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ENVIRONMENT VIS-À-VIS DEVELOPMENT:

IMPACTS, OPPORTUNITIES AND CONSTRAINTS

Review of the Impacts of Public Infrastructure and Identification of the Opportunities and Constraints the Environment offers Development

Working Paper

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ACRONYMS

ADB	Asian Development Bank
BPOA	Barbados Programme of Action + 10 Review National Assessment Report
BOA	Bureau of Agriculture
BMR	Bureau of Marine Resources
BPW	Bureau of Public Works
EIA	Environmental Impact Assessment
EQPB	Environmental Quality Protection Board
FEIM	Facility for Economic and Infrastructure Management
GDP	Gross domestic product
MPA	Marine protected area
MNRET	Ministry of Natural Resources, Environment and Tourism
MRD	Ministry of Resources and Development
MPIIC	Ministry of Public Infrastructure, Industry and Commerce
MTDS	Medium-Term Development Strategy
NAPCLD	National Action Plan to Combat Land Degradation
NBSAP	National Biodiversity Strategy and Action Plan
NMDP	National Master Development Plan
NPV	Net present value
OEK	Olbill Era Kelulau
OERC	Office of Environmental Response and Coordination
PES	Payment for environmental services
PSC	Project Steering Committee
SLMP	Sustainable Land Use Management Project
WB	World Bank
WWF	World Wide Fund for Nature

WEIGHTS AND MEASURES

ha	hectare
km	kilometre
m	million
m^3	cubic metre

I. INTRODUCTION

A. Facility for Economic and Infrastructure Management

1. During the 2006 Asian Development Bank (ADB) Country Programming Mission, the Government requested technical assistance to provide a fast-response facility to assist economic policy formulation, facilitate the budget process, strengthen private sector development, and foster infrastructure management. In response, ADB provided support for such a facility in the 2007 TA pipeline which included the Facility for Economic and Infrastructure Management (FEIM).

2. In respect of the environmental management aspects of the FEIM, following stakeholder consultation and review of various documents and reports, an *Environmental Overview Report* was submitted in December 2007 and the *Environmental Management and Natural Resources Development Action Plan* was submitted in July 2008.

B. Scope of this Report

3. The three items of the Terms of Reference covered in this working paper are as follows;

    3.1 Review of the environmental impact of existing public infrastructure;

    3.2 Assessment of the impact of potential environmental problems due to major infrastructure on livelihoods, health, the vulnerability of the poor, and vulnerable groups; and

    3.3 Identification of the opportunities and constraints the environment offers for development, particularly estimating how much the environment can contribute to economic growth.

II. ENVIRONMENTAL IMPACT OF EXISTING INFRASTRUCTURE

A. Generic Impacts

4. Without mitigation or implementation of an environmental management plan environmental impacts can occur during both construction and operation of major infrastructure such as roads and highways, port development, electricity and power generating plants and systems, water plant and supply, and waste management systems such as landfills and sewerage. Such impacts are widely documented and are summarized in the matrix shown as Table 1.

Table 1 – Generic Environmental Impacts of Infrastructure

Activities associated with construction and operation of infrastructure	Potential environmental impact (if unmitigated)
CONSTRUCTION IMPACTS	
Surveying and demarcation of work site area	Loss of vegetation (incl. productive crops and trees) during demarcation
Site clearance, digging, excavations, cut and fill activities, construction of embankments	Accidental discovery of archaeological assets, sites or resources Soil erosion and silt generation Increased runoff / erosion Sediment contamination of rivers Turbidity in near-shore and reef environments downstream Gravel extraction from rivers leads to erosion Stockpile and staging areas lead to loss of land uses Erosion on slopes, embankments
Mobilization of contractor, presence of construction workers and construction camps	Wastes generated at construction camps Various social impacts including: - Social disruption - Possibility of conflicts or antagonism between residents and contractor/construction workers - Spread of communicable diseases including STIs and HIV/AIDS - Impacts on general health and safety - Potential exposure of children to abuse or sexual exploitation in camps
Restrictions on land use, land and resource acquisition	Loss of land, removal of crops and trees Relocation of houses
Operation of construction plant and vehicles generating emissions	Emission of exhaust from vehicles and machinery Dust from aggregate crushing plant; Dust generated by heavy vehicles transporting materials or uncovered loads on trucks Dust from exposed stockpiles
Operation of construction plant and equipment creating noise	Noise in community Impacts on construction workers
Potential for contribution to climate change	Impacts on rainfall, groundwater depletion, or carbon emissions Need for climate-proofing in designs
Aggregate and other materials extraction	Removal of beach gravels removes shoreline protection, changes littoral drift & accelerates erosion Removal of corals damages reef and depletes marine resources

Activities associated with construction and operation of infrastructure	Potential environmental impact (if unmitigated)
	Extraction of river gravels from the beds or active channels of rivers changes hydrology Extraction from quarries or borrow pits leaves unusable land, exposed water table
Works in, or adjacent to, rivers and streams and in the vicinity of the coast	Effects on river structure including; - Changes to river water flows, including levels and velocity - Changes to channel depth, structure & location resulting from excavations, embedding new structures - Changes to riverbanks caused by destabilization (through equipment and traffic) - Damage to floodplain areas within meandering river systems affecting flood cycles, temporary flood storage, release of flood waters and loss of soil fertility through loss of flood silt Increased turbidity of river waters due to gravel extraction and bridge construction Increased siltation Construction materials are washed out into rivers and other areas
Run-off, discharges, generation of liquid wastes	Increased siltation, construction materials washed out into rivers, water bodies, or coast Potential contamination of water supply sources incl. groundwater Coral reefs are affected by increased turbidity and sedimentation (from rivers)
Emergency or accidental spills	Oil and other hazardous chemicals are spilled into the environment resulting in pollution Hydrocarbon leakage / spills from construction camps / workshops Soil contamination from fuels, chemicals Potential contamination of water supply sources incl. groundwater Accidents place people at risk
Encroachment and/or disturbance of marine and terrestrial habitats	Impacts on fisheries Direct impacts on coastal ecosystems including; coral reefs, coastal wetlands, mangroves, intertidal areas, seagrass beds, and rocky coasts Runoff and rivers carry turbid waters to coral reefs offshore Terrestrial habitats become more fragmented Loss of primary forests Endemic, rare or endangered species affected Workers poach animals Interference with migration patterns of certain species Protected areas affected
Encroachment into historical / cultural sites	Effects on cultural values Areas of cultural or historic significance affected

Activities associated with construction and operation of infrastructure	Potential environmental impact (if unmitigated)
Presence of vehicles and equipment, use of people's land for access to construction site, traffic and safety issues	Temporary disruptions to people's access to and from properties or sites of resource use Traffic flows disrupted during construction and traffic safety affected
Construction activities causing accidental damage to existing services	Water supplies contaminated or disrupted through breaking of pipelines Exposure of water table during material excavation (gravels, earthworks etc) Disruptions to electricity or telecommunication supply
OPERATION IMPACTS	
Emissions creation/generation	Emission of hydrocarbons, carbon monoxide, nitrous compounds, sulphur dioxide, and particulate matter Contribution to accumulation of greenhouse gases and climate change
Placement of permanent obstructions in rivers and water courses (dams, sluices, bridges and crossings etc)	Constriction of water flows Restriction of natural meandering of streams Restriction of natural flood cycles by filled approaches to bridges (including temporary storage of floodwaters and their release along floodplains) Reduced top-dressing of floodplain agricultural areas through restricted flood plain movements
Run-off from paved areas	Increased runoff Loss of soils and other forms of erosion Reduction in quality (increased turbidity) of water in rivers, lakes, and near-shore areas
Improved access to previously inaccessible, or difficult to reach, areas	Hunting and poaching increases Extraction of resources increases
Spread of communicable diseases	Infrastructure (i.e. roads) acts as pathway for spread of communicable diseases such as HIV and STIs Potential for human trafficking
Routine and ongoing maintenance	The need for material for on-going maintenance requiring acquisition of land and resources

B. Impacts from Infrastructure in Palau

5. Population growth requires minimum levels of infrastructure and service provision to sustain it. Unplanned or ad hoc development of such can threaten public and environmental health and seriously constrain productivity and economic growth when it occurs on unsuitable land (including foreclosure of future development options as well as more obvious topographical and geological suitability issues), or where the government is unable to facilitate investment in the necessary infrastructure and services to accommodate growth. As a result poorly managed growth imposes high costs; according to some sources, the cost of freshwater, marine and air pollution problems alone can add up to an equivalent of five percent of gross domestic product (GDP).[1]

6. The environmental consequences of provision of basic infrastructure and services also affect natural resource use and management such as depletion of water and forest resources and conversion of environmentally fragile lands. In the longer term, infrastructure developments tend to exacerbate water and air pollution problems, impacts from occupation of areas prone to flooding, landslides, or sea level rise (which represent major risks to human health and safety).

7. Site selection for infrastructure projects should take into account the potential environmental effects of their development and operation, for example soil and slope stability, the risk of flooding in low-lying sites, removal of vegetation and threats to watershed (water supply catchment development) and erosion, damage to sensitive ecosystems such as coastal areas and wetlands, and the implications for land acquisition and resettlement Including loss of access to customary land and resources) as well as conflict with culturally-valued land uses.

