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Foreword

Papua New Guinea's land and waters have provided sustenance and shelter to the people of the country for thousands of years. The spiritual and emotional links between the people and the environment are deep and strong, and most traditional cultures recognize this reciprocal relationship and consider each generation to be the custodians of natural resources, with an obligation to ensure that their benefits are passed on to future generations. This is a great strength, but today, as in many communities all over the world, the traditional respect and the mutually supportive relationship between people and the environment is starting to come under threat as the lure of short-term benefit confronts long-term concerns for the preservation of the environment. As Crocombe asserts, "no traditional precedents exist for chainsaws, bulldozers, hunting rifles, metal traps, power torches, spear-guns, scuba gear, filament nets, dynamite, outboard motors or global markets for timber, coral, bird of paradise feathers, sea shells, clams for soup and nautilus shells for tourist mantelpieces."[1] There are concerns regarding the unsustainable use of forests, pollution of streams and rivers by extractive industries, the need for clean drinking water and, in general, tradeoffs between development and environmental sustainability. This makes it critical that we begin to ask questions about the kinds of pressures that are beginning to be felt and the steps that need to be taken so the people of Papua New Guinea can both realize the economic benefits from its resources and ensure their long-term survival.

The Environment Monitor Series is prepared for countries of the World Bank's East Asia and Pacific Region, and presents a snap-shot of key environmental trends in the countries, to enable them to identify the environmental aspects of national development that need attention, or will need attention in the years ahead. This Environmental Monitor 2002 is designed to begin to provide basic information about the natural resources of PNG, the pressures that are starting to be felt, and the steps that need to be taken. It is the first in a series of Monitors that will aim to engage and inform stakeholders of key environmental issues. It has been developed in a participatory and consultative manner, with written contributions from a number of NGOs, and with the support of Government. A draft version was discussed at a meeting of concerned Government officials in Port Moresby in May 2002. We hope that it will provide a useful means for informing policy makers and helping people to understand the importance of environmental concerns, and the urgency with which these issues need to be addressed. This exercise takes on added significance for Papua New Guinea, as the Monitor is being issued at a time when the country faces major macroeconomic challenges. It has a very open economy (both exports and imports as percentages of GDP are high). This makes the economy vulnerable to external shocks leading to significant volatility in economic performance. The economy is greatly dependent on primary commodity exports (gold, oil, gas, oil palm, coffee, and cocoa). As international prices have declined dramatically in recent years the country has experienced several continuous years of recession, depreciation of its exchange rate, declines in per capita income, and consistently high inflation. As Papua New Guinea grapples with these pressing challenges, it needs to ensure that the use of natural resources is conducted in a manner that is sustainable, and does not lead to irreversible deterioration.

Environmental education and awareness is a strong and fundamental tool to empower resource owners and their successors to live with, care for, and preserve their environment in a complex, modern world. Once the problems are understood, the institutional capacities at all levels will need to be reinforced, information systems updated, and regulatory and monitoring controls strengthened. There is also an urgent need to improve the capacity of state agencies to develop and monitor programs on environmental degradation, species management, and effluent and solid waste management. There is a developing partnership between civil society and line agencies to address these issues. The commitment to environmentally sustainable development has to include a long-term strategy of working with and through the local level landowners. Successfully engaging the issues and challenges that face the country will require strong commitment and cooperative effort on the part of all these stakeholders, and the strengthening of such partnerships needs to be at the center of any environmental strategy. If this Monitor can help to bring more focus on these efforts, it will have successfully met its objective.

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THEMES	ISSUES	IMPACTS AND NEEDS
I. Land and the People		
PNG is home to 5.1 million people. It also has ■ 20,000 plant species ■ 600 fish species ■ 800 species of corals ■ 304 mammals species ■ 733 species of birds ■ 298 species of reptiles ■ 228 amphibian species ■ 45 types of forest /wetlands ■ Abundant fresh water ■ Pollution free atmosphere ■ Extensive mineral/oil deposits	■ The biological diversity belongs to the people, and is managed under traditional land tenure systems. ■ Forests provide the basis of livelihood and cultural life to the 80% of Papua New Guineans who live in rural communities. ■ Food supplies from the forests and seas remain a central component of diet. ■ PNG is greatly dependent on primary commodity exports. ■ PNG is also currently experiencing strong macroeconomic challenges. ■ It is necessary to ensure that the urgency and need for environmental action is not ignored in addressing these challenges.	The use of natural resources should be conducted in a manner that is sustainable, while respecting the traditional relationship between the land and the people. This would require: ■ **Working with landowners** to encourage continuation of traditional sense of stewardship ■ **Establishing strong partnerships** among the key stakeholders, including landowners, government, NGOs, the private sector, etc. ■ **Getting good data** and information systems and providing realistic and useful information to all stakeholders, and ■ **Getting the policy framework right.**
II. Forests and Biodiversity		
■ Forests: nearly 77% of PNG (36 million hectares) is still natural forest.	■ High deforestation rates: from 1975 to 1996, forest cover decreased 10%. Increasing with logging and conversion but **not much quantified information available.**	■ Estimates: at current rate of logging, first-cut logging in PNG can be exhausted within 25 years.
■ Bio-diversity: 5 to 7% of the world's species of plants and terrestrial life forms are found in PNG.	■ Increasing numbers of rare insects, birds and animals are threatened and endangered. ■ Growing illegal trade in wildlife; **data difficult to quantify.** ■ Official expenditure for bio-diversity conservation has decreased 60% from 1998 to 2002.	■ Some of these species could be lost forever if their numbers are hunted or their habitats are altered.

THEMES	ISSUES	IMPACTS AND NEEDS
III. Mines		
■ Mining and oil provide 27% of PNG's GDP.	■ River and sea pollution from dumping of mining sediments and tailings into waters has been occurring for decades. ■ Loss or decline of river and oceanic fish stocks, loss of land, coral reefs, etc. resulting from disposal of toxic tailings.	■ More responsible mining, understanding of impacts, better management of mitigation and benefits needed. ■ Closer governmental monitoring and enforcement required.
IV. Marine Resources		
■ PNG's marine resources are relatively well preserved.	■ Coastal and marine resources could be declining because of degradation resulting from mining and logging, and potential over-harvesting of fish, etc. ■ Mangroves loss may be taking place.	■ Exploitation of marine resources is not fully measured, and **more data collection and monitoring are needed.**
V. Fresh water		
■ PNG has more than 170,258 cubic meters of fresh water per person, one of the world's highest stocks of fresh water per capita.	■ Only 29% of rural population has access to improved water sources. ■ Pollution of water sources is taking place from mining and unregulated effluent runoffs, or domestic contamination. ■ High incidence of water-related diseases like diarrhoea.	■ Improved water supply systems could probably contribute to the reduction of up to 40% of diarrhoeal mortalities and to improved health outcomes.

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ALRI	Acute Lower Respiratory Infection
AusAID	Australian Agency for International Development
BOD	Biological Oxygen Demand
BWR	Bureau of Water Resources
CITES	Convention on Trade in Endangered Species
CM	Conservation Melanesia
CRI	Coffee Research Institute
DAL	Department of Agriculture and Livestock
DEC	Department of Environment and Conservation
Dept	Department
DO	Dissolved Oxygen
DoH	National Department of Health
Eda Ranu	NCD Water Supply and Sewage Agency
EEZ	Exclusive Economic Zone
est.	Estimate
FAD	Fish Aggregating Devices
FCP	Forestry and Conservation Project
FMA	Forest Management Area
GHG	Green House Gases
GDP	Gross Domestic Product
GEF	Global Environment Facility
GoPNG	Government of Papua New Guinea
GPAL	Governance Promotion Adjustment Loan
g/l	Grams per Litre
HADC	Highlands Aquaculture Development Centre
hrs	Hours
ICAD	Integrated Conservation and Development
ILG	Incorporated Land Groups
ISO	International Standards Organization
IUCN	International Union for Conservation of Nature and Natural Resources
Km	Kilometers
Km^2	Square Kilometers
Km^3	Cubic Kilometers
m^3	Cubic Meters
Mg/l	Milligrams per Liter
MT	Metric Tons
NARI	National Agriculture Research Institute
NAQIA	National Agriculture and Quarantine Inspection Authority
NCD	National Capital District
NCDC	National Capital District Commission
NEC	National Executive Council
NFA	National Fisheries Authority
NFS	National Forest Services
NGO	Non-Governmental Organization
ODS	Ozone Depleting Substances
OCP	Oro Conservation Project
OTML	Ok Tedi Mining Limited
ORT	Oral Re-hydration Treatment
PNG	Papua New Guinea
ppm	parts per million
QABB	Queen Alexandra's Birdwing Butterfly
TAC	Total Allowable Catch
UNDP	United Nations Development Program
UNEP	United Nations Environment Program
UNFCCC	United Nations Framework Convention on Climate Change
WWF	World Wildlife Fund

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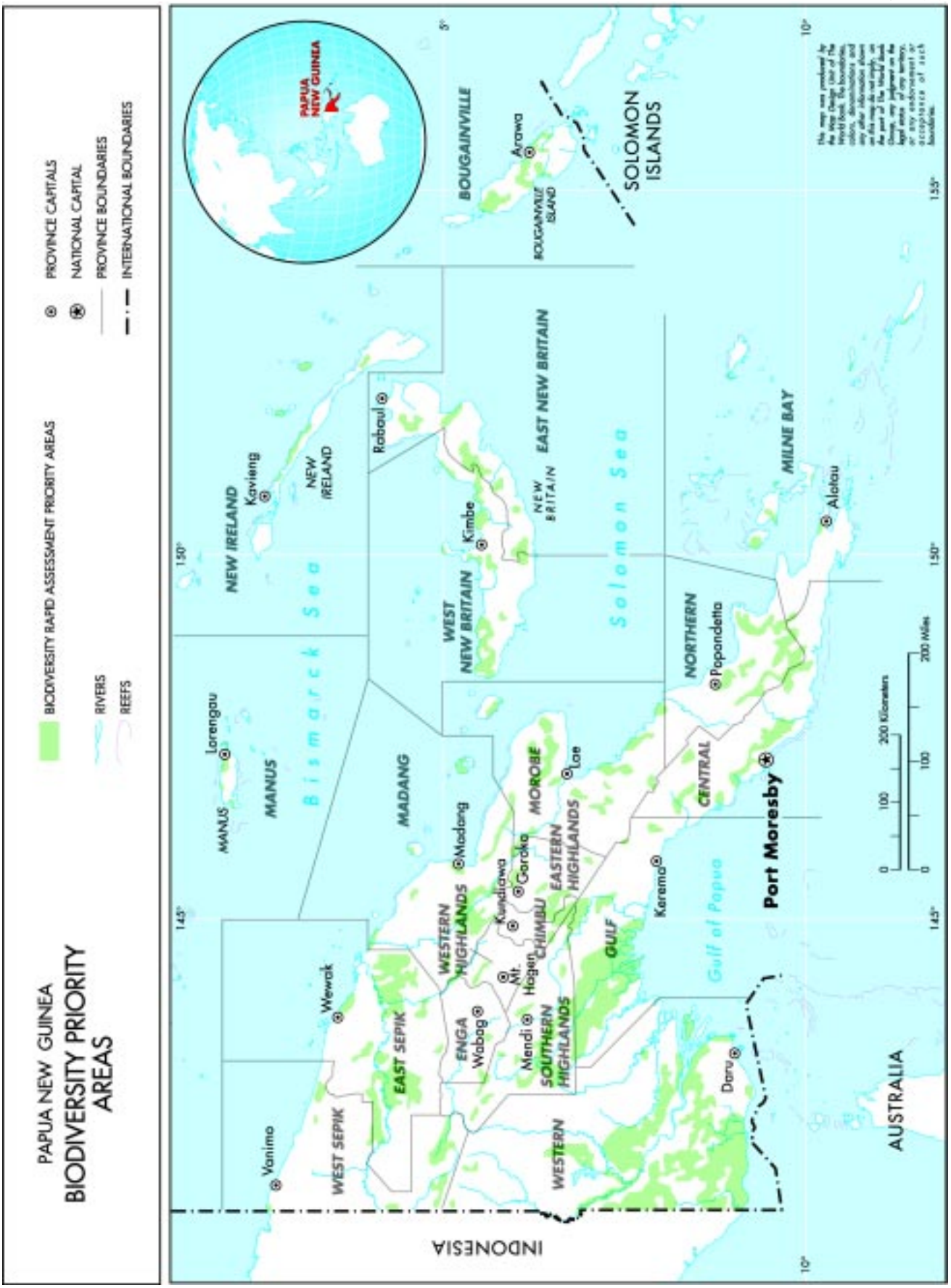


