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Economic cost scenarios for solid waste-related pollution in Palau

By Stefan Hajkowicz, Kyonori Tellames and Joseph Aitaro

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Glossary

Ameliorative expenditure	Costs of reducing the harmful impacts of environmental problems by treating the symptoms. Purchasing bottled water is an example of an ameliorative expenditure potentially resulting from poor drinking water quality.
Annuity	An annuity is a finite series of periodic cash flows. It can be used to calculate periodic payments into the future arising from upfront capital expenditure. This allows one-off payments to be expressed in annualised terms.
Benefit-cost analysis	An economic evaluation technique involving the comparison of a project's benefits and costs over time to help determine if the project is worthwhile.
Best, high and low estimates	The results are reported as low, high and best estimates. The best estimate is based on the set of assumptions judged to be most realistic. The low and high cost estimates are attained by varying the assumptions within set ranges.
Cost savings and avoidance (CSA)	The costs avoided (or saved) when environmental problems are effectively managed.
Depreciation	The decrease in asset value over time due to wear and tear or obsolescence (e.g. the emergence of new technologies).
Discount rate	This is the rate at which future payments are devalued. It is used in financial and economic calculations to incorporate the lost of opportunity of investing elsewhere and the tendency of people to prefer goods now rather than later.
Gross benefit	The magnitude of the economic benefit from correcting an environmental problem. Gross benefit does not account for the costs of remedial activities.
Imputed costs	The costs estimated (imputed) when market prices for items do not exist. For example, the loss of time resulting from illness can be handled as an imputed cost of labour being equal to the salary forgone while the patient recovers.
Inflation	The tendency for the prices of goods and services to rise over time often measured with the cost price index.
Intergenerational equity	The fair distribution of wealth between the current generation and the next.
Mitigatory expenditure	Expenses incurred in activities aimed at reducing the potential for a physical hazard to cause asset damage, e.g. building flood barriers.
Net benefit	The magnitude of the economic benefit from correcting an environmental problem minus the costs of remedial activities.
Net present value	This is equal to the present value of benefits less the present value of costs.
Opportunity cost	The lost opportunity of not pursuing the next best alternative. It can be considered the amount "sacrificed" because of selecting a particular course of action.
Present value	This is the present value of a stream of future payments derived using a discount rate and accounting formulae.
Residual value	The remaining value of an asset after depreciation over a set time period.

Acronyms

BCA	benefit–cost analysis
CM	choice modelling
CPI	cost price index
CSA	cost savings and avoidance
CVM	contingent valuation method
DCF	Discounted cash flow
FSM	Federated States of Micronesia
GDP	gross domestic product
ha	hectare
HDI	human development index
HIS	Health Information System (database)
ISWMP	Integrated Solid Waste Management Plan
IWP	International Waters Project
km^2	square kilometre
NPV	net present value
NZD	New Zealand dollar
OERC	Office of Environmental Response and Coordination
SPREP	Secretariat of the Pacific Regional Environment Program
t	tonne
TEVS	Tourism Economic Valuation Survey
UNDP	United Nations Development Program
USD	United States dollar
WTA	willingness to accept
WTP	willingness to pay
yr	year

Executive summary

Background

Palau is renowned for its pristine natural environment, which supports tourism, fishing and extractive industries, as well as the lifestyles of its residents. Effective solid waste management is crucial to ensuring the ongoing quality of Palau's natural environment. This report estimates the economic cost of solid waste-related pollution to Palau. It asks the question:

What costs could be avoided in the absence of solid waste pollution in Palau?

The result is an estimate of opportunity cost, which is the value of financial resources that could be "freed" for investment elsewhere were they not being spent to manage and mitigate solid waste pollution problems.

Economic cost scenarios

Due to uncertain and incomplete datasets,[2] three economic cost scenarios are presented: best estimate; low estimate and high estimate. The cost to Palau of waste-related pollution is estimated between USD 0.4–3.7 million per year. The best estimate is USD 1.9 million per year, which is 1.6% of gross domestic product, and imposes annual costs of USD 510 per household. A breakdown of the costs is given in Table i.

Table i: Summary of economic costs of waste-relate pollution

	(USD 000 per year)		
Cost categories	**Best Estimate**	**Low Estimate**	**High Estimate**
Healthcare and illness costs	697	292	932
Public waste collection and dump site operation	101	67	136
Litter collection	23	15	30
Vector control (mosquitos, rats)	17	14	21
Loss of recyclable aluminium	7	7	7
Loss of nearshore fish catch (reef fish, crabs, lobsters)	89	28	150
Mangrove timber loss	7	3	10
Lost tourism income	961	0	2,403
Total annual cost	**1,902**	**426**	**3,688**
As percentage of GDP	**1.6%**	**0.3%**	**3.0%**
Cost per household	**0.51**	**0.12**	**1.00**

[2] While this report makes use of the best attainable data and information, results are based on informed assumptions and rough estimates. This is due to poor data availability and a lack of documented scientific and socioeconomic knowledge about some environmental issues. The inclusion of expert judgements and assumptions introduces an element of uncertainty to the results. Caution should be taken in how the results are used in policy design and decision making. Before being used the results should be subject to independent verification and more detailed assessments.

The best estimate is particularly sensitive to two assumptions made in consultation with experts. First, the number of tourists lost to Palau due to waste-related pollution is assumed to be 2% of tourist arrivals in 2004, which equates to 1,961 tourists. Second, a series of estimates are made of the reduced fish catch due to land sourced pollutants (e.g. sediments, waste effluent) in each State of Palau. Koror and Airai have the highest assumed losses at 13% and 30%, which equates to 16 and 6 t of nearshore fish products (reef fish, crabs, lobsters), repsectively. In the low estimate the tourism costs are set to zero and nearshore fish resource losses are drastically reduced. Other assumptions have been made, which are discussed in the report.

It is anticipated that these cost estimates will be refined as datasets are improved and a better scientific understanding of the relationship between pollution and natural resources in Palau is obtained.

Policy relevance

The economic estimates presented in this report can be used to help (a) raise awareness of the hitherto hidden costs to Palau of solid waste pollution; (b) place waste pollution problems alongside other social issues using a comparable unit of value (i.e. dollars); (c) inform policy makers and investors (e.g. development lending and aid agencies) on the relative magnitude of environmental expenditure that may be justified; and (d) provide a platform for more detailed assessments of specific projects or policies.

Gross benefit (not net benefit)

The estimates presented in this report are gross, as opposed to net, benefits. The avoidable costs (i.e. potential savings) of waste-related pollution can be considered a gross benefit of improved waste management. The gross benefit does not take into account repair costs, e.g. the cost of implementing a recycling station to reduce waste. The relationship between net and gross benefits can be written as:

$$\textit{Net Benefit} = \textit{Gross Benefit} - \textit{Repair Cost}$$

The economic efficiency (desirability from an economic perspective) of remediation requires the assessment of net benefits. This is usually done via benefit–cost analysis. If the value of benefits exceeds the value of costs then the project or policy is worthwhile from an economic standpoint. While benefit–cost analysis will be important, it need not necessarily be viewed as the sole prerequisite for action. The incomplete datasets and considerable non-financial benefits of waste remediation in Palau mean that benefit–cost analyses should occur within a broader decision-making framework.

Building scenarios with assumptions and expert judgements

Many of the data and scientific analyses to establish a link between waste dumping and its environmental and social impact are not available. This study makes use of best available information and assumptions informed by experts. The expertise drawn upon relates to Palau specifically, and is in the fields of fisheries management, epidemiology, public health, waste management and tourism.

The results are presented as cost “scenarios”. These are the costs that would occur under a given set of assumptions. The best, low and high estimates provide three scenarios based on varying the assumptions. The high estimates assume a higher intensity of environmental impact arising from waste-related pollution. It is anticipated that better estimates of economic cost impacts will be generated over time as the science and datasets underpinning these estimates are improved. However, policy makers cannot wait for the perfect dataset before acting on solid waste pollution in Palau. Decisions will need to be based on the best available information and then revised as new information comes to hand.

Non-financial impacts

There are many important non-financial impacts of solid waste and water pollution in Palau, which are extremely difficult and perhaps impossible to value in monetary units. They should, nevertheless, be given consideration in policy formulation and decision making, alongside the financial impacts listed above. The non-financial impacts may be of equal or greater value to Palauans. Some of the main non-financial impacts of pollution in Palau include:

- The loss or damage to biodiversity.
- Loss of recreational amenities (e.g. fishing, swimming, diving).
- Loss of landscape aesthetics and scenery.
- Damage to natural or human-made assets of cultural significance.
- Non-financial human health impacts.

Improved solid waste management

Waste management strategies generally involve avoidance, reduce, re-use, recycling, composting and disposal. The environmental impact will be reduced if more waste is avoided, reduced, re-used or recycled (in that order) rather than disposed into landfill. When disposal into landfill is unavoidable then it should be done in a manner that minimises any damaging environmental impact.

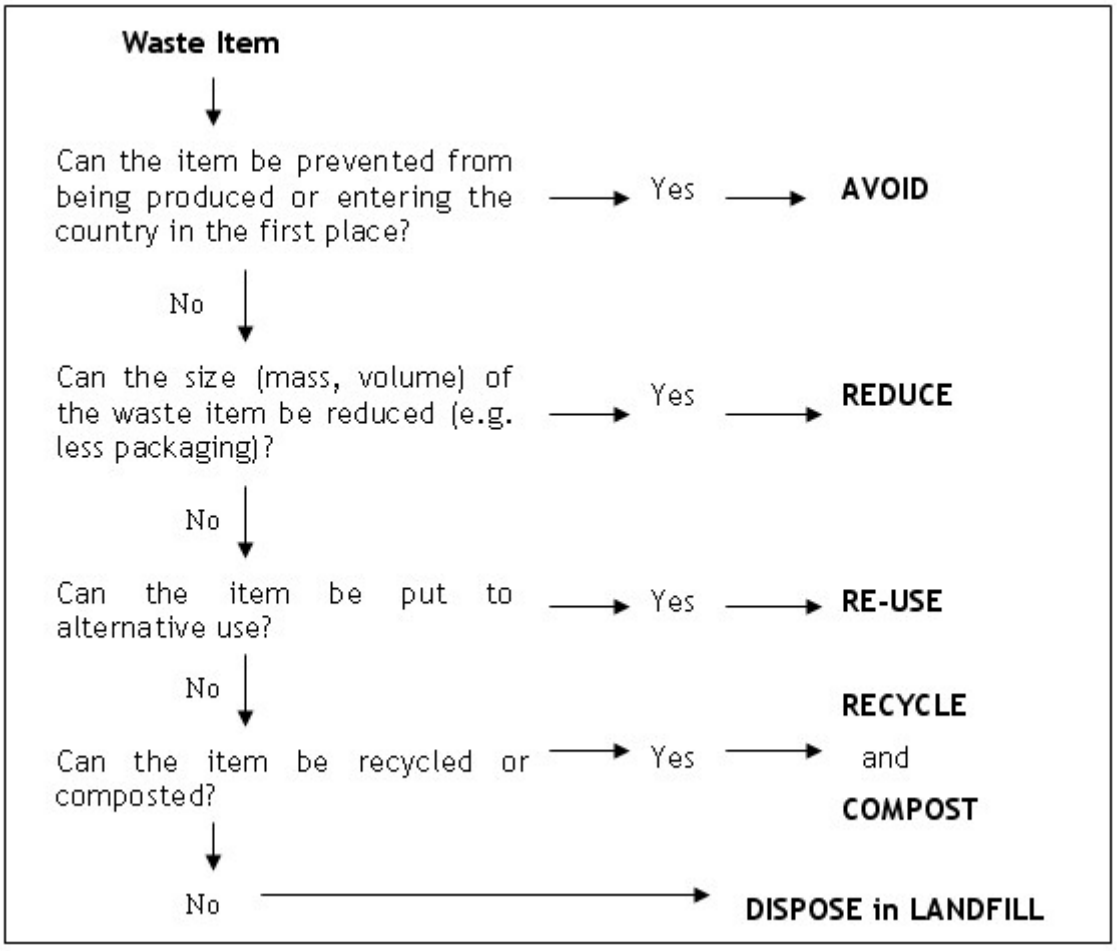


Figure i: Strategies to reduce waste

Recommendations

1. Continue with planning and implementation of suitably located, centralised and "green" waste dump facilities	Much of Palau's waste-related pollution problems arise because of poor waste disposal practices (e.g. dumping of waste in mangrove wetlands) and waste dumps being used beyond capacity. Given population growth trends Palau is likely to require new waste dump sites, which should be located away from residential areas and sensitive habitats. The dump facilities should also be designed to minimise any effluent discharge, avoid problems with pest animals (rats), and allow for appropriate treatment of different waste streams, e.g. separating recyclable and compostable material.
2. Develop a land use plan to aid with waste dump siting and pollution control	Waste management, including the siting of future dumpsites, does not currently occur within a broader land use planning framework. Site locations problems are solved on a case-by-case basis with no overarching or integrated system. Without a land use plan it will be difficult to control polluting activities and facilitate the adoption of more sustainable practices. The negative impact of inadequate land use planning can be observed at the dump site in Airai state, where houses are located within close proximity to the dump site. It is recommended that a land use plan be developed for Koror and Babeldaob in the first instance. Other less populated islands may require land use plans at a later stage.
3. Continue with waste management awareness and education programs	There is a need to continue and further deepen waste management awareness and education programs in Palau. These may be supported by the valuation results in this report. Some inappropriate dumping practices may result from a lack of knowledge about improved methods and consequences to the terrestrial and marine environment. The community requires practical and easily understood guidance on how to better manage (and avoid) waste.
4. Explore options and the need for improved household litter collection	The current domestic collection system involves the placement of household rubbish at the front of residences. Often the rubbish is exposed which creates a potential environmental a health issue (e.g. rats). The bins are also highly visible and have a detrimental impact on the scenic qualities, which is un desirable for both residents and tourists. A system whereby household waste is better contained and only placed at the curbside at collection times would reduce these problems. Improved systems need to be identified, then subject to some type of benefit–cost assessment.
5. Explore the options for subsidising collection and export of recyclable waste	Due to the costs of shipping the export of many recyclable products to overseas markets is likely to be unprofitable. Currently the only recyclable product exported by the private sector is aluminium. It may be possible for government to introduce further tax subsidies or incentive payments to make the export of other products (e.g. glass, plastics, paper, steel, car bodies) financially attractive to the private sector. An assessment should be made of the costs and benefits of such schemes from a social perspective.

