



Pacific
Community
Communauté
du Pacifique

Papua New Guinea Ridge to Reef Island Diagnostic Analysis Technical Report



Papua New Guinea Ridge to Reef Island Diagnostic Analysis Technical Report

Prepared and produced by GEF Pacific International Waters Ridge to Reef Regional Project,
Pacific Community (SPC), Suva, Fiji



Suva, Fiji, 2021

© Pacific Community (SPC) 2021

All rights for commercial/for profit reproduction or translation, in any form, reserved. SPC authorises the partial reproduction or translation of this material for scientific, educational or research purposes, provided that SPC and the source document are properly acknowledged. Permission to reproduce the document and/or translate in whole, in any form, whether for commercial/for profit or non-profit purposes, must be requested in writing. Original SPC artwork may not be altered or separately published without permission.

Original text: English

Prepared and produced by GEF Pacific International Waters Ridge to Reef Regional Project, Pacific Community (SPC), Suva, Fiji

Layout and Design by Navneet Lal/Pacific Community (SPC)

Prepared for publication at SPC's Suva Regional Office, Private Mail Bag, Suva, Fiji, 2021
www.spc.int | spc@spc.int

Printed by Quality Print, Suva, Fiji, 2021

CONTENTS

Abbreviations	v
List of Figures.....	vi
List of Tables	vi
Executive Summary	1
1. Introduction	2
2. Methodology	3
2.1 Background	3
2.2 PNG Methodology	3
Identifying and prioritising environmental problems:	3
Island Environmental Problem Prioritisation Criteria:	3
Determining environmental and socio-economic impacts:	3
Developing causal chains:	3
3. Description of Papua New Guinea	4
3.1 Physical and Geographical Characteristics	4
3.2 Socio-economic Situation	8
3.3 Ecological Status	14
4. Ridge to Reef Management in PNG	18
4.1 Natural Resources	18
Freshwater	18
Coastal Resources	19
Vulnerability and Adaptation (V&A) Assessments	20
Land	20
Solid Waste	20
Liquid Waste	21
Land rehabilitation	21
Forest	22
Minerals	22
4.2 Nature Reserves and Protected Areas	23
4.3 Island Vulnerability	24
4.3.1 Types of disasters	24
4.3.2 Issues and concerns	26
4.3.3 Measures to manage impacts	28
4.6. Institutional, Legal and Policy Factors	29
4.6.1 Institutional Setting	29
4.6.2 Constraints and Limitations	34
4.7 Public and Stakeholder Participation	37
5. National Priority Issues	37
5.1 Key Problems, Sectors, and Immediate Causes	37
6. Options for Reform and Action	44

7. Findings and Recommendations.....	46
References.....	47
Annex 1: List of environmental problems.....	52
Annex 2: Criteria for prioritising environmental problems.....	53
Annex 3: Criteria list for locating priority site.....	54
Annex 4: Template for cause and impacts.....	56
Annex 5: Criteria for prioritising identified options for reform and action	77
Annex 6: National Parks of Papua New Guinea.....	88

ABBREVIATIONS

ADB	Asian Development Bank
CEPA	Conservation and Environmental Protection Authority
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
FAO	Food and Agriculture Organization
GDP	Gross Domestic Product
GEF	Global Environment Facility
IDA	Island Diagnostic Analysis
IPA	Investment Promotion Authority
MDG	Millennium Development Goal
NDAL	National Department of Agriculture and Livestock
NRM	Natural Resource Management
R2R	Ridge to Reef
REDD/REDD Plus	Reducing emissions from deforestation and forest degradation
SAP	Strategic Action Plan
SDG	Sustainable Development Goal
SIDS	Small Island Developing States
UNDP	United Nations Development Programme
V&A	Vulnerability and Adaptation Assessment
WaSH	Water, Sanitation and Hygiene
WMA	Wildlife Managed Area

LIST OF FIGURES

Figure 1: Map of Papua New Guinea	4
Figure 2: Main geographical features of the southwest Pacific region discussed in the text.	5
Figure 3: Vegetation distribution in PNG (source: Shearman et al. 2008)	7
Figure 4: Mortality in PNG (Source: WHO 2013)	14
Figure 5. Progress in water supply and sanitation coverage.....	19
Figure 6: A young man on a mining site in PNG.....	21
Figure 7: Porgera Gold Mine – a large silver and gold mining operation in Enga Province, PNG.	23
Figure 8. Coastal erosion at Wewak township.....	25
Figure 9: Annual rainfall for Port Moresby. Light blue bars indicate El Niño years, dark blue bars indicate La Niña years and the grey bars indicate neutral years. (Source https://www.pacificclimatechangescience.org)	28

LIST OF TABLES

Table 1: PNG Demographics summary (http://www.indexmundi.com)	8
Table 2: Immigrants from Papua New Guinea by region of destination, 2010 (Source: World Bank 2010b)	11
Table 3: PNG and Australia Demographic Health Survey (Source: UNDP Human Development Report 2013)	13
Table 4: Key environmental legislations with formal status.....	15
Table 5: Special species of interest PNG	15
Table 6: Representation of habitat types in existing protected areas (source: Government of Papua New Guinea 2015).....	17
Table 7. Water Resources	18
Table 8: Protected Areas in PNG (Source: CEPA Database 2014).....	24
Table 9 Summary of PNG legislation relevant to the management of the catchment, coastal and marine environment, and resources	31
Table 10: Major multilateral environmental agreements signed by Papua New Guinea	32

EXECUTIVE SUMMARY

Environmental problems that affect Pacific Island countries affect the livelihood, socio-economic and general well-being of local communities with different impacts on men, women, children, youth, the elderly, and those living with disabilities. Many of these problems are cross-sectoral in nature and influence the entire system, from ridge to reef. The rising onslaught of climate change and the issues relating to unsustainable and irresponsible management of natural resources further compounds the problem. This report is a diagnostic analysis of priority environmental problems that were identified through extensive literature review and desktop research of current and previously identified environmental issues in Papua New Guinea (PNG).

The following six priority issues were common during stakeholder discussions and are documented in relevant national and environmental reports. These are issues that affect the ridge to reef system and have both direct and indirect socio-economic impacts. These identified priority issues of concern are listed as follows:

1. Deforestation and mining: 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. Agricultural expansion: loss of critical habitats and biodiversity.
6. Declining coastal and marine resources.

Simple analyses were then conducted to identify the root causes of these problems, along with practices and sources from which these environmental threats have risen. The main causes of the environmental problems in many areas of PNG were mainly related to deforestation, mining, and agricultural expansion; essentially poor land resource management practices. These would form the basis of potential leverage points where options for reform and intervention may be introduced.

Reviewing current policies, stronger enforcement measures, building local capacity and technical expertise, and tighter stakeholder collaborations could be preliminary measures towards addressing and mitigating these problems. The development of management plans, stakeholder collaborations, consultations and capacity building should be undertaken through a gender lens, taking into consideration the roles, responsibilities and needs of men, women, youth, the elderly, those with infirmities and minority groups within communities. Understanding stakeholders through such a lens will significantly strengthen future undertakings in environmental reform and mitigation and thus, social, and economic well-being.

1. INTRODUCTION

The close interconnections between the 'Ridge to Reef' system in Small Island Developing States (SIDS) covers a significant part of the land, water, and coastal systems. The integration of freshwater watershed management with coastal area management is considered essential to foster effective cross-sectoral coordination in the planning and management of these resources. Inherent in the approach is the philosophy of cross-sectoral coordination in the planning and management of freshwater use, sanitation, wastewater treatment and pollution control, sustainable land use and forestry practices, balancing coastal livelihoods and biodiversity conservation, hazard and risk reduction, and climate variability and change.

Proper and thoughtful diagnosis is necessary to effectively mitigate and address issues and challenges that affect the 'ridge to reef' system. Focussed dialogue and consultations with the relevant stakeholders is the beginning of identifying and highlighting priority issues that affect the environmental and socio-economic landscapes of SIDS.

The Island Diagnostic Analysis (IDA) was designed as a tool and a collaborative stepwise process to identify, quantify, and set priorities for environmental problems that are cross-sectoral (or from ridge to reef) in nature. The IDA is intended to help identify potential leverage points and options for reform and intervention.

Consequently, at the country level an IDA would provide the factual basis for the formulation of a Strategic Action Framework (SAF) and Strategic Action Plan (SAP) for Ridge to Reef. In addition to this, however, the IDA would be part of a process of engagement with stakeholders through the initial IDA development steps and the subsequent development of alternative solutions through the development of the SAF and SAP.

National stakeholders were engaged at the outset to form part of the IDA Development Team and perform the bulk of the analysis. National consultants were hired to develop specific aspects of the IDA reports, particularly the economic and social evaluations of options for reform. It is recognised that a comprehensive consultation process would need to include consideration of the roles, responsibilities and needs of men, women, youth, the elderly, those with disabilities and minority groups within communities.



2. METHODOLOGY

2.1 Background

Stakeholders from the various sectors and disciplines were present for the IDA workshop and included representatives from the Government, the private sector, civil society organisations (CSOs) and leaders of the local communities. Both genders and vulnerable groups were represented at the workshop. Effort was made to ensure that the group was representative of a range of areas of expertise including natural scientists, social, legal, political, and economic experts. While specific consideration was not given to conducting the IDA process through a gender lens, it has been noted that this is integral to a comprehensive study.

2.2 PNG Methodology

Identifying and prioritising environmental problems:

The IDA Development Team developed a complete list of the environmental problems in country and prioritised them based on the criteria provided in Annex 2 using printed score sheets. Each team member scored the environmental problems individually.

Island Environmental Problem Prioritisation Criteria:

Based on the set of defined criteria, a score was assigned to each transboundary problem as 0 (no importance), 1 (low importance), 2 (moderate importance) or 3 (high importance) to determine the relevance of the problem.

Determining environmental and socio-economic impacts:

Working in small breakout groups, IDA Development Team members identified the following for each of the priority cross-sectoral problems:

- The environmental impacts
- The direct and indirect socio-economic impacts
- Linkages between impacts and other island environmental problems
- Geographical location(s) of impacts/consequences.

Developing causal chains:

Each identified island environmental problem was reviewed, and its associated environmental and socio-economic impacts discussed.

For each problem, the following were identified and listed:

- The key sectors (e.g., industry, agriculture, fisheries, etc.)
- The immediate causes
- The underlying resource uses and practices that contribute to each immediate cause

- The underlying social, economic, legal, and political causes of each immediate cause
- Link the resource uses and practices, and social, economic, legal, and political causes
- Determine the root causes

The causal chain was developed for each of the issues identified.

The working groups reported their findings in plenary and refined their assessments with facilitated feedback, which was recorded.

3. DESCRIPTION OF PAPUA NEW GUINEA



Figure 1: Map of Papua New Guinea

3.1 Physical and Geographical Characteristics

Papua New Guinea (Figure 1) is the world's second largest island. It lies in the south-western Pacific Ocean between latitudes 3° and 11° and longitudes 141° and 156°. The country comprises about 600 small islands with an area of 452,860 km², surrounded by an Economic Exclusive zone of 3,120,000 km². With over 700 native languages, it is the world's most linguistically diverse country. Approximately 80 per cent of the country's population lives in rural areas with few or no modern amenities. Many tribes in the remote mountainous interior have little contact with one another, let alone with the outside world, and rely on a subsistence economy (PNG country profile 2019).

Papua New Guinea has one land border – that which divides the island of New Guinea from Indonesia. Across the 820 km (509 mi) border, the western half of New Guinea is officially known as [Papua province](#), governed by [Indonesia](#). Papua New Guinea's border with Indonesia is not straight; it loops slightly to the west in the south-central part of New Guinea. Papua New Guinea's [Western Province](#) contains that loop. There are maritime borders with [Australia](#) to the south and [Solomon Islands](#) to the southeast.

Geology

The main island of Papua New Guinea has been formed by interaction between the Australian Plate in the southwest, and the Pacific Plate in the northeast. Between these two major crustal elements – the platform and the oceanic crust and island arcs – is a highly deformed mobile belt (Dow 1977). Papua New Guinea’s rugged mountains, complex geology and its substantial mineral resources all result from its location along the collision zone between the continental crust of the Australian Plate to the south and the oceanic crust of the Pacific Plate to the north (Figure 2).



Figure 2: Main geographical features of the southwest Pacific region discussed in the text.

The light shaded areas are regions of submerged continental crust drawn at the 200 m bathymetric contour (Hall 2002).

Many aspects of Papua New Guinea’s geological and tectonic evolution are still poorly known, and this is partially a result of the dense rainforest cover, rugged terrain, and lack of infrastructure. It is also linked, however, to the lack of publicly accessible geochemical, geochronological, and isotopic data, and the scarcity of many rock units of well-constrained paleomagnetic data. Any description of the geological and tectonic evolution of Papua New Guinea must necessarily be rather speculative (Shepard et al. 2012).

Soils and Topography

The largest section of the country is the eastern half of New Guinea’s island, which is dominated by a massive central cordillera, or system of mountain ranges, extending from Indonesia’s Irian Jaya to Papua New Guinea’s East Cape at the end of the [Owen Stanley Range](#), including Mt. [Wilhelm](#). A second chain of mountains borders the north coast and runs parallel to the central cordillera. The

Highlands consist of a number of smaller ranges running west to east, such as the Finisterre Range, which dominates the Huon Peninsula to the north of the city of Lae.

Papua New Guinea has [several active and recently active volcanoes](#), as it is located along the [Pacific Ring of Fire \(Pieters 1982\)](#). Volcanic eruptions are not rare, and because of this, the region is vulnerable to [earthquakes](#) and [tsunamis](#). Papua New Guinea is also vulnerable to [landslides](#), which are mostly caused by massive deforestation. [Mount Wilhelm](#) is the highest peak at 4509 m (14,793 ft). Important rivers are the Sepik, which winds through lowland [swamp](#) plains flowing about 1130 km (700 mi) to the north coast, and the Fly, which is navigable for 800 km (500 mi) in the southwest and flows through one of the largest [swamplands](#) in the world to the south coast.

The smaller [islands](#) of Papua New Guinea are also areas of intense topographical contrast and usually feature mountain ranges that rise directly from the sea or narrow coastal plains. The northern part of New Britain and Bougainville is dominated by volcanic landforms and some of the smaller islands are extremely volcanic. The area of Bougainville–New Ireland includes the islands of Bougainville and Buka, New Britain's Gazelle Peninsula, New Ireland, New Hanover, the [St. Matthias](#) group and the Admiralty Islands (<http://www.nationsencyclopedia.com>).

Looking at soil taxonomy, 8 orders (Entisols, Elistosols, Inceptisols, Vertisols, Mollisols, Alfisols, Ultisols and Oxisols), 26 suborders and 61 great soil groups have been identified in Papua New Guinea (Bleeker 1983, 1988).

Climate

The climate in Papua New Guinea is hot and humid throughout the year along the coasts and in the plains, while it progressively becomes cooler, and then colder with increased altitude. There is no dry season in most of the region. Some areas are filled with thick rainforests and thus have an equatorial climate; there is a relatively dry season from July to September in some inland valleys and along the southern coast, where the climate is tropical. The climate is influenced by the monsoon circulation, the northwest monsoon from December to April, and the southeast monsoon from May to October, which usually bring rainfall in the exposed slopes, but in many areas even in both. Rainfall typically varies from 2000 mm to 4000 mm (80 inches to 160 inches) per year, with some higher peaks on the exposed slopes, where it reaches as high as 7 m – 8 m (23 feet – 26 feet) per year, while it drops to 1000 mm – 1500 mm (40 in – 60 in) in the southern coast, overlooking the Gulf of Papua and the Coral Sea (<https://www.climatestotravel.com>).

