur in this variable forest type. This forest type is the category most impacted by subsistence agriculture. Forests at this elevation that receive over 3,500 mm rain per annum have been separated into a sub-category, Lower Montane Wet Forest, by Saulei and Beehler, (1993).

Mid-Montane Forest:

Sometimes called “cloud forest”, this forest type occurs at elevations between approximately 2,000 and 2,500 metres and is typically ever-wet (perhumid), with fogs, mist and clouds ever present and almost daily rainfall producing luxurious growing conditions. These forests are rich in epiphytes (plants which grow on other plants, such as orchids and bromeliads), with broken, open and uneven canopies. Typically dominant tree species include *Nothofagus*, *Phyllocladus* and other podocarps.

Upper Montane Forest:

This forest type occurs between 2,500 and 3,200 metres, and forms the high altitude “cloud forest” that is characterised by a simpler forest structure of low canopy *gymnosperm* tree species heavily encrusted with mosses or moss-like epiphytes. These hang from the tree branches absorbing water from the almost permanent mists and fogs that characterise these high altitude forests.

Sub-alpine Forest and Grassland:

This vegetation type occupies the uppermost slopes and summits above 3,200 metres, up to approximately 3,900 metres elevation. Here the harsh climate (depressed temperatures, often falling to near zero during the night, and constant high winds) and thin, poor soils severely limit the composition and structure of

the plant communities. The sub-alpine forests usually contain very few different species, and are structurally simple with a canopy height of eight to twelve metres. Often the canopy is closed up, with the canopy branches of adjacent trees intertwined together to form a close mesh of upper branches providing some protection against the prevailing winds and harsh climatic conditions. Such low, closed canopy forests are often dominated by a single species such as *Dacrycarpus*.

Alpine:

In Papua New Guinea, the tree-line (the limit of growth of trees) is generally at about 3,900 metres, although this does vary locally dependent on local climatic factors such as prevailing winds, shelter and local minor temperature variations. Above the tree-line, shrubs gradually decrease in height and frequency up to approximately 4,400 metres (the limit of most plant growth in Papua New Guinea). Above 3,900 metres, rosette and cushion herbs, mosses, lichens and low ferns become progressively more abundant.

2.7 Inland Waters

The inland waters of Papua New Guinea are dominated by the major river systems that drain the central cordillera of the mainland. To the north is the Sepik River basin in the west and the Ramu River basin in the east. To the south the Fly and Strickland rivers in the west drain into the Fly Platform, which is the largest tract of low-lying land in Papua New Guinea, before discharging into the eastern Gulf of Papua, an extensive delta. Further east, the Purari River drains the central highlands and discharges into the Gulf of Papua, also through an extensive delta. These rivers are characterised by large flow volumes and high sediment loads, and in the upper and middle reaches are generally fast-flowing and turbulent.

The Sepik River is the largest river system in Papua New Guinea, with a catchment area of 77,700 square kilometres, and a discharge estimated to range between 4,500 and 11,000 cubic metres per second (Sekran and Miller 1994). It has a deep main river channel and is navigable for about 500 kilometres. The river discharges directly into the sea through a single outlet, in marked contrast to the rivers flowing south of the central cordillera, which characteristically have extensive deltas. There are approximately 1,500 oxbow and other lakes within the Sepik floodplain, the largest of which is Chambri Lake (see below). Many of the oxbow lakes in the lower floodplain are considerably deeper, but not as extensive.

The Fly River, although only 1,200 kilometres in length, has a discharge range of 6,000 to 7,500 cubic metres per second (Sekran and Miller 1994), making it the second largest river in Papua New Guinea. The river descends rapidly from its headwaters in the central cordillera, but in its lower reaches the gradient is much more gentle. The river is navigable as far as the port of Kiunga, which is 800 kilometres from the sea, but only 40 metres above sea-level. The fauna and flora of the highland forests in the upper catchment are amongst the richest in Papua New Guinea, whilst the plains of the middle and lower Fly River support a mosaic of internationally significant wetland and savannah habitats (IUCN 1995)

Rainfall in the upper catchment of the Fly River System regularly exceeds 10,000 mm per annum, and at times of flooding, the river level may rise by up to 10 metres (Sekran and Miller 1994), flooding the extensive areas of alluvial forest, swamp grassland and swamp savannah in the middle and lower floodplains. The river meanders across a wide and extensive floodplain in the lower reaches, where there are numerous lakes, backswamps and oxbows of variable depth depending on age. This river system has been described as the most significant river system, in terms of biological value, on the island of New Guinea (Sowei et al 2002), and therefore arguably one of the most biologically significant tropical river systems in the world, given Papua New Guinea's global biodiversity status (see Section 2.6). There is now strong evidence that the mining operations at Ok Tedi have increased the rate of sedimentation downstream (IUCN 1995), and may be one of the causes of extensive areas of vegetation dieback and damage to aquatic habitats observed in recent years (see Section 3.4.2.2).

The Purari River discharges to the Gulf of Papua through an extensive delta of mangroves and associated forest assemblages and together with the Kikori River and its delta immediately to the west of the Purari River, constitute one of the most important undisturbed natural mangrove assemblages in the South-East Asia and Pacific region.

Further to the east in Central Province, the Vailala, Lakekamu, Angabanga, Vanapa, Brown, Laloki and Kemp-Welch Rivers also have mangrove assemblages in the lower reaches, although not as extensive,

nor in as pristine a condition, as those of the Kikori and Purari Rivers. The upper catchment of the Laloki River system has undergone some modification with several upland tributary valleys flooded as a result of the construction of the Surinumu Dam as a water supply reservoir for Port Moresby, and the diversion of water to hydropower facilities at Rouna. This will have resulted in changes to the flow regime downstream, although an assessment of these changes is difficult as few records exist from before the construction of the dam and hydropower facilities.

There has also been considerable anthropogenic disturbance of the lower Laloki River as it meanders around and to the west of Port Moresby. In its lower reaches, the Waigani Swamp has been badly degraded as it receives about 80 % of the sewage from Port Moresby and major changes to the natural floristic composition have been recorded over the last thirty years (Sekran and Miller, 1994). More recently, the Angabanga River is showing possible signs of increased siltation and sedimentation in the lower reaches and river-mouth, which local people have attributed to mining in the upper catchment.

The Ramu and Markham Rivers flow west and east respectively from a watershed divide on an intermontane trough between the Finnessterre and central cordillera ranges. The Ramu River, which has a relatively small catchment area, flows in a westerly direction, approximately 720 kilometres long, and discharges through a flat, swampy floodplain to the east of the Sepik River mouth. The Markham River, 170 kilometres long, flows through a wide, braided channel into the Huon Gulf by the city of Lae.

There are over 5,000 lakes in Papua New Guinea, but most are small with only 22 having a surface area greater than 1,000 hectares (Sekran and Miller 1994). Over 80 % of the country's lakes lie below 40 metres above sea-level and most are associated with large rivers and surrounded by extensive wetlands. Lake Murray, in the Fly-Strickland Basin is the largest lake, with an area of approximately 650 square kilometres and a maximum depth of nine metres (mean depth of five metres). Lake Chambri, in the Sepik floodplain, is the next largest, and can extend up to 250 square kilometres during floods. Like Lake Murray, it is a shallow lake with maximum depth of four to six metres.

Most lowland freshwater wetlands are a mosaic of open water, herbaceous swamp, swamp savannah and woodland. These form a continuous sequence from open water to tall, mixed swamp forest, depending on the drainage, depth and flooding conditions, and the water quality (for example, the concentration of silts and nutrients which will affect the eutrophic status of the water). The aquatic vegetation consists of free-floating, floating-leaved and submerged plants that occupy the shallow margins between open water and the grass swamp. In many of the shallow lakes these vegetation types can cover the entire lake. Sedges, herbs and ferns are characteristic of permanent, relatively deeper, stagnant water swamps. Two invasive exotic pest species, *Salvinia molesta* and *Eichhornia crassipes* (Water Hyacinth) are now widespread in many of the lowland wetlands of Papua New Guinea (Sekran and Miller 1994).

Deep lakes are usually associated with calderas, such as Lake Wisdom on Long Island (360 metres deep) and Lake Dakataua on West New Britain (120 metres deep). Few studies have been carried out on these lakes and their biology remains largely unknown. Lake Kutubu, in the Southern Highlands petroleum fields, was formed when volcanic activity from Mt. Afuma blocked the watercourse. A number of biological surveys and studies have been conducted on Lake Kutubu by Chevron and WWF that have indicated a high degree of endemism in the lake fauna, with several species new to science. It remains to be seen whether similar endemism occurs in other upland or montane lakes, for example, the lakes in the high mountains of the central cordillera which were formed by glacial activity, such as Lake Piunde and Lake Aunde on Mt Wilhelm.

2.8 Coastal and Marine Environments

Papua New Guinea is surrounded by three seas and a major gulf, the Bismarck Sea to the north, the Solomon Sea to the north and east, the Coral Sea to the south and east, and the Gulf of Papua to the south, lying between Papua New Guinea and Australia. Papua New Guinea has a total sea area (EEZ) of 3,120,000 square kilometres and 17,110 kilometres of coastline (Soweï et al 2002). This huge area encompasses a diverse array of marine environments, ranging from tidal wetlands and estuaries to deep ocean basins. The country is renowned for the diversity and pristine quality of its coral reefs and coastal environments, but its waters extend beyond the coastal shelves to include deep ocean basins that are practically unexplored.

The principal marine environments in Papua New Guinea are as follows.

1. Reefs (fringing, patch and barrier reefs).
2. Seagrass beds.
3. Mangroves.
4. Sand and mud shorelines and intertidal flats.
5. Barrier dunes and their associated coastal lagoons.
6. Deltaic floodplains and estuaries.
7. Rocky shorelines.
8. Reef walls and drop-off areas of the continental slope.
9. Sea mounts.

(Sekran and Miller 1994: - based on Agardy and Pernetta, 1993).

Except for the sea-mounts and continental slope environments, all the others listed are coastal environments or are environments located on the continental shelf (such as barrier reefs).

Coral Reefs

Most of the coral reefs around Papua New Guinea are of the fringing or patch type, and extensive barrier reefs are only found along the south coast (e.g. the Motuan coastline), the Louisiade Archipelago and around to East Cape on the eastern coast. The northern coast (e.g. Madang) and the New Guinea Islands are dominated by fringing and patch reefs.

Corals are susceptible to any freshwater dilution of the sea-water, salinities of less than 35% suppress coral growth. This, together with their susceptibility to turbid waters, influences their distribution around the coasts of Papua New Guinea, where despite their widespread occurrence, they are noticeably absent from the coastal areas around the mouths of the major rivers.

Several recent studies have confirmed anecdotal evidence that coral diversity is typically very high in Papua New Guinea's reefs and this is globally significant.

A Rapid Ecological Assessment of the coral reefs of Kimbe Bay, in West New Britain Province, was conducted in 1994 by a team of scientists from Papua New Guinea, Australia and Hawaii on behalf of The Nature Conservancy - Asia/Pacific Program (Holthus 1994). A total of 78 sites were surveyed, and detailed information on coral species abundance and distribution were collected from 39 sites (Maragos 1994). A total of 345 species of coral were reported from these 39 sites. This number compares favourably to that of other detailed surveys conducted in Australia, Japan, Indonesia, the Philippines and elsewhere in Papua New Guinea, and at the time was amongst the highest ever reported from such a small area (Maragos 1994). Two thirds of the coral reefs surveyed had high levels of live reef cover (greater than 50 %), and many individual sites had extensive areas of very high coral cover (greater than 75 %) (Holthus and Maragos 1994), indicating the near pristine state of the coral reefs at those locations.

A report on the Madang Locally Managed Marine Network prepared by Wetlands International (Jenkins 2002), assessed the diversity of coral reef fishes as an indication of the biodiversity of the coral reefs in Madang's Marine Area Network. This report noted that the biodiversity of reef fish fauna within the network is of global, national and local importance.

A marine Conservation Needs Assessment Report of Milne Bay Province prepared on behalf of Conservation International reported that over 429 species of coral fauna, including 10 new species, were recorded during Rapid Assessment Program surveys carried out by Conservation International during 1998 (Seeto 2000). This is believed to be the highest coral diversity recorded so far in Papua New Guinea. This number of species is more than is found on the entire Great Barrier Reef, and is equal in diversity to the coral faunas of the Philippines and Indonesia, which were previously believed to be the most species rich in the world.

These reports clearly indicate the global significance of Papua New Guinea's coral reefs, but these reefs are also vitally important to the local people as a primary resource supporting their traditional culture and sustainable livelihoods.

Coral reef fisheries are a vital source of food and income for many coastal communities. They are important feeding and nursery habitats for many marine species. They provide a physical barrier to

ocean swells and storm surges, protecting the shoreline against erosion. Behind the reefs, the sheltered reef lagoons provide habitats for a variety of important coastal species, notably seagrass beds and mangrove stands, which further stabilise the shoreline by anchoring the sediments (see below).

Seagrass Beds

Seagrass beds are a common community in the reef flats and coastal lagoons of Papua New Guinea, particularly where these are situated close to small river estuaries that maintain a steady, but low level, supply of fine silt and mud sediments to the lagoon floor. However, if the concentration of suspended sediments is too high, seagrass growth is likely to be inhibited by the turbidity of the water in the lagoon.

There are many different species of seagrass occurring in Papua New Guinea coastal lagoons. The most commonly encountered species include turtlegrass (*Thalassia hemprichii*), *Enhalus acaroides* and species of the genus *Halophila*.

The seagrass beds are an important habitat for many species of marine invertebrates and juvenile fish. Their root network helps anchor the fine silts in which they grow, providing a stable substrate for many species of marine worms, which themselves are the basis for a complex food web that extends throughout the seagrass community.

Of particular note is the importance of seagrass beds to the survival of the dugong, a large herbivorous mammal that inhabits Papua New Guinea waters and feeds almost exclusively on seagrass. The dugong is a highly endangered species and is on the IUCN Red List as a vulnerable species. Formerly widespread in the tropical waters of southeast Asia, it is now close to extinction, probably due primarily to habitat loss, although indiscriminate hunting in the first half of the last century resulted in massive depletion of its numbers. The Papua New Guinea population of dugong, which is mainly centred on the Papuan Lagoon in the southwest of the country, is of global significance and conservation value as it is likely to be the world's largest population still remaining today.

Mangroves

Mangroves are widespread around the coastal regions of Papua New Guinea, with particularly extensive stands in and around the deltas of many of the major rivers, particularly those along the southern coast. These extensive stands of mangroves, with their close-knit lattice of aerial roots, stabilise the mud and silt sediments they inhabit by holding them in place and providing a sheltered environment in which deposition predominates. On a wider scale, these tough, securely-anchored root lattices provide physical protection against storms and surf, so that just a few metres inside the outer edge of a mangrove stand, the water is significantly less turbulent. At greater distances inside the mangrove stand (which may extend for 100's of metres back), still water conditions prevail, more or less regardless of the coastal sea conditions.

Mangroves provide an important shoreline protection function by anchoring shoreline sediments and providing a firm and resilient barrier to storm surges and their erosive effects. Substantial damage or loss of mangroves can result in significant changes to the erosion - deposition regime along coastlines, which can have profound effects on the coastal ecosystem, the use of its natural resources, and the stability and use of coastal infrastructure.

The protected still waters inside the mangrove stands are richly provided with habitat opportunities amongst the root lattice and its epiphytic communities. The organic matter and nutrients in the river mud and silts amongst the lattice, which are replenished daily by the ebb and flow of tidal currents, provide rich and productive habitats for numerous invertebrate species. This makes these waters ideally suited as nursery habitats for many marine and estuarine species, and several commercially important PNG fisheries have juvenile stages that are dependent on these rich and sheltered mangrove waters.

Mangroves are susceptible to changes in the coastal flow regimes, particularly as these affect the amount and composition of the local sedimentation. If rates of sedimentation increase, the roots of many mangroves can be effectively suffocated by the greater sediment load, leading to a cessation of growth and ultimately, death of the trees. A marked decline in sedimentation rates can result in insufficient sediment and organic matter entering the system to replace and replenish the natural loss of sediment and organic matter which occurs naturally as a result of sediment flushing, attrition and natural decomposition. In this case, growth of the mangroves can be limited by falling sediment nutrient concentrations.

In its worse case, the loss of sediment can expose the roots themselves, which are then susceptible to damage and disease, and ultimately the risk of structural failure as their anchorage in a thinner soil becomes less secure. This can result in widespread loss of the mangroves and exposure of the coastline to the erosive effects of storms and wave action.

Sand and mud shorelines, and inter-tidal flats

The organisms occurring in these habitats are adapted to the extremes of submergence and exposure that characterise much of these in-shore habitats, and specifically the inter-tidal flats. Many species adopt strategies of hiding in the sediments (which retain water) to escape desiccation between the tides, whilst others move with the tidal flow to remain in the aquatic environment. These depositional environments also exhibit wide variations in oxygen content and in deeper sediments, anoxic conditions are not uncommon.

In the permanently submerged lower reaches of sand and mud shorelines, seagrass beds are common, but are unable to survive in the fluctuating tidal environments of the inter-tidal mudflats and above the low water tidal level. In these habitats, organic production is dominated by decomposition processes and frequently supports an extensive community of aquatic, inter-tidal and terrestrial communities (members of which are transient inhabitants of this transitional zone, such as waders and other birds and many species of insects).

The importance of these rich and productive habitats to the coastal food webs extends well beyond their immediate area. Thus changes to these habitats as a result of changes in the hydrology and depositional regime can have significant consequences on the wider coastal ecosystem and the biological resources it contains.

Barrier dunes and their associated coastal lagoons

Barrier dunes are sand bars formed by coastal deposition processes which may cut off an inlet or bay to form a lagoon, or their formation may divert and extend the natural outfall of a small river or stream, to form a closed lagoon or an open or semi-closed lagoon respectively.

These coastal lagoons may be saline or brackish (partially saline, mixed with freshwater) waters. They are frequently highly productive, particularly where the euphotic zone extends to the bed of the lagoon promoting primary production throughout the water column. The higher level of productivity supports a variety of aquatic and semi-aquatic communities, including many juvenile stages, and are important feeding areas and habitats for many coastal communities. They are also frequently important from an anthropogenic perspective as valuable artisanal fisheries for both bony fish and shellfish such as prawns.

Deltaic floodplains and estuaries

These exhibit many of the features discussed in the “sand and mud shorelines and inter-tidal flats” section presented earlier. Both floodplains and estuaries are typical transition environments, with a wide range of habitats reflecting the transition from aquatic to terrestrial and from freshwater to seawater respectively. Superimposed on this spatial variation is the temporal variation of diurnal fluctuations in water levels and salinity reflecting the daily tidal cycle, and longer-term variations reflecting seasonal and meteorological (storms etc.) changes in river flows and the monthly “spring-neap” tide cycle.

Deltaic floodplains typically contain a wide range of habitat types. These include inter-tidal flats and wetlands, which are subject to diurnal fluctuations in the degree of submergence, water levels and salinity values as governed by the daily tidal rhythms. The more elevated floodplain levees above the mean high water mark, which are only occasionally submerged when extra high “spring” tides coincide with periods of high river flow, contain different species assemblages adapted to a drier, more terrestrial type environment.

In most coastal areas of Papua New Guinea, these deltaic floodplains are populated by mangrove communities, grading back to swamp vegetation communities on higher ground of the floodplain levees that are located above the saline influence of the tidal reaches.

With regard to estuaries, the habitats and conditions along the estuary margins, and outside of the main water channels within the deltas, have already been described above. The environmental conditions and habitats within the estuary waters are dominated by the diurnal fluctuations in salinity concentrations

that characterise all river-mouths. These daily tidal fluctuations vary according to the monthly tidal cycle and the river flows, resulting in complex and highly variable water current patterns within an estuary.

These water currents are generally carrying high sediment loads (from terrestrial runoff loads in the river and from suspended silts and mud in the saline waters). The sediment deposition and re-suspension regimes exhibit complex and highly variable patterns, particularly over the longer-term as areas of net daily deposition become areas of net daily re-suspension, and vice versa.

Despite the highly variable nature of estuarine environments, many organisms have adapted to, and thrive in, this “difficult” environment, which is rich in nutrients and organic matter. Estuarine waters are typically turbid and do not support high levels of primary production, the principal organic production is through detrital feeding and the decomposition food chain.

Rocky shorelines

These are typically exposed shorelines characterised by turbulent waters and strong water currents, often with considerable erosive potential, and are sometimes referred to as high energy environments alluding to the energy of the turbulent water. Other characteristics include high dissolved oxygen saturations, moderately high levels of suspended material, and little if any sediments, except in sheltered pools and backwaters in the lee of the rocks. These habitats have their own characteristic faunal and floral (seaweeds) communities, and add an important dimension to the country’s coastal habitats and the diversity of species they contain.

Reef walls, continental slopes

Reef wall and continental slope habitats occur at the sea-ward edge of reefs and the continental shelf, respectively. They constitute transition zone habitats. Reef walls link the reef habitat and its community with the pelagic community of the open, and deeper, sea. For many pelagic community dwellers, the reef walls provide important feeding and reproduction / nursery habitats. Continental slope habitats offer similar opportunities for the oceanic (bathyal and abyssal) communities.

2.9 Biodiversity

Papua New Guinea has an extraordinary range of ecosystems because of its geographical and geological complexity. It ranks in the top 20 most biologically diverse countries in the world, with a wide range of remarkably diverse environments that support a great variety of different habitats rich in species. Between 5 and 7 % of the world’s total number of animal and plant species are found in Papua New Guinea, even though it occupies less than 1 % of the world’s total land area (Department of Environment & Conservation 2002b). Some of the forests in Papua New Guinea are known to be amongst the richest in the world in terms of their biodiversity (the different number of species they contain), and represent an important natural gene pool for future generations of Papua New Guineans, particularly as many of these species are endemic to the country, or the island of New Guinea.

Forest cover is the dominant vegetation in Papua New Guinea. The total land area of Papua New Guinea is approximately 460,000 km², of which 360,000 km² (78 %) are covered by forests (Sowei et al 2002). These forests are characterised by very high tree species diversity when compared to other tropical forests around the world, reflecting the wide range of climatic, geographical and geological conditions that occur in the country. It is estimated that there are 1,500 tree species that are native to Papua New Guinea (Sowei et al 2002). This large number of different tree species provides a wide range of diverse forest habitats for other flora and fauna, with the notable exception of mammals, which for a variety of reasons are only poorly represented in the wildlife of Papua New Guinea. This species richness is the principal reason why Papua New Guinea figures so highly on the world’s biodiversity ratings.

On the flora side, the forest trees provide habitats for an extraordinarily large number of epiphytes (plants that grow on other plants), ranging from the opportunistic associations of vines and other climbing plants to the close, sometimes symbiotic associations of lichens in the cloud forests and orchids and bromeliads in the lowland and lower montane forests. It is estimated there are between 15,000 and

20,000 native plant species, of which possibly 60 % are endemic (Johns, 1993, in Sekran and Miller 1994). There are over 3,000 species of native orchids alone (Howcroft, 1992, in Sekran and Miller 1994), including the world's largest orchid, *Grammatophyllum papuanum*. One of Papua New Guinea's most characteristic and recognisable trees, the klinkii pine (*Araucaria hunsteinii*), which occurs as one of the predominant species in the Lower Montane Forests between 1,000 and 2,000 metres altitude, is also recognised as the world's tallest tropical tree. Appropriately enough, as cultivated varieties of the banana (*Musa spp*) are one of the country's principal food-stuffs, Papua New Guinea is also home to the world's largest banana, *Musa ingens*, which at 12 metres tall is also possibly the world's largest herbaceous plant.

On the faunal side, the country's high diversity of birds, reptiles and insects is well documented. Papua New Guinea's rich avian fauna has been well studied compared to other animals, and displays a high degree of endemism, with 405 of the total 762 native species being considered endemic (Sekran and Miller 1994). Prominent amongst the avian fauna are the exotic birds of paradise with 90 % of the world's species (Sowei et al 2002), bowerbirds and cassowaries. Papua New Guinea is home to probably the largest number of parrot species of any country (including the world's smallest parrots *Micropsitta spp*), the world's largest pigeon (the Victorian crowned pigeon, *Goura victoria*) and the world's only poisonous bird, *Pitohui spp*, which possesses a toxin similar to that found in the poison arrow frogs of Central and South America (Sowei et al 2002).

The reptilian fauna includes two species of crocodile (an endemic freshwater species and the widely distributed salt-water crocodile), 13 species of turtle of which 7 are freshwater species (3 of these are endemic), 195 species of lizards (including the world's longest lizard, *Varanus salvadorii*) and 98 species of snakes, of which about 60 % are endemic. There are 197 described species of amphibians, the majority of which are endemic, and include the world's largest tree frog (*Litoria infrafrenata*) (Sekran and Miller 1994).

It has been estimated that there are 300,000 native insect species in Papua New Guinea, including the world's largest butterfly, *Ornithoptera alexandrae*, the Queen Alexandra's birdwing butterfly, and one of the world's largest moths (the Hercules moth, which has the largest wings of any moth in the world).

The comparative paucity (when compared to close South-east Asian neighbours) of mammalian fauna in Papua New Guinea probably reflects the geological and evolutionary history of the New Guinea island. Although less than 200 species of mammals occur in the country, these include approximately 70 species of marsupials, of which 60 % are considered to be endemic (Sekran and Miller 1994), and two species of monotremes, including the long-beaked echidna which is the world's largest monotreme. Papua New Guinea is home to 75 species of bats, including the world's largest bat, *Pteropus neohibernicus*, the Bismarck flying fox, which can have a wingspan of over five feet (Sekran and Miller 1994).

Within the forest habitats of Papua New Guinea, diverse assemblages of animals, plants and micro-organisms have developed that are unique to these warm, humid, shaded environments. However, most of these remain poorly studied and largely unknown to science. As a biological and genetic resource they are largely unexplored, yet because of their considerable differences to most of the explored and researched natural world, they have the potential to deliver genetic source material and other bio-resources that cannot be obtained anywhere else. The unknown but potentially immense value of this unique diversity is one of the primary reasons for protecting and conserving Papua New Guinea's natural heritage of tropical rain forest.

The coastal and marine environments of Papua New Guinea are likely to be at least as biologically rich and diverse as the terrestrial environments, but are much less studied. With a total sea area of 3,120,000 square kilometres and over 17,000 kilometres of coastline (Sowei et al 2002), the process of cataloguing and describing the range of habitats and the organisms that dwell there has hardly begun, and it is quite possible that in years to come, Papua New Guinea may be recognised as having one of the highest, if not the highest, marine biodiversity.

Reference has already been made to the significance of the coastal and marine habitats and biodiversity in Papua New Guinea in Section 2.6 of this report. The country's coral reefs are amongst the most diverse in the world and are also more immediately important as the principal source of protein (as the premier fishing spots are usually located on or close to the reefs) for the majority of Papua New Guineans

living close to, or on, the coast. This may pose a threat to their biodiversity unless more sustainable fishing practices and conservation measures can be implemented effectively.

Other globally important coastal habitats within Papua New Guinea's territorial waters include the seagrass beds in the shallow waters of the western Gulf of Papua and Torres Strait that are home to one of the world's last remaining dugong populations. The extensive mangrove forests that characterise the major river deltas along the southern coast of Papua New Guinea such as the Kikori and Purari Rivers are also of global biodiversity significance, and in need of further more intensive study if their global importance is to be more accurately assessed and effective conservation measures implemented.

In regard to the largely unknown deeper waters that surround Papua New Guinea, recent reports in the media have indicated that the Bismarck Sea has a globally significant population of sperm whales, hitherto undetected. This latter news highlights the fact that in terms of biodiversity and environmental resources, there is still much that is unknown about Papua New Guinea, and this lack of information makes it imperative that a rational and cautious approach is adopted towards the exploitation of its natural and biological resources.

3. Key Development Sectors and the Major Environmental Threats associated with each of these

3.1 Development Overview

Papua New Guinea has a rich wealth of natural resources that it can, and does, exploit to generate development revenues. There is a widespread expectation of improvements in the quality of life amongst both the urban and rural populations as a result of the exploitation of these resources. Yet these improvements are slow in coming for a number of reasons, not least of which are the logistical difficulties of bringing development to a country characterised by large tracts of inaccessible and intractable land which make transport and communication extremely difficult. As a consequence, development costs are high and the level of in-country trade is generally low which is one of the key factors contributing to very high unemployment.

The rising expectations of a newly independent nation have in the past led the governments of the day to aggressively pursue the development of the country's natural resources. In the pursuit of development, environmental considerations and the sustainability of the resource base had often been relegated to a lower level of priority as the demands for the benefits of development, together with the need to minimise high development costs, superseded all other considerations.

However, as development progressed through the 1990s, increasing concern over environmental and resource sustainability issues led successive governments to promote sustainable yield management and downstream processing in the extractive industries such as forestry and fisheries. These initiatives are intended not only to conserve the stocks of natural resources, but also to retain more of the resource value on-shore, and in the process increase the opportunities for employment, particularly in the rural sector.

This increasing industrialisation of the country does result in an increasing range and scale of environmental risk as new processes and products are introduced to Papua New Guinea. Increasing demands are being placed on managers and regulators to control and minimise these potential risks, often in circumstances made more difficult by capacity and logistical problems. In a country where transport and communication are difficult, and costly, it is often not possible for the necessary technical expertise to be available when needed for environmental impact mitigation and remediation purposes. Furthermore, the same applies to the regulatory agencies and their ability to effectively monitor and enforce compliance with the relevant environmental regulations. In these circumstances, new and innovative approaches to environmental management and regulation may be required to ensure that effective environmental protection can be achieved in the more remote and inaccessible areas of the country.

This is particularly so for the small and medium-scale development enterprises, which cannot afford to maintain a high level of environmental expertise on their staff, although increasingly some of the processes and products they use may require such a level of expertise in the event of an environmental incident occurring. Generally speaking, the large-scale development enterprises with high costs and turnovers are able to, and do, maintain adequate levels of expertise and generally have a good record of dealing satisfactorily with environmental incidents.

Recent downturns in the international commodities markets have highlighted the need for a more comprehensive, innovative and cross-sectoral approach to rural development (National Planning Office, 1997). In particular, the downturn in log export prices, often the only employer in the more remote rural areas, and the downturn in "smallholder" commodities such as coffee, copra and cocoa, which provided a small, but vital cash income to many rural families, has significantly reduced rural incomes in recent years. This has resulted in the perception that the quality of life in many rural areas is declining, and has increased the rate of urban migration in search of employment and income, particularly amongst the young adult rural populations.

This urban drift has resulted in settlements springing up around all the major centres. These settlements are characteristically unplanned, unregulated and un-serviced, with many lacking any system of power, water supply, sanitation or domestic wastes management. As a result they pose an imminent and increasing threat to the environmental quality and values of these areas.

