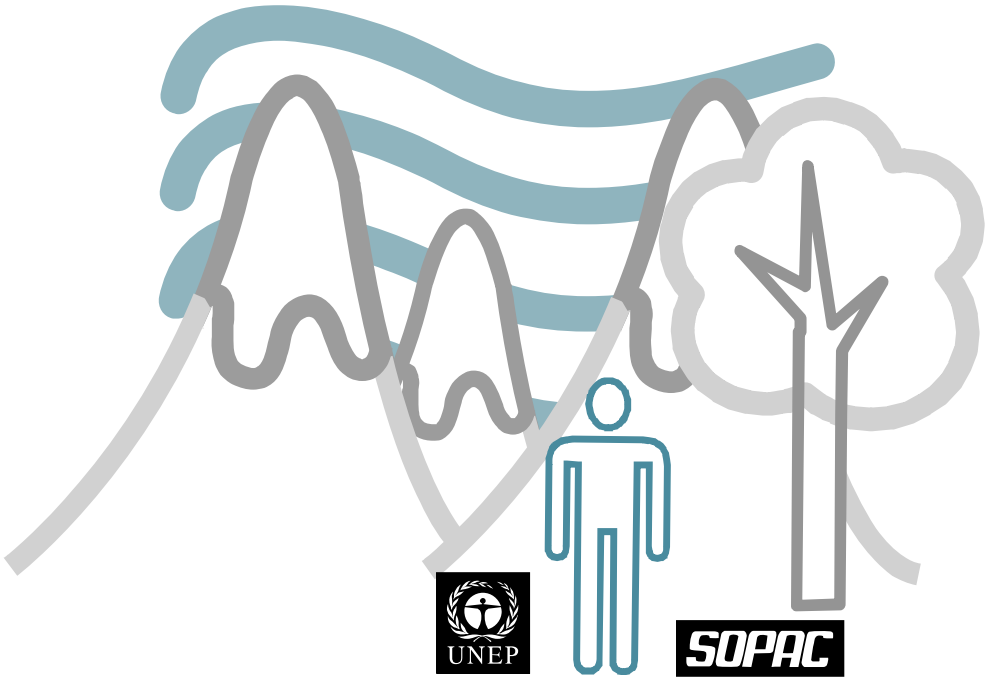
Environmental Vulnerability Index

EVI DRAP PNG 2005

Discussion Paper:

EVI Country Diagnostic Report and

Action Plan (DRAP) for Papua New Guinea



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Discussion Paper:

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Action Plan (DRAP) for Papua New Guinea

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June 2005

SOPAC Report XXX

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Why Environmental Vulnerability?

An environment in good condition provides us with all of the raw materials we need to develop economically and socially. This includes material *goods* like forests, soils, fisheries, water, minerals, chemicals and fuels. It also includes what are termed ecosystem *services* such as productivity, reproduction to renew biological resources, water cycling, the breakdown and recycling of pollutants, and rebalancing of chemistry (like carbon dioxide removal from the atmosphere). These goods and services are collectively what we call the *environmental support system*. Without the environment none of our endeavours are possible. But the environment can be damaged by both natural and human factors. In order to create a good quality of life for ourselves and ensure the needs of future generations, we need to find ways to develop that do not damage the system that supports us. The EVI has been designed to provide us with information on how vulnerable our environments are to damage, how sustainable our choices have been to date, and point the way to better policies and actions in the future. The EVI has been designed to assist countries to engage in smart development as they work towards their Millennium Development Goals.

Benefits of the EVI

- Issues. Identifies the most important issues now operating in a country that is leading to environmental vulnerability
- What policies, how much action? Indicates the direction and amount of change needed to decrease environmental vulnerability and increase resilience
- Trade-offs. Can be used to identify possible trade-offs between environment, economy and society in sustainable development
- Monitoring & Evaluation. Provides a way for monitoring the outcome of actions and movement towards sustainable development goals
- Tool. A tool to assist countries with Millennium Development Goals, BPoA, CSD, and a range of related processes such as ISDR / Disaster Risk Reduction, UN Framework Convention on Climate Change, Convention on Biological Diversity and others.

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1. Vulnerability index – environment

Contents

1. Purpose of the EVI

A global focus on sustainable development over the past 10 years has highlighted the need for monitoring, evaluation and the development of sustainability thresholds to guide us in making choices that will ensure our future. Development is often achieved through trade-offs made between the three pillars of sustainability, namely a country's economy, its society and the environment. All of these aspects of countries may be damaged by natural events (storms, earthquakes), human activities (pollution, wars, poverty), and increasingly through interactions between them (effects of natural disasters can be worse in areas already damaged by chronic human impacts).

Of these three pillars of sustainable development, our focus in the Environmental Vulnerability Index (EVI) is on the environmental support system which underpins the wealth and success of countries, providing raw materials, renewable resources and attenuating wastes. Without a healthy, resilient environment that is able to provide the resources and services people need, economies and social systems must fail. Proper planning and mainstreaming of environmental concerns is therefore not just necessary for developing nations, but a critical process for all.

As we continue to put more pressure on the environment it is becoming increasingly important to be able to measure how vulnerable our ecosystems are to damage and to identify ways of building resistance to damage and/or the ability to bounce back (resilience). With this information the development pathways and outcomes for countries can be optimised for their unique situations and goals.

The EVI was developed in response to the Global Summit on the Sustainable Development of Small Island Developing States (SIDS) held in Barbados in 1994 and a range of other sustainable development processes. Its purpose is to complement information on economic and social vulnerability of countries to ensure that development can be balanced for all three pillars and sustainable conditions promoted. The South Pacific Applied Geoscience Commission (SOPAC), United Nations Environment Programme (UNEP), Ireland, Italy, New Zealand, Norway, other institutions, and 32 collaborating countries developed the EVI as a globally-applicable tool to obtain information and feedback on the vulnerability of the environment of nations. A full explanation of the mechanics of the EVI and the results obtained for 235 countries and territories to date is embodied in reports and pamphlets that can be obtained from SOPAC or downloaded from www.vulnerabilityindex.net.

This report represents the first step in applying the results of the EVI for Pacific Island Countries (PICs). These country diagnostic reports with recommended action plans have been developed individually for each of SOPAC's Member Countries. They identify the key issues threatening the environmental support system of each country, as well as areas of existing good resilience that could be preserved to prevent vulnerabilities from developing in the future. In this report, we use the EVI to provide clear guidance for addressing issues of vulnerability, including policy directions, specific actions and/or amounts of change needed to effect changes in vulnerability, and projects that could be implemented in support of sustainable conditions. This Diagnostic Report and Action Plan (DRAP) identifies the

highest priority issues that need to be addressed to build the environmental resilience of countries by the most efficient routes.

It is also expected that the application of the EVI will assist countries to meet internationally agreed reporting and goals. These include the Commission on Sustainable Development (CSD), World Summit of Sustainable Development (WSSD), Review of BPoA in Mauritius, United Nations Framework Convention on Climate Change (UNFCCC), Convention on Biological Diversity (CBD), The International Strategy for Disaster Reduction (ISDR) and others.