Natural disasters

Located across the tropical area and along the Pacific Ring of Fire, Papua New Guinea is vulnerable to natural disasters such as volcanic eruptions, floods, cyclones, landslides, tsunamis, etc. The National Disaster Centre has classified certain hazards (Table 1) which are prevalent in Papua New Guinea (<http://pngndc.gov.pg>).

ORIGIN	PHENOMENA/EXAMPLES
<p>Hydrometeorological Hazards Natural processes or phenomena of atmospheric, hydrological, or oceanographic nature</p>	<ul style="list-style-type: none"> • Flood, debris, and mudflows • Tropical cyclone, storm surge, wind, rain, and other severe storms • Drought, temperature extreme, frost and desertification
<p>Geological Hazards Natural earth processes or phenomena that include processes of endogenous origin or tectonic exogenous origin, such as mass movement</p>	<ul style="list-style-type: none"> • Earthquake, tsunami • Volcanic activity and emission • Mass movements, landslides, rockslides, liquefaction, sub-marine slides • Surface collapse, geological fault activity
<p>Biological Hazards Processes of organic origin or those conveyed by biological vectors, including exposure to pathogenic micro-organisms, toxins, and bio-active substances.</p>	<ul style="list-style-type: none"> • Outbreak of epidemic disease, plant, or animal • Contagion and extensive infestation

Natural hazards common in PNG

Vegetation

Between 15,000 and 20,000 plant species thrive in New Guinea, many in the island’s forests. The favourable soil types, climate and species migration from other areas have brought about this extraordinary diversity. (<http://wwf.panda.org>)

Papua New Guinea’s flora is rich and varied, with habitats ranging from tidal [swamps](#) at sea level to alpine conditions. Various mangrove species form the main vegetation in low-lying coastal areas, along with the beautiful casuarina, sago, and palm. The majority of the country is covered by [tropical](#) rainforest and [savanna](#), where valuable trees such as kwila and cedar are found. Orchids, lilies, ferns, and creepers abound in the rainforests. There are large stands of pine at elevations between 910 m and 1220 m (3000 ft –4,000 ft). Mosses, lichens, and other alpine vegetation predominate at the highest altitudes (<http://www.nationsencyclopedia.com>). Figure 3 provides an illustration of the vegetation distribution in PNG.

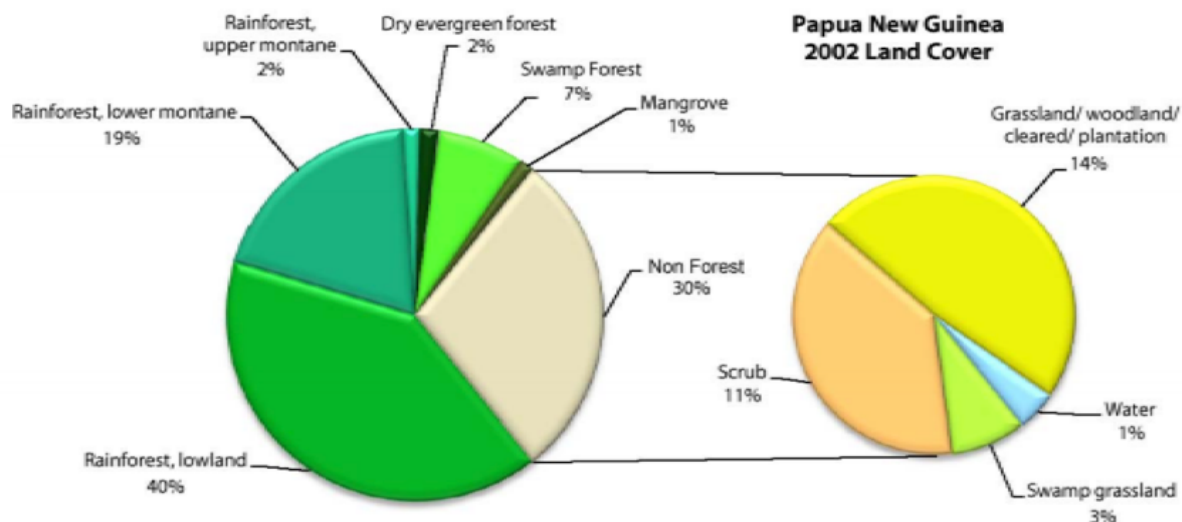


Figure 3: Vegetation distribution in PNG (source: Shearman et al. 2008)

Hydrogeology

Geologically, Papua New Guinea is a young country. The presence of high mountain ranges and abundant rainfall across much of the country contributes to high runoff. There are nine divisions of the hydrological drainage (basins). The Sepik, Fly, Purari and Markham River basins are the largest. While the Sepik has the lowest annual discharge, it has the largest catchment area, 78 000 km², followed by the Fly River with 61 000 km², Purari with 33 670 km², and Markham with 12 000 km². The other catchments have areas of less than 5000 km² and are very steep (FAO 1999).

3.2 Socio-economic Situation

Demographic processes

Papua New Guinea is geographically highly diversified, with a range of habitats and climate regimes, which favoured a broad range of human settlements over the ages (Bryant 1983). This led to a high diversity of ethnic groups within the country.

According to the 2020 UNDP Human Development Report, Papua New Guinea has a Gender Inequality Index (GII) value of 0.725, ranking it 161 out of 162 countries in the 2019 index. In Papua New Guinea, 0 per cent of parliamentary seats are held by women, and 10.0 per cent of adult women have reached at least a secondary level of education compared to 15.2 per cent of their male counterparts. For every 100,000 live births, 145.0 women die from pregnancy related causes; and the adolescent birth rate is 52.7 births per 1,000 women of ages 15-19. Female participation in the labour market is 46.3 percent compared to 48.0 for men (UNDP 2020).

Table 1: PNG Demographics summary (<http://www.indexmundi.com>)

Population	6,791,317 (July 2016 est.)
Age structure	0-14 years: 33.93% (male 1,173,034/female 1,131,387) 15-24 years: 19.86% (male 683,474/female 665,245) 25-54 years: 36.65% (male 1,281,641/female 1,207,658) 55-64 years: 5.39% (male 185,846/female 180,255) 65 years and over: 4.16% (male 143,851/female 138,926) (2016 est.)
Dependency ratios	total dependency ratio: 67.1 youth dependency ratio: 62.1 elderly dependency ratio: 5 potential support ratio: 19.9 (2015 est.)
Median age	total: 22.9 years male: 23 years female: 22.8 years (2016 est.)
Population growth rate	1.75% (2016 est.)
Birth rate	24 births/1,000 population (2016 est.)
Death rate	6.5 deaths/1,000 population (2016 est.)
Net migration rate	0 migrant(s)/1,000 population (2016 est.)
Urbanisation	urban population: 13% of total population (2015) rate of urbanisation: 2.12% annual rate of change (2010-15 est.)

Population	6,791,317 (July 2016 est.)
Major cities - population	PORT MORESBY (capital) 345,000 (2015)
Sex ratio	at birth: 1.05 male(s)/female 0-14 years: 1.04 male(s)/female 15-24 years: 1.03 male(s)/female 25-54 years: 1.06 male(s)/female 55-64 years: 1.03 male(s)/female 65 years and over: 1.06 male(s)/female total population: 1.04 male(s)/female (2016 est.)
Infant mortality rate	total: 37.4 deaths/1,000 live births male: 40.9 deaths/1,000 live births female: 33.8 deaths/1,000 live births (2016 est.)
Life expectancy at birth	total population: 67.2 years male: 65 years female: 69.5 years (2016 est.)
Total fertility rate	3.1 children born/woman (2016 est.)
HIV/AIDS - adult prevalence rate	0.79% (2015 est.)
HIV/AIDS - people living with HIV/AIDS	40,100 (2015 est.)
HIV/AIDS - deaths	900 (2015 est.)
Drinking water source	improved: urban: 88% of population rural: 32.8% of population total: 40% of population unimproved: urban: 12% of population rural: 67.2% of population total: 60% of population (2015 est.)
Sanitation facility access	improved: urban: 56.4% of population rural: 13.3% of population total: 18.9% of population unimproved: urban: 43.6% of population rural: 86.7% of population total: 81.1% of population (2015 est.)
Major infectious diseases	degree of risk: very high food or waterborne diseases: bacterial diarrhea, hepatitis A, and typhoid fever vector-borne diseases: dengue fever and malaria note: active local transmission of Zika virus by Aedes species mosquitoes has been identified in this country (as of August 2016); it poses an important risk (a large number of cases possible) among US citizens if bitten by an infective mosquito; other less common ways to get Zika are through sex, via blood transfusion, or during pregnancy, in which the pregnant woman passes Zika virus to her fetus (2016)
Nationality	noun: Papua New Guinean(s) adjective: Papua New Guinean
Ethnic groups	Melanesian, Papuan, Negrito, Micronesian, Polynesian

Population	6,791,317 (July 2016 est.)
Religions	Roman Catholic 27%, Protestant 69.4% (Evangelical Lutheran 19.5%, United Church 11.5%, Seventh-Day Adventist 10%, Pentecostal 8.6%, Evangelical Alliance 5.2%, Anglican 3.2%, Baptist 2.5%, other Protestant 8.9%), Baha'i 0.3%, indigenous beliefs and other 3.3% (2000 census)
Languages	Tok Pisin (official), English (official), Hiri Motu (official), some 839 indigenous languages spoken (about 12% of the world's total); many languages have fewer than 1,000 speakers note: Tok Pisin, a creole language, is widely used and understood; English is spoken by 1%-2%; Hiri Motu is spoken by less than 2%
Literacy	definition: age 15 and over can read and write total population: 64.2% male: 65.6% female: 62.8% (2015 est.)
People - note	the indigenous population of Papua New Guinea (PNG) is one of the most heterogeneous in the world; PNG has several thousand separate communities, most with only a few hundred people; divided by language, customs, and tradition, some of these communities have engaged in low-scale tribal conflict with their neighbors for millennia; the advent of modern weapons and modern migrants into urban areas has greatly magnified the impact of this lawlessness
Education expenditures	NA
Maternal mortality rate	215 deaths/100,000 live births (2015 est.)
Children under the age of 5 years underweight	27.9% (2011)
Health expenditures	4.3% of GDP (2014)
Physicians density	0.06 physicians/1,000 population (2010)
Obesity - adult prevalence rate	25.5% (2014)

Migration Processes

In PNG, the number of emigrants and immigrants is significantly lower than the world average. The main factors contributing to this lower percentage of both immigration and emigration in PNG include cultural land ties, strong societal bonds, lack of educational, finance and network resources, and customary land ownership system (Naser 2014). Until the early 1990s, PNG had experienced relatively low growth and high unemployment rates over long periods (Browne and Mineshima 2007). Nevertheless, no significant emigration trend from PNG has been observed (ibid.). The traditional Wantok system has a significant motivating effect on trends and patterns of migration within PNG. The Wantok system provides strong support, both socially and in terms of livelihoods. The system provides members with social insurance and the sharing of responsibilities for the care of the needy. A PNG researcher also corroborated this concept by the fact that migrants often maintain their Wantok relationships by sending money back, allowing them to resume their former positions within the community whenever they return (Naser 2015).

Nonetheless, the study on migration by the African Caribbean Pacific (ACP) Observatory identifies more practical aspects for a relatively low percentage of emigration. In PNG, a high percentage of the population living in rural areas lacks access to higher education and other resources necessary for emigration. These people are unable to meet the skilled migration requirements set by developed countries' immigration policies, such as neighbouring Australia and New Zealand. However, in recent years, international migration to Australia and other neighbouring countries has increased. According to the World Bank's Bilateral Migration Matrix, more than 90 per cent of migrants originating from PNG move within the continent of Oceania (2010).

Table 2: Immigrants from Papua New Guinea by region of destination, 2010 (Source: World Bank 2010b)

	Stock	Share of stock
Oceania	55,261	90.30%
Europe	2,181	3.56%
North America	2,778	4.53%
South America	22	0.03%
Asia	540	0.88%
Other South	413	0.67%

State of Economy

PNG has vast reserves of natural resources, but exploitation has been hampered by rugged terrain, land tenure issues, and the high cost of developing infrastructure. The economy is focused mainly on the extraction and export of the abundant natural resources. Mineral deposits, including copper, gold and oil, account for nearly two-thirds of the export earnings. Agriculture provides a subsistence livelihood for 85 per cent of the people. Natural gas reserves amount to an estimated 227 billion cubic metres. There are five liquefied natural gas (LNG) projects in PNG. The LNG sector is an important contributor to PNG's GDP; the value of LNG exports in 2017 was estimated to be at USD3.6 billion while GDP was estimated to be at USD20.5 billion (Wikipedia).

Economically, the overall economic growth performance of PNG has been consistent since the mid-2000s with real per capita gross domestic product (GDP) averaging 3 per cent. While revenues continue to be challenged by low global commodity prices, good macroeconomic management and well-calibrated services delivery are needed to ensure that more citizens will have access to development benefits in the future (World Bank 2020).

The country's economy remains dominated by two sectors: the agricultural, forestry and fishing sector, which engages most of the labour force (the majority informally); and the minerals and energy extraction sector, which accounts for the majority of export earnings and GCP (Country Profile: PNG 2015).

To diversify PNG's asset base and increase employment, investment is needed to strengthen capacity in institutions, human capital, and physical infrastructure. Electricity, telecommunications, road, and other transport infrastructure remain critical to enabling growth driven by the private sector (The World Bank 2020).

Obtaining more revenue from the mineral and petroleum sector by discontinuing the practice of granting significant tax concessions to companies operating in this sector will improve both the fiscal balance and the foreign exchange position in PNG. Furthermore, translating income into strong, tangible improvements in living standards for all Papua New Guineans remains a key challenge for the Government of PNG, yet other challenges are also immense. It is important to improve public financial management and efficiency of public spending in order to convert resource revenues into inclusive growth and, consequently, a genuine improvement in livelihoods (Pumwa 2013).

Industry

In general, the economy of Papua New Guinea relies heavily on imports for manufactured goods. Its industrial sector excluding mining accounts for only 9 per cent of GDP and contributes little to exports. Small-scale industries manufacture beer, soap, concrete products, clothing, paper products, matches, ice cream, canned meat, fruit juices, furniture, plywood, and paint. The small domestic market, relatively high wages, and high cost of transport are constraints to industrial development (IBP 2015).

Agriculture and Crops

Between 7000 and 10,000 years ago, people in PNG began practising agriculture. The earliest evidence for this is in the [Kuk Swamp](#) area, where plants were grown, dug, stacked and perhaps drainage was used to grow taro, banana, sago and yam (Bourke 2011).

Between the 17th to 19th centuries, a small number of plant species, including [sweet potato](#), [cassava](#) and [tobacco](#) were brought from the Americas by Europeans and introduced to Indonesia from where they spread to New Guinea. Further crops were introduced directly by Europeans in the second part of the 19th century and especially after 1870, including beans, pumpkin, corn, watermelon, papaya, mangosteen, durian, orange, lemon, coffee, lime, and guava (ibid).

Papua New Guinea has fertile soils and a favourable climate that allows a wide range of cash crops to be cultivated, especially in highlands, coastal and island regions. Production of cash crops is usually centred on plantations, but significant smallholder production among rural communities also exists. Small scale farmers either sell their produce to the plantations, or to the numerous community boards that act as centralised buyer and seller set up to stabilise prices and enhance negotiating power. The main agricultural exports of the country include cocoa, coffee, copra, palm oil, rubber, and tea (www.pwc.com).