6. Explore options for levies, duties, taxes or outright bans on environmentally damaging waste products	Selectively placing levies on the production and sale of environmentally damaging waste products may help reduce pollution problems. In some cases harmful waste products could be banned outright through legislation. As the vast majority of consumable waste items in Palau are imported the impact on local industry may be manageable. However, such a policy could lead to increased prices. The sectoral economic impacts and trade implications of any such policies would require careful consideration.
7. Improve knowledge regarding the impact of pollution and potential overharvesting on fisheries	Further work is required to understand and quantify the impact of terrestrial pollution and over harvesting on the valuable fish resources of Koror, Babeldaob and other populated islands within Palau. Currently there is little scientific evidence available to policy makers, but there is a growing concern in the community. Anecdotal observations of higher fishing effort required for decreasing harvests need to be substantiated and the causes investigated. The causes may be overfishing or land-sourced pollutants. The social and economic importance of fish resources warrant an improved understanding of the potential risks.
8. Improve natural resource information and databases for Palau	Data on the location, condition, market value and extent of marine and terrestrial natural resources in Palau is limited. For example, data needed to analyse fish harvest per unit effort over time (in order to establish trends) is unavailable. Data on socio-economic aspects of natural resources (prices, cultural uses, health issues, recreational activities etc.) is also limited. These data will be required for a range of natural resource management policies in Palau. As the collection of new data will come at some cost, it may be desirable to set priorities for data collection to support natural resource management decisions.

1 Introduction

Palau is renowned for its pristine natural environment (Fig. 1) which attracts over 80,000 tourists per year and supplies Palau's residents with clean water, clean air, recreational opportunities and stunning coastal scenery. Protecting Palau's natural resources and mitigating existing problems is of paramount importance to the nation. Some of the most significant environmental problems facing Palau are solid waste disposal and waste related pollution.

This report estimates the magnitude of costs that could be avoided in the absence of solid waste-related pollution in Palau. This can be considered the opportunity cost of waste, which is the value of alternatives forgone due to pollution. By measuring opportunity cost it is possible to assess resources that could be "freed" for investment elsewhere. If Palau did not have solid waste pollution problems, how much money would be saved by the government, industry and households? Many of the required datasets and scientific models of environmental and economic systems are unavailable or incomplete. Therefore, the results depend significantly on expert judgements and informed assumptions.

Figure 1: Palau's Rock Islands

The environmental valuation described here is based on the cost savings and avoidance (CSA) approach. This measures damage costs and defensive expenditures that would be avoided in the absence of pollution. The CSA approach is based on market goods only and excludes non-market goods such as biodiversity and cultural assets. These important issues should still be considered, and should be incorporated into policy and decision making processes through other means.

Another consideration with CSA (as applied in this study) is that it provides a gross, as opposed to net, cost estimate. Pollution remediation activities will come at a cost, and may not always be economically efficient. The economic efficiency (desirability from an economic perspective) of remediation options needs to be investigated via some type of benefit-cost

framework or another policy/project evaluation framework.

Assuming appropriate consideration is given to these caveats, a CSA valuation can be an extremely effective policy tool, and is increasingly be applied in the Pacific region. The reasons for conducting this valuation are:

1. To raise awareness of the hitherto hidden costs to Palau of solid waste pollution.
2. To place pollution problems alongside other social issues, using a comparable unit of value (i.e. dollars).
3. To inform policy makers and investors (e.g. development lending and aid agencies) regarding the relative magnitude of environmental expenditure that may be justified.
4. To provide a platform for more detailed assessments to set environmental remediation priorities and evaluate specific projects or policies.

The report commences with a brief review of previous valuation studies within small island states of the Pacific Region. The following two sections discuss methodological approaches to valuation and Palau's background social, environmental and economic issues. The results are then presented along with data sources and key assumptions. The closing sections discuss policy implications arising from this study and areas of future related work.

2 Background to the study

This study has been undertaken as part of the International Waters Project (IWP) in Palau. The IWP aims to strengthen the management and conservation of marine, coastal and freshwater resources in the Pacific Islands region. It is financed through the International Waters Programme of the Global Environment Facility, implemented by the United Nations Development Programme, and executed by the Secretariat of the Pacific Regional Environment Programme (SPREP), in conjunction with the governments of the 14 participating independent Pacific Island countries. IWP is working with those governments to identify practical ways to strengthen environmental management in three key areas:

a) Coastal fisheries;

b) Waste reduction; and

c) Freshwater protection.

The IWP is a regional effort intended to address the root causes of degradation in international waters of the Pacific Island, through the use of regionally consistent, country-driven, targeted actions that integrate development and environmental needs.

Under IWP in Palau, a pilot project has been established to address waste. IWP has selected the communities of Madalaii and Ngarchelong to host the pilot activities and provide a case study for addressing waste generally in Palau. A number of activities have already occurred under IWP in Palau, including community awareness meetings. The next stage in supporting IWP is to conduct an economic evaluation of waste that is impacting Palau's environment.

In Palau IWP is managed by the Office of Environmental Response and Coordination (OERC). It aims to supply rough estimates of the economic costs of solid waste related pollution and develop improved capacity for policy analysis of waste management options within Palau. The project aims and scope are given in Appendix A.

3 What is solid waste pollution?

Solid waste can be defined as any material that no longer serves a useful purpose for society and does not form part of the natural environment. For solid waste to be considered "pollution", it must have some detrimental impact on humans or the natural environment.

Solid waste is frequently linked to liquid waste and water pollution. For example, a solid waste dump site can produce harmful leachate (e.g. from metals or food scraps) which can enter the marine environment and damage coastal habitat. Earth moving equipment can dislodge sediments which can be transported by rain and streams into the marine environment, again causing damage to coastal habitats. While this report focuses on solid waste many of the impacts occur through water pollution.

Some examples of solid waste materials in Palau include paper, metals, organic matter, soil, putrescible, green matter (grass, leaves and wood), glass, ceramics textiles, rubber, car/truck bodies and batteries. These materials can be considered pollution because they are damaging (albeit to varying extents) to the natural environment and, thereby, human wellbeing.

4 Valuation studies in the Pacific region

Economic valuation is a policy tool of growing importance for the management of natural resources in the Pacific region. It has been applied in the Cook Islands (Hajkowicz and Okotai 2006); Fiji (Lal 1990) and Hawaii (Cantrell et al 2004) to name a few places. A similar valuation study to this one is currently underway in Tonga[3], also with IWP funding. In Palau the concept of environmental valuation has previously been explored, but not yet widely applied in policy.

A meeting in January 2003 at the Palau International Coral Reef Center with staff from the Government of Palau and World Bank explored how economic valuation of environmental resources could inform Palau's natural resource policies. This meeting was followed by the Palau Tourism Economic Valuation Survey (TEVS) in 2004. This involved a survey of 200 tourists at the airport departure lounge in English, Taiwanese and Japanese. The TEVS was designed to supply the "tourism" component of future environmental valuation work. The TEVS results have been used in this study. In discussing the purpose of valuation studies, the TEVS states that (Ministry of Finance 2004: 2):

> "…economic valuation enables the assessment of monetary losses to the economy when natural resources are damaged as a result of human activities."

A similar valuation study to that described in this report, and also funded under the IWP, was completed in the Cook Islands (Hajkowicz and Okotai 2006). The Cook Islands study estimated the economic costs of water pollution to Rarotonga, which is the largest of the Cook Islands by population and area. The report estimates damage costs in the range of NZD 3.2–17 million per annum, with a best estimate of NZD 7.4 million per annum. Damage cost categories include: healthcare and illness costs (diarrhoea, gastroenteritis, dengue fever and fish poisoning); downstream household water filters; upstream public water filters; household rainwater tanks; bottled water; mosquito control; loss of fish stocks in lagoon; water pipe upgrades; and lost tourism income.

In Fiji Lal (1990) estimated damage costs that could be avoided by protecting mangroves. It was found that mangrove habitats supplied economic benefits of: 6 USD/hectare/year (ha/yr) for forestry benefits; 100 USD/ha/yr for fishery benefits and; 2600 USD/ha/yr for nutrient filtering involving human waste treatment. A study by Cantrell et al. (2004) based on contingent valuation (see Appendix C) assessed people's willingness to pay for environmental services. It was found that people's net willingness to pay for the current average catch rate of 3.8 fish per trip is USD 7.95.

These, and other such studies, provide information on the economic value of natural resources

[3] This study was being conducted at the time of writing this report and is being managed by the Secretariat of the Pacific Regional Environment Program (SPREP) and Government of Tonga. It is looking at the economic costs and benefits of solid waste treatment; see Lal and Takau 2006.

and the potential gross benefits of remediation. They are highlighting hitherto unseen costs and thereby enabling more informed policy decisions.

5 Environmental valuation method

5.1 Alternative approaches

The field of environmental valuation has attracted much attention in economics over the past few decades. The main approaches to valuation are as follows:[4]

1) *Cost savings and avoidance.* This technique estimates the defensive expenditure and damage costs through market goods and services following a change in environmental conditions (see Section 5.2).
2) *Revealed preferences*. The market value of an environmental good or service is inferred from the buying and selling of a related market good. An example might be the premium paid for a house with scenic views, as opposed to the same house without views. This can allow an estimate of the unit price of an environmental good.
3) *Stated preferences*. These techniques rely on surveys of the general populous about their willingness to pay for environmental services or their willingness to accept compensation for the loss of those services. The market is typically treated as hypothetical, as payments do not occur in reality.
4) *Non-monetary metrics*. These approaches combine a set of environmental attributes in a variety of units into an overall performance metric that states the relative value of one environmental asset relative to another. They make no attempt to express value in monetary units, rather they define a non-monetary metric that measures the value of one option relative to another (i.e. they can allow ranking).
5) *Qualitative approaches*. These approaches abandon the notion of quantitatively measuring environmental value due to ethical, methodological or data constraints. The worth of environmental goods is expressed through clear and concisely worded statements of value.

5.2 Technique applied in this study: cost savings and avoidance

In this study the cost savings and avoidance (CSA) technique of environmental valuation is applied. The CSA approach asks the question:

> In the absence of pollution (solid and liquid waste), what costs currently being incurred would be avoided?

This means CSA aims to measure the opportunity cost of pollution by identifying the amount of defensive expenditure that could otherwise be redirected towards alternative activities. In other words, how much money (that could be invested elsewhere) are we losing because of solid waste and water pollution? Some important considerations of CSA as applied in this study are that:

- CSA is based on marketed goods and services only. Market goods, as opposed to non-market goods, are bought and sold in the marketplace and therefore can readily be priced in dollar units. Non-market goods are not traded and unpriced. They may include items such as biodiversity and non-financial aspects of human health.
- CSA provides gross, as opposed to net, cost estimates. As such it does not inform decision makers about the economic efficiency of remediation options. For this

[4] The description of techniques is extracted from Hajkowicz and Okotai (2006).

benefit–cost analysis (BCA) is required. To conduct BCA the remediation options must be well defined.

- Only some part of the gross cost estimate made in a CSA study is recoverable. While it is reasonable to expect the recoverable portion will be significant, it is not quantified, partly because remediation options and their effectiveness are unknown or unspecified. Large gross costs are not sufficient to justify intervention. At some point the costs of remediation need consideration within some type of benefit–cost framework.

Results from a CSA study can help raise awareness of an environmental problem by revealing previously "hidden" costs. This can help place the environmental problem alongside other societal issues in terms of relative importance. CSA can provide an effective catalyst to informed debate about the need for policy interventions to remediate solid waste and water pollution.

5.3 Limits to monetary valuation

The cost estimates presented in this study include only the market impacts of pollution. Some examples of market impacts are the loss of fisheries resources, decreased tourist expenditure, loss of mangrove timber, costs of medical treatment for waste related diseases and costs of dump site operation. The non-market impacts of pollution are excluded. Some examples of non-market impacts include biodiversity, non-financial aspects of human health, landscape scenery, cultural values and spiritual values. Whether such highly intangible goods as these can be valued in dollar units is questionable and presents methodological complexities.