2. The Papua New Guinea Context

2.1 Economy

Papua New Guinea is rich in natural resources, including gold, copper, oil, natural gas, agricultural land, forests and maritime fisheries. The economy of the country has two aspects, comprising a dominant capital-intensive minerals sector, and 75-85% of the population deriving their livelihood from subsistence activities and low-productivity labour-intensive farming [(1)(2)]. Increasing numbers of people are becoming part of the cash economy producing small scale export crops such as coffee, copra, palm oil, tea and cocoa[1]. The resulting GDP per capita was US $566 in 2003, an increase $512 in 2002.

About 40% of the country is covered with exploitable trees, and South East Asian companies are active in the timber industry. The World Bank (WB) and other donors have withdrawn support from the sector over concern for unregulated deforestation and environmental damage. Although an official moratorium on log exports is currently in place, it is poorly enforced and logging continues at an unsustainable rate. PNG has an active tuna industry but much of the catch is made by boats of other nations fishing in PNG waters under license. Locally produced fish exports are confined primarily to prawns[5].

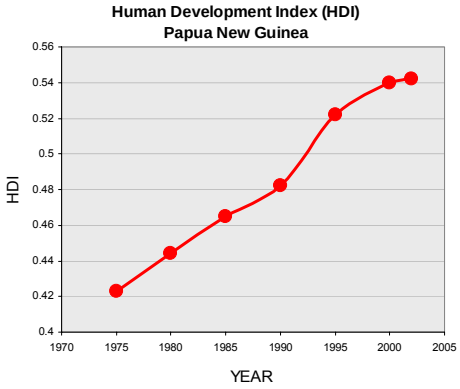
In general, the Papua New Guinea economy is highly dependent on imports for manufactured goods, with its industrial sector accounting for only 9% of GDP and contributing little to exports. Small-scale industries produce beer, soap, concrete, furniture, plywood, and paint. The small domestic market, relatively high wages, and high transport costs are constraints to industrial development[5].

Australia, Singapore, and Japan are the principal exporters to Papua New Guinea, and Australia is Papua New Guinea's most important export market, followed by Japan and the European Union. Australia is by far the largest bilateral aid donor, offering about $300 million a year in assistance. Other major sources of aid to Papua New Guinea are Japan, the European Union, the People's Republic of China, the Republic of China, the United Nations, the Asian Development Bank, the International Monetary Fund, and the World Bank. Foreign assistance to PNG is substantial at US $75 per capita[4].

PNG's economy is small, fragmented, and highly vulnerable to external influences, with 90% of its exports and 42% of its GDP[4] comprising oil, agriculture and minerals. Economic growth in 2003/2004 followed high commodity prices[1] and government steps toward

spending control. The economy grew modestly and the government deficit fell from 8% of GDP to 1.7%[5]. The commodity boom will be temporary and the nation continues to have serious problems of corruption, a lack of law and order, land tenure concerns stifling investment, political interference in businesses, and a lack of political will to adapt needed sweeping reforms. More generalised economic development in the country has been constrained by the difficulties of establishing transportation and communication between population centres, which are separated by rugged terrain on the mainland and large distances between the islands. The opening of an oil refinery and commercialisation of the country's estimated 22.5 trillion cubic feet of natural gas reserves through the construction of a gas pipeline from Papua New Guinea to Queensland could have a significant impact on the PNG economy(5).

2.2 Social and Human context



The people of Papua new Guinea are largely Melanesian, with more than 800 distinct language groups in the country(2). The population is over 5.62 million people (2003) with an annual average growth rate of 2.7%. In 2003 the growth rate was 1.8%, down from 3.3% in 2002. PNG ranked 133 on the UN Human Development Index (HDI) in 2003, with a steady increase in index value over the period since 1975(6) (see figure right). Despite this, PNG currently ranks last in the Pacific in the HDI and poverty indices(7), with an estimated 37% of the population living in poverty, nearly all of them in rural areas(7).

Papua New Guineans have very low average life expectancy and very high maternal and infant mortality rates. Many deaths are the result of preventable and treatable diseases such as malaria, pneumonia, tuberculosis and diarrhoea. Malnutrition, HIV/Aids and an increasing use of tobacco and alcohol are contributing factors.

The main urban areas in the country are Port Moresby, Lae, Madang, Mt Hagan and Goroka. These areas house 13% of the population, while the majority (87%) still live in rural communities based on the traditional village structure and dependent on subsistence farming supplemented by cash cropping.

Lack of law and order adversely affects a range of factors associated with wellbeing including, social tension and conflict and inhibits social growth(8). In addition, general development continues to be hampered by the still deteriorating situation, which is worsened by tribal fighting in the Highlands Region(9).

PNG had put in place policies and strategies to improve the provision of social services, especially in the health and education sub sectors. Programmes are being implemented to improve health; pharmaceutical and medical supplies; strengthen institutions, improve literacy, increase education, reduce poverty; and improve the living standard of the people, particularly in the rural areas(10).

2.3 Environment

Papua New Guinea is geologically complex, lying across two of the planet's major tectonic plates, the Australia & Pacific plates, and forming part of the "Ring of Fire" around the edge of the Pacific, a zone of frequent earthquakes and volcanic eruptions. The country comprises the eastern half of the sub-continental island of New Guinea, the large islands of the Bismarck Archipelago and the northernmost parts of the Solomon Group, plus 600 smaller islands. PNG shares political borders with Australia, Solomon Islands, Guam and Indonesia. PNG has a diverse geography characterised by high mountain ranges, deep valleys and swift rivers in the interior and open plains, tropical forests and swampy inlets in the coastal region. The islands comprise coral islands, atolls, and archipelagos. There are also around 120 volcanoes, and a central core of mountains which runs east to west across the country, with almost a quarter of the land area over 1,000 metres above sea level. Mount Wilhelm is the highest peak at 4,509 metres. Several large rivers traverse the country, the largest and most significant of which are the Fly, Markham and Sepik rivers.

Situated in the wet and humid equatorial tropics, PNG has little seasonal temperature variation, but significant regional variation. Coastal temperatures range from 23º to 30ºC, while the highland areas are considerably cooler, very occasionally falling to zero degrees. Most of the country has more than 2,000 millimetres of rain a year, with some parts having a rainfall which is five times greater. The wettest seasons are January to April and September to December, the first period bringing the northwesterly monsoons and the latter carrying heavy rain on the South East trades. Port Moresby (the capital) is relatively dry with less than about 1000 millimetres a year.