The agricultural sector accounts for approximately a quarter of Papua New Guinea's GDP. Agriculture remains the principal economic activity, which provides livelihood for 85 per cent of the rural population who rely directly on subsistence farming for their basic needs, having only little contact with the formal economy (ibid).

Livestock

No ceremony, no feast is complete in PNG without many pigs being slaughtered. Pigs live under the houses with dogs and poultry and are a sign of wealth. Other livestock includes goats, cattle and sheep, cassowary, wallaby, and deer, although their numbers are comparatively low. Currently factory methods are used in the processing of poultry and egg. In the last few years crocodiles have been added to the farmers' produce. They lie around in ponds until large enough to be turned into products such as meat and skin hide ([Fridriksson](#) 2015).

Social development and living conditions

People living in rural areas live in a variety of traditional houses made from bush materials, whereas people in towns tend to live in Western-style housing. Traditional housing in rural areas appears to be adequate, but in urban areas there are acute shortages because of migration. Squatter settlements have been established in most urban areas. New housing has generally fallen far short of meeting the demand, especially for medium- and low-cost units. As of 1988, the housing stock totalled 555,000 and the number of people per dwelling averaged 5.8. As of 2000, about 87 per cent of the population lived in rural areas.

A survey conducted by World Vision Australia (2013) on health and well-being in PNG highlights that the main problems are limited access to basic health and education services. Roads do not often exist or are of a poor standard. Due to the high rainfall and soil erosion, they are hard to maintain. People must walk long distances to get to school or get to a medical facility. Diet is what can be grown in gardens – sweet potato, taro, and greens. Only 10 per cent of people have a telephone and less than two per cent have access to the internet (World Vision Australia 2013).

The following table was extracted from the UNDP Human Development report (2013) illustrating demographics of PNG when compared to similar information in Australia.

Table 3: PNG and Australia Demographic Health Survey (Source: UNDP Human Development Report 2013)

Category	PNG	Australia
Population	7.2 million	23 million
Urban population	13%	89%
Human Development Index	156/187	2/187
% of children reaching Year 5	68%	100%
Population using improved water sources	39%	100%
Adult literacy rate	Male: 63% Female: 51%	Male: 99% Female: 99%
Life expectancy at birth	63 years	82 years
Under-five mortality rate (per 1000 live births)	58	5
Maternal mortality (per 100,000 live births)	733*	7
Population under 15 years	41%	20%

Health and Hygiene

Health services across PNG are extremely poor, particularly in rural areas, where roads often do not exist and there is a shortage of skilled health workers. Such limitations have a negative impact on the prevention and treatment of health problems. In addition, people in remote areas lack access to clean drinking water and adequate sanitation. This means that communicable diseases like diarrhoea and cholera are major causes of illness and death, especially in young children. Malnutrition and HIV and AIDS are also long-term health problems, and tobacco and alcohol use is becoming increasingly problematic. The limited number of skilled health-care professionals and hospitals available to the population is a major health challenge in PNG. PNG has a total of fewer than 400 doctors and only 51 works outside the capital Port Moresby even though 87 per cent of people live in rural areas. For every 17,068 people, PNG has one doctor compared to one doctor for every 302 people in Australia. PNG has a similar shortage of nurses, with approximately one nurse for every 2270 people. In Australia, there is one nurse for every 100 people (World Vision Australia 2013; World Bank 2010).

Leading causes of mortality in PNG

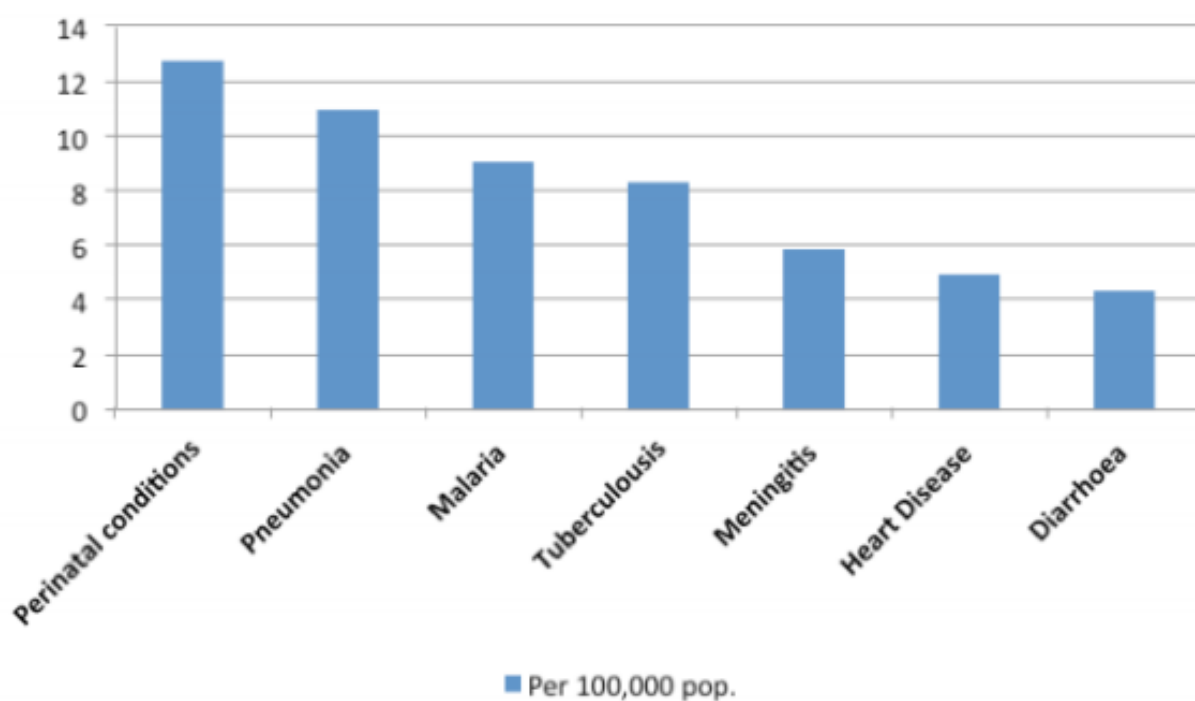


Figure 4: Mortality in PNG (Source: WHO 2013)

3.3 Ecological Status

PNG is seen as one of the last places on earth that have untouched, pristine natural environments. PNG contains more than 7 per cent of the world's biodiversity in less than 1 per cent of the world's land area (FAO 2016). The PNG government has various policies concerned with protected areas in the country. According to the country's constitution, such policies were formulated so that "Papua New Guinea's natural resources and environment should be conserved and used for all and should be replenished for the benefit of ourselves and prosperity of the environment and its sacred, scenic and historical qualities for future generations" (SPREP and EDO NSW 2018). Under the National Parks Act 1982, the Protected Area is seen as "an area that has been reserved for: (a) the recreation and amusement of the public; (b) a national park; (c) a botanical or zoological garden and (d) a reserve or sanctuary for the protection of flora or fauna" (PacLII database). There are currently eight national parks in PNG, comprising one per cent of the land area.

Table 4: Key environmental legislations with formal status.

1982	Fauna Act
1978	Conservation Areas Act
1982	Crocodile Trade Act
1982	International Trade Act
2000	Environment Act
1982	National Parks Act

The relative government ministries had their difficulties in implementing the policies, resulting in environmental degradation through unsustainable use of the land resources. The reasons for the ineffectiveness of policy enforcement by the ministries concerned have been attributed mainly to the lack of resources and funding to be able to monitor whether companies complied with the regulations. This allowed companies to indiscriminately extract resources. The PNG government has amended and endorsed new policies to help protect its environment, namely the Protected Areas policy.

The protected areas policy is closely related to the protected areas project which is a partnership between Conservation and Environment Protection Authority (CEPA), Tenkile Conservation Alliance, Woodland Park Zoo, the United Nations Development Programme (UNDP) and the Global Environment Facility (GEF). The protected areas project aims to improve conservation efforts at three important natural sites in PNG from 2015 to 2020 (UNDP 2015).

Biodiversity hotspots

Biodiversity hotspots are areas that support natural ecosystems that are largely intact and where native species and communities associated with the ecosystems are represented. To qualify as a biodiversity hotspot, a region must satisfy two strict criteria. It must have at least 1500 endemic vascular plants and 30 per cent or less of its original natural vegetation (Myers et al. 2000). Biodiversity hot spots are also characterised by a high diversity of endemism. Hot spots help prioritise funding for management of areas of biological and ecological importance.

Biodiversity

New Guinea contains the third largest tropical rainforest in the world following the Amazon and the Congo Basin with over 80 per cent of the total land area containing forests (REDDPlus). PNG is said to have a very high biodiversity with many undiscovered species. It is home to more than 18,894 described plant species, 719 birds, 271 mammals, 227 reptiles, 266 amphibians, 341 freshwater species, 600 species of corals and 3000 species of reef fish (IUCN 2008), Ind. State of PNG 2014). Overall, approximately a third of the species are endemic to Papua New Guinea (Kula 2010).

Table 5: Special species of interest PNG

Aquatic /Marine Species of Interest			
<i>Kogia breviceps</i>	<i>Pygmy sperm whale</i>	<i>Melanotaenia lacustris</i>	<i>Kutubu rainbowfish</i>
<i>Dugong dugon</i>	<i>Dugong</i>	<i>Stenella longirostris</i>	<i>Spinner dolphin</i>
<i>Crocodylus porosus</i>	<i>Salt-water crocodile</i>	<i>Cheilinus undulatus</i>	<i>Humphead wrasse</i>

Aquatic /Marine Species of Interest			
Crocodylus novaeguineae	<i>New Guinea freshwater crocodile</i>	<i>Chelodina parkeri</i>	<i>Parker's snake-necked turtle</i>
Terrestrial Species of interest			
<i>Dendrolagus matschiei</i>	<i>Huon tree kangaroo</i>	<i>Zaglossus bartoni</i>	<i>Long-beaked echidna</i>
<i>Phalanger sericeus</i>	<i>Mountain cuscus</i>	<i>Dactilopsila palpator</i>	<i>Long fingered triok</i>
<i>Nyctimeninae sp.</i>	<i>Tube-nosed fruit bat</i>	<i>Litoria graminea</i>	<i>Northern New Guinea tree frog</i>
<i>Dorcopsulus vanheurni</i>	<i>Forest Wallaby</i>	<i>Thylogale browni</i>	<i>New Guinea Pademelon</i>
Birds of PNG			
<i>Casuarus bennetti</i>	<i>Dwarf cassowary</i>	<i>Harpyopsis novaeguineae</i>	<i>New Guinea harpy-eagle</i>
<i>Psitttrichas fulgidus</i>	<i>New Guinea vulturine parrot</i>	<i>Parotia wahnesi</i>	<i>Wahnes's parotia</i>
<i>Paradisaea guilielmi</i>	<i>Emperor bird of paradise</i>		

The flora and fauna of PNG are of both intrinsic cultural and economic significance. The bird of paradise, for example, is seen on the nation's flag, whereas Huon tree kangaroo is sought for its meat by the locals. The Environment Act, the Crocodile Act and the International Trade Act regulate any use or trade of flora and fauna. The PNG Conservation and Environmental Protection Agency (CEPA), Kamiali Group and the Protected Areas Network are a few of the nation's leading bio-conservation institutions.

Major threats and concerns

Four major threats have been listed in the National Report to the Convention on Biological Diversity:

- Rapidly expanding human population
- Industry
- Forest conversion and degradation
- Climate change

PNG's expanding population also puts pressure on the environment to provide resources. The population growth rate between 2000 and 2005 was estimated at 3.2 per cent per annum with rates of 2.2 per cent and 3.9 per cent in urban and rural areas respectively (Shearman et al. 2008). The increase in population directly affects the industry sector. Coconuts, coffee, cocoa, timber, fisheries, forestry, mining, tea, and vanilla industries continue to expand to meet the national and world demand (Kula 2010).

PNG forests are being degraded at a rate of 1.41 per cent per year (Shearman 2010). For the period from 1972 to 2002, 48.2 per cent of forest change was due to logging (0.9 million ha deforested; 2.9 million ha degraded) and 45.6 per cent (3.6 million ha) was cleared for subsistence agriculture (Shearman et al. 2008).

Finally, climate change will also have an impact on biodiversity mainly due to habitat loss and changes in the temperature of the environment. An ecosystem's vulnerability to climate change depends on the tolerance of its species towards change, the degree of change and the other stresses that already affect it (Lawler 2009).

Review of Rapid Coastal Assessment

In 2009, the Papua New Guinea government in conjunction with Australian Aid, CSIRO (Commonwealth Scientific and Industrial Research Organization) and the University of Queensland conducted a major coastal and marine assessment. The results of the report have been used by CEPA and the PNG government to improve environmental decision-making. The report summarises efforts toward marine and coastal conservation and identifies key areas to be protected. PNG is also party to several multilateral agreements including the Convention on Biological Diversity, the Coral Triangle Initiative and the World Convention on the Protection of Cultural and Natural Heritages. Through these agreements, the country policies adopt targets such as identifying and managing priority seascape, establishing, and effectively managing marine protected areas, measuring climate change adaptation achieved, improving the status of endangered species, etc. The government objectives are to protect at least 10 per cent of its marine areas and 20 per cent of its coastal areas. Current efforts have shown that approximately 2.2 per cent of the total reef habitat of PNG is protected. For deep-water habitats, 1 per cent is currently protected and 13 per cent of all mangroves are within the protected areas.

Table 6: Representation of habitat types in existing protected areas (source: Government of Papua New Guinea 2015)

	% of total habitat area contained in existing reserves	BIOREGIONS				
		Pacific warm pool	Bismarck Sea	Solomon Sea	Coral Sea	Eastern Arafura
Important Bird Areas (IBA)	0.31	0.31	0.00	0.00	0.00	0.00
Coral Reef	2.20	1.90	5.95	0.07	0.00	0.00
Deep Habitats	0.36	0.08	0.73	0.35	0.39	4.33
Mangroves	13.73	10.38	13.76	2.01	55.60	13.42
Spawning aggregations	15.61	15.61	0.00	0.00	0.00	0.00
Important Turtle Sites	1.69	1.69	0.00	0.00	0.00	0.00
Important Whale Areas	0.00	0.00	0.00	0.00	0.00	0.00

4. RIDGE TO REEF MANAGEMENT IN PNG

4.1 Natural Resources

Freshwater

PNG's high mountain range and rainfall contribute to the abundance of surface water resources. A total of nine hydrological drainage divisions are present, the largest river basins are the Fly Sepik, Purari and Markham basins. Sepik has the largest catchment area, 78,000 km², followed by the Fly River with 61,000 km², Purari with 33,670 km² and Markham with 12,000 km² (FAO 2011). Ground water is increasingly being used as a reliable source of clean drinking water. Since the 1980s groundwater has been developed for urban water supply. The abundance of water and geography of the land allows water energy to be harnessed for electricity. The gross theoretical hydropower potential for Papua New Guinea is 17,5000 GWh/year. The Sirinumu dam and the Yonki dam are two of the major dams providing electricity and water for the bulk of the nation's urban areas. In 2009, the total dam capacity was estimated at 665 million m³. The Sepik basins and the Fly River basin have respectively, 3 per cent and 7 per cent of their total area across the border in Indonesia. The CEPA is responsible for the management and protection of the country's water resources, pollution control, water-related laws and regulations, and their enforcement. Its Water Resources Management Branch is responsible for the management, conservation, and control of the natural water resources. The Branch's policy states that the role of the Bureau is: "To monitor, manage and control the country's water resources in an effective and efficient manner for the benefit of the community, as stipulated in the Water Resources Act 1982" (FAO 2011, IPA 2006).