JUNE 2002

View of Eastern Highlands (Photo : Rocky Roe)

1. Background

Papua New Guinea has an extraordinary range of ecosystems, ranging from mountain glaciers to humid tropical forests, from swampy wetlands to pristine coral reefs. These ecosystems are relatively unspoiled, and some areas, particularly the larger areas of wetland, still have very low human population densities (two to four persons per square kilometer). However, the environment in general is coming under pressure. Terrestrial ecosystems, especially forests, are subject to increasing resource extraction and are being depleted through commercial forestry operations, or cleared to make way for mining and agriculture. Freshwater ecosystems in some parts of the country are being degraded through the disposal of mining, agricultural, and urban wastes. This degradation ultimately impacts marine systems, which are also being affected by additional pressures from fisheries and pollution.

An Environmental NGO Comment on the State of the Environment

(Jaru Bisa, Eco-Forestry forum)

Environmental issues should be a priority agenda to promote sustainable growth and development.

It is often taken for granted that the state of environment in PNG is intact and environmental degradation is of no immediate concern. The level of Government funding and support provided to institutions of state mandated to safeguard the environment to effectively monitor and develop an up-to-date database and information system on the state of the environment in PNG is inadequate. It is imperative for the state government to put in place sustainable management tools which should include sustainable agriculture, long-term sources of funding for conservation and sustainable development, strengthen the capacity of state agencies to enforce environmental legislations and have in place an environmental audit.

2. Biodiversity

Papua New Guinea has a total land area of 46.28 million hectares, of which about 36 million ha, or 77% of total land area, is still covered by closed natural forest. This constitutes one of the most complex, species-rich significant tropical rainforest wildernesses remaining in the world. Although this biodiversity has not been extensively surveyed, the best current scientific estimates are that 5% to 7% of the world's biodiversity is found in PNG. Terrestrial biodiversity includes 304 mammal species, 15,000-20,000 plant species, 1,500 tree species, and 733 bird species. This includes many unique species not found anywhere else on earth. Best known birds include the birds of paradise (90% of the world's total species), bowerbirds, mound builders, and cassowaries. Many of PNG's mammals are marsupials, and include the tree kangaroo, cuscus, and possum. PNG's reptiles include an endemic freshwater crocodile and the world's longest lizard. Outstanding PNG insects abound such as the world's largest butterfly, Queen Alexandria's Birdwing.

PNG's Record-breaking Biodiversity

Monitoring the World's Largest Monitor!

Papua New Guinea has such a rich biodiversity that a quick search on the Internet provides a list of species that could well have originated from the Guinness Book of World Records. Some of these include:

- World's largest orchid, *Grammatophyllum papuanum* syn. *speciosum.* With large yellow-green flowers marked with brown or maroon, it is also called the tiger orchid.

- World's largest egg-laying mammal, *Zaglossus bruijnii.* Otherwise known as the long-beaked echidna, it is primarily nocturnal, and forages the forest floor for worms and possibly ants and termites. It is currently on the IUCN "Endangered" list, and it appears to be extinct in large areas of the Central Highlands. It is a highly prized game animal, and is not protected from traditional hunting.

- World's only poisonous bird, *Pitohui* spp. There are several poisonous species of pitohui in PNG. It was only discovered by accident in 1989 when a biologist handling the bird experienced sensory numbness. The poison is homobatrachotoxin, and is similar to the toxin in the poison arrow frogs of Central and South America.

- World's longest lizard, *Varanus salvadorii.* Known as the crocodile monitor, it can grow up to 15 feet long and is found only in the tropical forests of New Guinea. It is hunted for its skin and for its meat.

- World's largest pigeon, *Goura victoria.* Commonly called the Victorian crowned pigeon or the blue crowned pigeon, it is named for the delicate feathers on its head, and ranks as one of the prettiest and brightest pigeons. It is typically hunted for its plumage.

- World's largest bat, *Pteropus neohibernicus.* The Bismarck flying fox is the largest bat and can have a wingspan of over five feet.

- World's largest butterfly, *Ornithoptera alexandrae.* The Queen Alexandria's Birdwing Butterfly, with the female reaching a wing-span of up to ten inches, is found in just a few valleys near Popondetta, and is severely endangered by forest clearing.

Source: various internet sites; photograph courtesy Erich Krammer.

This wealth of biodiversity is essentially superimposed on a tract of land where local clans and communities maintain rights of access for subsistence, hunting, foraging and as such use. Virtually all forests are subject to these systems, with access regulated under customary arrangements. Forests provide the basis of livelihood and cultural life to the 80% of Papua New Guineans who live in rural communities. These people continue to depend upon forest services and products to meet subsistence and development needs, including building materials, medicines, and food. Food supplies from the forests and seas remain a central component of the Papua New Guinean diet. This diversity is not confined to the forests, and there are an estimated 5,000 cultivars of sweet potato found within the country. Numerous native plant species have traditionally been cultivated, including more than 30 root crops, 21 legume species, 40 leafy green vegetables, 60 other vegetables and roots, 43 varieties of nuts, 102 fruits, and 89 other plants used for food or seasonings.

3. Threats to Forest Biodiversity

The Kiunga-Aimbak Road (Photo: Rocky Roe)

There is general agreement that the most significant threat posed to PNG's biodiversity value stems from the degradation of terrestrial habitats by the total or partial removal of natural forest cover. This is caused by commercial logging, commercial agriculture and, to some extent, subsistence agriculture. Available data indicate that cultivated land is not expanding rapidly in PNG, and more than 50% of the rural population practice low-intensity agriculture. However, the impact on land use systems is evident in the populated rural areas with more sensitive environments. While there is potential for soil erosion in localized parts of the country, with eventual significant impacts on biodiversity, soil retention techniques and planting of mixed crops in traditional gardens generally reduce the impacts of surface runoff and soil erosion.

Besides land clearing, there are other threats to biodiversity. The impact of localized hunting and wildlife trade in PNG is significant. Few, if any, studies have been conducted to evaluate the extent and impact of the trade in cockatoos, other parrots, birds of paradise, reptile skins, and marine products (see the section on oceans for an expanded description of marine species at risk). Similarly the impact of the illegal trade in endangered species is considered significant, but has not been quantified.

Approximately 150,000 to 180,000 hectares are selectively logged annually, arguably in an unsustainable manner. Another 25,000 hectares of natural forest are cleared for agricultural, clear-cutting, and infrastructure construction. It is estimated that shifting cultivation clears another 200,000 hectares, although it is not clear whether much of this is primary forest. A more likely problem is the reduced fallow period for regeneration, which results in degradation of forests, decreased yield, and a tendency to extend the range of the shifting agriculture pattern to other forest areas.

How long will these primary forests last? Presently, it is estimated that approximately 15 million hectares of forests could be designated as production forests. Of this, an estimated 6 to 8 million hectares could be considered suitable for logging, with the remainder not meeting standards for logging because of excessive slope, inundation, etc. It is estimated that some 3.5 million hectares had already been logged by the end of 1998, leaving approximately 4 million hectares for future logging. A small percentage of these potential operable logging areas would be reserved for priority biodiversity and conservation set-aside. (More than 1.5 million hectares have been located in identified high-priority biodiversity areas.) At this rate, the available forest is sufficient for about another 25 years of first-cut logging primarily for log export. With proper forest and conservation management, it is possible that current levels of production and returns from the forestry sector to both the state and landowners can be maintained in the medium term, while protecting biodiversity and environmental values.

4. Institutional Responsibilities and Legislation

Although PNG's constitution and its National Forest Policy commit the country to sustainable forest management, its policies have failed to deliver on these commitments during the last two decades. The 1989 Barnett Commission of Inquiry into the PNG Forestry Sector concluded that logging practices were out of control, causing irreversible damage to forests, land, and local communities, while also diminishing biodiversity and other environmental values.

Logging operations in the Western Province (Photo: Rocky Roe)

Following the inquiry, sweeping changes were made progressively throughout the forest sector to improve the regulation of forest extraction and the management of forest resources on a more sustained yield basis. These changes were to improve forest-harvesting regulations; to protect environmentally significant areas from harvesting impacts; and to improve the forest resource management to a sustainable timber yield basis. However, all of the 51 new projects approved between 1990 and 1992 permitted an unsustainable reduction of forest resource, allowing up to 87% cutting within 10 years. This slowed down significantly later in the '90s, reflecting the combined effect of new measures (The Forestry Act 1991 was certified in April 1993).