Papua New Guinea (PNG) is the largest island nation in the Pacific and has the richest in flora and fauna of all nations in the Pacific Rim. It harbours about 6% of the world's bio-diversity and has one of the last remaining tracts of tropical rainforest on earth[(2)]. Geographically PNG stretches from the equator to 12 degrees south latitude and encompasses some 465,000 square kilometres. The diverse geography supports a remarkable range of equatorial environments from high alpine peaks, several of which rise above 4,000m to extensive pristine tracts of lowland alluvial rainforest as well as coral reef systems. As a result, PNG has a high biological diversity, in terms of species count and endemism, placing it in the top ten countries for biodiversity. PNG also has high biodiversity at the scale of habitats with all significant marine ecosystems and island types represented - from reef systems to sea beds, mangrove deltas and deep ocean trenches. Over 40,000 square kilometres of coral reefs are found along PNG's coastline.

Development has been rapid over the past few decades with most being driven by the exploitation of the rich natural resources. This together with climate issues and an increasing population has placed increasing demands on the natural environment. Some of the key environmental issues that have been identified in PNG include:

- Climate Change & Sealevel rise: Vulnerability to the impacts of climate change and sea level rise, especially to its small islands and low-lying atolls, low coastal plains, and fragile mountain ecosystems. Further, the country is being affected by unprecedented

environmental and natural disasters. The major drought in mid-1997 to 1998 caused by the El Nino/La Nina phenomenon was attributed to climate change [10].

- Wastes: There is a growing problem in PNG with the disposal of solid, liquid and hazardous wastes, particularly given the poor waste disposal practices[10].
- Coastal & Marine areas: Threats to coastal and marine ecosystems by human activities, such as mining, forestry, wastes (including sewage); shipping; destructive fishing methods, land reclamation and coastal developments [10].
- Biodiversity: Threats to PNG's rich biological diversity from mining, logging, agriculture; and the utilization of fisheries and marine resources[10].
- Logging: The widespread logging activities in the country are a serious threat to the country's terrestrial biodiversity resources[10].
- Agriculture: Agriculture activities, including for subsistence and commercial purposes requires the clearing of large areas of forests and grasslands and threaten ecosystems and biodiversity. Unsound agriculture practices affect soil structure and fertility[10].
- Mining: The most serious threat to the terrestrial and marine biodiversity is from the disposal of chemical and other wastes from mining[10].

3. EVI Results for PNG

3.1 Country Profile

Papua New Guinea has an overall EVI score of 254 based on data collected for 92% the EVI indicators (a valid evaluation requires >80%). With this value, PNG's environment is considered **At Risk**, but is not currently considered highly vulnerable to damage by natural and human events and processes. This situation has arisen because many of the human impacts on the country are still relatively low overall, particularly in the areas of natural resources and ecosystem services, development and population. That is, the "Damage" aspect of vulnerability is low (Damage=1.30). PNG also has some innate structural conditions that have lead to some vulnerability (Resistance=3.38), meaning it has a lower than ideal resistance to damage and ability to bounce back after damage occurs. Hazards to the environment are moderate in PNG (Hazards=2.75). This implies that most of the vulnerability in the country derives partly from innate conditions which result in decreased resistance, and to a lesser extend partly from hazards which have the potential to damage it. These are mainly concerned with geographic and geological features and weather and climate. For the moment, relatively little of the country's vulnerability derives from damage sustained in the past, or that associated with ecological services or human activities.

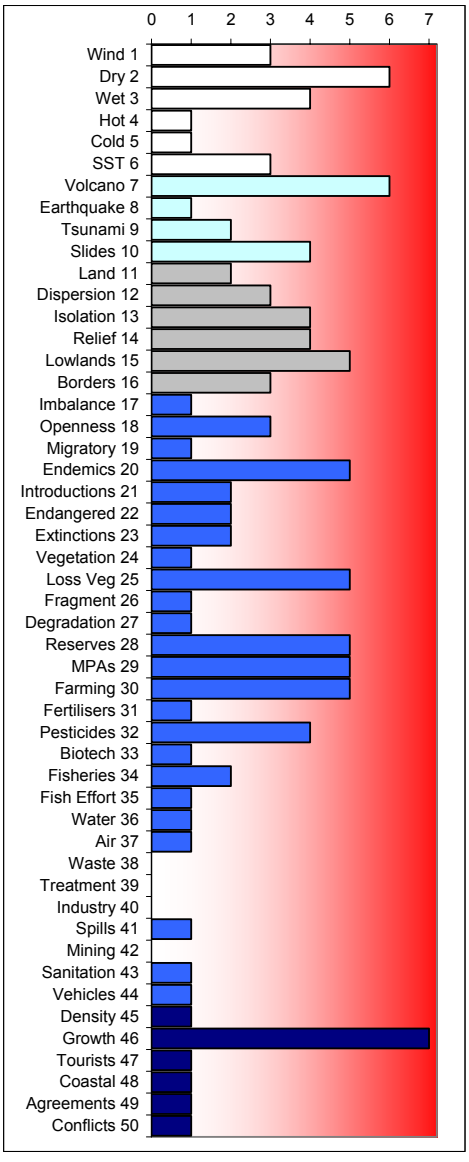
Overall, there is still a lot of resilience in PNG's environment, which if managed well will contribute greatly to its overall sustainable development in the future.

This result does not discount cases where localised impacts are high and localised vulnerability is great. The EVI has been applied at a national scale to examine overall priorities, but could be applied at the scale of provinces, islands or other geographical scales. Such application of the EVI would allow decision-makers to examine localised issues of vulnerability which may differ from the overall picture.

Summary EVI Report Sheet for Papua New Guinea. This is a VALID evaluation, based on >80% of indicators being evaluated. Data are primarily from international public data sources, see www.vulnerabilityindex.net for full access to all reports and technical background. Note that some indicators could not be evaluated – some of these may represent significant vulnerability issues that need to be identified in the future.

Papua New Guinea

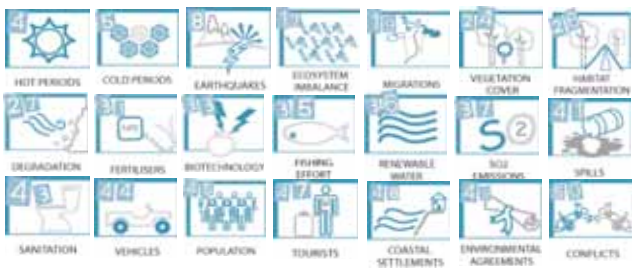
	SCORE	DATA%
EVI	**254**	**92**
CLASSIFICATION:	**At risk**	
ASPECTS OF VULNERABILITY:		
Hazards	2.75	88
Resistance	3.38	100
Damage	1.30	100
LEGEND FOR INDICATOR TYPES:		
Weather & Climate	3.00	100
Geology	3.25	100
Geography	3.50	100
Resources & Services	2.21	86
Human Populations	2.00	100
POLICY-RELEVANT SUB-INDICES:		
Climate Change	2.69	100
Exposure to Natural Disasters	2.73	100
Biodiversity	3.00	100
Desertification	2.91	100
Water	3.08	92
Agriculture / Fisheries	2.53	100
Human Health Aspects	1.60	83



Resilient ⟷ Vulnerable
Blanks = No data or Not applicable;
EVI scores are 1-7

ISSUES OF GREATEST ENVIRONMENTAL VULNERABILITY

ISSUES OF LEAST VULNERABILITY / GREATEST RESILIENCE



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3.2 Issues of high vulnerability (High EVI values)