PNG's growing population and the mining and logging industries are seen as the country's greatest threat to the available water resources. Due to the lack of policies protecting the water sources, settlers have occupied areas around the headwaters causing concern for pollution at the original source. Additionally, there are no proper catchment management plans that would dictate the land use type in the area and equally distribute water resources (www.pacificwater.org).

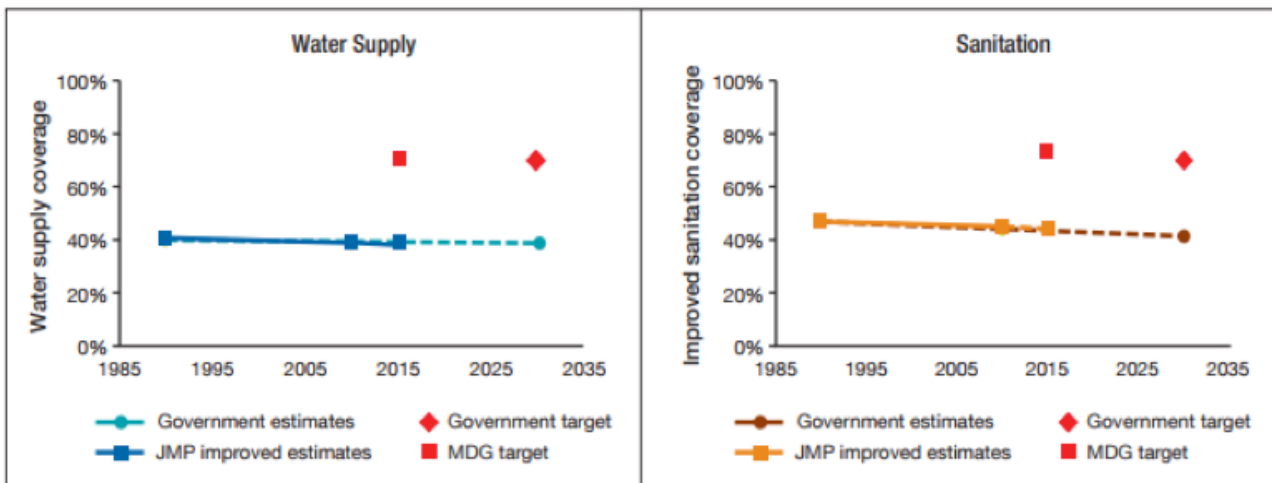
Table 7. Water Resources

Water resources

Renewable freshwater resources			
Precipitation (long-term average)	-	3 142	mm/yr
	-	1 454 000	million m ³ /yr
Internal renewable water resources (long-term average)	-	801 000	million m ³ /yr
Total actual renewable water resources	-	801 000	million m ³ /yr
Dependency ratio	-	0	%
Total actual renewable water resources per inhabitant	2009	119 499	m ³ /yr
Total dam capacity	2009	665	million m ³

SOURCE: www.fao.org/nr/water/aquastat/countries_regions/PNG/

Government targets for access to safe drinking water are conservative compared with the Millennium Development Goals (MDG), which aimed to achieve 70 per cent access to water and 70 per cent access to improved sanitation by 2015. The government expects to achieve these same targets 15 years later than MDG commitments (Figure 5).



Source: JMP (2012).
Note: Broken lines represent projections.

Figure 5. Progress in water supply and sanitation coverage

Note: Broken lines represent projections

Because of the decline in access for both water and sanitation and the inability to keep pace with rapid population growth, PNG was unable to meet its MDG targets for both water and sanitation (Independent State of PNG 2015). Significant and urgent investment in sustainable water supply and sanitation is needed if the country is to meet its national targets to 2030, as projected in Figure 5.

Already, diarrhoea and other water, sanitation, and hygiene (WASH)–related illnesses are a leading cause of mortality in PNG, especially for young children. Declining water and sanitation access rates pose a significant public health threat, and more outbreaks such as the cholera outbreak in 2009–2010 can reasonably be anticipated (WSP 2013).

Coastal Resources

PNG 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. PNG has a total sea area – exclusive economic zone (EEZ) – of 3,120,000 km² and 17,110 km of coastline (Sowei 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 (Nicholls 2004).

The coral reefs of PNG are considered one of the most diverse in the world; recent surveys have reported that the country’s reef is in good health, and this is largely due to the geographical isolation of these areas and lack of anthropogenic activity in the area (ADB 2014). However, reefs closer to the mainland and settlements are more degraded because of boats, motors, anchors, and explosives (Drew et al. 2015). In addition, high influxes of sediment and freshwater into the marine coral habitats from human activities such as mining, deforestation, and agriculture, especially near river mouths, are disruptive to coral reef development (Longenecker et al. 2019)

Papua New Guinea has extensive coastal systems over 150,000 ha. This centre of biodiversity provides spawning and nursery grounds for prawn and fin fisheries. There is a lack of information on the mangroves, however, some areas such as the Hanuabada and Motukea coastline on the outskirts of Port Moresby have lost large areas of mangrove forests to development (ADB 2014). Decline in mangroves is mainly caused by pollutants, such as heavy metals from mine tailings, oil

spills, industrial wastes, and sewage, as well as fertiliser runoff. Mangrove forests are also utilised for firewood, medicines, and building materials. Large tracts of mangrove forests have been cut down, opening mangrove canopies, which has resulted in short, stunted species of some fish. Pollution, habitat destruction, overfishing and climate change are listed as PNG's major threats to its coastal areas. Many of the threats to marine and coastal environments originate upstream. Little is known as to what the impact this is having on coastal areas. Thus, EIAs conducted for development in inland/upstream areas should consider the impacts the development will have on coastal areas.

Vulnerability and Adaptation (V&A) Assessments

Climate change poses one of the greatest challenges for PNG. The country's Vision 2050 document (Government of Papua New Guinea 2009) states that there is a poor understanding of climate change thus, inadequate adaptation measures are in place. The Vision 2050 aims to strengthen policies regarding climate change adaptation. The Climate Change Act 2015 provides for adapting and preparing for disasters. The policy also focuses on building the country's resilience as well as promoting and managing climate change mitigation activities.

In Papua New Guinea's climate action plan to the UN Framework Convention on Climate Change, the country has committed to a 50 per cent reduction in emissions by 2030 and for the country to be carbon neutral by 2050. Other adaptation efforts include the:

- Vision 2050 (to conserve 70% of PNG's Forest for carbon purposes);
- Endorsement of the National REDD+ Strategy.
- Implementation Act of Paris Agreement (October 2016)

These plans target the protection of forests and the management of Green House Gas (GHG) emissions. Moreover, they provide the opportunity for PNG to strengthen and conserve biodiversity (PNG 2009). PNG is one of 43 nations in the Climate Vulnerable Forum and has been a vocal proponent in limiting temperature rise from global warming to 1.5° Celsius. The Paris Agreement on Climate Change seeks to limit temperature rise to 2° Celsius.

Land

PNG has four large islands (Manus, New Ireland, New Britain, and Bougainville) and 600 smaller islands, most of which are located to the east. The country is rich in natural non-renewable resources such as gold, copper, oil, and natural gas reserves. Traditional agricultural practices have resulted in the clearing of 200,000 ha annually. Between 1975 and 1996 nearly 8 per cent of the forested areas were logged with a further 3 per cent subjected to other forms of clearing resulting in the permanent conversion of forest areas to other land uses (<https://www.iucn.org>). Forest reserves account for 70 per cent of the nation's total land area, which is approximately 36 million ha. With the loss of forest areas, there is an increase in soil erosion leading to sedimentation, which will negatively affect coastal areas.

Solid Waste

Solid waste refers to the range of garbage materials that are discarded as unwanted and useless. This would be inclusive of, but not limited to, wastes such as hospital chemicals, batteries, fertilisers, and household waste. A study carried out by Wangi (2013) looked at two cities in PNG and their respective landfills: "Baruni" dump for Port Moresby and the "Second seven" dump for Lae. The two

landfills practice open burning, and this posed a serious environmental and health concern to the public. Apart from the Public Health Act, the 2000 Environment Act and their bylaws, there are no policies specific to solid waste management. Given the increasing population and economic growth, the waste generation in both cities is expected to increase (Wangi 2013).

Liquid Waste

Wastewater from homes and septic tanks is considered liquid waste or grey water. Sewage systems have been mainly developed for urban areas and were first put into place by the colonial Australian Government, and later improved and extended with assistance from the Asian Development Bank (ADB). Surprisingly, there is no sewage treatment plant in the coastal area of Port Moresby, with a population of 67,000 people. For this reason, faecal sludge, once pre-treated in the septic tanks, is discharged directly into the ocean through undersea discharge pipes (Ellery 2018). The current discharge quality is much above the recommend tolerance values and this contributes greatly to the contamination of the coastal areas.

Land rehabilitation

There are several open-cut mines in PNG which pose serious land degradation problems. Under the Environment Act, mining companies are required to have a land rehabilitation plan for the area; however, this is sometimes impossible due to the altered geography, presence of heavy metals and other chemicals as a side effect of mining activities. Limited data has also hampered efforts to carry out land rehabilitation management programmes.



Figure 6: A young man on a mining site in PNG

In developing countries such as PNG, these limitations are often accompanied by poor government guidance and support and the inability of the local communities and often, the mining companies, to see the long-term benefits of sound rehabilitation programmes based on good scientific research. In many cases, the most practical rehabilitation endpoint is to return the disturbed area to some agreed functional system (<https://www.pecc.org>).

Forest

PNG's forests form part of the third largest expanse of tropical rainforests in the world after the Amazon and Congo Basins. The Food and Agriculture Organization (FAO) estimates PNG's total forest cover to be 29 million ha although other sources estimate a slightly higher value of 33 million ha. PNG's forests represent more than 60 per cent of the country's total land area of 46 million ha². According to the latter study, forest cover composition includes lowland rainforest (40%); lower montane rainforest (19%); upper montane rainforest (2 per cent); dry evergreen forest (2 per cent); swamp forest (7 per cent); mangrove (1 per cent); scrub (11 per cent); swamp grassland (3 per cent) and combinations of grassland/woodland/cleared/plantation at 14 per cent. Despite this high forest cover, forests continue to face acute and imminent threats through land use, land use change and forestry activities including deforestation and forest degradation (Forest Trends 2016).

The forestry sector plays an integral part in building PNG's economy. Approximately 80 per cent (37 million ha) of the total land area is classified as forest. However, logging over the past 20 years has reduced the forest area, and is also likely to have reduced the quality of the remaining forests (FAO 2009).

The Forestry Policy sees to the proper management of this resource by setting logging quotas, forestry management programmes, training and recruiting the needed expertise and finally, carrying out forestry stocktake. Forests are key in the protection of watersheds. Water quality reaching coastal areas is also determined by the state of forests upriver. The government's participation in REDD (reducing emissions from deforestation and forest degradation) is part of their plans to carry out the conservation and sustainable management of forests.

Minerals

With mineral export revenues driving the economy and services in the country and a GDP of USD1900 per capita, PNG is undoubtedly a mining state area, with almost 7 million people spread over a land area of 462,840 km². It has vast natural resources in all sectors, including minerals, oil and gas, agriculture, forestry, and fisheries.

The mineral wealth of Papua New Guinea is the result of its geology and includes elements such as silver, copper, nickel, cobalt, chromium, molybdenum, iron, and platinum, several of which are already being mined.

The mineral sector in Papua New Guinea is vibrant and progressive, by far being the major contributor to the GDP, providing more than one third of government tax revenue, as well as royalties to landowners, dividends to equity holders, business development income, and many tangible benefits to host communities that would not otherwise be provided from any source.

Information from the Mineral Resources Authority confirm that most of the mines in PNG mine gold. The two largest gold mines are the Porgera (Enga Province) and Lihir (New Ireland Province) mines. Mining has had drastic environmental effects ranging from land degradation to sedimentation of waterways. The Ok Tedi mine is an example of how sedimentation from mining can inundate a river and displace those that depended on the water source. Deep sea mining ventures are currently in exploration stages in the Pacific (Samar and Lakamanga 2012).



Figure 7: Porgera Gold Mine – a large silver and gold mining operation in Enga Province, PNG

4.2 Nature Reserves and Protected Areas

The Protected Areas Policy was endorsed by the Government in 2014. To ensure its effective implementation, the government – through the CEPA (formerly known as the Department of Environment and Conservation) – hosted public consultation to seek inputs for the implementation plan and progress on the legal framework of the Policy document.

More than 150 representatives from the Government, civil society and private sector groups participated in the public workshops. The consultations allowed stakeholders, including Provincial government administrations to provide meaningful inputs to the Policy Implementation Plan Framework and the Draft Protected Areas Bill. At present PNG has 58 Protected Areas and more yet to be gazetted. It covers 4 per cent of the country's land surface and less than 1 per cent of the seas (Independent State of PNG 2014). Annex 6 documents existing national parks in PNG.

There is no distinction between terrestrial and marine managed areas. However, Wildlife Managed Areas (WMAs) covers both terrestrial and marine. In the past, there has been no legislation governing Marine Protected Areas. Approximately 4 per cent of PNG's terrestrial area and about 6 per cent of the total coral reefs found in the country are under protection and management. There are at least 57 such areas together covering 2.3 million ha (Table 8).

Table 8: Protected Areas in PNG (Source: CEPA Database 2014)

Reserve designation	Number	Area (ha)
Locally Managed Marine Area	12	159,259
National Park	8	28,013
Protected Area	2	20,245
Conservation Area	3	75,000
Protected Seascape	3	39,609
Provincial Park	2	210
Ramsar Site, Wetland of International Importance	2	594,924
Reserve	2	126
Sanctuary	4	36,006
Wildlife Management Area	32	1,348,357
TOTAL	72	2,441,689

4.3 Island Vulnerability

4.3.1 Types of disasters

- PNG has faced a number of disasters both human-induced and natural. The disasters range from health problems to pressing environmental problems such as climate change.
- In the Vision 2050 policy document, PNG sets goals to provide clean drinking water to all communities and improve the country's sanitation standards. This was in light of a cholera outbreak in 2008, which had occurred after a lapse of five decades.
- Civil unrest is a major problem in PNG. A World Bank report in 2014 considers PNG as one of the countries with the highest rate of crime (Lakhani et al. 2014). Robberies, carjackings and rape cases are a major problem; foreigners are advised to take extra caution as they are regularly targeted. The high rate of crime, to include those committed by the infamous "Raskol" gangs, can be opportunistic. Sophisticated criminal enterprises do exist, and their capabilities often exceed that of local enforcement authorities. The civil unrest is accredited to the lack of control by the government and individual economic woes. There have been demonstrations

regarding government entitlements/pensions and landowner disputes regarding payments associated with natural resource projects (e.g., Pangauna Mine).

- PNG's resources have brought wealth and with it a number of environmental hazards such as oil spills, leakage of toxic waste into environment, landslides, etc. The Ok Tedi mine environmental disaster is by far the worst to occur. In 1989 the government allowed BHP mining company to dump tailings waste into the Ok Tedi river using the justification that the economic and social welfare outweighed the ecological damage. This has led to loss of many species and sources of livelihood for villages living down-river. Many villages have had to relocate due to the river being polluted. The unsustainable rate of deforestation is also a major problem. This has contributed to the loss of prime forests and caused landslides.
- PNG is a natural disaster-prone country. Lying along the Pacific "ring of fire" PNG experiences frequent earthquake and volcanic eruptions and tsunami hazards. One of the worst natural disasters is the Mt Lamington volcano eruption in 1951, which claimed the lives of 3000 people. The year 1997 was the last time for a major drought to occur; this was caused by a severe El Nino event. The drought had affected over a million people.