Intangible goods are undoubtedly important but it may not be necessary (or possible) to express their value in monetary units. They can be handled within decision making processes via other means. For example, Lal (2003) notes the incomplete information, uncertainties and limited resources of many Pacific region small island states. As an alternative to valuation Lal proposes an integrated, adaptive decision-making process which involves structured and iterative stakeholder input to choices. This is one of many alternative approaches for including non-monetary goods within policy formulation and decision making.

Decision makers will need to consider to the extent to which intangible environmental and social goods are expressed in dollar units. There is likely to be a point when environmental assets become too intangible and alternative decision procedures, capable of handling non-monetary units, are needed. When used within appropriate bounds, however, valuation is a powerful and informative policy tool. Valuation will continue to help inform policy makers and assist in resolving difficult natural resource management issues.

5.4 Discount rates

In this study damage cost impacts from solid waste pollution are reported on an annual basis (i.e. dollars per year). Observations of environmental and social conditions are based on the most recent full year of data, i.e. 2004, where possible. The cost price index (CPI) is used to adjust historical price data to 2004 prices. Capital upgrades for waste disposal (e.g. bulldozers and excavators) are included over a 30-year period. These costs are converted to annual payments using discounted cash flow (DCF) analysis. The discount rate used for these items is 5%. This discount rate is only used for the amortisation of future capital expenditure, i.e. to express future capital costs (e.g. bulldozers, excavators) in annual terms (dollars per year).

A discount rate is used with DCF to express a series of future payments as a present value (net present value) and convert an upfront payment into a series of payments over time (annuity). Discount rates have the effect of devaluing costs and benefits that occur into the more distant future. For an introductory discussion on methodological and ethical issues surrounding the application of discount rates, especially in social analyses where inter-generational equity is important, see Campbell and Brown (2003) or Hollick (1993).

6 Background — environmental and social issues in Palau

6.1 Society, economy and physical geography

The population of Palau in 2000 was 19,129 persons, with a growth rate of 2.1% per annum (Ministry of Finance 2003). Palau is relatively wealthy compared to other Pacific Island nations. The United Nations Development Programme's (UNDP) Pacific Human Development Report for 1999 gives Palau the highest human development index (HDI)[5] and highest per capita income (USD 8,027) within the region (UNDP 1999).[6] Palau has relatively low unemployment (2% in urban areas and 7% in rural areas). The UNDP report states that 86% of Palau's population has access to safe water.

Tourism statistics compiled by the Office of Planning and Statistics, Ministry of Finance, show that 94,894 visitors arrived in 2004. The vast majority of visitors were from Taiwan and Japan, (38,739 and 24,181, respectively). The number of visitor arrivals has grown steadily since 1999, when 55,493 persons arrived (this represents a 71% increase over five years). The 2004 Palau Tourism Economic Valuation Survey found that 58% of tourists based their decision on the nation's reputation as an outstanding dive site and 32% due to its environmental quality (Ministry of Finance 2004).

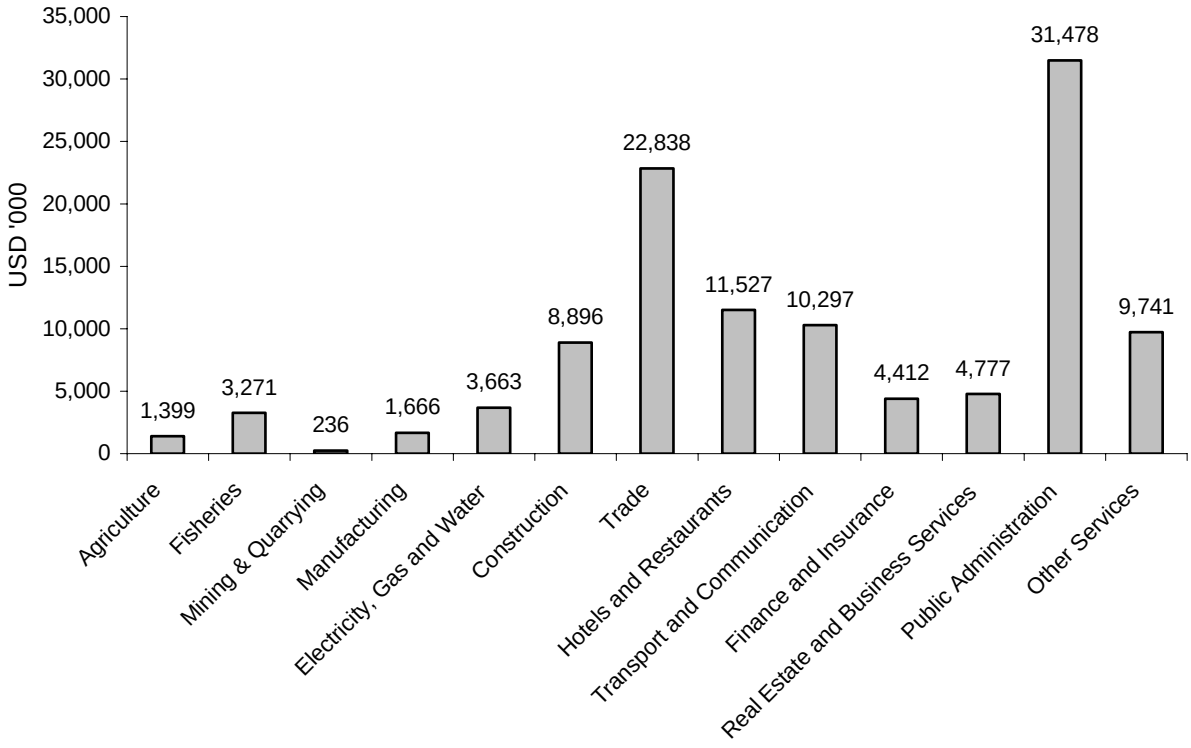


Figure 2: Palau's gross domestic product by industry sector in 2003

[5] The HDI is defined by three indicators: (a) life expectancy at birth; (b) an education index comprised of adult literacy and educational enrolment; and (c) per capita income.

[6] The Pacific nations listed in the UNDP (1999) report include: Cook Islands; Fiji; Federated States of Micronesia; Kiribati; Marshall Islands; Nauru; Niue; Palau; Papua New Guinea; Samoa; Solomon Islands; Tokelau; Tonga; Tuvalu and; Vanuatu.

Palau is made up of 586 islands, 10 of which are inhabited. It has a total land area of around 500 square kilometres. About 80% of the land area is forested and the remaining 20% is covered by grasslands, croplands or urban development. Around 70% of the population live in the capital, Koror, where the majority of businesses and government offices are also located.

Public administration is the largest sector of the economy followed by trade, restaurants and hotels. The majority of government revenues comes from taxation, followed by the Compact of Free Association funds.

The majority of Palauan people obtain their drinking water from rain catchment. The 2000 Palau Census (Ministry of Finance 2003) found that residents obtain drinking water as follows: 55% from rain supplies (e.g. rainwater tanks); 13% from public mains supply; 10% from bottled water; and 3% from a mix of rain and bottled water (the remaining 7% is not stated).

The mains water supply to Koror is obtained from the Ngerikiil and Ngerimel rivers located in Babeldaob. This water is piped to a treatment plant, which was rebuilt in 1998. The treatment plant has five filters and provides chemical feed and flocculation. Water is then distributed to Koror using pumps and a piping system comprised of various materials. The sewage treatment plant located on Malakal Island in Koror uses gravity collection, a trickling filter system and lagoons.

6.2 Solid waste pollution problems in Palau

There is minimal data on the severity and extent of Palau's environmental problems. A listing of the main environmental issues of relevance to this project was compiled from the 2004 State of the Environment Report (Sakuma 2004) and through consultations with the Palau Conservation Society and government agencies.

Economic cost impacts estimated in this study result from the following waste pollution problems:

- Disposal into landfill of waste materials for which disposal could be avoided, or which could be reduced, reused, recycled or composted, leading to higher public waste disposal costs and the loss of potentially recyclable materials.
- Leachate runoff from waste dump sites, causing damage to nearshore marine habitats that support fish, crab, trochus and lobster populations.
- Increase in pest animal populations (primarily rats) from dump sites. Rats are a vector for leptospirosis and scrub typhus and present an environmental health problem.
- Potential contamination of food and drinking water from inappropriate waste disposal. People can become ill with gastroenteritis when harmful bacteria associated with waste materials come into contact with food and drinking water.
- Visual disturbance and odour associated with waste dump sites. In this study it was found that the burning of waste can potentially increase the number of respiratory infections.
- Visual disturbance and environmental health problems caused by general litter in public places.
- Dumping of waste on mangroves resulting in damage to the mangrove habitat and loss of mangrove timber.
- Damage to fish habitat caused by general terrestrial pollutant runoff including sediments, fertilisers, pesticides and waste effluent.

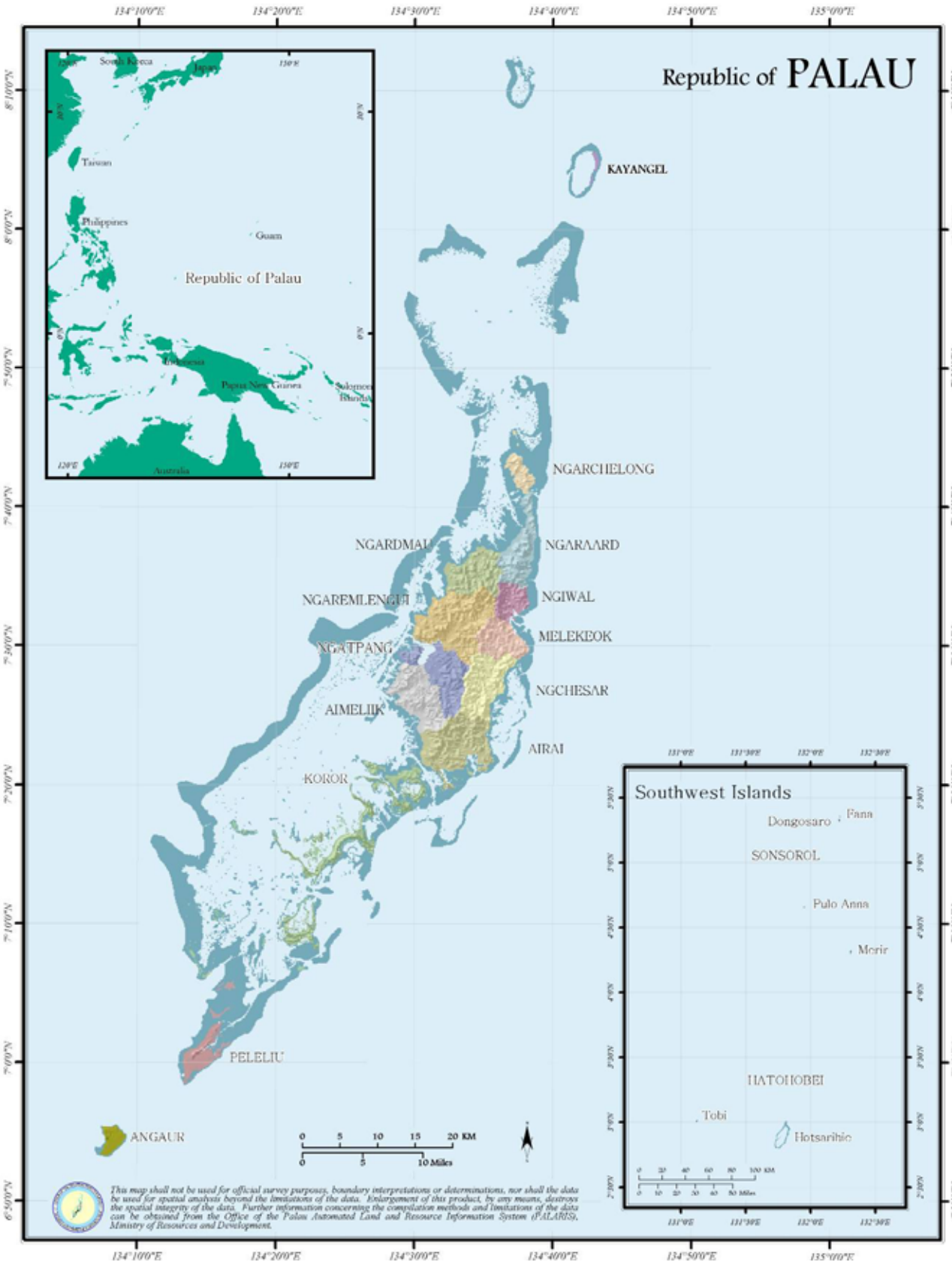


Figure 3: Location and map of The Republic of Palau Source: Ministry of Resources and Development, Republic of Palau)

7 The costs to Palau of solid waste and water pollution

This section of the report describes how estimates were generated for each cost category. Overall results for Palau are supplied for three scenarios: best estimate; low estimate; and high estimate. Unless otherwise stated the discussion of costs under each category relates to the best estimate.

7.1 Healthcare and illness costs

Consultations with doctors and epidemiologists from the Palau Ministry of Health (Bureau of Public Health) revealed that the diseases scrub typhus, leptospirosis, and dengue fever, and the conditions of gastroenteritis and respiratory infections (upper and lower), were to some extent exacerbated by poor waste management (Table 1). A portion of the estimated healthcare and lost labour productivity costs of these illnesses are included in the study results.

The potential impact of waste runoff through fish poisoning (ciguatera) was considered, but was not included because few cases are reported.[7] In 2004 there were no reported cases. Since 2000 the number of fish poisoning cases per year has not exceeded 3 (average of 1.2 cases per year). It is, however, being monitored by the Ministry of Health.

