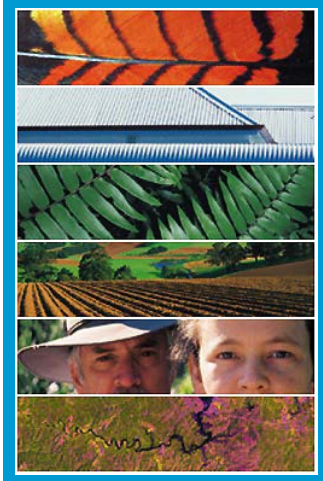

Economic Cost Scenarios for Solid Waste Related Pollution in Palau

Stefan Hajkowicz, Kyonori Tellames and Joseph Aitaro

DRAFT REPORT

OERC

SPREP

International Waters Programme

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About the Study and Report Authors

This study was funded under the International Waters Program (IWP) of Palau. The study was jointly managed by the Government of Palau with input from the South Pacific Regional Environment Program (SPREP). The project team included Stefan Hajkowicz, Kyonori Tellames and Joseph Aitaro. Stefan Hajkowicz is a policy analyst with CSIRO Sustainable Ecosystems based in Brisbane, Australia. CSIRO is the Australian Commonwealth Scientific and Industrial Research Organisation. Kyonori Tellames is a Planning Analyst with the Office of Planning and Statistics, Ministry of Finance. Joseph Aitaro is the national coordinator of the International Waters Program in Palau and works within the Office of Environmental Response and Coordination.

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Data Uncertainties

Whilst this report makes use of the best attainable data and information results are based on informed assumptions and rough estimates. This is due to data unavailability and a lack of documented scientific and socio-economic 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.

Legal Disclaimer

REPORT SUMMARY

About This Study

Palau is renowned for its pristine natural environment which supports tourism, fishing and extractive industries and the lifestyles of 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 three economic cost scenarios are presented: best estimate; low estimate and high estimate. The cost of waste related pollution to Palau is estimated between US$0.8 to US$3.5 million per year. The best estimate is US$1.9 million per year which is 1.6% of gross domestic product and imposes annual costs of US$0.51 per household. A breakdown of the costs is below.

	('000 US dollars per year)		
Cost categories	Best Estimate	Low Estimate	High Estimate
Healthcare and illness costs	697	669	745
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**	**803**	**3,501**
As percentage of GDP	**1.6%**	**0.7%**	**2.9%**
Cost per household	**0.51**	**0.22**	**0.95**

The best estimate is particularly sensitive to two assumptions made in consultation with experts. Firstly, the number of tourists lost to Palau due to waste related pollution is assumed at 2% of tourist arrivals in 2004 which equates to 1,961 tourists. Secondly, 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 tonnes 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.

Policy Relevance

The economic estimates presented in this report 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) 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 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.

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 underpinning science and datasets are improved. However, policy makers cannot wait for a '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.