8. The main impacts of infrastructure that exist in Palau derive from road construction, port development, water supply, and sewerage and waste disposal. Construction of infrastructure also creates some common effects such as sedimentation (discussed in more detail below in Section II B 4. The following notes highlight some of effects of major parts of existing infrastructure system in Palau, and do not represent a full account of all possible impacts of construction and operation of certain infrastructure.

1. Impact from Road Construction

9. Road construction and drainage works can result in the involuntary resettlement of households and, if drains are not maintained, possible contamination with solid and liquid wastes, floods and the resulting spread of pathogens. Road construction has resulted in fragmentation of habitats and forest, the clearing and filling of mangrove areas, and sedimentation (see Section II B 4). The environmental impact assessment (EIA) of the Compact Road completion identified reclamation and removal of mangrove areas as a significant environmental impact of the project and recommended the establishment of a number of protected areas of mangrove as a mitigation/compensation measure.

[1] World Bank; *Environmental Impact from Urban Development* - Update No. 19, Washington D.C (October 1997).

10. The native invasive vine *Merremia peltata* has spread extensively because of the increased amount of land clearing and construction of new roads providing new opportunities for colonization. Expanded road building, following completion of the Compact Road, has exacerbated this problem as well as the impact of other several invasive species. It should be noted that this is a significant effect that was not identified or addressed in the EIA.

11. During operation the impacts from roads include air pollution/quality impacts such as particulates and emissions, vehicle generated debris (including petrol and oil) and run-off to stream and inter-tidal areas, extraction of gravels and other materials (aggregates, sand) for routine maintenance, and contribution to greenhouse gases such as carbon monoxide.

12. A benefit that can be derived form road construction is associated with roadside planting and road maintenance, which can be used to reduce the amount of run-off, reduce damage to the road surface and drainage system by attenuating the velocity/force, and reducing the amount of sediment or debris from reaching the mangroves and eventually the reefs.

2. Impact of Port Development

13. The main impacts from port development and/or extensions include reclamation and infill of mangrove and inter-tidal areas associated with new construction and additional landfill for extensions with attendant effects. Any earthworks in the coastal area include the risk of erosion and sedimentation, with silt laden run off affecting both mangroves and reefs. Permanent structures in the coastal zone can change alter local marine hydrology causing either erosion of accretion of beaches upstream or downstream of the structure.

14. The environmental impacts from operation include leakage of oil and diesel (including risks of accidental spills), pollution from discharge of bilge/ballast water (which has the potential to contain alien marine species as well as pollutants), and effects on both water quality and sandy/muddy bottom ecosystems from ongoing dredging of channels and berthing areas. Impacts of climate change and extreme weather events may have an effect on the sustainability of both location and structure of port/docks.

3. Impact of Water Supply, Sewerage, and Waste Disposal

15. Construction of water supply projects include involuntary resettlement of households, removal of vegetation and fragmentation of habitats and forest, and loss of access to forest and other resources in the catchment area. During operation water supply projects will increase the volumes of wastewater. They may also result in groundwater depletion if the aquifer is tapped, and surface water abstraction can affect aquatic and bird life. There are also issues of dam/reservoir safety.

16. Some of the potential negative impacts of sanitation and sewerage systems include interference with other utilities, impacts from sludge disposal, subsurface leaching to groundwater, degradation of water quality from overflows of, or improperly treated, sewage, and health and safety hazards associated with sewers (trench cave-in during construction, toxic gas build-up, and exposure to pathogens in

sewage and sludge).

17. The impacts from sewerage and waste disposal in Palau are mostly associated with lack of funding for emergency maintenance, and potential eutrophication of water bodies. Nutrient input from sewage outfalls degrades reef systems by favouring the growth of algae and suspension-feeding animals rather than corals. It can also increase bio-erosion rates by boring bivalves and sponges, and increase bacterial infections in corals. [2]

18. The potentially adverse effects of solid waste management arise from poorly sited or managed dumps or sanitary landfills, aquifer contamination, improper disposal of hazardous wastes, air pollution from burning wastes, landfill gas migration, subsurface leaching, increased human exposure to disease vectors, and landscape degradation.

19. The impacts related to development of the landfill, also include the conversion of land (a limited resource in Koror) adjacent to the coast to a use that is not suitable for the coastal zone and not appropriate to adjacent resort/tourist developments. Eventual removal of the landfill to an alternative site will not completely remove this issue as converted landfills will only be suitable for a narrow range of uses.

20. During operation there are impacts from leaching (it is unclear of the degree of lining provided when the landfill was constructed, therefore the degree of marine and groundwater sources as a result of leachates can only be known following comprehensive monitoring. Pests (such as rodents and flies) and nuisance related to smell are ongoing problems. All of the foregoing create risk of disease and human health impacts.

4. Impact Association with Sedimentation

21. As indicated above most infrastructure development projects incur a number of impacts during their construction, especially on the sensitive coastal areas and inshore marine ecosystems. Road construction, port/dock improvements, and landfill expansion have all contributed to increases in sedimentation. During the community consultations conducted in connection with the development of the National Biodiversity Strategy and Action Plan (NBSAP), most communities on the island of Babeldaob identified sedimentation as one of their key concerns.[3]

22. Sedimentation and subsequent nutrient input has been listed as a threat to coral reefs ecosystems and their associated flora and fauna. The effects of run-off on coral reefs are well documented and are the most studied impact on coral reefs. Sedimentation associated with runoff from coastal developments around Palau poses one of the most serious threats to water quality in the marine environment, particularly around the biggest island, Babeldaob. The increase in development (including demand for infrastructure) following improved access from the Compact Road may result in tons of soil being transported each year into mangroves,

[2] ADB (a); *Republic of Palau Country Environmental Analysis*, TA 6204-REG, Final Report (April 2007).
[3] Government of Palau – OERC (a); *National Biodiversity Strategy and Action Plan*, Koror, Palau (2004).

seagrass beds, and coral reefs.[4]

23. A recent study conducted by the Palau International Coral Reef Center (PICRC) showed severe impacts of soil erosion on lagoon ecosystems.[5] Physical smothering may be the most obvious effect of sedimentation. In addition, a range of organic and inorganic chemicals used for fertilizer and pesticides in agriculture may contaminate runoff, and end up in marine ecosystems. Excessive sedimentation can adversely affect the structure and function of the coral reef ecosystems by altering both physical and biological processes.

24. Alteration of watersheds and associated changes in vegetative cover typically decrease the ability of the land to absorb rainfall, which flows through streams and rivers into near-shore areas. Increased sedimentation is a significant threat to coral reef ecosystems, with sedimentation associated with runoff from development in the coastal zone posing a serious threat to reefs around Babeldaob. A study in the Ngerikiil watershed showed an alarming rate of sedimentation (exceeding 1500 mg/L during flood events) which is attributed to road construction (as well as clearance of land for housing and agriculture).[6]

25. Current sediment monitoring activity in the Ngerdorch watershed shows a direct link between the level of water clarity and runoff from the Compact Road Project. By comparing the level of activity in the two watersheds (Ngerikiil and Ngerdorch), it is possible to observe a direct correlation between the level of human activity in the area and the observed rate of sedimentation. The Ngerikiil watershed area has experienced an increase in development activity and has a sedimentation rate that is 10 to 19 times higher than Ngerdorch watershed, which is relatively pristine. These studies also showed that the mangrove systems fringing the estuaries in each watershed can only trap about 30% of the sediment. Increased sedimentation can smother seagrass and coral habitats, causing mortality in some cases. Furthermore, sedimentation has the potential to affect coral recovery in Palau by blocking recruitment of coral larvae. [7]

III. ENVIRONMENTAL PROBLEMS FROM MAJOR INFRASTRUCTURE

26. The Government of Palau is struggling to keep up with the pace of development in Koror and Airai, as well as other states on Babledaob, following completion of the Compact Road. These pressures are only likely to continue, increasing demands for infrastructure and services such as water and sanitation, roads, power systems, and waste collection. In many cases, the demand far outstrips the capacity to supply. The development process, and the investments required to facilitate it, tend to generate many complex environmental problems. The critical environmental problems facing growing and urbanising populations (such as Airai state) include deteriorating living conditions and potential health problems caused by inadequate water, sanitation, drainage, and solid waste services, poor waste management, and air pollution.

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4 Golbuu. Y et al (a); *The State of Coral Reef Ecosystems of Palau*, NOAA Technical Memorandum NOS-NCCOS # 11.
5 PICRC; *Fish Abundance Report* (unpublished).
6 Golbuu. Y et al (a); op cit.
7 Victor. S et al; Fine Sediment Trapping in Mangrove-fringed Estuaries, Koror, Palau (2004).

27. This item of the TOR requires an assessment of potential environmental problems due to major infrastructure on livelihoods, health, the vulnerability of poor communities, and vulnerable groups. To start, a definition of the poor and vulnerable in Palauan context is provided.

A. Definition of the Poor and Vulnerable in Palau Context

28. In terms of the poor or persons living with economic hardship, analysis of the 2006 Household Income and Expenditure Survey (HIES) has determined that one-in-five households and one-in-four persons were living with economic hardship. The number of households and persons affected is probably higher today (2008) due to rapid inflation caused by escalating energy and food prices.