Number of Timber permits issued in the 1990s

1990	12
1991	17
1992	22
1993	0
1994	0
1995	8
1996	4
1997	1
1998	0
1999	0

Forest Management

This slowing down of approvals for timber extraction increased the pressures on the PNG Forest Authority to "fast-track" new projects, leading to fears that some aspects of the formal resource acquisition and allocation process set out in the Act were being circumvented, or improperly applied. In addition, there was a perception that attempts were being made to use loopholes in the Act to fast-track the availability of additional forest resources for exploitation, in particular the addition of large forest areas to existing Timber Permit areas as "extensions", and the use of limited volume Timber Authorities by extensive forest conversion to agriculture or high volume extraction in the name of road line clearing. These perceived loopholes were addressed through an amendment to the Forestry Act in January 2001. To ensure that all Timber Permits, extensions, and Timber Authorities were processed correctly, the Government also imposed a moratorium on the further processing of new forestry projects. Furthermore, they ordered an independent review of all "in process" forestry projects to evaluate compliance with the requirements of the Forestry Act

1991 and supporting regulations, legislation, plans, procedures, and guidelines. The independent review recommended that none of the 32 projects reviewed be approved immediately, and that 20 of the applications should be shelved pending a review of consolidation options or alternative approaches to forest utilization.

The review also proposed a number of changes in the resource allocation process. The Government has committed to implementing these with support from the recently approved Forestry and Conservation Project, funded from the Global Environment Facility (to support conservation measures and the Mama Graun Conservation Trust Fund), and the World Bank. The project will also assist the major Government Agencies, principally the PNG Forest Authority and the DEC, to ensure compliance of operators in the sector, as well as direct support for increasing landowner involvement in managing and conserving forests, increased monitoring of existing operations, and reviewing of further resource allocations. The Government will also maintain an independent reporting service on log exports.

Biodiversity Conservation

In many countries, biodiversity conservation is achieved in part by the establishment of protected areas systems. In Papua New Guinea, because clans maintain rights to the use and access to almost all the forest land of the country, only a few protected areas have been established (0.2 % of the land area) and these tend to be small. Many of these locations are not controlled by the government, but are run by local "landowner" communities as wildlife management areas. Despite the fact that a number of donor- or NGO-funded studies have been undertaken to determine conservation or protected area priorities, no system of reserves has been established. However, it is often suggested that such protected area concepts formalizing strict nature reserves and national parks may not even be appropriate in the PNG social context. Furthermore, it is often suggested that effective conservation lies in a number of alternatives, which more appropriately recognize the traditional clan land rights and cultural practices. The answer probably lies somewhere in between.

Several species have been declared protected. The principal Act protecting species is the Fauna Protection Act 1977.

Protected Species

(based on limited survey data)

Species	Total Number	Endemic	Protected
Mammals	304	61	10
Birds	733	82	46
Reptiles	298	-	1
Amphibians	228	-	-
Insects	-	-	1

The land tenure system also complicates the issue of conservation and development. The integrated conservation and development (ICAD) concepts have been tested in PNG, with varying results. The successes and failures of the ICAD programs between communities may be attributed to landowners' varying perceptions of socioeconomic development as opposed to conservation. Programs failed where sufficient attention was not paid to enlisting the full support of landowners, who were attracted by logging offers. Subsequent programs that recognized this experience paid greater attention to providing full information to landowners, and built consensus about development options, and were thus more successful. Clearly, the social elements of establishing conservation areas are as important as the purely environmental elements. Challenges for land management include development of landowner-supported conservation measures, application of environmental legislation and land tenure, development of community-based sustainable land use management systems through farming systems research, and promotion of suitable soil conservation techniques.

The Queen Alexandria's Birdwing Butterfly: Survival at Stake?

The world's largest butterfly was unknown to the outside world until 1907, when the naturalist Meek shot down a female near Kokoda. After many years of collection of specimens, the Queen Alexandria's Birdwing Butterfly (QABB) and six other birdwing butterflies were brought under the protection of the Fauna Protection and Control Ordinance of 1968 (superceded in 1974 by the Fauna Protection and Control Acts). In the 1980s, the QABB has been cited in the endangered species list of the IUCN Data Book and in Appendix 1 of CITES.

The QABB is endemic to Oro Province. Recent conservation efforts started in 1991, when the DEC established a QABB project. The World Bank's involvement in conserving the QABB began between 1989 and 1992, during the extensive preparation of a smallholder oil palm project, when it was recognized that some of the oil palm production in Oro Province was contiguous with areas inhabited by the QABB. A conservation program was developed with assistance from NGO consultants, and funding of $1.7 million for a QABB conservation component to support DEC was provided under the loan in 1993. This was on the understanding that the Government would seek additional grant support for a more complete program. An early 1992 request led to feasibility studies by AusAID, which were completed in 1993 and resulted in the more comprehensive Oro Conservation Project (OCP) that was implemented from 1995 to 1999. The OCP assumed all of the funded elements for conservation under the previous component, whose funds were limited to the development of a GIS mapping project that is now a key element in the QABB conservation program. These efforts have been supplemented by the involvement of other agencies such as Conservation Melanesia and the Oil Palm Industry Corporation, either independently or as part of the projects themselves.

The underlying approach of these efforts was to develop an ecological understanding with the landowners to manage the habitat of the QABB for the long-term survival of the species. But this is not an easy task, especially if the concerned stakeholders do not see tangible benefits from the QABB conservation efforts on their own if no alternative development needs other than oil palm are provided. Partly reflecting the delicate nature of these issues, the conservation efforts have sometimes proceeded in fits and starts. Key inputs (like the appointment of registered surveyors to map out conservation areas) were delayed, and some efforts (like the appointment of butterfly monitors to collect data, or the establishment of the Queen Alexandria lodge to promote eco-tourism) did not meet with much success. However, there is little doubt that landowner awareness of the issues surrounding the QABB has been heightened, and there has been serious research relating to the habitat and distribution of the QABB. Captive rearing has successfully been carried out, and a program to stimulate school students' interest in QABB has also been successfully implemented. The Bank-supported smallholder project has recently been assessed[2] as having had a crucial role in preventing and slowing degradation of the Popondetta Plains and achieving oil palm expansion activities with minimal detriment to QABB habitats. The area under oil palm production in Oro Province as of December 2001 is 23,041 hectares, of which smallholder

blocks make up 14,500 hectares.

However, more efforts continue to be necessary. There is currently no Government or external donor involvement in the butterfly conservation efforts in Oro Province. An agreement was signed between Conservation Melanesia and the Oro Provincial Government to allow CM to take custody of the former OCP facilities to continue with the QABB conservation efforts, and current efforts for conservation of the QABB are through CM and the oil palm developers.

Source: World Bank documents, and Tom Diwai Vigus

Land Management

The Department of Agriculture and Livestock (DAL) and the National Agriculture Research Institute (NARI) have been mandated to conduct research and development activities, complemented by other line agencies and NGOs, on sustainable management of land use systems to combat land degradation.

5. Challenges

Planning for conservation requires greater emphasis. Even with the concerned institutions attempting to undertake their statutory responsibilities, resource and personnel constraints are significant concerns and barriers. For example, internal allocations by the GoPNG to biodiversity conservation have declined, as shown by the funds allocated to protected area management within DEC, despite its commitment as a signatory to international conventions on environmental protection. This may indicate the low priority that the GoPNG gives to environmental conservation protection, or it may merely reflect a fiscal condition. There are also a number of significant projects and activities funded by the international community, but the ability of government agencies, even in partnership with these projects, is constrained.

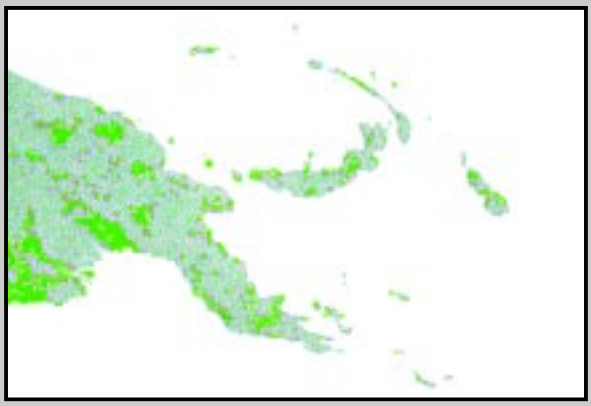
Although a number of initiatives have been attempted, issues associated with development and conservation with informed landowner consent need to be addressed urgently. At the present time, the resources to do this are modest and the necessary functioning data systems and supportive mechanism require upgrading. The BioRap exercise (see box) highlights the need for national land use planning, but provincial and district planning will also be essential. There is also an urgent need for upgrading, increasing the utility and inter-operability of existing resource data systems, and making information readily available.

BIORAP - Priority Areas for Conservation - A Planning Tool

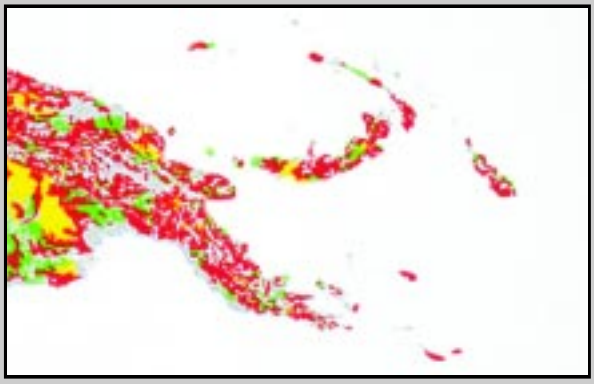
The BioRap (Biodiversity Rapid Assessment) study was a project developed during 1994-95 by a consortium of four Australian scientific/technological agencies with World Bank/AusAID support. It was set up with the goal of establishing a national protected area network, and to identify the explicit options and constraints for land management within the forestry and agricultural sectors. The objective of this study was to devise a biodiversity conservation plan for Papua New Guinea (PNG), based on a set of biodiversity priority areas. These priority areas developed in partnership with GoPNG agencies are to be subject to ongoing revision by them, in response to change in land use patterns, change in economic, social and political conditions, and change in ecological and biological knowledge.

Figure a) represents a set of biodiversity priority areas which together represent 608 environmental domains, based on spatial modeling tools developed by Hutchinson et al in 1996, 564 vegetation types, 10 species of bioclimatic clusters and 25 rare and threatened species. This set also includes all existing protected areas and samples all Conservation Needs Assessment (CNA) priority one areas (from a previous experts' study in the 1980s). In addition, the set minimizes foregone opportunities for timber production, avoids areas of high

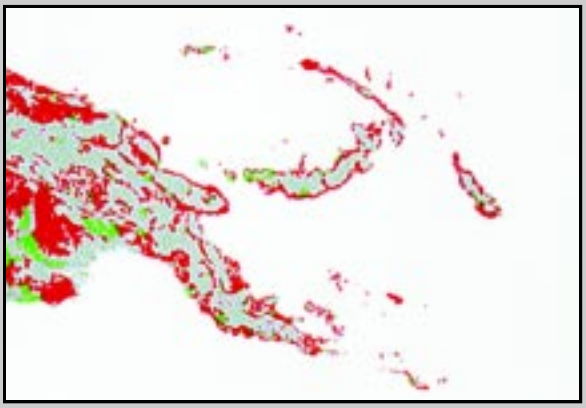
agricultural potential, avoids areas of high existing agricultural intensity and gives preference to areas of low human population density areas. This can be superimposed on various other data sets.