Even within the urban centres themselves, a lack of capacity and resources has resulted in a decline in the quality and efficiency of these services, in part due to a lack of adequate monitoring and maintenance, but also in large part because the provision of these services is unable to keep up with the rate of growth of authorised urban developments.

The key development sectors discussed below have been selected on the basis of the significance and comparative importance of the principal environmental threats associated with each sector. The approaches that have been tried to date to address these threats, and options for more effective methods (where needed) in the future, are discussed in the later chapters of this report.

3.2 Agriculture and Land Clearance

3.2.1 Overview

It is estimated that subsistence agriculture clears up to 200,000 hectares of forested land annually in Papua New Guinea (Sowei et al 2002), although it is uncertain how much of this is primary forest, and how much is secondary re-growth on land previously gardened or otherwise altered by man. However, increasing rural populations, and improvements in transport infrastructure that allow greater opportunities for income generation from cash crops, will inevitably increase the demand for cultivated land in rural areas. This in turn will result in more land being converted to agricultural and garden use, particularly along roadsides and riversides where access is easier. Anecdotal evidence also indicates that these pressures are leading to the introduction of shorter fallow periods and more intensive cropping methods to maximise crop returns. This is likely to result in progressive reductions in soil fertility, reducing crop harvests in the medium to long term, and exacerbating the demand for further new (primary forested) land clearances.

In upland areas, subsistence agricultural practices can have more damaging longer-lasting impacts where thin soils and / or slope stability render exposed soils much more prone to erosion and nutrient leaching. In highland regions many of the streams and rivers carry large loads of silts and soil sediments, partly through natural landslips and erosion, but also in part due to the construction of gardens on the steep slopes that characterise these upland areas. As rising populations and economic pressures increase the demand for food and cash crops production in these areas, gardens will continue to be constructed in ever more marginal areas, with inevitable increases in erosion and downstream siltation. Alternative agricultural practices and crops will have to be developed for the local populations if this degrading of watersheds and downstream catchments is to be curtailed and improved over the long term.

More recently, the effects of droughts in the late 1990s and the rapid decline in the exchange rate of the Papua New Guinean kina against its major trading partners (which has made at least two of the country's staple foods, rice and flour, unaffordable for the many rural and urban dwellers who do not have regular or adequate income) has resulted in real food shortages being suffered by significant proportions of the rural and urban populations. In response to this the government has established a food security program, which is promoting food self-sufficiency as its primary goal. This program includes initiatives to develop more resilient and/or higher yielding garden crop varieties, and experiments with smallholder and community rice growing projects at a number of locations around the country.

Government policies to develop the rural sector through smallholder and nuclear agro-industrial initiatives will also contribute to the rate of land clearance, although the introduction of more sustainable agricultural methods in these programmes may result in a reduction in the rate of land clearance in the medium to long term.

Large-scale commercial estates such as oil palm have also converted locally extensive areas of forested land to monoculture plantations in West New Britain, Oro Province and Milne Bay Province. Although many thousands of hectares have been put under oil palm in the last 20 to 30 years, the annual rate of new conversions is relatively low and varies considerably from year to year. Recent increases in the international market price of palm oil, particularly the high quality oil produced in Papua New Guinea, and the government's desire to see more export-orientated agricultural development in the rural sector, suggest that the recent relatively low rate of new land conversions may increase in the next few years.

It has been estimated that approximately 25,000 hectares of natural forest are cleared annually for both

agricultural and infrastructure construction purposes (Sowe et al 2002). However, unlike the subsistence agriculture clearances, these plantation and infrastructure clearances will not revert to secondary re-growth during a fallow period. These cleared areas become, in effect, ecologically alienated areas that are inaccessible to many of the local fauna and flora, resulting in habitat fragmentation and barriers to movement and dispersal of species.

3.2.2 Land clearance

The principal environmental threats posed by land clearance are:

- Direct loss of habitat in the area(s) cleared of vegetation.
- Fragmentation of the wider habitat range as a result of the loss of habitat from the cleared areas, which become barriers to movement and distribution.

Cleared areas of forest and bush can become impenetrable barriers for many animal and plant species, restricting their range and so reducing the population's capacity to respond to locally unfavourable conditions. Roads, particularly where the width of clearance is of the order of 10's or even 100's of metres, can have a profound effect on the integrity of animal and plant communities by restricting their range, migration or passive distribution routes;

- The introduction of invasive species to previously undisturbed native habitats.
Roads and other land clearances can also provide an access route for invasive pioneer and alien species, some of which, such as feral dogs and cats, can roam beyond the transition or buffer zone at the margins of the cleared area and extend their range into the undisturbed habitats with dire consequences for many of the native species;

- Human intrusion and disturbance of previously inaccessible native habitats.
Land clearance, particularly for roads, also provides a much easier access route for human intrusion into previously remote or inaccessible habitats. This makes possible a much greater intensity and extent of hunting, gathering and collecting of plant and animal products, including timber for construction purposes, and opens up the possibility for further clearances of the undisturbed area for gardens and housing.

The extent of penetration by humans and feral animals depends on a number of factors including the nature of the buffer strip or transition zone that separates the cleared area from the undisturbed area, the vegetation and terrain in the immediately adjacent undisturbed areas, and the proximity of human habitation as a source of human and feral intrusion.

- Degradation of soil quality.
The removal of vegetation during land clearance also exposes the soil surface to the direct impact of rain, sun and greater temperature fluctuations. These quickly result in significant changes to the soil communities, which are adapted to a less extreme climate, insulated and protected from the weather extremes by the vegetation that has now been removed. As these soil communities become degraded, the composition and structure of the soil can also change, affecting its water and nutrient retention capacities, and rendering it more friable and subject to desiccation.
- Erosion and loss of soil from cleared and exposed ground.
The removal of surface vegetation exposes the surface soils to water and wind abrasion that can substantially increase the rate of surface erosion, resulting in significant soil loss and the silting of downstream catchments. In good agricultural practice, soil conservation measures are incorporated in the clearance program, including avoiding the clearing of sloping or heavily saturated ground, and the immediate replanting of cleared areas with soil-anchoring ground-cover plants.
- Disturbance of the downstream hydrological regime
Soils and surface sediments act as a sponge during periods of rainfall, absorbing the precipitation and releasing it slowly through the water table into the surface waters. This process of absorption is facilitated by vegetation, which increases soil infiltration rates so that less water will accumulate on the soil surface, less overland flow will be generated, and consequently there will be less opportunity for soil erosion to occur. Removal of the vegetation reduces infiltration rates, and

inter alia, increases overland flow and soil erosion. This increased overland flow results in river levels rising more rapidly and in heavy rainfall this can result in surge flows which travel rapidly downstream, scouring riverbeds and riverbanks, and generating flash floods which can cause significant damage to riverside habitats, human settlements and their activities.

- Contamination of downstream waters by suspended sediments and other particulate matter derived from terrestrial soils, and by the soluble components associated with these soils.
Increased rates of soil erosion result in greater sediment loads entering catchment waters. These increased sediment loads, whilst they remain in suspension, can have substantial effects on the water column, increasing turbidity and reducing light penetration, physically smothering and/or abrading the small invertebrate and algae communities such as the *periphyton*, and affecting the concentration of other key water quality parameters including the concentration of nutrients and organic matter in the water column.
- Nutrient enrichment (eutrophication) of downstream freshwaters.
Elevations in the concentrations of these parameters (nutrients and organic matter) can give rise to nutrient enrichment downstream, which may significantly affect aquatic communities in the lower reaches of the river and its floodplain wetlands.
- Silting of downstream watercourses, waterbodies and wetlands.
Depending on the size of the watershed and the scale of soil erosion into surface waters, significant silting (deposition, re-suspension/remobilisation, and re-deposition of silts and sediments) can occur in the calmer waters of the middle and lower catchments. This can result in changes to the bed morphology, river alignment and water-levels, affecting the depth and extent of inundation in the floodplains and wetlands, and altering local habitat conditions. Although these biological communities are adapted to fluctuations in habitat conditions, when these fluctuations extend beyond the normal tolerance ranges of species in these communities, as may result from large-scale land clearances in the catchment, there may be significant impacts on some species.
- Silting, organic enrichment and eutrophication of coastal environments such as mangroves, lagoons, reef flats and reefs, and near-shore waters.
Many coastal water habitats are particularly susceptible to silting and enrichment. Many of these habitats are spawning and nursery areas harbouring the sensitive juvenile stages of many marine species, and disturbance of these can result in severe impacts on local fisheries and other marine species through loss of recruitment from these nursery areas.

3.2.3 Agricultural developments

All agricultural enterprises generate organic wastes. These wastes can be divided into two categories, field wastes from weeding, pruning and harvesting, and process wastes resulting from the processing of the harvested crop, such as palm oil and coffee beans.

Field wastes are left in the field to break down naturally *in situ*, and for most of the crops grown in Papua New Guinea the amounts of wastes generated are small and within the assimilative capacity of the soils. However, in large-scale commercial operations with intensive cropping and high yields, the amount of field wastes produced may generate organic and nutrient loads in excess of the soil's assimilative capacity, so that runoff from these areas may contain significant concentrations of organic matter and nutrients. Where this runoff enters water-bodies (streams, wetlands or lagoons) draining the area, this may result in nutrient enrichment and eutrophication of the receiving water. Evidence of this is limited, but has been reported from intensively cropped oil palm estates, where discarded fruit bunches (from the processing) are returned to the plantations as composts or mulches and where the crop is regularly irrigated to maintain soil water levels. The extent and severity of this nutrient enrichment has not been investigated thoroughly, but it appears likely that there is some degree of eutrophication downstream of intensively cultivated oil palm plantations.

Process wastes pose a much greater environmental threat to downstream watercourses due to their very high organic content, which unless adequately treated would generate significant adverse impacts on downstream aquatic communities and uses. Much of this organic waste is water soluble and thus would

rapidly generate a very high oxygen demand giving rise to severe and extensive oxygen deficits in the downstream catchment. This would be accompanied by the release of highly soluble phosphate and soluble nitrate loads that would give rise to eutrophic conditions further down the catchment.

Oil palm is the most important export cash crop in Papua New Guinea today, and is a critical component of the government's agricultural exports policy, as well as being the largest employer and revenue source in the provinces that have large oil palm developments.

At most of the oil palm processing operations in Papua New Guinea, the process waste is a watery sludge, referred to as Palm Oil Mill Effluent (POME) and contains high concentrations of organic wastes with a very high Biochemical Oxygen Demand (BOD_5), approximately 100 times as polluting as domestic sewage. Most of this waste comprises sludge, fibre, oil and other components of plant origin, but unlike domestic sewage, it contains no pathogens. The very high concentration of organic material in Palm Oil Mill Effluent (POME) requires several stages of treatment before it can be safely discharged or used for irrigation purposes in oil palm nurseries and plantations (Department of Environment & Conservation 1997).

These treatment stages include residual oil removal, temperature equilibration, buffering, anaerobic and aerobic treatment in a succession of treatment ponds designed to yield a final effluent BOD_5 concentration of less than 100 mg l^{-1} , for river discharges. This would still require a minimum 5 to 10 fold dilution factor to fall within a normal ambient range of lowland streams and rivers. However, in the absence of any nutrient-stripping treatment, the treated effluent discharge may still carry nutrient loads sufficient to cause some eutrophication downstream.

Several of the industry's operators in Papua New Guinea are now moving away from the discharge of palm oil mill effluent into water courses to its use for irrigation, particularly in nursery areas where its high organic content makes it an excellent fertilising irrigant. When used as an irrigant, palm oil mill effluent is only partially treated to a BOD_5 concentration of approximately 5000 mg l^{-1} , allowing the operator to dispense with the aerobic treatment ponds, which being large shallow ponds, occupy a large area of land which might otherwise be used for nurseries or plantations. However, using partially-treated palm oil mill effluent as an irrigant does pose a significant risk of surface water and/or groundwater contamination. Areas irrigated with this partially treated effluent must be located and designed with adequate safeguards to ensure that none of this partially treated effluent is at risk of entering any surface water or groundwater, where it would cause significant adverse impacts on water quality and aquatic habitats.

Historically, the global oil palm industry was a heavy user of artificial fertilisers, but in Papua New Guinea today the industry has moved away from the large-scale and widespread use of artificial fertilisers to the application of empty fruit bunches (EFB's) recycled from the milling process, and other waste vegetable matter. Recently, the industry in Papua New Guinea has developed an enhanced composting technique using the empty fruit bunches and partially treated palm oil mill effluent to generate a richer and more rapidly assimilated compost than the application of empty fruit bunches. It is probably too early to say whether the use of this new compost will affect the nutrient concentration of plantation drainage waters, but as an integrated waste management methodology, it is a good step forward in the right direction for reducing the oil palm industry's impact on the environment.

Coffee is the second most important export cash crop in Papua New Guinea, and shares with oil palm a noxious waste problem. Coffee is processed by the "wet" method that generates an organically rich effluent with a high biochemical oxygen demand (BOD). Most of the larger commercial coffee "factories" do have primary treatment systems which remove solid organic pulp from the effluent, but these still leave a very high concentration of dissolved organics in the effluent. Only a few factories have secondary treatment to reduce the concentrations of dissolved organics in the discharge, and anecdotal evidence suggests that even fewer of these are operating effectively.

Approximately 65 % of the country's coffee is grown and processed by smallholders who have neither the resources nor the skills to install and operate effluent treatment systems (Sowe et al 2002). As a consequence, it is likely that up to 65 % of the raw coffee effluent generated in Papua New Guinea finds its way directly into the streams and rivers that flow through the coffee growing areas. In these areas

many of the waterways are badly polluted with coffee wastes to the extent that the local natural aquatic communities are severely affected and the water is unfit for potable use. According to the Coffee Research Institute, further research is necessary to develop effluent discharge standards for coffee factories, conduct surveys to document water usage and process techniques, and to design appropriate technology for smallholders (Sowei et al 2002).

The author is unaware of any significant use of artificial fertilisers in the agricultural sector, cost considerations probably mitigate against their use, and nutrient enrichment of downstream catchments as a result of artificial fertilisers does not appear to be a significant issue in Papua New Guinea.

There is some use of biocides (pesticides and herbicides) in the agricultural industry, but this appears to be mainly limited to the large commercial operations such as oil palm and sugarcane. However, there appears to be little information on the types and use of these chemicals in the agricultural sector, and this aspect of the industry remains largely unknown, and to that degree, a cause for concern.

3.3 Forestry

3.3.1 Overview

There are approximately 36 million hectares of closed natural forest in Papua New Guinea, which represents 77 % of the total land area of 46.3 million hectares. Approximately 15 million hectares of these forests could be designated as production forests (forests with a commercial value) (Sowei et al 2002), of which more than 50 % occur in the species rich lowland forests. An estimated 6 million to 8 million of these production forests could be considered suitable for logging under present regulations (Sowei et al 2002), which limit logging in areas where environmental conditions, such as steep slopes and inundated areas, would result in unacceptable environmental damage if logging were to be allowed.

Of the 6 to 8 million hectares of production forest suitable for logging, approximately half, 3.5 million hectares, had been logged by the end of 1998. It is currently estimated that approximately 150,000 to 180,000 hectares are selectively logged annually. At this rate of logging, the remaining forestry resource would last for about another 25 years of first-cut logging (Sowei et al 2002).

Although the forestry industry in Papua New Guinea operates under regulations and codes of practice that describe a sustainable-yield selection logging regime, the system has been criticised for the following reasons.

- Adopting an unrealistic sustainable cut cycle of 35 - 40 years.
- ineffective enforcement of environmental regulations.
- Focussing on a sustainable yield perspective rather than an ecologically sustainable use of the country's forest resource.

It is unclear what the rationale was for the adoption of a sustainable yield cut cycle of 35 - 40 years. In 1989, the World Bank used a 50-year cutting cycle to estimate the allowable cut that might lead to sustained yield management (Shearman and Cannon 2002). However, several commentators believed that this grossly underestimated the period required for adequate regeneration and re-growth to reproduce the yields per unit effort that were available during the first cut cycle.

The rationale for this criticism is that the high yields obtained during the first cut were frequently due to the cutting of "emergents" (the biggest, mature trees whose crowns extend "head and shoulders" above the main tree canopy), which would not be replaced in a cutting cycle of much less than 70 years. It remains to be seen what sort of yields can be achieved revisiting a first-cut area after a regeneration period of 35 years. It is quite likely that yield per unit effort would be significantly reduced compared to the "first-cut" yields, given that there would be few, if any, high yield "emergents" in the cut. It is possible that the yield per unit effort could be reduced in subsequent cutting cycles to a level that is only marginally economic, particularly if the present relatively low prices continue into the future.

The lack of reliable and accurate environmental monitoring, and ineffective enforcement of environmental regulations and codes of practice are widespread throughout Papua New Guinea, cutting across all sectors, and particularly in the more inaccessible areas where many commercial logging operations are prevalent.

Although existing regulations and the PNG Logging Code of Practice prescribe measures to protect soils, natural waters, and the residual tree stock, further regulations and standards that would extend the underlying principle of sustainable yield to that of ecologically sustainable development have been proposed. Whilst this is arguably reasonable and appropriate given the very high biodiversity value of some proposed logging areas, it can also be argued that it is premature, given the inability of the country to monitor and enforce the current, much less stringent sustainable yield regulations and standards.

This issue of how to successfully implement effective field monitoring and enforcement at the site of operations has already been cited as one of the principal issues facing environmental protection in Papua New Guinea at the present time. It is most unlikely that either national or local government will have the capacity and resources to successfully implement effective field monitoring and enforcement in the future, so more realistic and innovative solutions must be found to address this issue.

One of the strategies commonly proposed is to raise the level of environmental awareness amongst the local population, and particularly the landowners whose resources are threatened by unsustainable and environmentally damaging forestry operations. However, to be effective this strategy must move beyond the level of environmental awareness to embrace practical means and measures to empower the local people to act to protect their environment and its natural resource values. This would entail not only a more comprehensive and practical environmental skills training strategy and program, but also complementary skills development in the areas of negotiation, collaboration, conflict resolution and enforcement (requirements under the legislation, rules of evidence, procedural requirements, etc.).

This would be an enormous task, requiring considerable resources and training capacity, and would need to engage not only all the local leaders and landowners within the concession area, but also local government and the concession operators themselves. However, it is interesting to note that the recently advertised World Bank Forestry and Conservation Project has a similar component in its programme.

The following subsections briefly describe the potential environmental threats from the various activities involved in forest harvesting operations that use selection logging techniques.

3.3.2 Forest roads

The principal threats to the environment from selection logging as currently practiced in Papua New Guinea are direct and indirect threats to forest biodiversity and direct and indirect threats to watershed values such as stable hydrological regimes and water quality.

Although selection logging does not result in widespread land clearance, it does result in widespread physical disturbance throughout the logging area. This commences with the surveying of road alignments and clearance of vegetation along the line of the road. Although the alignment, width, construction, drainage and operation of the road are controlled by regulations and standards, these are frequently not complied with. As a consequence forest roads can produce a large number of impacts on the fauna and flora including:

- Direct damage and loss of habitats in the areas cleared for road construction;
- Direct effects due to habitat fragmentation, particularly where the width of forest clearance is of the order of tens of metres or more.
- The introduction of invasive species to previously undisturbed native habitats.
- Human intrusion and disturbance of previously inaccessible native habitats.

Forest roads also generate, at a local level, a number of impacts on the soils and waters including, albeit at a lower level of impact, all the impacts on watershed values associated with land clearance that have been described in Section 3.2. As forest roads are characteristically unsealed, with little in the way of firm foundations and often with poorly compacted surfaces that regularly suffer saturation and inundation, these road surfaces generate considerable dust or silt-laden drainage, depending on the weather conditions, that is carried into the surrounding vegetation and surface streams.

Most streams that receive drainage and surface runoff from forest roads show clear signs of periodically severe siltation. This is particularly so at stream and river crossing fords (fords are frequently constructed at streams and river crossing presumably to avoid the expense of bridge construction), where the impacts

of road drainage are compounded by soils and other materials that enter the stream from the vehicles using the ford.

The PNG Logging Code of Practice advises on a number of devices and measures that can be taken to minimise downstream contamination from road drainage and runoff, such as requirements for road drains, culverts, cut-off and interceptor drains, flow breakers and sediment sumps, but anecdotal evidence suggests these are rarely applied.

These impacts will have effects on biodiversity downstream, particularly in habitats that are more sensitive to disturbance by siltation and enrichment such as coastal lagoons and near-shore waters. The proximity of many commercial logging operations to the coast gives particular cause for concern in regard to fisheries nursery and spawning areas, many of which occur in these sensitive coastal environments.

3.3.3 Selection logging

The selection logging of an area commences following the construction of access roads. This usually involves survey teams locating and selecting target trees for logging, and then marking out snig track routes along which the tree log will be dragged to the access road. The selection of this snig track route should have a significant environmental input to minimise unnecessary disturbance and damage to the under-storey forest habitat, including its vegetation, soils and surface waters. After the snig track alignments have been marked out, the felling teams move in and cut the selected trees using directional felling and other techniques such as vine clearance to minimise damage to the residual trees (young / immature trees that will be left behind to grow for the next cutting cycle). Once a tree has been felled, the snigging vehicle, usually a bulldozer or industrial tractor drags the felled log out, supposedly along the marked out snig track.

Papua New Guinea's forestry regulations set out clear criteria and standards to minimise unnecessary disturbance and damage during felling and snigging operations, but compliance with these is less than effective, and avoidable environmental disturbance and damage does occur.

The types of environmental impact that can occur during selection logging as a result of felling and snigging operations include:

- The loss of most, if not all, of the mature trees in an area selected for harvesting. These trees are critical habitats for many *epiphytic* plants (such as orchids and bromeliads) and *arboreal* fauna;
- In addition to the loss of the trees that are felled, damage is also suffered by the residual trees and under-storey vegetation as a result of careless or inappropriate logging techniques. Common instances of such damage include:
 - Indirect damage to adjacent trees as a result of the incomplete removal of vines and other climbing plants, so that adjacent boughs and/or crown tops are ensnared and damaged by vines caught up in the felling.
 - Physical impact damage to adjacent trees as a result of poor directional felling.
 - Avoidable damage to buttress roots and the lower stems of residual trees, juvenile trees and saplings as a result of careless snigging of logs from the felling point to the road. This damage can become infected, resulting in disruption to growth patterns, and in severe cases death of the individual tree.
 - Damage to the forest shrubs, ferns, stems and aerial roots of vines and other climbing plants, tree seedlings and herbaceous plants that make up the under-storey as the felled log is dragged along the snig track.
 - Damage to the leaf-litter / soil surface communities along the snig track. These fungal communities are largely made up of the fungal *mycelia* that extend laterally throughout the upper few millimetres of the topsoil and are responsible for much of the decay and decomposition processes that recycle the inorganic nutrients in the forest ecosystem. If these suffer significant damage, this crucial supply of nutrients to the trees and other forest flora could be disrupted, affecting the health and growth of the trees.
 - Compaction and/or ripping of the topsoil, by the inappropriate use of heavy machinery. This affects soil infiltration rates, surface water and soil water movement, and soil

water capacity, and may adversely affect the uptake of soil water by plant rooting systems, which will also directly affect the availability of nutrients.

- Direct effects due to habitat fragmentation, particularly where the width of forest clearance is of the order of tens of metres or more.
- The introduction of invasive species to previously undisturbed native habitats.
- Human intrusion and disturbance of previously inaccessible native habitats.

Although many of these impacts can be avoided by careful planning and management of field operations, this is not always followed, and many of these impacts are commonly encountered by the regulatory agencies when they are able to conduct field inspections.

3.3.4 Camps, workshop areas, log storage and log load-out areas

Four principal environmental issues arise from the establishment, operation and abandonment of forestry work camps, workshop areas, log storage and log load-out areas.

- Wastes management.
- Water supply and sanitation.
- Soils conservation and stormwater management.
- Effects of human and feral species intrusion into previously remote and isolated environments.

Camps, workshop areas and log storage and load-out areas produce a wide range of wastes including kitchen scraps, other biodegradable wastes, non-biodegradable wastes such as plastics, glass, metals, and discarded vehicle tyres and vehicle parts, and hazardous wastes such as waste oils, solvents, cleansers and other residues, and contaminated containers such as discarded oil filters and oil drums. To address this wide range of wastes effectively requires the camp management to adopt a Total Wastes Management approach identifying:

- Waste reduction opportunities, reducing the use of unnecessary packaging and non-reusable or non-returnable containers;
- Waste recovery and re-use measures, such as the common use of waste engine oil to lubricate chain-saw blades and grindstones, and the re-use of uncontaminated containers;
- Waste recycling, such as composting of kitchen scraps and other appropriate biodegradable wastes, and the use of discarded vehicle tyres in stormwater flow breakers and bank stabilisation devices

An effective wastes management strategy requires the preparation of a practical and cost-effective Total Wastes Management Plan. This plan should clearly identify all the residual and intractable wastes that require specific treatment, disposal or end-use measures, and how these will be carried out.

Commercial logging operations are required to submit a Waste Management Plan to the Department of Environment and Conservation, but in the absence of regular monitoring and effective enforcement, it is arguable as to what extent this plan is implemented.

The failure to properly manage and contain wastes can result in a wide range of environmental impacts. Some of these can be locally severe, such as contaminated ground and surface waters in the vicinity of workshops, and contaminated watercourses, which carry significant health risks for downstream users as well as having adverse impacts on aquatic habitats and their communities.

Water supply and sanitation can have significant environmental consequences unless proper and effective provision is made to protect downstream catchments. The identification and selection of suitable water sources requires an accurate assessment of the water demand and its uses. Consultations with the local people need to be conducted to identify downstream water usage, including *in situ* uses and abstractions to ensure that even under base flow conditions (which follow extended periods of low or zero rainfall), abstractions for the camp and workshops do not interfere with existing downstream uses.

A biological survey, supplemented by consultations with the local people, should also be conducted to identify habitats that would be critically affected by reductions in the flow regime in order to ensure that the abstraction rates under low flow conditions do not have adverse impacts on these downstream habitats.

If the potable water supply is to be treated, and in most instances this will be necessary to ensure the supply meets public health standards, the facilities and management of the treatment system must be

adequate to ensure that there is no contamination of natural waters by treatment chemicals or their wastes and/or residues.

Regardless of the sanitation system that is selected, it must ensure that there is no contamination of downstream waters by faecal coliforms or pathogens, as in many instances these downstream waters will be someone else's water supply. If a water-based sanitation system is used, an effective primary and secondary treatment system must be installed and properly maintained to ensure that the treated discharge is pathogen free, with a low turbidity and low biological oxygen demand. Discharge of the treated effluent should be located at a site and in a manner that ensures that the dilution at the outfall is sufficient to rapidly disperse the organic and nutrient loads in the discharge.

The discharge of partially treated or untreated sewage into watercourses in Papua New Guinea should not be regarded as an acceptable disposal method as it poses an unacceptable public health risk. The subsistence livelihoods of most rural people depend on the potable quality of most natural waters and there is an implicit assumption by most rural dwellers that unless the water is turbid, muddy, odorous or contains foreign matter, it is generally fit to drink.

The discharge of partially treated or untreated sewage into watercourses will also result in the deterioration of water quality downstream. The extent of this deterioration will depend on the dilution factors at the time of discharge, and the existing nutrient status and organic load of the receiving water. The principal impacts from the discharge of partially treated or untreated sewage into watercourses are:

- A reduction in downstream dissolved oxygen concentrations which may result in severe oxygen deficits developing at some distance below the discharge point.
- An increase in the organic and nutrient loads that can lead to the development of eutrophic conditions further downstream.

The construction of logging camps invariably requires the clearance of forest and vegetation, exposing the soils to weathering and erosion. Unless appropriate remedial measures are promptly implemented this can result in the impacts identified in Section 3.2 under Land Clearance.. All areas of exposed bare ground not subject to traffic movement should be planted with fast-growing, soil-anchoring plants to minimise soil erosion and restore soil infiltration rates. This will prevent, or at least reduce, the incidence of standing water accumulating on the surface and generating overland flows / surface runoff. Nevertheless, there will be areas within the camp and workshop areas which remain bare ground, and particularly so in the log storage and log load-out areas, which because of the constant churning of the ground surface by heavy machinery, are never able to re-vegetate, until such time as the area is abandoned.

Bare soil areas, particularly those that have a severely disturbed surface as a result of heavy traffic movement (or in another circumstance, unstable slope) will continue to generate soil loss, particularly under intense rainfall and storm events. To reduce and contain this soil loss, a "dual stream / flow" (clean and dirty) stormwater drainage system should be installed. This should consist of a "clean water" drainage system that will intercept relatively clean surface runoff flowing onto the bare soil areas from the surroundings, and channel these away from the site. These systems also include a "dirty water" drainage system that will collect the heavily silted surface runoff from the bare soil areas and reticulate these through sedimentation traps and solids settlement sumps prior to discharge.

The discharge channels and outlets for both the clean and dirty stormwater systems should incorporate flow breakers ahead of dispersal outlets to ensure that the force of the discharge does not erode and mobilise soils and sediments in the vicinity of the discharge outlet. To minimise further erosion at the discharge point, this should be located in an area of dense, well anchored, vegetation that will disrupt and slow the discharge flow and increase soil infiltration rates to reduce the overall volumes of residual surface runoff.

The fourth principal environmental issue to be addressed in regard to logging camps and workshops relates to the effects of human intrusion. Camp workers and their associated feral species, such as dogs, cats, and possibly rats and mice, intruding into previously remote and isolated environments that in all likelihood characterise the surroundings of the logging camp and workshop areas, can cause significant impacts on local habitats and biodiversity. In particular, hunting, fishing and the disturbance or removal of plants and animals has a direct impact on the fauna and flora in that area. Although humans can exercise care in minimising their disturbance, their feral species do not.

Furthermore the escape and successful invasion of feral species into new areas poses a very real and imminent threat to isolated populations of fauna and flora, which may suffer predation, disease or be out-competed by new and vigorous invading alien species. The examples of dogs, cats, rats and mice are well-known and generally well understood, but other alien invading species can have just as disastrous consequences on the indigenous and endemic fauna and flora.

Intrusion by outsiders, such as many of the camp workers, may also contravene local custom and may constitute trespass. The land surrounding the logging camp is owned by a landowner under customary land ownership rights which do not *per se* recognise the right of others outside of the landowner's family or clan to enter, access or use that land and the resources on that land. In other words, stepping outside the perimeter of the camp may be an act of trespass, and taking any animal, fish, plant, flower or fruit from that land is likely to be seen as an act of theft.

3.3.5 Downstream processing

In recent years, the government's forestry policy focus has been to promote downstream processing in the industry as a means of capturing more of the resource value on-shore, and providing employment opportunities. The policy promotes the development of industrial capacity to export value-added forestry products including plywood and veneer as well as finished timber. This capacity would also serve the domestic timber market, bringing to an end the situation whereby Papua New Guinea exported logs at raw commodity prices while being forced to import timber and timber products at added-value prices using precious foreign exchange.