Table 1: Illnesses related to solid waste pollution in Palau

Illness	Relation to solid waste pollution
Dengue fever	Dengue fever is spread by mosquitos. Waste dump sites provide breeding grounds for mosquitos (e.g. tyres and plastic containers filled with stagnant water). This can increase the frequency and severity of mosquito outbreaks, thereby increasing the number of dengue fever cases.
Scrub yyphus	Spread by mites that live on rats. Inappropriate waste dumping provides food and shelter for rats, thereby increasing rat populations and scrub typhus cases.
Leptospirosis	Outbreaks of leptospirosis are usually caused when humans are exposed to water, food or soil contaminated with urine from infected animals. Rats, pigs and dogs are believed to be vectors of leptospirosis in Palau. Rat populations are increased by inappropriate waste dumping.
Gastroenteritis	Food and drinking water can come into contact with waste materials or effluent runoff leading to bacterial contamination which can cause gastroenteritis. Increased levels of ambient waste, especially near residential areas or water sources, can increase the number of gastroenteritis cases.
Respiratory infections	Inhalation of smoke from burning of rubbish can cause an irritation in people's lungs making them more susceptible to bacterial infection. This was observed directly after the September 2004 dump fire in Koror (Fig. 4).

Data on the number of cases per year for each illness were obtained from the Palau Ministry of Health. Dengue fever, Gastroenteritis and respiratory infections were sourced from the Ministry's Health Information System (HIS) database (Table 2). Scrub typhus and leptospirosis were not available on the database but were assembled from departmental memos as supplied by an epidemiologist. The 2004 observations are used for the cost estimates in this report. They were considered by health experts to provide the best representation of future trends.

Doctors and epidemiologists from the Ministry of Health supplied estimates of the portion of 2004 cases that could be avoided with effective waste management. The question asked was:

[7] Based on data from the Ministry of Health's Health Information System (HIS) database.

"How many fewer cases would you expect in the absence of waste management problems?" The results are given in Table 2. Additional data on the costs of pharmaceutical products, average time spent in hospital and lost labour productivity are given in Appendix F. From these data it is possible to obtain estimates of health costs caused by solid waste pollution in Palau (Table 3). The total annual solid waste-related health cost for Palau is estimated at USD 697,000.

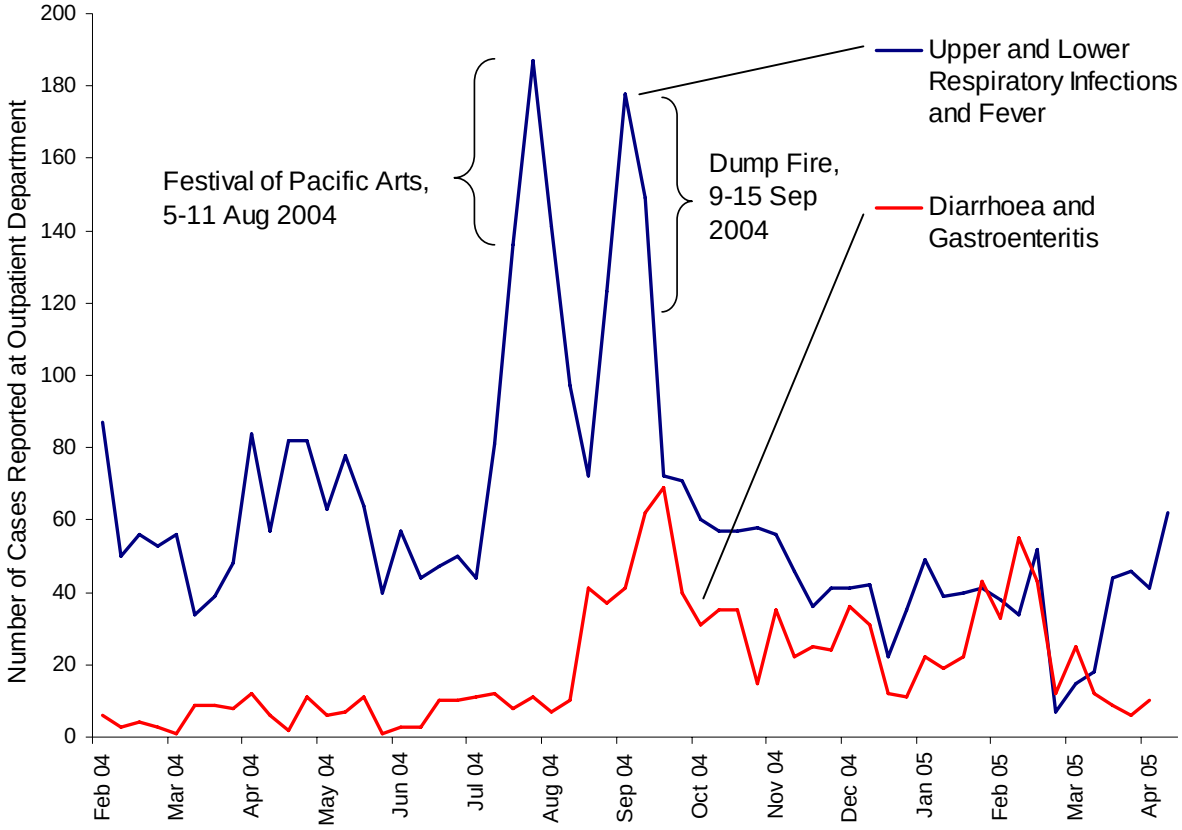


Figure 4: Increased respiratory infection, diarrhoea and gastroenteritis cases during the Koror national landfill dump fire in September 2004 (Source: Palau Ministry of Health, Public Health Epidemiology March 2005, from HIS data).

Table 2: Reported cases of waste related illnesses in Palau

Illness	2000	2001	2002	2003	2004	Percent of 2004 cases avoidable with effective waste management[2]
Scrub typhus[3]	ND[1]	ND	ND	ND	5	30%
Dengue fever[4]	341	483	23	7	22	75%
Leptospirosis[3]	MD	MD	1	0	10	80%
Gastroenteritis[4]	560	492	261	418	709	10%
Respiratory infections[4]	1845	2057	769	1401	2501	15%

1. ND = no data
2. Estimates supplied by a doctor and epidemiologist from the Palau Ministry of Health
3. Supplied by epidemiologist from the Palau Ministry of Health
4. Sourced from the Bureau of Public Health, Health Information System Database

Table 3: Health-related costs arising from solid waste in Palau (USD 000 per annum)

Diseases	Hospital costs	Pharmaceutical treatments	Lost labour productivity	Total
Scrub Typhus	4	0	0	4
Dengue Fever	41	1	5	47
Leptospirosis	30	1	2	33
Gastroenteritis	71	20	3	95
Respiratory infections	375	120	23	519
Total	521	142	34	697

7.2 Avoidable public waste disposal

Even with highly effective waste management strategies involving avoidance, recycling, composting and reuse, some waste will continue to be disposed of in landfills in Palau. This cost estimate covers only the portion of waste for which disposal could be avoided, through improved management. The aim is to determine the costs of disposing of waste that under effective management would not be generated.

Two steps were involved in estimating the annual cost of disposing of potentially recyclable or compostable waste. The first step was to determine the cost of public waste disposal per unit of quantity (i.e. dollars per kilogram [kg]). Secondly, an assessment was made of the feasible reduction in Palau's waste via avoidance, reuse or recycling strategies.

Data were used for waste disposal in the state of Koror, which contains over 70% of Palau's population. The data were supplied by waste management staff from the Koror State Government and the Palau Ministry of Public Works. The total value of avoidable waste generation is calculated from:

1. Average waste generation of 0.25 kg per person per day in Koror assessed in a 2004 survey by the State Government (Solid Waste Management Office 2004).[8]
2. Non-domestic waste generation by hotels, restaurants, bars and retailers of 1,948 tonnes (t) for Palau based on data reported by Golder Associates (1999). It is assumed that with 70% of Palau's population Koror produces 1,354 t of non-domestic waste per year.
3. Projections from the 2000 census, at 2% growth rates, yield populations of 14,688 and 21,120 in 2005 for Koror and Palau, respectively. Multiplying the populations by waste generation rates and adding non-domestic waste generation yields annual waste generation for Koror of 2,695 t and for Palau of 3,875 t.[9]
4. Annual costs of rubbish collection with garbage trucks, including operating (USD

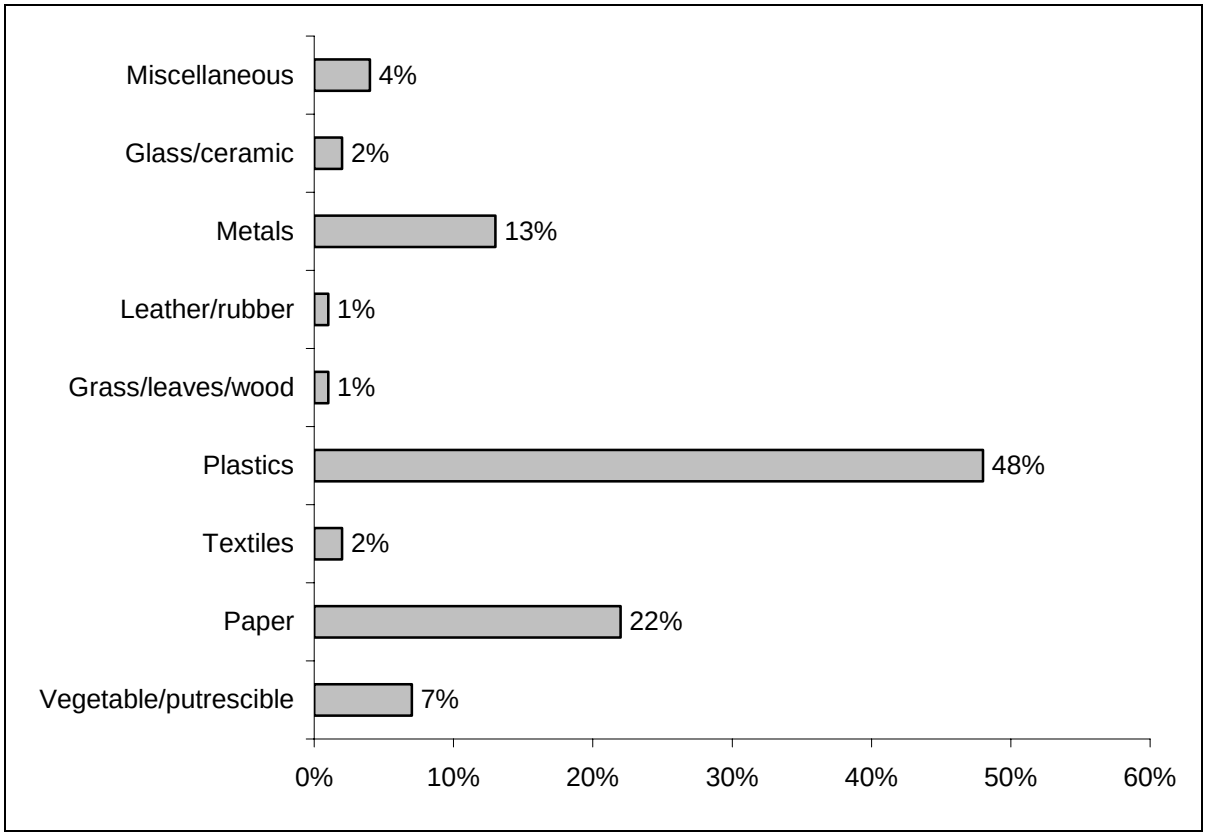
[8] The 1999 Integrated Solid Waste Management Plan (Golder Associates 1999) estimates per capita waste generation for Palau residents at 1 kg/person/day. This is based on interpolation of data from Samoa, Tuvalu, Tonga, Australia and the United States. The more recent detailed survey of actual Palau residents by the Koror State Government Solid Waste Management Office in 2004 estimates lower waste generation per capita (0.25 kg/person/day). The Koror State Government survey results have been used in this study as they are more recent and are based on a survey in Palau (as opposed to extrapolation from other countries).

[9] The per capita waste generation for Palau as a whole is assumed equal to that of Koror, which contains 70% of Palau's population.

24,000), labour (USD 49,000) and capital upgrades (USD 4,000). A truck requires 3 full time staff and 3 trucks are in operation for Koror. This gives a total annual cost of rubbish collection at USD 78,000. Capital upgrades are based on the purchase of second hand (used) equipment, which is standard practice.

5. Total annual costs (operating, labour, capital) of running Koror's national landfill public waste disposal site of USD 157,000 (see Table 4).
6. An estimate of 30% reduction in waste achievable via avoidance, reuse and recycle strategies (provided by waste management staff). This reduction is considered feasible based on Koror's waste stream analysis (Figure 5), which shows a considerable quantity of recyclable and compostable materials.

From these data the unit cost of public waste disposal was estimated at USD 87 per tonne. This gives total annual costs of waste disposal for Palau of USD 338,000. Given that 30% is avoidable, the national value of avoidable costs from waste generation is estimated at USD 101,000 per annum.