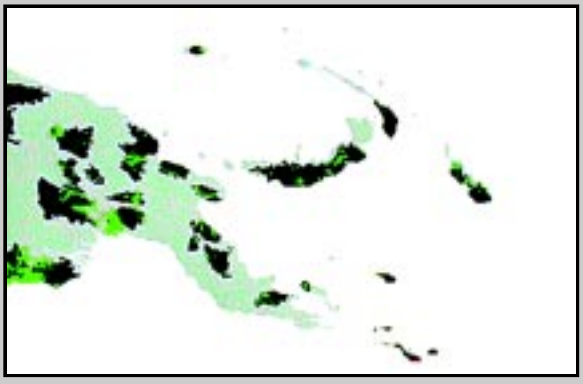
a) The current best set of priority areas - green



b) Portion of proposed set (green) that overlaps with high timber volume areas - yellow highest, followed by orange



c) Portion of proposed set (green) that overlaps with agricultural potential areas - red areas having agricultural potential according to a simple index



d) Portion of proposed set (green) that overlaps with CNA priority one areas- in black

Sources:

Faith, D. P., C. R. Margules, P. A. Walker (2001) A biodiversity conservation plan for Papua New Guinea based on biodiversity trade-offs analysis Pacific Conservation Biology. 6(4): 304-324.

Hutchinson, M.F., Belbin, L., Nicholls, A.O., Nix, H.A., McMahon, J.P. and Ord, K.D. 1996. BioRap Volume Two: Spatial Modelling Tools. The Australian BioRap Consortium, Centre for Resource and Environmental Studies, Australian National University, Canberra, 142 pp.

1. Background

Mining is of major economic significance in PNG, but has in the past had some of the most disastrous environmental and social impacts compared to anywhere else in the world. It has been a significant contributor to the economy since PNG's first large mine (Panguna) came on stream in 1972, and contributes 17.1% to the nation's gross domestic product. In 2001, the mining sector alone contributed approximately 49 % of foreign export earnings. Primary commodities mined are gold, copper, silver, nickel, cobalt, petroleum, and natural gas. In 2000, Papua New Guinea was the 13th largest copper and the 11th largest gold mining country in the world[3]. Mining is, therefore, a very large and important part of the national economic activity. Although the mining sector in PNG has potential for growth and much of the country remains to be explored, exports have not grown over the past few years and mineral exploration activities have declined. Some of the factors that have contributed to this are exceedingly difficult terrain, poor infrastructure, extreme weather conditions, unpredictable tax levies, political unrest, land disputes, and unstable world prices for minerals. An extreme example of the difficult terrain and lack of infrastructure is in the mountains 100 km north of Port Moresby, at the Tolukuma Mine, the only mining operation in the world that has been built, serviced, and operated with materials and personnel transported to its site entirely by helicopters. Mining activities range in scale from artisanal (by individuals using shovels and pans), to large-scale, or industrial mining (with significant capital investments of up to US$ 50 million for large heavy equipment and specific high-technology processing plants). Medium- to large-scale mining is highly capital intensive and generally only employs about 3% of the workforce. Small-scale mining directly employs approximately 80,000 people.

PETROLEUM:

The petroleum sector contributes 9.1%[4] to the GDP. A refinery is being constructed in Port Moresby, but currently there are no operating oil refineries in PNG, and all oil production is transported to Asian and Australian markets for processing via the Gulf of Papua. Chevron Asiatic Ltd is working on a proposed natural gas pipeline that would extend from the PNG highlands to the central eastern coast of Queensland, Australia. This would include 635 km of pipeline in PNG (320 km onshore, 315 km offshore) and 2,615 km within Australian territory[5].

The petroleum sector has a lower environmental impact than mining; oil extraction requires digging of offshore or land wells, and transport of crude oil by trucks or lengthy pipelines to refineries. The clearing of land and soil in the exploration and development stages contributes to some habitat loss, erosion, flooding, and landslides.

2. Environmental Impacts of Mining

Severe impacts to the environment can occur at all stages in the mining cycle from exploration, construction, operation, and closure, to post-closure. All these impacts are being felt in PNG.

During mineral exploration, large expanses of land are subjected to test drilling, trenches, and shafts by heavy drill rigs and machinery, and ore is accessed by rock-blasting with explosives; material is then transported to crushers and processing plants. Hard-rock mineral processing generates significant waste from overburden (soil and vegetation located above the ore deposit) and further adjacent land is cleared to store the overburden. During mineral processing, the rock is crushed, and a variety of chemicals and heavy metals are added along with extreme heat (smelting) to extract the purified metal from the rock. Added chemicals or metals may

include cyanide, mercury, arsenic, copper, cadmium, chromium, lead, iron, cobalt, kerosene, sodium sulfide, ammonia, and lime. The waste product is tailings (slurry containing at least 50% water and residual chemicals and metals from the extraction process). Tailings are usually disposed of in impoundments (dams) or in waterways. Environmental risks with impoundments include seepage of reagents (such as cyanide) or metals into surface or groundwater, the production and leaching of sulfuric acid, and significant potential risks of tailing dam rupture due to PNG's high geologic instability/activity and high rainfall and storm waters. Where impoundments are considered too risky because of seismic instability, tailings are disposed of in rivers and in the marine environment.

Untreated tailing disposal has significant environmental effects. Disposal of toxic and other tailings into rivers affects water quality, stream hydrology, coral reef life, and aquatic biodiversity. Increased sedimentation clouds the waters, decreasing the amount of light available to aquatic plants for photosynthesis. Sedimentation and pollution are therefore some of the greatest threats to coral reefs. Sedimentation also eliminates food sources of other aquatic organisms by smothering benthic organisms (species occurring in the depths of the water habitat). Moreover, since some fish prefer slower moving clear water, the ability of fish to spawn and migrate may be impeded[6]. Sedimentation may also decrease the depth of streams, resulting in a greater risk of flooding during times of high stream flow[7]. In addition, since some species tolerate higher concentrations of metals and acidic water, aquatic biodiversity may be affected, with populations of various species being altered. Finally, heavy metals such as mercury, bioaccumulate or increase in concentration as they move up the food chain, reaching the highest concentrations in humans.

Even closure of mines has environmental impacts. It involves backfilling, re-contouring the landscape to its original topography, and re-vegetating the site with previous plant species. There can be environmental risks in the closure phase relating to incomplete or neglected final closure work, leaving tailing wastes untreated and the landscape prone to erosion, landslides, and flooding.

Unfortunately, the extraction industries in Papua New Guinea have been associated with river and sea pollution due to mine wastes for years. As early as 1988, landowners protested against the environmental damage caused by the Bougainville Panguna copper mine. This mine dumped approximately 150,000 tons of waste rock and tailings per day into the Kawerong River, from which it flowed into the Jaba River and to the coast. Over a ten-year period, more than 360 million tons of ore were deposited. Significant negative environmental effects include loss of fish throughout the entire 480 km. Jaba River watershed, declines in coastal fish stocks, declines in local wildlife populations, and loss of land for agriculture[8]. The Ok Tedi mine (see Box) is another example of a mine that has caused considerable environmental damage through untreated river tailing disposal. The allowable discharges are regulated under the relevant water use permits issued by the Department of Environment and Conservation, however estimates of the generated wastes, particularly in remote areas, are difficult to quantify or monitor.

The Ok Tedi Mine: Lessons and Environmental Trade-offs

The Ok Tedi Pit (Photo: Rocky Roe)

The Ok Tedi mine is located on Mount Fubilan in the remote highlands of the Star Mountains on the Ok Tedi River. It is the world's largest copper mine and contributes significantly to the economy of PNG. Ok Tedi Mining Ltd. (OTML) operates the mine, with a 20% Government stake. The operation provides approximately 10% of PNG's gross domestic product, and nearly 20% of its export income[9].

The Ok Tedi mine has been disposing its tailings into the Ok Tedi and Fly Rivers ever since successive major landslides forced the abandonment of a tailings dam construction, shortly after the mine started operating in 1984. Consequently, it has been discharging significant quantities of waste rock and tailings into the Fly River system at an average annual discharge rate of 65 million tons, and is expected to continue to do so until mining ceases. The Fly River System is the most significant river on the island of New Guinea in terms of biological value. The buildup of sediment has produced flooding of the Ok Tedi and Fly Rivers causing contaminated sediment deposition and a 100km^2 dieback of vegetation on the flood plains, loss of food gardens, loss of fish habitat, and reduced fish populations.

As early as 1992, World Bank specialists prepared a review of environmental issues in the mining sector, which raised concerns regarding the environmental impacts of the Ok Tedi operation. The report also pointed out the need for improvements relating to environmental legislation as well as regulatory and institutional capacity building needs.

In 1994, ten years after Ok Tedi began operation and during which it became one of the world's leading producers of copper, virtually all the landowners living along the Ok Tedi and Fly Rivers joined a lawsuit seeking compensation for environmental damages resulting from the river tailings disposal from the Ok Tedi mine. OTML signed an out-of-court settlement in 1996 with the communities for the payment of US$ 28.6 million to be paid out during a 13-year period as compensation for the severe environmental damages caused by the mine's disposal of tailings.

OTML acknowledged the social and environmental impact of the mine's operation, and commissioned various studies to assess the available options to address the environmental problems. In 1998, it commissioned a risk assessment to identify and quantify the risks associated with various waste mitigation options and the financial exposure associated with each option. This included assessing the impacts of (1) continued mining until the scheduled end of mine life, with continued dredging of sediment to reduce downstream impacts, (2) discontinue dredging immediately, and continue mining until the scheduled end of mine life, (3) continue operation until 2001, and divert and store tailings by constructing a dam, and (4) discontinue all mining operations immediately.

In 1999, the Government asked the World Bank to carry out a desk review of the Risk Assessment. According to the review, 'significant and unacceptable' environmental impacts much greater than originally predicted appeared to be occurring, and the impacts downstream of the mine would be felt for a long time after mine closure.

The trade-off was that the best environment option, early closure of the mine, would severely affect national and provincial economies and have significant impacts on the social stability, benefits, and well-being of the affected communities, especially in the enclave surrounding it. The Government subsequently indicated that an early closure of the Ok Tedi mine was not acceptable[10].

On its own, OTML set up the Ok Tedi Development Trust. The fund allocates US$ 3 million per year to help build local infrastructure and to introduce sustainable development projects for affected communities. It will also work with communities to help them support themselves after the mine closes. In spite of this, the question remains whether the lessons learned from Ok Tedi will be used to guide new projects, and whether a regulatory and policy framework is in place to prevent such a recurrence. Or can this happen again?