3.2.1 Issues that can be directly modified

Population Growth – Indicator 46 (EVI=7). Papua New Guinea has only one indicator with an EVI score of 7 (most vulnerability). The aspect giving the highest vulnerability signal is human population growth rate (Indicator 46) which is recorded with the value 2.48% for average annual growth rate between 1996 and 2001 (US Bureau of Census 1996-2001). In the years since 2001, growth rate in PNG increased to 3.3% in 2002 and fell to 1.8% in 2003. If growth were permanently reduced to the 2003 level, the EVI score would be reduced to EVI=6, still high. Rapidly expanding human populations are associated with increasing rates of habitat damage, exploitation of natural resources and problems associated with pollution and disposal of wastes. Although PNG's population size and density is low and does not at present contribute significantly to environmental vulnerability (EVI=1), the rate of expansion means that rapid changes need to be assimilated into the environment. To reduce environmental vulnerability, population growth needs to be slowed. In many countries that can mean to near-zero or in some cases, negative levels for sustainable conditions to be met. In some countries population density is already very high, leading to vulnerability in its own right, but this is not the case in PNG, where it is likely that some population growth is still possible within sustainable limits. The important strategies and options that should considered for PNG are concerned with (i) slowing the rate of human population growth, (ii) ensuring that adequate development controls are in place to minimise damage as infrastructure, services and resource exploitation are expanded (including forestry, minerals, fisheries, water, agriculture), and (iii) that pollution and wastes are properly handled so that they do not result in damage to supporting environments.

	Value now		Value to reduce score to:		
Indicator	**EVI**	**Raw**	**EVI=6**	**EVI=5**	**EVI=1**
46 Population Growth (annual % change over 5 years)	7	2.48	< 2	< 1.5	< 0
25 Rate loss vegetation (% change over 5 years)	5	-0.36			> 0
28 Terrestrial reserves (% land area)	5	0.1			≥ 20
29 Marine reserves (% continental shelf)	5	2.67			≥ 20
30 Intensive farming (t / km^2 / year)	5	352.43			≤ 6.39

Rate of loss of natural vegetation – Indicator 25 (EVI=5). The rate of loss of natural vegetation cover (Indicator 25) is relatively high in PNG, resulting in an EVI score=5 and a value of -0.36% change over the 5 years 1990-1995 (WRI 2001). The cover of natural vegetation remaining (Indicator 24) is however, still good (EVI=1), so there is a good opportunity here for examining policies to ensure that sustainable conditions are not exceeded. Maintaining natural forest cover over as much of the country as possible (while allowing for development of agriculture etc) has significance for general resilience building against the effects of natural hazards (cyclones, tsunamis, landslides etc), maintaining good water resources, soil building, preventing run-off / sedimentation problems in nearshore coastal environments, and maintaining biodiversity.

The Government of PNG has recognized that all forest development must give due consideration to the protection of soils, water, fauna and ecosystems, and meet basic needs of the people for fuel, food, water, and shelter. In 1991, the Government endorsed the National Forest Policy and that was followed by the National Forestry Guidelines of 1993. These Policy and Guidelines were put in place to guide operation of the logging industry[(10)]. Further on from these steps, important strategies and options should focus on (i) attaining a net zero loss of natural vegetation cover with at least 80% of natural vegetation cover remaining on the land; and (ii) examining national policies on the logging industry in relation to these targets.

Terrestrial and Marine Reserves – Indicators 28 & 29 (EVI=5). The area set aside for terrestrial (Indicator 28) and marine reserves (Indicator 29) in PNG is low at 0.1% of the land area (WRI 2001) and 2.67% of the continental shelf (WCMC 1999) legally set aside as reserves. These values resulted in an EVI score=5 for each indicator, which for maximum resilience targets 20% set aside as reserves. Establishing reserve areas is one of the few steps that can be universally taken by countries to positively build resilience and off-set vulnerability in other areas more difficult to address. Reserves on land and in the sea can increase resilience through promoting areas of excellent ecosystem function (not compromised by human activities) that allow for pollution attenuation, groundwater recharge, preserve biodiversity and provide organisms to recolonise adjacent damaged areas. Having adequate reserves also indicates a high level of environmental management and awareness in a country. The benefits of reserves increase with increasing area, increasing representation of ecosystem types, and increasing degree and time period of protection. Permanent no-take reserves that are representative of major ecosystem types and occupy 20% of the land and sea area would be considered ideal. Reserves would be especially important if there are many endangered species, sensitive ecosystems, and interactions with on-going human impacts in the country. Strategies and options that PNG could consider to increase the environmental resilience of the country would include (i) setting targets on the number, size and location of land (including river areas, freshwater lakes and swamps) and marine reserves in the country needed to achieve 20% as reserves and a time frame over which they could be established, and (ii) examining approaches for making reserve areas more economically valuable to the country through direct and indirect tourism, fisheries, forestry, biodiversity and other benefits.

Intensive Farming – Indicator 30 (EVI=5). According to the FAO (2000) and other sources, PNG produces an average of approximately 352 tonnes per square kilometre per year of intensively-farmed animal products (equivalent to almost 160,000 tonnes/year, a figure we believe should be re-examined for accuracy). This mostly involves pigs, with small amounts of turkeys and aquaculture. High levels of intensive farming, if the figures are accurate, represents a risk of pollution, eutrophication of water bodies, ecosystem loss or damage and the risk of diseases and plagues. This indicator focuses on lands being used for intensive agriculture, which we define as those in which the wastes produced over the land are in excess of the ability of that same land area to attenuate them, and usually involves clearing of land, feeding, heavy use of pesticides and other medications and a concentrated production of wastes. Countries with a large production through intensive farming methods

are also considered more at risk of inadvertent introductions of diseases. The effects of intensive farming would be especially important if there are many endangered species, sensitive ecosystems that could be affected by key species, and interactions with on-going human impacts. To address this source of vulnerability, we suggest: (i) the data on intensive farming should be re-evaluated to ensure the signal given by the EVI is accurate and if it is examine policies, (ii) ensuring that adequate controls are in place to minimise damage from intensive farming relating to stock feeds, disease control and use of medicines and other chemicals, and (iii) that wastes are properly handled so that they do not result in damage to supporting environments.

3.2.2 Structural issues that can be improved indirectly

Papua New Guinea receives some of its vulnerability from innate structural characteristics that became part of the country when its borders were defined. It may also derive part from processes that occur, and can be influenced, only at a greater scale than the country itself. The innate issues that affect the environmental vulnerability of the country include the presence of many volcanoes, vast areas of lowlands and a high degree of endemism of its species. The country also has a strong vulnerability signal deriving from significant dry periods (over a recent 5 year period) that show up against the long term (30 year) climatic mean. This latter issue could be innate, or could be part of a shift associated with climatic change.