Source: Koror State Government Solid Waste Management Office

Figure 5: Waste stream for Koror, Palau

Table 4: Annual costs for the "M-Dock" National Landfill in Koror State[1]

Item	Cost (USD /year)	Notes
Staff salaries	76,000	Manager, supervisor, operators, mechanics
Operating expenses: Equipment maintenance and dumpsite operation	53,000	Includes fuel, spare parts, oil, respirators, hard hats, soil cover, and special clothing. Maintenance is for machines including 3 bulldozers, 1 truck loader and 1 excavator.
Capital upgrades[2]	29,000	Bulldozers, trucks and excavators.
Total	167,000	

1. Data supplied by the Palau Ministry of Public Works and the Koror State Government Solid Waste Management Office.

2. A schedule for purchasing new capital was identified in consultation with Koror State Government dump site managers. The annual figure is an annuity of the net present value of scheduled capital purchases over a 30-year period using a discount rate of 5.0%.

7.3 Litter collection

The Koror State Government maintains a litter collection program for the removal of general waste in public places. This has the benefit of improving the visual amenity of Koror, reducing environmental health risks and reducing other environmental problems associated with waste. It is included in this study as a form of defensive expenditure which could be partially avoided with effective waste management.

The main expense item is the employment by the Koror State Government of around 12 litter wardens. The annual salary costs for these personnel in 2004 was USD 75,075. It is assumed that 30% of these costs would be avoidable with effective waste management (this is the proportion of waste currently entering the landfill that could feasibly be removed from the waste stream; see Section 7.2). This results in avoidable costs of litter collection of USD 22,522.

7.4 Environmental health vector control (mosquitos and rats)

The Palauan Ministry of Health, Bureau of Public Health has a disease vector control program which aims to reduce mosquito and rat populations. Increased mosquito populations can increase the frequency and severity of dengue fever outbreaks. Increased rat populations can lead to increased cases of leptospirosis and scrub typhus. The control of mosquitos and rats is a significant public health issue.

Inappropriate waste dump sites (i.e. exposed garbage) and general litter will generally lead to higher mosquito and rat populations. Mosquitos breed in stagnant water that becomes trapped in car tyres, plastic bottles and other waste items. Rats can use dump sites and household rubbish for shelter and as a food source.

The Bureau of Public Health supplied estimates of rat and mosquito control costs for the last financial year that records were available, namely 1 August 2001 to 31 August 2002 (the Palauan financial year is from August until September). These cost estimates are shown in Table 5. Staff involved in undertaking the vector control and communication activities estimated that 10–15% of these costs could be avoided with effective waste management. This study uses a best estimate of 12.5%, a low of 10% and a high of 15%. The best estimate of avoidable cost is USD 17,000.

Table 5: Costs of environmental health vector control (for 2001/02)

Item	Cost/year (USD)
Salary (4FTE & 1 PTE)	72,634
Equipment	
ULV sprayers (USD 8,000 x 2)	16,000
Vehicle upgrades	2,364
Supplies	28,329
Includes mosquito larvacides (Altosid), pesticides/insecticides (Mortein, Cislin), rodenticides (Hawk), dengue test kits, leptospirosis test kits, mosquito traps, rat traps, hand-held sprayers, backpack sprayers	
Car fuel and maintenance	9,600
Communication	2,400
Printing	4,500
Radio and television programs	1,900
Total annual cost	137,727
Portion avoidable in the absence of waste pollution	12.5%
Total avoidable cost	**17,216**

Data Source: Ministry of Health, Bureau of Public Health

7.5 Loss of nearshore fish catch

Palau's nearshore fisheries resources include reef fish, lobsters, crabs, and in some years, trochus. They are consumed on a subsistence basis and also marketed. Records on the market value and total catch of these fish are available from 1999 to 2003 (Ministry of Finance 2003).

While Palau's fisheries are considered to be sustainable and healthy, populations and harvests per unit of fishing effort for some species are in decline in some locations (The Environment Inc 2003). The locations likely to be most affected are the more populated states of Koror and Airai. There are numerous possible causes for the decline, including terrestrial pollution (e.g. sediments, waste effluent), overfishing and coral bleaching. Evidence for a declining fish catch in some locations comes from several sources: (i) the 2003 Resource Use Study of Palau (The Environment Inc 2003) states that "Biological Surveys (Maragos et al. 1994a, 1994b), fish aggregation studies (Johannes et al. 1999) and observations by fishermen indicate that there is a decline in the fisheries"; (ii) interviews of fishing communities in Airai state found that numerous nearshore fish species were "harder to find" and that respondents "attributed the decline in harvest to dead corals, pollution, too many collectors, fewer species, saltation, oil from boats and lower water levels" (The Environment Inc 2003: 63); and (iii) a comparison of the total reef yield over two five-year periods (1992–1996) and (1997–2001) shows a decrease of 38 metric t for the same reef area (The Environment Inc 2003).

Data and scientific studies that conclusively demonstrate a link between land-sourced pollution and declining fish catch over Palau are not available. Evidence of declining catches is largely anecdotal and the causes are uncertain.

The economic cost estimates presented here rely on assumptions informed by expert opinion from local marine scientists and consultants. The key assumption (and main source of uncertainty) is the portion of each state's fish catch that is lost due to land-sourced pollution. These estimates were made in consultation with a local environmental consultant with

longstanding experience in Palau's fisheries management and marine scientists. They do not include the loss of fish resources from overfishing, but only that lost due to land-sourced pollutants. The estimated losses are given in Table 6. Multiplying the percentage losses by the fish catch given in the 2002–03 Statistical Yearbook (Ministry of Finance 2003) gives an estimate of the quantity of reef fish, crabs and lobsters in each state.

Recognising the considerable uncertainties about actual fish catch losses, a low estimate has been given that records zero loss in all states other than Koror and Airai State (the two most populous states). In these states a minimum 10% loss in fish catch is assumed. This places the low estimate well below the high estimate and, thereby, increases the overall range of cost estimates.

The variation in percentage loss for the best estimate between states (Table 6) results from the different levels of land-sourced pollution. Koror and Airai have the highest populations in Palau with more development (roads, residential development and industry). By comparison, Kayangel and Ngarchelong have small populations and very limited pollution. Loss of fish catch from terrestrial pollution for Hatohobei and Sonsorol, two states with minimal population and negligible development, is assumed to be zero, and they are not included in the estimates.

Table 6: Estimates of fish catch loss resulting from all sources of land-based pollution (including solid waste, sedimentation, septic tank leakage and other unidentified sources) based on 2003 fish catch data.

State	Lost catch	Reef fish (kg)	Crabs (kg)	Lobsters (kg)
Aimeliik	15%	277	11	0
Airai	30%	5,908	217	59
Angaur	3%	1	0	0
Kayangel	3%	3	0	0
Koror	13%	15,619	121	67
Melekeok	18%	1,282	0	3
Ngaraard	10%	136	33	1
Ngarchelong	3%	71	0	0
Ngardmau	8%	457	25	3
Ngaremlengui	10%	1,013	62	5
Ngatpang	15%	708	27	0
Ngchesar	15%	63	25	0
Ngiwal	10%	60	21	0
Peleliu	10%	827	1	1
Unknown	13%	5	0	0

Local market prices for nearshore fish products (reef fish, crabs and lobsters) vary from State to State. For Palau the average market prices are USD 3.06/kg for reef fish, USD 11.19/kg for crabs, and USD 8.38 for lobsters. All States' local market prices are given in Appendix G. When the quantities of lost fish are multiplied by the prices the total gross value of lost fish catch is obtained (Table 7). The total value of fish resources lost due to land sourced pollutants is estimated at USD 88,000.

Where fish are consumed on a subsistence basis a market price is imputed (i.e. the imputed

price equals the market price the fish would have obtained were it sold instead of being consumed domestically). Despite not being sold at the market these fish still have economic value.

Table 7: Estimated value of fish lost due to terrestrial pollution (USD/year)

State	Reef fish	Crabs	Lobsters
Aimeliik	810	150	0
Airai	18,500	2,500	530
Angaur	0	0	0
Kayangel	10	0	0
Koror	49,210	1,390	550
Melekeok	3,680	0	30
Ngaraard	440	380	10
Ngarchelong	210	0	0
Ngardmau	1,440	280	30
Ngaremlengui	2,560	590	30
Ngatpang	2,110	290	0
Ngchesar	190	300	0
Ngiwal	180	250	0
Peleliu	2,040	10	10
Unknown	10	0	0
TOTAL	81,390	6,140	1,190

The relationship between land sourced pollutants and fish catch in Palau needs to be further explored to determine whether these estimates are realistic. The potential exists for very large pollution-related economic impacts, due to fisheries damage; the estimates given here are very rough approximations of the loss in fish value resulting from terrestrial pollution.

7.6 Mangrove timber loss

Palau has a total mangrove habitat area of 4,700 has (Metz 2000). Some solid waste dumps in Palau occur on or near mangrove habitats. This can damage the mangrove habitat either by pollutant runoff or direct clearance. Two main economic impacts result from mangrove habitat damage: the loss of fish catch and the loss of mangrove timber. The economic impact on nearshore fisheries is covered in section 7.5. This section considers the loss of timber value.

Data on the area of mangrove loss is available only for six of the more heavily populated states (Table 8), with correspondingly higher development pressures; most of Palau's mangrove loss is likely to be occurring in these states. The data report mangrove loss from all activities, including the construction of the Compact Road in Babeldaob. In this study an arbitrary assumption is made that 50% of total mangrove loss results from solid waste dumps and pollution.

Table 8: Mangrove loss in Palau

State	Mangrove loss (km^2)	Total mangrove area (km^2)
Ngatpang	0.166	4.76
Ngiwal	0.02	1.5
Airai	0.015	7.9
Melekeok	0.011	0.98
Koror	0.009	1.6
Ngaremlengui	0.006	3.9

Source: The Environment Inc (2003)

A 1996 mangrove valuation study in Kosrae, Federated States of Micronesia (FSM) (Drew and Naylor 1998; cited in Metz 2000) finds mangrove timber value in the range of USD 426 to USD 640 per ha. In this study the midpoint of USD 533 per ha is assumed for the best estimate, which equals USD 585 per ha in 2004 prices when adjusted for inflation.

From these data the lost value of mangrove timber can be estimated in the vicinity of USD 7,000 per annum. This assumes that the records for mangrove area destroyed are also on an annual basis. Even with considerable changes to the input data (e.g. making an upward revision of the area of mangroves destroyed, or increasing the timber value) the loss of mangrove timber value resulting from solid waste is a minor cost impact.

7.7 Loss of recyclable materials

A significant amount of potentially recyclable material enters Palau's landfills. This represents a loss of a marketable good, and can be considered an opportunity cost of ineffective waste management. Ideally, recyclable products would be sold on the global market, where it is profitable to do so. The profitability of exporting aluminium has been demonstrated by the success of the Belau Scrap Company, which currently exports recycled aluminium and copper products from Palau. Plastics, glass, paper and other recyclables in Palau may not be profitable due to the high costs of shipping relative to their prices (Golder Associates 1999). In this report only the lost value of aluminium is considered.

The disposal of aluminium is derived from the Integrated Solid Waste Management Plan (ISWMP; Golder Associates 1999). An analysis of waste entering the Ngerbeched Dump in the ISWMP found that aluminium accounts for roughly 4.2% of the total mass. This can be compared with an observation of 5% for FSM. This study assumes that 4.2% of the waste entering all dumps in Palau is aluminium, which equates to roughly 163 t (based on current waste generation estimates).

The local market price for aluminium scrap metal, paid by the recycling company to local collectors, is USD 0.05 per kg. The aluminium is then sorted, packed and shipped to overseas markets (usually in the United States or Taiwan). The local market price represents the value of the aluminium after all collecting, packaging, transportation and marketing costs are deducted. It can, therefore, be used to determine the opportunity cost of aluminium lost to landfill.

Multiplying the local scrap aluminium price by the total waste generation gives a cost estimate of USD 7,382 per annum. This amount could be attained were the aluminium sold for recycling rather than put into landfill. It is possible that plastics, glass, paper and other recyclables could be sold, but no a market was identified in Palau for these scrap products. The absence of such markets is most likely due to the high costs of shipping.

7.8 Lost tourism income

Records for visitor and tourist arrivals are available for Palau from 1998 to 2004 (Figure 6; see Government of Palau 2006) from the Office of Planning and Statistics, Ministry of Finance.[10] In the year 2004 a total of 94,894 visitors arrived in Palau, of which 83,041 were classed as tourists. Other visitors were on business trips or were returning residents. There is an expectation that tourist arrivals will continue to increase, but there is also significant uncertainty. Palau's tourism industry is sensitive to global issues such as terrorism, disease epidemics and natural disasters.

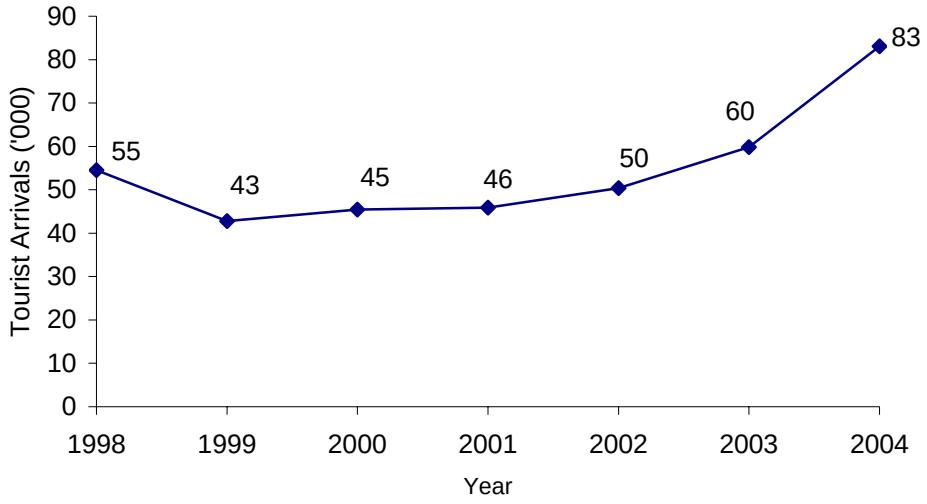


Figure 6: Tourist arrivals. Source: Government of Palau 2006.