Source: World Bank documents, Register of Pacific Mining, and newspaper reports

3. Institutional Responsibilities and Legislation

Exploration and mining activities have different scales and resulting impacts. The exploration and development of mining and petroleum are regulated through the Mining and the Petroleum Acts of 1992. This legislation regulates licenses, leases, rents, fees, and royalties, mining development contracts, and compensation for the owners and occupants of affected lands. All inventories of chemicals and explosives material plus procedural uses are regulated under the Mining Safety Act by the Department of Mining. This includes cyanide use for gold mining, sulfides used in copper mining, and nitrates used in explosives. Other environmental issues of mining are addressed under other environmental laws and regulations. The Environmental Planning Act requires all natural resource extraction, and industrial and human-development projects to review potential environmental and social impacts through an Environmental Plan. The Environmental Plan, similar to Environmental Impact Statements in other countries, describes expected changes and measures taken to minimize the impact, and includes plans for rehabilitation.

PNG's first two large-scale mines, Ok Tedi and Panguna copper mines, either predated the Environmental Planning Act of 1978, or were otherwise excluded from its requirements. Instead, each of these mines was operated under contracts developed specifically for each one and the Department of Mining and Petroleum was responsible for the environmental monitoring. The Department of Environmental Conservation is now responsible for monitoring environmental effects from mining activities, and in 1993 responsibility for monitoring Ok Tedi was also transferred to the Department of Environmental Conservation.

The impending closure of two mining projects has triggered the need to bring closure initiatives in terms of overall policy and legislation. The previous environmental legislation only addressed operations and did not cover closure. The different levels of impact are addressed in the Environment Act 2000 and proposed Regulations, so that all phases (exploration to post-closure) of projects will be subject to appropriate environmental controls. The government has also taken new initiatives to embrace the "cradle to grave" concept and requires companies to submit closure plans in conceptual form to the State in the pre-feasibility (PF) phase of project development. (These closure plans can be varied or refined throughout the life of the mine.) This will reduce overall closure cost at the end of the mine's economic life.

4. Challenges

Like the forestry sector, mining has the potential to generate significant revenue for the PNG Government and its citizens for development needs and poverty alleviation. However, unlike forestry, minerals are non-renewable resources. This poses particular challenges for ensuring that during the limited amount of time when mining revenues are realized, the environmental consequences have to be minimized, while the economic and social benefits to the country and to the landowners are managed to provide long-term and sustainable benefits. Mining in PNG has had an extremely poor environmental track record thus far. The negative environmental and social impacts from the Ok Tedi and Panguna mines are generally considered global disasters. These harmful environmental effects of mining have negative economic and social impacts on PNG's subsistence communities who live in the areas affected by the mines. Challenges for the future of PNG's mining sector will be to limit these negative environmental impacts; ensure that local communities benefit from mining activities; ensure that benefits lead to poverty alleviation, increased social services, and economic growth; and, lastly and most importantly, to closely monitor mining in remote locations.

1. Background

Papua New Guinea is surrounded by three major water masses - the Bismarck Sea, the Solomon Sea, and the Coral Sea. The total sea area is 3,120,000 sq. km, and there is over 17,110 km of coastline. The principal environments include coral reefs, mangroves, sea grass beds, sandy beaches, river deltas, rocky shorelines, inter-tidal flats with gradual mud or sand accumulation, estuaries, lagoons, and reef walls that drop off the continental slope. The marine environments of PNG are still relatively close to pristine, but are surprisingly poorly studied and there is a general lack of information on the resources. This makes it increasingly difficult to determine the rate of exploitation, and may lead to resources being degraded to dangerously low levels before their loss is realized.

A Case Study of Community Success: the PNG National Coastal Clean-Up Campaign

The PNG National Coastal Clean-Up Campaign was initiated by Conservation International (CIPNG) in conjunction with Eda Ranu in September 1999. The program was started in Port Moresby to encourage local communities in looking after the coastal environment. The PNG National Coastal Clean-Up Association has 16 full-time members representing various stakeholders, and is affiliated with the Centre of Ocean Conservancy, USA.

Print and electronic media, as well as billboards and advertisements, are used to raise awareness. The target groups are primary, lower secondary, and upper secondary school children, and the general public. The message is to care for the environment and be responsible for rubbish and litter. The increasing number of participants indicates the success of the clean-up campaign. The first year of the campaign attracted more than 3000 participants; this increased to more than 10,500 in 2000 and 38,000 in 2001. The success of the campaign improved the rating of PNG from 38th to 3rd within the 138 affiliated countries of Conservation International.

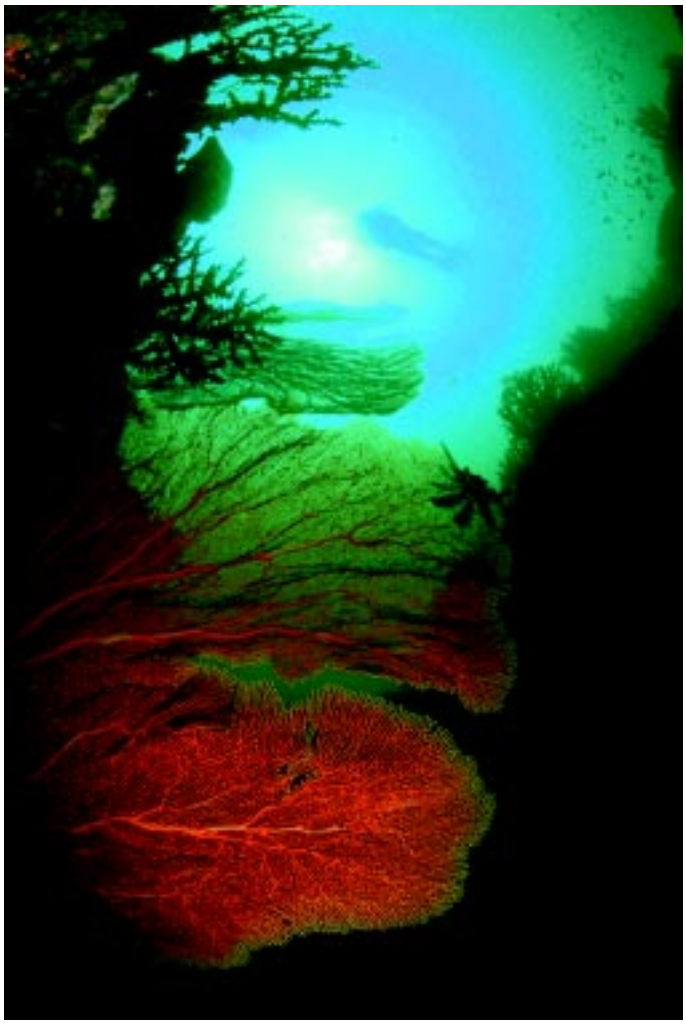
It is envisaged that the Coastal Clean-Up Campaign will be incorporated into the environmental education program through the Department of Education for elementary, primary, secondary, and vocational schools. A marine conservation and resource management module will be developed and tested in a pilot program in Milne Bay.

The community support for the program is an indication of the coastal community's concern for its environment, and for the marine ecosystem that is being affected by non-biodegradable waste generated from rural and urban maritime communities. Various foreign diplomats were involved in the clean-up campaign in 2000, and the Prime Minister of PNG was the patron of the Association in 2001. The initiative has also attracted support from businesses. The success of this campaign is an indication that Papua New Guineans do care and are willing to participate in looking after the environment for the benefit of both present and future generations.

Source: Conservation International PNG

2. Coral Reefs

The coral reefs of PNG are among the richest and most diverse in the world, and cover a total area of 40,000 sq km. Recent surveys and anecdotal accounts indicate that most reefs in PNG are in very good condition. Reefs surveyed recently had relatively high coral cover and little evidence of damage from human activity. This largely reflects the country's dispersed and isolated population and lack of technological development.



Gorgonian fans deep growing off the coast (Photo: Gerald Nowak)

However, reefs close to the shore, where there is increased access by humans, have experienced localized degrading effects. Reef coral is utilized for traditional jewelry, road construction, building materials by logging companies, and is also dried and crushed to produce lime for betel nut chewing. Threats to reefs result from fishing, boats, motors, anchors, and explosives. In addition, high influxes of sediment and freshwater into marine coral habitats, especially near river mouths, are disruptive to coral reef development. There is evidence of loss of coral reefs near mouths of major rivers and degraded shorelines. Some of the most serious threats to coral reefs and the associated coastal ecosystems are from terrestrial activities such as large-scale forestry and agriculture, as extensive tracts of coastal forest have been cleared or allocated for logging. Increased erosion and sedimentation creates turbid waters that cut off light needed for photosynthesis, and clogs and suffocates coral polyps. Studies in the region have indicated a direct relationship between inland activities and sedimentation; partial clearing of virgin forest can generate two to three times as much sediment as non-active forest areas, and clear-cutting can increase sedimentation load ten-fold[11].

Subsistence and artisanal fishing is the predominant human activity on PNG reefs. In general, reef fish harvests are thought to be below sustainable levels, however, there is evidence of over-fishing around Port Moresby and other large coastal centers. There is also evidence of substantial over-fishing of invertebrates such as sea cucumbers, trochus, green snail, and giant clams in many locations, particularly the Western and Milne Bay Provinces. The pressures on reef resources in PNG will almost certainly increase as the population continues to grow, especially in large coastal towns.

3. Mangroves

Papua New Guinea supports large tracts of extensive coastal mangrove ecosystems (150,000 hectares), and is a center of biodiversity, including 37 species belonging to 20 different genera. Mangroves are largely found on the southern coast of PNG, and in major river systems throughout the country, notably the Fly, Kikori, and Purari Rivers. They are internationally significant as spawning and nursery grounds for prawn and fin fisheries that are harvested. Mangrove forests are also utilized for firewood, medicines, and building materials. Large tracts of mangrove forests have been cut down, opening up mangrove canopies, which has resulted in short, stunted species of some fish. There have been proposals to selectively log mangrove communities (for valuable commercial mangrove cedar and other species); if carried out, this will diminish the values of commercial fisheries and subsistence fishing. In addition, mangrove habitats are greatly affected and even destroyed by polluted

waters and heavy metals from mine tailings, oil spills, industrial wastes, and sewage and farm fertilizer runoff. There has been a considerable loss of mangrove vegetation along the Hanuabada and Motukea coastline on the outskirts of Port Moresby; however, such losses in mangrove ecosystems around the country are not documented or monitored[12].