Dry Periods – Indicator 2 (EVI=6). PNG's average annual rainfall deficit is over the 5-year period 1992-1996 (latest available data) was 104 mm, measured across 33 climate stations. This represents a rainfall shortage compared with expected monthly rainfall patterns specific to each station and its 30 year means. This indicator captures not only the number of months with significantly lower rainfall, but also the strength of the deficit. A large deficit of rainfall is associated with vulnerability to drought, stress on water resources and downstream effects on ecosystems. Frequent and severe drought months could indicate shifts in weather patterns and climate, and could negatively affect a country's resilience to other hazards (e.g. fires, water movements and ability of ecosystems to attenuate pollution). This issue cannot be directly addressed, but need to be approached indirectly through general resilience-building and international processes where climate shifts are considered anthropogenic (e.g. UNFCCC). To address this source of vulnerability, we suggest that: (i) PNG ensures that adequate controls are in place to minimise damage to forests, surface and sub-surface water resources, and particularly wetlands which would likely be the first ecosystems to respond to periods of water stress. This includes good design of human settlements in terms of water supply and sanitation, (ii) PNG's long term rainfall patterns be examined in detail for climate stations around the country to determine where the greatest areas of stress are to build resilience in those places first, and (iii) the country continue with its efforts to understand and respond to changing climatic conditions.

Volcanoes – Indicator 7 (EVI=5). PNG has a total of 129 volcanoes, 96 of which have a Volcano Explosivity Index of VEI=2 or greater (NOAA/NGDC). The cumulative volcano energy in the country is 541 VEI units per million square kilometres of land area (calculated by summing all volcanoes by their VEI scores VEI2*2+VEI3*3+….+VEI8*8). The world values (limited to countries with volcanoes) ranges between 0.21 and more than 80,000 VEI units / million sqkm land. In addition to risks to human communities, volcano energy can disrupt the natural environment on which human depend, particularly if there are many interactions with other human or natural factors. PNG's environment is vulnerable to damage through eruptions, landslides, geysers, gas (e.g. SO2 and CO2), fires, ash, dust, kills threatening biodiversity of habitat & species, and the potential for repeated and long term habitat disturbance. This indicator captures the risk of damage to ecosystems from the physical, chemical and biological disturbances associated with volcanic eruptions. Because the risk associated with volcanoes varies according to size and type, the signal incorporates not only the number of volcanoes capable of affecting a country, but also each one's potential for damage. PNG of course can not alter the behaviour of its volcanoes, but can consider ways of minimising their impacts, largely through maintaining the natural ecosystems around them in good condition. In any case, volcanic areas do not make good human settlements. With good cover of trees (even if eruptions do kill them from time to time) and minimal disturbance to surrounding environments, slides, the effects of gases and run-off into nearshore areas would be moderated.

Lowlands – Indicator 15 (EVI=5). Despite the abundance of mountainous areas, approximately 51% of PNG is less than 50m above sea level, including coastal areas, islands and large parts of the Gulf and Western provinces. This indicator focuses on the impacts associated with pollution, ecosystem disturbance, flooding and coastal vulnerability. Areas of lowlands are those that will tend to be the first to flood, will tend to accumulate pollution that is mobilised by surface run-off, provide an important entry point (and extraction point) for groundwaters and if on the coast or inland swamps (e.g. Gulf, Sandaun and Western provinces) be subject to storm surges, tsunamis or sea level rise. They tend to be areas of high biodiversity and/or form critical habitats (e.g. the unique Nypa palm areas of the Gulf, the inland waterways around Balimo). They may also be critical areas for productivity, soil formation, erosion, natural resources and pollution attenuation. PNG's resilience to future hazards will be related to risks on lowland areas, especially given the many sensitive ecosystems susceptible to the loss of keystone species and interactions with on-going human impacts. To address this source of vulnerability, we suggest that: (i) PNG ensures that adequate controls are in place to minimise damage to lowland ecosystems, particularly wetlands, (ii) that damage in lowland areas from mining and pollution are minimised, (iii) the country continue with its efforts to understand and respond to the treat of tsunamis, storms and changing climatic conditions.

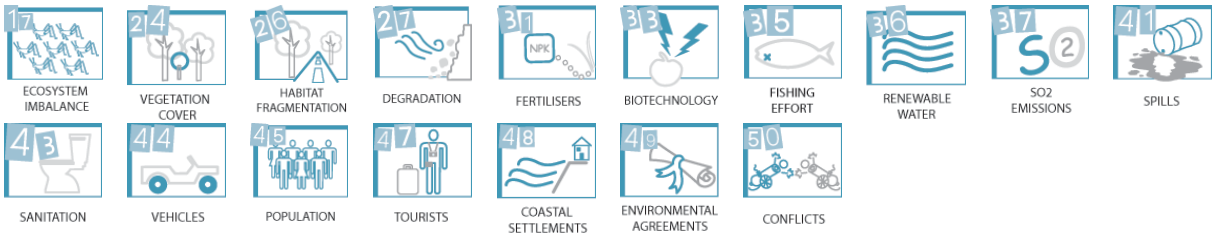
Endemic Species – Indicator 20 (EVI=5). PNG has 367 *known* endemic species (WRI 2001), and probably thousands more that have not been identified, particularly among the invertebrates. This equates to a density of 810 endemic species per million square kilometres of land area. The world median is 77 species, and values of *known* endemic species in countries range over 18,500 (China and Indonesia). The presence of endemic species can be critical to the way that ecosystems have formed and function in a country,

particularly where endemic species are habitat-forming (e.g. corals, mangroves, trees) or have become key species in ecosystems. They are also, of course, often central to the benefits of biodiversity directly derived by humans in a country, including pharmaceuticals, tourism and other activities that produce foreign exchange. The more endemic species a country has, the more vulnerable its environment is because localised extinction cannot be resupplied from elsewhere by natural or augmented recolonisation, and losses of species can lead to wholesale changes in the way that ecosystems function. Although the number of endemic species present is basically a fixed characteristic of the country, steps can be taken to reduce vulnerability. Environmental vulnerability in this case is not connected with the presence of endemic species, but their loss. We suggest that (i) PNG ensures that adequate development controls are in place to ensure that endemic species are protected as a priority. This action is aligned with the CBD (Convention on Biological Diversity, 1992) and other international treaties to which it is a signatory, (ii) that research on identifying key species and threatened endemic species is promoted, with such species coming under special protection as important to maintaining resilience and the environmental wealth of the country.

3.3 Areas of good resilience (EVI value of 1)

Many aspects of the environment of Papua New Guinea appear to be in a resilient state with and EVI score=1. This includes factors directly connected with human choices and innate characteristics only indirectly subject to human interventions.

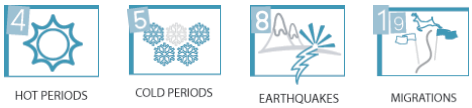
3.3.1 Issues that can be directly modified



At the time of this EVI evaluation, PNG had low vulnerability and good resilience scores for each of these indicators. These issues are of central importance to managing vulnerability in the country because they are in a good state now and steps need to be taken to ensure that vulnerability does not increase. Its is far simpler and less costly to preserve existing vulnerability than it is to reverse trends that have already become established in a country. PNG should consider policies that will ensure these areas of high resilience are maintained as a priority.