There are now several timber and plywood processing operations in the country, and Papua New Guinea is progressing towards self-sufficiency in timber and timber products for building and other construction purposes.

The environmental issues associated with the timber processing industry are mainly concerned with the use, storage, handling, transport, and disposal of the chemicals, and their wastes and residues, used in timber preservation treatments. These chemicals are by nature biocides and are extremely toxic and long-lived in the environment. Their use requires stringent hazardous materials management controls to avoid contamination of surface waters, groundwaters and soils.

Purpose-built facilities are required for the safe storage, handling and use of these chemicals, and in particular for the safe disposal or end-use of contaminated wastes, chemical residues and their containers. These facilities must ensure completely secure containment and separation from the environment so that even if major spills or leaks occur, they cannot escape into the environment (watertight, impermeable bunds with the capacity to contain all the material in the event of an entire loss scenario).

Likewise these facilities must be located on stable ground well above maximum possible flood levels. They must be equipped with adequate protection from extreme rainfall and high surface runoff (bunded operational and storage areas must be covered and ring drained) to avoid inundation or overtopping of the bunded area under extreme weather conditions.

Strict management controls must also be enforced, at all stages of the treatment and end-use processes to ensure worker safety and secure environmental containment. These chemicals are dangerous and all workers must be fully trained in the health, safety and environmental risks and in the appropriate emergency response procedures, as well as being fully equipped with effective personal protection equipment. These management controls should ensure full and effective compliance with the relevant Material Safety Data Sheets (MSDS) and HazMat (Hazardous Materials) standards.

These management controls must also include contingency plans to ensure public health and safety, and as far as possible take timely and effective action to minimise the extent and severity of environmental impacts in the event that these extremely hazardous toxic materials escape or are lost to the environment.

3.4 Mining and Petroleum Sector

3.4.1 Overview

Papua New Guinea possesses rich mineral resources including gold, copper, silver, nickel, cobalt, petroleum and natural gas. The exploitation of these resources over the last 30 years has provided the country with substantial foreign earnings, infrastructure, training and employment. The mining and petroleum sector continues to be of major economic importance, contributing approximately 75 % (K. 1,064.5 million) of the total value of merchandise exports (K.1,410 million) in the September quarter of 2002 (Bank of Papua New Guinea, 2002). Mineral export receipts, excluding crude oil, made up 49 % of total merchandise exports in this quarter, whilst receipts from crude oil exports accounted for 26 % of the total merchandise exports during this period.

Gold mining has a relatively long history in relation to the development of the country, and has played a key role in its development as a nation. Early in the nineteenth century, small deposits of gold had been discovered at several locations, including sites in the foothills of the Port Moresby hinterland (the remains of some of these workings are still visible today). By the 1920s, the country was the centre of a “gold rush” boom, attracting prospecting miners from around the world, some of whom reaped considerable rewards. Gold prospecting was the reason for the exploratory treks taken by Leahy, Taylor and others in the late 1920s and early 1930s that led to the discovery and opening up of the Highlands. One of these “gold rush” areas was the area around Wau and Bulolo in Morobe Province, which at that time was only accessible by air transport, so that most of the people and all their equipment had to be flown in.

Although Wau and Bulolo are now connected by road to Lae, the provincial capital of Morobe, this problem of access remains a serious logistical issue in the industry. Most prospective mining and petroleum exploration sites are located in remote and rugged terrain, often at elevated altitude in the highland provinces, and are only accessible by air so that all workers and equipment have to be flown in, usually by helicopter. One gold mine, the Tolukuma Gold Mine in Central Province, which is located approximately 200 kilometres north-west of Port Moresby in remote and very rugged mountainous terrain with no possibility of road connection, has been entirely developed and operated through the use of helicopters.

In most areas, once a mineral or petroleum resource has been proven economic, it is more cost-effective for the developer to construct roads connecting the mine to the national transport system, as the costs of air transport are high. One of the principal benefits of mining developments to the country, apart from the revenue generated, is the construction of major highways and all-weather road networks that link the mine, and the local area, to the national transport system. For example, several highlands provinces, notably Enga and Southern Highlands Provinces, now have much-needed all-weather road networks as a result of the Porgera Gold Mine and the Kutubu-Gobe Oilfields respectively, which were constructed by the developers. Although these roads were primarily constructed to service and support the development, they have provided many valuable opportunities for the development of local trade and commerce in these previously remote and underdeveloped provinces.

Although most commentators agree that Papua New Guinea has considerable potential for growth in this sector, as much of the country remains to be explored, mineral exploration has declined over the last five years. This is due to a number of factors including the relatively high cost of mineral exploration in Papua New Guinea arising from a lack of existing infrastructure and the extremely difficult terrain and weather conditions. Other factors include land ownership disputes, unpredictable compensation claims which are often related to land ownership disputes, and a perception by overseas investors of some degree of uncertainty in regard to fiscal stability and economic operating conditions in the medium to long-term horizon.

3.4.2 Medium and large-scale mining operations

3.4.2.1 Environmental risks and mitigation strategies

Environmental impacts can occur at all stages of the mining cycle depending on the mining methods used and degree of activity, commencing with exploration, construction, operation, closure and post-closure, when residual impacts can continue to occur long after mine closure and abandonment.

Exploration

Local environmental disturbance may occur during the early stages of exploration as a result of seismic exploration and test drilling. These can easily be reduced by minimising the areas of disturbed ground along seismic lines and around drill rig sites, and by the application of strict management controls on drilling mud during drilling operations. Following the completion of drilling, the rehabilitation of drilling sites, including replanting with local species, minimises exposure of surface soils to weathering and erosion.

More severe environmental impacts may occur later in the exploration cycle as a result of trenching and the drilling of rock shafts, which can pose a contamination threat to downstream catchments. However the adoption of effective controls will considerably reduce the severity and duration of potential impacts. Such controls include installation of clean and dirty stormwater separation and treatment systems, effective containment and erosion protection on-site of all waste rock, environmentally secure containment and management of all hazardous materials and wastes, and the implementation of sound rehabilitation measures such as ground stabilisation and replanting with local species.

Construction

The construction of mine sites and related infrastructure may include roads, camps, workshops, ore processing plants and related facilities such as tailings impoundments (ponds and dams) and treatment facilities, assay labs and hazardous materials storage, handling and end-use facilities. The scale of these constructions may pose more widespread threats to the environment, particularly the downstream catchments and the surrounding habitats and human communities within the wider area of disturbance. This area of disturbance can often extend several kilometres beyond the mine site perimeter.

Strict imposition of environmental management controls and environmental protection systems throughout all stages of the construction phase are crucial to minimising these threats. In essence, the key strategy must be to minimise as far as practicable, or completely avoid, the loss or movement off-site of any:

- Waters that may be contaminated with soils, rock sediments, wastes, chemicals or other materials.
- Soils, rock sediments, wastes, chemicals or other materials.
- Plant or animal species, particularly any feral species or species that do not occur locally.
- Toxic, noxious or odorous aerial emissions.

There are many management strategies and environmental protection systems that can be used to achieve or approach these objectives, depending on local conditions and circumstances. At each mine construction site, a comprehensive integrated environmental management regime that is specifically designed to the circumstances of construction and the local ambient conditions, including monitoring and response procedures and systems, should be implemented..

Operation

The operation of mine sites, and in particular the operation of ore processing and tailings treatment facilities, pose the greatest environmental threat among the various mining-related activities.

The vast majority of large-scale mining in Papua New Guinea is open-cut mining and this generates huge quantities of excavated material that has to be removed before the ore can be mined. This material has to be re-deposited in a stable and secure area that is under long-term environmental management to ensure that it does not pose a threat to the adjacent environments and downstream catchments. Waste characterisation, particularly in regard to assessing and managing potential long-term environmental effects, stormwater controls, soil conservation and ground stabilisation measures, landscaping and continual re-vegetation of new deposits with appropriate species, are all critical components of this long-term environmental management.

Ore processing involves crushing the ore rock to maximise yields from the surface area and subsequent chemical treatment. This may involve the application of extreme heat or pressure to concentrate the ore (e.g. copper is exported as a concentrate from Ok Tedi Mine) and ultimately extract the purified metal (e.g. gold at Porgera, Lihir and Tolukuma Mines) from the treated ore mix. The waste product from this chemical treatment is called “tailings” and is generally a slurry composed of at least 50% water, with high residual concentrations of the treatment chemicals and metals mobilised from the host rock during

the extraction process. Depending on the processes used and the composition of the host rock, the tailings may include high residual concentrations of cyanide, arsenic, sulphide, and heavy metals such as copper, cadmium and chromium. Raw tailings are extremely toxic and often corrosive (tailings are usually acidic with a low pH) and are therefore treated prior to discharge.

The treatment of tailings involves a variety of techniques depending on the nature and composition of the tailings slurry. Common to most is temperature equalisation, pH adjustment to a neutral or slightly alkaline condition to stabilise (“fix”) metal concentrations and oxidation with compressed air, oxygen or chlorine to separate out metal residues as precipitates or flocs. Treated tailings are usually disposed of in impoundments (dams) referred to as tailings ponds, which are designed and constructed for secure long-term storage. In some situations, where secure impoundment is not feasible due to a lack of available storage area, ground instability, or high rainfall, treated tailings may be discharged directly into high flow volume rivers or through long outfalls into the marine environment, where high dilution factors rapidly disperse the discharge.

In Papua New Guinea, none of the mines currently in operation have tailings dams, due to concerns regarding ground stability, and the treated tailings are disposed of into receiving waters, utilising a mixing zone strategy. This strategy requires the receiving water containing the tailings discharge to reach prescribed water quality standards at the boundary of the mixing zone that may be many kilometres downstream, or surrounding the end of an outfall.

Even beyond the mixing zone, any residual toxicity and turbidity of these waters can pose an environmental threat to aquatic habitats, and may extend into the coastal and marine habitats depending on their proximity to the mixing zone boundary. Heavy metal contamination and turbidity are significant threats to coral reefs, which are particularly sensitive to these contaminants.

Sedimentation smothers and asphyxiates the benthic communities in inland and coastal waters, severely disturbing food webs and the production and re-cycling of organic material and nutrients. Inshore coastal waters are important spawning and nursery grounds for many key species, including several species of commercial importance. Their contamination by sediments and excessive turbidity, or toxic materials, will have a widespread impact on many important marine species.

The heavy metals that may be present in residual concentrations in tailings discharges are known to bio-accumulate (increase in concentration) in the food chain. The contamination by these metals of subsistence and commercial river and marine fisheries species poses a significant threat to those in the human population who consume fish on a regular basis. For many coastal people in Papua New Guinea, locally caught fish are not only their primary source of protein, but together with garden produce, are part of their staple diet.

Mine Closure

Mine closure has a number of potential environmental impacts that may arise from ongoing contamination of surface and groundwaters from contaminated sites, soil erosion and downstream siltation from unstable or exposed ground surfaces and habitat fragmentation from inappropriate landscaping or re-vegetation programmes. However, these impacts can be minimised or avoided by ensuring effective environmental rehabilitation measures are implemented well ahead of relinquishment (final mine closure). These measures should be consistent with an agreed (among the stakeholders) final land-use plan, taking into account state of the art technology and knowledge. They should include backfilling and re-contouring of the landscape to a stable form and topography, including water-courses and water-bodies where feasible, and re-vegetating the site with local native plant species. In collaboration with the landowners, management controls and restrictions on use and access should be implemented so that the area has a reasonable chance to fully recover.

A joint initiative by the Department of Mining and the Department of Environment and Conservation has resulted in a draft rehabilitation framework that considers many of the issues raised in the preceding paragraph. It is envisaged that this framework will form the basis of the rehabilitation component of the Mine Closure phase of the EIA process in the Mine Closure Policy, which is referred to in the following section. It is intended that the Department of Environment and Conservation will consult further with industry, NGOs, and other government agencies, prior to adapting the generic framework into the new Environment Act regulations.

3.4.2.2 Monitoring and regulation of medium and large-scale operations

In the years immediately before and following independence, there was a strong imperative to develop the rich mineral resources of the country as a source of revenue for development. In this push for development there was a temptation to “cut corners” by imposing less rigorous requirements than were needed to ensure the full protection of the environment, which was compounded by a lack of information and understanding on the environment of Papua New Guinea, and its particular vulnerabilities.

In its earlier years, mining in Papua New Guinea had a history of serious environmental and social impacts (Sowei et al 2002), most notably the Panguna Mine on Bougainville which over a ten-year period dumped more than 360 million tons of tailings and waste rock into the Kawerong / Jaba river system. This resulted in the entire loss of fish from the 480-kilometre catchment and associated declines in coastal fish stocks and local wildlife populations (Sowei et al 2002). Commencing in 1988, local landowners protested against these disastrous impacts, but received little support. At the start of the 1990s the landowners decided to take matters into their own hands and closed down the mine. This led to a state of civil war on the island that lasted for almost 10 years. Only recently have reconciliation moves led towards a resolution of the conflict and the beginnings of a return to normal life.

Similar environmental impacts threaten the Fly River system in the remote west of the country (see Section 2.4). The Ok Tedi Mine, which is the world’s largest copper mine and contributes 10 % of Papua New Guinea’s gross domestic product and 20 % of its export income (Higgins R. 2002), has been disposing its tailings and waste rock into the Ok Tedi River (a tributary of the Fly River) since the mid 1980s, at an average discharge rate of 65 million tons per year (Sowei et al 2002). The accumulation of natural and mine-derived sediments in the river system has produced flooding of the Ok Tedi and Fly Rivers, depositing these sediments across a wide area of the floodplains. This is believed to be one of the primary causes of the extensive vegetation dieback observed on the floodplains, together with the loss of food gardens, fish habitats and reduced fish populations that have been reported from this area (Sowei et al 2002).

In recent years it has become increasingly more difficult for government to find the resources and capacity needed to conduct regular site assessments and effective monitoring of impact risks. Given the lessons learned at Panguna and Ok Tedi Mines, it is assumed that the commercial mining industry could now be relied on to minimise environmental impacts as a co-operative partner in the sustainable development of Papua New Guinea, and that self-regulation by the industry is a workable and effective means of protecting the environment in mining areas. To this end the Department of Environment and Conservation is close to completing the preparation of a code of environmental practice for the mining industry, which will be administered under the new Environment Act 2000.

Recently the mining industry has made significant moves towards improving its environmental performance through greater public disclosure and more widespread availability of information. One component of these initiatives has been the establishment of new fora for the participation of stakeholders and their meaningful involvement in assessing and discussing monitoring data and other information made available by the mining companies (Sowei et al 2002).

In addition, the government, through the Department of Mining has overseen the preparation of:

- A Sustainable Development Policy and Sustainability Planning Framework for the Mining Sector in Papua New Guinea, and;
- A Mine Closure Policy, addressing mine decommissioning and rehabilitation.

Both documents focus on the planning and management of mining projects so that their benefits can contribute more in practical and effective ways to the long-term sustainable development of their local communities and the country at large.

Several of the major mining companies operating in Papua New Guinea are now preparing, or have prepared, company and corporate environmental policies that embrace values of environmental best practice, public environmental reporting and disclosure, community participation and sustainable development. Many of these corporate policies reflect the changing trends to view the environment as part of the “triple bottom line” in terms of decision-making, tri-sector partnering concepts and stewardship. One of the challenges that will be faced by the government in the near future is to facilitate the implementation of these corporate policies with regulations and regulatory mechanisms that are compatible

with, and promote in a proactive manner, the implementation and practice of these policies.

One of the fundamental principles of good environmental management and practice is the precautionary principle, and this should be a guiding principle at each stage of mining development design and implementation. This requires appraisal by skilled technical personnel with expertise in environmental impact assessment and mining technologies (in order to know, for example, what options are available and realistic in Papua New Guinea's circumstances to avoid or mitigate the potential impacts that are identified during the appraisal). Obviously the employment of specialists and the need to carry out comprehensive baseline field investigations and consultations with the local people at the site and throughout the downstream catchment will inevitably entail considerable expense, well beyond the resources of government.

Such comprehensive project appraisals, necessary to ensure the mistakes made at Panguna and Ok Tedi are not repeated, fall within the ambit of "user-pays". It is now an accepted part of commercial mining development by international partners operating in Papua New Guinea (where establishment costs are upwards of US\$50 million) that the cost of environmental and social impact assessment will be paid by the project proponent, regardless of whether the project proceeds or not, and in the case of "not proceeding", regardless of the cause(s) or reason(s) for this decision.

The problems faced by potential overseas investors is often not the final cost estimate as such, but uncertainties in its calculation, particularly in terms of risk assessment and potential compensation. Any relatively small costs (compared to the overall establishment costs) that reduce this risk and the possibility of massive compensation claims later in the development cycle is most likely to be cost-effective at the bottom line. As such, it is reasonable and equitable that this should be a part of the operating costs that are borne by the project developer.

3.4.3 Small-scale artisanal mining

3.4.3.1 Environmental risks and mitigation strategies

Small-scale alluvial mining for gold is estimated to employ approximately 80,000 Papua New Guineans (Sowei et al 2002), a much greater number than those directly employed in the highly technical and capital-intensive large scale mining operations. Although in terms of production and revenue generation this part of the industry plays only a minor role, it is an important artisanal industry and often the principal source of income for local communities in the areas where it occurs.

Some of these artisanal mining areas are in the vicinity of old, worked out goldfields such as around Wau and Bulolo, whilst others are located in the vicinity and downstream of existing operations such as Porgera and Tolukuma Mines. The majority, however, are not located near any mines. In these areas particularly, they are a vital source of cash-income for the local communities.

Most of these operations are located in stream and creek beds and are run by the local landowner families using shovels and occasionally mechanical diggers mounted on agricultural tractors to mine the streambed and sandbanks along the side of the river. The simple portable screens are usually set up on the riverbank or a sandbank close to the diggings, and are fed by a small water pump extracting directly from the stream. The highly turbid screen-waters are discharged directly back into the stream or small river, creating severe turbidity and high sediment loads downstream.

In areas where alluvial gold occurs, there are usually many of these small artisanal operations, often in the same small river or stream, and consequently these rivers and streams are severely impacted for considerable distances by the high sediment loads resulting from these operations. Much of the Bulolo River catchment's aquatic habitat shows signs of sediment related impacts and similar localised effects are to be found at gold-bearing locations around Papua New Guinea.

Mercury is used to extract the gold from the river sediments. There is little awareness amongst the alluvial miners of the environmental and health risks that this use of mercury produces, and environmental contamination of downstream waters is likely to be a significant and fairly widespread problem in the catchments affected by alluvial mining. However, the logistical difficulties and lack of resources that have been mentioned previously mean that there is very little, if any, information on mercury contamination

of these waters.

This is a serious concern not only in regard to the impacts on downstream habitats and their aquatic communities, but more importantly on the public health of those people and settlements downstream who use these waters for washing, bathing, and sometimes direct consumption. Fishing in potentially contaminated waters downstream poses a particular threat to health given the well-documented bio-accumulation of mercury through the food chain.

There is also a growing weight of evidence indicating that the uninformed use of mercury by the miners themselves is contributing directly to an increasing incidence of personal health problems such as “mercury cough” and loss of hair and finger-nails. The author has been told (field survey, Eddie Creek, Bulolo River catchment, 1992) it is not uncommon for the mercury to be boiled off from the gold amalgam at the end of each day inside the miner’s house (apparently so that others cannot see how much gold he has), contaminating not only his lungs, but also the lungs and bodies of all his family.

3.4.3.2 Monitoring and regulation of small-scale artisanal mining

Regulation and control of small-scale artisanal mining operations is difficult, in no small part due to the sheer number of individual operators and the methods used, which being highly portable, are easily moved to avoid detection. There appears to be a pressing need for local environmental awareness programs backed up by some sort of locally-based regulatory system that has widespread support, if the recommendations in any code of environmental practice for small-scale alluvial mining are to be adhered to in any degree.

In this regard, the Department of Mining has recently completed an awareness program in the Sepik and Morobe Provinces that was funded by AusAID. However, a follow-up survey would need to be undertaken to see whether attitudes have changed as a result of this initiative, and it is to be hoped that funds can be found to carry out such a survey, as the feedback obtained would be a most valuable input into the preparation of any code of environmental practice for the artisanal mining industry in Papua New Guinea.

3.4.4 Petroleum and gas

The petroleum and gas sector is also a major contributor to the national economy, being the second most important contributor to foreign export earnings after the mining sector (see Section 3.1). However, as with the mining sector, its contribution to the national workforce is small. Like exploration in the mining sector, the petroleum and gas sector is also going through a period of decline as existing reserves of oil approach the end of their commercial life. However, unlike the mining sector there is a commercially viable option ready to be exploited, natural gas, which is present in abundance in the same fields but has not been exploited to date because of a lack of markets.

Esso Highlands, in a consortium with others, is working on the development of a natural gas pipeline that would extend from the gas fields in the Southern Highlands across the Gulf of Papua and the Torres Strait to Australia, and thence south to Queensland and beyond into New South Wales. If adequate markets can be found for the gas in Australia, and the current expectations are that they can, then detailed engineering design is likely to commence in 2003, with the commissioning of the pipeline and gas sales projected for 2006 / 2007.

At the present time the petroleum and gas sector in Papua New Guinea is limited to extraction and upstream processing of crude oil and natural gas from the petroleum fields in the Southern Highlands province. The nature of these operations means they have a smaller and more localised environmental impact than mining. These impacts are limited to:

- Land clearance during the construction of access roads, well sites, oil and gas transport pipelines and upstream processing facilities.
- Wastes management, mainly arising from camp and workshop wastes as the produced water and unused gas is re-injected into the petroleum bearing strata to maintain pressures for oil extraction.
- Some localised disturbance to adjacent habitats as a result of normal working operations, including flaring of gas (particularly at night) and traffic movements.

There is currently an oil refinery under construction at Port Moresby that is located inside harbour bay. This refinery will process crude oil from the Southern Highlands fields, brought to the refinery by sea tanker. Petroleum products will be transported from the refinery by road to Port Moresby and Central Province and by coastal tanker to other parts of Papua New Guinea. The refinery will also export petroleum products overseas by sea tanker.

The principal environmental risk associated with the refinery will be the risk of oil spills during manoeuvring through the reef passage into the harbour bay and within the bay itself. Any sizeable spill, in excess of more than a few tons is likely to have severe environmental impacts on the bay's habitats and biota, and on the many human settlements located around the bay shore. However, until more details are known regarding the refinery operation and the transport of crude oil and petroleum products to and from the refinery, it is premature to do more than highlight these concerns at the present time.

3.5 Fisheries Sector

3.5.1 Overview

Papua New Guinea has an Exclusive Economic Zone (EEZ) of 2,437,480 square kilometres, with a wide range of coastal and marine environments that have the potential to support a large and robust sustainable fisheries industry. At the present time, 2001, the fisheries industry contributes export earnings in excess of 200 million kina and employs 3,500 people in the formal commercial sector (Sowei et al 2002).

3.5.2 Commercial fisheries

The main commercial fishing species are tuna and prawns. Most tuna is caught by *purse seine* net fishing. The total annual catch has varied between 135,000 and 350,000 metric tonnes over the last ten years, including licensee catches from foreign vessels (Sowei et al 2002). Papua New Guinea has agreements with seven neighbouring countries to limit the number of licensed purse seine vessels to 205. The total foreign vessels' catch in 2000 was estimated at 160,000 tonnes, with a value of approximately US\$100 million (Sowei et al). However, there is a concern that these vessels are catching non-target species (by-catch), such as big eye tuna, whose stock is more vulnerable to over-exploitation. Information on the amount of by-catch is not available, and the lack of such important information could lead to over-exploitation of vulnerable species. Given that Papua New Guinea cannot afford rigorous monitoring and inspection of foreign vessels fishing within the EEZ, this important information is unlikely to become available in the near future, unless more innovative means of collecting the information can be found.

The domestic tuna industry has grown significantly in recent years, particularly in long-line fishing, surface tuna fisheries and fish processing (canning). In 1997, 6,250 tonnes of tuna were exported at a value of 14 million kina. In 2001, 40,730 tonnes were exported at a value of 144 million kina (Sowei et al 2002). This rapid increase in growth over the last four years (an average 60 % annual increase year on year for the last four years), if continued into the future, may pose a threat to the long-term sustainability of this fishery. If the present rate of annual increase were to continue through 2005, estimates for year 2005 exports are 267,000 tonnes, which is approaching the largest annual catch reported over the last ten years from the entire EEZ. Figures on the incidence and amount of by-catch are unavailable, but given the fishing methods used, by-catch is unlikely to be a major concern at present levels.

The prawn fishery is based on trawling in the Gulf of Papua, the Torres Strait and the Orangerie Bay. The main species taken are tiger prawns, banana prawns and endeavour prawns. Some of these fisheries are managed using catch quotas based on mean sustainable yield estimates, whilst others are managed using limited entry, annual total allowable catch levels, and the closure of specific areas to protect nursery stock. The National Fisheries Authority limits prawn fishing in the Gulf of Papua to 15 licences per year, including 2 reserved for traditional resource owners, and a four month closure of the main fishing grounds to rest the stock and protect juveniles after the spawning season (Sowei et al). These limitations generally limit catches to within the estimated annual sustainable yield average of 600 tonnes of banana prawns. In order to protect juvenile prawns and breeding stocks, and to avoid any transgressions on traditional fishing areas, trawl fishing is not permitted within the 3-mile limit of the Gulf of Papua. The main concern in regard to the prawn fishery is the sizeable by-catch, which in many cases is greater

in weight than the target species catch (prawns).

Another component of the fisheries industry that can give rise to environmental impacts is the fish processing and canning industry. Under the government's policy of promoting added-value exports, the fish processing industry has grown during the last few years and appears set to continue its growth, with another new processing plant soon to be constructed at Wewak. Fish processing, like other food processing, produces a concentrated organic effluent that usually has the consistency of a loose slurry and is composed of a mixture of water, fish tissue, fluids and macerated body parts such as fish heads, bones, fins, scales and soft tissues such as the gut and liver. This mixture is usually skimmed and screened to remove the larger floating and suspended solids before being discharged through a marine outfall.

The potential impacts associated with the discharge will primarily depend on the location of the discharge and the rate of dispersion and dilution at the point of discharge. The discharge effluent has a high biological oxygen demand, primarily from the dissolved organic fraction, and contains a high concentration of particulate matter that is likely to have near neutral buoyancy. As such it is unlikely to settle rapidly and will remain in suspension for considerable time. Given that this material is fish in origin, it is likely to attract large numbers of scavengers and opportunistic feeders, which in turn may attract other larger predatory species. The dissolved organic fraction will exert an oxygen demand that, depending on the rate of discharge and rates of dispersion and dilution, may result in some degree of oxygen depletion in the water around the outfall. This may have impacts on the species composition of sedentary benthic communities in the vicinity of the outfall. (This assumes the outfall is located on, or slightly raised above, the seabed).

If the outfall is not located beyond the influence of tidal or on-shore currents, the effluent plume may extend into shallow and tidal waters, where dispersion and dilution will be less effective in reducing concentrations to below significant impact levels. In these circumstances, impacts on the water quality and biota may be severe enough to cause disturbance and damage to tidal and near-shore habitats and communities, and affect the recreational and fisheries use of these waters. The closer the outfall is to the shore, the more thorough the baseline studies have to be to ensure that the degree of risk to shoreline users is acceptable. Even then, there is the risk that further extension of the outfall may be required in the future or, alternatively, that additional treatment be installed prior to discharge if unanticipated levels of impact subsequently occur.

Whilst such direct environmental threats are a locally significant concern in areas that may be affected, the principal environmental threat currently facing the commercial fisheries industry is the lack of detailed and accurate data on fish numbers, diversity, catch rates for target species and non-target species and the range of factors and environmental conditions that affect population recruitment and population growth rates. In the absence of this information, it is difficult to accurately estimate sustainable harvest yields (catch rates) and a cautious approach to the development of fish stocks' management plans has to be taken in order to effectively protect the fish populations from over-exploitation.

3.5.3 Subsistence and artisanal fisheries

Although the commercial sector is the major fishery in terms of catch weight, subsistence and artisanal fisheries are arguably more important in socio-economic terms. Fish is the major source of protein for the coastal populations throughout the Papua New Guinea mainland and islands, and is a part of the staple diet in these areas.

Fish are also one of the main sources of cash income for coastal communities, many of whom will take their catch 100 kilometres or more to reach a market where they can be sold for cash. In many communities, fish that are not consumed immediately and those that will be taken to market, are smoked to extend their "shelf-life", as fresh fish deteriorate rapidly in the tropical climate. The subsistence and artisanal sector provide most of the fish for the domestic market, and for export, including niche markets such as shellfish and *beche-de-mer*. The *beche-de-mer* fishery is reported to be the most valuable coastal fishery in Papua New Guinea (Australian Marine Science and Technology, 1997, reported in Mitchell et al 2001).

The subsistence and artisanal fisheries are concentrated in coastal and near-shore waters (generally within the 3-mile limit), and use a variety of methods, depending on the target catch. Although these

fisheries have supported the coastal populations of Papua New Guinea for centuries, the rapid growth in coastal populations and the increasing demand for cash income has in recent years led to an increase in subsistence and artisanal fishing activity, raising serious concerns over the sustainability of coastal fish stocks.

This is particularly so for those species that have a high export value, such as *beche-de-mer* and some shellfish such as *trochus* and the giant clam, which attract high overseas earnings and are therefore particularly at risk of over-harvesting in a cash-poor economy (Mitchell et al 2001). Rural island households in Milne Bay Province have responded to their loss of purchasing power (the effects of inflation and decreasing commodity prices such as copra) and the increasing demand for sedentary fish products by increasing their harvesting levels of commercially valuable species.

The government attempts to regulate catch rates through Total Allowable Catch limits and “closed seasons” for *beche-de-mer* and some of the shellfish such as the various species of commercial prawns. However, concerns remain regarding the level of sustainable harvest yield for several of these species in view of the lack of adequate and detailed data on stock numbers and population densities. A recent study on the Sustainable Use of *Beche-De-Mer* Resources in Milne Bay Province (Skewes et al 2002) found that although overall population estimates were reasonable given historical catch rates, the overall density of commercial species in Milne Bay is very low compared to similar fisheries in Torres Strait and the northern Great Barrier Reef. They report that the *beche-de-mer* resource in Milne Bay Province is grossly over-exploited for some species at least, notably the sandfish *Holothuria scabra* and the black teatfish *Holothuria nobilis*, and make several interim management recommendations to address this.

Although anecdotal evidence increasingly suggests that some of these coastal stocks are declining, there appears to be a lack of reliable and accurate information on either coastal fish stocks or fish catches, so that accurate estimates of sustainable yield cannot be calculated, or indeed how serious the risk of over-exploitation is at the current levels of fishing. In these circumstances, a precautionary approach should be adopted. However, subsistence and artisanal fisheries are, by their nature, difficult to manage and regulate by government agencies. Experience to date (see Section 5.2.6) suggests that sustainable management of these fisheries is best achieved through a combination of agency regulation and community-based awareness programs and local skills’ development programs for the local fishing communities. These should be designed to engage and then empower the local fishing communities to monitor and manage their own local fisheries resources in a more sustainable manner.