29. Work is being undertaken by UNDP to further define poor households and identify their characteristics. Those findings are currently unpublished but discussion with the specialist undertaking the work indicates the following:[8]

- While the poor, in terms of households, are not geographically clustered, they are distributed throughout both urban (19%) and rural (21%) areas, the poorest are located on islands other than Babeldaob and include the more remotes islands of Angaur and Kayangal;
- Poor households are larger than non-poor households. Households in the lowest three deciles (5.2 people) are twice as large as households in the highest decile (2.6 people);
- Poor households comprise larger numbers of children. The children from poor households are often sent to live with older relatives while parents work in Koror. These households face the additional burden of larger school related expenses for uniforms and books (even with subsidized school transportation and lunches);
- Poor households are most often one income households or households with irregular income;
- The "working poor" include those in informal sector and unskilled employment including shop workers, semi-formal tourism, and personal services. Often these people earn wages that are less than the minimum standard of living line; and
- Poor and low income households are forced to make choices between food and non-food essential items and to reduce expenditure on non-essential items during times of high prices.

30. Work undertaken by FEIM on identifying the needs of the medium-term development strategy in respect of disadvantaged and/or *v*ulnerable populations states that in consultation with service providers, several populations were identified as disadvantaged or vulnerable due to their social or physical characteristics.[9] These are: (a) persons with disabilities and other special health

[8] David Abbott, UNDP – Pacific Regional Macro Economic & Poverty Reduction Advisor, MDG Team Leader. Pers. Comm. 04th July 2008.

[9] FEIM (a); Medium-Term Development Strategy for Vulnerable Populations, Koror, Palau (June 2008).

care needs;[10] (b) adolescents;[11] (c) women and children who are victims of abuse or (in the case of children) neglect; (d) certain other categories of women who are under stress;[12] and (e) certain categories of elderly. There is no definitive count of Palau residents who live with full or partial disabilities nor is there a nationally accepted definition of "disabled."

B. Impacts of Environmental Problems Due to Infrastructure

31. Environmental problems arise mainly from inadequate maintenance and system upgrades. FEIM's infrastructure working paper notes that neglected assets increases the risk of accidents, collapses, ruptures, spills with damage to people and the environment.[13] The estimate presented in the working paper is that approximately $50 million (m) is required for the backlog of maintenance, and that the future maintenance liability is considered to be in the order of $18m/year increasing to about $25m/year from 2018.

32. In respect of maintenance of sewerage and wastewater services the system is in crisis (old pipes, leaks, intakes of storm-water, risks, and costs). According to the Country Environmental Analysis (CEA),[14] Palau could potentially avoid costs of US$2m per year by reducing or preventing solid waste pollution.

33. The most significant costs of this type of pollution were found to be through lost tourism (US$1m annually), healthcare and illness (US$700,000), public waste collection and dumpsite operation (US$100,000) and the loss of near-shore fish catch (US$90,000). These estimates are opportunity costs, that is, money that could be spent on other goods and services rather than for pollution management.

34. The economic valuation is based on market goods only and therefore excludes non-market goods such as biodiversity and cultural assets. Some of the main non-financial impacts of pollution in Palau include: (i) the loss or damage to biodiversity; (ii) loss of recreational amenity (e.g. fishing, swimming, diving); (iii) loss of landscape aesthetics and scenery; (iv) damage to natural or human made assets of cultural significance; and (v) non-financial human health impacts.

35. Furthermore, the above costs are exclusive of the fines charged to violators, costs of stopped work resulting from cease and desist/stop work notices, and associated costs borne by Environmental Quality Protection Board (EQPB) for issuing, implementing and following up on such notices of violation. The CEA notes that while the number of violations notified by EQPB doubled between 2003 and 2004, in total number they have remained consistent over the period 2003 and 2006. The increased incidence of permit violations and expirations, along with earth moving

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10 This group includes people suffering from intermittent or long term mental illness as a result of drug or alcohol abuse.

11 This group is particularly vulnerable to a range of social problems including (i) tobacco, alcohol, and drug use; (ii) high risk sexual behavior; (iii) depression, suicide ideation, and suicide; and, (iv) substandard educational performance leading some to drop-out of school.

12 The strategy notes that because of Palau's matriarchal and matrilineal heritage, women are not a classic disadvantaged group in Palau. In general women enjoy better health and achieve higher levels of education than men. While less likely to participate in the labor force, when employed, women earn more than men. Despite this overall favorable situation, service providers identify three categories of women as vulnerable: (a) pregnant women; (b) single mothers; and (c) women who are caregivers for the chronically ill.

13 FEIM (b); Infrastructure Needs, Priorities, Maintenance and Regulations, Koror, Palau (April, 2008).

14 ADB (a); op cit

without a permit, are matters of considerable concern, especially given the issues of erosion and sedimentation discussed in Section 2.

36. Of the 59 violations notified by EQPB in 2006, 26 were associated with infrastructure including; no permits for road construction (3), illegal discharges of sewage (15), and illegal solid waste dumping (11). There were also 12 violations for expired permits but these were not further defined. Between March and September 2007 there were a total of 34 notices of violation and 12 orders imposing fines issued by EQPB.[15]

1. Impacts on the Poor and Vulnerable

37. Vulnerability is defined as the inability of individuals or households to easily withstand economic shocks such as death of a breadwinner or loss of employment. Vulnerability is moderately high in Palau due to high consumption patterns, low levels of savings, and high levels of indebtedness. Vulnerability will increase unless attention is paid over the medium term development strategy (MTDS) period to strengthening the safety net represented by Palau's natural resources and almost universal access to land, cultural tradition of "caring and sharing," and extended family networks.

38. Environmental impacts and problems that affect food sources (fishing and taro) and tourism will adversely affect a wide group of people including poor and low income households.

39. Food security is a critical issue for poor and vulnerable households, even with low levels of home production (compared with other countries in the Pacific). Imported food is a large proportion of all food consumed by a household and therefore increasing food and fuel prices will have higher impacts on poor households and those households which already find it difficult to meet minimum basic needs. With the exception of Koror and Airai most households rely on fishing, if not for income then for subsistence, any damage to fisheries through over-fishing or climate change would increase the vulnerability of those households as access to an important food source would decline.

40. In the longer term it is critically important to proceed with measures to mitigate the impact of climate change – such as implementation of the Climate Risk Management and Adaptation (CRMA) Road Map - since climate change represents a significant source of vulnerability for the nation as a whole.[16 & 17]

41. The single greatest threat to Palau's sustainability is climate change and associated sea level rise. In Palau, causeways, seawalls and other coastal infrastructure are slowly being degraded by sea level rise. The states of Angaur

[15] EQPB pers. comm July 2008.

[16] Government of Palau – OERC (b); First National Communication to United Nations Convention on Climate Change, Koror, Palau (2002).

[17] ADB (b); *Draft Climate Risk Management and Adaptation Road Map*, Manila, Philippines (June 2008). The Road Map notes that to achieve the cross-sectoral outcomes of risk reduction and climate resilience, CRMA needs to be mainstreamed into the priority sectors of; (i) integrated water supply; (ii) forestry; (iii) agriculture; (iv) infrastructure (coastal development and tourism); (v) coral reefs, fishery and tourism. The Road Map also notes that disaster risk management priorities are to be blended with climate risk management approaches to maximize resource and agency synergies and avoid unnecessary duplication of risk management activities and investment.

and Peleliu, as well as much of the western coast of Babeldaob sustained significant losses to much of their taro crops during the 1998 El Niño Southern Oscillation (ENSO) event (refer to Section III B 1 above). These losses were caused by saltwater intrusion and prolonged drought. Sea level rise also threatens Palau's mangrove forests, beaches, and coastal communities where most of the infrastructure and economic development activities are located.

42. The Pacific Island Economic Report (PIER) noted that while Palau is highly monetized, the environment remains an important source of food, raw materials, and medicine, and further, is linked with Palauans' sense of place.[18] The PIER concludes that a pro-poor policy must, therefore, preserve this safety net by ensuring sustainability (including climate change adaptation) of resources and continued access for all.

43. Any livelihood or health impacts stemming from lack of access to resources fundamental to subsistence as well as environmental issues associated with climate change and other issues related to infrastructure problems, will clearly be more significant for already vulnerable populations.

2. Livelihood Impacts

44. The main livelihood impacts (income and food security) from environmental problems associated with infrastructure are in respect of (i) reduced tourism as a result of poor condition or inadequate infrastructure (i.e. water, solid waste management, wastewater, pollution, physical siting of hotels and resorts); (ii) non-climate proofed designs and susceptibility of infrastructure to climate change; and, (iii) subsequent impact on subsistence and incomes derived form agriculture or forestry affected by climate change.

45. As noted above, a significant threat to Palau's environmental stability is climate change, impacts from which can include extreme events such as storms and frequent drought, sea level rise, increased sea temperature, coastal erosion, and coral bleaching. The ENSO phenomenon is an ocean-atmosphere circulation that affects Palau significantly on a regular basis. During an El Niño year, Palau generally experiences drought conditions that can last from weeks to months, and the country must ration fresh water use.[19]

46. While it should be recognised that there is debate, and to that degree uncertainty, within academic, scientific, and popular journal articles about the nature, cause, and effects, of climate change, two recent climate change reports in Palau have projected that ENSO extremes are likely to become more frequent with increasing greenhouse gas concentrations.[20] By way of example, the 1997-1998 ENSO resulted in a wide range of impacts that serve as an indication of longer term livelihood and socio-economic changes that could be imposed on Palau by climate change, and underscores the need to plan for, and develop within, a framework of climate change adaptation.