Indicator	Value now (EVI=1)	Value that will result in EVI score of 2+
17 Ecosystem imbalance (weighted average change in trophic level)	0.15	≤ -0.02
24 Vegetation cover (% of original cover remaining)	85.4	≤ 80
26 Habitat fragmentation (length roads / land area)	0.04	> 0.22
27 Degradation (% land severely or very severely degraded)	0	> 5
31 Fertilizers (kg / km^2 / year)	28.11	> 53.60
33 Biotechnology (number of deliberate field trials)	0	> 0
35 Fishing effort (mean annual number of fishers / km coastline)	0.79	> 6.39
36 Renewable water (water use as % renewable)	0.01	> 10
37 SO_2 emissions (t/km^2/yr)	0.05	> 0.28
41 Spills (spills >1,000 litres over 5 years)	0	> 0
43 Sanitation (people / km^2 without access to safe sanitation)	0.89	> 3.48
44 Vehicles (vehicles / km^2)	0.04	> 1.72
45 Population (people / km^2)	5.22	> 19.09
47 Tourists (average people / km^2 / year)	0.14	> 19.09
48 Coastal settlements (people / km^2 coastal land)	3.2	> 19.09
49 Environmental Agreements (treaties signed / in force)	73	≤ 60
50 Conflicts (average conflict years / decade over last 50 years)	0	> 0

3.3.2 Structural issues



PNG has no existing vulnerability issues with extremes of climate temperatures, earthquakes and migrations of species. These are all innate characteristics and do not require any action on the part of the country. Resilience is natural and, except for the case of climate change, will not be affected by developments in the country.

3.4 Indicators with No Data

Although PNG has a large proportion of the data needed for EVI evaluation (92%), there were some indicators for which no data were available, or which were provided from in-country sources but were rejected because they contained errors. We therefore have no information on issues of waste management, and vulnerability due to industry and mining. PNGs position paper for Mauritius 2005[10] clearly identifies potential issues connected with mining. These need to be assessed in terms of their contribution to the overall vulnerability of the country as soon as possible.

4. Action Plan

4.1 Policy debate for reducing vulnerability and building resilience

The following is a list of topics for policy debate in PNG for reducing vulnerability and building resilience in the country based on its existing conditions and potentials.

1. Develop an overall policy on vulnerability and its role in promoting sustainable development. This should include elements of all three pillars of sustainable development and interactions among them. The policy should focus on an understanding of trade-offs and the real costs and benefits of development pathways to the country.
2. PNG should consider adopting the EVI and other measures (e.g. Economic Vulnerability Index, support development of Social Vulnerability Index, and use HDI, ESI and others) as part of its monitoring of sustainable development and meeting its Millenium Development Goals. This would include establishing data collection mechanisms in the country and a way of re-evaluating the EVI regularly either through a regional clearinghouse or in-country. The results of such evaluations should have identified feed-back mechanisms to allow for adjustments to policy as necessary to achieve the overall SD goals. Missing indicators for the EVI should be evaluated as a priority – these could identify further vulnerability or resilience issues that need to be addressed and that could not be identified in this first EVI evaluation.
3. PNG should consider developing a policy on preserving its existing resilience as the cheapest, most efficient first step in overall vulnerability management and promoting sustainable development. Using the EVI's thresholds, PNG should set limits on the amount of risk to damage that accumulates in the country for issues that can be affected by direct interventions (see section 4.3.1). There is still a lot of resilience in the environmental support system of the country, some of which can be used to promote development as long as limits of sustainability are not exceeded.
4. PNG needs to consider policies on population growth and size of the population in relation to sustainable development. The present population is low and not a vulnerability issue, but the rate of population growth is high. The Government needs to examine mechanisms for limiting damage to the supporting environment resulting from meetings the needs of a rapidly expanding population. The tendency is to put in infrastructure and services as quickly as possible to meet the demand, without putting adequate controls on how resources (water, land, forests) and ecosystem services (such as pollution attenuation) are utilised. PNG's rapidly-expanding population is a source of vulnerability for the country that does not have to result in damage if smart development pathways and options are used.
5. A policy on the use of PNG's forestry resources in urgently needed. Although the amount of forest remaining in the country is still high (85.4%), the rate of loss of the existing forests is also very high (-0.36% / year). PNG needs to consider setting an absolute limit on the total forest cover to be lost in the country and then establish a no net loss of forests policy. To promote good resilience and long term sustainability, at least 80% cover by original forests should be retained in the country (including losses from urban areas, agriculture and logging), and then continue with sustainable logging that results in no further net loss.

6. PNG could consider establishing a policy on protected areas designed to ensure there are sufficient areas set aside to maintain resilience, preserve biodiversity, support fisheries, maintain ecosystem services and attract tourism to the country. A long term target of 20% of the land area and continental shelf areas is recommended.

4.2 Examples of Projects that could be developed

1. Establish an EVI data node in the country. Funding could be sought to train and staff a position in the Statistics, Environment or another department to take the role of Sustainable Development Monitoring Officer. This position would be established to collect data for the EVI, MDG and other sustainable development processes from other ministries and departments. The data could then be re-evaluated regularly in-country and/or passed on to a Pacific EVI Node for evaluation and reporting.
2. Forestry Sector Review. Funding could be sought to review the forestry sector in PNG. The review should focus on economic, social and environmental costs and benefits to the country. It should propose policies that could be adopted to ensure sustainable use of forestry resources. Other options for foreign exchange through use of the forestry resources such as through bio-prospecting and tourism, should be contrasted with the services they provide in pollution / CO_2 attenuation, soil formation, water resources and prevention of excessive run-off, including down-stream effects in coastal areas. The focus should be on the overall welfare of people in the country derived indirectly as well as directly from forests, and how best to utilize them to promote development without creating vulnerability.