There is considerable concern, at both local and national levels, over recently introduced destructive fishing methods such as poisoning with derris powder and dynamite fishing. These methods are non-selective in impact and destroy large numbers of individuals of all species, and in the case of dynamite fishing, physically destroy the habitat as well.

The detonation of dynamite on or close to a coral reef will immediately physically destroy a very large area of reef, its coral and benthic organisms, and fish that are caught within the blast impact zone. However, the blast also generates a large amount of debris and sediment which is carried by the currents and tide along and across the reef, and settles out beyond the blast area, smothering and killing living coral and benthic organisms that have survived beyond the immediate blast zone. It is estimated that it will take many years, even several decades, for reefs blasted with dynamite to recover, during which time the fishery resource once available from that area of reef will be lacking, or at the very least, significantly poorer.

In addition to the impact on fishery resources, dynamite fishing and poisoning also have profound impacts on habitat availability and biodiversity. Although poisoning is generally a short-term phenomenon, with reasonable recovery rates, dynamite fishing destroys the entire habitat and its biota, leaving a desolate wasteland in its wake that is slow to re-colonise and recover. Most coral reefs are the result of centuries of biological accretion, and will take many years, even several decades, to recover the breadth of biodiversity present before the blast. Recent public awareness programs on the disastrous effects of dynamite fishing appear to have had some effect in areas where the programs have been conducted, but the problem still persists.

3.6 Public Health Sector

3.6.1 Rural public health

The major public health issues in the rural sector are water supply and sanitation, and the collection, handling and safe disposal of solid wastes.

According to the Demographic and Health Survey carried out by the National Statistical Office (NSO 1996), only 29 % of the rural population had access to an improved water source (public standpipes, boreholes, protected wells or springs). Most rural areas do not have a water supply infrastructure, and water is obtained directly from source, which most commonly is surface water, such as a stream or river, or a shallow well, that serves several households. Water hauling is a major daily task for many Papua New Guineans and is mainly carried out by women and female children (Sowei et al 2002). These supplies can be supplemented by rainwater harvesting, usually by collecting the runoff from roofs, although the efficiency of collection is generally poor.

Sanitation facilities are generally poor in most rural areas. Approximately 96 % of rural households use traditional (pit latrines) toilet facilities (Sowei et al 2002), most of which are only poorly protected from rain and the intrusion of surface runoff. As a result, contamination of the soils surrounding the pit is commonplace and can extend some distance from the pit. In coastal areas where sandy soils predominate the extent of contamination around pit latrines can extend for some distance. These coastal areas are often characterised by a lack of surface freshwater, and many are dependent for their water supply on shallow wells. In some of the more populous coastal villages housing densities are high which can result in wells and latrines being dug in relatively close proximity to each other. Given the highly permeable nature of the sandy soils that characterise these locations, contamination of the well water by lateral seepage from the latrine is possible.

The issue of poor sanitation is compounded by a generally poor knowledge of hygiene, which together with a lack of readily available clean water (most water has to be carried to the house and is conserved by using wash water several times over), often results in less than effective personal hygiene practices.

Experience from rural water supply projects from around the world indicate that improvements in water supply alone do not produce many health benefits. However improvements in water supply and sanitation together can produce much greater benefits in rural areas, particularly if accompanied by community-based health and hygiene awareness programs. The evidence indicates that improved quantities of water (such as piping water directly into or near the house so that it is readily available) are more important than improved quality of supplies for improvements in health (Sowei et al 2002). This suggests that health improvements might be due to improved cleaning (of cooking and eating utensils) and better personal hygiene (more frequent and effective personal washing, particularly the hands), rather than consumption of water.

The importance of community-based health and hygiene awareness programs goes beyond the issue of water and sanitation. These programs should address other hygiene practices such as the importance of hand-washing, particularly when preparing food, nursing the sick and after tending domestic animals. They should also address the protection of water, food, food preparation utensils and surfaces, and public places, from faecal and other contamination. A further hygiene issue that is common in parts of the country is the sheltering of domestic animals within the house and an awareness program should emphasise the need to keep domestic animals outside the house for family health and hygiene reasons.

These community-based health and hygiene awareness programs must also address the problems of solid wastes (primarily domestic refuse and litter) in the rural communities. Traditional subsistence livelihoods generate very little solid waste, and what was generated would usually be recycled as fuel (combustible materials), composts or mulches for the gardens, sea-shells for lime-making, ornaments or scrapers for peeling vegetables such as bananas. The advent of the cash economy to these rural areas brought with it the importation of a wide variety of products for which there was no “end-use” other than as a waste. This problem is particularly severe in those rural communities with relatively easy access to the market economy as a source of cash for their produce and a source of products to take back to the village. Coastal fishing communities with relatively easy access by sea to market towns, and communities in areas where economic developments such as commercial agriculture, forestry or mining offer

opportunities for cash incomes and access to retail products, are most at risk from this “waste” threat. Today the issue of solid wastes, particularly the non-biodegradable plastics, metals and glass, and the toxic wastes such as spent engine oils, solvents, cleansers and dry-cell and lead-acid batteries, are becoming an increasing problem in rural communities. Most wastes are simply dumped in a hole in the ground close to the house, or discarded on a patch of unused ground close by the house, possibly to be burnt later. In the absence of any awareness or understanding of the risks of environmental contamination, the site chosen is often selected on the basis of convenience alone. It is not uncommon for the selected site to be an area of waterlogged ground, which because of its condition could not be used for gardening, recreation or construction, exacerbating the problem by allowing direct and immediate contamination of surface water and extending the area of impact. Furthermore, rarely is the site fenced to keep out pigs, young children or vermin.

Such waste “dumps” not only pose a direct threat to public health, but also threaten wells and domestic surface water sources through contamination of soils, surface waters and the water table. Common contaminants include toxic materials such as spent engine oils, solvents, cleansers and dry-cell and lead-acid batteries, and pathogens from putrescible domestic wastes and disease carrying vermin and flies attracted to the “dump” by these wastes. Many of these wastes are highly mobile in the soil and surface water environments and can contaminate an extensive area around the waste site, particularly under the wet climatic conditions that characterise most of Papua New Guinea.

This is a particular concern in coastal regions where most domestic water is obtained from shallow wells, which are usually located close to the house and thus fairly close to the household’s waste pit. These wells are often by necessity shallow as deeper wells penetrate the saline waters that lie below the freshwater in most coastal water tables. These shallow wells, often sunk only a metre or two into the sandy soils, are readily contaminated by material deposited on the ground surface or in shallow pits within the vicinity of the well.

It should be noted that burning of these wastes, whilst it may reduce the volume, does not necessarily reduce the risk of contamination, as many of the toxic elements will remain in the ash. Indeed burning of the rubbish may pose additional risks such as the generation of toxic fumes or the risk of conflagration if the wastes contain inflammable substances such as organic solvents or fuel residues.

Obviously, it would be much better from both a public health and environment perspective if each community’s solid wastes could be disposed of at a designated site located well away from any wells of surface waters at a location that is not at risk of inundation. However, as all land is owned, someone will have to give up some of their land to house this waste site, and issues of compensation, and possible liability in the event of impacts occurring, will have to be resolved. Such issues are not easily resolved in the community situation. It appears unlikely that an effective long-term solution can be found until such time as environmental and public health awareness programs have alerted the community to the risks, and facilitated the selection of a waste site with the compensation and fees (charges) that should be paid to the owner determined for its long-term use.

In many instances, it may not be possible to identify a suitable site or willing landowner, and each household will have to deal with its own wastes on-site. Environmental awareness programs focussing on the issues raised above and highlighting the long-term need to reduce the amount of wastes that are produced, will need to be conducted by community-based organisations (CBOs) if this problem is to be addressed in an effective and sustainable manner. Some NGOs working in the environment/conservation sector at the community level, have begun to develop and deliver such programs at the local village level as part of a wider sustainable development or biodiversity conservation focus. Although at the moment, these are small, localised initiatives usually implemented under a broader-based awareness program, they provide valuable knowledge and insight into the design and delivery of such programs for the future.

While some wastes can be reduced at source by the consumer’s choice of, for example, packaging, and other wastes such as plastics (bags and bottles) and organic material can be re-used or recycled, the problem of toxic and other intractable wastes will remain. As increasing demands for cash incomes drive development in the rural sector, there will inevitably be increasing demands for improved crop

productivity levels and mechanisation (including small-scale power generation to supply small milling, processing and cold store facilities). This will inevitably generate more toxic and intractable solid waste, such as spent engine oils, used solvents, dry-cell and lead-acid batteries, and containers with pesticide residues, cleansers and other toxic residues.

Rural communities, and the agencies responsible for their welfare and development, will need to develop more innovative and long-term effective solutions to these waste issues, particularly the issue of intractable wastes, if future development is not to place an unsustainable burden on the environment, traditions and subsistence livelihoods of the rural communities of Papua New Guinea.

3.6.2 Urban public health

The increasing phenomenon of urban drift, in which poor and frequently poorly educated rural dwellers migrate to the major commercial centres in search of employment and a better lifestyle, has resulted in the establishment of many settlement areas around the major urban centres of Papua New Guinea. These settlements are characteristically unplanned and unregulated, with few if any of the basic services such as power, reticulated water supply, hygienic sanitation systems, and domestic waste services.

The lack of power severely constrains opportunities for small business development in these settlements, which could provide much needed income from “cottage industries” and incentives for self-improvement.

The lack of reliable and clean water supplies for settlement dwellers poses immediate and long-term threats to public health. This also poses a threat to public safety as many of these settlements are constructed largely of flammable materials and in the absence of a reliable water supply, any outbreak of fire could very rapidly develop into a major blaze.

The lack of effective sanitation facilities means most settlement households depend on pit latrines, which in high density housing poses significant threats of soil and water-table contamination, as well as the obvious risks to personal hygiene and public health that will be exacerbated by a lack of adequate water supplies.

The lack of any domestic wastes management in these settlements results in the arbitrary dumping of trash and refuse at any undeveloped sites around the settlement. Rarely, if ever, is any consideration given to the selection of these sites, and there is inevitably contamination of soils, the water table, surface runoff and downstream catchments. Not only does this have an adverse impact on downstream habitats, but also poses a public health risk where the downstream watercourses are used by other settlement dwellers for washing and bathing purposes.

Even within the urban centres themselves, a lack of capacity and resources has resulted in a decline in the quality and efficiency of these services. In many cases the provision of these services is unable to keep up with the rate of growth of even the authorised urban developments. For example in Port Moresby, the sanitation system is grossly overloaded. So much so that the city’s sewage treatment ponds bordering Waigani swamp appear to be ineffective in treating present day loads (site visit and pers comm, NCDC, 1991) as they were designed for a population of 60,000 to 70,000, whereas estimates of the population today are in the order of 200,000. As a result, inadequately treated sewage is entering the Waigani Swamp wetlands at the head of the Laloki River floodplain. This is almost certainly leading to severe environmental degradation of the wetland and significant damage to the habitats and biota in the floodplain and possibly extending as far as the coastal waters directly to the west of Port Moresby. The contaminated state of the Waigani Swamp poses a threat to public health, not only because these areas are frequented by the public for recreation, but are also because they are used for subsistence gardening and fishing by some of the local residents.

In many other urban centres around the country, the treatment of sewage is inadequate for the method of disposal. As in the case above, the rapid increase in urban population has far exceeded the design capacity of the sewerage system, which is consequently overloaded and unable to achieve its intended discharge specifications. This overload is compounded by the lack of maintenance that has resulted in recent years from budget constraints. As a consequence the receiving waters are becoming increasingly polluted, adversely affecting other uses and users and the aquatic habitats.

This is not only the case with most sewage river discharges, but also with the many coastal outfalls, which frequently discharge only partially treated sewage or untreated sewage into waters where the dilution is inadequate for the increasing loads. As a consequence, many of the local coastal waters around urban centres show signs of sewage pollution. This threatens public health by way of recreation and the close proximity of many peri-urban villages to the waterside, as well as adversely affecting the diversity and productivity of coastal habitats. This not only affects the biodiversity value of these coastal habitats for conservation and recreation use, but, more immediately, affects their economic value as an artisanal fisheries resource upon which the livelihoods of many of the local people depend.

The issue of solid waste management in the urban sector is coming increasingly to the fore as the rapid growth in urban populations results in increasing volumes of domestic wastes. Consideration must be given to the reduction of these domestic wastes at source, with innovations such as the re-use or recycling of packaging and containers (Sinclair Knight Metz 2000).

A start has been made with the re-cycling of aluminium beer and soft drink cans in one or two urban centres where aluminium can collection centres have been established, but a broader nationwide effort, backed by appropriate economic incentives, is needed. Plastic packaging waste, particularly the plastic bags given out freely to shoppers at supermarkets and other retail outlets needs to be addressed with similar economic incentives, such as charging 10 or 20 toea for each plastic bag that is supplied. Obviously this would have to be a fixed mandatory charge to preserve market forces, and could probably be enacted through municipal or local government by-laws.

More efficient and effective waste management strategies are needed to reduce the amounts of litter and other wastes discarded in public places, which continue to pose an increasing nuisance and public health risk in the urban environment. Widespread discarding of litter, garbage and other solid wastes around the urban centres pose a public health risk by attracting vermin, flies and other disease vectors to decaying foodstuffs and other organic wastes in litter and garbage. In some cases the waste material poses a direct health risk, particularly to inquisitive children, such as discarded lead-acid batteries, discarded containers containing corrosive, toxic or inflammable residues or wastes, broken glass and other sharp materials.

Legislation exists under which penalties can be enforced for littering. Several urban centres have at times implemented such legislation, which has resulted in marked improvements in the quality of the urban environment during the period of enforcement, but unfortunately in many instances this lapsed after a few months, and unsightly and unhygienic conditions returned. There appears to have been a lack of political will to maintain these initiatives, despite the initial expenses of public awareness campaigns and setting up of enforcement measures. Until such time as there is political will to back public awareness campaigns and enforcement measures, this issue is unlikely to be dealt with effectively.

There is an increasingly urgent need to implement more effective waste handling and disposal at municipal waste facilities throughout Papua New Guinea, which are generally characterised by a lack of effective management of the various waste streams entering each facility (Sinclair Knight Metz 2000).

Even the wastes that are regularly collected by municipal authorities are disposed of in municipal waste dumps that rarely comply with even the basic requirements of sanitary landfills. It is not uncommon for refuse to be burnt *in situ* at landfill sites to reduce the waste volume. Once started such fires are often difficult to extinguish, and may continue to burn for many days, generating noxious, and possibly toxic, fumes that can affect the inhabitants of local communities. Such fires also pose a risk of more serious conflagrations at landfill sites where there is little if any segregation of hazardous and flammable waste materials.

There appears to be no attempt to contain on-site and treat contaminated surface runoff or leachate, which in the high rainfall areas that are characteristic of most municipal landfill sites (in this regard Port Moresby's low rainfall is a fortuitous exception) should be a basic requirement of all landfills. As a consequence, severe contamination of downstream watercourses and the local water table is likely to become increasingly widespread. This poses a serious threat to public health, and can also result in locally severe impacts on vegetation, aquatic habitats and their communities. There also appears to be little attempt to segregate and protect hazardous materials and wastes (Sinclair Knight Metz 2000), which is very likely to increase the toxicity of contaminated runoff and leachate, and also poses a risk of

dangerous chemical reactions occurring which could generate noxious or toxic fumes, or lead to the outbreak of serious fires.

As the nation develops further, increasing population growth and increasing industrialisation of urban centres is most likely, particularly as successive governments promote added-value to their export produce and products. Unless action is taken soon to reduce the quantities of waste produced, and better manage the wastes that cannot be reduced, waste-related environmental and public health impacts are likely to become the major threat not only to the environmental values of the country, but also to the health and livelihoods of many of its people.

4. Environmental Regulation and Conservation Legislation in Papua New Guinea

4.1 Environmental Regulation

Until recently the environmental legislation of Papua New Guinea consisted of three separate acts: the Environmental Planning Act (1978), the Environmental Contaminants Act (1978) and the Water Resources Act (1982).

The Environmental Planning Act sets out an environmental impact assessment process for projects that might significantly affect the environment (although the Act does not specifically state this, it has been consistently interpreted in this manner) or that are of national significance (as stated in the Act).

Under this Act, a developer was required to obtain environmental planning consent from the National Executive Council by submitting an Environmental Plan to the Department of Environment and Conservation. The Department would evaluate the Environmental Plan and advise the Minister for Environment and Conservation on whether the Plan should be approved including any terms and conditions.

Although this Act was criticised as being deficient in some ways, such as a perceived lack of full and open public consultation and transparent processes of decision making, it did provide a process that allowed for the identification of potential environmental impacts and remediation methods to avoid or minimise these impacts. However, as many of the major developments were situated in remote areas of the country, the Department of Environment and Conservation did not have the capacity or resources to adequately monitor compliance with the Environmental Plan's commitments and its approval conditions. As a result, implementation of the Environmental Plan's commitments, and in particular, compliance with approval terms and conditions, was sometimes less than satisfactory, resulting in adverse environmental and socio-economic impacts.

The content of the Environmental Plan was set out in guidelines attached to the Act. There were several sets of such guidelines, including a general set applicable to all Environmental Plans, and sector-specific guidelines for a few industries such as large-scale commercial forestry and oil palm developments.

The Environmental Contaminants Act was principally concerned with environmental protection through the control and regulation of pollutants. The Act contains requirements for the licensing of discharge of environmental contaminants, the emission of unreasonable noise, the permitting of hazardous environmental contaminants for the purposes of importation, sale, manufacture or distribution, and regulations to control littering.

Two key features of this Act were:

- Provision for the appointment of Environmental Inspectors, Environmental Analysts and Environmental Officers by the Minister of Environment and Conservation; and,
- Provision for the appointment of an Environmental Contaminants Advisory Council, which would give advice on any matter referred to it by the Minister before any action is taken by the Minister under the Act and in relation to that matter.

However, since the passing of the Act in 1978, the Environmental Contaminants Advisory Council has never been appointed, and this has imposed a severe constraint on the implementation of the Act, to the extent that no action has ever been brought under this Act.

The Water Resources Act governed the protection and management of the country's natural water resources, and the wise and beneficial use of these natural waters. In this regard it addressed water resource planning and allocation issues, including such matters as water abstraction, diversion, damming and flooding of areas, and the right to discharge water or waste in accordance with prescribed conditions and standards.

The Act established the Water Resources Board, whose functions included considering and deciding on all applications for Water Use Permits. In Papua New Guinea, any use of natural water other than traditional use, domestic use, stock watering or fire-fighting requires the user to obtain a Water Use Permit. In this context, "water use" included:

- The taking, or abstraction, of water from a natural water body or water course.
- The discharge of any material (liquids including water, solids or a mixture of these) to a natural water body or water course.
- The damming or obstruction of a natural water body or water course (including flooding).
- The diversion of a natural water body or water course (including flooding of areas).

However, by the mid 1990s, this environmental regulatory system was widely recognised as not working (Saulei et. al., 2002). Environmental planning and protection had not been effective in preventing unsustainable resource use practices, habitat destruction and pollution due to inadequate implementation and enforcement. With three separate Acts of varying efficacy, in which overlaps and gaps were commonplace, the processes of environmental regulation were cumbersome, inefficient, and often ineffective due to capacity shortfalls within the Department of Environment and Conservation. The problems surrounding the previous legislation are discussed more fully in Section 5.3.5.

Recognising this, the Department embarked on developing a new regulatory framework in the mid 1990s as part of the AusAID-funded DEC Strengthening Project. This framework was developed to provide a more closely integrated and efficient regulatory system that would reduce some of the demands on the department's capacity and resources by emphasising "self-regulation" for those activities that did not pose a serious or large-scale threat to the environment. Based on this new environmental regulatory framework, a new Environment Act was drawn up. This new act integrated the three previous environmental planning, protection and water resources acts and offered a broader range of environmental tools and economic instruments for more cost-effective regulation by the department.

The new integrated Environment Act, 2000, which gives a new, more efficient and hopefully more effective environmental regulatory process, is based on three levels of regulation, dependent on the magnitude and significance of the activity.

- **Level 1** activities are those that require a minimum level of environmental protection. Regulation of such activities will be based on standards, codes and regulations that set benchmarks for environmentally acceptable activities under a self-regulatory framework.
- **Level 2** activities are those that require a framework of environmental approvals allowing for water discharge permits, or licensing for importation, sale and use of environmental contaminants and for site-specific environmental conditions. Level two activities will be regulated by means of conditions in environmental permits, environmental improvement plans and environmental management programs.
- **Level 3** activities cover those with the potential of major environmental impact and are projects of national significance or of large scale. Such activities will be subject to a process of detailed appraisal of environmental implications and public consultation through the EIA process.

Recognising that capacity and resources are major constraints to monitoring and enforcement roles, the department is now looking at self-regulation and using economic instruments to encourage compliance. In this regard, it is moving toward pro-active prevention approaches by encouraging companies to adopt "environmental best practice" management systems that comply with "environmental guidelines" and Environmental Codes of Practice issued by the Department.

A number of these guidelines and Environmental Codes of Practice have been prepared to date, including:

- Sanitary Landfill Sites Code of Practice (2002).
- Motor Vehicle and Machinery Workshops, Hydrocarbon Fuel Storage, Re-sale and Usage Sites

Code of Practice (1998).

- Palm Oil Processing Industry Code of Practice (1997).
- PNG EIA Guidelines for Roads and Bridges (1996).
- PNG Logging Code of Practice (1996).
- Specific Guidelines for Commercial Forestry Harvest Operations (1993).

More guidelines and environmental codes of practice are planned for the future, although these are temporarily on hold, as the Department's resources are currently focussed on formulating Regulations for the new Act. In regard to the formulation of these regulations, the Department will need to take due cognisance of the various international commitments made by the Government of Papua New Guinea in signing and ratifying the international treaties and conventions referred to at the end of Section 5.2.2.

4.2 Conservation Legislation

Conservation policy has not worked effectively in Papua New Guinea, despite the country having signed and/or ratified a number of international treaties and conventions related to conservation and biodiversity (Saulei et al 2002). There are currently three conservation acts: the Conservation Areas Act, the National Parks Act, and the Fauna (Protection and Control) Act, but effective implementation of these acts has proved difficult.

A new legislative framework needs to be developed that takes into account more effective approaches to conservation such as local and community-based wildlife management areas and integrated conservation and development programmes, and other biodiversity conservation methodologies. This will be difficult in Papua New Guinea with its customary system of clan-based land tenure and many competing land use forms. Some compromise will be necessary. Conservation of marine areas is also new to Papua New Guinea. The development of a PNG Biodiversity Strategy and Action Plan is currently being considered, though its present status is uncertain.

Under the recent Organic Law on Provincial and Local-Level Governments, most of the responsibility for conservation and biodiversity conservation appears to have passed to the provincial and local-level governments. However, these bodies do not have the capacity or resources to carry out their responsibilities. As a consequence, government involvement in the conservation sector appears to be in a state of limbo at the moment, unclear of its role and the direction it should take.

In the absence of government action on the ground, there has been increased involvement by national and international NGOs in conservation in recent years. This NGO activity has mainly focussed on working closely in the field with local communities on the implementation of integrated conservation and development (ICAD) activities and the establishment of wildlife (biodiversity) management areas. These are discussed in more detail in Section 5.2.5, 5.2.6 and 5.3.1 of this report.

The Department of Environment and Conservation is currently preparing a national Biodiversity Conservation Policy for Forests (Department of Environment & Conservation 2002c), which defines conservation priorities and identifies mechanisms (legislation and management systems) to achieve these, and should serve to clarify the role and direction of government in conservation. It is understood that this policy will provide a basis for the subsequent development of a Papua New Guinea Biodiversity Strategy and Action Plan, which would set out the government's conservation responsibilities and directions in the medium term.

Part of this strategy would appear to be the development of a new legislative framework that more clearly takes into account wildlife management areas, ICADs and biodiversity conservation, and recognises the key role that the NGOs have played, and will continue to play, in conservation in Papua New Guinea. The key role of NGOs in the conservation of Papua New Guinea's critical habitats and biodiversity is discussed more fully in Section 5.2.5 and 5.2.6 of this report.

5.0 Principal Environmental Issues and Problems in PNG, their Causes, and the Efforts made to date to Mitigate or Remedy these

5.1 Principal environmental problems, their causes and mitigation responses

This chapter analyses the immediate and underlying “root” causes of the major environmental threats and problems identified in Chapter 3, and the efforts (responses) that have been carried out to date to mitigate or remedy these threats and problems. To facilitate this analysis, the wide range of environmental threats and problems identified in Chapter 3 have been summarised under ten principal environmental issues or themes.

1. Increasing land degradation: topsoil depletion, damage to soil structure, fertility and water retention capacities.
2. Increasing environmental risk from hazardous materials storage, transport and use, and from solid and hazardous waste generation and improper management (collection, containment, treatment and final end-use/disposal).
3. Declining water quality in rivers and coastal waters.
4. Disturbed or unpredictable hydrological regimes.
5. Loss of critical habitats and biodiversity.
6. Declining coastal and marine resources.
7. Inadequate or unsatisfactory water supplies.
8. Declining air quality in some urban areas.
9. Noise pollution.
10. Climate change.

The analysis of these ten principal issues has been set out in tabular form in the following pages. In each table, the left hand column describes the immediate causes such as increasing land conversion to agriculture causing increasing land degradation such as soil erosion, or the inadequate treatment and disposal of sewage causing a decline in water quality of rivers and coastal waters.

The central column analyses the underlying “root” causes of each issue. In the examples given above, “why is it that increasing land conversion to agriculture is allowed to cause increasing soil erosion, etc.?”, given that soil conservation methods exist which could reduce this. Likewise, “why is it that inadequately treated sewage enters natural receiving waters and threatens the water quality?”. The column on the right of the each table sets out the mitigation/remediation efforts (referred to in the table as “Responses”) that have been carried out to date to address these causes, including government and non-government initiatives.

Immediately following the Table there is a description of these responses and an analysis of the limitations and constraints on their effectiveness. This chapter then goes on to identify common themes amongst these causes and responses, and analyses how effective these responses have been to date, in order to determine constraints and shortfalls in these responses.

Table 1: Increasing Land Degradation: topsoil erosion, damage to soil structure, fertility and water retention capacities

IMMEDIATE CAUSE(S)	UNDERLYING CAUSE(S)	RESPONSE(S) 1
Increasing land conversion for agriculture, resource development projects such as mining and forestry, settlements and other uses including infrastructure developments, particularly strip development along new roads	Inability of government to provide extension services and technical support for the adequate monitoring and application of soil conservation guidelines and standards during land conversion operations, requiring closer collaboration with operators, backed up by cost-effective enforcement measures	PNG Logging Code of Practice of Roads & Bridges; DEC Gu & Oil Palm; PNG RIS Enviro on Land Use
Inappropriate agricultural practices, especially in upland areas and other marginal areas (eg skeletal soils) such as the establishment of urban gardens on the steep slopes of Port Moresby hillsides	Lack of understanding and application of soil conservation measures in these communities, requiring community-based awareness and skills development programmes.	NARI Soil Conservation project Agriculture Research Station
Increasing intensity of subsistence agriculture, notably the reduction in fallow period length, appears to be increasing the long-term decline in soil quality and structure.	Pressures from population growth and expanding influence of the cash economy resulting in increasing demands on subsistence production and requiring the development and dissemination of improved land management techniques and measures to raise crop production levels.	Research conducted by NARI

Table 2: Increasing environmental risk from hazardous materials storage, transport and use, and from solid and hazardous waste generation and improper management (collection, containment, treatment and final end-use / disposal)

IMMEDIATE CAUSE(S)	UNDERLYING CAUSE(S)	RESPONSE(S)
Lack of effective environmental regulation of hazardous materials' management (storage, transport, use and end-use / disposal)	Low priority given to hazardous materials management and lack of information on the types, composition and amounts of hazardous materials in PNG, making it difficult to identify regulation priorities in this area. Lack of adequate management tools / mechanisms to control and regulate these risks.	Papua New Guinea National Management 1997 - 2000
Increasing incidence of improper disposal of litter, solid and hazardous wastes in urban and rural environments, in many cases caused by the lack of collection, treatment and disposal facilities, particularly in the rural areas	Lack of public awareness and support for the safe and environmentally secure management and disposal of all solid wastes, particularly non-biodegradable wastes such as plastics, and hazardous wastes such as toxic residues' containers. Limited resources available to government to police and enforce regulations	DEC Environmental Code of Landfill Sites
Lack of integrated solid waste management systems with realistic options for reduction, re-use/recovery or recycling of wastes that can reduce the demand for waste treatment and disposal capacity	Low priority given to waste reduction strategies as they are not seen as being cost effective	Solid Waste Management Ch and Management Plan for PT
Lack of waste treatment facilities for toxic or other hazardous or intractable wastes	Low priority given to long-term risks arising from toxic and hazardous wastes	Papua New Guinea National Management 1997 - 2000; I Code of Practice for Sanitary
Lack of effective implementation of regulations or codes of practice for solid waste management	Low priority given to solid waste management	DEC Environmental Code of Landfill Sites

Table 3: Declining water quality in rivers and coastal waters

IMMEDIATE CAUSE(S)	UNDERLYING CAUSE(S)	RESPONSE(S)
<p>Degraded quality of surface runoff from watershed developments including land clearance, construction and operation of infrastructure and settlements.</p>	<p>Lack of effective application of good soil conservation and stormwater management techniques.</p>	<p>DEC Draft Guidelines for 1 Water Resources in the Fc Petroleum Sectors (BWR, PNG Logging Code of Pr</p>
<p>Inadequate treatment/disposal of domestic sewage This is becoming a major issue in many coastal villages where rapidly growing populations and a lack of any treatment is resulting in increasing contamination of the water table and surface waters.</p>	<p>Lack of public awareness and understanding of the need for, and safeguard of, the water quality of all surface waters, groundwater and coastal waters.</p>	
<p>Disposal of industrial effluents into rivers & streams: mining tailings and waste rock to river catchments, alluvial mining waste waters and chemical wastes; crop and food processing wastes, eg. palm oil mills, large-scale coffee, fish and meat processing</p>	<p>Inadequate monitoring and compliance with regulatory standards & codes of practice.</p>	<p>Various DEC regulations a incl. Coffee Processing, Fo Petroleum (BWR, 1990 & for Forestry & Oil Palm; I Code of Practice for Palm</p>
<p>Nutrient/fertiliser enriched agricultural runoff and water-born wastes containing high organic loads. Pesticide and herbicide contamination may be locally significant where large-scale commercial operations are operating.</p>	<p>Lack of awareness and understanding of the risks associated with nutrient and organic enrichment and the need for, and safeguard of, the water quality of all surface waters, groundwater and coastal waters.</p>	<p>DEC Guidelines for Forest Operations.</p>
<p>Careless or inappropriate disposal on land of solid and liquid wastes (both domestic and industrial) allowing contamination of surface runoff and the water table, with toxic or high BOD wastes.</p>	<p>Lack of awareness and understanding of the risks, and, lack of adequate monitoring and compliance with guidelines and standards.</p>	<p>DEC Environmental Code Sanitary Landfill Sites; Gui & Oil Palm; DEC Environ Practice for Palm Oil Proc</p>

Table 3 (cont.)