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18 ADB (c); Palau – Achieving Sustainable Development, Draft PIER, (October 2007).
19 Government of Palau – OERC (b); op cit
20 Government of Palau – OERC (b); op cit and ADB (b); op cit

47. The impacts have been identified as:[21]

- Induced drought causing the complete loss of the taro crops in several states. On low-lying coral islands, the water lens was displaced upward by the rise in sea level, causing flooding of taro patches by saltwater intrusion. These taro areas have not yet recovered;
- Uncontrolled fires burned on a daily basis during March (1998) and destroyed 20% of Palau's forest, savannah and agricultural lands;
- A rise in sea temperature (August and September 1998) where sea surface temperatures exceeded 30^{o}C. Impacts of the elevated water temperature were seen in habitats such as Jellyfish Lake which experienced a complete mortality of the medusa stage of *Mastigias spp*;
- Loss of an estimated 563km^2 of patch reef, barrier reef, outer reef and inner reef. Massive coral bleaching and mortality and six years after the event, the reefs in Palau have still not fully recovered. Approximately one-third of Palau's corals died, with coral mortality as high as 90% in some areas, and devastated Acroporid corals. A 3.3% reduction in gross domestic product (GDP) as a result of decline in tourism (which may be associated with coral bleaching);[22]
- Taro is an essential part of Palau's food base and plays a unique role in its culture. Taro is used as a major component of food exchange in all traditional customs. The lost taro crop represented US$ 0.75m (0.7% of GDP); and
- Economic impacts, measured largely in reduction in GDP, in the order of a $91m or 88% of the total 1998 GDP loss from the tourism sector.

3. Health Impacts

48. Health impacts from environmental problems of infrastructure include threats to drinking water quality from erosion and sedimentation, chemical pollution, problems with operation and maintenance of water treatment and distribution systems, and malfunctioning wastewater systems. As identified in Section II, the cost of health impacts associated with pollution from poorly maintained sewerage and landfills is in the order of US$700,000.

49. In addition the Infrastructure Report noted that illegal water, sewerage and electricity connections lead to risk of damage and failure of systems with associated risk for people's health and safety and environmental problems.

50. Palau's water supply is extremely vulnerable to droughts. Although rainwater is a renewable source of water, it is subject to seasonal and yearly variations and Palau has inadequate water storage capabilities.

51. Another major constraint on water supply is lack of distribution infrastructure. Access to safe water and adequate sanitation has been in decline (as shown in Table 2), with potential health impacts.

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21 Government of Palau – OERC (c); *Current and Projected Impacts of Climate Change* (September 2001).

22 Golbuu. Y (b); 'Status of Palau's Coral Reefs in 2005 and their Recovery from 1998 Bleaching Event' in *Coral Reefs of Palau*, Palau International Coral Reef Centre/JICA (2007).

Table 2 – Access to Safe Drinking Water & Sanitation

Item & Location of population	Year (%)		
	1990	1995	2004
Access to safe drinking water			
Total	80	89	85
Urban	71	84	79
Rural	99	97	94
Access to improved sanitation			
Total	66	…	80
Urban	72	99	96
Rural	54	…	52

Source: Millennium Goals Database and ADB Country Strategy and Program Update 2007-2009 (2006)

52. Threats to Palau's water resources include human-made contamination and drought. Increasing development, poor land use, and deforestation in combination with heavy rainfall are leading to increasingly turbid and contaminated water.

53. The Koror/Airai Public Water System provides drinking water to about 95% of the population in the service area from two main sources (Ngerimel Dam and Ngerikiil River Pump Station), both of which are affected by high turbidity during heavy rains, with recently elevated levels of turbidity being attributed to road construction. The water must be purified before being distributed, putting a greater strain on the water distribution system, which is currently operating at capacity, and furthermore, is subject to disruptions, water shortages, and low pressure, as a result of inadequate maintenance, management, and planning.

54. In general while the quality of rural public water systems has improved, the filter technology used (rapid sand filters) is unable to provide adequate treatment - some filters are not operational while others are in need of repair and maintenance – and although most of rural water supply systems are supplied with chlorination systems, many are either not used regularly or are out of service. Consequently, all rural water supply systems regularly test positive for coliform bacteria in violation of EQPB's regulations and only 20% of the facilities are able to provide the public with water that is consistently chlorinated.

55. As a result of this inconsistent water quality and supply, 67% of the population relies on rainwater catchments as their main source of drinking water. This is of concern, since over 90% of tested rainwater catchments are contaminated with faecal and total coli form bacteria.[23]

56. Water supply projects will increase the volumes of wastewater, which can give rise to deleterious health impacts if not properly managed. Koror State provides a centralized wastewater collection system covering about three-quarters of its

[23] Government of Palau – OERC (d); Barbados Programme of Action + 10 Review National Assessment Report, Koror, Palau (January 2005).

population.

57. When the wastewater can not flow by gravity, it is collected by pump and booster stations which pump the sewage to the main treatment plant. Treated effluent is discharged through a deepwater outfall pipe into the lagoon located offshore from Malakal Island.

58. The PIER notes that environmental and health problems arise from the centralized system in Koror from improper operation and maintenance of the collection system and treatment plant which results in sewage over-flows and discharges of inadequately treated sewage into the lagoon. Another risk posed is cross-contamination of the public water supply because of the absence of a back-flow prevention system.

59. All rural states are un-sewered, and use septic tanks, leach fields and pit latrines. Individual wastewater systems that are either poorly designed/constructed or located on unsuitable sites – such as marine clay soils which do not provide fast enough water percolation rates - are potential sources of groundwater contamination, especially from nitrogen and pathogens.

60. While solid waste collection services are provided in Koror and Airai, safe waste disposal remains an issue, especially with the main landfill of Koror located adjacent to the coast. Faecal coli form counts per 100ml samples taken from six sites in the Koror-Airai area indicate an urgent need to improve marine water quality.[24]

61. The *Barbados Programme of Action National Assessment* (BPOA) reported that the Division of Environmental Health (DEH) within the Ministry of Health provides sanitation services to all households in Palau, including regular and comprehensive inspection of all households, focusing on identifying any aspect of the environment around the household that may be a potential cause for disease.

62. The report noted some examples of the links between household sanitation and medical visits; (i) households in areas with higher population density (placing stress on existing infrastructure and services) presented more frequently at community health centres; (ii) households with low scores for environmental health presented more frequently at health centres; and (iii) zones with overall low scores in environmental health tend to have higher proportions of households visiting both health centres and dispensaries.[25]

63. The BPOA concludes that Palau lacks many of the resources necessary to accommodate infrastructure improvements and technological changes that are driven by the desire of the public to improve the quality of life. The lack of implementation of waste management plans increases the frequency of diseases caused by unsanitary conditions, and leaves public health at risk.

[24] ADB (a); op cit
[25] Government of Palau – OERC (d); op cit

IV. ENVIRONMENTAL CONSTRAINTS AND OPPORTUNITIES FOR DEVELOPMENT

64. This section provides an assessment of the opportunities and constraints the environment offers development.

A. Environmental Constraints on Development

65. The National Master Development Plan (NMDP) identified general constraints for development in Palau as including; (i) a narrow resource base; (ii) vulnerability to external shocks and natural disasters; (iii) a small domestic market compounded by geographical dispersion of islands within countries; (iv) high unit costs for infrastructure and industry services; (v) heavy dependence on external trade and foreign assistance; (vi) adverse terms of trade in terms of price of exports relative to price of imports; (vi) ongoing tensions between state and national government as to land and resource ownership; and, (vii) the traditional structure of clan ownership, which adds complexities to defining clear title to land and resources (with subsequent development opportunities with foreign investors being limited by land title issues).

66. FEIM's *Environmental Overview Report* noted that Pacific Island Countries (PICs) are highly dependent economically on their natural environment and that the vulnerability of fragile ecosystems such as coral reefs, mangrove forest and coastal zones as well as rare or endangered species is further increased by climate variability, droughts, water pollution, soil erosion, poor land management (degradation), and unsustainable development.[26]

67. The most significant environmental problems facing PICs include eight priority concerns: threats to freshwater resources, degradation of the marine and coastal environment, degradation of land and forest, urbanization and waste management issues, depletion of biological diversity, energy-related environmental concerns, adaptation to climate change, and weak environmental governance.[27] Environmental issues in Palau are similar to other PICs, these include global threats such as climate change, and risks associated with national infrastructure development and management such as inadequate facilities for disposal of solid waste and sewage; urbanization, and weak enforcement of existing laws, regulations and policies.

68. The critical sustainable development issues or constraints highlighted in the BPOA divided along both environmental and socio-economic concerns include; pollution control; waste management; water supply and quality; and coastal erosion from development; as well as sustainable management of marine and terrestrial resources; climate change and sea level rise; and damage by invasive alien species. The FEIM *Environmental Overview Report* summarised risks and constraints of development, as shown in Table 3.