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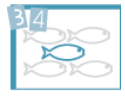
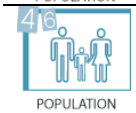
Appendix 1: Summary of indicators

	INDICATOR	Value	EVI Score
	Average annual excess wind over the last five years (summing speeds on days during which the maximum recorded wind speed is greater than 20% higher than the 30 year average maximum wind speed for that month) averaged over all reference climate stations 1 148 2 200 3 270 4 365 5 445 6 601 7 *Indicator scaling: (cut-off values are knots of excess wind annually)*	206.05	3
	Average annual rainfall deficit (mm) over the past 5 years for all months with more than 20% lower rainfall than the 30 year monthly average, averaged over all reference climate stations 1 10.9 2 18.0 3 29.7 4 48.9 5 80.7 6 133.0 7 *Indicator scaling: (cut-off values are mm annual rainfall deficit)*	-104	6
	Average annual excess rainfall (mm) over the past 5 years for all months with more than 20% higher rainfall than the 30 year monthly average, averaged over all reference climate stations 1 5.0 2 9.8 3 16.2 4 24.2 5 33.8 6 45.0 7 *Indicator scaling: (cut-off values are mm annual rainfall excess)*	17.4	4
	Average annual excess heat (degrees) over the past 5 years for all days more than 5°C (9˚F) hotter than the 30 year mean monthly maximum, averaged over all reference climate stations 1 18 2 30 3 50 4 82 5 135 6 224 7 *Indicator scaling: (cut-off values are degrees Celsius of excess heat annually)*	1.85	1
	Average annual heat deficit (degrees) over the past 5 years for all days more than 5°C (9˚F) cooler than the 30 year mean monthly minimum, averaged over all reference climate stations 1 18 2 30 3 50 4 82 5 135 6 224 7 *Indicator scaling: (cut-off values are degrees Celsius of heat deficit annually)*	2.03	1
	Average annual deviation in Sea Surface Temperatures (SST) in the last 5 years in relation to the 30 year monthly means (1961-1990) 1 3.7 2 5 3 6.7 4 9 5 12.2 6 16.4 7 *Indicator scaling: (cut-off values are average degrees/year)*	5.99	3
	Cumulative volcano risk as the weighted number of volcanoes with the potential for eruption greater than or equal to a Volcanic Explosively Index of 2 (VEI 2) within 100km of the country land boundary (divided by the area of land) 1 6.4 2 19.1 3 53.6 4 147.4 5 402.4 6 1085.8 7 *Indicator scaling: (cut-off values are weighted numbers of volcanoes VEI 2+)*	541.01	6
	Cumulative earthquake energy within 100km of country land boundaries measured as Local Magnitude (ML) ≥ 6.0 and occurring at a depth of less than or equal to fifteen kilometres (≤15km depth) over 5 years (divided by land area) 1 1 2 2 3 3 4 4 5 5 6 6 7 *Indicator scaling: (cut-off values are number of earthquakes of ML ≥ 6,Depth ≤ 15 km)*	1.00	1
	Number of tsunamis or storms surges with run-up greater than 2 metres above Mean High Water Spring tide (MHWS) per 1000 km coastline since 1900 1 0 2 1 3 2 4 5 5 10 6 15 7 *Indicator scaling: (cut-off values are number of tsunamis / surges with run-up >2m above MHWS (years 1900-2000) / length of coastlines (maritime) * 1000)*	0.50	2
	Number of slides recorded in the last 5 years (EMDAT definitions), divided by land area 1 0 2 0.65 3 1.72 4 3.48 5 6.39 6 11.18 7 *Indicator scaling: (cut-off values are Number of slides recorded between 1996-2000, per million square kilometres of land)*	2.21	4

	INDICATOR	Value	EVI Score
 LAND AREA	Total land area (km^2) 1 1.2M 2 163K 3 22K 4 3K 5 403 6 55 7 *Indicator scaling: (cut-off values are square kilometres of land area*	452860.00	2
 COUNTRY DISPERSION	Ratio of length of borders (land and maritime) to total land area 1 7.4 2 20.1 3 54.6 4 148.4 5 403.4 6 1096.6 7 *Indicator scaling: (cut-off values are total length of land and sea borders (km) / land area of country (accumulated across islands, if present) (1000 km^2))*	46.41	3
 ISOLATION	Distance to nearest continent (km) 1 0 2 50 3 100 4 400 5 800 6 1600 7 *Indicator scaling: (cut-off values are distance (km) to the nearest continent)*	120.00	4
 RELIEF	Altitude range (highest point subtracted from the lowest point in country) 1 1500 2 3000 3 4500 4 6000 5 7000 6 8000 7 *Indicator scaling: (cut-off values are altitude range in metres)*	4509.00	4
 LOWLANDS	Percentage of land area less than or equal to 50m above sea level 1 0 2 15 3 30 4 45 5 60 6 75 7 *Indicator scaling: (cut-off values are percent of land area less than or equal to 50m above sea level)*	51.16	5
 BORDERS	Number of land and sea borders (including EEZ) shared with other countries 1 0 2 2 3 4 4 6 5 8 6 10 7 *Indicator scaling: (cut-off values are number of other countries connecting with the borders of a country)*	4.00	3
 ECOSYSTEM IMBALANCE	Weighted average change in trophic level since fisheries began (for trophic level slice ≤3.35) 1 0 2 -0.02 3 -0.04 4 -0.06 5 -0.08 6 -0.10 7 *Indicator scaling: (cut-off values are trophic level change values)*	0.15	1
 ENVIRONMENTAL OPENNESS	Average annual USD freight imports over the past 5 years by any means per km^2 land area 1 2.72 2 4.48 3 7.34 4 12.18 5 20.09 6 33.12 7 *Indicator scaling: (cut-off values are average annual freight density as thousands of USD of freight moved into the country per sq km of land)*	5.86	3
 MIGRATIONS	Number of known species that migrate outside the territorial area at any time during their life spans (including land and all aquatic species) / area of land 1 1.72 2 3.48 3 6.39 4 11.16 5 19.09 6 32.12 7 *Indicator scaling: (cut-off values are density of migratory species expressed as number of species per 1000 sq km land area under various categories of GROMS migrants)*	0.06	1
 ENDEMICS	Number of known endemic species per million square kilometre land area 1 0 2 6.39 3 53.60 4 402.43 5 2972 6 22025 7 *Indicator scaling: (cut-off values are species per million sq km land area)*	810.40	5
 INTRODUCTIONS	Number of introduced species per 1000 square kilometre of land area 1 0 2 1.72 3 3.48 4 6.39 5 11.16 6 19.09 7 *Indicator scaling: (cut-off values are species per 1000 sq km land area)*	0.12	2
 ENDANGERED SPECIES	Number of endangered and vulnerable species per 1000 sq km land area (IUCN definitions) 1 0 2 1 3 2 4 3 5 4 6 5 7 *Indicator scaling: (cut-off values are species per 1000 sq km land area)*	0.59	2
 EXTINCTIONS	Number of species known to have become extinct since 1900 per 1000 sq km land area (IUCN definitions) 1 0 2 0.25 3 0.5 4 0.75 5 1 6 1.25 7 *Indicator scaling: (cut-off values are species per 1000 sq km land area)*	0.00	2