IMMEDIATE CAUSE(S)	UNDERLYING CAUSE(S)	RESPONSE(S)
Increasing siltation and contamination of stormwater runoff due to lack of effective stormwater management systems at development sites. Lack of effective flood controls in urban and rural development areas results in widespread contamination of floodwaters with silts and other contaminants caught up in the floodwaters.	Inadequate monitoring and compliance with regulatory standards & codes of practice. Low priority given to flood control systems in urban and rural development and their cost-effectiveness over the long-term	DEC Draft Guidelines for Water Resources in the Forestry & Petroleum Sectors (BWR, Guidelines for Forestry & Logging Code of Practice)
Lack of accurate information and reliable data on the water quality and other characteristics of PNG's rivers, lakes and wetlands, and coastal waters	Lack of resources to conduct investigations and surveys, and lack of awareness of the value in maintaining environmental quality	UNDP/WMO Strengthened Resources Assessment & Bureau of Water Resource

Table 4: Disturbed or unpredictable hydrological regimes

IMMEDIATE CAUSES(S)	UNDERLYING CAUSE(S)	RESPONSE(S)
Loss of water retention capacity in watersheds as a result of widespread land clearance, or other change in land-use resulting in soil degradation and soil loss.	Failure to apply effective soil conservation measures and timely restoration of vegetation.	DEC Construction of Roads & Guidelines for Forestry & Oil Environmental Constraints on
Changes to river morphology, including river channelling, and riverbed sedimentation patterns.	Failure to apply effective soil conservation measures and adequate stormwater systems to temporarily store flood surges.	
Changes in local weather patterns.	Unclear, a lack of long-term records limits the causal analysis of such changes.	

Table 5: Loss of critical habitats / biodiversity

IMMEDIATE CAUSE(S)	UNDERLYING CAUSE(S)	RESPONSE(S)
Increasing conversion of forested lands to subsistence gardens and small-scale cash crops.	Increasing population pressures impose a greater economic burden on rural families. Lack of public awareness and understanding amongst local rural people of the effects of degrading forest cover on the availability and quality of other natural resources upon which their subsistence livelihoods depend.	DEC / GTZ Landowner A
Land use changes, including selective logging, forest clearance, the establishment of agricultural monocultures, and major infrastructure developments such as hydro-schemes and mining.	Lack of an effective rural planning system that allows for critical habitats and areas of high biodiversity to be identified and incorporated into provincial land use planning and decision-making.	PNG Conservation Needs PNG Protected Areas Prog Biodiversity Data of PNG Resource Information Proj ICADs & other conservat WWF - Kikori, Madang L Ranges & Tonda
Encroachment and exploitation of formerly remote / inaccessible areas as a result of infrastructure and natural resource developments improving access to these areas.	Lack of adequately detailed information for planning purposes on the characteristics and distribution of critical habitats and areas of high biodiversity.	CI - Milne Bay, CM - Colli TNC - Walindi, Josephstal
Unsustainable use of critical habitats such as the cutting of mangrove stands and other wetland forest areas by local communities for firewood or timber (mangroves are important spawning and nursery areas for many coastal and estuarine species).	Lack of effective protected areas legislation that is compatible with customary land tenure systems and lack of local / community-level enforcement capacity.	PNG Protected Areas Proj
Destructive fishing practices and associated damage to critical habitats such as reefs and seagrass beds.	Lack of public awareness, motivation and support needed to ensure local communities and other stakeholders adopt a more pro-active environmental stance.	NGO Community-based a
Invasive species, particularly weeds and other pest species, feral and domesticated animals.		

Table 6: Declining coastal and marine resources

IMMEDIATE CAUSE(S)	UNDERLYING CAUSE(S)	RESPONSE(S)
<p>Increasing exploitation of coastal and marine resources by artisanal and commercial fishing</p>	<p>Increasing coastal populations impose increasing demands on coastal and marine resources. Decreasing marine resources elsewhere (such as Indonesia & Philippines) resulting in commercial fishing moving to newer waters such as PNG</p>	<p>Several important NGO initiatives WWF, TNC, VDT and others NFA: National Fisheries Conservation of Fisheries Resources</p>
<p>Increasing pollution of coastal and near-shore environments from land-based development, including:</p> <ul style="list-style-type: none"> - Increasing loads of river-borne sediments, wastes and other contaminants entering coastal systems from land clearance and other inland developments. - Direct disposal of wastes with a high oxygen demand into the coastal and marine environments, particularly refuse and plastics and organic wastes such as sewage. - Increasing levels of silts and contaminants in surface runoff from increasing development of the coastline fringes and waterside. 	<p>Increasing pressure on the assimilative capacity of the coastal and marine environments which degrades the quality of the resources and the habitats. Inadequate pollution control measures at source. Mistaken perceptions and inaccurate estimates of the assimilative capacity of the coastal and marine environments. Low priority given to coastal and marine environments. Lack of environmental awareness of the impacts of these pollutants on the coastal and marine environment and its resources.</p>	<p>DEC Environmental Guidelines Practice for some of the land Several important NGO initiatives WWF, TNC, VDT and others 5.2.6. NGO Community-based activities</p>
<p>Inappropriate fishing methods resulting in capture of (or damage to) non-target species and undersize individuals with no market value.</p>	<p>Lack of awareness / low priority given to conservation of fish stocks and non-target species.</p>	<p>Several important NGO initiatives WWF, TNC, VDT and others 5.2.6. NFA: National Fisheries Conservation of Fisheries Resources</p>

Table 6 (cont.)

IMMEDIATE CAUSE(S)	UNDERLYING CAUSE(S)	RESPONSE(S)
Damage and destruction of habitats as a result of destructive fishing practices such as dynamite fishing the use of poisons such as poisonous roots or cyanide.	Lack of public awareness and / or lack of civic responsibility.	NGO Community-based a including CI, WWF, TNC, Section 5.2.6.
Lack of adequate information and data on the quantity, quality and status of these resources that is suitable for management planning purposes at the local, provincial or national levels.	Lack of resources and capacity to conduct data gathering and compile information into effective management planning datasets.	Several important NGO ini WWF, TNC, VDT and ot NFA: National Fisheries Conservation of Fisheries N Marine Science Research F
Adverse impacts from invasive species either actively introduced or passive arrivals in ship bilge waters and attached to the hulls of ships.	Lack of awareness amongst the relevant agencies of the environmental risks posed by this potential impact.	

Table 7: Inadequate or unsatisfactory water supplies

IMMEDIATE CAUSES(S)	UNDERLYING CAUSE(S)	RESPONSE(S) 1
Loss of water retention capacity in watersheds as a result of widespread land clearance, or other change in land-use resulting in soil degradation and soil loss.	Failure to apply effective soil conservation measures and timely restoration of vegetation.	DEC Construction of Roads & DEC Guidelines for Forestry & PNG RIS Environmental Cons
Changes to river morphology, including river channelling, and riverbed sedimentation patterns.	Failure to apply effective soil conservation measures and adequate stormwater systems to temporarily store flood surges.	
Changes in local weather patterns.	Unclear, a lack of long-term records limits the causal analysis of such changes.	

Table 8: Declining air quality in some urban areas, notably in Port Moresby

IMMEDIATE CAUSE(S)	UNDERLYING CAUSE(S)	RESPONSE(S)
Vehicle emissions from increasing numbers of old / poorly maintained vehicles.	Inadequate policing and regulation of vehicle emissions as a result of the low priority given to air quality concerns.	
Smoke from grass burning and the burning of refuse.	Low priority given to air quality concerns and lack of awareness/civic responsibility in regard to the health and safety risks.	
Industrial emissions, localised and / or intermittent, particularly odorous emissions from food processing plants.	Low priority given to air quality concerns and lack of monitoring and effective regulation of industrial emissions.	DEC Environmental Code of Practice Oil Processing Mill.
Dust and other suspended particulate matter from construction sites, cleared areas of ground and landfill disposal sites.	Low priority given to air quality concerns and lack of awareness / civic responsibility in regard to the health and safety risks.	

Table 9: Noise Pollution

IMMEDIATE CAUSE(S)	UNDERLYING CAUSE(S)	RESPONSE(S)
Excessive noise from commercial / industrial activities and construction sites.	Inadequate monitoring and inadequate enforcement of Noise Abatement Notice Laws.	DEC Environmental Code (Vehicle & Machinery Work Fuel Storage, Re-sale & Use Sites, Construction of Road Landfill Sites.
Excessive noise from residential areas, educational & recreational facilities.	Inadequate monitoring and inadequate enforcement of Noise Abatement Notice Laws.	

Table 10: Climate Change

IMMEDIATE CAUSE(S)	UNDERLYING CAUSE(S)	RESPONSE(S)
Global warming.	Increased greenhouse gas emissions from burning fossil fuels and industrial emissions together with a reduction in global greenhouse gas "sinks" such as forests and other net absorbers of carbon dioxide.	Capacity building for adaptation. Identification of national mitigation opportunities to reduce greenhouse gas emissions.
Sea-level rise.	Increased sea surface temperatures related to global warming.	
Ozone depletion.	Emissions and increased concentrations of CFC's, halons, and other man-made chemicals that react with and deplete the ozone layer.	DEC: Annual reports of Ozone Consumption.

5.2 The Responses to the Issues

5.2.1 Increasing land degradation

Land degradation covers a wide range of effects of varying degrees of severity, ranging from the disturbance of soil nutrient balances and fertility, to the physical loss of soils through widespread exposure of the surface and erosion. Varying degrees of damage result from all land-based development but these can be minimised through the application and use of sound agronomic practices and soil conservation techniques.

Land degradation has primarily been addressed by the development of guidelines and codes of environmental practice, and by the training of government officers in the application and use of these guidelines and codes of practice. These guidelines and codes are based on the concept of Best Environmental Practice, and most of the material in them refers to the field activities that are associated with the particular industry the guideline or code refers to. In this regard their effective implementation is critically dependent on the ability of the regulatory agency to monitor and audit their compliance in the field. It is for this reason that the preparation of these guidelines and codes of practice were always accompanied by field training in their application and use for those responsible for monitoring and auditing compliance.

Unfortunately in recent years, the Department of Environment and Conservation, like many other government agencies, has suffered from a severe shortage of funds with which to conduct field monitoring and audits of compliance. As a result it is not possible for the Department to ascertain whether or not operators are complying with these guidelines or codes of practice.

In some industries, such as commercial agriculture, which depend on the quality of their soils to maintain productivity levels, it is likely that they are complying with many of the practices set out in these guidelines, as maintaining the quality of their soils and land is commercially important. However, in other instances, where for example the activity or operation is not dependent on maintaining the environmental quality of the soils, such as land clearances for infrastructure development, there is less of an imperative for the developer to follow good environmental practice, particularly if this entails additional costs.

Concerns have been raised regarding many commercial forestry operations in this context, which although operating under a sustained yield programme of harvesting, are generally perceived as paying only lip service to the practices of environmentally sound land management, particularly in regard to the post-harvest rehabilitation of logging coupes and access roads.

By contrast, mining, in recent years, has adopted many of these land management practices, so that rehabilitation of mined-over areas is generally good in the operations where adequate provision for rehabilitation was made from the outset. The Department of Mining and the Department of Environment and Conservation is developing a rehabilitation framework as part of its Mine Closure Policy that will address many of these issues at an early stage, during the EIA process, of mine planning (see section 3.4.2.1).

The Papua New Guinea Resource Inventory System (PNG RIS) has developed over recent years an Environmental Constraints on Land Use mapping system that provides valuable information on a variety of environmental parameters for land management. This system collates a wide range of mainly physical parameters (rainfall, soil types and compositions, soil fertility, slopes/ruggedness of terrain, flooding and inundation patterns, and many others) into a set of environmental constraints that can be used for land-use planning and management purposes. However although this information is available and widely disseminated, it is unclear how often it is used in development planning.

Reflecting the importance of effective land management to maintaining agricultural production, the National Agricultural Research Institute (NARI) has conducted several soil conservation and land management research projects, particularly in regard to subsistence agriculture in recent years. However, getting the findings of this research to the subsistence farmers on the ground remains a logistical problem in terms of the shortage of capacity in district extension services, and the physical problems of reaching the more remote communities.

5.2.2 Increasing risk from hazardous materials and wastes management

Two recent studies have focussed on the chemicals and wastes issues in Papua New Guinea.

- Papua New Guinea National Profile of Chemical Management 1997 - 2000 prepared by Dr. D. Mowbray, NCDS ANU and Environmental Sciences UPNG.
- Solid Waste Management Characterisation Study and Management Plan for PNG prepared for the South Pacific Regional Environment Programme by the consultants Sinclair, Knight, Metz, 2000;

The PNG Chemical Management Profile (Mowbray et al 2000) provides a comprehensive assessment of the state of chemicals management (including hazardous wastes) in Papua New Guinea. The Profile identifies the country's priority chemical management concerns as:

- Pollution of waterways especially from mining, forestry and agriculture operations and from the contamination of drinking water by human waste (as discussed in Section 5.2.6 on the issues of multiple-use water sources) and by hazardous wastes treatment and disposal.
- Pollution/contamination which, by its nature, is difficult to detect and control. This includes:
 - Air pollution, groundwater pollution, soil contamination.
 - Occupational health issues in agriculture, forestry and small industries.
 - Chemical accidents in small industries and small transporters.
 - Importation of unknown chemicals.
 - Storage and disposal of obsolete chemicals.
 - Household wastes contaminated with chemicals.
 - Chemical residues in food, and chemical poisoning.

The PNG Chemical Management Profile identifies several categories of chemicals that are believed to cause most of the environmental/public health problems in Papua New Guinea. These include heavy metals, organic and human wastes, hazardous chemicals such as pesticides and timber treatment chemicals, and chemicals in air pollutants. It provides valuable insights into chemical risk in Papua New Guinea, but is clearly constrained by the lack of available information and data on the nature and amounts of chemicals in the country (see below, and Saulei et al 2002). Unfortunately since its publication in 2000, there appears to have been little response to its findings either by government or the private sector. This reinforces the perception that the environmental issues surrounding waste management and hazardous materials in general are currently given a low priority in Papua New Guinea.

The author's own experience in the country over the last twelve years, during which he has attended many development site inspections at mining, forestry and agriculture operations, reinforces this view. On some of these occasions, one of the principal concerns arising from the inspection was the management of wastes, particularly hazardous and / or intractable solid wastes, and the management of hazardous materials (particularly toxic, corrosive and inflammable chemicals) during transport, storage, handling and disposal of residues. It should be pointed out that on several occasions where this was a concern, it did appear to be the result of complete ignorance of the risks, both to the environment and to personal health and safety.

The Solid Waste Management Characterisation Study examined the collection and disposal of municipal solid wastes in Port Moresby. The study conducted an audit and characterisation of household solid wastes which indicated that 50 % of the waste was biodegradable kitchen and garden waste, and 45 % paper, plastics glass and metals. The report evaluated several options for waste management systems and recommended the development of an integrated solid waste management plan for Port Moresby that proposed a number of waste minimisation initiatives and the need for an audit of hazardous substances in the waste streams.

Within the last year, the Department of Environment and Conservation has completed its most recent Code of Practice on Sanitary Landfill Sites. This code of practice incorporates many of the findings from the Solid Waste Management Characterisation Study as well as appropriate landfill practices to securely manage and contain the different categories of solid wastes.

The National Assessment Report (Saulei et al 2002) provides an overview and brief analysis of the waste management issues currently facing Papua New Guinea and concludes that at the present time

industrial emissions and discharges and solid waste management are the principal waste problems in the country.

This report also points out that at the present time there is virtually no available statistical data on pollution by chemicals and effects on human health in Papua New Guinea other than from the mining sector. There is a real lack of systematically collected data and any adequate databases in the country related to pollution and chemicals. Information on inventories of hazardous chemicals and wastes, and on emissions and discharges is lacking. Regular environmental auditing and monitoring of chemical importation, transport, storage, use and disposal is not carried out, and there is little information on industrial or consumer chemicals currently in the country.

Attempts by the Department of Environment and Conservation to collect information to develop a 'pollutant release and transfer register' by compiling an industrial emissions inventory failed because most companies had no idea of what wastes they were producing or the amounts they produced. There is little documentary material on the activities of departments in areas of chemical and waste management, other than the Department of Environment and Conservation's own documentation on chemicals. There is no government or private laboratory that can do the wide range of analytical tests required to support the government's chemical monitoring needs in overall environmental management, particularly in regard to identifying the composition of unknown but suspected hazardous wastes.

As noted earlier, there appears to be little priority given to this area of concern, probably partly due to ignorance of the pernicious long-term effects of chemicals exposure on public health and environmental qualities. This is also probably due in part to these long-term effects of chemical contamination not yet appearing, or being recognised as such, in the country.

A recently commenced GEF initiative in the Department of Environment and Conservation may serve to raise the level of awareness and priority given to this area of concern. This GEF initiative is a 2-year Pilot Project to develop a National Implementation Plan for the Management of Persistent Organic Pollutants. The project will develop action plans for the management of various chemicals and will include reviews of the legislation to improve their regulation. In particular, it is hoped that this project will be able to establish and improve cross-sectoral and inter-departmental linkages and mechanisms for more efficient and effective management and regulation of these chemicals.

In view of the above points, it should be noted that Papua New Guinea has signed, and in some cases ratified and incorporated into law, a number of international agreements which commit it to taking action in these areas. These include aspects of the Montreal Protocol on Substances that Deplete the Ozone Layer and the Stockholm Convention on Persistent Organic Pollutants (POPs). Prior Informed Consent (PIC) procedures have been recognized in the past but Papua New Guinea has yet to sign the Rotterdam Convention on PIC. Papua New Guinea is a signatory and has ratified both the (international) Basel Convention and (regional/ Pacific) Waigani Conventions on trade / trans-boundary movement in, and dumping of, hazardous chemicals and hazardous wastes. It has signed and ratified the London Dumping Convention (Convention on the Prevention of Marine Pollution by Dumping of Wastes and other materials), MARPOL (Convention for the Prevention of Pollution from Ships), and the South Pacific Nuclear Free Zone Treaty. It has also signed the Protocol for the Prevention of Pollution of the South Pacific Region by Dumping and the Protocol for Cooperation in Combating Pollution Emergencies in the South Pacific Region (Saulei et al 2002).

5.2.3 Declining water quality in rivers and coastal waters

Being a tropical, wet country water has always assumed a prominent position in Papua New Guinea's environment hierarchy, and many of the environmental initiatives during the last ten to fifteen years have focused on inland and coastal waters. In the early 1990s, draft environmental guidelines were prepared, and associated training modules given, to the Bureau of Water Resources (then a Division of the Department of Environment and Conservation, now the Water Resources Branch of the Department) as part of the UNDP/WMO Strengthening of Water Resources Assessment and Management project. These guidelines, and their associated training programs, addressed the potential environmental impacts of forestry operations, coffee processing, mining exploration, mining developments, and oil exploration activities on natural waters, and appropriate mitigation strategies and practical remediation techniques.

Since then there have been many other environmental guidelines and codes of practice (see the relevant table in Section 5.1) prepared for, and by, the Department of Environment and Conservation which include water quality impacts and their mitigation. However, it is not a lack of regulations and guidelines that limit the efficacy of measures to control declining water quality, but a lack of capacity and resources within the regulatory agencies to monitor, audit and enforce compliance with these regulations and guidelines.

This lack of capacity and resources within the regulatory agencies appears to reflect the low priority given to the environmental and socio-economic risks posed by declining water quality. This is a concern in a country in which most of the population are critically dependent on the quality of natural waters, not only for their direct use, but also as the basic environmental resource that supports their subsistence lifestyle and livelihood.

Within the commercial sector, the lack of regular field monitoring, audits and enforcement by the regulatory agency appears to have led to a more casual and careless attitude towards environmental protection in some operations. However, it must be said that others are maintaining and even improving the quality of their environmental management despite this.

The issue of declining water quality is also affected by a lack of baseline water quality data, particularly the range and frequency of parameter values in the Papua New Guinea environments, and information on the tolerances of key and critical habitats and the communities they contain. Unlike the more affluent temperate countries which have a wealth of baseline data, most tropical countries suffer from a severe shortage of baseline water quality data and information on the tolerances of many of their aquatic and coastal/marine communities. This makes the setting of accurate standards and criteria, at best, estimates, often based on extrapolating from the closest temperate situations. Until the level of knowledge as well as the availability of hard data can be improved, this makes it even more important to apply the precautionary principle to environmental management in the tropical setting.

Efforts were made in the late 1980s and early 1990s under the UNDP/WMO Strengthening of Water Resources Assessment and Management project (see above) to collect and collate baseline water quality data for the Bureau of Water Resources (now part of the Department of Environment and Conservation). However, the costs of collection, reflecting the difficult logistics in such a diverse and inaccessible country as this, meant that the small amount of water quality data that was collected was insufficient to give even an accurate measure of baseline water quality in the areas sampled, let alone in the country at large.

To date the only baseline water quality data available in Papua New Guinea comes from this short-lived exercise and from a number of other local studies conducted in the main by developers as part of their environmental baseline investigations. This lack of hard data and information on the range of natural variations and the tolerances of habitats and their communities remains a critical constraint on accurately assessing the extent and severity of declining water quality throughout the country.

5.2.4 Disturbed or unpredictable hydrological regimes

Hydrological regimes in Papua New Guinea are characteristically highly variable, ranging from flash floods at one extreme to complete cessation of flow at the other, where for example ephemeral surface flows occur in Karst country. To that extent they are unpredictable, and the variation within a hydrological regime, and in particular the rate of change, can be exacerbated by human activity. Activities that result in a loss of water retention capacity in watersheds as a result of widespread land clearance can result in flash floods and/or significant reductions in base flow volumes, which can cause significant adverse effects on water users and habitats downstream.

Some of the Department of Environment and Conservation's environmental guidelines and codes of practice do address the land clearance issue (see Section 5.2.1), and the PNG Resource Inventory System that maps out environmental constraints on land use does indicate areas and catchments particularly at risk from these situations and activities. However, greater use needs to be made of these systems by government and development proponents in the planning and methods of implementation of developments, if these risks are to be minimised.

The comments made in Section 5.2.3 also apply to the hydrology of rivers, and indeed coastal waters as well. There is a lack of up to date and consistent hydrological data for most of the river systems and coastal waters of Papua New Guinea, with one or two notable exceptions where developers, particularly in the mining industry, have extensive local hydrological records. Apart from these few limited situations, the lack of hard data makes it difficult to reliably assess the frequency and level of high flow events, or to assess the duration and minimum levels of base flows. But this information is vital for development planning purposes, where the frequency and severity of floods, and the reliable calculation of maximum sustainable (continuous) abstraction rates and minimum dilution coefficients for waste discharges, are required.

This absence of accurate hydrological information means that the design of flood control measures and the setting of water abstraction and discharge conditions may need wider safety margins than would be the case in situations where the hydrological regime is more accurately defined.

Most current hydrological data in Papua New Guinea comes from baseline and compliance monitoring requirements of the EIA process, and is supplied by developers as part of their compliance to environmental approval conditions (see above). Although this may be seen as an onerous imposition by the government on developers, it is the only means the country has at the present time to collect this important data. It is to be hoped that as partners in the development of Papua New Guinea, the private sector development projects continue to be willing and able to provide this important environmental service to the country.

5.2.5 Loss of critical habitats / biodiversity

During the last few years there have been several conservation initiatives and reviews on conservation and protected areas management which have been carried out by the Department of Environment and Conservation, Conservation International, the World Wide Fund for Nature, and the United Nations Development Programme. These have included the World Bank and AusAid funded National Forest and Conservation Action Program (NFCAP) that ran through the early 1990s, and developed the first “pilot” Integrated Conservation and Development (ICAD) project at Lak in New Ireland Province. This program assisted and supported the Conservation Needs Assessment (Beehler 1993) and the Papua New Guinea Country Study on Biological Diversity (Sekran and Miller 1994). The environmental guidelines for commercial forestry and the key standards for selection logging, which formed the basis of the PNG Logging Code of Practice, were also developed under this program, as were many other forestry initiatives.

The Department of Environment and Conservation was the lead agency for the Biodiversity Rapid Assessment Project (BIORAP), which was developed during 1994-1995 by a consortium of four Australian scientific agencies with World Bank and AusAID support (Sowe et al 2002). The aim of this project was to develop the basis for establishing a national network of protected areas and identifying the options and constraints for land management in the agricultural and forestry sectors. Spatial and conservation modeling tools were developed that allowed the identification of a set of biodiversity priority areas that included all existing protected areas and samples of all the Conservation Needs Assessment (see above) priority one areas. By incorporating the options and constraints for land management, the set minimised foregone opportunities for timber production, avoided areas of high agricultural potential and existing agricultural intensity, and gave preference to areas of low population density. As this set of biodiversity priority areas was built into a national GIS framework, it can be updated in response to changing land use patterns etc. and changes in ecological and biological knowledge, as well as being able to be superimposed on other data sets.

Most of the responses in recent years to the loss of critical habitats and biodiversity have come from the national and international NGOs working in the conservation field in Papua New Guinea. In the last few years the number of NGO conservation initiatives has grown considerably, as has the scope and geographical range of their programs. Some of the NGOs currently active in the conservation field in Papua New Guinea include: the World Wide Fund for Nature (WWF), Conservation International (CI), The Nature Conservancy (TNC), the Research and Conservation Foundation (RCF), the Foundation for Community Development, Conservation Melanesia, and the Village Development Trust, as well as many other national and international NGOs.

Most of these programs focus on an integrated conservation and development approach in which local

conservation management programs are integrated into a locally-based development model that utilises the local natural resources in an ecologically sustainable manner to generate community benefits. These benefits may include not only cash incomes, but also improvements in community infrastructure and services through capacity-building and re-investment of part of the cash income. These programs involve working closely with the local communities to build conservation awareness and develop environmental and conservation skills, in addition to the business management and technical support skills needed to conduct the development side of the program. The developments that have been “piloted” to date include eco-forestry programs, many based on the portable “*wokabut somils*” supplying niche timber markets, and a few eco-tourism programs.

Many of these initiatives are based on the establishment, through community consensus, of Wildlife Management Areas (WMAs). There are now more than thirty WMAs established, or in the process of being established. These WMAs are areas that the landowners have decided to set aside for specific purposes involving the active management of wildlife and natural resources. They are currently the most appropriate and effective form of conservation and natural resource management for Papua New Guinea under its customary land ownership arrangements.

WMAs are governed by a local committee made up of representatives of the local clans/tribes and, in essence, are similar to many community-based organisations. The NGOs’ role extends beyond community awareness building and skills development. They also provide a facilitating role in assisting the WMA committee to set up the management infrastructure including the development and implementation of the specific purposes and development activities for which the WMA has been set aside.

A key component of the management infrastructure is the interaction between the WMA committee and the Local-Level Government in the area. The recent Organic Law on Provincial and Local-Level Governments gives considerable responsibility and law-making powers (Section 142 of the Law) for conservation and the sustainable development of local natural resources to the provincial and local-level governments. As such, they are clearly important stakeholders in this process, but as most operate under severe budget constraints, they neither have the capacity nor resources to carry out these responsibilities.

Close cooperation between these two bodies is critical to the effectiveness of the conservation initiatives and the efficient establishment and management of these, and this is now recognised by the NGO community, who foster this collaboration as an important key to the overall success of the conservation effort. Many NGOs now recognise that their efforts with the local communities can be reinforced by also working in close collaboration with the local-level government. This not only facilitates their involvement in the WMA and ICAD processes, but also in terms of awareness and capacity building at this level of governance. This approach is becoming increasingly common among the larger NGO initiatives such as Conservation International’s Milne Bay Community-Based Coastal and Marine Conservation Program and the WWF Integrated Conservation and Development program at Kikori, where in both cases the NGO is working closely with both local-level and provincial governments.

Other recent conservation initiatives include the establishment of the PNG Conservation *Mama Graun* Trust Fund with the mission to support biodiversity conservation and related sustainable development initiatives. The Nature Conservancy provided technical assistance for the establishment of this trust fund, whose aim is to provide an ongoing and reliable source of in-country funding for biodiversity conservation and the sustainable development of Papua New Guinea’s natural resources.

Another recent initiative has been the establishment of the PNG Institute of Biodiversity (PINBio) to strengthen biodiversity related research and training in Papua New Guinea. This institute is currently housed in the Department of Environment and Conservation, although it is an independent entity. As part of its mandate to strengthen biodiversity related research and training, it has been involved in the preparation of the PNG Country Programme Strategy, Operational Phase III, for the UNDP-GEF Small Grants Programme (Department of Environment and Conservation 2002b).

In partnership with WWF and The Nature Conservancy, the University of Papua New Guinea is jointly developing a conservation leadership initiative/conservation area planning and capacity building training program. Another initiative, focussing on raising the level of public awareness through the schools, is the conservation and environment curricula that have been introduced into the teacher education courses at The University of Goroka (Saulei et al 2002).

5.2.6 Declining coastal and marine resources

The evidence of declining coastal and marine resources in some areas that have been surveyed has already been presented in Section 3.5.3. Responses to declining coastal and marine resources have come from the National Fisheries Authority, which has developed National Fisheries Plans for a number of commercially important fisheries species, and from the national and international NGO community in Papua New Guinea.

National Fisheries Plans have been developed for the tuna fishery, the prawn in the Gulf of Papua and the *beche-de-mer* fishery, and more are due in the near future. Each of these fisheries management plans:

- Identifies the fishery and its characteristics, including its current state of exploitation.
- Specifies the objectives to be achieved in the management of the fishery.
- Identifies any possible adverse environmental effects of the operation of fishing activities in the fishery.
- Identifies, where appropriate, any relevant customary fishing rights or practices.

The National Fisheries Authority is also proposing to develop a Conservation of Fisheries Management Plan that will address a number of commercially important artisanal fisheries stocks such as mud crabs, *trochus*, giant clams and reef fish.

The last five years has seen a rapid growth of NGO involvement in the marine and coastal area of conservation. The primary focus of this involvement has been community-based coastal and marine conservation, associated with the identification of development options that are compatible with the conservation aims of each program (see preceding section).

The Marine Resource and Conservation Planning document (Hunnan et al 2001) identifies four main issues facing the conservation of coastal and marine ecosystems.