Climate change is a current pressing issue faced by PNG; according to the Pacific Climate Change Science Program (PCCSP 2011), coastal water temperatures in the PNG region have risen gradually since the 1950s. Since the 1970s the rate of warming has been approximately 0.11°C per decade (IPCC 2018). The township of Wewak is facing the brunt of rising sea levels. Each year, the ocean line creeps closer to the town area. Beach areas and road infrastructure have been inundated with sea water or are slowly eroding away (Figure 8).



Figure 8. Coastal erosion at Wewak township

Regarding climate change, structural developments close to the foreshore have seen the degradation of some beaches. Plans to erect barriers such as sea walls were made however, no action has been taken. Coastal areas close to logging and mining areas have seen an increase in water turbidity due to land run off during heavy rains. This, in turn, has affected coral populations and overall reef health in the area (Department of National Planning and Monitoring 2010).

4.3.2 Issues and concerns

Inundation of water resources

Inundation of water resources regularly occurs during tropical cyclones and La Nina years (UNDP 2012). During flooding, wastewater discharge from large urban areas contaminates the natural water sources. Mining, logging, and major agricultural activities also contribute to increased sediment build-up, bacterial and chemical pollution in waterways during the rainy season.

Saltwater intrusion

Climate change and rise in sea levels are closely correlated with saltwater intrusion, thus mainland coastal areas, as well as islands in PNG, are more susceptible to these problems. The intrusion of saline water into coastal farmlands also occur during tidal surges. Saltwater intrusion puts communities at a disadvantage due to the limiting effect on agriculture expansion as well as causing the loss of consumable drinking water sources (UNDP 2012).

Water quality impacts from pollution

According to Water Aid Australia (2016), six out of every ten people in PNG do not have access to clean water. Weak land management policies, improper waste disposal and population growth are affecting the government's capacity to supply safe consumable water resources in terms of quantity and quality (FAO 2016). Water catchment areas have been put under stress due to its exploitation in agricultural land use (SOPAC 2007). PNG is currently working on rectifying its water woes by improving water and sewage policies as well as identifying and protecting water catchment areas in the country.

Wetlands

PNG has three major wetland types: the alpine wetlands, arid wetlands, and estuarine wetlands (Osborne 1993). Wetlands assist in protecting freshwater catchments while coastal swamp forests protect the coastline from erosion. All wetlands support a wide range of flora and fauna. The CEPA is mandated to contribute to the conservation and wise use of wetlands in PNG, as well as the strengthening of capacities based on the technical implementation of the Ramsar Convention (Department of Environment and Conservation 2011)

Inland water

PNG Inland Waters are the lifelines for biodiversity. Forest ecology, wetlands, low land areas, estuaries and coastal marine life are interconnected by rivers. Thus, the health of waters upstream greatly affects the ecology of communities downstream. The Fly River and the Sepik River are the major river systems in PNG. The Sepik River forms the largest unpolluted freshwater system in New

Guinea. It is also one of the largest and most intact freshwater basins in Asia-Pacific (WWF 2012). The Fly River Ok Tedi environment disaster is by far PNG's worst environmental disaster. The river ecosystem has been destroyed, biodiversity lost, and villagers displaced; at the heart of the problem is the river being polluted by the mining industry.

Increasing Land Degradation

Land degradation is a major issue of concern in PNG. The main drivers for the land degradation are the mining as well as the forestry sector. The mining (industry) and forestry (agriculture) sector contribute the most towards the country's GDP. This has come at the expense of the land.

Foreshore and PNG's waters

Foreshore is the area between the mean high-water mark on the beach and 30 metres inland from there. PNG is seen to have poor waste disposal practices. Aside from tourist hot spots, the beaches are littered with garbage. This affects tourism, the marine environment and impacts people's health. Fish that people eat can be contaminated by consuming plastics, the toxic smoke from burning garbage is extremely poisonous and garbage also makes a perfect home for mosquitoes to breed and spread disease (Naime 2016). PNG waters provide a sustainable livelihood for those dependent on it. Along the coastal areas, fishing practices such as the use of cyanide is prevalent and has led to the decimation of biodiversity. PNG waters help contribute to the country's GDP through the tuna fishery in the Bismarck Sea area (National Fisheries Authority 2012).

Loss of Habitat and biodiversity

Widespread fragmentation of forests is caused by new roads for settlers as well as loggers to access forests. Fragmented forests handicap the area's ability to support wildlife, thus leading to loss of species and biodiversity. PNG forests are being degraded at a rate of 1.41 per cent per year (Shearman et al. 2008). It is estimated that by 2021 most commercially accessible forests will be degraded (Shearman et al. 2008). Most accessible forests are under logging concessions while the remaining accessible areas are subject to industrial agriculture or the impacts of a rapidly expanding human population.

Rapidly expanding human population

Many of the world's environmental issues stem from an increase in demand for resources due to the increasing population. PNG's population is drastically increasing, and the government's ability to cope with the nation's demands is lagging. In 2009, PNG's population was estimated to be 6,057,263. The population growth rate between 2000 and 2005 was estimated at 3.2 per cent per annum with rates of 2.2 per cent and 3.9 per cent in urban and rural areas respectively (Shearman et al. 2008).

Droughts

In 2015–2016 PNG experienced a severe El Nino event which caused drought in the highland regions. Three million people in PNG were affected, with 400,000 severely impacted across the highlands

and 24 people confirmed dead because of prolonged drought (IFRC 5 Sep 2015). The other major drought event had occurred in 1997 and affected water and food sources. The future climate models have shown that drought projections are inconsistent for PNG. However, very hot days, extreme rainfalls and less frequent but stronger cyclones are expected for the 2030 period (Pacific Climate Change Science Program 2011).

Climate Change and Sea level rise

According to the Climate Change Adaptation Initiative, there is evidence in climate change through the increased temperatures in Port Moresby. The maximum temperatures have increased at a rate of 0.11°C per decade since the 1950s and sea levels have also risen. Satellite data indicate that sea level has risen near PNG by about 7 mm per year since 1993. Data collected have shown that since the 18th century, the level of ocean acidification has been slowly increasing in PNG waters.

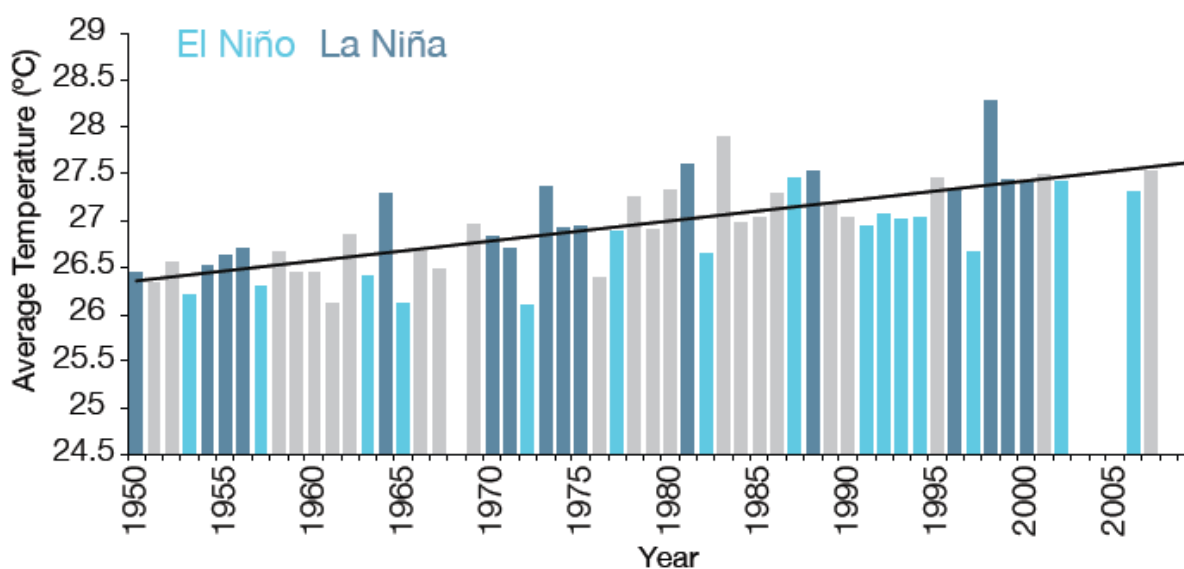


Figure 9: Annual rainfall for Port Moresby. Light blue bars indicate El Niño years, dark blue bars indicate La Niña years and the grey bars indicate neutral years. (Source <https://www.pacificclimatechangescience.org>)

4.3.3 Measures to manage impacts

PNG has mapped out its climate change resilience plan in accordance with the Vision 2050. Key outcomes of the plan include:

- Establishment of a pool of trained and qualified specialists to support climate change risk management mainstreaming activities at national and sectoral levels and within vulnerable communities.
- Legal establishment and effective operation of PNG's Climate Change Trust Fund, and the establishment of a small grants programme to support priority adaptation projects for farmers, fisherfolk and vulnerable communities, in particular women.
- Coastal fisheries that are more resilient to impacts of climate change.
- Critical infrastructure less vulnerable to impacts of climate change and disasters.
- Vulnerable communities in remote islands and atolls made more resilient to climate change risks.

The above is being overseen by PNG's climate change development and disaster management authorities, in collaboration with AusAid and Pacific Adaptation to Climate Change, to foster discussions toward a Joint National Action Plan for both disaster risk management and climate change adaptation.

4.6. Institutional, Legal and Policy Factors

4.6.1 Institutional Setting

Sector-based Laws

This section describes the legislative and policy documents that provide the appropriate mandates for the institutions responsible for the various sectors:

Environment

The Conservation and Environment Protection Authority (CEPA) is the governing authority in charge of matters concerning the environment in PNG. The Fauna Act, Conservation Areas Act, Environment Act and National Parks Act, are seen as PNG's environmental conservation pioneering policies. However, the country has faced problems in implementing the regulations stated by the policies. Thus, the Protected Areas Act is seen as the country's renewed efforts in contributing to global biodiversity.

Water

In 2015 the PNG Government through the Department of National Planning and Monitoring implemented the Water, Sanitation and Hygiene (WaSH) policy. The WaSH policy 2015 "embodies the commitment of the Government of the Independent State of Papua New Guinea to sustainably improve the quality of lives of people both in the rural and urban areas of the country" (Papua New Guinea government 2015). The policy focuses on improved service delivery of drinking water, sanitation and promoting long term hygiene. The policy was prioritised following an outbreak of cholera in 2009, the first outbreak in 50 years. The policy also aims to establish an improved service delivery and performance monitoring framework that links the ambitions of existing Government development policies to improved services on the ground. "PNG Water" and "EDA RANU", both state-owned enterprises, are the companies tasked with providing the nation with water services.

Coast

The CEPA sees to the protection and sustainability of biodiversity through the legislative provisions. This includes terrestrial, freshwater, wetlands, coastal and marine environment. The Environment Act 2000, National Parks Act 1984, Conservation Areas Act 1978, Fauna (Protection and Control) Act 1966, and the International Fauna and Flora Trade Act 1978 are policies related to the protection of coastal areas. The CEPA works in conjunction with the National Fisheries Authority as well as local governments to help implement the legislation and regulations.

Land

The Department of Lands and Physical Planning is mandated with promoting the best use of land in the interests of PNG citizens. The Land Act 1996 is the governing policy which defines how the land in PNG is to be used. The CEPA plays a significant role in implementing this policy regarding the establishment of protected areas and national parks.

Forest

The Forestry Act 1991 is the set of principles and guidelines adopted by the PNG public authority, which assist in decisions concerning forest management and conservation. Currently only the national government has policies regarding forestry; none of the 19 provinces have policies specific to forestry. The PNG Forest Authority is the lead institution in this sector (www.fao.org/forestry).

Agriculture

The National Department of Agriculture and Livestock (NDAL) administers all legislation relating to Agriculture and Livestock. NDAL liaises with the Rural Development Bank and the National Plantation Management Authority and operates experimental stations and laboratories which research into the preparation and production of agricultural goods. The NDAL also advises on policies dealing with agriculture and livestock. There are several policies which contribute directly and indirectly to the sector. These include The Land Act 1996, Natural Resource Management (NRM) and sustainability policies, Trade Policy and various commodity governing policies such as the Coffee Industry Corporation Act, Oil Palm Industry Act (1992), etc.

Minerals

The mineral resources authority in PNG oversees the mining and mineral extraction activities carried out within PNG's borders. The Mining Act 1992 and Mineral Resources Act 2005 are seen as the governing policies regulating the mining sector. Other policies related to mining include the Environment Act 2000 as well as the Mining (Safety) Act and Regulations 2007. PNG is a mining state with mineral exports a major contributor to GDP, providing more than a third of government revenue (<http://www.mra.gov.pg>). Recently, PNG has also unilaterally ventured into offshore and seabed mining, creating much regional controversy (Childs 2020).

Disaster and Climate Change

The Climate Change Development Authority and the National Disaster Centre are the focal institutions dealing with climate change and disaster management. The Authorities are currently undergoing restructuring to ensure their functions and responsibilities are effectively and efficiently deployed. The Disaster Management Act 1984 and the Climate Change Management Act 2015 are the main governing policies with formal status.

Table 9 captures relevant policies/legislation titles and the respective focal institutions.

Table 9 Summary of PNG legislation relevant to the management of the catchment, coastal and marine environment, and resources

Policy/Legislation Title	Year Enacted	National Focal Institution	Coordination Mechanism
Fauna Act	1982	Conservation and Environment Protection Authority (CEPA)	Conservation and Environment Protection Authority (CEPA)
Conservation Areas Act	1982		
Environment Act	2000		
National Parks Act	1982		
Land Act	1996	Department of Lands and Physical planning	Department of Lands and Physical planning
Forestry Act	1991	PNG Forest Authority	PNG Forest Authority and FAO
National Forest Plan	1996		
National Forestry Development Guidelines	2009		
Mineral Resources Act	2005	Mineral Resources Authority (MRA)	
WaSH policy	2015	Department of National Planning and Monitoring	WATSAN
Water and Sewer Act			
Disaster Management Act	1984	National Disaster Centre	
Climate Change Management Act	2015	Climate Change Development Authority	

Linkages between policies

Each of the policies is aligned with the Sustainable Development Goals (SDGs) as well as goals set out in the Vision 2050 document.

The Papua New Guinea Vision 2050 is the framework for a long-term strategy that maps out the future direction for the country. The Vision 2050 is supported by seven focus areas.

- Human Capital Development and service delivery
- Wealth creation
- Institution development
- Security and international relationships
- Environment sustainability and climate change
- Spiritual, cultural and community development
- Strategic planning, integration, and control

In line with the environment sustainability and climate change focus area for the PNG Vision 2050, the Protected Areas Network policy was formed to protect and support PNG’s unique biological and cultural heritage. The Protected Areas Network policy deals with challenges such as climate change and development and food and water security. The policy keeps the more development-based sectors such as agriculture, mining, and forestry in check to ensure sustainable development is pursued by the nation.

Multilateral Environmental Agreements (MEAs)

The main legal response to many environmental problems is by way of Multilateral Environmental Agreements (MEAs), many which have been ratified by Pacific Island countries. Countries still formulate policies and laws, which are domestic in origin and scope, but as with MEAs, there is a tendency towards harmonisation amongst countries because of benchmarking against international standards and in adopting best environmental practices and sharing lessons learned.