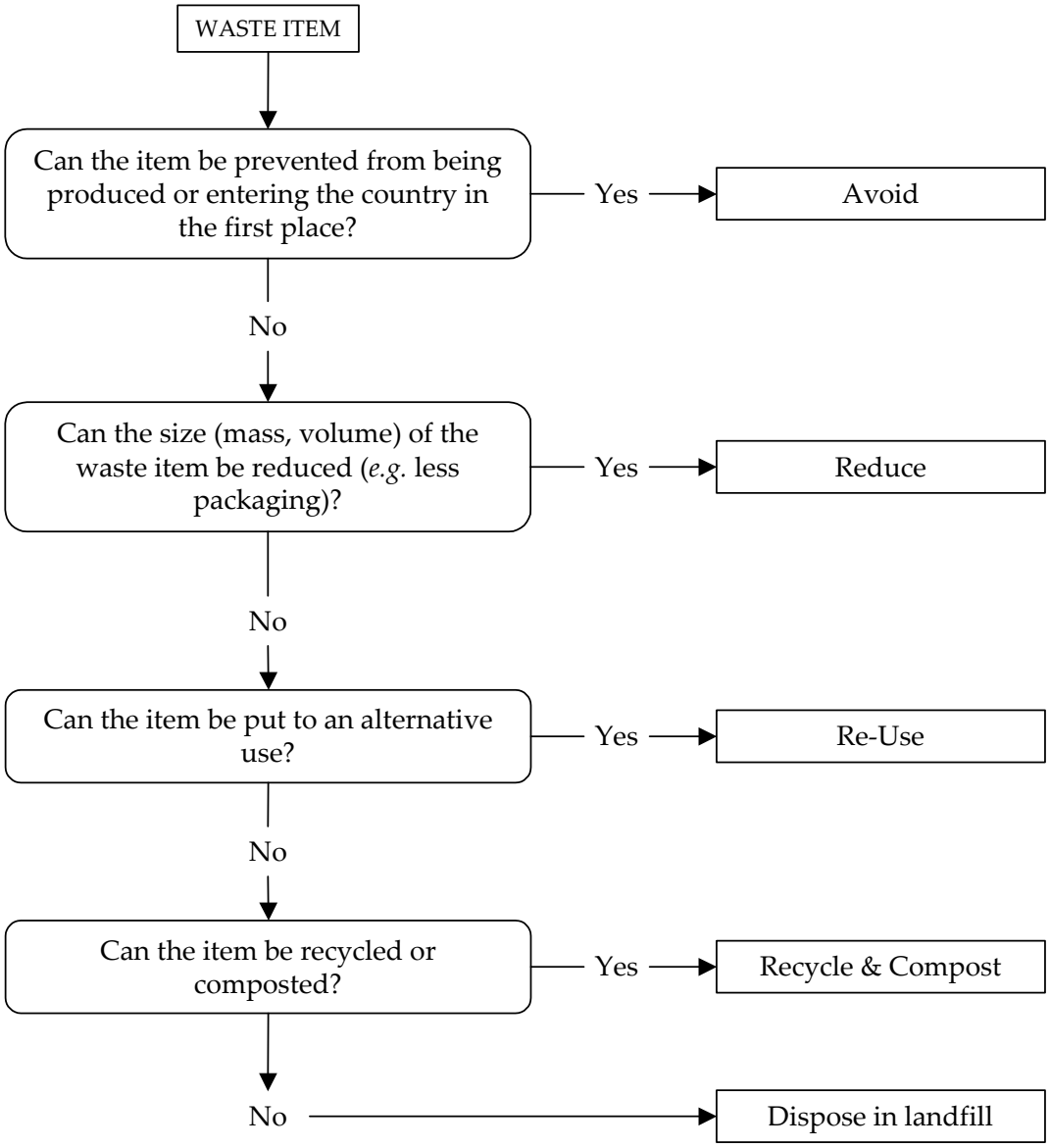
Non Financial Impacts

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, nevertheless, be given consideration alongside the financial impacts listed above in policy formulation and decision making. It is possible the non-financial impacts are 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 amenity (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.



RECCOMENDATIONS

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. Explore options 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 kerbside at collection times would reduce these problems. Improved systems need to be identified, then subject to some type of benefit cost assessment.
3. 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.

4. 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. Some inappropriate dumping practices may result from lack of knowledge about improved methods and consequences to the terrestrial and marine environment. The community requires practical and easy to understand guidance on how to better manage (and avoid) waste.
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 (glass, plastics, paper, steel, car bodies *etc*.) 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 or 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 on impact of pollution and potential over harvesting 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.

REPORT CONTENTS

GLOSSARY

Glossary of Terms[1]

Ameliorative Expenditure	Costs of reducing the harmful impacts of environmental problems, *i.e.* treating the symptoms. Purchasing bottled water is an example of 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 once 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 whether 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. These can also be referred to as gross benefits.
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 whilst the patient recovers.

[1] Some of the terms and acronyms here are extracted from Hajkowicz and Okotai (2005).

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 less 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.