- Destruction or degradation of marine and coastal habitats.
- Over-harvesting of marine species.
- Conflicts between different marine resource users (eg. effluent disposal and fisheries).
- Limited management capacity of the local communities (management by central agencies is seen as unworkable at most of these areas, which are too remote for effective central agency intervention).

The document goes on to describe some of the critical elements needed in an effective marine resources management and conservation program.

- Models of sustainable subsistence and artisanal fisheries.
- Options for sustainable livelihoods and income generation in coastal communities.
- Control of impacts from urban and marine development and operations.
- Reduction in the downstream impacts from land-based activities such as land clearance, forestry, mining and agriculture.
- More widespread awareness and understanding of marine ecological processes and resources.
- Local capacity for marine resources management.
- Supportive legal, policy and institutional framework.

There are a number of key NGO initiatives that provide an overview of the responses to declining coastal and marine resources in Papua New Guinea.

Conservation International has produced a Marine Conservation Strategy for Papua New Guinea, based on a consultative planning process that involved over 100 participants from 60 different organisations, to guide and co-ordinate marine conservation efforts. The goal of this strategy is to “advance a common national agenda for marine conservation that is supported by a national network of interested stakeholders”. The main objectives of this strategy relate to government policies, networking, awareness, education, scientific research, capacity building and marine protected areas.

Conservation International is conducting the development of the Milne Bay Community-Based Coastal and Marine Conservation Program. This project has conducted rapid appraisals of Milne Bay’s marine biodiversity and a conservation needs assessment study of the marine area which identified three

representative Marine Management and Conservation Zones (MMCZs) in which the project would primarily operate. Each area would be zoned for strict protection and for sustainable use (Conservation International 2001, Seeto 2000, Mitchell et al 2001, Skewes et al 2002).

The project will promote community-based conservation in these areas by working not only with the local communities, but also with the local, provincial and national government agencies, with whom it will support government planning and capacity building to reinforce the long-term sustainability of the project objectives.

Another Conservation International coastal initiative in Papua New Guinea is the Coastal Clean-up Campaign. This campaign is an annual event that was initiated by Conservation International in collaboration with the National Capital District Commission to remove plastics and litter from the shorelines around Port Moresby. The campaign, which involves schools, communities and the public has now spread to other centres and some rural locations around the country, and has been successful in highlighting and raising the level of public awareness of the adverse effects of littering the shoreline.

The Nature Conservancy (TNC) has a marine programme based at Kimbe in West New Britain, which has been running since the early 1990s. In 1994, The Nature Conservancy carried out and published a rapid ecological assessment of Kimbe Bay in association with a local NGO, Mahonia Na Dari Research and Conservation Centre. This 7-volume assessment included a summary Synthesis Report (Holthus 1994), and specific assessments of Coral Reef Habitat (Holthus and Maragos 1994), Fish Diversity (Allen and Munday 1994), Food Reef Fish Resources (Mobiha and Hair 1994), Biodiversity of Stony Corals (Maragos 1994), Commercial Sedentary Marine Resources (Hair et al 1994), and Marine Mammals (Munday 1994).

The Nature Conservancy has made a major commitment to inshore fisheries work through this program, particularly in the management and regulation of the live reef food fish trade, on which it works closely with the National Fisheries Authority. In association with Mahonia Na Dari Research and Conservation Centre, The Nature Conservancy is also conducting work on reef research, an awareness and education programme (Grades 1 to 6), production of a handbook, curriculum development support and a regular local radio program for children (Hunnam et al 2001).

The Village Development Trust, a national NGO based in Lae, successfully established the Kamiala Wildlife Management Area in 1996 around Lasonga Island on the south Morobe coast, which covers a marine area of 18,000 hectares. This WMA included a training centre, guesthouse, a boat to help local communities travel to and from Lae, and an artisanal fishing operation. The Village Development Trust is now actively promoting the Marine and Coastal Ecosystems Management Programme, which will extend from Huon Gulf to the border of Morobe and Oro Provinces, and further south to include the Tufi Fjords (Hunnam et al 2001).

The World Wide Fund for Nature (WWF) has a number of projects that include marine components. These include supporting community and local government initiatives to manage and develop the Tonda and Maza wetland WMAs in the Western Province, the Kikori Basin ICAD project, and the Sepik Community LandCare-Lukautim Graun project. This latter project is involved in conservation and development issues at several locations in the Sepik basin, including the coastal zone between Murik Lakes, Cape Wom and Sissano Lagoon, and the province's offshore islands (Hunnam et al 2001).

Although this does not give a complete picture of NGO involvement in the coastal and marine sector, it does provide some indication of the range of activities being undertaken and some of the approaches and mechanisms that have been adopted in establishing marine conservation programs in areas often remote from government services and infrastructure.

Some of the attributes common to these programs are:

- The paramount importance of the local communities' active participation and ownership of the program.
- Building local capacity to develop and manage the program.
- The active involvement of local, provincial and national levels of government.
- Building capacity at the local and provincial levels of governments to actively support and assist the development and management of the program.

- The importance of awareness and education programs that reinforce the local communities' participation and raise the profile of involvement.
- The need to address and meet the development needs and aspirations of the local communities involved in the program within the context of the conservation objectives.
- The importance of public relations campaigns and the media in promoting public awareness of, and active involvement in, these programs.

5.2.7 Efforts to protect and improve water supplies

As has been previously stated, with the vast majority of Papua New Guineans obtaining their potable water from natural sources, the protection of these sources from pollution and environmental degradation is vitally important. Water supplies in the rural and peri-urban areas are particularly at risk and there are currently several on-going efforts to protect and improve these.

The risks to water supplies comes from the increasing burden of multiple use of the same resource for extraction and other potentially contaminating uses such as washing and contamination by surface and ground-waters. In recent years several NGOs and provincial and local-level government health divisions have conducted environmental health awareness programs, with mixed success.

The underlying problem is widely recognised as the multiple use of the supply that inevitably poses potentially serious health risks of contamination. More recently government, with support from aid donors such as the European Union and JICA, has embarked on a program of dedicated (single-use) safe water supply systems in the rural areas. These are generally solar-powered pumped well-bores which supply a large storage tank, from which the supply is piped to surrounding standpipes conveniently located in the local villages. As these are fairly new initiatives, it is too early to say whether these can be sustained in the long-term, particularly in regard to maintenance of the power supply, but where these have been installed, the availability of safe water has resulted in personal health and hygiene improvements. Similar programs are also being carried out in some of the peri-urban settlements around the country.

In some of the more accessible rural areas, Local and Provincial government Health Divisions are also conducting water supply monitoring programs using simple water-quality field testing kits that provide an on-the-spot assessment of potential contamination and trends in the water quality of multiple use sources.

5.2.8 Air pollution and noise pollution

The general consensus from the survey replies and other respondents, and stakeholders at the workshop, was that air pollution and noise pollution were of a lower priority at the current time although both can cause locally significant impacts and thus should not be discounted. Both are perceived to be urban or industrial development issues, and as such should be easier to regulate and control, although there is a paucity of information regarding the baseline quality of each against which impacts could be assessed.

Several of the environmental guidelines and Codes of Practice referred to previously contain guidance on acceptable aerial emission and noise, whilst Department of Transport legislation could be used to regulate unacceptable vehicle emissions.

5.2.9 Climate change

Papua New Guinea has responded to the issues of climate change by signing the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocols, and thus it has made commitments at the national and international levels. Papua New Guinea has established a climate change office, the Greenhouse Unit (GHU), under the auspices of the Department of Environment and Conservation as the implementing agency.

Working with the Department of Environment and Conservation, and other government agencies, the Greenhouse Unit has begun to address issues at the local level. These have included capacity building to prepare itself to respond to climate change, the identification of appropriate response measures to address

the country's vulnerability to climate change and how adaptation to climate change can be achieved. The Unit has also identified what can be done nationally to abate greenhouse gas emissions.

Papua New Guinea has already completed and submitted its Initial National Communication and compiled a National Inventory of Greenhouse Gases. The results of this inventory suggest that these emissions are relatively small per capita and therefore reduction of these levels is practically insignificant (Saulei et al 2002).

The Greenhouse Unit is also addressing ozone layer depletion by tracking the national consumption of ozone depleting substances, and reporting annually on the consumption of these substances.

5.3 Common causes underlying the principal environmental problems in Papua New Guinea and the efforts made to address these

5.3.1 Lack of environmental awareness and understanding amongst public

A recurring theme throughout the listing of causes is the lack of environmental awareness and practical understanding by the public of environmental risks and the means by which these risks can be reduced or avoided altogether. This lack of environmental awareness and understanding is prevalent throughout the population, both rural and urban. It is a particular concern in the rural communities, which being far removed from government services, receive little if any technical and regulatory support in regard to environmental impacts and their mitigation. In these circumstances, environmental impacts can reach levels of severity that can result in serious damage to resource stocks such as fisheries or forestry stocks, and even impact public health such as water-related sicknesses, before the impact is noticed and action can be taken to mitigate the effects.

Many of the NGOs involved in conservation-related programs around the country (see Section 5.2.5) have carried out community-based environmental awareness programs at an early stage in the program cycle. A key component of these awareness programs is the active and meaningful participation of the community in all aspects of the program's development and delivery. This not only ensures that the program is relevant to, and focussed on, the community's concerns, but also that the community genuinely owns and takes "on board" the awareness program and its outcomes. Unless this is achieved, experience has shown that the intentions and effects of the awareness program are not sustainable over the long term.

One of the keys to success (measured as community acceptance and ownership of the program) appears to be to have a primary purpose or reason for conducting the awareness program. In many cases this purpose could be described as identifying and developing options for the ecologically sustainable development of the communities' natural resources so that conservation is successfully integrated with a development use that provides a local source of sustainable income. Often the development use that is selected builds on existing uses and local skills, such as the development of an artisanal fishery or eco-forestry operation. The existing skills base is enhanced with environmental management and resource conservation skills, appropriate low-impact technologies, and marketing and organisational assistance.

Although most of these NGO community awareness programs have only commenced in the last few years, the indications are that this intensive community-based approach to raising environmental awareness and understanding in the rural sector (particularly where government services and support is minimal) can achieve considerable success. Measures of success include reducing environmental degradation and the over-harvesting/unsustainable use of resources, as well as increasing local incomes and raising the quality of life in the participating communities.

The lack of environmental awareness and understanding of the environmental problems and their causes is not confined to the rural communities and those outside the formal sector. One of the underlying causes frequently associated with development-related environmental problems is an apparent lack of environmental awareness within the formal development sector itself. This has been noted by several of the questionnaire respondents and other commentators, who have identified the low priority given to environmental concerns in the drive for development. This was identified as the primary underlying cause for the lack of adequate or efficient solid waste management systems, particularly in the municipal centres.

This lack of environmental awareness, and in particular the risks associated with water pollution from sewage, agricultural runoff, and the careless disposal of wastes and hazardous materials, was cited by many of the respondents as one of the primary underlying causes of declining water quality (inland and coastal) and declining coastal and marine resources.

5.3.2 Low priority given to environmental concerns

Many of pollutants derive from operations and activities that are conducted within the formal sector under management that could reasonably be expected to be informed and aware of environmental issues. This suggests that there is a widespread and prevailing casual attitude towards environmental risks, environmental protection and the conservation of natural resources. This is reflected in the relatively low priority apparently given to environmental concerns by many in the private and public sector, although there are signs that this has recently begun to change as the environment has assumed a more prominent position in the global arena.

There have been many initiatives conducted by government and NGOs aimed at raising the level of priority given to environmental concerns. In the rural sector these have largely been confined to the NGO initiatives described in the previous section, and local community school initiatives.

In the urban and peri-urban sectors several of these initiatives have utilised the media and government channels to raise the profile of the environment, with varying degrees of success. An annual coastal clean-up campaign (see Section 5.2.6), first commenced a few years ago, has had some success in keeping beaches and coastlines clear of litter in the urban and peri-urban areas. Within the formal sector numerous workshops on a wide range of environmental topics serve to remind those in government and the private sector of the importance of the environment, but the words and recommendations from these workshops are often slow to translate into action on the ground. An apparent lack of urgency continues to pervade government and private sectors that translates into the low priority apparently given to environmental concerns.

This low priority remains one of the primary underlying causes of environmental degradation in Papua New Guinea, and is reflected in an apparent lack of a culture of environmental stewardship and environmental compliance.

5.3.3 Low profile of the national and provincial regulatory agencies and their lack of “field presence”.

The low priority apparently given to environmental concerns by many in the private and public sector appears to be due in part to the low profile of the Department of Environment and Conservation at the “cutting edge” of development. Several respondents and commentators noted their lack of presence on the ground at many development project sites, particularly during the initial stages of land clearance and construction.

This results in a more casual attitude to impact avoidance and mitigation during these critical early stages. It also makes it much harder to establish a sound and appropriate working relationship with the developer and crucially with the local landowners, who reasonably expect government to work on their behalf, looking after their interests and ensuring that the development proceeds as planned and is properly regulated.

This lack of presence, particularly during the initial stages of development, has the potential to damage relationships with both landowners and developers from the outset of the development cycle, and puts the Department permanently “on the back foot”. It is also likely to significantly harm the Department’s credibility as its lack of presence on the ground at this crucial time could easily be seen as the actions of an ineffective agency with an overly casual attitude towards its role and responsibilities.

In fact, this is not the case. The Department of Environment and Conservation does continually strive to maintain an effective role in the field, but is severely constrained by a lack of funds and shortage of staff. The Department, like many other agencies in government at the present time, is critically short of funds and has no money for field/site visits. In fact this has been a problem for a long time, because even in

years gone by when travel funds were available, the very high costs of visiting field sites, which are often in remote locations inaccessible by road and thus involved air travel/helicopter charter, meant that the annual travel budget was quickly used up.

In response to this dilemma, the Department has at various times over the last few years examined the options for a user-pays system, but to date no further action has been taken on this subject. It should be pointed out here that in recent years most of the major operators in the mining and petroleum sectors, and the oil palm industry in the agricultural sector, have funded regular site visits by the Department, although they are under no legal obligation to do so.

In these companies' operations environmental problems are now generally resolved in a more efficient and effective manner than elsewhere in the country, no doubt in part because the companies show a willingness and commitment to work with the regulator in resolving environmental issues. The benefits of this cooperation "on-the-ground" go beyond the timely and effective mitigation of environmental impacts. They have also included the resolution of landowner concerns, many of which relate to claims for environmental damage compensation, in which the Department can act as an independent arbiter, mediating on behalf of both sides to achieve a fair and acceptable resolution of the issue.

However, this collaboration is still far from universal, and the indications are that there are many development operators around the country who do not share this sense of environmental stewardship and partnership with the regulator. For these operations, the only solution appears to be the formal enactment of user-pays legislation that will provide the Department, through receipt of environmental fees and charges, the funds necessary to carry out its field monitoring, inspection and audit role.

This lack of field inspections and monitoring has been suggested in several of the questionnaires and by other respondents, who highlighted inadequate environmental monitoring and compliance, and ineffective impact mitigation and/or remediation, as one of the frequent underlying causes of environmental pollution and degradation.

5.3.4 Inadequate environmental monitoring and management skills

A lack of effective environmental monitoring, management (including impact mitigation and remediation), inspection and enforcement was highlighted ten years ago during the design of the environmental component of the National Forestry and Conservation Action Program. This program, which focused on the forestry sector, identified this shortcoming as one of the principal reasons for the very poor environmental record of the country's forestry industry at that time. The program was funded by the World Bank, AIDAB (now AusAID) and NZODA, and set out to strengthen the government institutions involved in the forestry sector, including the Department of Environment and Conservation.

The program assisted the Department of Environment and Conservation through capacity building and direct funding to establish a Forest Monitoring Unit, which was responsible for the environmental regulation, monitoring and enforcement of all forestry operations. To this end, the capacity building program adopted a dual focus, the development of legal instruments and the training of Departmental staff. The legal instruments developed included the Environmental Guidelines for Forest Harvesting Operations and standardised Approval Conditions for Forestry Environmental Permits. Training for Departmental staff was conducted in the areas of environmental planning, monitoring, management, regulation and enforcement of environmental standards and conditions in the forestry sector.

This continued after the National Forestry and Conservation Action Program ceased in early 1994, as the capacity building component was picked up by the AusAID funded Department of Environment and Conservation Strengthening Project (DEC SP), which continued the training and completed the development of Papua New Guinea's first Code of (Environmental) Practice, the PNG Logging Code of Practice.

Based at the Department's head office in Port Moresby, the original design called for the decentralisation of the Forest Monitoring Unit into four regional centres, where the staff would be closer to the field operations they were responsible for. This decentralisation was never implemented, and subsequent problems with resources and funding resulted in the demise of the Forest Monitoring Unit, the fully trained staff being re-assigned to other departmental duties.

The DEC SP also carried out a wide range of other institutional strengthening and capacity building initiatives within the Department, many of which focussed on technical training in sector specific environmental monitoring, management and enforcement and the preparation of environmental guidelines and Codes of Practice, including the Motor Vehicle and Machinery Workshops, Hydrocarbon Fuel Storage, Re-sale and Usage Sites Code of Practice, and the Oil Palm Processing Industry Code of Practice. The DEC SP also assisted the Department in developing the new legislative framework that provided the basis for the development and formulation of the new Environment Act 2000, which is discussed in more detail below.

However, despite this considerable amount of institutional strengthening and capacity building effort some years before, the department today is unable to carry out its responsibilities for environmental planning and regulation in an effective and efficient manner due to a severe shortage of government funding and other resource constraints. Clearly identifying alternative means of securing funding for field inspections and monitoring is crucial to the future effectiveness of the Department's regulatory role.

5.3.5 Inefficient and cumbersome environmental legislation

Partly in response to these funding difficulties, but also recognising the inherent inefficiencies and cumbersome workings for both user (developer/applicant) and regulator (DEC), Papua New Guinea's environmental legislation has recently undergone major revision and realignment with the enactment of the new integrated Environment Act 2000. This act is designed to be more "user-friendly" and improve environmental permitting efficiencies by providing a "one-stop shop" system of environmental regulation and permitting. It is also significantly more transparent and publicly accountable in its decision-making, and more comprehensive in its scope.

The new act embraces the concepts of environmental harm and environmental improvement. The Act puts a greater onus of responsibility on the developer, not just in terms of compliance with prescribed standards and approval conditions, but also significantly, the responsibility on the part of the developer to avoid material or serious environmental harm.

Under the previous environmental legislation (see Section 4.1), most significant developments in Papua New Guinea required environmental approvals and permits to develop and operate. In many cases the Environmental Approval Conditions attached to these required the developer to comply with appropriate environmental standards and safeguards. Guidance on the precise nature and requirements of these was given in Schedules and Regulations to these earlier environmental acts, and in several technical guidelines and codes of environmental practice. Thus in many industries, such as forestry, mining, agriculture, the developer was informed of what was required under the terms of his development approval to protect the environment. (These guidelines and other regulatory instruments are listed in the Table 5.1).

However, monitoring of compliance to these environmental standards and conditions of approval was almost invariably left to the developer as the Department of Environment and Conservation had neither the capacity nor the resources to undertake its own site inspections or compliance monitoring at the development site. Consequently the Department was unable to maintain its policing role in ensuring environmental management systems were adequate and effective, or to verify the veracity of the compliance monitoring results obtained by the developer, which were forwarded to the Department for their scrutiny.

Furthermore, without regular and consistent contact with the development managers and staff at the field site, the level of liaison and understanding between developer and regulator, crucial to the efficient and effective resolution of unforeseen issues that invariably arise from time to time, gradually deteriorated.

In the absence of inspections and independent compliance monitoring by the Department, legal enforcement of the regulations and approval conditions was seen as being a contentious and probably untenable option. Consequently, to the author's knowledge, no environmental prosecution was ever pursued by the Department as far as the courts.

By the late 1990s, the then existing environmental legislation was deemed by all to be unworkable, and the new legislation framework and integrated Environment Act were formulated (see Section 4.1). This focuses on self-regulation for low risk activities and developments under the guidance of various Codes of (Environmental) Practice, which set out the environmental requirements for particular activities. It

should be noted that self-regulation does not preclude the operator from environmental prosecution in the event that his activities cause environmental harm or otherwise contravene the Environment Act 2000.

As the Act is so recent, it is too early to gauge whether this system of self-regulation for low risk activities and developments will prove to be effective. However, the publication of environmental guidelines and Codes of Practice do provide the stakeholders, and the general public, with information on what is environmentally acceptable, and as such make a significant advance towards good environmental governance and transparency in Papua New Guinea.

Activities and operations that carry a higher risk of significant environmental impact will be regulated by means of conditions in environmental permits, environmental improvement plans and environmental management programs. Those operations that have the potential of major environmental impact and are projects of national significance or of large scale will be subject to a process of detailed appraisal of environmental implications and public consultation through the Environmental Impact Assessment process.

In these cases, where there is a risk of significant or major environmental impacts, there will still be a need for environmental inspections and verification and/or independent compliance monitoring. The Department of Environment and Conservation is currently considering a number of options to provide these important environmental regulation services. These include economic instruments such as user-pays mechanisms (permitting charges, cost-recovery mechanisms, etc.), environmental levies and environmental bonds. The Department may also consider out-sourcing these services, particularly for the more technical industries such as the mining and downstream petroleum sectors.

5.3.6 Lack of reliable and accurate environmental and conservation information

One of the principal constraints on accurately identifying the potential impacts of a proposed development during the EIA process is the lack of reliable and accurate information on environmental parameters and conditions, and on the composition, tolerances and relational dynamics of the diverse range of habitats and ecosystems that occur in Papua New Guinea.

This lack of information is widespread and covers all aspects of the environment and the biological systems it contains, including much information of direct economic value such as detailed climate data, river flows and water quality data. Commercially important biological information that is lacking includes data on the population sizes, distribution, age structure and recruitment rates of most stocks of commercially important species (commercial or potentially commercial species of trees, fish and shellfish, agricultural cultivars, etc.). This data is necessary to not only calculate sustainable harvest rates, but also to ensure that these populations are protected from environmental harm and continue to thrive and provide value and income to future generations.

Most of the environmental data and information on biological communities and biodiversity that is currently available has come from baseline surveys conducted as part of an EIA process for environmental approval submissions, as a result of NGO programmes and initiatives (see Sections 5.2.5 and 5.2.6), or as a result of a few government surveys conducted as part of an aid development programme (such as the UNDP/WMO Strengthening of Water Resources Assessment and Management and the AusAID-funded Department of Environment and Conservation Strengthening Project).

However, the lack of available information is not simply a lack of data, there has been considerable amounts of data collected over the last ten - twenty years, but it widely scattered, both within Papua New Guinea and in many overseas institutions. There is a pressing need, as was identified in the Conservation Needs Assessment programme in the early 1990s, to collect all this different data and information together into a central location in Papua New Guinea where it could be made available for government, NGO and private sector use. Unfortunately, nothing has been done to implement this, and the availability of environmental data and information on biological communities and biodiversity remains a major constraint affecting environmental protection and conservation management.

ruption at all levels.

- 3) Lack of co-ordination between departments and an inability to communicate since office machines and telephones often are not working.

- 4) Move to decentralize powers and activities to provincial and local level government without concomitant financial, manpower and institutional support.
- 5) Little government and community support given to environmental concerns, and in particular to the Department of Environment and Conservation.
- 6) Lack of awareness and training in environmental best practice, and low priority given to environmental considerations in all sectors.
- 7) Lack of proper environmental accounting and unwillingness to adopt triple bottom line accounting giving true values to environmental assets .
- 8) Lack of communication/networking/integration at both policy development and implementation levels between sectors, levels of government, private sector and government, and between the community and the government.
- 9) The prevalent ideologies of development and tendency to accord high priority to generation of revenue at expense of environmental best practice or sustainability
- 10) Other important constraints include:
 - i) Poverty and inequity throughout Papua New Guinea.
 - ii) The dominance and territoriality of sectoral departments. Inadequate environmental governance.
 - iii) Confusion of responsibilities due to ill-defined legislation.

6.0 Future Options to more effectively address Papua New Guinea's Principal Environmental Concerns

6.1 Overview

Chapter 5 identified ten principal environmental issues or themes that summarise the wide range of environmental threats and problems facing Papua New Guinea at the current time.

1. Increasing land degradation: topsoil depletion, damage to soil structure, fertility and water retention capacities.
2. Increasing environmental risk from hazardous materials storage, transport and use, and from solid and hazardous waste generation and improper management (collection, containment, treatment and final end-use/disposal).
3. Declining water quality in rivers and coastal waters.
4. Disturbed or unpredictable hydrological regimes.
5. Loss of critical habitats and biodiversity.
6. Declining coastal and marine resources.
7. Inadequate or unsatisfactory water supplies.
8. Declining air quality in some urban areas, notably Port Moresby.
9. Noise pollution.
10. Climate change.

There have been a number of efforts made to address each of these concerns with varying degrees of success (see Section 5.1 and 5.2), but for a number of reasons these efforts have often not resulted in effective and sustained remediation of the problem. This is despite the fact that over the last ten years there has been considerable efforts made to address these problems with environmental guidelines and environmental codes of practice, and recently a new Environmental Act. The problem is not a lack of information on what should be done and how it should be done, but rather a lack of action in applying, implementing and enforcing adherence and compliance to these legal instruments.

Chapter 5 also identifies a number of underlying (“root”) causes that are common to most of these issues.

- Lack of environmental awareness and understanding amongst the public.
- Low priority given to environmental concerns.
- Low profile of the national and provincial regulatory agencies and their lack of “field presence”.
- Inadequate environmental monitoring and management skills.
- Lack of reliable and accurate environmental and conservation information.

It should be noted here that the underlying cause “Inefficient and cumbersome legislation” has been left off the list here, as with the enactment of the new legislation, and the impending formulation and amendment of existing regulations and guidelines to match the new legislation, this particular cause has, hopefully, been remedied, although as noted later in Section 6.3, there are still some concerns regarding its effective, and consistent, implementation.

The PNG National Assessment Report (Sowei et al 2002) identifies the following list of common constraints and barriers that are limiting effective implementation:

- 1) Inadequate manpower and funding to implement and enforce policy coupled with significant staff cuts and redundancy, mobility of staff, and scarcity of technical skills and experience.
- 2) In many departments, continuous political interference and continually changing organizational structures wherein decision making process lacks accountability and transparency, coupled with corruption at all levels.
- 3) Lack of co-ordination between departments and an inability to communicate since office machines and telephones often are not working.
- 4) Move to decentralize powers and activities to provincial and local level government without concomitant financial, manpower and institutional support.

- 5) Little government and community support given to environmental concerns, and in particular to the Department of Environment and Conservation.
- 6) Lack of awareness and training in environmental best practice, and low priority given to environmental considerations in all sectors.
- 7) Lack of proper environmental accounting and unwillingness to adopt triple bottom line accounting giving true values to environmental assets .
- 8) Lack of communication/networking/integration at both policy development and implementation levels between sectors, levels of government, private sector and government, and between the community and the government.
- 9) The prevalent ideologies of development and tendency to accord high priority to generation of revenue at expense of environmental best practice or sustainability
- 10) Other important constraints include:
 - i) Poverty and inequity throughout Papua New Guinea.
 - ii) The dominance and territoriality of sectoral departments. Inadequate environmental governance.
 - iii) Confusion of responsibilities due to ill-defined legislation.
 - iv) The weakening capacity of universities and training institutions.
 - v) The inability of the system to couple local capacity building with that overseas expertise, and to base training programs in local training institutions.
 - vi) Community attitudes and pragmatism.
 - vii) The key players in the resource sector, be they national or provincial governments, private companies, aid donors, development facilitators, international NGOs, local NGOs and communities, have differing agenda.

Although this comprehensive assessment of the constraints and barriers outlines the circumstances hindering effective implementation of good environmental practices, some of these relate to matters of governance and national policy that are beyond the scope of this report, which focuses on specific environmental issues and problems.

However, many of these do reflect the underlying causes identified in Section 5.3. The lack of environmental awareness and understanding and the low priority given to environmental concerns is implicit in constraints 5), 6), and 9), which comment on the lack of support and training for environment, and the low priority environmental concerns are accorded in the development process. This will be exacerbated by the lack of communication between government departments, between national agencies and their provincial counterparts (communication facilities in the Department of Environment and Conservation, like many other government departments, are minimal at the present time, due to budget constraints), and between government, the private sector and the general public.

As the National Assessment Report points out, this lack of communication results in poor coordination and integration at both policy development and implementation levels between sectors, levels of government, private sector and government, and between the community and the government (constraint 8). This has inevitable consequences on the consensus for, and relevance and applicability of, policies, and on the ability of these to be implemented in an efficient and effective manner.

The constraints on manpower and funding noted in 1) and 4) will require innovative ways and means to be identified to overcome this problem. Obviously the development of a transparent, accountable and consistent (across sectors) user-pays policy will make a significant contribution to alleviating this problem, but there will still be some areas, particularly in regard to public issues (where the user is the general public) that cannot be covered by a user-pays policy.

The underlying cause “inadequate environmental monitoring and management skills” is also reflected in the National Assessment Report’s findings, where it notes (10 iv. and 10 v.) two other constraints.

- Weakening capacity of universities and training institutions.
- The inability of the system to couple local capacity building with that of overseas expertise, and to base training programs in local training institutions.

Despite the numerous institutional strengthening and capacity building projects that Papua New Guinea has undertaken, these do not appear to have had a lasting effect on the quality of environmental monitoring

and management in the country. In large part this is probably because once these projects finish, there is little, if any, follow-up support, so that the skills learnt, often in a fairly short time frame, are not reinforced and further developed by periodic contact with the trainers. This is often compounded by the fact that once the project finishes, there are frequently no funds to maintain the field programmes, so that the monitoring and management skills learnt by the trainees are quickly forgotten through lack of use.

Certainly more use should be made of local universities and training institutions in these capacity building programs. Greater active involvement of these local institutions in these programs would add value to the capacity building by building on and enhancing their existing expertise. More importantly perhaps, it would also provide the opportunity to establish in these institutions a “training reinforcement” facility, where the project’s clients (government staff, etc.) could return periodically to discuss and develop further the skills they acquired through the capacity building project. This is likely to add considerable value to the capacity building by providing an in-country, relatively low cost, mechanism for sustaining the program over the long term, to the extent that subsequent recruits could receive the benefits of the capacity building program even after the project itself has finished.

The following sections in this chapter discuss future options for addressing more effectively the ten principal environmental issues first identified in Chapter 3 of this report.

6.2 Increasing Land Degradation

Increasing land degradation is an issue that cuts across many development sectors, and any effective resolution of this issue will require a co-ordinated and integrated response involving all these development sectors. It is also an issue that is prevalent in geographical areas far removed from government influence and services, and one that can only be effectively remedied on site by establishing a site-specific land management system of restrictions on land use activities and effective soil conservation measures.