[26] FEIM (c); Environmental Overview and Stock-take Report, Koror, Palau (December 2007)
[27] ADB (d); *Pacific Annual Report*, Manila, Philippines (2006)

Table 3 – Environmental Risks Associated with Development

Risk	Nature of Risk and Consequence
Loss of traditional and subsistence livelihoods (incl. cultivation of 100 varieties of taro, 17 varieties of sweet potato, many varieties of cassava, bananas and other fruits for food, 44 species of trees used for timber and firewood, 82 plants used for traditional medicines); changes in resource consumption patterns	Land degradation and deforestation (incl. mangroves); Loss of endemic species including traditional medicines; Increasing shift to imported food, utensils and equipment resulting in loss of traditional hunting, fishing, building knowledge and other cultural associations; Increasing pressure on ecological resources (export, different and/or intensified use)
Population growth, development, and uneven population distribution	Adverse environmental impacts of additional infrastructure; Impacts of increasing foreign labor (including risk of exposure to STIs and HIV/AIDS); Pressure on agricultural land and impacts of slash-burn techniques; Increasing pollution, uncoordinated, inadequate waste management
Forest loss and fragmentation, reduction in vegetation cover, filling of mangrove areas, habitat loss	Lack of land-use planning and poorly planned development; Threat of invasive species; Increased fire risk; Completion of Compact Road providing easier access to previously remote forest resources and land; Erosion and silt run-off impacts; Loss of critical habitats for various species
Capacity to manage solid and liquid waste, about 95% of sewage is untreated,[28] main landfill in Koror reaching capacity	Pollution from untreated waste and leaching from inappropriately sited landfill (in coastal zone) entering waters; Marine organisms consuming raw sewage creating serious health risks (human consumption of contaminated marine species) and illness or death of marine organisms; Public health and safety issues; EQPB's monitoring sites increasingly indicate thresholds breached
Trade in coral and live reef species	Trade in marine ornamental fish rapidly growing worldwide over past several years, popularity of home aquaria that mimic coral reef ecosystems has made live fish and marine invertebrate trade a profitable venture; Reef degradation by targeting important juvenile fish or species that are ecologically important
Characteristics that make Palau's tourism sector such a large contributor to GDP are the same characteristics that are at risk from poor land use practices and environmental degradation (e.g. hotels and restaurants predominantly located in Koror, Palau Royal Resort located near to the bulk oil storage plant and in proximity to the commercial port, and the siting of the Landmark Hotel next to the Koror Landfill); tourism sector has developed largely around diving (need to manage watersheds and land use and protect coral reefs and marine resources)	Mixed uses threaten the viability of high-end tourism; Capacity of basic services (electricity, water, sewerage) inadequate for existing population and visitors, hotel and resort development placing additional burden on existing services; Selling of some goods at gift and souvenir shops contravene CITES; Congestion and over-crowding at dive sites causing damage to reef ecosystems (anchors, divers colliding with corals, fuel spills from boats, inappropriate moorings); Spear-fishing leading to depletion of fish stocks at certain sites; Reduction in attractiveness of sites as a result of debris, garbage, sedimentation and silt-laden run-off impacting water quality
Invasive marine and terrestrial species	Threat to biodiversity, economy, human health, agriculture, and Palauan way of life; Cause serious damage to reefs, forest and savanna environments and habitats

[28] Government of Palau – OERC (e); *Environmental Vulnerability Index*, Koror (2001)

1. Constraints on Development from Natural Resource Depletion

69. Changes have occurred in the ways resources are used, why they are used and who uses them. People are collecting resources, especially from the marine environment with new and more effective equipment, and rarely follow traditional methods that posed limits on catch or harvest. An increasing number of people are collecting or harvesting resources for income rather than for local subsistence uses. Both the NBSAP and BPOA report contain detailed descriptions of the effects of natural resource depletion, the following is a summary of these to indicate the constraints that resource depletion may place on economic growth.[29]

a. Depletion of Marine Resources

70. Palau has extensive marine resources which include, amongst other things more than 3,500 species of which at least 270 species of fish and invertebrates are sources of food, 250 species are sold in the aquarium trade and at least 100 species have medicinal use. Traditionally, every Palauan family produced much of its protein requirements by the harvest of inshore and near-shore marine resources. This practice continues today. As is the case for agriculture, much of this productivity is not recorded in official statistics. Statistics on marketed production show that catch rates are generally declining despite growing domestic demand and high market prices.

71. Depletion of inshore fishery resources results from: (i) abrogation of traditional conservation practices; and, (ii) ineffectual management of fishery resources by traditional, state, and national authorities.

72. Although Palau has extensive deep-water fish resources, the offshore fishing industry contributes only marginally to the economy and those contributions are declining; in 1992 fisheries accounted for 16% of GDP while in 1999 fisheries accounted for 2.6% of GDP.

b. Decline in Reef Yields

73. Based on an average total production of 1,800 metric ton/year for a total reef and lagoon area of 1,706 km^2, in the past two decades Palau's reefs have yielded an average of 1 metric ton of fish and invertebrates per km^2. The total maximum yield of reef from nine of the 16 states between the periods of 1992 - 1997 and 1998 - 2001 shows a decline. For example, the total landings of *Trochus niloticus* declined by 72%. This decline may be caused by several factors including large scale fishing operations, the 1998 coral bleaching event and loss of habitat, and other human activities such as dredging of reefs and sedimentation from land development activities.

74. The BPOA noted that based on a 2002 survey, 31% of key informants perceived that the inshore fisheries were being harvested unsustainably. They included reef fish as a whole, humphead wrasse, humphead parrotfish, sea urchins, sea cucumbers, crabs, clams, tuna, mangrove clams, and aquarium fish. The survey suggested that the catch was at least a third less than it had been a decade before. The top threats to resources identified in the survey included (i) over-harvesting in

[29] Government of Palau – OERC (a) and (d); op cit

the marine environment; (ii) loss of traditional knowledge and practices; and (iii) sedimentation.[30]

c. Depletion of Terrestrial Resources

75. Land-based resources are not as heavily exploited as marine resources, but are still being used for activities such as mahogany logging, taro and farm crop cultivation and Pandanus use for baskets. It should be noted that some agro-forestry resources (such as coconuts, betel nut, and fruit trees) are not being replanted in all areas.

76. In some states, mangrove areas are rapidly being filled in to create new land while in other states mangroves are used as a source of wood for small building projects. There is also evidence that mangroves are being shifted seaward as result of increasing sedimentation levels in near-shore waters. Mangrove species such as crab are collected.

2. Unsustainable Tourism Practices

77. Tourism is the most important source of non-aid income in Palau and represents the major private sector-led component of the economy. Based on the number of tourist arrivals relative to the population, Palau now ranks second only to the Bahamas among small island countries. The tourism planning work undertaken for FEIM suggests that assuming the current tourism profile, tourist arrivals could increase to 100,000 by 2013, representing a potential total value added to the economy of $42.3m.[31]

78. The adverse side effects of tourism may outweigh the benefits if it is not developed in a sustainable and responsible manner. Recreational uses of coral reefs in Palau include SCUBA diving, snorkelling, boating and yachting, fishing, and kayaking. Depending on the location of the reef, these uses are frequently very high.

79. FEIM's tourism paper notes that while to date, concern about tourism's environmental impacts has been confined to the relatively minor damage to reefs at popular dive sites, the recent virtual destruction of a prominent rock island on Makalal has created a backlash of resentment against inappropriate development.

80. The Tourism Action Plan Committee (TAPC) have identified the key challenges and constraints in Palau with respect to sustainable tourism as: (i) lack of public and political understanding of the concepts of eco-tourism and high-end tourism; (ii) lack of public and political support for sustainable, high-end eco-tourism development, including private investors and developers; (iii) inadequate Palauan participation in the tourism industry which consequently inhibits the flow of benefits derived from tourism to local communities; and, (iv) lack of support for sustainable tourism policies and planning. Further the TAPC identified a number of environmental concerns as threats or constraints to tourism's contribution to economic growth including; pollution; declining marine life; inadequate enforcement; lack of incentives for waste minimization; global warming issues; and over-fishing.

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30 Government of Palau – OERC (d); op cit

31 FEIM (d) *Tourism Action Plan*, Koror, Palau (June 2008)

81. FEIM's *Environmental Overview Report* noted that characteristics that make Palau's tourism sector such a large contributor to GDP are the same characteristics that are at risk from poor land use practices and environmental degradation (e.g. hotels and restaurants predominantly located in Koror, Palau Royal Resort located near the bulk oil storage plant and in proximity to the commercial port, and the siting of the Landmark Hotel next to the Koror Landfill); and the development of the tourism sector largely around diving (with the need to manage watersheds and land use and protect coral reefs and marine resources).[32]

82. The report noted a number of environmental risks that directly threaten the nature of tourism, and thereby potentially constrain economic growth in Palau, including:

- Mixed land-uses threaten the viability of high-end tourism;
- Capacity constraints of basic services (electricity, water, sewerage) inadequate for existing population and visitors, hotel and resort development placing additional burden on existing services;
- Selling of some goods at gift and souvenir shops that contravene CITES;
- Congestion and over-crowding at dive sites causing damage to reef ecosystems (anchors, divers colliding with corals, fuel spills from boats, inappropriate moorings);
- Visitors not being advised to not touch corals, remove clams or other marine organisms;
- Spear-fishing leading to depletion of fish stocks at certain sites;
- Reduction in attractiveness of sites as a result of debris, garbage, sedimentation and silt-laden run-off impacting water quality and polluting sites; and
- In order to address a number of the foregoing risks, a tourism site capacity assessment is required. The assessment would assist in setting targets and minimum environmental standards for tourism overall (sectoral approach) as well as set clear guidelines as to the carrying capacity of specific and individual sites that are important to tourism in Palau.