In 2004 an estimated 66% of tourists arrived on a package tour, which typically covers all food, accommodation, airfares and activities (Ministry of Finance 2004). Package tours generally involve brief stays and only part of the package price is retained within Palau. A draft report currently under preparation by the Office of Environmental Response and Coordination and the World Bank (OERC and World Bank 2004) estimates the value added to the Palauan economy by tourists from different home countries (Table 9). These expenditure estimates are adjusted for package tours and are derived from the 2004 Palau Tourism Economic Valuation Survey (Ministry of Finance 2004).

It is not easy to determine how many additional tourists choose another destination over Palau due to concerns about environmental quality, and in particular solid waste and water pollution. Tourist choices are driven by many factors, of which environmental quality is but one. No readily available dataset or survey result exists that provides a definitive answer. Estimates of the percentage loss are therefore based on expert judgements, observations of tourist motivations in previous studies and interviews with tourism operators.

The 2004 Palau Tourism Economic Valuation Survey found that 58% of tourists selected Palau because of its reputation as dive location and 32% because of its reputation for having a pristine natural environment (Ministry of Finance 2004). These results show that Palau's natural environment is an important (arguably the most important) factor attracting tourists. Therefore, any significant and prolonged change to Palau's environmental quality is likely to impact tourist arrivals and national income.

While the environment is important to Palau's tourists, most are highly satisfied with Palau's environmental quality. The 2004 survey finds that only 3% of visitors reported "disliking" their most recent diving/snorkelling trip due to poor environmental quality. Most tourists report

[10] The visitor arrival data can be accessed by the public on the internet www.palaugov.net/stats.

high levels of satisfaction with the quality of snorkelling and dive sites. This is in part because the dive sites are located primarily in the Rock Islands, far away from the more populated islands of Koror. The rock islands have negligible development and are unpolluted. The tourist exit-survey did not cover the issue of solid waste or pollution in other locations (e.g. Koror and Airai States).

The main impact on tourists is likely to be through the loss of landscape scenery (Figure 7) and odour from dump sites in Koror and Airai States. There may also be problems with rats and dogs that live around dump sites. While there is minimal litter in the Rock Islands, they are very clean and are mostly be perceived as a pristine environment.

a)

b)

Figure 7: Visible impacts of solid waste pollution in prominent locations: (a) from the road on Meyuns Island where several resorts are located and; (b) the Koror State landfill on the road to the aquarium, a popular tourist attraction.

In this study the best estimate scenario assumes that tourist arrivals could increase by 2% in the absence of solid waste related pollution in Koror and Airai States. The low and high estimates are for increases of 0.0% and 5.0%. Therefore, the low estimate removes the tourism impact altogether. The high estimate is an arbitrary assumption. Even though these represent small percentage variations, the cost impacts are significant. For 2004 the best estimate is a gross value of USD 1,902,000 for lost tourism income.

Table 9: Lost tourist value, assuming no pollution resulted in a 2% increase in visits

Home Country	Value added to Palau per visit (USD /visitor)	Number of tourist arrivals 2004	Total value added (USD/ year)	Additional tourists in absence of pollution	Lost opportunity (USD per year)
United States	911	4,794	4,367,000	96	87,000
Japan	698	23,411	16,341,000	468	327,000
Europe	889	1,199	1,066,000	24	21,000
Taiwan	154	38,175	5,879,000	764	118,000
Other	670	30,450	20,402,000	609	408,000
Totals		98,029	48,055,000	1,961	961,000

1. Source for value added per tourist: Office of Environmental Response and Coordination and World Bank draft report "Economic Value of Coastal Resources in Palau" (OERC and World Bank, 2004).

These estimates represent a cost scenario, as the actual number of tourists lost due to pollution is unknown. Further studies will be required to test the relationship between tourist arrivals and environmental quality in Palau. Questions designed to assess this relationship were prepared as part of this study and have been proposed for inclusion in the Palau Visitors Authority tourist exit survey (Appendix I). The survey is in English, Taiwanese and Japanese and is planned to be conducted in November 2005. Hopefully the results will supply a better understanding of how environmental quality impacts tourist arrivals and expenditure in Palau.

7.9 Overall economic cost scenarios

Overall results for Palau are presented as three (best, low and high) cost scenarios (Table 10). These represent costs that would occur under a given set of assumptions. The high estimates assume a higher intensity of environmental impact arising from waste related pollution. The assumptions used to generate the scenarios are given in Appendix H.

Table 10: Solid waste pollution economic cost scenarios for Palau

	(USD/year)		
Cost categories	**Best Estimate**	**Low Estimate**	**High Estimate**
Healthcare and illness costs	697,000	292,000	932,000
Public waste collection and dump site operation	101,000	67,000	136,000
Litter collection	23,000	15,000	30,000
Vector control (mosquitos, rats)	17,000	14,000	21,000
Loss of recyclable aluminium	7,000	7,000	7,000
Loss of nearshore fish catch (reef fish, crabs, lobsters)	89,000	28,000	150,000
Mangrove timber loss	7,000	3,000	10,000
Lost tourism income	961,000	0	2,403,000
Total annual cost	**1,902,000**	**426,000**	**3,688,000**
As percentage of GDP	1.6%	0.3%	3.0%
Cost per household	**0.51**	**0.12**	**1.00**

The cost of waste related pollution to Palau is estimated between USD 0.4–3.7 million per year. The best estimate is USD 1.9 million per year which is 1.6% of gross domestic product and imposes annual costs of USD 510 per household.

The best estimate is particularly sensitive to two assumptions made in consultation with experts. First, the number of tourists lost to Palau due to waste-related pollution is assumed to be 2% of tourist arrivals in 2004, or 1,961 tourists. Second, a series of estimates are made of the reduced fish catch due to land-sourced pollutants (e.g. sediments, waste effluent) in each state of Palau. Koror and Airai have the highest assumed losses at 13% and 30%, which equates to 16 and 6 t of nearshore fish products (reef fish, crabs, lobsters). In the low estimate the tourism costs are set to zero and nearshore fish resource losses are drastically reduced. Other assumptions have been made, which are discussed in the report.

It is anticipated that these cost estimates will be refined as datasets are improved and better scientific understanding of the relationship between pollution and natural resources in Palau are obtained.

8 Non-financial impacts

Although not expressed in dollar units, there are many important non-financial impacts of solid waste and water pollution in Palau. These are extremely difficult and perhaps impossible to value in monetary units. They should be given consideration in policy formulation and decision making, alongside the financial impacts listed above. Some of the main non-financial impacts of pollution in Palau include:

- the loss or damage to biodiversity;
- loss of recreational amenities (e.g. fishing, swimming, diving);
- loss of landscape aesthetics and scenery;
- damage to natural or human made assets of cultural significance; and
- non-financial human health impacts.

9 Policy implications

This study has shown that solid waste related pollution carries a significant economic cost burden to Palau. When accrued over a 30 year period at a discount rate of 5% the best estimate yields a net present value of USD 30 million. This provides a starting point for considering upfront expenditure on waste management programs, policies and projects over the same time period. Activities of a considerable size may be justified, given the large cost impact arising from solid waste pollution. However, a specific project would need to be subject to benefit cost analysis on a case-by-case basis.

These results can be used to help (a) raise awareness of the hitherto hidden costs of solid waste pollution to Palau; (b) place waste pollution problems alongside other social issues using a comparable unit of value (i.e. dollars); (c) inform policy makers and investors (e.g. development lending and aid agencies) regarding the relative magnitude of environmental expenditure that may be justified; and (d) provide a platform for more detailed assessments of specific projects or policies.

A key consideration for policy and decision making is that the cost estimates are gross, as opposed to net, benefits. The avoidable costs (i.e. potential savings) of waste-related pollution can be considered a gross benefit of improved waste management. The gross benefit does not take account of repair costs, e.g. the cost of implementing a recycling station to reduce waste. The relationship between net and gross benefits can be written as:

$$\textit{Net Benefit} = \textit{Gross Benefit} - \textit{Repair Cost}$$

The economic efficiency (desirability from an economic perspective) of remediation requires the assessment of net benefits. This is usually done via benefit–cost analysis. If the value of benefits exceeds the value of costs then the project or policy is worthwhile from an economic standpoint. However, benefit–cost analysis need not necessarily be a prerequisite for action. The incomplete datasets and considerable non-financial benefits of waste remediation in Palau mean that benefit–cost analyses should reside within a broader decision making framework.

A series of recommendations arising from this study are given in the report's opening sections. They relate to strategies for the management of waste, better land use planning and improving natural resource management datasets.

Waste management strategies generally involve avoidance, reduce, re-use, recycling, composting and disposal (Figure 8). The environmental impact will be reduced if waste is reduced, re-used or recycled (in that order), rather than disposed of into landfills.

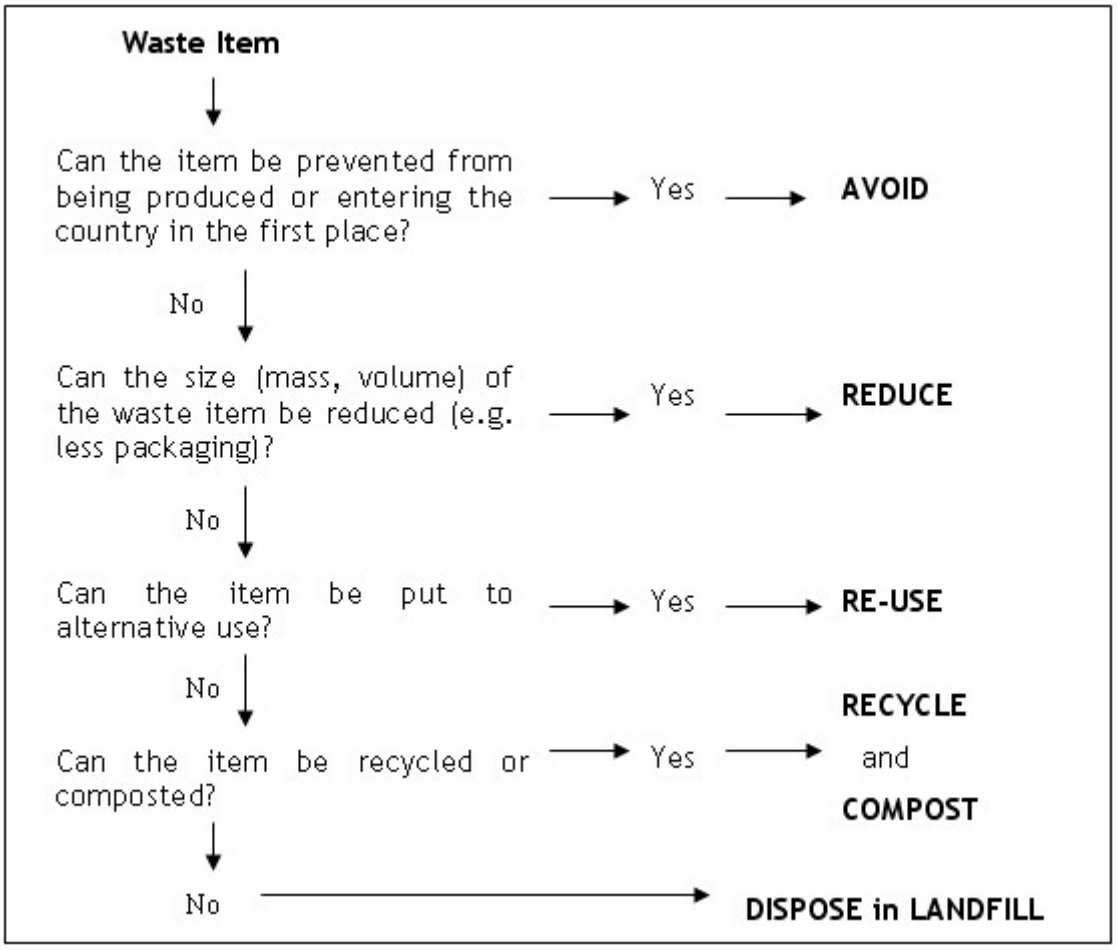


Figure 8: The waste strategy decision hierarchy

Policy levers such as taxation incentives, disincentives, subsidies, education and awareness may be used to increase waste avoidance, reduction, re-use, recycling and composting. However, there will continue to be a requirement for a waste landfill in Palau. This requirement is likely to grow in the future with rising populations, increasing visitor arrivals and economic growth. It is likely that Palau will need to plan for centralised landfill facilities designed to mitigate damaging environmental impacts.