Although in some sectors, such as forestry, roading and bridges, there are environmental guidelines and codes of practice that set out measures to minimise land degradation, these are often not adhered to. In the absence of regular and effective enforcement (of compliance), considerable land degradation occurs. Often this goes unchallenged because neither the local population, nor the local government officers, are aware of land management issues or do not have the support and technical back-up of the regulatory agencies.

This lack of awareness and agency support needs to be addressed in a systematic manner, and in a way that brings regulators and developers together towards a consensus on actions to reduce land degradation and agreement on cost-effective methods of achieving this.

One option that should be considered is the development of a Land Management Policy that specifically addresses land degradation. This policy would provide a framework of land management strategies and constraints on use that could be modified to site-specific needs by local government and the private sector. Its aim would be to ensure that the basic requirements of sound land management are made available to all potential users. In this regard it should serve both awareness building and information dissemination.

To be workable, the policy must be inclusive of all levels of government (national, provincial and local), the private sector and civil society (NGOs, churches, user and special interest groups). However government’s ability to implement the policy on the ground will be severely constrained by logistical and budgetary constraints. Thus it is vital for successful implementation that the private sector, most notably forestry and agriculture, and civil society are genuine partners in its development, as in many instances they will be the ones to implement it.

This policy could also provide a framework for including land degradation as a component in NGO environmental awareness programs, and in the agricultural extension programs carried out by provincial and local government officers. By providing the framework and basic information, the policy would allow the NGOs and agricultural extension officers to develop site-specific land management plans in collaboration with the local people. This should give greater ownership by the people and thus more likelihood of sustaining its effective implementation.

There is already considerable information on environmental constraints on land use in the PNG Resource Inventory System, which should be incorporated into the policy framework. The National Agricultural Research Institute (NARI) is conducting a wide range of research on soil conservation and land management techniques, and this work should provide the technical basis for much of the policy. As a first step, DEC could approach NARI to establish a collaboration that would initiate development of such a policy.

6.3 Increasing Risk from Hazardous Materials and Wastes

With increasing development, and increasing population, the environmental risks posed by hazardous materials and wastes (all wastes, not just hazardous wastes) will increase considerably over the next few years. Thus there is an urgent need now to put in place management systems and structures that will manage and control these risks before the problem escalates beyond the resources and the capacity of the country.

In regard to hazardous chemicals and hazardous wastes, there is clearly a need for a concerted cross-sectoral initiative that will identify the scale and nature of the risk, and strategies and methods for reducing the risk. The PNG Chemicals Management Profile publicised this need, but was constrained by a lack of information and data on the nature and amounts of chemicals in the country. More recently, attempts by the Department of Environment and Conservation to collect information for a “pollutant release and transfer registry” failed because most companies had no idea what wastes they were producing or the amounts they produced. This suggests that there is a pressing need to raise the profile of chemicals and hazardous wastes risk in Papua New Guinea, primarily targeting government departments with regulatory responsibility in this area, and the industrial private sector, as the users of chemicals and the producers of hazardous wastes.

Given the technical nature of this issue, most of the skills needed to address it reside in the private sector, which will have to take a very active and possibly even leading role in identifying the scale and nature of these risks, and strategies and methods for reducing them. This will require establishing a strong collaborative relationship between government and the key players in the industrial sector, in particular in the mining, manufacturing and downstream processing areas. Most of the key industrial players who volunteer to be a part of this collaboration are likely to have a good record in this area and it is in their interests to see that others also apply the same precautions and management systems.

The format of this collaboration is likely to be a government-private sector committee in the first instance. This committee would identify strategies for raising the profile of hazardous chemicals and hazardous wastes management, such as targeted (industry-specific) awareness building campaigns. They would also need to identify a methodology for identifying the scale and nature of the risk (similar to the “pollutant release and transfer registry”) which must include technical support for those industries unable to identify the nature and amounts of the wastes they are producing, as well as identifying mitigation strategies for reducing the risk, such as codes of practice and other regulatory instruments.

To be successful, the partners in this collaboration must be assured that their efforts will deliver results. As this is dependent upon the availability of technical support for developing and delivering targeted awareness building campaigns, for identifying the nature and amounts of wastes produced, and for the development and dissemination of codes of practice and other regulatory instruments, this initiative will require considerable resources in terms of technical assistance and operational funds. As the government currently has neither of these, this initiative would best be progressed by a development aid project.

The new GEF Pilot Project to develop a National Implementation Plan for the Management of Persistent Organic Pollutants referred to in Section 5.2.2 offers a timely opportunity to initiate this collaboration by providing a vehicle with which to commence the identification of these methodologies for some of these hazardous chemicals and wastes. This project should be able to offer practical assistance and technical support to the committee by identifying the scale and nature of the risks, and suitable mitigation strategies for reducing these risks, at least for Persistent Organic Pollutants. This could then provide a blueprint for addressing other chemicals and hazardous wastes issues in the country.

Migration of rural populations to urban centres has increased urban domestic wastes considerably in

recent years. In many urban centres, sewerage systems which were designed for much smaller populations are now heavily overloaded and unable to comply with the regulatory standards for treated discharges. There is an urgent need to upgrade these sewerage systems, but financial constraints means that provincial and municipal authorities do not have the resources to undertake this at the present time.

This presents a difficult problem, as contamination of inland and coastal waters by sewage and sewage-derived contaminants is becoming serious, with the prospect of increasing siltation and eutrophication (nutrient-enrichment) causing significant and long-term damage to these habitats and their biological communities. As a first step, a public awareness program, initiated by municipal authorities in collaboration with the Department of Environment and Conservation, might render the public, who will ultimately have to pay for the sewerage system upgrades, more amenable to the idea of increased sewerage charges.

Household and commercial wastes have also grown considerably in recent years and urban solid waste management systems are also now heavily overloaded. However, there is scope to reduce the amount of these wastes by applying the “5-Rs” concept, “re-think, reduce, recycle, reuse, recover”, particularly at source, in the home or at commercial enterprises.

Waste reduction awareness, public education campaigns and promotional activities should be developed and disseminated through the media (most urban centres are well serviced by the media) and schools. Community-based organisations such as Women’s Fellowship groups could be encouraged and assisted to participate in these initiatives, such as sorting of wastes at source into different groups for re-use, recovery or final disposal. These awareness campaigns and other initiatives could be developed by the Department of Environment and Conservation in collaboration with other government departments, the municipal authorities, NGOs and Community-based Organisations. However, they will need to be supported by other incentives, such as local recycling centres, where material sorted for reuse or recovery can be collected, and initiatives developed to find alternative end-uses for wastes that are currently disposed to landfills.

The identification of practical and cost-effective alternative end-uses for wastes will be crucial to developing a sustainable recycling mentality among the public and industrial sectors. The Department of Environment and Conservation, in collaboration with schools, municipal authorities and NGOs, should consider options such as public, or school, competitions for the best alternative end-use/recycling options that could be applied to domestic refuse. Such an initiative would not only raise public awareness of the waste issue, but may also deliver some innovative ideas that could be cost-effectively implemented by municipal authorities or the private sector.

Increasing amounts of domestic wastes, including sewage and solid wastes, generated in the villages and communities of the rural sector threaten to poison local water supplies, increase the threats to public health, threaten the quality and productivity of the local natural resources and the habitats upon which their subsistence livelihoods depend. Several NGOs and government departments, notably the Department of Health through its provincial and local extension services, have begun to address this problem with awareness programs. However there appears to be a clear need to raise the profile of this issue throughout government and civil society so that a more coordinated and widespread response can be brought to bear on the issue. As in the urban situation, the application of the 5-Rs concept in rural villages would probably result in the reduction of wastes accumulating around the village and the concept should be a foundation of these awareness programs. Likewise, the participation of women’s groups in the village situation is likely to facilitate the effective implementation of waste initiatives, particularly the sorting of wastes for recycling.

In regard to solid wastes in the urban and rural sectors, provincial and local level governments should also be encouraged by national agencies such as the Department of Environment and Conservation to make greater use of the law-making powers in the area of environmental protection that they have under Section 142 of the new Organic Law on Provincial and Local Level Governments. This allows them to regulate the collection and disposal of wastes, including requirements for waste reduction and the prohibition of littering and other illegal disposals.

6.4 Declining Water Quality in Rivers and Coastal Waters

This is seen by many commentators and interview/survey respondents as the priority environmental issue, being a major cause of loss of critical habitats and biodiversity, degradation of water supplies, and declining coastal and marine resources. Despite a variety of legislative instruments (water quality standards and regulations, water quality guidelines and the inclusion of water quality safeguards in all the environmental codes of practice), water quality in Papua New Guinea's rivers and coastal waters continues to decline. This is an issue of compliance, and given the logistical and resource problems that prevent regular and effective compliance monitoring and enforcement by the regulator (DEC and/or provincial environmental officers), alternative means of achieving compliance need to be identified, tested and if successful, implemented.

An approach that was used under the previous legislation with some success was the nomination of Provincial Health Inspectors as Environmental Inspectors who would then conduct routine environmental monitoring in the course of their regular field patrols. This approach should be revitalised under the new legislation, with an emphasis on providing adequate training and field equipment to the nominated provincial and local district officers so that they can conduct these tasks in an efficient and effective manner. In 1991, the author of this report conducted a UNDP-funded two-week water quality monitoring and assessment training course for provincial health inspectors from around the country. The course was enthusiastically attended by 24 health inspectors, and covered basic sampling and analysis techniques, the interpretation and assessment of results, and reporting and follow-up actions.

However, if this approach is to be revitalised under the new legislation, the Department of Environment and Conservation will need to reinforce and further develop its collaboration with provincial government departments. A commonly held view in the provinces is that the national government rarely steps outside Waigani, and offers little useful or effective assistance to the provincial departments. If the Department is to rely on the provinces for an effective environmental regulatory presence on the ground, it must first establish a good working relationship with each province. This does not necessarily mean going to the provinces, although this is preferable, but it does mean establishing regular and constructive communication with each province, and in particular, with the key personnel such as the line managers, health inspectors and extension officers.

If the Department of Environment and Conservation intends to develop this collaboration with provincial government departments, it might consider raising its own profile through a targeted public relations exercise. Such an exercise could focus on the importance and role of provincial governments in environmental issues under the new Organic Law on Provincial and Local Level Governments, under the new Environment Act 2000, and under the new conservation legislation that is intended to be developed in the near future. This exercise should set out in clear detail the various ways in which the Department can assist and support the provincial governments in fulfilling this role, the commitments it will make to achieve this, and names and contact details of the Departmental officers who will assist and support each (named) provincial government in the implementation of this initiative.

It must be borne in mind that even with regular monitoring, in many instances of non-compliance, the regulator is first informed of the incident by a third party, usually a local landowner or local government officer with whom the matter has been raised by local people in the community. Usually the incident has been noticed because there has been some change or impact to the quality of the water that has resulted in adverse effects on public health or damage to resources. If this means of notification could be utilised to identify potential water quality problems before significant impacts occur (such as effects on public health or damage to resources), then it might provide a useful means of monitoring water quality.

However, the monitoring of water quality *per se* requires a high level of technical skill, regardless of whether the techniques used are chemical, in which case they also require sophisticated analytical equipment that requires skilled maintenance, or biological, which uses indicator species and community compositions to indirectly monitor the water quality. (These latter techniques, which are still in their infancy in many inland tropical waters, although quite well-established in coastal and marine situations, require considerable skill and experience to apply accurately).

An approach that has been tried in other countries with some success has been the introduction of river and coastal wardens who are recruited from the local community. These wardens are selected by the

community as “guardians” of the local water resources, and should be members of the local community whose knowledge of the river or coast is held in high regard by the community.

The remit of these wardens is to patrol a given stretch of river or coast with a view to noting and investigating any signs of damage or disturbance to the habitats and biota (particularly fish stocks), any reports of sickness and/or tainting of water which may indicate pollution, and any potential sources of pollution (such as new developments and/or changes to existing developments and uses). These wardens would report on a regular basis to local government officers such as extension workers when they visit the area on their regular patrols. The extension worker would then pass on the warden’s report to the appropriate regulatory authorities at the district, provincial and national levels.

Under the new environmental legislation, local communities will be informed of the environmental issues and implications of major new developments in their area that pose a risk of potentially serious environmental consequences. As this process of informing will involve environmental professionals meeting with the local people, it provides an opportunity to build local environmental awareness across a broad range of issues beyond the immediate implications of the development. If this contact with the local communities can be maintained after the initial contact, either directly or through local government officers, it offers the opportunity of developing a long-term collaboration on environmental and public health matters.

Such a longer-term collaboration could provide a sound basis for establishing a community-based environmental organisation that could develop and implement a number of environmental initiatives such as improved water supplies and waste management practices. It may even lead to the establishment of other community-based environmental organisations, networking and exchanging ideas and beneficial environmental practices throughout a larger area.

6.5 Disturbed or Unpredictable Hydrological Regimes

As the primary anthropogenic cause of disturbed or unpredictable hydrological regimes (with the possible exception of climate change, see Section 6.10) is land degradation and its consequent impacts on surface runoff yields and the water retention capacity of watersheds, many of the comments made in Section 6.2 apply here. A Land Management Policy should reduce the level of downstream disturbance by identifying watersheds that could pose a significant risk of disturbance to downstream hydrological catchments if they are degraded, and the appropriate methods that could be used to minimise degradation in that type of watershed. As mentioned previously, some of this information is already available through the PNG RIS database.

One of the constraints in predicting disturbance to hydrological regimes is the lack of up-to-date, reliable and accurate long-term hydrological data. However, the Department of Environment and Conservation does have some hydrological records it can access, through the regular hydrological monitoring conducted by several development operators, particularly in the mining sector. Although these records cover only a small part of the country, they are generally accurate and in some cases, where the development has been operating for a long time, such as the Ok Tedi Mine, they extend back for many years and could provide a useful indicator of national trends, particularly in regard to long-term effects such as climate warming. The Department of Environment and Conservation should ensure that it maintains a complete and systematic archive of these records, and any others it may have, for future reference.

With increasing signs of unpredictable weather, generally ascribed to global warming, there is likely to be increasing occurrences of unpredictable and/or extreme hydrological events. As the source of hydrological data and expertise in government, the Department of Environment and Conservation should be playing an active role with other agencies in developing appropriate responses and adaptive strategies to extreme hydrological events.

6.6 Loss of Critical Habitats / Biodiversity

As has already been mentioned in Section 5.2.6, much of the current work being conducted in the field is by NGOs. This work includes the collection of information and data on a wide range of habitats and their species compositions, current status, and threats to their integrity and long-term survival. The collection of this information has been necessary because there is a lack of available detailed information on the habitats and biodiversity of Papua New Guinea.

However, this problem is not simply a lack of environmental data and information on habitats and biodiversity, it is also that the information and data that has been collected is widely scattered, both within Papua New Guinea and in many overseas institutions. There is a pressing need, as was identified in the Conservation Needs Assessment program in the early 1990s, to bring this data and information together, sort and collate the different data sets into a consistent and user-friendly format, and locate this PNG Environmental Databank at a central and easily accessible location in the country.

However, it is crucial that this information is widely used, and by its use updated, if this initiative is to be of any value. In terms of its location, this could be decided at a later time, but once it is set up, its operations should be self-sustaining, as information could be made available on a cost-recovery basis to users and customers.

One of the findings, and now an important focus of these NGO initiatives, is the lack of environmental and ecological understanding among many in the rural communities. There is clearly a need for a more concerted cross-sectoral approach to this key issue involving not only community-based awareness programs, but also schools and government extension services. Recently the Curriculum Division of the Department of Education has developed an environment course for use in local community schools and the Department of Environment and Conservation should take an active role in assessing the feedback from this course and assisting in appropriate amendments and reviews. The Department should also extend this public education role into collaborating with national and provincial extension services to investigate the opportunities they may be able to provide in the environment and conservation areas of adult education.

One of the constraints on controlling the loss of critical habitats and biodiversity is the lack of an effective land-use planning system for rural areas. The current land-use planning systems appear to relate to, and be used for, urban planning only. PNG RIS is a comprehensive land inventory system that could be used as a basis for the development of a broad-based land-use planning system for rural Papua New Guinea. This could be refined and developed to a more appropriate scale for detailed development planning purposes as more site-specific data becomes available. Although such a land-use planning system would probably reside in the Department of Lands and Physical Planning, the Department of Environment and Conservation should consider collaborating with that department to promote and develop a broad-scale "pilot" system. This would be an important first step towards developing a rural land-use planning system that meets the needs of developers and the requirements of the Department of Environment and Conservation in regard to the protection and conservation of critical habitats and biodiversity values.

Although a number of NGOs are investigating alternatives to protected areas for community-based conservation, the Department of Environment and Conservation should also take an active role in this area, not only as it will be responsible for any legislation measures that might be needed to support these initiatives, but also as the appropriate link between national and provincial governments, which will inevitably be involved in the establishment and operation of protected areas.

As one of the key areas of critical habitat and biodiversity loss occurs in the forests of Papua New Guinea, the Department of Environment and Conservation should consider taking a more active role in promoting all aspects of eco-forestry, including Forest Stewardship Council certification for commercial operations which is currently being addressed by a European Union funded Eco-Forestry Project based in the National Forest Authority. The Department could also consider collaborating with the Forest Authority and the Eco-Forestry Project to re-invigorate the promotion of Non-Timber Forest Products, and other non-destructive uses of the national forest estate.

6.7 Declining Coastal and Marine Resources

Most of the current initiatives and field work being conducted in this area in Papua New Guinea is by NGOs and the National Fisheries Authority. The NGO initiatives focus on community-based programs, although as is the case with Conservation International's marine integrated conservation and development project in Milne Bay, this increasingly involves active participation by both local-level and provincial governments. Although resource constraints mean that the Department of Environment and Conservation cannot be actively involved on the ground in these initiatives, it should develop its active role at the national level to promote and facilitate the implementation of these initiatives. The Department should also seek access to the findings and the information that these initiatives produce so that these can be incorporated into the PNG Environmental (and Conservation) Database (see Section 6.6).

One of the principal roles of the Department under the new and focussed regime of more efficient and targeted services should be to maintain and provide environmental and conservation information and data to national and international users. The information obtained by NGOs, much of which is detailed and up-to-date, will be a highly important component of this database that should not be overlooked. If the Department of Environment and Conservation is to have ready access to this information, it must make stronger efforts to support the NGO community and become an active, contributing and respected partner in their programs and projects.

The Department of Environment and Conservation should also seek to strengthen its collaboration with the National Fisheries Authority, as both parties have many common interests, and responsibilities, in the coastal and marine resources area. As mentioned previously, the Authority has already developed and is currently implementing a number of National Fisheries Plans, and is intending in the near future to develop a Conservation of Fisheries Management Plan that will address a number of important artisanal fisheries such as *trochus*, giant clams, mud crabs and reef fish. The Department should seek active involvement in the development and implementation of this conservation management plan as it is likely to overlap with its own plans to develop new conservation legislation in the future.

6.8 Efforts to Protect and Improve Water Supplies

As was mentioned in Chapter 3, programs to establish safe drinking water supplies in rural communities should be integrated with safe and appropriate local sanitation measures. Both of these must be supported by environmental and public health awareness and community school education programs if the initiative is going to result in real and sustainable improvements to the local population's health.

General education and literacy levels in the rural areas are low, and until recently, there was little if any environment-related subjects in the community and elementary school curricula, which for many in the rural sector is the limit of their education. Recently however various donor funded projects have started to address this need by developing, in collaboration with the Department of Education, a number of environmental components that will be included in the national community school curricula. It is understood that initially these focus on the public health aspects of the environment such as safe water supplies and sanitation.

Although this initiative caters for the children, who may pass on their environmental awareness and knowledge to their parents, the rate of population growth and the pace of development in the rural sector make the need to raise the level of environmental awareness and practical understanding within the adult (decision-making) population a matter of considerable urgency. In this regard, these education initiatives should not be viewed in any way as a replacement for environmental and public health awareness programs.

Many of the contributors to this report raised concerns regarding the issue of solid waste management in rural communities, and the risks the current situation poses to public health and environmental contamination. Future rural development initiatives relating to water and sanitation should also include integrating into their program an awareness of solids waste issues and their management in the community, not only because the three are physically inter-connected, but also because the message and the means of delivery are similar and for a small marginal increase in effort, a wider and more effective impact is possible.

6.9 Air Pollution and Noise Pollution

The relatively low priority given to air pollution and noise pollution suggest that efforts to address these more effectively in the future should be put on hold at the present time, in view of other more pressing initiatives that the Department of Environment and Conservation should pursue with its limited resources. It should be pointed out that the Department will continue to attend to serious odour and noise problems that are brought to its attention by the public. These may include noise from a nightclub in an urban setting, or odour from a large piggery located in a village, district station or town.

6.10 Climate Change

The principal climate change issues for Papua New Guinea in the near future are:

- The need to engage other government agencies, the private sector and the public in considering what adaptive responses needs to develop in order to cope with climate change in an efficient and effective manner.
- The need to integrate climate change into existing and proposed sectoral policies and strategies so that some of its anticipated impacts can be addressed through focussed, sector-specific initiatives that are likely to be more efficient and effective in delivering some of these adaptive responses.

As a first step in these processes, the Greenhouse Unit should consider drawing up a program to raise its profile, and the profile of the climate change issue and what it means for Papua New Guinea, among other government departments and agencies and in the private sector. The purpose of raising the profile is to provide a sound and constructive basis for developing collaborative partnerships that will deliver development policies and strategies incorporating climate change issues such as adaptation. As such a collaboration is a two-way street, the profile-raising program should highlight the information and “tools” the Greenhouse Unit, through its connections with the UNFCCC, can bring to these partnerships.

It should also seek NGO partners, which have local experience in successfully conducting environment-related public awareness programs, to develop and conduct public awareness programs on the climate change issue and its likely implications for urban and rural dwellers. A key component of these public awareness programs will be mechanisms to provide feedback to the Greenhouse Unit (and hence the government) that can guide policy making and the development of appropriate and acceptable adaptive responses.

7.0 The Magnitude, Significance and Priority Ranking of Papua New Guinea's Principal Environmental Concerns

7.1 The Assessment of Magnitude, Significance and Priority

In considering the magnitude and significance of these ten principal environmental concerns, one must bear in mind the natural causal relationships that link these issues.

Land degradation can cause direct loss of habitats by damage or removal of forest cover, causing impacts on biodiversity in the affected areas. Land degradation can cause a decline in downstream water quality, notably siltation and eutrophication (nutrient and organic enrichment), and in severe cases, disturbance to downstream hydrological regimes.

However in Papua New Guinea one of the primary causes of declining water quality in rivers and coastal waters is the inadequate management of wastes and hazardous materials. These can enter the water directly through discharges and indirectly through contamination of groundwater and surface runoff.

Water is the primary medium by which environmental impacts move from their source and extend their effect beyond the immediate impact site. All impacts affecting water will spread beyond the site of impact, albeit with a concomitant dilution of the effect as the impact is dispersed through the water-body.

Declining water quality and disturbed hydrological regimes have impacts on water supplies, particularly in rural areas where most water supplies are untreated river or well-waters. They also affect downstream habitats and biodiversity (including habitats and their biological communities that are some distance removed from the river but are dependent on the river, its aquatic habitats and species for their own well-being), and the coastal and marine ecosystems into which the rivers and streams flow.

Air pollution, caused by aerial emissions of wastes, smoke from man-made and natural fires, and volcanic emissions, can in severe cases lead to a decline in water quality as surface waters are contaminated by aerial fallout. Air pollution can also directly affect habitats and biodiversity. However in Papua New Guinea the very localised nature of man-made air pollution, which is generally at low levels and limited to urban areas and a few industrial development sites, is not regarded as a significant environmental threat at the present time.

Likewise, noise pollution, which is also at low levels and limited to these same sites, is not regarded as a significant environmental threat at the present time.

Climate change, which it is now generally accepted as being caused by various air pollutants, could cause a variety of environmental impacts of varying degrees of severity in the medium to long-term. Although Papua New Guinea's contribution to global climate change is practically insignificant (Saulei et al 2002), it could be susceptible to the effects of climate change, particularly in regard to the disturbance of local climate and weather patterns, and disturbed hydrological regimes. Both of these could have significant effects on many of these principal environmental issues, in particular, water supplies, habitats and biodiversity, and coastal and marine resources.

Many of the interviewees, survey respondents and those at the workshop felt they were unable to rank the magnitude and significance of these issues in a clear and distinct order of priority. Most were able to agree on what were the priority issues, and what issues were of less pressing importance, but many were unable to clearly set out an order of ranking (1st, 2nd, 3rd, etc.) within the group of priority issues. Consequently, we have tried to set out below a systematic framework within which these issues can be assessed relative to one another, in order to derive a priority ranking of these issues.

The assessment of the magnitude of these concerns (the ten principal issues) implies the consideration of several distinct but related aspects of the potential environmental impacts that could arise from each of these issues, including:

1. The severity in terms of the intensity of potential impacts.
2. The geographical extent of the potential impacts.
3. The spatial and temporal occurrence of the potential impacts.

The table on the following page sets out the relative magnitude of these three aspects for each of the ten principal environmental issues, and provides a systematic basis for assessing the overall magnitude of each issue.

In terms of the severity of the potential impacts, four issues head the list, namely:

- Increasing Environmental Risk from Hazardous Materials and Wastes.
- Loss of Critical Habitats and Biodiversity.
- Declining Coastal and Marine Resources.
- Inadequate or Unsatisfactory Water Supplies.

In terms of geographical extent, one issue stands out above the others, namely:

- Declining Water Quality in Rivers and Coastal Waters.

Accurate assessment of some of the other issues is constrained by a lack of reliable information and accurate data.

This is particularly so for two issues:

- Loss of Critical Habitats and Biodiversity.
- Declining Coastal and Marine Resources.

Many interview and survey respondents identified these as being amongst the priority environmental concerns in Papua New Guinea

It should also be noted that when a hazardous material or waste enters water, it is subsumed under Declining Water Quality in Rivers and Coastal Waters for the purpose of this assessment. Given that hazardous materials and wastes frequently do enter water (either rivers or coastal waters),

- Increasing Environmental Risk from Hazardous Materials and Wastes should probably be given a comparable standing to that of Declining Water Quality.

In terms of frequency of occurrence, the only issue that has been assessed as both widespread and frequent is:

- Declining Water Quality in Rivers and Coastal Waters.

It should be noted however that four others have had the “frequency of occurrence” status assessed as “unclear” due to a lack of reliable information. These are:

- Increasing Environmental Risk from Hazardous Materials and Wastes.
- Loss of Critical Habitats and Biodiversity.
- Declining Coastal and Marine Resources.
- Inadequate or Unsatisfactory Water Supplies.

These may be more widespread and frequent than the limited amount of available information indicates.

Given these information constraints, it is difficult to accurately assess the relative magnitude of these five issues, reflecting the responses from the surveys and interviews, and it is worthy of note that these five issues correlate very closely with the groupings of priority issues that were obtained from these respondents.

If we consider the significance of these issues, we must also consider the natural causal relationships amongst them. If we take the most widespread issue, which is frequently encountered throughout Papua New Guinea, namely “declining water quality”, this can be caused by a number of impacts, but increasingly the primary cause of declining water quality is the increasing entry into natural waters of wastes, either directly or indirectly through surface runoff and groundwaters. If inappropriate waste management practices are the primary cause of the most widespread environmental issue in Papua New Guinea, then they have a high priority in the order of ranking. But declining water quality is not solely due to wastes. There are other contributing impacts such as those from land degradation.

If we look in the other direction at the effects of declining water quality, it is an important contributor to the other three issues in our priority group of five. Clearly it is a direct and primary agent in “inadequate or unsatisfactory water supplies” and in “declining coastal and marine resources”. It is also a direct and primary agent in the loss of many “critical habitats and biodiversity”, in the aquatic, wetlands, and coastal and marine ecosystems, which constitute a large part of Papua New Guinea’s critical habitats

ISSUE	Severity of potential impact(s)	Geographical Extent	Frequency of Occurrence
Land Degradation	Varying degrees of severity	Localised to area affected	Widespread but infrequent
Hazardous Materials & Wastes	Significant to severe levels of impact	Potentially extensive distribution if contaminant / waste enters water (see below)	Unclear - lack of data, but likely to become increasingly widespread and more frequent
Declining Water Quality	Varying degrees of severity	Widely distributed throughout many catchments in PNG	Widespread and frequent
Disturbed Hydrology	Varying degrees of severity	Localised to affected catchments	Widespread but infrequent
Habitats & Biodiversity	Significant to severe levels of impact	Increasingly widespread, but the accuracy of this assessment is limited by lack of data	Unclear - lack of data, but indications are that this is widespread and becoming increasingly frequent
Coastal & Marine Resources	Significant to severe levels of impact	Increasingly widespread, but the accuracy of this assessment is limited by lack of data	Unclear - lack of data, but indications are that this is widespread and becoming increasingly frequent
Water Supplies	Significant to severe levels of impact	Generally localised to catchment or affected area	Unclear - lack of data, but indications are that this is widespread and becoming increasingly frequent
Air Pollution	Mild to significant levels of impact	Localised to urban areas and some development sites	Rare and infrequent outside the local areas affected
Noise Pollution	Mild to significant levels of impact	Localised to urban areas and some development sites	Fairly rare and infrequent even in affected areas
Climate Change	Potentially severe impacts, but current level of impact hard to accurately assess	A global weather phenomenon: thus if impacts occur, these are likely to be widespread	Precise nature of potential impacts is unclear, so it is not possible to assess the frequency of occurrence.

and biodiversity. Given that many terrestrial habitats are also critically dependent on the integrity and well-being of the aquatic habitats in their midst, declining water quality in the rivers will also be a significant contributor to the loss of critical habitats and biodiversity in the terrestrial ecosystems of Papua New Guinea.

Given the pivotal role that declining water quality in rivers and coastal waters has in these top five priority environmental concerns, this report will put this issue at the head of the list of priority environmental concerns. As the primary contributor to declining water quality in Papua New Guinea, this report will put the issue of increasing environmental risk from hazardous materials and wastes as the second ranking in order of priority.

To distinguish a ranking between the other three issues in the priority grouping is more difficult, particularly as an accurate assessment of the relative magnitude of each is severely constrained by a lack of data. However, the significance of one of these, namely “inadequate or unsatisfactory water supplies”, directly affects public health and well-being, and thus directly affects the future sustainable development and livelihoods of the majority of Papua New Guineans who depend on the quality of natural waters for basic sustenance. Given this, the importance of safe and reliable water supplies for all Papua New Guineans must take priority over biodiversity values and the values of the coastal and marine resources. For this reason, this report will put the issue of inadequate or unsatisfactory water supplies as the third ranking priority issue in order of importance.

The author would like to point out that the reason this issue of water supplies is not at the top of the list is because safe and secure natural water supplies for the majority of Papua New Guineans (those living in the rural areas) can only be assured if priorities one and two are satisfactorily addressed, as a matter of priority, in an effective manner.

With regard to assigning a ranking for the two remaining priority issues, namely “the loss of critical habitats and biodiversity” and “declining coastal and marine resources”, a brief consideration of the relationship between these two issues may serve to clarify their appropriate rankings.