4. Introduction of Exotic Species

Several non-endemic species have been introduced to PNG over the years. Introduction of exotic fish began in 1930 when *Gambusia affinis* was introduced by the Department of Health for malaria control. Apart from pest control, other objectives have been to improve nutrition and welfare, ornamentation, sport, and aquaculture. Most introductions have not been successful, and only nine of the 26 species of fish introduced to PNG have established naturally reproducing populations. Introductions of food species fish include trout, carp, catfish, perch, and tilapias. Two of them, tilapia and carp, have not become the basis of an aquaculture industry as originally intended, but are components of large inland commercial or subsistence fisheries. The introduction of Mozambique tilapia has had both positive and negative impacts; while it now provides a major subsistence source of protein to villagers living along inland waterways, it has come to dominate native fish faunas, has little commercial value outside PNG, and increases turbidity in clear waters.

Two introduced aquatic weeds have also greatly affected fisheries, notably water hyacinth and salvinia. Both have grown rapidly in waterways and lakes throughout PNG, causing significant blockages of the Sepik and Ramu Rivers in the 1980s. A salvinia control project (PNG/FAO/UNDP) was initiated in 1981 on the Sepik River using mechanical and chemical removal, but was only partially successful and has been since abandoned. A biological control program, developed by the Australian Commonwealth Scientific and Industrial Research Organisation, was instituted by releasing a South American weevil that feeds on salvinia. This has reduced salvinia populations in the Sepik River to acceptable levels for navigation. However, aquatic weeds continue to affect fish catches adversely, as well as sago gathering in other waterways.

5. Species at Risk

Several saltwater and freshwater species are endangered by human activities. Saltwater and freshwater crocodile populations are the best-known examples of species that were threatened with extinction in the 1950s and 1960s because of over-hunting for their skins. In 1969, the Crocodile Trade Protection Act banned the trade in skins below 5.1 centimeters belly width, helping to slow the decline in numbers[13]. It also led to the emergence of commercial crocodile ranch-farming, replacing the trade in wild skins by captive-raised populations. In spite of this, it appears that the trade of crocodile products is underreported and unsustainable. A 1994 survey showed damage to populations based on observed trends, and led to CITES imposing management restrictions on the crocodile trade. There are also other marine species at risk, particularly sedentary and slow-moving species that are easily accessible in shallow reefs, and are susceptible to overexploitation. These include sea cucumber, green snail, mother of pearl shells, giant clams, and trochus shells. Giant clams are listed by CITES (Convention on International Trade of Endangered and Threatened Species), and some species are extinct in many other Pacific countries. Fishing is also moving to previously unexploited areas, exposing new sedentary populations to threats.

6. Commercial and Subsistence Fishing

In general, PNG's fisheries are relatively unexploited compared to some of its Asian and Pacific neighbors. In spite of this, localized species depletions have been recorded. However, good data on the numbers, diversity,

catch rates, non-target (or by-catch) catch rates, and harvest rates of various species are severely lacking. Because there is no monitoring or awareness of these issues, many fisheries could be in danger of being over-fished.

PNG has an Exclusive Economic Zone (EEZ) of 2,437,480 sq. km, and the fisheries industries contribute export earnings of over 200 million Kina (2001) and employ 3,500 individuals in the formal fisheries sector. The economic contribution towards the GDP is small, but growing, and the importance of fisheries to the coastal population and in particular at the subsistence level is significant. Tuna fishing is primarily undertaken by purse seine vessels (a large purse-like net designed to be operated by two boats to encircle an entire school of fish). The total annual catch has fluctuated between 135,000 and 330,000 MT per year over the last ten years, with variations reflecting oceanographic conditions and the status of access arrangements. The domestic tuna industry has recorded very large growth, particularly in long-line fishing, surface tuna fisheries, and onshore processing (canning). In 1997, 6,250 MT were exported at a value of 14 million Kina, rising in 2001 to 40,730 MT at a value of 144 million Kina.

PNG and seven neighboring countries have a long-standing agreement not to allow the number of licensed purse seine vessels to exceed 205. Taiwan, Philippines, Korea, and other countries operate foreign-based purse seiners. The total foreign vessels catch in 2000 was estimated at 160,000 MT, valued at approximately at US$ 100 million. However, there is considerable concern that the vessels are catching non-target species of fish (by-catch) as well, such as big eye tuna whose stock is more vulnerable to over-exploitation. The fact that full data is not available for these catches could lead to a risk of resource overexploitation; this warrants further study.

The other main commercial fishing is prawn trawling in the Gulf of Papua, the Torres Strait, and in the Orangerie Bay. The main species captured are tiger prawns, banana prawns, and endeavor prawns. Several fisheries have established Mean Sustainable Yields (MSY) and catch quotas to manage their fisheries. Others are managed using limited entry, established annual total allowable catch levels, and area closures to protect nursery stock. However, as with tuna, there is a large unutilized by-catch of non-target fish species, which in many cases is greater in weight than the prawns. The National Fisheries Authority limits prawn fishing in the Gulf of Papua to 15 licenses a year, including two reserved for traditional resource owners, and a 4-month closure of the main fishing grounds to limit fishing and protect juveniles after the spawning season. These limitations generally keep catches within the estimated sustainable average of 600 MT of banana prawns per year. In addition, trawl fishing is not permitted within the 3-mile limit of the gulf in order to protect juvenile prawns and breeding stocks, and not to transgress on traditional fishing areas.

While the largest overall catch is taken by the commercial sector, subsistence and artisanal fishing remains the most important in socioeconomic terms to most Papua New Guineans. Subsistence fishing uses low technological methods and uses virtually everything that is caught. The artisanal sector sells catch for cash income, and uses a variety of traditional and modern methods to harvest fish products. This sector provides the most fish for the domestic market, as well as some for export.

7. Institutional Responsibilities and Legislation

The Fisheries Management Act 1998 essentially empowers National Fisheries Authority to manage, control, and regulate PNG's fishery resources, whether inland, coastal, or offshore. The Act recognizes and allows for customary uses, rights, and traditional resource ownership; however, it does not in itself empower provincial, or lower-level government to manage fisheries in what they may consider their areas of jurisdiction.

The Crocodile Trade Protection Act of 1969 regulates the commercial crocodile skin industry. DEC has a National Crocodile Management Unit that monitors crocodile nest numbers by aerial surveys. PNG is a party to the UN framework Convention on Highly Migratory Fish Stocks. NAQIA manages applications to import aquatic species for aquaculture in the country, and the Highlands Aquaculture Development Centre in Aiyura distributes manages fish farms.

8. Challenges

This sector suffers from a severe lack of data, thereby hampering efforts to effectively understand and manage the priorities for PNG. It is not clear if this is a priority area yet, but if the experience with logging is any indication, it is quite likely that the current levels of fish-catch are pushing the limits of sustainability and that by-catch and target fish catch should be monitored. There are serious threats to some species, and some are at risk of disappearing altogether. It is also necessary to monitor the impact of introduced fish species, and to better understand the dynamics of freshwater and marine ecosystems. Initiatives on community fisheries management and enforcement of fisheries regulations should be supported. Improved public awareness, and enforcement and management systems using community-based initiatives are important for sustainable economic returns for the resource owners.

1. Availability of Fresh Water

The total freshwater area in Papua New Guinea in 1997 was estimated at 64,341 sq. km, comprising approximately 5,383 freshwater lakes and wetlands, and around 14 major rivers (such as the Fly, Strickland, Sepik, Ramu, and the Markham Rivers). This represented a decline of freshwater swamps by 24% from 1986 levels (see chart below). Approximately 91 sq. km of the total freshwater area is designated as protected. Papua New Guinea receives an average rainfall of about 3000 mm per year and is wet all year round; rainfall is therefore another important source of freshwater (particularly for all small coral atolls and islands). The limestone composition of the country, with volcanic sand and karst rocks, also provides a good high-quality groundwater supply, especially along the coast.

Surface Water Bodies in Papua New Guinea

	1986 (IUCN,km^2)	1997 (Km^2)	Protected (Km^2)
Freshwater Swamp	78,962	59,621	4
Lakes	1,526	1,526	87
Rivers	3,191	3,194	0

Source: Protected Areas Systems Review of the Indo-Malayan Realm, Asian Wetland Bureau, 1997

Beaver Falls, Southern Highlands (Photo: Rocky Roe)

The total renewable water resources per capita (including river flows, groundwater flows from rainfall in the country, and river flows from the Indonesian part of the island), were 170, 258 m^3 in 1999[14]. This is very high compared with many other countries in the region and extremely high compared to most countries in other regions of the world.

Annual Renewable Water Resources

	Total Resources (Km^3)	Water Resources available in 1999 (m^3/person)
World	41,022.00	8,240
East Asia	13,206.74	3,680*
Oceania	1,614.25	54,795*
PNG	801.00	170, 258
Indonesia	2,530.00	13,709
Lao PDR	270.00	55,251
Thailand	110.00	1,845
Cambodia	88.10	40,505
Solomon Islands	44.70	107,194*
Fiji	28.55	34,732*

*1998 figures

Source: World Development Indicators database

2. Water Uses and Access

Water Supply for Domestic Use

Despite this abundance of fresh water resources, Papua New Guinea ranks in the bottom ten countries of the world for access to safe water[15]. In rural areas, only 29% of the population has access to an improved water source[16] (including public standpipes, boreholes, protected wells, or springs). Most rural areas do not have a water supply infrastructure but take water directly from the source. There is direct consumption from major river tributaries, shallow wells on the coastal fringes or dug at the base of sago palms, and from rainwater harvesting. In urban areas, 91% have access to improved water[17], but only 60% of urban households have water piped directly into the home[18]. Water hauling is a major preoccupation for many Papua New Guinean families, a task that is primarily undertaken by women and female children[19].

Village water supply, Kiriwina (Photo: Rocky Roe)

3. Health Effects

Causes of Water Pollution

Water pollution is caused mainly by unregulated runoff from industrial activities, illegal dynamite fishing, and the dumping of tailings by mining companies into rivers (see section on mining). Direct dumping of wastes (domestic solid wastes, hazardous wastes, industrial effluent and sewage) into water bodies also contributes to water pollution. Additionally, sanitation facilities are underdeveloped in Papua New Guinea. Approximately 96% of rural households use traditional toilet facilities. Sanitation facilities are better in urban areas, but fewer than half of these households have flush toilets and many unplanned urban settlements have only very rudimentary facilities.