The Secretariat of the Pacific Regional Environment Programme (SPREP) assists countries with implementing their MEA obligations through activities such as negotiations training and provision of technical support for major MEA meetings. It also acts as the Secretariat for two regional MEAs, the Noumea (marine pollution) and Waigani (transboundary movement of hazardous waste) Conventions. At the domestic level, SPREP assists with environmental legislative reviews, formulation of policy and drafting of environmental laws.

MEAs are agreements between states, which may take the form of “soft-law”, setting out non-legally binding principles, which parties will respect when considering actions that affect a particular environmental issue or “hard-law” which specifies legally binding actions to be taken to work toward an environmental objective.

Several important MEAs were entered into at the 1992 United Nations Conference on Environment and Development (or the “Earth Summit”), which was held in Rio de Janeiro, Brazil. The Earth Summit produced five key documents on sustainable development issues: two “hard law” – the Convention on Biological Diversity, and the Framework Convention on Climate Change, which many PICTs have signed and ratified (see below); and three “soft law” – the Rio Declaration, Agenda 21, and the Forest Principles, which were adopted by consensus at Rio.

Table 10: Major multilateral environmental agreements signed by Papua New Guinea

Name of Convention	Focus Area	National Focal Institution
Noumea Convention	Protection of natural resources and environment of the South Pacific region. Prevent, reduce, and control pollution	Secretariat of the Pacific Regional Environment Programme (SPREP)
Convention on Biological Diversity (1992)	The convention encourages the participating parties to conserve of biological diversity (or biodiversity); the sustainable use of its components; and the fair and equitable sharing of benefits arising from genetic resources.	Jointly served by United Nations Environment Programme (UNEP) and the Food and Agriculture Organization (FAO)
Basel Convention	An international treaty that was designed to reduce the movements of hazardous waste between nations, and specifically to prevent transfer of hazardous wastes from developed to less developed countries.	The Secretariat of this Convention is administered by United Nations Environment Programme (UNEP)

Name of Convention	Focus Area	National Focal Institution
Waigani Convention	The Waigani Convention to Ban the Importation into Forum Island Countries of Hazardous and Radioactive Wastes and to Control the Trans-boundary Movement and Management of Hazardous Wastes within the South Pacific Region	Secretariat of the Pacific Regional Environment Programme (SPREP)

Structure of Public Environmental Organisations

In matters relating to the management of PNG’s biodiversity and natural environment, the CEPA is regarded as the leading authority. PNG is a constitutional monarchy, and Queen Elizabeth II is recognised as the country’s head of state. A governor-general, who is appointed by parliament and serves as a senior adviser to the country’s prime minister, represents the Queen. Both the government and parliament have legislative power. The executive branch consists of several ministries, each of which is led by a cabinet member. The ministries are listed below

- Conservation and Environmental Protection Authority (CEPA)
- Department for Fisheries
- Department for Forestry
- Department for Planning and Monitoring
- Department for Mining

The responsible departments under the executive branch of government see to the sustainable development of PNG’s environment and natural resources. Each department is responsible for areas dictated in their governing policies. However, there are cases where the jurisdiction of the individual departments will overlap, and more than one department is used to implement policies and plans. For example, to implement PNG Marine Programme, the collaboration of the CEPA, National Fisheries Authority and Department of National Planning and Monitoring was necessary for effective implementation of the plan.

Environmental NGO membership

Conservation International, Nature Conservancy, Wildlife Conservation Society, Worldwide Fund for Nature, and the Milne Bay Eco-Forestry Association are some of the NGOs associated with the PNG environment conservation. The NGOs provide support to the government through technical assistance and advice on matters concerning the environment. The NGOs are key players in forming partnerships with local communities and providing funding for conservation initiatives.

Information on policies and legislation on NGO membership in PNG is scarce. The PNG Civil Society Organisation (CSO) forum is seen as the interim body serving as the liaison point for the Pacific Islands Association of Non-Government Organisations (PIANGO) in PNG. PIANGO is a regional coordinating body offering support to NGOs in 21 Pacific Island countries. PIANGO seeks to strengthen and build the civil society sector through fostering collaboration between NGOs as well as with government and other bodies in the Pacific region.

4.6.2 Constraints and Limitations

An analysis of PNG conducted by the Lowy (Australian) Institute (2016) placed particular emphasis on a few key trends that have developed over the last forty years, since independence. Despite the many positive developments that have taken place, there are some trends recorded which have affected the country's economy, law and order, health, and education and other aspects of their development. Some of these trends recorded are as follows:

1. **Weak governance:** PNG's poor governance has been a source of concern for successive Australian governments, which have expressed concern about weak institutions, a lack of capacity in the public sector, corruption, political instability, ineffective leadership, and a weak civil society ill-equipped to hold the government to account. "Many PNG and Australian businesspeople and government officials have told the author that the most significant barriers to development in Papua New Guinea are a lack of capacity and inadequate skills in the public sector" (Hayward 2015).
2. **Poor law and order:** Papua New Guinea's law and order problems are insurmountable. The high levels of crime and violence are a major impediment to economic development. The most commonly reported crimes are robbery, assault, and domestic violence. High crime rates can be found in urban areas such as the capital, Port Moresby, the industrial town of Lae, and Mount Hagen in the Highlands. Surprisingly, the physical features of business centres and residential areas of these urban centres are security walls. Tribal violence occurs without recourse to the legal system. Many victims of domestic violence face insurmountable obstacles in obtaining legal redress (Hayward 2016).
3. **A failing health system:** the health situation in PNG is dire. Malaria, diarrhoea and waterborne diseases, and other diseases linked to PNG's climate and environment, are among the top five causes of morbidity and mortality. Vaccine-preventable diseases like tuberculosis, however, are included in the top five. Immunisation coverage has fluctuated in recent years, but it still falls short of WHO guidelines. Approximately 30,000 people in PNG are HIV positive. The maternal mortality rate is extremely high, at 230 per 100,000 live births, more than double the United Nations Millennium Development Goal target for PNG in 2015 (Hayward 2016).
4. **A mediocre national education system:** adults in PNG have an average of four years of formal education (UNDP 2015). This is the lowest level of education in the Pacific Islands region, and it is comparable to adult education levels in Sub-Saharan Africa. In PNG, the current primary school completion rate is 59 per cent (UNDP 2014).
5. **An over-reliance on the extractives industry:** PNG is fortunate to have a vast natural resource endowment as well as geographic proximity to rapidly growing Asian markets for these resources. However, as many developing countries have discovered, such blessings can also be a curse. Although PNG policymakers are aware of the resource curse, they have been unable to avoid it (Hayward 2016).
6. **The unrealised potential of subsistence agriculture:** approximately 80 per cent of the population is fed by subsistence agriculture. The ability of the rural population to feed themselves from crops they grow means that the country avoids many of the severe hunger issues that plague much of the developing world. A diet based on subsistence agriculture has also helped Papua New Guineans avoid diet-related non-communicable diseases like obesity and Type 2 diabetes, which has afflicted their Polynesian and Micronesian neighbours (World Bank 2014).
7. **Growing population:** Dame Carol Kidu, a former Community Development Minister, believes that the biggest challenges facing PNG in the next 40 years are "rapid population growth, increasing, unmanaged urbanization, and underlying social breakdown." The urban population of PNG is estimated to be 1.2 million people, spread across three cities: Port Moresby, Lae, and Mount Hagen, according to the Papua New Guinea Urbanisation Office (Jones 2012).

Policy/Legislation Title	Environment Act
Coordinating Mechanism	Conservation and Environment Protection Authority (CEPA)
Objectives	<ul style="list-style-type: none"> • ensure natural and physical resources are managed to sustain environmental quality and human well-being; • environmental impact assessment of major projects including forestry, mining, and petroleum proposals; • environment policy development; • pollution control and the regulation of hazardous substances; • management of water resources • manage the Service through effective and efficient administration of management systems.
Tasks	<ul style="list-style-type: none"> • Provides for the protection, conservation, and management of the environment in a sustainable manner, and explicitly supports the conservation and management of biodiversity through provisions to establish Protected Areas and regulate or prohibit activities within these protected areas
Activity Areas	<ul style="list-style-type: none"> • General environment from ridge to reef

Policy/Legislation Title	Fisheries Management Act
Coordinating Mechanism	Conservation and Environment Protection Authority (CEPA) National Fisheries Authority
Objectives	<ul style="list-style-type: none"> • to promote the management and sustainable development of fisheries, and • for related purposes.
Tasks	<ul style="list-style-type: none"> • Achieving sustainable fisheries through dynamic, innovative, and consultative fishery management • Licensing and Data Management • Monitoring, Control and Surveillance
Activity Areas	<ul style="list-style-type: none"> • Marine and fisheries environment • Inland river fisheries, aquaculture, coastal beche-de-mer and reef fisheries to the prawn trawl and large-scale deep-water tuna fisheries. Domestic prawn and tuna longline operators to large international purse seine fleets in the deep-water tuna fishery

Policy/Legislation Title	Forestry Act
Coordinating Mechanism	Papua New Guinea Forest Authority (PNGFA)
Objectives	<ul style="list-style-type: none"> • Promote the management and wise utilisation of the forest resources of Papua New Guinea as a renewable asset for the well-being of present and future generations.”
Tasks	<ul style="list-style-type: none"> • Control and regulate logging in the country • Plan forestry rehabilitation programmes • Forest management
Activity Areas	PNG Forest areas

Policy/Legislation Title	Protected Areas Act
Coordinating Mechanism	Protected Areas Network Conservation and Environment Protection Authority (CEPA)
Objectives	To provide for the conservation and protection of the environment in accordance with the Fourth National Goal and Directive Principle (National Resources and Environment) of the Constitution
Tasks	Establish the Conservation and Environment Protection Authority and repeal the National Parks Act
Activity Areas	<ul style="list-style-type: none"> • Forests • Lakes, streams, and rivers • Estuaries and wetlands • Marine environment • National Parks • Lagoon and coastal waters

Policy/Legislation Title	WASH Act
Coordinating Mechanism	Department of National Planning and Monitoring
Objectives	<ul style="list-style-type: none"> • To improve water quality through better sanitation measures • To ensure that domestic wastewater is treated safely, effectively and in a sustainable manner • To ensure that commercial and residential animal farmers, particularly piggeries, to manage their animals in ways that minimise potential impacts on the environment
Tasks	<ul style="list-style-type: none"> • To work in conjunction with the Water and Sewage Act to improve integrated water resources management across the country. • Safe collection, treatment, and disposal of wastewater to an approved standard for: <ul style="list-style-type: none"> • Domestic residential homes • Commercial facilities including tourist accommodation • Community and public buildings • The promotion of appropriate practices for wastewater management.
Activity Areas	<ul style="list-style-type: none"> • Safe disposal of sewage and other wastewater; and • The promotion of health and hygiene practices in the Papua New Guinea

4.7 Public and Stakeholder Participation

As noted earlier, there are still challenges associated with coordination and uniting civil society groups.

A success story of collaboration between external NGOs and local CSO is the Kamiali group. This involved a group of Dutch NGOs collaborating with the local Village Development Trust to construct an eco-tourism lodge at Kamiali. The lodge provides visiting scientists and ecotourists with accommodation and meals (<http://kamiali.org/about.html>). However, stories like this are few and far between, due to the CSO's limited management capability, minimal collaboration and networking with other sectors, poor communications, transportation difficulties and limited financial resources (ADB 2015). Australia Aid supports training, skills building and professional-development activities for CSOs and the government. It also focuses on projects that “provide training experience and skills transfer, helping to build capacity among organisations and individuals across PNG (ADB 2015).

5. NATIONAL PRIORITY ISSUES

5.1 Key Problems, Sectors, and Immediate Causes

Six environmental problems were identified as priority issues of concern during the extensive desk-top research and literature review:

1. Deforestation and Mining: increasing land degradation - topsoil depletion, damage to soil structure and 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. Agricultural expansion: loss of critical habitats and biodiversity.
6. Declining coastal and marine resources.

The following provides an overview of the identified environmental problems, along with their environmental and socio-economic impacts. The tables also present the identified causes of the existing problems.

Issue 1: Deforestation and Mining - Increasing land degradation	
Environmental Impacts	Socio-economic Impacts
<ul style="list-style-type: none"> • Increase in sedimentation • Increase in erosion • Change in terrain • Changes in flora and fauna • Impact on groundwater • Catchment • Increase in surface flooding • Loss of grass along streams and wetlands • Erosion • Loss of nutrient sink • Coastal tree removal – coastal erosion • Reduction of trees – impact on hydrological cycle • Soil degradation • Silting of waterways and offshore reefs • Loss of wildlife habitat and food resources • Loss of tourist potential • Chemical pollution of soil and water • Climatic changes. 	<ul style="list-style-type: none"> • Sedimentation – food stocks lagoon • Loss of good topsoil • Water loss • Loss of natural erosion protection – trees, vegetation needs to be replaced with expensive hard infrastructure • Increased flooding, massive costs to homes and infrastructure • Degraded lagoon/landscape – loss of native trees and species • Changes in human demography with increases in local population. • Overtaxing of food, water, and hygiene resources. • Dislocation of cultural frameworks and social order. • Downgrading of social values and increase in lawlessness.
<p>Immediate Causes</p> <p>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</p> <p>Inappropriate agricultural practices, especially in upland areas and other marginal areas (e.g., skeletal soils) such as the establishment of urban gardens on the steep slopes of Port Moresby hillsides</p> <p>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.</p>	<p>Underlying Causes</p> <ul style="list-style-type: none"> • 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 • Lack of understanding and application of soil conservation measures in these communities, requiring community-based awareness and skills development programmes. • 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.

Issue 1: Deforestation and Mining - Increasing land degradation

Environmental Impacts	Socio-economic Impacts
Sectors responsible:	<ul style="list-style-type: none"> • Logging • Mining • Agriculture • Housing • Forestry • CEPA

Issue 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).

Environmental Impacts:	Socio-economic Impacts:
<ul style="list-style-type: none"> • Litter • Biodiversity loss • Environment pollution/unhealthy • Contamination of water tables/sources • Increase in erosion • Change in terrain • Changes in flora and fauna • Impact on groundwater 	<ul style="list-style-type: none"> • Affects communities' livelihoods • Negative impact on tourism • Unhealthy environment for living • Diseases • Visual impact – negative/eye sore • Litter/waste
Immediate Causes:	Underlying Causes
<ul style="list-style-type: none"> • Lack of effective environmental regulation of hazardous materials' management (storage, transport, use and end-use / disposal) • 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 integrated solid waste management systems with realistic options for reduction, reuse/recovery or recycling of wastes that can reduce the demand for waste treatment and disposal capacity • Lack of waste treatment facilities for toxic or other hazardous or intractable wastes • Lack of effective implementation of regulations or codes of practice for solid waste management 	<ul style="list-style-type: none"> • 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. • 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 residue containers. • Limited resources available to government to police and enforce regulations • Low priority given to waste reduction strategies as they are not seen as being cost effective • Low priority given to long-term risks arising from toxic and hazardous wastes • Low priority given to solid waste management

Issue 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).

Environmental Impacts:	Socio-economic Impacts:
Sectors responsible:	<ul style="list-style-type: none"> • Agriculture • Tourism • Infrastructure/Construction • Land development • Local communities

Issue 3: Declining water quality in rivers and coastal waters.