The rich and diverse range of coastal and marine resources that can be found around Papua New Guinea are dependent on, and part of, the rich and diverse range of habitats and biodiversity that occur in these waters, in particular, those critical habitats that are vital spawning and nursery grounds for many coastal and marine species. If these critical habitats suffer damage or loss, either directly, or indirectly through damage or loss of their biodiversity, then this will have profound effects on the size and status of the important coastal and marine resources. The protection of these critical coastal and marine habitats and their biodiversity is fundamental to maintaining the coastal and marine resources. Thus in order of priority, the issue of “loss of critical habitats and biodiversity” should take precedence over the issue of “declining coastal and marine resources”.

As an important contributor to declining water quality and the loss of critical habitats and biodiversity (in terrestrial ecosystems), “increasing land degradation” has been given a ranking of sixth in order of priority.

“Disturbed or unpredictable hydrological regimes” is ranked seventh, as it can impact directly on the availability of satisfactory water supplies, and during times of flood, can significantly increase the environmental risks posed by hazardous materials and wastes that can become caught up in the floodwaters.

Although it is not an immediately pressing issue in terms of current impacts, the international commitments made by Papua New Guinea in regard to Climate Change, and in consideration of the long lead-in time required to develop effective adaptive responses to the potential impacts of climate change, this report will put the issue of Climate Change as the eighth ranking issue in order of importance.

Air pollution is given a ranking of ninth in order of importance, as several incidents of air pollution have been reported in urban areas, generally resulting from the burning of grass and rubbish, and traffic fumes.

Noise pollution has been given the lowest ranking in the list of principal issues, reflecting the negligible level of impact that has been recorded to date.

Thus, in order of ranking, the priority environmental concerns of Papua New Guinea are:

1. **Declining Water Quality in Rivers and Coastal Waters.**
2. **Increasing Environmental Risks from Hazardous Materials and Wastes.**
3. **Inadequate or Unsatisfactory Water Supplies.**
4. **Loss of Critical Habitats and Biodiversity.**
5. **Declining Coastal and Marine Resources.**
6. **Increasing Land Degradation.**
7. **Disturbed or Unpredictable Hydrological Regimes.**
8. **Climate Change.**
9. **Air Pollution.**
10. **Noise Pollution.**

7.2 The Priority Environmental Concerns and the IWP Focal Areas

This final section of the report discusses the connections between each of these ten Priority Environmental Concerns (PECs) and the four IWP focal areas, and the opportunities each PEC offers for the development and implementation of a community-based pilot project within one or more of the four focal areas. The four IWP focal areas are:

- Marine protected areas.
- Sustainable coastal fisheries.
- The protection of freshwater resources.
- Community-based waste reduction.

7.2.1 Relevance of IWP Focal Areas to each Priority Environmental Concern

In the following paragraphs, the relevant IWP focal areas are highlighted in bold.

Priority 1: Declining Water Quality in Rivers and Coastal Waters

Addressing declining water quality is directly relevant to **the protection of freshwater resources** and the **sustainability of coastal fisheries**, the habitats of which are *inter alia* threatened by declining water quality. One of the principal causes of declining water quality is the quantity of wastes entering rivers and coastal waters. Part of this waste load comes from the many river-side and coastal communities, and **reductions in the amount of community wastes** is likely to reduce this waste load, with beneficial effects on the water quality.

Priority 2: Increasing Environmental Risks from Hazardous Materials and Wastes

The level of environmental risk from hazardous materials and wastes is increasing in communities throughout Papua New Guinea as the quantities and varieties of these materials increases. These include increases in the amounts and variety of plastics, drink cans, used torch and vehicle batteries, waste engine oils and lubricants, paints and solvents, increasing amounts of kerosene and motor fuels, and the greater sanitary load imposed on the local environment by a rapidly growing population.

Community-based waste reduction programs that reduce this rate of increase will directly result in a lowering of the risks to the local environment. In riverside and coastal communities much of this waste enters the local rivers and coastal waters. Thus any reduction in these wastes will also **protect the freshwater resources** (in the case of riverside communities) and protect coastal habitats (in the case of estuarine and coastal communities), which is vital to the **sustainability of coastal fisheries**.

Priority 3: Inadequate or Unsatisfactory Water Supplies

One of the principal causes of inadequate or unsatisfactory water supplies, particularly in the rural sector, is the declining water quality of these supplies resulting from increasing multi-use demands. **Protection of these freshwater resources** is a crucial component in any program to remedy inadequate or unsatisfactory water supplies.

As one of the principal causes of declining freshwater quality is contamination by wastes generated within the local communities (see Priority (1) above), **community-based waste reduction** programs would have direct relevance to improving the quality of local water supplies. It should be noted this

applies to both surface water supplies, which are at risk from waste contaminated runoff and the direct disposal of wastes into rivers and streams, and well-waters, which are at risk from waste contamination of the water-table.

Priority 4: Loss of Critical Habitats and Biodiversity

Critical habitats and biodiversity are threatened by declining water quality, waste contamination and over-exploitation for commercial and/or subsistence purposes, among other risks. **Protection of freshwater resources, community-based waste reduction** programs, and the establishment of **sustainable coastal fisheries** will directly contribute towards reducing the loss of critical habitats and biodiversity in these areas.

The establishment of representative protected areas will also help ensure the loss can be remedied by providing a reserve area of habitat and biodiversity from which recruitment to threatened or disturbed areas can occur. In the case of marine habitats and biodiversity, a **marine protected area**, if it is of adequate representative size and diversity, and is regularly monitored and properly managed, can provide a suitable recruitment reserve to mitigate environmental threats and damage to critical habitats and biodiversity beyond its borders.

Priority 5: Declining Coastal and Marine Resources

As noted earlier, the apparent decline in coastal and marine resources appears to be caused by over-exploitation, inappropriate harvesting methods, and possibly a decline in coastal water quality. Over-exploitation of the coastal resources and inappropriate harvesting methods can be addressed by an effective **sustainable coastal fisheries** programme, particularly if this is augmented by the establishment of a **marine protected area** along the lines suggested above.

In some coastal areas, declining coastal water quality may also be a contributing factor to the decline in coastal and marine resources, particularly in those marine species which spawn and/or have juvenile stages dependent on coastal habitats. Coastal water quality is threatened by declining water quality of freshwaters entering the coastal zone, and by the direct discharge or disposal of wastes into coastal waters. This latter is a particular concern around large coastal village communities, from which increasing amounts of wastes can enter the coastal waters directly, or indirectly through surface runoff and contamination of the water table. Thus **protection of freshwater resources** (upstream of the coast) and **community-based waste reduction** programs can also mitigate the impacts that may be contributing to the decline of coastal and marine resources.

Priority 6: Increasing Land Degradation

One of the causes of land degradation is the contamination of soils and groundwater by wastes. At the community level, a **community-based waste reduction** program would reduce the amount of contaminant material and, if accompanied by improvements in waste management practices (particularly final disposal), should result in a reduction in the rate of land degradation and over the long-term allow more of the community's land to be put to more beneficial uses.

Furthermore, as land degradation is implicated in the degrading of water quality through contamination of surface runoff by eroded soils and wastes, and groundwater contamination, a program addressing the **protection of freshwater resources** would need to consider the issue of land degradation in the catchment, particularly in regard to exposed areas at risk of erosion and contamination.

Priority 7: Disturbed or Unpredictable Hydrological Regimes

Disturbed or unpredictable hydrological regimes can have serious consequences on downstream communities. At one extreme, unusually high floods can have devastating effects on subsistence communities and their livelihoods. At the other extreme, a significant reduction in base flows can also severely affect communities by reducing the amount of available water during low flow conditions, particularly where that water is subject to a variety of conflicting multi-use demands such as drinking, washing and irrigation.

The mitigation of the potential effects of disturbed or unpredictable hydrological regimes should also be included in programs for the **protection of freshwater resources**, where practicable. Whilst it may not be possible to do anything practical to remedy the disturbance or unpredictability of the regime, measures

could be designed and implemented to alleviate the effects. For example, flood avoidance measures such as relocation of houses and gardens, and alternative water supplies for low base flow conditions could be identified, as well as other adaptive responses.

Priority 8: Climate Change

Given the time-scale that climate change appears to be operating at, and the current uncertainties of its specific effects at the local level, it is unlikely that community-level adaptations to climate change effects would readily fit into the current IWP community-based Focal Area programs. However, the long-term effects of climate change and the adaptations it may require, particularly in regard to rising sea-levels and the implications for coastal communities in terms of their location, and their access to traditional resources and means of livelihood, should be raised and discussed, and where appropriate, accommodated in project plans and implementation programs.

Priority 9: Air Pollution

Not directly relevant to any of the four IWP community-based Focal Areas.

Priority 10: Noise Pollution

Not directly relevant to any of the four IWP community-based Focal Areas.

7.2.2 Priority Ranking of IWP Focal Areas for Papua New Guinea

This section is based on the relevancies identified in the preceding section, and sets out an assessment of the Priority Environmental Concerns that can be addressed under each of the four IWP Focal Areas. This provides a basis for prioritising these four focal areas in terms of their relevance and application to Papua New Guinea's ten Priority Environmental Concerns.

Marine protected areas address two of the Priority Environmental Concerns:

- Loss of Critical Habitats and Biodiversity.
- Declining Coastal and Marine Resources.

However, the viability of a marine protected area will also be dependent on, and may need to address:

- Declining Water Quality in Rivers and Coastal Waters.
- Increasing Environmental Risks from Hazardous Materials and Wastes;

Sustainable coastal fisheries also address these two PECs:

- Declining Coastal and Marine Resources.
- Loss of Critical Habitats and Biodiversity.

As noted in section 7.2.1, sustainable coastal fisheries will be affected by, and may need to address:

- Declining Water Quality in Rivers and Coastal Waters.
- Increasing Environmental Risks from Hazardous Materials and Wastes.

The protection of freshwater resources directly addresses:

- Declining Water Quality in Rivers and Coastal Waters.
- Increasing Environmental Risks from Hazardous Materials and Wastes.
- Inadequate or Unsatisfactory Water Supplies.
- Loss of Critical Habitats and Biodiversity.
- Disturbed or Unpredictable Hydrological Regimes.

As noted in section 7.2.1, the protection of freshwater resources will be affected by, and may need to address:

- Land Degradation.

Community-based waste reduction directly addresses:

- Increasing Environmental Risks from Hazardous Materials and Wastes.
- Declining Water Quality in Rivers and Coastal Waters.
- Inadequate or Unsatisfactory Water Supplies.
- Loss of Critical Habitats and Biodiversity.
- Declining Coastal and Marine Resources.

- Land Degradation.

Based on the relevancies identified in the preceding section, and these assessments, the priority ranking for the IWP Focal Areas for Papua New Guinea is:

- **Community-based waste reduction.**
- **The protection of freshwater resources.**
- **Sustainable coastal fisheries; and of equal (third-place) ranking,**
- **Marine protected areas.**

8.0 Bibliography

- Agardy M. and Pernetta J. (1993): A Preliminary Assessment of Biodiversity and Conservation for Coastal and Marine Ecosystems in Papua New Guinea. in Beehler B. (ed.), Papua New Guinea Conservation Needs Assessment, Volume 2. Department of Environment and Conservation, Boroko, Papua New Guinea.
- Allen G. R. and Munday P. (1994): Kimbe Bay Rapid Ecological Assessment Vol 3. Fish Diversity. Prepared for The Nature Conservancy - Asia / Pacific Program.
- Bank of Papua New Guinea (2002): Quarterly Economic Bulletin. Vol. XXX No 3. September 2002. Port Moresby.
- Beehler B. (ed.) (1993): Papua New Guinea Conservation Needs Assessment, Volume 2. Department of Environment and Conservation, Boroko, Papua New Guinea.
- Conservation International (2001): Community-based Coastal and Marine Conservation in Milne Bay Province Project Document. Prepared for the United Nations Development Programme.
- Department of Environment & Conservation (1993): Specific Guidelines for Commercial Forestry Harvest Operations.
- Department of Environment & Conservation (1996): PNG EIA Guidelines for Roads and Bridges. Prepared for DEC and Office of Works by Cardno & Davies International Pty on behalf of AusAID.
- Department of Environment & Conservation (1997): Environmental Code of Practice for Oil Palm Processing Industry.
- Department of Environment & Conservation (1998): Environmental Code of Practice for Motor Vehicle & Machinery Workshops, Hydrocarbon Fuel Storage, Resale and Usage Sites
- Department of Environment & Conservation (2002a): Environmental Code of Practice for Sanitary Landfill Sites.
- Department of Environment & Conservation (2002b): PNG Country Programme Strategy. Operational Phase III GEF - SGP (July 2002). A report prepared for the UNDP GEF - Small Grants Programme.
- Department of Environment & Conservation (2002c): Papua New Guinea's Biodiversity Conservation Policy for Forests. Draft report, March 2002.
- Hair C., Potuku T., Ade J., Kaminiel K. and Eliakim S. (1994): Kimbe Bay Rapid Ecological Assessment Vol 6. Commercial Sedentary Marine Resources. Prepared for The Nature Conservancy - Asia / Pacific Program.
- Higgins R. (2002): Article in the Australian Financial Review, April 3, 2002, by the Managing Director, Ok Tedi Mining Limited.
- Holthus P. (1994): Kimbe Bay Rapid Ecological Assessment Vol 1. Synthesis Report. Prepared for The Nature Conservancy - Asia / Pacific Program.
- Holthus P. and Maragos J. (1994): Kimbe Bay Rapid Ecological Assessment Vol 2. Coral Reef Habitat. Prepared for The Nature Conservancy - Asia / Pacific Program.
- Howcroft N. (1992): An Enumeration of Papuanian Orchid Genera Associated with Major New Guinea Environments. Papua New Guinea Orchid News, May 1992: 6 - 12.
- Huber M. and McGregor K., (2002): A Synopsis of Information Relating to Marine Protected Areas in the Pacific Islands, South Pacific Regional Environment Programme, Apia, Samoa.
- Hunnan p., Jenkins A., Kile N., and Shearman P. (2001): Marine Resource Management and Conservation Planning. Bismarck - Solomon Sea Eco-Region. Papua New Guinea, Solomon Islands. A report prepared for the World Wide Fund for Nature.
- IUCN (1995): The Fly River Catchment, Papua New Guinea - A Regional Environmental Assessment. Published in collaboration with the Department of Environment and Conservation, Boroko, Papua New Guinea. IUCN, Gland, Switzerland and Cambridge U.K.
- Jenkins A. (2002): Madang Locally Managed Marine Area Network. A report prepared on behalf of Riwa and Siar Villages, Madang Lagoon and Madang Province, Papua New Guinea, for Wetlands International.
- Johns, R. (1977): The Vegetation of Papua New Guinea. Volume 10. Bulolo: Training Manual for the Forestry College.

- Johns R. (1993): Biodiversity and Conservation of the Native Flora of Papua New Guinea, in Beeler B.M. (ed.): Papua New Guinea Conservation Needs Assessment, Volume 2. Department of Environment and Conservation, Boroko, Papua New Guinea.
- Jones G.P., McCormick M.I., Caley M.J. and Sin T. (1997): Biodiversity and Conservation of the Coral Reefs of Kimbe Bay, New Britain, Papua New Guinea. A report prepared on behalf of the Mahonia Na Dari Research Station, West New Britain Province, Papua New Guinea.
- Maragos J. (1994): Kimbe Bay Rapid Ecological Assessment Vol 5. Biodiversity of Stony Corals. Prepared for The Nature Conservancy - Asia / Pacific Program.
- Mitchell D.K., Peters J., Cannon J., Holtz C., Kinch J. and Seeto P., (2001): A Sustainable Use Options Plan, A report to the United Nations Development Programme for the Milne Bay Community-Based Coastal and Marine Conservation Program, PNG/99/G41, Port Moresby, Papua New Guinea.
- Mobiha A. and Hair C. (1994): Kimbe Bay Rapid Ecological Assessment Vol 4. Food Reef Fish Resources. Prepared for The Nature Conservancy - Asia / Pacific Program.
- Mowbray D. (2000): Papua New Guinea National Profile of Chemical Management 1997 - 2000. A report prepared by Mowbray D., NCDS ANU and Environmental Sciences UPNG.
- Munday P. (1994): Kimbe Bay Rapid Ecological Assessment Vol 7. Marine Mammals. Prepared for The Nature Conservancy - Asia / Pacific Program,
- National Planning Office, (1997): Medium Term Development Strategy 1997 - 2000. A Bridge into the 21st Century. A report prepared for the Government of Papua New Guinea.
- National Statistical Office (1996): Demographic and Health Survey. Papua New Guinea.
- Papua New Guinea Forest Authority and Department of Environment & Conservation (1996): Papua New Guinea Logging Code of Practice.
- Saulei S. and Beehler B. (1993): Biodiversity and Conservation of Humid Forest Environments of Papua New Guinea, in Beehler B. (ed.) Papua New Guinea Conservation Needs Assessment, Volume 2. Department of Environment and Conservation, Boroko, Papua New Guinea.
- Saulei S., Dambui C., Faiteli A., Ila'ava V., Kewibu V., Kwa Eric., Kwa Enaha., Manoka B., Mowbray D. and Tolaget T. (2002): Papua New Guinea National Assessment Report. Response to Rio and Agenda 21. A report prepared for the Independent State of Papua New Guinea by a team from the University of Papua New Guinea.
- Seeto P., (2000): A Conservation Needs Assessment Report, A report to the United Nations Development Programme Milne Bay Community-Based Coastal and Marine Conservation Program, PNG/99/G41, Port Moresby, Papua New Guinea.
- Sekran N. and Miller S. (eds.), (1994): Papua New Guinea Country Study on Biological Diversity, Department of Environment and Conservation, Conservation Resource Centre, and Africa Centre for Resources and Environment.
- Shearman P. and Cannon J. (2002): PNG Forest Resources and the Log Export Industry. A working paper prepared for the Papua New Guinea Eco-Forestry Forum.
- Sinclair Knight Metz (2000): A Solid Waste Characterisation Study and Management Plan for Papua New Guinea. A country report prepared for the South Pacific Regional Environment Programme, Apia, Samoa.
- Skewes T., Kinch J., Polon P., Dennis D., Seeto P., Taranto T., Lokani P., Wassenberg T., Koutsoukos A. and Sarke J. (2002): Research for sustainable use of beche-de-mer resources in Milne Bay Province, Papua New Guinea. CSIRO Division of Marine Research. Final Report. Cleveland, Australia.
- Sowei J., Koi H., Mamae H. and Sivusia-Joyce B., (2002): Papua New Guinea Environment Monitor 2002. A report prepared by a team from the National Research Institute, Papua New Guinea for the World Bank.
- Thaman R.R. (2002): Island Life in the 21st Century: Current status and challenges for mainstreaming the conservation and sustainable use of biodiversity in the Pacific Islands. A paper prepared for the 7th Pacific Islands Conference on Nature Conservation and Protected Areas, Rarotonga, Cook Islands.

ANNEXES

Annex I: Stakeholder Survey Questionnaire on Priority Environmental Issues, Causes & Effective Responses

PRO-FORMA

This questionnaire was provided in electronic form, either on diskette or by e-mail, to all stakeholders who had access to a computer, in order to facilitate a more comprehensive and detailed response.

STAKEHOLDER SURVEY QUESTIONNAIRE
on
Priority Environmental Issues, Causes & Effective Responses

NAME: _____ Date: _____
POSITION: _____
AGENCY: _____ Contact No.: _____

1. ENVIRONMENTAL ISSUE(S) / PROBLEM(S):

2. ROOT CAUSE(S):

3. RESPONSES to ADDRESS PROBLEM(S) & CAUSE(S), and by WHOM:
RESPONSE WAS EFFECTIVE / or IF RESPONSE NOT EFFECTIVE

4. HOW COULD PROBLEM or ROOT CAUSES be dealt with EFFECTIVELY:

5. SIZE OF PROBLEM, TODAY & POTENTIALLY in the FUTURE:
 - a). EXTENT of PROBLEM:

 - b). SEVERITY of PROBLEM

6. PRIORITY / RANKING of PROBLEM:

Annex II: Workshop Attendance and Membership of Working Groups

PRIORITY ENVIRONMENTAL CONCERNS WORKSHOP WORKING GROUP MEMBERS

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Urban Development Working Group

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Annex III: Workshop Working Groups' Presentations

Fisheries Working Group Presentation

ISSUES (in order of priority)	Action to date / why not effective	Actions to be done	Magnitude & Severity
1. Water quality degradation	Policies & Codes of Practice exist, but, Lack of enforcement & compliance	Education and awareness; Improved networking with NGOs, and National, Provincial & Local-level Governments; Improvement of enforcement policies and existing legislations; Continue data collection & monitoring	Localised impacts; Country wide Health hazard.
2. Increasing land degradation	Currently in research phase; Not effective due to lack of full implementation of research findings	Public education & awareness of research findings Food security programmes Appropriate technology (eg recycling)	Large scale; Country wide Clearance of vegetation directly related to population growth
3. Disturbance to natural hydrological processes	Relevant laws & policies	Resource management plans, and contingency (emergency response) plans; Continuous nationwide data collection & monitoring	Localised but very severe; Significant
4. By-catch dumping	Environmental legislation Conservation legislation Bio-netting	Proper planning: Development Options Studies Public education & awareness of existing data (eg PNG RIS) Establishment of inventory to identify biodiversity values Appropriate technology (to avoid over-exploitation)	Localised National programmes National importance which has commercial implications

Agriculture, Infrastructure and Land Clearance Working Group Presentation

ISSUES (in order of priority)	Action to date / why not effective	Actions to be done	Magnitude & Severity
1. Water quality degradation	Policies & Codes of Practice exist, but, Lack of enforcement & compliance	Education and awareness; Improved networking with NGOs, and National, Provincial & Local-level Governments; Improvement of enforcement policies and existing legislations; Continue data collection & monitoring	Localised impacts; Country wide Health hazard.
2. Increasing land degradation	Currently in research phase; Not effective due to lack of full implementation of research findings	Public education & awareness of research findings Food security programmes Appropriate technology (eg recycling)	Large scale; Country wide Clearance of vegetation directly related to population growth
3. Disturbance to natural hydrological processes	Relevant laws & policies	Resource management plans, and contingency (emergency response) plans; Continuous nationwide data collection & monitoring	Localised but very severe; Significant
4. By-catch dumping	Environmental legislation Conservation legislation Bio-netting	Proper planning: Development Options Studies Public education & awareness of existing data (eg PNG RIS) Establishment of inventory to identify biodiversity values Appropriate technology (to avoid over-exploitation)	Localised National programmes National importance which has commercial implications

Agriculture, Infrastructure and Land Clearance Working Group Presentation, Continued

ISSUES (in order of priority)	Action to date / why not effective	Actions to be done	Magnitude & Severity
<p>5. Infrastructure Developments: urban development roads & bridges major resource projects, eg. mining, etc.</p>	<p>Relevant policies are available: codes of practice; physical planning regulations not effective due to: Lack of good (continuous) data; Lack of proper land-use planning; Poor designs</p>	<p>More forward (longer-term) planning, & integrated planning approach; Continuous data collection; Landowners / developers partnerships; Need for better mechanisms to address environmental impacts and land / resources use compensation demands</p>	<p>Localised Significant</p>
<p>6. Climate change</p>	<p>Ratified the relevant conventions; Localised programmes including data collection Resettlement activities</p>	<p>More continued public education and awareness; Better long-term planning, including: national development priorities; bio-technology</p>	<p>Moderate to severe</p>

Forestry Working Group Presentation

Major Environmental Problems

- Contamination of waterways, coastal and marine environments;
- Forest habitat degradation;
- Introduction of exotic species (flora and fauna);
- Impact on coastal and marine habitats;
- Increased natural disasters;
- Soil erosion and land degradation;
- Vectoral diseases;
- Carbon sinks

Immediate and “Root” Causes

Lack of effective monitoring;
Change of lifestyle;
Lack of education and awareness;
Lack of services and infrastructure;
Push for economic gains;
Population pressure

Review what has been done to date and Why this was not entirely effective

Legislative reviews (DEC / NFA etc.): Lack of effective monitoring, & lack of environmental considerations in the Acts

PNG Logging Code of Practice	Voluntary, and Site specific
Environmental Impact Assessments	Lack of effective monitoring, and Political willingness

Assess what still need to be done to address the causes of these problems effectively

Refine legislation and adopt environmental friendly measures;
Education and awareness on alternative ways of developing the resources;
Provide incentive schemes for sustainable living;
Improvements to the E.I.A. process;
Improve the Code of Practice;
Introduce penalties for non-compliance

Assess the magnitude and significance of these problems

Habitat loss	Priority 1
Water quality	Priority 2
Introduction of exotic species	Priority 2
Increased natural disasters	Priority 2
Soil erosion / land degradation	Priority 2
Vectoral diseases	Priority 2
Low water supply / availability	Priority 3
Carbon sinks	Priority 3

Mining & Petroleum Working Group

ISSUES (in order of priority)

1. Degradation of water quality
2. Social impacts

CAUSES

Disposal of tailings;
Disposal of waste rock & overburden;
Disposal of excess sanitation water;
Accidental spills of oil, chemicals, etc.;
Excessive extraction of water - depleting water resource stocks.

Introduction of large amounts of cash disturbing the local economy;

	Urbanisation of traditional subsistence societies
3. Increased waste generation	Lack of proper waste management tools; Lack of wastes' sorting & recycling; Lack of proper landfill areas; Lack of proper guidelines & enforcement criteria
4. Soil erosion	Forest clearance for infrastructure and economic development; Excessive exposure of soils; Lack of proper rehabilitation policies & programmes
5. Loss of biodiversity	Forest clearance / infrastructure development; Loss or destruction of habitats; Smuggling of native species
6. Declining air quality	Increased emissions from vehicles & industrial plants; Dust from roads
7. Introduction of alien species	From roads & pipeline routes; Feral species from human introductions; From ship ballast waters
8. Degradation of in-shore & coastal waters, impacting fisheries stocks	Sedimentation & contamination from: tailings & overburden discharges from mining operations; inadequately treated sewage discharges; stormwaters and wastes from infrastructure & pipeline construction

Mining & Petroleum Working Group

ISSUES (in order of priority)	CAUSES
1. Degradation of water quality	Disposal of tailings; Disposal of waste rock & overburden; Disposal of excess sanitation water; Accidental spills of oil, chemicals, etc.; Excessive extraction of water - depleting water resource stocks.
2. Social impacts	Introduction of large amounts of cash disturbing the local economy; Urbanisation of traditional subsistence societies
3. Increased waste generation	Lack of proper waste management tools; Lack of wastes' sorting & recycling; Lack of proper landfill areas; Lack of proper guidelines & enforcement criteria
4. Soil erosion	Forest clearance for infrastructure and economic development; Excessive exposure of soils; Lack of proper rehabilitation policies & programmes
5. Loss of biodiversity	Forest clearance / infrastructure development; Loss or destruction of habitats; Smuggling of native species
6. Declining air quality	Increased emissions from vehicles & industrial plants; Dust from roads
7. Introduction of alien species	From roads & pipeline routes; Feral species from human introductions; From ship ballast waters
8. Degradation of in-shore & coastal waters, impacting fisheries stocks	Sedimentation & contamination from: tailings & overburden discharges from mining operations; inadequately treated sewage discharges; stormwaters and wastes from infrastructure & pipeline construction

Urban Development Working Group

Major Environmental Issues:

1. Degradation of Water Quality and Quantity of Water Supplies

Immediate & "Root" Causes	Responses
<p>Quality Contamination by sewage;</p> <p>Stormwater runoff (contaminated & non-contaminated);</p> <p>Direct discharge of industrial effluents;</p> <p>Inappropriate disposal of solid wastes & litter;</p> <p>Contamination from infrastructure developments such as land reclamation and wharf developments</p>	<p>Permitting of sewage discharges (WRA)¹ and monitoring of discharges;</p> <p>Water use permitting (WRA) (incl turbid, discoloured, or contaminated stormwaters);</p> <p>Permitting of industrial discharges (WRA); Environmental Codes of Practice on: Motor Vehicle & Machinery Workshops, Fuel Storage, Re-sale & Usage Sites; and, Sanitary Landfill Sites (leachates).</p> <p>Urban authority by-laws on littering; Urban waste management strategies (collection & disposal); Environmental Codes of Practice on Sanitary Landfill sites; Education & awareness programmes (eg. NCD² & NGOs);</p> <p>Environmental Planning Process (EPA) requirements; DEC³ Environmental Guidelines for the Construction of Roads and Bridges</p>
<p>Quantity: Low rainfall and droughts;</p> <p>Leakage within delivery systems;</p> <p>Increasing demand</p>	<p>Control of water use and allocation of water resources (WRA); Maintenance of water delivery systems (Eda Ranu in NCD, and Water Board elsewhere);</p>

¹ WRA Water Resources Act

² NCD National Capital District - Port Moresby's urban authority

³ DEC Department of Environment & Conservation

2. Air Pollution

Immediate & "Root" Causes	Responses
<p>Motor vehicle emissions;</p> <p>Industrial emissions;</p> <p>Burning of landfill wastes;</p> <p>Burning of grass and bushfires;</p> <p>Solid Particulate Matter (SPM) emissions, particularly from infrastructure developments and other construction works</p>	<p>Motor vehicle licensing - Land Transport Act;</p> <p>Permitting and regulation under the ECA⁴ (but the provisions of this Act were never exercised); Industries' self-regulatory schemes: eg. COPs⁵: Motor Vehicle & Machinery Workshops,</p> <p>Permitting and regulation under the ECA⁶ (but the provisions of this Act were never exercised); COP for Sanitary Landfill Sites</p> <p>Environmental Planning Process (EPA) requirements; DEC⁷ Environmental Guidelines for the Construction of Roads and Bridges</p>

3. Noise Pollution

Immediate & "Root" Causes	Responses
<p>Entertainment venues;</p> <p>Construction and industrial sites;</p> <p>Public gatherings</p>	<p>Noise Abatement Notices (under the ECA); Physical Planning Act / Building Act; Police</p>

4. Land Degradation

Immediate & "Root" Causes	Responses
<p>Inadequate landfill management;</p> <p>Urban gardening on unsuitable slopes and other marginal ground;</p> <p>Inappropriate / temporary storage of hazardous materials and wastes</p>	<p>COP for Sanitary Landfill Sites; EPA requirements;</p> <p>Education & awareness programmes (NGOs and city authorities);</p> <p>COP for Motor Vehicle & Machinery Workshops COP for Sanitary Landfill Sites; Pesticide guidelines under the ECA</p>

⁴ ECA Environmental Contaminants Act, superseded by the new Environment Act 2000

⁵ COPs Environmental Codes of Practice

⁶ ECA Environmental Contaminants Act, superseded by the new Environment Act 2000

⁷ DEC Department of Environment & Conservation