A key consideration for waste and pollution management in Palau is the siting of dump facilities. Currently these decisions are made on a case-by-case basis and do not form part of a broader land use plan. The absence of a land use plan will continually hamper efforts to manage waste and all forms of pollution in Palau. Without a land use plan it is difficult to promote and prevent urban, industrial and green-space land uses in appropriate locations.

Further work is required to test and refine the assumptions used in generating the estimates presented in this report. This will involve data gathering and scientific studies that test the relationship between human activities and detrimental environmental impacts.

It is anticipated that better estimates of economic cost impacts will be generated over time as the science and datasets underpinning these estimates are improved. However, policy makers cannot wait for the perfect dataset before acting on solid waste pollution in Palau. Decisions will need to be based on the best available information and then revised as new information comes to hand.

References

Abdalla, C.W., Roach, B.A. and Epp, D. 1992. Valuing environmental quality changes using averting expenditures: An application to groundwater contamination. Land Economics 68(2): 163–169.

Barton, D.N. 2002. The transferability of benefit transfer: contingent valuation of water quality improvements in Costa Rica. Ecological Economics 42: 147–164.

Bastian, C., McLeod, D.M., Matthew, J., Germino, W.A., Reiners, B.J. and Benedict J.B. 2002. Environmental amenities and agricultural land values: A hedonic model using geographic information systems data. Ecological Economics 40: 337–349 .

Cantrell, R.N., Garcia, M., Leung, P. and Ziemann, D. 2004. Recreational anglers' willingness to pay for increased catch rates of Pacific threadfin (*Polydactylus sexfilis*) in Hawaii. Fisheries Research 68: 149–158.

Campbell, H. and Brown, R. 2003. Benefit cost analysis: Financial and economic appraisal using spreadsheets. Cambridge University Press.

Carson, R.T., Mitchell, R.C., Hanemann, M., Kopp, R.J., Presser, S. and Ruud, P.A. 2003. Contingent valuation and lost passive use: Damages from the Exxon Valdez oil spill. Environmental and Resource Economics 25: 257–286.

Chen, W., Hong, H., Liu, Y., Zhang, L., Hou, X. and Raymond, M. 2004. Recreation demand and economic value: An application of travel cost method for Xiamen Island, China Economic Review 15(4) 398-406.

Drew, M., and Naylor, R. 1998. Policy options: Valuing mangrove resources in Kosrae, Micronesia. Environment and Development Economics, 3: 471-490.

Golder Associates. 1999. Integrated solid waste management plan. Consultancy report submitted to the Design Engineering Office, Bureau of Public Works, Republic of Palau.

Government of Palau. 2006. Tourism statistics. Palau Office of Planning and Statistics, Ministry of Finance. Accessed from the internet on 08 November 2006 at http://www.palaugov.net/stats.

Hajkowicz, S.A. and Okotai, P. 2006. An economic valuation of watershed management in Rarotonga, Cook Islands. IWP Technical Report no. 18. Apia, Samoa: Secretariat of the Pacific Regional Environment Programme.

Hollick, M, 1993. An introduction to project evaluation. Melbourne: Longman Cheshire.

Johannes, R.E., Squire, L., Graham, T., Sadovy, Y. and Renguul, H. 1999. Spawning aggregations of groupers (Serrenidae) in Palau. Marine Conservation Research Series, Publication #1, The Nature Conservancy.

Lal, P.N. 1990. Conservation or conversion of mangroves in Fiji—an ecological economic analysis. Environment and Policy Institute, East West Centre, Honolulu.

Lal, P.N. 2003. Economic valuation of mangroves and decision-making in the Pacific, Ocean and Coastal Management, 46: 823–844.

Lal, P.N. and Takau, L. 2006. Economic costs of waste in Tonga. IWP Technical Report no.33. Apia, Samoa: Secretariat of the Pacific Regional Environment Programme.

Maragos, J.E., Birkeland, C., Cook, C., Des Rochers, K., Di Rosa, R., Donaldson, T.J., Geermans, S.H., Guilbeaux, M., Hirsch, H., Honigman, L., Idechong, N., Lobel, P.S., Matthews, E., McDermid, K.J., Meier,K.Z., Myers, R., Otobed, D., Richmond, R.H., Smith, B. and Smith, R. 1994b. Marine and coastal areas survey of the Palau Islands:

Rapid ecological assessment synthesis report. Koror, Palau: Bureau of Resources and Development, Republic of Palau.

Maragos, J.E., Kelper, A.K., Hunter-Anderson, R.L., Donaldson, T.J., Geermans, S.J., McDermid, K.J., Idechong, N., Patris, S., Cook, C., Smith, B., Smith, R. and Meire, K.Z. 1994a. Synthesis report: Rapid ecological assessment of the southwest islands of Palau. Koror, Palau: Bureau of Resources and Development, Republic of Palau.

Metz, W.D. 2000. The Palau mangrove management plan, Volume 1, Ministry of Resources and Development, Republic of Palau, Koror, Palau.

Micronesia Water and Wastewater Training Program, 2005. Micronesia Water and Wastewater Training Program Website www.omip.org.

Ministry of Finance, 2003. Statistical yearbook 2002-03. Bureau of Budget and Planning the Ministry of Finance. Koror, Palau.

Ministry of Finance, 2004. Palau Tourism Economic Valuation Survey. Office of Planning and Statistics, Bureau of Budget and Planning, Ministry of Finance. Koror, Republic of Palau.

OERC [Office of Environmental Response and Coordination] and World Bank. 2004. Economic Value of Coastal Resources in Palau, Draft 2.0. Office of the President, Palau.

Pires, M. 2004. Watershed protection for a world city: the case of New York. Land Use Policy 21: 161–175.

Sakuma, B. 2004. Status of the Environment in the Republic of Palau. Koror, Palau: Palau Conservation Society.

Sengupta, S. and Osgood D.E.. 2003. The value of remoteness: a hedonic estimation of ranchette prices. Ecological Economics 44: 91–103.

Solid Waste Management Office. 2004. Waste Generation Rate Survey, Koror State Government, Koror, Palau.

The Environment Inc. 2003. Resource use study of Palau. Koror, Palau: The Environment Inc.

United Nations Development Program, 1999. Pacific Human Development Report 1999. Suva, Fiji: United Nations Development Programme.

Van Bueren M. and Bennett J. 2004. Towards the development of a transferable set of value estimates for environmental attributes. The Australian Journal of Agricultural and Resource Economics 48(1): 1-32.

Appendix A: Project aims and scope

Project aims

The objectives of this consultancy are:

1. To provide information for IWP Palau to highlight the importance of addressing waste through the IWP or other current or future initiatives (advocacy).
2. To assist in resource management and planning by (a) providing a context for the waste management activities conducted in Palau, especially (but not limited to) those activities conducted under the IWP; and (b) providing baseline values/descriptions for environmental activities conducted in countries.

Project scope

The consultant will work with a local individual ('facilitator') nominated and appointed by the Government of Palau to conduct an economic evaluation of IWP related waste in Palau. The consultant will guide the facilitator in tasks to be conducted and oversee work produced. Payments to the facilitator and the management of the facilitator's contract will be handled by the Government of Palau. The Government of Palau will appoint the facilitator prior to the commencement of the project.

In the process of conducting the work, the consultant is expected to liaise closely with individual institutions heavily involved in the IWP, particularly the IWP national coordinator for Palau and national task force as relevant.

A key outcome from this project will be the development of skills for the local facilitator.

The consultant will provide skills in environmental economics and policy analysis for this project. The consultant will not provide expertise in engineering or biophysical aspects of waste management or pollution. The study will rely on readily accessible data relating engineering and biophysical issues.

It may not be possible to make quantitative (e.g. dollar values) estimates of some or all economic impacts due to data unavailability. If it is not possible to make quantitative estimates qualitative assessments (e.g. textual descriptions) will be made instead. The final report is likely to contain a mix of qualitative and quantitative information.

Appendix B: Valuation techniques

This extract from a valuation study in the Cook Islands by Hajkowicz and Okotai (2006) describes alternative techniques to CSA, which have not been applied in this study.

Travel cost

This is a revealed preference technique. It involves determining people's expenditure incurred in travelling to a scenic location to enjoy its natural beauty. The use of travel cost is limited to environmental resources closely connected to eco-tourism or recreation. The key challenge with the travel cost technique is separating out the "environmental" component from a multi-purpose trip. One example of travel cost valuation comes from China (Chen et al., 2004). Here it was found that the recreational benefits of a beach on the eastern coast of Xiamen Island in China had a total value of USD 53 million.

Hedonic pricing

The hedonic pricing technique is a revealed preference method that attempts to discern the premium being paid for a commonly marketed good or service to attain some level of a related environmental service. For example, people may be willing to pay more for a property with access to natural areas or beautiful scenery. The price difference between the "environmentally superior" property and another property of equal size can be considered the cost of the environmental good.

Generally hedonic price models involve the construction of a regression equation, where price is the dependent variable and a set of environmental and other attributes are the independent variables. Using statistical analysis it may be possible to determine the marginal impact of an environmental variable on price. Whether such a relationship is found will depend partly on the availability and quality of data. Often the data required to obtain statistically valid estimates is unavailable.

Bastian et al. (2002) use hedonic pricing to analyse the increased prices of land with better/more wildlife habitat, angling opportunities and scenic vistas. Sengupta and Osgood (2003) used hedonic to find that ranch property values increased by USD 1,416 per acre for a one per cent improvement in a satellite greenness index.

Contingent valuation

The contingent valuation method (CVM) is a stated preference technique involving surveys of stakeholders and the general citizenry. In CVM surveys people are asked how much they would be willing to pay (WTP) for an environmental service or how much they would be willing to accept (WTA) in compensation for the loss of that service. As with other stated preference techniques CVM is used when the environmental good or service under question has no market, *i.e.* it is not bought or sold. The CVM technique attempts to create a hypothetical market, and guess the likely prices of environmental goods if they could be traded.

One famous example of CVM was a valuation of the economic impacts of the Exxon Valdese oil spill in Alaska in 1989. The researchers (Carson et al., 2003) estimated the aggregate loss of passive use of environmental resources at USD 4.87 billion.

Choice modelling

The choice modelling technique is a stated preference method with a similar aim to contingent valuation. It differs to contingent valuation by presenting the questions to survey respondents as a series of choices from which values can be inferred. A choice modelling survey presents survey respondents with a series of carefully designed choices about their willingness to accept different levels of environmental service at the cost of other factors. The value of the goods and services is inferred from the respondent's choices using statistical techniques. A

statistically significant result, *i.e.* one for which the data shows sufficiently strong relationships, is not always assured and will depend upon how people answer the questions. Choice modelling has been used by Van Bueren and Bennet (2004) to estimate the annual impact of water pollution, landscape aesthetics, species loss and social change to Australian households at A$29.72 per household.

Other methods

A range of other methods have been applied amidst the hundreds of valuation studies conducted worldwide. One example is the dose-response approach. This involves defining the relationship between environmental damage (response) and the cause of that damage (dose). A common example of dose-response methods is in the assessment of healthcare costs emerging from environmental pollution. In this case the dose is the environmental contaminant and the response is poorer health.

The difficulty with the dose-response approach is establishing a causal link between the environmental problem and people's healthcare needs. This link will depend on complex scientific principles and may require large amounts of specialised data to substantiate. Where the scientific models or data are unavailable it may be necessary to rely upon expert judgements, which adds an element of subjectivity.

Another approach can be described as the benefits-transfer method. This takes the results of a valuation study conducted in one location and transfers it to another. This is generally done because it is too expensive or impractical to conduct a valuation study in the area of interest. There are three ways of conducting benefit transfer (Barton, 2002):

- transfer of fixed values or unadjusted mean value estimates;
- value estimator models or benefit function transfer; and
- expert judgement methods.

Benefits transfer is a complex process and can easily produce large errors if incorrectly applied. Often it will not be applicable. This is because valuation results are typically highly context dependent. The results depend on the preferences of a particular population, the production techniques and technology, input prices (e.g. the cost of labour), characteristics of the physical environment and regional economic conditions. Often it will not be possible to accurately adjust for all these factors. Generally a tailored site and issue specific valuation will be required.

Appendix C: Summary table of valuation techniques

Type	Technique / Measure	Description	Data requirements	Sources of uncertainty	Examples
Cost savings and avoidance (CSA), market prices	Preventative and mitigatory expenditure (PME)	Cost of activities to prevent or reduce the negative impacts of environmental problems	Need to know additional expenditure required because of environmental service loss. Details of preventative and mitigatory activities (timing & inputs) and costs of those activities.	Not always clear how much expenditure is induced by an existing or potential environmental problem. There are many different ways to prevent or mitigate environmental damage. It may not be clear which ones to cost.	Spurgeon (1998) finds habitat & rehabilitation costs of USD 10,000 to 6.5 million/hectare for reefs; USD 3000-510,000/ha for mangroves; and USD 9000-680,000/ha for seagrasses and USD 2000-160,000/ha for salt marshes.
	Replacement cost (RC)	Cost of replicating environmental services with manufactured systems	Details on costs of the next best option to replace lost environmental service. Effectiveness of replacement. Capital and operating costs of replacement.	Difficult to know the extent to which the manufactured system replicates the environmental system. Hard to say what is the next best option as there often exist several alternatives.	Pires (2004) explores the value of replacing clean water supply services from the New York catchment with an extremely expensive water filtration system estimated at USD 6 billion in design and construction and $300 million in annual operating.
	Ameliorative expenditure (AE)	Cost of reducing the harmful impacts of environmental problems (*i.e.* treating the symptoms)	*Amount of ameliorative expenditure induced by environmental problem.* Industry and household response. Cost of actions & effectiveness of actions.	Unclear how much ameliorative expenditure occurs from the loss of an environmental service versus how much would occur anyway. Can require data on purchasing habits which is often difficult to obtain.	Abdalla et al. (1992) estimate the costs of purchasing bottled water, installing water purifiers and boiling water in Southern Pennsylvania, USA at USD 0.40 per household per week. The study is described in the NSW *Envalue* Database.
	Repair cost (RC)	Cost of repairing assets damaged by environmental problems	*Amount of asset damage occurring (where, when, which assets)* Repair activities & costs	Difficult to separate repair costs induced by environmental problems from routine maintenance. Sometimes hard to define point at which an asset has been fully "repaired".	Tol (1996) describes the numerous costs of repairing assets damaged directly or indirectly by global warming.