3. Development Constraints Resulting From Land Degradation

83. Land degradation imposes a significant constraint on sustainable development and economic growth in Palau. Land degradation not only results in loss of productivity and reduced income, but also threatens the survival of communities (by reducing the nutritional status of populations and the food security of the country). The negative impacts of land degradation include the undermining of the structure and function of ecological systems which often lead to soil and water resource degradation and a reduction in flora and fauna bioactivity. While changes in land cover and vegetation status contribute to climate change, land degradation, in and of itself, has been identified as the second greatest threat to Palau after climate change.[33]

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[32] FEIM (c); op cit

[33] Government of Palau – OERC (f); *National Action Plan to Combat Land Degradation*, Koror, Palau (December 2005).

84. As set out in the *National Action Plan to Combat Land Degradation* (NAPCLD) the major causes of land degradation in Palau have been identified as potential constraints on development and are summarized below:[34]

a. Lack of Land Use Planning

85. To date, there are limited land use plans for the individual states in Babeldaob. A lack of land-use planning, and the poorly planned, piecemeal development that results, are major threats to water catchment areas and forests in Palau. Threats relate to both direct loss of forests through clearing of forests for various types of development, housing and or hotel/resort development of unsuitable sites, and fragmentation of forests, opening them up to the threat of invasive species, and increased fire risk.

86. The island of Babeldaob (the second largest island in Micronesia) has the largest intact native upland forest in Micronesia and large-scale development of the island was limited in the past by poor road access. Until the early 1990s, most of the ten states in Babeldaob could only be reached by boat. However, within the past 10-15 years, all have become accessible by land, and the new Compact Road circumnavigated the island and significantly improves access. The Compact Road (see below) is expected to open up new areas for development opportunities. A proportion of the population in Koror is also expected to shift to Babeldaob following relocation of the Government Capital from Koror to Melekeok. This will inevitably cause an increase in the need for infrastructure, housing and building materials.

87. It should be noted that the effects of ad hoc land use development and lack of sustainable land use plans have been identified as major constraints on economic growth in several of the reports and working papers produced by the FEIM.

b. The Compact Road

88. Construction of the Compact Road is, to date, the largest infrastructure project in Micronesian history. Between 1995 and 2001 the road construction had resulted in the loss of 3.087 km^2 of vegetation.

89. Key issues are soil erosion, wetland destruction, and impacts to habitats of rare, endemic, or endangered species. Major dredging of inner reefs for coral sub-base material and filling of wetlands and mangroves are occurring throughout Babeldaob.

90. In 2001, Typhoon Utor caused major landslides along existing roads and especially along the Compact Road in Airai State. The storm resulted in estimated damages of US$ 4.0m.

c. Loss of Soil Fertility

91. Eighteen types of soils are found in Palau but up to 93% of Palau's soils are considered infertile, acidic, or have high aluminum content, and therefore are a poor soil for agriculture. Less than 18% of Palau's land is suitable for agriculture (with a slope of less than 12%).

92. Savanna or grassland covers a quarter of the land area and is subject to frequent fires during drought periods. The cycle of burning and erosion results in the depletion of vegetation. This, in turn, causes high sedimentation with deleterious

[34] Ibid

effects in low-lying areas, mangrove forests, and the reefs. Burning vegetation also tends to spread invasive plant species.

d. Invasive Species

93. Invasive species are considered to be a serious threat to sustainable land management practices and forest resources in Palau. Invasive species include: species that are presently subjects of eradication programs (4); species that are in known to be invasive or potentially invasive (53); species that are invasive or weedy elsewhere and are common, weedy or cultivated (95); native species (or Micronesian introductions) that exhibit aggressive behavior (15); and, 249 species that are potentially invasive i.e. they are invasive elsewhere in similar ecosystems but not currently known in Palau (249).

94. Of the other invasive plants already widespread in Palau, eradication or extensive control is out of the question for all of these species, but control in sensitive, natural and protected areas such as the national parks and reserves is required.

e. Uncontrolled Fires

96. At one time, most of Babeldaob was believed to be forested, and fire is considered to be one of the main reasons why grasslands are now the more prominent type of vegetation on the island. Although forests in Palau do not easily burn, and fires burning into forested areas burn out fairly quickly, adjoining grassland areas are burnt regularly. This means that forest species are unable to regenerate in the grasslands and fires gradually impact the important edges (or buffer zone) of forests.

97. Grasslands originating from abandoned agricultural land have thus failed to return to forest cover, and in many cases have been subject to loss of vegetation cover and subsequent soil erosion.

B. Environment's Contribution to Economic Growth in Palau

98. The NMDP identified economic opportunities for Palau as stemming from its unique and fragile environment. Key environmental features that affect the environment include: (i) pristine coastal environments, reefs, and fisheries resources providing a driver for tourism (including some of the best diving sites in the region); (ii) environmental protection as a key part of national political agenda; (iii) largely untapped land and forest resources; (iv) an extensive exclusive economic zone providing potential in the fisheries sector; and, (v) geographic location providing proximity to growing and large populations and markets throughout Asia.

1. Overview of Environmental Goods and Services

99. A number of goods and services are derived from the environment and natural processes. Goods include water, food (seafood, meat, fruit, vegetables), fodder for domesticated animals (pasture, grasses, and grains), fuel, timber, pharmaceutical products (plants, fungi, bacteria, insects, vertebrates), various other goods including paper, minerals, thatch, rubber, cotton, and hemp.

100. Fundamental services provided by ecosystems include purification of air and water, detoxification and decomposition of wastes, regulation of the climate, mitigation of

droughts and floods, pollination of vegetation, recycling of nutrients, pest control, regeneration of soil fertility, production and maintenance of biodiversity, provision of basic ingredients for agriculture, fisheries, and industrial sectors, and provision of aesthetic beauty and intellectual stimulation.[35]

101. The goods and services (derived through functions) provided by coastal ecosystems and threats to the same from development are summarized in Table 4.

Table 4 – Goods and Services from Coastal Ecosystems

Element	Goods & Services	Threats
Coral reefs	Dissipation of wave action and storm surges, coastal/beach protection from wave damage and shoreline erosion, replenishment of sand, food production and food source, wildlife habitat, nutrient accumulation, supports highest species diversity of any marine ecosystem (role in global bio-diversity), source of medicinal and drug products	Sedimentation (from human and natural activities), polluted or contaminated run-off, eutrophication (from agricultural effluent and sewage), destructive fishing practices and/or over-fishing, dredge and fill operations (port and tourism development activities), unsustainable tourism activities, fuel and oil spills
Coastal wetlands	Provide protective habitat, act as buffer between land and sea and protect shoreline from storms and erosion, nursery areas for spawning and juvenile marine fauna	Reclaimed and converted to land-uses (farming, forestry, fish-farming), damaged by industrial and agricultural development (roads, dams and irrigation systems), dredging and filling activities, accidental spills, polluted run-off, use as solid waste dumps and landfills, over-use as fuel-wood
Mangroves	Marketed; poles, charcoal, wood chips, mangrove crabs, fish or shell fish in adjacent waters Non-marketed; medicinal uses, domestic fuel wood, food, nursery for juvenile fish, feeding ground for estuarine fish and shrimp, nutrient flows to estuaries, buffer to storm damage, coastal stabilization, pollutant traps, protection against erosion, cultural importance, wildlife habitat, filter and purify water	Reclaimed and converted to land-uses (farming, forestry, fish-farming), damaged by industrial and agricultural development (roads, dams and irrigation systems), dredging and filling activities, accidental spills, polluted run-off, use as solid waste dumps and landfills, over-use as fuel-wood
Seagrass beds	Produce food for dugongs, manatees, turtles and birds, function as nurseries for some commercially exploited fish, protect coastlines from erosion by slowing wave movements, stabilisation of bottom sediments and reduces turbidity	Any physical or chemical changes in coastal water characteristics from; increased siltation and silt loads, effluents, run-off, thermal pollution, removal through reclamation
Rocky coasts	Perform important biological functions, provide attachment for marine algae and filter-feeding invertebrates, habitat for finfish and shellfish for subsistence or commercial purposes, support food-webs, feeding and breeding sites for seals, sea-birds and other fauna not found in other ecosystems, help dissipate wave energy, protect sediments and soils from erosion	Mining and quarrying, pollution and polluted/contaminated run-off and effluent and spills can damage habitat values and functions, construction projects can increase turbidity and water temperature, aesthetic value undermined by unsightly development

Source: Adapted from World Bank – Environmental Assessment Sourcebook Update No. 7 (March 1994)

[35] Ehrlich et al; Eco-science: Population, Resources, Environment (1977)

2. Economic Value of Natural Resources

102. The economic value of a natural resource consists of use and non-use values; use values are derived from net benefits that arise from direct and indirect use (e.g. forestry, fishery, tourism); and, non-use values are derived from the perceived value of an ecosystem to humans, regardless of whether it is used or not. As an example of economic values attributed to the environment, the types of values of protected areas are summarised in Table 5.