Environmental Impacts:	Socio-economic Impacts:
<ul style="list-style-type: none"> • Impacts on ecosystem health • Loss of biodiversity in streams • Impacts on marine biodiversity (decline in biodiversity, coral deaths, fish deaths, etc) • Contamination – groundwater, lagoon water, surface water • Algae blooms 	<ul style="list-style-type: none"> • Impacts on human health • Prevalence of disease/infection • Loss in labour productivity • Decline in safe drinking water • Loss of commercial revenue • Decline in tourism • Decline and loss in marine resources
Immediate Causes:	Underlying Causes
<ul style="list-style-type: none"> • Degraded quality of surface runoff from watershed developments including land clearance, construction and operation of infrastructure and settlements. • 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. • 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, e.g., palm oil mills, large-scale coffee, fish, and meat processing • 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 • 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. 	<ul style="list-style-type: none"> • Lack of effective application of good soil conservation and stormwater management techniques. • Lack of public awareness and understanding of the need for, and safeguard of, the water quality of all surface waters, groundwater, and coastal waters. • Inadequate monitoring and compliance with regulatory standards & codes of practice. • 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. • Lack of awareness and understanding of the risks, and lack of adequate monitoring and compliance with guidelines and standards.

Issue 3: Declining water quality in rivers and coastal waters.

Environmental Impacts:	Socio-economic Impacts:
Sectors responsible	<ul style="list-style-type: none"> • Agriculture • Tourism accommodation • Poor infrastructure – drainage • Chemical/household detergents • Communities

Issue 4: Disturbed or unpredictable hydrological regimes.

Environmental Impacts:	Socio-economic impacts:
<ul style="list-style-type: none"> • Decline in water quality • Reduced availability of safe drinking water • Decline in ecosystem health • Damage to crops and gardens • Flooding 	<ul style="list-style-type: none"> • Decline in water supply – particularly for households • Decline in availability of safe drinking water • Increase in prevalence of disease and infection for human and aquatic life • Floods and inundation • Damages to food gardens and crops
Immediate Causes:	Underlying Causes
<ul style="list-style-type: none"> • Loss of water retention capacity in watersheds because of widespread land clearance, or other change in land-use resulting in soil degradation and soil loss. • Changes to river morphology, including river channelling, and riverbed sedimentation patterns. • Changes in local weather patterns. 	<ul style="list-style-type: none"> • Failure to apply effective soil conservation measures and timely restoration of vegetation. • Failure to apply effective soil conservation measures and adequate stormwater systems to temporarily store flood surges. • Unclear, a lack of long-term records limits the causal analysis of such changes.
Sectors responsible	<ul style="list-style-type: none"> • Agriculture • Water Authority • Municipalities • Communities - Unreported leaking pipes deterioration of water pipe • Tourism - accommodation • Infrastructure/Construction • Lands Department

Issue 5: Agricultural expansion - Loss of critical habitats and biodiversity.

Environmental Impacts	Socio-economic Impacts
<ul style="list-style-type: none"> • Loss of terrestrial habitat • Decline in native species • Species loss from overhunting 	<ul style="list-style-type: none"> • Contamination of freshwater lenses • Major economic impacts on major production sectors caused by poorly managed mining and logging operations
<p>Immediate Causes:</p> <ul style="list-style-type: none"> • Increasing conversion of forested lands to subsistence gardens and small-scale cash crops. • Land use changes, including selective logging, forest clearance, the establishment of agricultural monocultures, and major infrastructure developments such as hydro-schemes and mining. • Encroachment and exploitation of formerly remote / inaccessible areas because of infrastructure and natural resource developments improving access to these areas. • 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). • Destructive fishing practices and associated damage to critical habitats such as reefs and seagrass beds. • Invasive species, particularly weeds and other pest species, feral and domesticated animals. 	<p>Underlying causes</p> <ul style="list-style-type: none"> • 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. • 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. • Lack of adequately detailed information for planning purposes on the characteristics and distribution of critical habitats and areas of high biodiversity • Lack of effective protected areas legislation that is compatible with customary land tenure systems and lack of local / community-level enforcement capacity • Lack of public awareness, motivation and support needed to ensure local communities and other stakeholders adopt a more pro-active environmental stance.
<p>Sectors responsible</p>	<ul style="list-style-type: none"> • Tourism Industry • Communities • Trade Industry • Biosecurity department • Ministry of Agriculture • CEPA

Issue 6: Declining coastal and marine resources

Environmental Impacts	Socio-economic Impacts
<ul style="list-style-type: none"> • Ecosystem imbalances • Overharvesting • Littering • Habitat loss • Loss of coral species and organism's dependent on corals • Depletion of inshore fisheries • Declining catches 	<ul style="list-style-type: none"> • Food security impacts • Affects tourism who come to enjoy the marine life and coasts • Inundation to coastal homes • Impact on economic value of fisheries
Immediate Causes	Underlying Causes
<ul style="list-style-type: none"> • Increasing exploitation of coastal and marine resources by artisanal and commercial fishing • Increasing pollution of coastal and near-shore environments from land-based development, including: <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 • Inappropriate fishing methods resulting in capture of (or damage to) non-target species and undersize individuals with no market value • Damage and destruction of habitats because of destructive fishing practices such as dynamite fishing the use of poisons such as poisonous roots or cyanide • 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 • Adverse impacts from invasive species either actively introduced or passive arrivals in ship bilge waters and attached to the hulls of ships 	<ul style="list-style-type: none"> • 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. • 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. • Lack of awareness / low priority given to conservation of fish stocks and non-target species. • Lack of public awareness and / or lack of civic responsibility • Lack of resources and capacity to conduct data gathering and compile information into effective management planning datasets. • Lack of awareness amongst the relevant agencies of the environmental risks posed by this potential impact.
Key sectors contribution	<ul style="list-style-type: none"> • Infrastructure developments • Tourism sector • Lands department • Fisheries department • CEPA • Communities/Resource users

6. OPTIONS FOR REFORM AND ACTION

“The ultimate success of projects and initiatives to combat pollution throughout the Pacific relies on empowering island populations to better manage the problems themselves. It is not enough to give them equipment, show them how to use it and then leave them to it. The key to making real change is to upskill the people, to build their knowledge and understanding. That is quite an iterative process, and one that takes time.” (Dr. Julie Hall, NIWA regional manager)

The following table presents the highlighted issues and options for reform, for the way forward.

PROBLEM	OPTIONS FOR REFORM
1. Deforestation and Mining: Increasing land degradation – topsoil depletion, damage to soil structure, fertility, and water retention capacities.	<ol style="list-style-type: none"> 1. Righteous and honest government – end corruption and bribery from large companies. 2. CEPA – conduct field monitoring and audits of compliance to ascertain whether operators are complying with these guidelines or codes of practice. 3. Quota on timber exports – strict monitoring by authorities. 4. Long-term planning – educating and empowering of tribe men and communities on sustainability and stewardship; before ‘agreeing’ to lucrative and generous offers.
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).	<ol style="list-style-type: none"> 1. Environmental issues surrounding waste management and hazardous materials in general are currently given a low priority in Papua New Guinea (SPREP 2004). This needs to change. 2. Education and awareness using more effective means e.g., technology to effectively communicate and remove ignorance of risks – to environment and to personal health and safety. 3. Need for proper and thorough auditing of hazardous substances in the waste streams. 4. Need for systematically collected data and adequate databases in the country related to pollution and chemicals. Information on inventories of hazardous chemicals and wastes and on emissions and discharges is needed. 5. Regular environmental auditing and monitoring of chemical importation, transport, storage, use, and disposal needs to be carried out.
3. Declining water quality in rivers and coastal waters.	<ol style="list-style-type: none"> 1. Increase the capacity and resources within the regulatory agencies to monitor, audit and enforce compliance with water quality regulations and guidelines. 2. Based on literature and published reports more priority needs to be given to the environmental and socio-economic risks posed by declining water quality in PNG. 3. Reviewing of policies. 4. People taking ownership of the environmental issues, ensuring that viable and appropriate long-range plans are followed.

PROBLEM	OPTIONS FOR REFORM
<p>4. Disturbed or unpredictable hydrological regimes.</p>	<ol style="list-style-type: none"> 1. Risks need to be minimised through proper research and planning by government and development proponents. 2. Reports show that there is a lack of up to date and consistent hydrological data for most of the river systems and coastal waters of PNG. 3. Need for more accurate and revised systems for flood control measures.
<p>5. Agricultural expansion: Loss of critical habitats and biodiversity.</p>	<ol style="list-style-type: none"> 1. Reviewing of policies. 2. Establishing of protected areas in affected regions and effective surveillance and monitoring. 3. Raising more public awareness through educating communities, schools, and resource users on these related issues; and include in school curriculum in partnership with CSO's and other stakeholders.
<p>6. Declining coastal and marine resources</p>	<ol style="list-style-type: none"> 1. Focus on working to strengthen the capacity of the local communities, and 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 resource management. 2. Run relevant campaigns on 'littering', 'threatened species protection' etc. in schools, communities, hotels, and other necessary areas. 3. Harsher penalties and stronger enforcement – anti-corruption. 4. Building capacity at the local and provincial levels of governments to actively support and assist the development and management of the programme.

7. FINDINGS AND RECOMMENDATIONS

- i. Need for honest and transparent leadership at all levels of the PNG Government.
- ii. Strengthening of advisory bodies and mandatory advisors (within the existing stakeholder circle) to provide the necessary counsel to Government to minimise risks that affect the land and other natural resources.
- iii. Reviewing of policies and stronger enforcement measures – harsher penalties and fines on companies and institutions that practice illegal and unsustainable land management practices within the ridge to reef system, particularly for deforestation, mining, and agricultural expansion projects.
- iv. Transparency and close collaborations between stakeholders, including men, women, youth, elderly, and other minority groups, are pivotal for addressing the existing environmental and socio-economic problems and to strengthen the use of ridge to reef approaches in the policy, regulatory and institutional frameworks governing land and resource use in PNG.
- v. Awareness workshops/materials and capacity building (on a consistent basis) are necessary particularly for sustainable and responsible land and marine resource use – for resource users, landowners, tourism operators and other stakeholders. This should be conducted by the relevant authorities with information and current statistical evidence. Government investment into facilities/resources and technical expertise.
- vi. Strategic and focussed capacity building and educational programmes to educate and equip community leaders and tribal heads on issues relating to stewardship and sustainability, particularly in view of the lucrative and generous offers for their land, by large companies. Setting up of accountability and advisory bodies for landowners before decisions are approved for logging, mining etc.
- vii. There is a need for review and support for pilot testing of water quality, monitoring for agricultural chemicals (pesticides), and analysis to determine if these are having a significant negative impact on the lagoon or reefs. Ground-truth results and data through necessary socio-economic and biological assessments and EIAs.

REFERENCES

- Asian Development Bank (ADB). 2014. State of the Coral Triangle: Papua New Guinea.
- Bleeker P. 1983. Soils of Papua New Guinea. Commonwealth Scientific and Industrial Research Organization and Australian National University Press, Canberra, London, and Miami. 383 p.
- Bleeker P. 1988. Explanatory notes to the soil map of Papua New Guinea. Natural Resources Series N° 10. Division of Water and Land Resources, Commonwealth Scientific and Industrial Research Organization, Canberra. 64 p.
- Bourke R. Michael. 2011. History of agriculture in Papua New Guinea in Food and Agriculture in Papua New Guinea, ANU Press, 2011
- Browne C. and Mineshima A. 2007. Remittances in the Pacific Region. International Monetary Fund Working Paper MP/07/35. Available from www.imf.org/external/pubs/ft/wp/2007/wp0735.pdf.
- Bryant A. 1983. Human geography of Papua New Guinea. *Journal of Human Evolution* 12:3-23. DOI: 10.1016/S0047-2484(83)80010-4.
- Central Intelligence Agency. 2011. The World Factbook-Papua New Guinea. Retrieved from: <https://www.cia.gov/library/publications/the-world-factbook/geos/pp.html>
- Childs J. 2020. Performing 'blue degrowth': critiquing seabed mining in Papua New Guinea through creative practice. *Sustainability Science* 15: 117–129. <https://doi.org/10.1007/s11625-019-00752-2>.
- Coral Triangle Initiative on Coral Reefs, Fisheries and Food Security (CTI-CFF). 2009. CTI Regional Plan of Action. Available at <http://www.coraltriangleinitiative.org/library/cti-regional-plan-action>
- Country Profile: Papua New Guinea. 2017, December. Retrieved from: <https://pacifictradeinvest.com/explore-our-work/insights/country-profile-papua-new-guinea>
- Department of Environment and Conservation. 2011. In celebration of World Wetlands Day 2011.
- Department of National Planning and Monitoring. 2010. Papua New Guinea Development Strategic Plan: 2010-2030, Our Guide to Success, Department of National Planning and Monitoring, Waigani.
- Drew J.A., Amatangelo K.L. and Hufbauer R.A. 2015. Quantifying the human impacts on Papua New Guinea reef fish communities across space and time. *PLoS ONE* 10: e0140682. doi:10.1371/journal.pone.014068.
- Ellery M.E. 2018. Papua New Guinea: Faecal Sludge Management in Port Moresby. Asian Development Bank, 35 p.
- Encyclopedia of the Nations: Papua New Guinea. (n.d.). <https://www.nationsencyclopedia.com/Asia-and-Oceania/Papua-New-Guinea.html>
- FAO. 2016. The State of Papua New Guinea's Biodiversity for Food and Agriculture. Compiled July 2016.