Illnesses

Diarrhoea is a major contributor to childhood morbidity and mortality, accounting for 9% of admissions to a health facility among children aged 1-4 years and 6% of child deaths in health facilities[20]. The burden of illness ascertained from health facility statistics is, however, greatly underestimated, as many cases of diarrhoea are managed at home (ranging from 45% in the Islands region to 80% in the Highlands[21]). In addition, diarrhoea may not be recorded as a primary diagnosis even if it contributed to admission and death[22]. Diarrhoea occurs most frequently among children aged 1-2 years and is especially common in the Highlands and Momase regions[23]. Children typically have between two and three bouts of diarrhoea a year[24], but the frequency can be higher among families living in rural areas more and among children of mothers without schooling. Repeated bouts of diarrhoea can be fatal, and are associated with weight loss and growth faltering, including stunting, which is difficult to reverse if experienced early.[25]

Admissions and deaths from diarrhoea have declined in the last two decades[26], similar to other low- and middle-income countries, where reductions in deaths from diarrhoea are considered to be the largest single contributor to the worldwide decline in child mortality. However, this trend is probably due to better case management at peripheral facilities, especially with the use of oral re-hydration treatment (ORT) rather than a reduction in incidence of disease. An exception to the trend in PNG was in 1999 when diarrhoea outbreaks were observed in several provinces, and diarrhoea deaths at health facilities increased by 25%.

Typhoid is increasing. Before the 1980s only sporadic cases were recorded. Now, however, typhoid represents one of the most important public health problems in the highlands, especially among young adults[27], and has spread to all other regions. The rise in the number of case does not, however, appear to be due to water pollution, as epidemiological investigations suggest that transmission appears to occur primarily from person-to-person contact[28]. However, availability of water and its impact on personal hygiene could be an issue.

Improvements in water supply alone will not produce many health benefits, but improvements in water supply and sanitation together can produce greater impacts than either alone, especially in rural areas. A reduction in diarrhoeal morbidity of between 15-25% and mortality of up to 40% can result if water is pumped directly into or near the household[29]. Evidence from several sources suggests that improved quantities of water are more important than improved quality, perhaps indicating an effect through cleaning rather than consumption. In addition, the impact of any improvements in water and sanitation would need to be accompanied by changes in behavior regarding hygiene practices, including not sheltering domestic animals within homes, protection of water, food and public places from fecal and other contamination, and hand-washing.

4. Institutional Responsibilities and Legislation

The right to allocate water resources is vested in the Department of Environment and Conservation (DEC). Major users of water resources include the PNG National Water Board (to manage and operate most of the water supply systems), the Eda Ranu (the National Capital District management system for Water Supply and Sewage), National Department of Health - Environmental Health Division (the Department coordinates water supply to rural areas), Municipal Councils, Local Governments, agricultural or commercial processing facilities, and manufacturing and mining industries.

Three legislations deal with water resource management: the Water Resources Act 1982 (to be replaced by provisions of the new Environment Act 2000), National Water Supply and Sewage Act 1986, and the Public Health Act. These broadly cover the regulatory provisions for managing and monitoring the quality of water in PNG, the statutory provisions dealing with unauthorized discharge of effluents into water, the schedule and standards currently in existence, and the by-laws to ensure the proper discharge of effluent, including issue of formal permits regulating discharges and requiring water quality monitoring. However, no definite water management policies have been formulated to support the Water Resources Act. A water control district can be declared by the Environment Minister for DEC to manage the catchments area and the water resource. This prohibits cutting or destruction of trees, construction or altering of drains or channels, construction or removal of embankment, etc. All new economic and infrastructure developments and extensions to existing projects are required to have comprehensive environmental health impact assessment plans in place.

Waste Water Management in Coffee Production

Coffee ranks along with oil palm as one of the two most important cash crops in PNG, primarily for the export market. Processing of coffee is by the "wet" method, which causes large quantities of organic matter to be released into the water. Only coarse-level screening is carried out to separate the skin or pulp before discharging the organic-rich effluent directly into creeks and rivers. Although the effluent is not toxic, the high Biological Oxygen Demand (BOD) results in a depletion of oxygen in the water, affecting aquatic life. There are no specific water quality or effluent standards for coffee wastewater in PNG, but there is a requirement under the water use permits system to achieve an effluent concentration of 100mg/L of BOD within five years.

Inspection of factories by the Bureau of Water Resources indicates that most factories screen the coffee pulp from wastewater before discharge. A few factories have oxidation ponds that may not be operating properly due to lack of proper engineering design and poor maintenance. This needs continued attention because 65% of coffee is grown and processed by small holders who cannot afford and do not have the skill for operating individually designed wastewater treatment systems. There may be significant point pollution issues associated with the use of herbicides and fertilizers even with smallholdings, which have yet to be monitored. According to the Coffee Research Institute, further research is necessary to develop water quality models for river control regions; develop effluent discharge standards for coffee factories; conduct surveys to document water usage, and process techniques; and to design appropriate technology for small holders.

Source: NRI

5. Challenges

Issues relating to the proper maintenance of water supplies need to be addressed if a lasting impact is to be made. Communities have not always been willing to take responsibility for ongoing maintenance of installations with the result that a high percentage can become inoperable after a few years[30]. Clearly, the challenge lies in both educating the users and in providing services.

1. Background

PNG is prone to natural disasters. The country is located along the active volcanic 'Pacific Rim of Fire,' with 14 active and 22 dormant volcanoes. The earliest record of an eruption was that of Mt Lamington, which erupted in 1951, killing over 3000 people in Oro Province. The most recent eruptions were Mt Uluwan and Mt Tavurvur, both of which erupted in 1994, and Manam in 1997. The Australian and Pacific Tectonic Plates are still moving, with potential for volcanic eruptions, earthquakes, and tsunamis. The tsunami in Aitape in 1998 was attributed to the movement of the tectonic plates. An earthquake with a magnitude of 7 on the Richter scale had its epicenter about 30 km offshore from the coastal villages of Sissano, Warapu, Arop, and Malol. It caused a series of giant waves that crashed into a 30 km section of the beach. A total of 2,217 people were killed, many were seriously injured, and 9,000 people were left homeless. PNG is second only to Japan in the number of recorded tsunamis.

PNG lies just outside the Main Tropical Cyclone belt within the Southwest Pacific region. However, there is a high probability of tropical cyclones forming outside and tracking into PNG. The part of the country located from 8 to 20 degrees south is prone to cyclones. On average, cyclones hit the country at the rate of one cyclone per year. Heavy rainfall in parts of the country can cause flooding of villages located in major catchments areas. Landslips and landslides are also common, especially in localized regions where the landscape has been degraded due to land clearing.

The drought and frost of 1997/98 was caused by the El Nino phenomenon. In a normal year, the temperature of the sea around the island of New Guinea is high. This causes trade winds to be blown in and hot humid air rises up into the cool atmosphere, producing normal rain patterns for PNG. In an El Nino year, for reasons not yet understood, the area of the sea that has a high temperature moves away from the island of New Guinea towards South America. As a result, high rainfall then occurred in South America, and drought conditions occurred in PNG. Natural calamities such as drought and frost, and the outbreak of pests (locusts) and diseases (coffee rust) threaten food security and the economic base of the rural primary industry.

2. Institutional Responsibilities and Legislation

The National Disaster Management Act of 1984 provided for the establishment of a National Disaster Management Office to develop policies and plans, in collaboration with line agencies, for natural disaster risk management preparedness and response. Based on recent experiences, awareness programs have been developed to educate people on the risks of natural disasters and how to avoid, or be prepared to manage, situations after disasters. The lessons learned from various natural disasters have enhanced the understanding of the impact of these natural disasters. These recent experiences have helped the institutions and line agencies to improve surveillance and develop the capacity to manage natural and man-made disasters.

3. Challenges

It is important that environmental risk be more appropriately inserted in the development framework in terms of both preparedness and mitigation. One of the main constraints to effective disaster management is the absence or continued vandalism of seismic equipment, weather recording and telecommunication facilities, and navigational aids such as lighthouses. Provision of these facilities improves safety of coastal shipping, monitors and forecasts volcanic eruptions, cyclones, and rainfall patterns for planning purposes, and facilitates disaster management and response programs. Public education is needed to preserve these essential warning systems.

Convention	Date signed/ acceded	Date ratified/ joined/ entry into force
Convention on Biological Diversity	13 June 1992	16 March 1993
UNFCCC	13 June 1992	16 March 1993
Kyoto Protocol	2 March 1999	
Vienna Convention on Substances that Deplete the Ozone Layer		October 27,1992; May 4,1993 (London amendment)
Montreal Protocol		October 27,1992;
Stockholm Convention on Persistent Organic Pollutants	May 23, 2001	
UN Convention to Combat Desertification		December 6,2000; entry into force 6 March 2001
Ramsar Convention on Wetlands		16 July 1993
CITES	12 December 1975	11 March 1976
World Heritage Convention		28 July 1997 (acceptance)
Antarctic Treaty		March 16, 1981 (acceding state)

Source: DEC/various web sites

Papua New Guinea is a signatory to a number of International Conventions addressing global and trans-boundary environmental concerns, and is implementing several projects towards these efforts. Some of these are summarized below.

Convention on Biological Diversity:

PNG is preparing the "National Biodiversity Strategy and Action Plan" to meet its commitments to the Convention on Biological Diversity, as well as to ensure that the country's globally significant biodiversity is fully considered in any natural resource development.

Kyoto Protocol to the UN Framework Convention on Climate Change:

Anecdotal evidence of the impact of climate change comes from the reporting of malaria cases in the highlands of PNG, and the cultivation of mid-altitude crops in high altitude agro-ecosystems. The PNG Climate Change Assistance Project under implementation aims to develop methods, build capacity, and strengthen national institutions to assess the socio-economic and environmental impact of climate change. In addition, the regional South Pacific Sea Level & Climate Monitoring Project (funded by the AusAid program) involves the monitoring of sea level, and water and air temperature, and has monitoring stations at Lombrum Naval Base on Manus Island, on an island off Port Moresby.

Montreal Protocol on Substances that Deplete the Ozone Layer:

PNG's country program for phase-out of Ozone Depleting Substances (ODS) was prepared in 1996, and PNG has received Montreal Protocol funding through the United Nations Environment Program (UNEP) for phase-out activities. PNG's reported consumption of ODS is 45.2 MT in the refrigeration sector.

Ramsar Convention on Wetlands:

PNG submits triennial national reports to the Conference of Contracting Parties. PNG is working towards developing a National Wetlands Management Policy. There are currently two declared wetlands (Tonda and Lake Kutubu), and the country is investigating an additional potential wetland to declare under the Convention.

Environmental Institutions and Responsibilities

The key environmental institutions, which are mandated to safeguard the environment in PNG, are the Department of Environment and Conservation (DEC), National Forest Service/National Forest Authority (NFS/NFA), National Fisheries Authority (NFA) and the National Agricultural Quarantine and Inspection Authority (NAQIA), which operates under the Department of Agriculture and Livestock (DAL).

Department of Environment and Conservation (DEC)

DEC reports directly to the Environment and Conservation Minister. DEC has statutory obligations to formulate policies and legislations for the National Executive Council (NEC) to enact bills in relation to environmental protection. DEC's mission statement is "to ensure natural and physical resources are managed to sustain environmental quality and human well-being." There are three divisions: Top Management and Corporate Services, Environment Management and Protection, and Conservation Management and Development. DEC is also responsible for evaluating environmental plans, issuing water use permits under the Water Resources Act 1982 for the abstraction of water for domestic and industrial uses, and for controlling the disposal of industrial and domestic effluents into the waterways and marine environments. DEC is tasked to monitor the compliance and enforce environmental legislations.