Table 5 – Economic Values of Protected Areas

Values		Use/Values
Use values	Direct use value	Recreation; tourism; sustainable harvesting; wildlife harvesting; fuel-wood; grazing; agriculture; gene harvesting; education; research
	Indirect use value	Ecosystem services; climate stabilisation; flood control; groundwater recharge; carbon sequestration; habitat; nutrient retention; natural disaster prevention; watershed protection; natural services (pollination, pest control)
	Option value	Future information; future uses (direct and indirect)
Non-use values	Bequest value	Knowing others benefit (now or in the future); legacy
	Existence value	Biodiversity; ritual or spiritual; cultural or heritage; community values; landscape

Source: Cardiff University/IUCN (1998) adapted from Barbier et al (1997)

103. Some environmental goods and services are traded in formal markets –payment for environmental services (PES) - while others are non-commercial and have not been assigned a "value" or "price" and therefore changes in supply and demand are more difficult to monitor. Collectively the value of global environmental goods and services is estimated to be in the order of US$33 trillion, higher than the global gross national product.[36]

104. Measuring the direct use values of resources, which can be traded on commercial markets, is more straightforward than measuring other values derived form the resources because the markets have already assigned values as shown in Table 6.[37]

Table 6 – Means of Capturing Direct Use Values

Benefit	Market	Capturing Values
Sustainable harvest	Income from sales; market prices for similar goods; proportion of income from final products	User fees; access charges
Recreation	Leisure and tourism expenditures	Gate fees; concessions; rents; tax; value added
Education	Price of alternative courses on offer elsewhere	User fees; interpreter fees; entrance fees
Scientific	Proportion of income from final research products	Access charges
Ecosystem services	Price of alternative service	Tax; user fees

Source: Cardiff University/IUCN (1998)

[36] WWF; Payments for Environmental Services, Netherlands (June 2006)

[37] A resource's contributions to the economy are its transaction or financial values. Values which fall outside of financial transactions i.e. non-use and indirect values are often the values which can contribute to the overall economic value of a resource.

105. It can be argued that natural resources such as mangroves have already been given a monetary value in Palau where areas of mangroves have been set aside as conservation/protected areas in lieu of payment of cash fines imposed by EQPB (as penalties for violation of the Environmental Quality Protection Act). In which cases the areas of mangrove have effectively been valued at the amount of the fines.

106. A research paper funded by World Wide Fund for Nature (WWF) (2003) estimated the potential economic value of coral reefs.[38] The paper concluded that, provided that coral reefs are properly managed, the potential net benefit streams for the world's coral reefs are in the order of US$30 billion per year with a corresponding global asset value - net present value (NPV) - of US$800 billion.

107. The paper also concluded that the estimated value for coral reefs in the Pacific (excluding USA) was in the order of US$2 billion per year and an NPV of US$55.5 billion.[39]

108. As shown in Table 7, assuming the values of benefits are in proportion to the area of coral reef, applying the proportion of value from the Pacific reef area to Palau's reefs yields an NPV of US$954 m. As shown in Table 7, in the estimate of NPV, the stream of values generated by Palau's reef includes US$4.6m associated with tourism and recreation. The potential contribution to economic growth from tourism is discussed more fully below in Section IV B 3.

Table 7 – Potential Net Benefit Streams from Palau's Coral Reefs

Net benefit streams	US$ million	
	Pacific	Palau
Reef Area (km2)	67,000	1,150
Fisheries	1060	18.2
Coastal protection	579	9.9
Tourism/recreation	269	4.6
Biodiversity value	172	2.9
Total	2,080	35.7
Net present value	55,584	954.1

Source: WWF/Cesar et al (2003)

109. In addition to the above, the CEA included the results from a study of scuba divers and snorkelers who were interviewed to determine their willingness to pay for a use permit.[40] The CEA noted that average willingness-to-pay was US$34 among scuba divers and US$26 among snorkelers, and with 50,000 divers and snorkelers visiting Palau each year, these figures suggest an industry consumer surplus of about US$1.5m.

110. The CEA also noted that nearly 60% of those interviewed stated that their willingness-to-pay was dependent on the condition of the corals and reef, indicating the significance of maintenance of coastal and reef quality.

38 Cesar et al; *The Economics of Worldwide Coral Reef Degradation*, WWF Netherlands (February 2003).
39 Calculated at a 3% discount rate and a 50 year timeframe.
40 ADB (a); op cit

3. Contribution to Economic Growth Through Tourism

111. A paper compiled in 2004 by World Bank and OERC demonstrated the economic value of Palau's coastal resources which included fisheries value, tourism value, traditional use value, mangrove use value, coastal protection value, bio-prospecting value, and global biodiversity value. [41] Based on an exit survey, the paper estimated the total gross revenue of the tourism sector as well as the economic value (value added) per tourist. The paper calculated that the total value added was in the order of US$27.5m (based on exit survey numbers providing a total of approximately 60,000 tourists). Value added per tourist ranged form US$154 per Taiwanese tourist to US$911 per American tourist.

112. The value added estimates from 2004 were used to calculate the contribution to economic growth from tourism over the MTDS period (i.e. to 2013). The following methodology was used in the estimation. Applying the 2004 value added per tourist by country of origin to 2006 tourist numbers provides an estimated total value added attributable to tourism in the order of US$43.2m. Based on 82,397 tourists in 2006 this implies an average value added of US$524 per tourist. This figure was then used along with projections of total tourists to estimate value added from tourism until 2013.

Table 8 – Data Used for Estimation of Economic Value of Tourism

Nationality	2004		2006	
	No. of tourists	Value added per tourist (US$)	No. of tourists	Total value added (US$)
USA	3,495	911	5,922	5,394,942
Japan	20,952	698	26,892	18,770,616
Europe	1,123	889	2,263	2,011,807
Other	6,571	670	18,871	12,643,570
Taiwan	27,710	154	28,449	4,381,146
Total	59,851		82,397	43,202,081

Source: World Bank/OERC (2004) and PVA (2006 tourist numbers)

113. The following assumptions have been used:

- Based on an exit survey undertaken by PVA in February 2008 and figures from 2007, the number of tourists estimated in 2008 is 88,000;
- Due to a slowdown in the world market as well as some local factors, the number of tourists would remain at 2008 levels in 2009;
- The growth, after 2009, remains constant over the MTDS period and reaches

[41] World Bank/OERC; *Economic Value of Coastal Resources of Palau*, Koror, Palau (June 2004).

the cap of 100,000 by 2013 as specified in the Tourism Action Plan;

- The geographic distribution (by country of origin) of tourists until 2013 remains the same as it was in 2004; and
- Value added per tourist remains the same as that derived in 2004, as explained above.

114. As shown in Table 9, the total value added is estimated to be in the order of US$46.1m in 2008 and US$52.4m in 2013 in 2004 dollars.

Table 9 – Economic Value of Tourism during MTDS Period, in 2004 $US

Parameter	Year					
	2008	2009	2010	2011	2012	2013
No. of tourists	88,000	88,000	90,858	93,808	96,855	100,000
Value added US$ (total tourists)	46,139,825	46,139,825	47,638,192	49,185,218	50,782,483	52,431,619

Source: PVA (2006 and 2008 tourist number and estimates)

4. Contribution to Economic Growth Through Forestry

115. The NBSAP and FEIM's *Agriculture Sector Report* state that currently, there is very little commercial forestry in Palau. Timber harvested is usually used locally and is rarely bought and sold, apart from small volumes for local construction or crafts such as storyboards (Palauan legends carved on pieces of wood).[42]

116. The commercial forestry sector in Palau is thus underdeveloped, but it is clear that large-scale commercial timber production for export could be a sustainable venture, due to the relatively small volumes that would be available and the risk of environmental damage from broad-scale logging.

117. There is, however, potential for small-scale timber production for local use and value-added products such as storyboards, wooden bowls and other utensils, furniture, and other non-forest timber products such as woven Pandanus mats and/or baskets, some of which may have potential for export.

118. The majority of wooden products and timber is imported, and as a result there is potential for some substitution from local sources. The volume of standing timber in Babeldaob has been estimated to be 2.9 million m^3 of which an estimated 2.5 million m^3 is located in upland forest. However, the actual accessible volume would be smaller due to the steep and difficult terrain, erodible soils, and small tree size or poor tree form in much of the natural forest.

119. The Forestry Unit of the Bureau of Agriculture for some years has promoted development of small-scale plantations for wood production. Free seedlings have been supplied to landowners from the forestry nursery at Nekken, together with extension advice on how to grow and manage the plantations. More recently, the

[42] Government of Palau – OERC (a) and FEIM (e); *Agriculture Sector Report - Final*, Koror Palau (February 2008).

Ministry of Trade and Commerce and private entrepreneurs have been promoting an expansion of the plantation program through funding the supply of more free seedlings to landowners and state governments in an effort to stimulate the development of a timber industry for both local use and export. The main species being promoted are teak (*Tectona grandis*) and mahogany (*Swietenia* spp).

120. The CEA suggests that there have been a few attempts to make use of Palau's forests, savannas, or wetlands as tourist attractions. These include short forest walks to two waterfalls on Babeldaob, and more recently the development of a trail in Lake Ngardok Nature Reserve in Melekeok State as part of efforts to stimulate ecotourism benefits for local communities. The Bureau of Marine Resources supports local communities in Ngaremeduu Bay Conservation Area in attempts to develop kayaking tours amongst the mangroves of the conservation area.

121. The Agriculture Sector Report[43] notes that there are significant areas of savannah land on Babeldaob which have potential for commercial forestry. While the soils are of poor quality and subject to degradation, there are tracts of land that could be afforested with benefits from lumber sales and carbon trading.[44] The report notes that with sustainable management practices, including staggered planting and harvesting systems and mixed planting of species, these soils could be forested. The economic advantages to landowners include carbon sequestration and lumber production.

122. While the potential benefits from carbon trading will vary according to the price of tradable carbon, calculations show that over the life of a planted forest, income from carbon trading would be in the order of US$170-260 per acre per year, depending on species, soil type and rotation length and could result in annual income in the order of US$498,717 and US$767,257 (as shown Annex 1).