- FAO. 1999. Irrigation in Asia in figures. FAO Water Report no.18. Rome.
- FAO. 2009. Papua New Guinea Forestry Outlook Study. Asia-Pacific Forestry Sector Outlook Study. Papua New Guinea Forest Authority.
- Independent State of Papua New Guinea. 2014. Papua New Guinea Policy on Protected Areas. Conservation & Environment Protection Authority, October 2014, Waigani, National Capital District, Papua New Guinea.
- Independent State of PNG 2015. Summary Report for Papua New Guinea: Millennium Development Goals 2015.
- IUCN. 2008. Summary of Species on the IUCN RedList – Papua New Guinea
- Forest Trends REDD+ Report. 2016. Papua New Guinea: Mapping REDD+ Finance Flows 2009–2014.
- Fridriksson G. and Fridriksson T.A. 2015. Destination Papua New Guinea. Retrieved from: <https://www.destinationpng.com/section-3/agriculture-and-livestock-overview/>
- Government of Papua New Guinea .2009. Papua New Guinea Vision 2050, National Planning Committee and National Strategic Plan Task Force, Parliament House, Waigani.
- Government of Papua New Guinea. 2015. National Marine Conservation Assessment for Papua New Guinea; Conservation and Environment Protection Authority, 51pp.
- Hayward J. 2015. Papua New Guinea in 2015 – At a Crossroads and Beyond. Retrieved from: <https://www.lowyinstitute.org/sites/default/files/papua-new-guinea-in-2015-at-a-crossroads-and-beyond.pdf>.
- Hayward J. 2016. The Future of Papua New Guinea: Old Challenges for New Leaders. Retrieved from: <https://www.lowyinstitute.org/publications/future-papua-new-guinea-old-challenges-new-leaders>
- IBP, Inc. 2015. Papua New Guinea Energy Policy, Laws and Regulation Handbook Volume 1 Oil and Gas Sector: Principal Laws, Regulations and Policies.
- Independent State of Papua New Guinea. 2014. Papua New Guinea Policy on Protected Areas. Conservation & Environment Protection Authority, Waigani, National Capital District, Papua New Guinea.
- IPA (Investment Promotion Authority). 2006. Department of Environment and Conservation.
- IPCC. 2018. Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla,
- Japanese ODA (official development assistance) loans. 2010. Port Moresby Sewerage System Upgrading Project.
- Jones P. 2012. Managing Urbanization in Papua New Guinea: Planning for Planning’s Sake? *Working Paper* No. 33. Retrieved from: https://www.academia.edu/9418130/Managing_Urbanisation_in_Papua_New_Guinea_Planning_for_Planning_s_Sake

- Kamiali Biological Research Station-PNG. (n.d.) <http://kamiali.org/about.html>
- Kula G. 2010. Papua New Guinea's Fourth National Report to the Convention on Biological Diversity. Retrieved from: <https://www.cbd.int/doc/world/pg/pg-nr-04-en.pdf>
- Lakhani S. and Willman A.M., 2014. Drivers of crime and violence in Papua New Guinea.
- Lawler J.J. 2009. Climate change adaptation strategies for resource management and conservation planning. *Annals of the New York Academy of Sciences* (1162). pp-79-98.
- Longenecker K., Roberts T.E. and Colin P.L. 2019. Papua New Guinea. *In: Loya Y., Puglise K., Bridge T. (eds) Mesophotic Coral Ecosystems. Coral Reefs of the World, vol 12.* Springer, Cham. https://doi.org/10.1007/978-3-319-92735-0_18.
- Munday P.L. and Allen G.R. 2000, Diversity and Abundance of Reef Fishes in Papua New Guinea. Chapter 3. *In: Munday, P.L. (2000). The Status of Coral Reefs in Papua New Guinea. Global Coral Reef Monitoring Network (GCRMN) Report. Cited in* http://www.reefbase.org/global_database/dbr3,60,PNG,1.aspx
- Mineral Resources Authority 2020, Dec 14. Papua New Guinea: Minerals for Life. Retrieved from: <https://mra.gov.pg/About-Us>
- Myers N., Mittermeier R.A., Mittermeier C.G., Da Fonseca G.A. and Kent J. .2000. Biodiversity hotspots for conservation priorities. *Nature*, 403(6772), pp: 853-858.
- Naime Q. 2016. Sustainable Coastlines PNG. Retrieved from: <https://www.looppng.com/tags/sustainable-coastlines-png>
- National Plan of Action 2010. Papua New Guinea Marine Program on Coral Reefs, Fisheries and Food Security.
- Naser M. 2015. Assessing the Evidence: Migration, Environment and Climate Change in PNG.
- Nicholls S. 2004. The priority environmental concerns of Papua New Guinea. IWP-Pacific Technical Report (International Waters Project) no.1
- NLA (National Library of Australia). 1963. Official opening, Sirinumu Dam, by the Hon. Sir Robert Menzies on 7th September 1963
- Osborne P.L. 1993. Wetlands of Papua New Guinea. *In: Whigham D.F., Dykyjová D., Hejný S. (eds) Wetlands of the world: Inventory, ecology, and management Volume I. Handbook of vegetation science, vol 15-2.* Springer, Dordrecht
- Pacific Climate Change Science Program 2011. International Climate Change Initiative
- Pacific Climate Change Science – www.pacificclimatechangescience.org Office of Climate Change and Development Papua New Guinea - www.occd.gov.pg
- Pacific Islands Legal Information Institute (PacLII). 2018. Papua New Guinea Consolidated Legislation: National Parks Act, 1982. Retrieved from: http://www.pacii.org/pg/legis/consol_act/npa1982159/
- Papua New Guinea country profile. 2019, July 10. BBC NEWS. Retrieved from: <https://www.bbc.com/news/world-asia-pacific-15436981>

- Papua New Guinea National Disaster Centre. (n.d.). <https://pngndc.gov.pg/>
- Pirani, A., Moufouma-Okia, W., Péan, C., Pidcock, R., Connors, S., Matthews, J.B.R., Chen, Y., Zhou, X., Gomis, M.I., Lonnoy, E., Maycock, T., Tignor, M. and T. Waterfield (eds.)). Intergovernmental Panel on Climate Change, 630 pp.
- REDD Plus <https://www.redd.plus/countries/papua-new-guinea> (Retrieved December 2019)
- Rivett-Carnac M. 016). El Niño–Related Drought Has Triggered Severe Food Shortages in Papua New Guinea, Times magazine (<http://time.com/4189869/papua-new-guinea-drought-el-nino-food-shortage/>)
- Pieters P.E. 1982. Geology of New Guinea. *In*: Gressitt J.L. (eds) Biogeography and Ecology of New Guinea. Monographiae Biologicae, vol 42. Springer, Dordrecht. https://doi.org/10.1007/978-94-009-8632-9_2
- Pumwa, J. 2013. Engineering Education in Papua New Guinea. *The Proceedings* (p.86).
- Samar P. and Lakamanga A. 2012. Mining & Exploration Bulletin. Port Moresby, Papua New Guinea. The Mineral Resources Authority.
- Secretariat of the Pacific Regional Environment Programme (SPREP). January 2018. Papua New Guinea: Review of Natural Resource and Environment Related Legislation. Retrieved from: <https://www.sprep.org/attachments/Publications/EMG/sprep-legislative-review-png.pdf>
- Sheppard S. and Cranfield L. 2012. Geological framework and mineralization of Papua New Guinea — an update.
- Shearman P.L., Bryan J.E., Ash J., Hunnam P., Mackey B., and Lokes B. 2008. The state of the forests of Papua New Guinea: Mapping the extent and condition of forest cover and measuring the drivers of forest change in the period 1972–2002, University of Papua New Guinea, Port Moresby.
- Shearman P.L., Bryan J., Ash J., Mackey B., and Lokes B. 2010. Deforestation and degradation in Papua New Guinea: a response to Filer and colleagues, 2009. *Annals of Forest Science*, 67(3), p300
- SOPAC. 2007. Integrated Water Resources Management Programme’s Diagnostic Reports.
- Thomas Wangi, 2013, Solid waste management in Papua New Guinea <http://devpolicy.org>
- SOPAC. 2007. Integrated Water Resources Management Programme’s Diagnostic Reports. (Available at: <http://www.pacificwater.org/pages.cfm/country-information/papua-new-guinea.html>)
- 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.
- SPREP: Nicholls, S. 2004. The priority environmental concerns of Papua New Guinea
- The World Bank in Papua New Guinea (2020, April 30). Our work in Papua New Guinea. Retrieved from: <https://www.worldbank.org/en/country/png/overview>

- United Nations Development Programme 2012. Enhancing Adaptive Capacity of Communities to Climate Change Related Floods in the North Coast and Islands Region of Papua New Guinea 2012-2015(http://www.pg.undp.org/content/papua_new_guinea/en/home/operations/projects/environment_and_energy/enhancing-adaptive-capacity-of-communities-to
- United Nations Development Programme 2014. National Human Development Report: Papua New Guinea.
- United Nations Development Programme 2015. Human Development Reports. Retrieved from: <http://hdr.undp.org/en/composite/HDI>
- United Nations Development Programme 2020. Human Development Report: PNG. Retrieved from: <http://hdr.undp.org/sites/default/files/Country-Profiles/PNG.pdf>
- The World Bank 2014, July 12). Pacific Islands: Non-Communicable Disease Roadmap. Retrieved from: <https://www.worldbank.org/en/news/feature/2014/07/11/pacific-islands-non-communicable-disease-roadmap>
- Wangi T. 2013. Solid Waste Management in Papua New Guinea. Retrieved from: <https://devpolicy.org/solid-waste-management-in-papua-new-guinea-20130812/>
- World Vision Australia 2013. PNG – Health and Wellbeing. Retrieved from: <https://www.worldvision.com.au/docs/default-source/school-resources/global-education-papua-new-guinea.pdf>
- WHO Global Task Force on Cholera Control, 2010. Cholera Country Profile: Papua New Guinea
- WSP. 2013. Water Supply and Sanitation in Papua New Guinea (Available at: https://www.wsp.org/sites/wsp.org/files/publications/WSP_EAP_SDA_PNG_Report.pdf)
- WWF. Forests. (n.d.). <https://explore.panda.org/forests>

ANNEX 1

List of environmental problems

Water systems	Exploitation of resources (living/non-living)	Global changes	Habitat and community modification	Pollution
Deterioration of water quality	Decline in commercial fish stocks	Coastal erosion	Habitat and biodiversity changes	Eutrophication
Changes in hydrological flow	Deforestation	Changes in hydrological cycles	Invasive species	Microbiological
Stress on ground and surface water resources	Deterioration of soil productivity	Increase in catastrophic events	Land degradation	Solid and liquid waste management
		Flooding	Ecosystem degradation (nearshore, terrestrial, surface water)	Suspended solids
		Sea level changes		

ANNEX 2:

Criteria for prioritising environmental problems

Criteria list for national prioritisation exercise

Criteria	Weighting (1 – 4)
Whole-of-island nature of a problem – geographical and temporal scale.	1 = no importance 2 = low importance 3 = moderate importance 4 = high importance
Future risk of the problem – (in 10 years)	1 = no importance 2 = low importance 3 = moderate importance 4 = high importance
Relationship with other environmental problems.	1 = no importance 2 = low importance 3 = moderate importance 4 = high importance
Expected multiple benefits that might be achieved by addressing a problem.	1 = no importance 2 = low importance 3 = moderate importance 4 = high importance
Progress in addressing this problem at the national level	1 = high progress 2 = moderate progress 3 = low progress 4 = no progress
Urgency of addressing this problem	1 = no urgency 2 = low urgency 3 = moderate urgency 4 = high urgency

ANNEX 3:

Criteria list for locating priority site

Criteria	Rating	Weighting (1 – 4)	Score
Size of the affected area (as percentage of the total national land area)	1- < 10sq.km 2- 10 to 100sq.km 3- 100 to 1000sq.km 4- 1000 to 10,000sq.km 5- >10,000sq.km	1 = no importance 2 = low importance 3 = moderate importance 4 = high importance	
Affected population (as percentage of national population)	1- < 1000 2- 1000 to 10,000 3- 10,000 to 100,000 4- 100,000 to 500,000 5- >500,000		
Extent to which the natural catchment, aquifer or receiving coastal and marine waters support the livelihood of local communities (e.g., subsistence or commercial farming, forestry, mining, tourism, fisheries)	1- very low importance (<10%) 2- low importance (10-30%) 3- average importance (30-50%) 4- important (50-80%) 5- very important (>80%)		
Extent to which the natural catchment, aquifer or receiving coastal and marine waters support the national development (e.g., commercial farming, forestry, mining, tourism, fisheries)	1- very low importance (<10%) 2- low importance (10-30%) 3- average importance (30-50%) 4- important (50-80%) 5- very important (>80%)		
Extent to which the site is a recognized government priority (refer to National Sustainable Development Strategy, or other strategic action plans e.g., NEAPs)	1- no, not a priority 2- yes, low priority 3- yes, medium priority 4- yes, high priority 5- yes, very high priority		
Extent to which the site is of regional and/or global significance and priority (see WWF ecoregions, IUCN categories, UNESCO world heritage sites, etc.)	1- no, not a priority 2- yes, low priority 3- yes, medium priority 4- yes, high priority 5- yes, very high priority		
Degree of Degradation at the site (e.g., type of degradation)	1- very low 2- low 3- average 4- high 5- extremely high		
Extent of degradation on catchment and/or aquifer and any receiving coastal and marine resources and systems	1- very low 2- low 3- average 4- high 5- extremely high		

Criteria	Rating	Weighting (1 – 4)	Score
Cultural or traditional value of the site	1- very low 2- low 3- average 4- high 5- extremely high		
Extent of community management at the site	1- very low 2- low 3- average 4- high 5- extremely high		

ANNEX 4:

Template for cause and impacts

Environmental Problem	Environmental Impacts and socio-economic consequences	Rank	Sector	Rank

ANNEX 5:

Criteria for prioritising identified options for reform and action

Criteria	Rating	Weighting (1 – 4)	Score
Level of certainty that implementation will produce the expected/desired outcome		1 = no importance 2 = low importance 3 = moderate importance 4 = high importance	
Level of expected impact			
Feasibility of implementation			
Nationally appropriate approach			
Others			

ANNEX 6:

National Parks of Papua New Guinea

NATIONAL PARKS OF PAPUA NEW GUINEA						
Protected Area	Management type	Size in hectares	Marine area	IUCN Category	Latitude	Longitude
Abau		0		III	-3.259806	36.895437
Bagiai (I)	Wildlife Management Area	13,760		IV	-4.83	38.5
Baiyer River	Sanctuary	740		III	-2.429963	31.847983
Bamu River		0		III	-3.507468	35.808082
Cape Wom International Memorial Park	Park	105		III	-4.88	38.67
Crown Island (III)	Wildlife Management Area	5,969		IV	3.193536	33.979088
Finisterre		0		IV	-4.156592	36.083477
Kamiali	Wildlife Management Area	47,000			-2.532438	34.586366
Kikori River		0		IV	-7.401046	37.224594
Lake Lavu (I)	Wildlife Management Area	2,640		IV	2.174969	34.661203
Long Island (III)	Wildlife Management Area	41,922		III	1.851311	34.168748
Maza (I)	Wildlife Management Area	184,230		V	1.355554	34.571692
McAdam	National Park	2,080		IV	-6.669863	39.238025
Morobe		0		V	-3.049639	37.343877
Mt Gahavisuka	Provincial Park	77	Marine		-5.501571	39.076576
Mt. Balbi		0		VI	-7.553422	34.637579
Mt. Bamus		0			-4.996183	35.986394
Mt. Bangeta		0			-4.917909	38.660112
Mt. Bosavi		0		VI	-2.922976	32.287364
Mt. Capella		0		V	-2.936783	33.477798

NATIONAL PARKS OF PAPUA NEW GUINEA						
Protected Area	Management type	Size in hectares	Marine area	IUCN Category	Latitude	Longitude
Mt. Dremsel		0			-3.8257	32.835054
Mt. Menawa		0			-7.828924	38.036953
Mt. Michael		0		VI	-5.78	38.83
Mt. Onuare		0		III	-3.096507	31.584053
Mt. Suckling		0		IV	-6.104041	31.381312
Mt. Wilhelm		0		IV	-9.124313	33.663282
Mts. Albert Edward/ Victoria		0		IV	-3.842739	32.585916
Namanatabu Historic Reserve	Reserve	27	Marine	IV	-6.282743	39.175954
Ndrolowa (I)	Wildlife Management Area	5,850		IV	1.485708	30.978258
Nuserang (I)	Wildlife Management Area	22			-2.543512	32.887693
Pokili (I)	Wildlife Management Area	9,840			-3.237886	36.800289
Popondetta		0		Ia	-4.795454	38.282144
Ranba (I)	Wildlife Management Area	41,922			-4.676115	29.633676
Sawataetae (I)	Wildlife Management Area	700		III	-6.245411	29.925957
Sepik River		0			-6.901639	39.089977
Sinub Island	Wildlife Management Area	12		IV	-6.885576	31.31565
Siwi Utame (I)	Wildlife Management Area	12,540			-7.755344	36.641498
Strickland River		0			-6.983121	37.749412
Tonda (I)	Wildlife Management Area	590,000		IV	3.400327	31.53382
Varirata	National Park	1,063		IV	-6.699576	39.269997

NATIONAL PARKS OF PAPUA NEW GUINEA

Protected Area	Management type	Size in hectares	Marine area	IUCN Category	Latitude	Longitude
Whiteman Mts		0			-7.717469	35.729501
Yakopi Nalenk Mts		0		IV	-10.678258	38.8234