Type	Technique / Measure	Description	Data requirements	Sources of uncertainty	Examples
Revealed preference	Lost production (LP)	Decreased profits in primary industries due to lower crop/pasture yields, timber yields or fish harvests	Gross margin or profit function for primary industry (prices, current yields, variable costs, fixed costs) Increased yields or harvest without the environmental constraint	Relationships between environmental conditions and yields or harvests are complex and uncertain. Often requires maps on the location of environmental problems	Hajkowicz and Young (2002) use this approach to estimate the costs of lost crop/pasture yields from soil salinity, sodicity and acidity across Australia.
	Travel cost (TC)	Amount paid by tourists for the environmental component of their trip	Surveys of tourists obtaining information on costs and activities	Difficult to segregate the "environmental" component of a multi-purpose trip. If travel costs are taken from surveys people's estimates might be inaccurate. Large differences in costs between locals and overseas visitors.	Chen et al. (2004) estimate the value of a beach in Xiamen Island in China at USD 53 million using the travel cost method.
	Hedonic pricing (HP)	Premium paid for an environmental service that is connected to a marketed good	Prices for the proxy market good (dependent variable) Data on a set of environmental and non-environmental attributes impacting price (independent variables)	Hard to find a proxy market good for many non-market environmental goods. Often the statistical model will lack significance due to poor data.	Bastian et al. (2002) use hedonic pricing to value environmental amenities using land values in Wyoming in the United States.
Stated preference	Contingent valuation method (CVM)	Survey questions of willingness to pay (WTP) for environmental goods and willingness to accept (WTA) compensation for the loss of environmental goods.	Knowledge of people's understanding & perceptions of environmental goods Surveys of relevant persons	Based on a hypothetical market which introduces possibility of bias and/or inaccurate responses. Survey respondents may have little knowledge of the environmental good or service under question.	Carson et al. (2003) use CVM to estimate the cost of environmental damages resulting from the Exxon Valdez oil spill.

Type	Technique / Measure	Description	Data requirements	Sources of uncertainty	Examples
Other	Choice modelling (CM)	Infers the prices of environmental goods from peoples choices for "bundles" of goods in surveys.	Knowledge of people's understanding & perceptions of environmental goods Surveys of relevant persons	Based on a hypothetical market which introduces possibility of bias and/or inaccurate responses. Survey respondents may have little knowledge of the environmental good or service under question. Possible that results may lack statistical significance pending on survey responses.	Van Bueren and Bennet (2004) use choice modelling to estimate the annual impact of water pollution, landscape aesthetics, species loss and social change to Australian households at A$29.72 per household.
	Benefits transfer (BT)	Uses the results of other valuation studies in different locations.	Data from a related valuation study covering similar environmental issues Rules and procedures for adjusting the prices for the target study	Valuation estimates are highly context dependent (environment, preferences, input costs etc). Generally not possible to transfer prices.	Barton (2002) tests the reliability of benefits transfer methods in Costa Rica using a CVM study of water quality improvements. Finds no evidence to support the notion that benefits transfer is more reliable as proximity to original study decreases.
	Dose-response (DR)	Defines the "end of pipe" response to an event impacting on the environment. Then attempts to value that response.	Scientific models of the dose-response relationships (which require detailed environmental data) Data on human impact, e.g. health, infrastructure. Cost & value of that impact	Considerable uncertainties in the dose-response scientific relationships. Valuing the response may require the valuation techniques described above, thus introducing the same uncertainties.	Ostro et al. (1998) estimate the economic benefits of improving air quality by reducing ambient particulate matter in the United States at USD 14-$55 billion annually, with a mean estimate of $32 billion.

Appendix D: Persons consulted

Ministry of Health

1. Dr. Stevenson Kuartei
   Director, Bureau of Public Health
   Ministry of Health
2. Julie Erb Alvarez, MPH
   Epidemiologist, Bureau of Public Health
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3. Joanne M. Sengebau-Kingzio
   Chief, Division of Environmental Health
   Bureau of Public Health
4. Rosemary Kiep
   Vector Control Program Supervisor
   Division of Environmental Health, Bureau of Public Health
5. Biribo Tekanene
   Pharmacy Supervisor
   Bureau of Hospital and Clinical Services

Ministry of Resources and Development

1. Theo Isamu
   Director, Bureau of Marine Resources
   Ministry of Resources and Development
2. Calvin Ikesiil
   Manager, Solid Waste Management Office
   Bureau of Public Works, MRD

Koror State Government

1. John Ngiraked, Jr.
   Chief, Solid Waste Management Office
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2. Joyce Kyota
   Director of Finance
   Koror State Government

Palau Visitors Authority

1. Dorothy T. Ueda
   Administrative Assistant
   Palau Visitors Authority

The Environment, Inc

1. Ann Kitalong
   Biologist,
   The Environment, Inc.

Palau Conservation Society

1. Asap Bukurrow
   Marine Conservation Officer, PCS
2. Foober O. Skebong
   Community Conservation Coordinator, PCS
3. Kenneth Coonrad
   Peace Corps Volunteer-Marine Monitoring, PCS
4. Scottie Kiefer
   Education/Conservation Officer, PCS

Environmental Quality Protection Board

1. Portia K Franz
   Executive Officer
2. Jerome Sakurai
   Laboratory Supervisor

Palau International Coral Reef Center

1. Dr Mark Tupper
   Senior Scientist

Office of Environmental Response and Coordination

1. Andrew Bauman
   Chief, Marine Unit

Appendix E: Additional health cost data

These costs and impacts were estimated in consultation with pharmacist, doctor and epidemiologist from the Palau Ministry of Health.

Illnesses related to waste and pollution (all prices are in 2004 USD)

Diseases	Cases reported in 2004	Portion attributable to waste & pollution	Adjusted cases	Average cost per patient for pharmaceutical products	Average time off work	Average time in hospital (days)
Scrub typhus	5	30%	1.5	$32.00	15	5.0
Dengue fever	22	75%	16.5	$38.49	20	5.0
Leptospirosis	10	80%	8	$133.18	15	7.5
Gastroenteritis	709	10%	70.9	$288.00	3	2.0
Respiratory infections	2501	15%	375.2	$320.56	4	2.0

Notes regrading labour prices and working population: Imputed cost of labour = $2.88/hr or $23.04/day; number of working-age persons = 14,241

Appendix F: Local market prices for nearshore fish

The local market prices were obtained from the 2002–03 statistical year book by dividing market values by quantities for each state. They have been adjusted to 2004 prices from 2003 prices to account for inflation. Where a price for a state and fish type was unavailable, the average of other prices has been used. Prices are given in 2004 USD per kg.

State	Reef Fish	Tuna & Mackerel	Crabs	Lobsters
Palau	$3.06	$2.54	$11.19	$8.38
Aimeliik	$2.94	$3.01	$13.49	$8.63
Airai	$3.13	$3.01	$11.49	$8.91
Angaur	$2.31	$2.65	$11.30	$8.63
Kayangel	$2.54	$2.55	$11.30	$8.63
Koror	$3.15	$2.58	$11.51	$8.22
Melekeok	$2.87	$2.71	$11.30	$8.80
Ngatpang	$2.99	$3.03	$10.48	$8.63
Ngiwal	$3.01	$2.65	$12.07	$9.26
Ngarchelong	$2.93	$3.05	$11.75	$8.63
Ngaraard	$3.22	$2.65	$11.46	$9.26
Ngaremlengui	$2.53	$2.79	$9.62	$7.14
Ngchesar	$3.08	$1.87	$12.01	$8.63
Ngardmau	$3.15	$2.65	$11.23	$8.89
Peleliu	$2.47	$2.00	$9.26	$8.79
Unknown	$2.31	$2.65	$11.30	$8.63

Appendix G: Key input assumptions

Following is a listing of the key input assumptions used to generate the best estimate, low estimate and high estimates of solid waste pollution in Palau. These assumptions were developed in consultation with local experts in the fields of fisheries management, epidemiology, public health, waste management and tourism.

Variable	Best	Low	High
Discount rate	5%	3%	7%
Tourist arrivals lost	2%	0%	5%
Portion of avoidable waste	30%	20%	40%
Portion of mangrove loss attributable to waste dumping	50%	30%	60%
Value of mangrove land for timber habitat (1996 USD /year/ha)	533	426	640
Scrub typhus - percent caused by pollution	30%	10%	35%
Dengue - percent caused by pollution	75%	50%	90%
Leptospirosis - percent caused by pollution	80%	50%	90%
Gastroenteritis - percent caused by pollution	10%	7%	15%
Respiratory infections - percent caused by pollution	15%	5%	20%
Percent increase in fish catch without pollution - Aimeliik	15%	0%	30%
Percent increase in fish catch without pollution - Airai	30%	10%	50%
Percent increase in fish catch without pollution - Angaur	3%	0%	5%
Percent increase in fish catch without pollution - Kayangel	3%	0%	5%
Percent increase in fish catch without pollution - Koror	13%	5%	20%
Percent increase in fish catch without pollution - Melekeok	18%	0%	35%
Percent increase in fish catch without pollution - Ngaraard	10%	0%	20%
Percent increase in fish catch without pollution - Ngarchelong	3%	0%	5%
Percent increase in fish catch without pollution - Ngardmau	8%	0%	15%
Percent increase in fish catch without pollution - Ngaremlengui	10%	0%	20%
Percent increase in fish catch without pollution - Ngatpang	15%	0%	30%
Percent increase in fish catch without pollution - Ngchesar	15%	0%	30%
Percent increase in fish catch without pollution - Ngiwal	10%	0%	20%
Percent increase in fish catch without pollution - Peleliu	10%	0%	20%
Portion of vector control costs avoidable	13%	10%	15%
Portion of avoidable litter collection costs	30%	20%	40%

Appendix H: Environmental cost of a curbside trash can volume of waste

The average cost of a volume of waste equal to a typical curbside trash can in Palau was determined to assist with communication and awareness efforts. This was attained by dividing annual costs by total annual waste production in different categories. The trash can is assumed to contain 5 kg of waste.

Cost category	USD
Environmental health impacts	0.92
Potential lost tourism income	0.93
Waste collection and disposal	0.44
Damage to fish habitats and mangroves	0.06
Recyclable material lost to landfill	0.01
Total	2.36

This is based on the "best estimate" cost scenario and involves some adjustments to the main results given in this report:

- The entire amount of disposal costs for Palau (USD 338,043) are used, and not just the avoidable portion. This is because all waste in the "trash can" must be disposed of. Litter collection costs are not included.
- Damage to fish habitats also results from sedimentation due to construction activities. Only 50% of the cost impact is assigned to the trash can waste volume, thereby excluding sedimentation from these estimates.
- Tourism loss also results from sedimentation of diving and snorkelling locations. This is less because most dive and snorkel sites are in the Rock Islands. The main impact on tourism is visual disturbance and odour. Therefore, 75% of the tourism cost is assigned to the trash can.

Appendix I: Questions for tourism survey

These questions have been proposed for inclusion in the Palau Visitors Authority survey of departing tourists to test the impact the quality of the natural environment (and what aspects of the environment) has on visitor experiences.

Q1. How important is the quality of Palau's natural environment (corals, landscapes *etc*.) to your decision whether to return?

Very important	Important	Not sure	Unimportant	Irrelevant
1	2	3	4	5

Q2. Please indicate whether you found any of the following environmental issues to be a problem TO YOU during your visit?

	Not a problem ⟷				A big problem
Coral damage	1	2	3	4	5
Poor marine visibility (e.g.muddiness / murky water)	1	2	3	4	5
Water pollution	1	2	3	4	5
Traffic	1	2	3	4	5
Tree / mangrove damage	1	2	3	4	5
Noise	1	2	3	4	5
Overcrowding and natural sites (e.g. dive site)	1	2	3	4	5
Waste dumps sites (for garbage disposal)	1	2	3	4	5
Air pollution (smog)	1	2	3	4	5
Rubbish and litter	1	2	3	4	5
Other (please say what):	1	2	3	4	5
Other (please say what):	1	2	3	4	5

Q3. Would any of these issues (see Q2) make you not want to come back?

Please circle: Yes Maybe No

If 'yes' or 'maybe', which one(s)?

Q4. Which, if any, of the above environmental problems do you think should attract the most government resources to improve things? (say if don't know)

_____

Q5. Overall were you satisfied with the natural environmental quality (corals, landscapes etc.) of Palau?

Very poor	poor	Acceptable	Good	Outstanding
1	2	3	4	5