5. Other Form of Contribution via Traditional Use and Indirect Values

123. The environment can also contribute to economic wealth through traditional uses and indirect aspects as follows: (i) terrestrial protected areas and conservation (re-forestation of buffer zones, sustainable resource management, entrance fees and other recreation-related enterprises); (ii) production of non-timber forest products; (iii) bio-prospecting (pharmaceutical companies and traditional medicines).

a. Terrestrial Resources

124. The NBSAP highlights that terrestrial habitats are vital components of the economy and culture of Palau. In addition to using terrestrial resources for food, tools, traditional clothing, and building materials, Palauans also use many trees and other plants for traditional medicines and other customary purposes (e.g., first childbirth ceremonies). For example, forests are used to produce items integral to Palau's culture, such as omsangel boxes used to store traditional money, building materials for traditional bai (men's meeting houses), and kabekel (war canoes).

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43 FEIM (e); ibid

44 Carbon trading has developed out of the Kyoto Agreement where polluting industries are able to buy carbon credits from non-polluting activities. Because trees have the ability to remove significant amounts of carbon from the atmosphere, forestry is a favored source of carbon credits. For further information, visit www.pointcarbon.com.

125. Palauans cultivate over 100 varieties of taro, 17 varieties of sweet potatoes, and many varieties of cassava, as well as bananas and other fruits for food. Over 44 species of trees are used for timber and firewood, and over 82 plants have medicinal properties. Some food plants, such as coconut, guava, mango, papaya, pineapple, banana, and taro, have also been used for their medicinal properties. Many of these plants are planted near homes, while others are collected from the savannas, wetland taro patches, and forests.[45]

126. Pandanus is harvested for weaving materials. The leaves of this plant are collected, dried, cut into strips and woven into baskets and mats. In some states, women receive income from their sales of woven items comparable to or greater than the local income from fishing.

127. The main agro-forestry systems in Palau are the traditional taro patch farming areas (mesei), coconut forest areas (although many of these are now in disuse), and family farms. The taro patch system enabled the people and culture of Palau to flourish, with taro being an important item in customary food exchange. Traditional taro production includes growing fruit and medicinal plants in cultivated wetland areas. There is a wealth of knowledge held by women who know the traditional taro farming techniques.

128. Indirect values have been broadly discussed in Section IV B 2. Indirectly, forests play an important role in the economy through the ecosystem services they provide, in particular their role in maintaining healthy reefs and fisheries, and contributing to the aesthetic character and visual amenity, which provide the basis for the tourism sector on which much of Palau's economy depends. For example, the forested character of the Rock Islands plays a vital role in maintaining their beauty and value as a major tourist attraction.

129. The CEA concludes that in addition to their direct biodiversity values, forests provide vital ecological services that help to maintain the health and ecological integrity of all of the terrestrial and marine ecosystems (e.g. sediment trapping, climate stability, nurseries for reef fish, soil production and conservation).

b. Coastal Ecosystem Resources

130. In respect of traditional values, marine resources have been a vital source of protein to the people of Palau for centuries. Several hundred species of fish and invertebrates are still important food sources. These fish and invertebrate species support an extensive semi-subsistence economy throughout Palau. Women collect marine invertebrates such as clams, sea cucumbers, and crabs from near-shore reef flats, seagrass beds, and mangrove areas and men catch reef fish, octopus, squid, mangrove crabs, and giant clams. They often have motorized boats and are able to fish both inside and outside Palau's extensive barrier reefs.

131. Traditionally, the reef and lagoons served as learning grounds to pass traditional knowledge about the tides, moon phases, and the behaviour of marine life from one generation to the next. Rights of passage for young men often depended upon their skill as fishermen. Men acquired status and power by their levels of skill and knowledge about fishing and navigation, and chiefs have been selected because of

[45] Government of Palau – OERC (a); op cit

their knowledge of fish and wise management of local marine resources (with the authority to open and close fishing seasons and fishing grounds).[46]

132. At one time, Palauan villages were established behind stands of mangroves to protect villagers from raids by canoes of warriors from other villages. The mangroves were important sources of firewood and also used for building materials. Channels through the mangroves were maintained to keep transportation passages clear. Mangroves remain important habitat for mangrove crabs, which are an important commercial and subsistence catch. Some women maintain mangrove clam collection sites and sell either sell clams or use them for household consumption.

133. The indirect values of coastal ecosystems have been discussed in Section IV B 2 and particularly emphasised in Table 4.

[46] Government of Palau – OERC (a) op cit

ANNEX 1 – ESTIMATED INCOME FROM POTENTIAL CARBON TRADING

Carbon Sequestration Value - Palau

Site quality *(soils, rainfall, etc):*	**Acacia species[1]**					**Mahogany[2]**				
	MAI/acre	*Rotation length[3]*	*Carbon t/m3*	*Total carbon t/ac/yr*	*Total carbon/ rotation*	*MAI/acre*	*Rotation length*	*Carbon t/m3*	*Total carbon t/ac/yr*	*Total carbon/ rotation*
Poor	4.5	15	1.5	6.7	100	2.9	30	1.5	4.3	130
Average	6.9	15	1.5	10.3	155	4.5	30	1.5	6.7	201
Very good	8.9	15	1.5	13.4	200	5.8	30	1.5	8.7	261

Growth rates - mean annual increment - m3 (MAI)

Assuming:

1. Soils are poor; 2. Carbon value is Euro22/tonne (US$31/tonne); 3. Euro/US$ exchange rate is 1:1.4

The annual carbon sequestration income per acre could prudently be expected to be 50% good quality:50% average soils

Species	US$ per ac	Forest size[6]	Annual average income (US$) from carbon
1. Acacia	262	2,930	767,257
2. Mahogony	170	2,930	498,717

Sensitivity test - impact on revenue of carbon price variations

Carbon at (US$/t):	15	25	35
1. Acacia	373,664	622,773	871,883
2. Mahogony	242,882	404,803	566,724

Notes:

1. The favoured acacia species in Palau is A*cacia auri.*
2. Slower growth rates - MAI of about 65% of acacia species
3. Rotation to medium saw-log stage
4. Spot European carbon price as at 29 October, 2007 <http://www.pointcarbon.com>
5. There are 23,700 ha (58,500 acres) of quality soils in Palau with a slope of greater than 12% - ie potentially re-forestable
6. Assume planted forest area is 5% of 58,500 acres - 7,200 acres

Source: FEIM; Agriculture Sector Report – Final (February 2008)

REFERENCES

ADB (a). 2007. *Republic of Palau Country Environmental Analysis*, *TA 6204-REG, Final Report.* Manila.

ADB (b). 2008. *Draft Climate Risk Management and Adaptation Road Map*. Manila.

ADB (c). 2007. *Palau: Achieving Sustainable Development, Draft PIER.* Manila.

ADB (d); 2006. *Pacific Annual Report.* Manila.

Cesar. H, Burke. L, & Pet-Soede. L. 2003. *The Economics of Worldwide Coral Reef Degradation*. Netherlands: WWF.

Ehrlich. P, Ehrlich. A, & Holdren. J. 1977. *Eco-science: Population, Resources, Environment*, San Francisco: Freeman and Co.

Golbuu.Y (a) [Golbuu, Bauman.A, Kuratei, J & Victor, S]; *The State of Coral Reef Ecosystems of Palau*, NOAA Technical Memorandum NOS-NCCOS # 11.

Golbuu. Y (b) [Golbuu & Fabricius]. 2007. 'Status of Palau's Coral Reefs in 2005 and their Recovery from 1998 Bleaching Event' in *Coral Reefs of Palau*, Palau International Coral Reef Centre/JICA, Koror, Palau.

FEIM (a). 2008. *Medium Term Development Strategy for Vulnerable Populations*. Koror, Palau.

FEIM (b). 2008. *Infrastructure Needs, Priorities, Maintenance and Regulations.* Koror.

FEIM (c). 2007. *Draft Environmental Overview and Stock-take Report*. Koror.

FEIM (d). 2008. *Tourism Action Plan*, Koror.

FEIM (e). 2008. *Agriculture Sector Report - Final*, Koror.

Government of Palau – OERC (a). 2004. *National Biodiversity Strategy and Action Plan*. Koror.

Government of Palau – OERC (b). 2002. *First National Communication to the United Nations Framework Convention on Climate Change.* Koror.

Government of Palau – OERC (c). 2001. *Current and Projected Impacts of Climate Change*. Koror.

Government of Palau – OERC (d). 2005. *Barbados Programme of Action + 10 Review National Assessment Report*. Palau.

Government of Palau – OERC (e). 2001. *Environmental Vulnerability Index.* Koror.

Government of Palau – OERC (f). 2004. *National Action Plan to Combat Land Degradation*. Palau.

IUCN/Cardiff University. 1998. *Economic Values of Protected Areas; Guidelines for Protected Area Managers*, Best Practice Protected Area Guidelines Series No. 2, IUCN Cambridge.

Victor. S, Golbuu. Y, Wolanski. E & Richmond. R. 2004. *Fine Sediment Trapping in Mangrove-fringed Estuaries.* Palau.

World Bank/OERC. 2004. *Economic Value of Coastal Resources of Palau*. Palau.

World Bank. 1997. *Assessing the Environmental Impact of Urban Development* – EA Sourcebook Update No. 19. Washington D.C.

World Wide Fund for Nature. 2006. *Payments for Environmental Services*, WWF – Forests Program, Zeist, Netherlands.