	INDICATOR	Value	EVI Score
 VEGETATION COVER	Percentage of natural and re-growth vegetation cover remaining (include forests, wetlands, prairies, tundra, desert and alpine associations) 1 80 2 20 3 40 4 20 5 10 6 0 7 *Indicator scaling: (cut-off values are percent of land area under natural original or re-growth vegetation cover)*	85.40	1
 LOSS OF COVER	Net percentage change in natural vegetation cover over the last five years 1 >0 2 None 3 None 4 0 5 -1 6 -2 7 *Indicator scaling: (cut-off values are percent net change in forest cover over the last 5 years)*	-0.36	5
 HABITAT FRAGMENTATION	Total length of all roads in a country divided by land area 1 0.2 2 0.4 3 0.6 4 0.8 5 1.0 6 1.2 7 *Indicator scaling: (cut-off values are latest measure of length of all roads in the country (km) / land area (sq km).*	0.04	1
 DEGRADATION	Percent of land area that is either severely or very severely degraded (FAO/AGL Terrastat definitions) 1 5 2 10 3 15 4 20 5 25 6 50 7 *Indicator scaling: (cut-off values are percent of land area that is severely or very severely degraded FAO/AGL Terrastat definitions - lighter forms of degradation are not included).*	0.00	1
 TERRESTRIAL RESERVES	Percent of terrestrial land area legally set aside as no take reserves 1 20 2 15 3 10 4 5 5 None 6 0 7 *Indicator scaling: (cut-off values are percent of total land area legally set aside as reserves)*	0.10	5
 MARINE RESERVES	Percentage of continental shelf legally designated as marine protected areas (MPAs) 1 20 2 15 3 10 4 5 5 None 6 0 7 *Indicator scaling: (cut-off values are percent of total area of the continental shelf legally set aside as reserves)*	2.67	5
 INTENSIVE FARMING	Annual tonnage of intensively farmed animal products (includes aquaculture, pigs, poultry) produced over the last five years per square kilometre land area 1 6.4 2 19.1 3 53.6 4 147.4 5 402.4 6 1095.6 7 *Indicator scaling: (cut-off values are tonnes / sq km of land area)*	352.43	5
 FERTILISERS	Average annual intensity of fertiliser use over the total land area over the last 5 years 1 54 2 402 3 1096 4 2980 5 8102 6 22025 7 *Indicator scaling: (cut-off values are kg/yr/km^2 of land area)*	28.11	1
 PESTICIDES	Average annual pesticides used as kg/km2/year over total land area over last 5 years 1 0 2 0.7 3 1.7 4 6.4 5 19.1 6 53.6 7 *Indicator scaling: (cut-off values are kg/yr/km^2 of land area)*	2.59	4
 BIOTECHNOLOGY	Cumulative number of deliberate field trials of genetically modified organisms conducted in the country since 1986 1 0 2 None 3 None 4 None 5 20 6 50 7 *Indicator scaling: (cut-off values are cumulative number of deliberate field trials)*	0.00	1
 PRODUCTIVITY OVERFISHING	Average ratio of productivity : fisheries catch over the last 5 years 1 3.2M 2 1.2M 3 442K 4 163K 5 60K 6 22K 7 *Indicator scaling: (cut-off values are tonnes carbon/km2 EEZ/yr : tonnes fisheries/km2 shelf / yr) [M=millions; K=thousands]*	174698 4.25	2

	INDICATOR	Value	EVI Score
 FISHING EFFORT	Average annual number of fishers per kilometre of coastline over the last 5 years 1 6.4 2 11.2 3 19.1 4 32.1 5 53.6 6 89.0 7 *Indicator scaling: (cut-off values are average number of fishers / km coastline)*	0.79	1
 RENEWABLE WATER	Average annual water usage as percentage of renewable water resources over the last 5 years 1 10 2 20 3 40 4 60 5 80 6 100 7 *Indicator scaling: (cut-off values are water usage as a percent of available renewable resources)*	0.01	1
 SO2 EMISSIONS	Average annual SO_2 emissions over the last 5 years 1 0.28 2 0.65 3 1.12 4 1.72 5 3.46 6 6.39 7 *Indicator scaling: (cut-off values are tonnes/km^2/year)*	0.05	1
 WASTE PRODUCTION	Average annual net amount of generated and imported toxic, hazardous and municipal wastes per square kilometre land area over the last 5 years 1 1.7 2 6.4 3 19.1 4 53.6 5 147.4 6 402.4 7 *Indicator scaling: (cut-off values are tonnes/km^2/year)*	ND	ND
 WASTE TREATMENT	Mean annual percent of hazardous, toxic and municipal waste effectively managed and treated over the past 5 years 1 100 2 80 3 60 4 50 5 40 6 30 7 *Indicator scaling: (cut-off values are percent of waste treated)*	ND	ND
 INDUSTRY	Average annual use of electricity for industry over the last 5 years per square kilometre of land 1 5 2 10 3 20 4 50 5 100 6 200 7 *Indicator scaling: (cut-off values are toe/km^2/year) [toe=tonnes of oil equivalent]*	ND	ND
 SPILLS	Total number of spills of oil and hazardous substances greater than 1000 litres on land, in rivers or within territorial waters per million km maritime coast during the last five years 1 0 2 50 3 100 4 150 5 200 6 250 7 *Indicator scaling: (cut-off values are number of spills/million km)*	0.00	1
 MINING	Average annual mining production (include all surface and subsurface mining and quarrying) per km^2 of land area over the past 5 years 1 1.7 2 6.4 3 19.1 4 53.6 5 147.4 6 402.4 7 *Indicator scaling: (cut-off values are tonnes/km^2/year)*	0.00	1
 SANITATION	Density of population without access to safe sanitation (WHO definitions) 1 3.5 2 6.4 3 11.2 4 19.1 5 32.1 6 53.6 7 *Indicator scaling: (cut-off values are human population without safe sanitation /km^2)*	0.89	1
 VEHICLES	Number of vehicles per square kilometre of land area (most recent data) 1 1.7 2 3.5 3 6.4 4 11.2 5 19.1 6 32.1 7 *Indicator scaling: (cut-off values are vehicles/km^2)*	0.04	1
 POPULATION	Total human population density (number per km^2 land area) 1 19.1 2 32.1 3 53.6 4 89.0 5 147.4 6 243.7 7 *Indicator scaling: (cut-off values are people/km^2)*	5.22	1
 POPULATION GROWTH	Annual human population growth rate over the last 5 years 1 <0 2 0 3 0.5 4 1 5 1.5 6 2 7 *Indicator scaling: (cut-off values are average yearly % change in population)*	2.48	7
 TOURISTS	Average annual number of international tourists per km^2 land over the past 5 years 1 19.1 2 32.1 3 53.6 4 89.0 5 147.4 6 243.7 7 *Indicator scaling: (cut-off values are knots of excess wind annually)*	0.14	1

	INDICATOR	Value	EVI Score
 COASTAL SETTLEMENTS	Density of people living in coastal settlements (i.e. with a city centre within 100km of any maritime or lake* coast). (* To be included, lakes must have an area of at least 100 sq km) 1 19.1 2 32.1 3 53.6 4 89.0 5 147.4 6 243.7 7 *Indicator scaling: (cut-off values are people/km^2 coastal land)*	3.20	1
 ENVIRONMENTAL AGREEMENTS	Number of environmental treaties in force in a country 1 60 2 50 3 40 4 30 5 20 6 10 7 *Indicator scaling: (cut-off values are number of treaties in force)*	73.00	1
 CONFLICTS	Average number of conflict years per decade within the country over the past 50 years 1 0 2 None 3 None 4 None 5 2 6 5 7 *Indicator scaling: (cut-off values are knots of excess wind annually)*	0.00	1