National Forest Authority (NFA)

NFA was established in 1993. The mission statement is "to promote the management and wise utilization of the forest resources of Papua New Guinea as a renewable asset for the well-being of the present and future generations." NFA is responsible in formulating and maintaining the National Forest Plan and the National Forest Development Plan as defined under the Forestry Act, and maintaining a monitoring and compliance program and sustainable yield management.

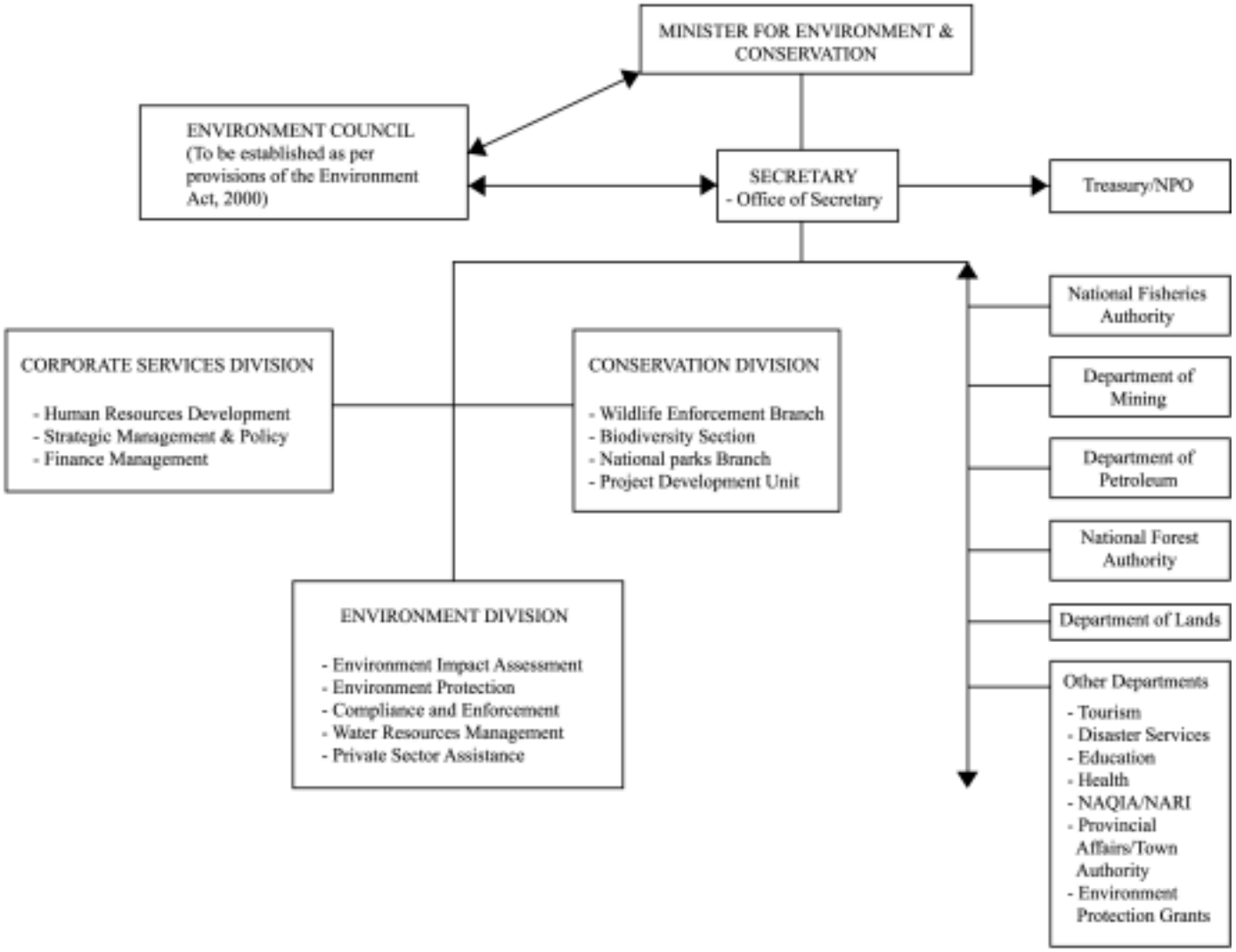
Other state institutions

Other state institutions that are involved in the environmental protection in PNG include the Departments of Mining, Fisheries, Education, Attorney General, Lands, Tourism, Petroleum and Energy, Health, Works, National Agricultural Quarantine and Inspection Authority (NAQIA), National Disaster Office, Water board/Eda Ranu, and City/Town Authorities.

Non-Governmental Organizations (NGOs)

NGOs, specifically environmental NGOs, in Papua New Guinea play an important role in developing community-based conservation programs so that local landowners realize their right to a safe and clean environment. The NGOs monitor compliance with PNG's environmental regulations of resource developers in the processing facilities, agricultural industries, fisheries, forestry, and the mining sector.

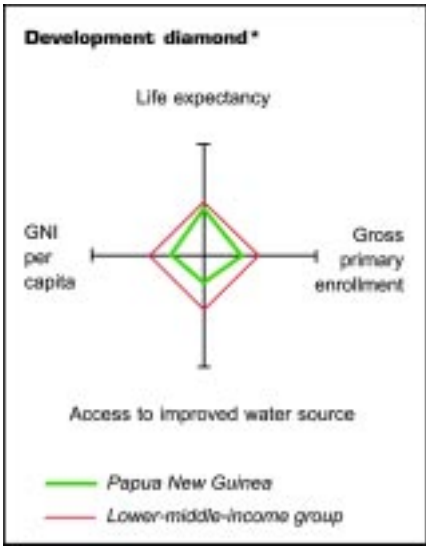
DEPARTMENT OF ENVIRONMENT & CONSERVATION : STRUCTURE AND LINE AGENCIES



Papua New Guinea

9/13/01

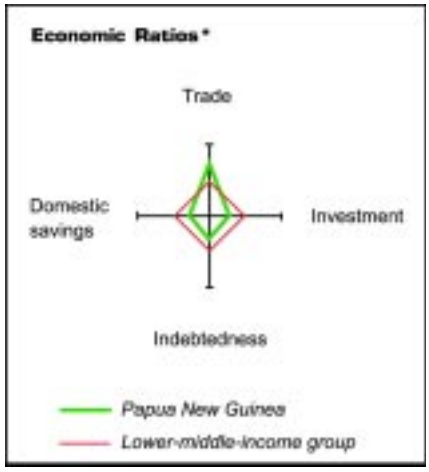
POVERTY and SOCIAL 2000	Papua New Guinea	East Asia & Pacific	Lower - Middle - income
Population,mid-year (millions)	5.1	1,853	2,046
GNI per capita (Atlas method,US$)	690	1,060	1,140
GNI (Atlas method,US$ billions)	3.5	1,964	2,327
Average annual growth,1994-00			
Population(%)	2.7	1.1	1.0
Labor force (%)	2.3	1.4	1.3
Most recent estimate (latest year available,1994-00)			
Poverty (% of population below national poverty line)	38	-	-
Urban population (% of total population)	17	35	42
Life expectancy at birth (years)	58	69	69
Infant mortality (per 1,000 live births)	58	35	32
Child mulnutrition (% of children under 5)	30	13	11
Access to an improved water source (% of population)	42	75	80
Illiteracy(% of population age 15+)	35	14	15
Gross primary enrollment (% of school-age population)	80	119	114
Male	87	121	116
Female	74	121	114



KEY ECONOMIC RATIOS and LONG-TERM TRENDS

	1980	1990	1999	2000
GDP(US$ billions)	2.5	3.2	3.7	3.8
Gross domestic investment/GDP	25.2	24.4	17.4	15.4
Exports of goods and services/GDP	43.2	40.6	44.5	47.7
Gross domestic savings/GDP	15.1	16.1	14.5	17.4
Gross national savings/GDP	19.0	9.0	15.8	15.8
Current account balance/GDP	- 12.2	- 9.8	- 5.0	1.1
Interest payments/GDP	2.0	4.8	1.5	2.3
Total debt/GDP	28.2	80.5	73.2	69.7
Total debt service/exports	13.8	35.5	9.9	17.3
Present value of debt/GDP	-	-	-	-
Present value of debt/exports	-	-	-	-

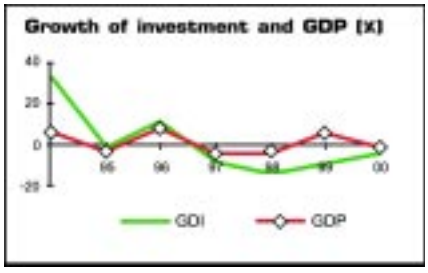
	1980-90	1990-00	1999	2000	2000-04
(average annual growth)					
GDP	1.9	4.1	5.4	- 1.8	1.4
GDP per capita	- 0.4	1.4	2.6	- 4.4	- 1.3
Exports of goods and services	3.3	2.8	- 4.4	- 7.6	- 4.3

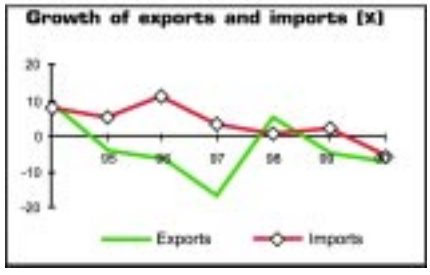


STRUCTURE of the ECONOMY

	1980	1990	1999	2000
(% of GDP)				
Agriculture	33.1	29.0	29.4	25.9
Industry	26.8	30.4	38.4	43.6
Manufacturing	9.5	9.0	8.4	7.8
Services	40.0	40.6	32.2	30.5
Private consumption	60.9	59.0	64.5	63.2
General government consumption	24.1	24.8	21.0	19.4
Imports of goods and services	53.3	48.9	47.3	45.7

	1980-90	1990-00	1999	2000
(average annual growth)				
Agriculture	1.8	3.9	5.1	3.5
Industry	1.9	5.6	2.5	- 0.9
Manufacturing	0.1	5.3	- 1.9	- 7.0
Services	2.0	3.1	8.7	- 7.1
Private consumption	0.4	6.2	17.1	- 0.9
General government consumption	- 0.1	2.6	0.9	3.9
Gross domestic investment	- 0.9	- 0.7	- 10.4	- 6.1
Imports of goods and services	- 1.3	2.4	1.4	- 5.8





Notes: 2000 data are preliminary estimates.

* the diamonds show four key indicators in the country (in bold) compared with its income-group average.If data are missing,the diamond will be incomplete.

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