Glossary of Acronyms

BCA	Benefit cost analysis
CM	Choice modelling
CPI	Cost Price Index
CSA	Cost savings and avoidance
CVM	Contingent valuation method
GDP	Gross Domestic Product
HDI	Human development index
HIS	Health Information System (database)
ISWMP	Integrated Solid Waste Management Plan
IWP	International Waters Project
NPV	Net present value
OERC	Office of Environmental Response and Coordination
SPREP	South Pacific Regional Environment Program
TEVS	Tourism Economic Valuation Survey
UNDP	United Nations Development Program
WTA	Willingness to accept
WTP	Willingness to pay

1 INTRODUCTION

Palau is renowned for its pristine natural environment (Figure 1) which attracts over eighty thousand tourists per year and supplies Palauan residents with clean water, clean air, recreational opportunities and stunning coastal landscape 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 opportunity cost of solid waste related pollution to Palau. Opportunity cost 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 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 is based on the cost savings and avoidance (CSA) approach. This measures damage costs and defensive expenditure that would be avoided in the absence of pollution. The CSA approach is based on market goods

only and, therefore, excludes non-market goods such as biodiversity and cultural assets. These important issues still need consideration and should be handled within policy formulation and decision making processes via other means.

Another consideration with CSA (as applied in this study) is that it provides a gross, as opposed to net, cost estimate. Any pollution remediation activities will come at a cost and are unlikely to be entirely effective. Only some part of the CSA estimate will be recoverable. 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.

When consideration is given to these caveats a CSA valuation can be an extremely effective policy tool and it has growing application in the Pacific region. The reasons for conducting this valuation are:

1. To raise awareness of the hitherto hidden costs of solid waste pollution to Palau.
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) on 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 quick 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 WHAT IS SOLID WASTE POLLUTION?

Solid waste can be defined as any physical 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 inextricably 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. Whilst 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.

3 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, 2005); Fiji (Lal, 1990) and Hawaii (Cantrell *et al.*, 2004). Another valuation study is currently underway in Tonga[2]. 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 (PICRC) 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; page 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, 2005). 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 NZ$ 3.2 - 17 million per annum with a best estimate of $7.4 million per annum. Damage cost categories include: healthcare and illness costs (diarrhoea, gastro enteritis, dengue fever & 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

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

US$/ha/yr for forestry benefits; 100 US$/ha/yr for fishery benefits and; 2600 US$/ha/yr for nutrient filtering involving human waste treatment. A study by Cantrell *et al.* (2004) based on contingent valuation (see Appendix C) assessed people's willingness to pay for environmental services. It was found that people's net willingness to pay for the current average catch rate of 3.8 fish per trip is US$ 7.95.

These, and other such studies, provide information on the economic value of natural resources and the potential gross benefits of remediation. They are highlighting hitherto unseen costs and thereby enabling more informed policy decisions.

4 ENVIRONMENTAL VALUATION METHOD

4.1 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[3]:

1. *Cost savings and avoidance.* This technique estimate the defensive expenditure and damage costs through market goods and services following a change in environmental condition (see section 4.2).
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 provide a 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.

[3] The description of techniques is extracted from Hajkowicz and Okotai (2005).

4.2 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 a gross, as opposed to net, cost estimates. As such it does not inform decision makers about the economic efficiency of remediation options. For this 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. Whilst 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.

4.3 The 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 fish 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 islands states. As an alternative to valuation Lal (2003) 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. However, used within appropriate bounds valuation is a powerful and informative policy tool. Valuation will continue help inform policy makers and unlock difficult questions of natural resource management.

4.4 Handling of Time in This Study

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).

5 BACKGROUND ENVIRONMENTAL AND SOCIAL ISSUES IN PALAU

5.1 Society, Economy and Physical Geography

The 2000 Census recorded Palau's (Figure 3) population at 19,129 persons with a growth rate of 2.1% per annum. Palau is a relatively wealthy nation within the Pacific region. The United Nations Development Program's (UNDP) Pacific Human

Development Report for 1999 gives Palau the highest human development index (HDI)[4] and highest per capita income (US$8,027) within the region (UNDP, 1999)[5]. Palau has relatively low unemployment at 2% in urban areas and 7% in rural areas. The UNDP (1999) 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; 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).

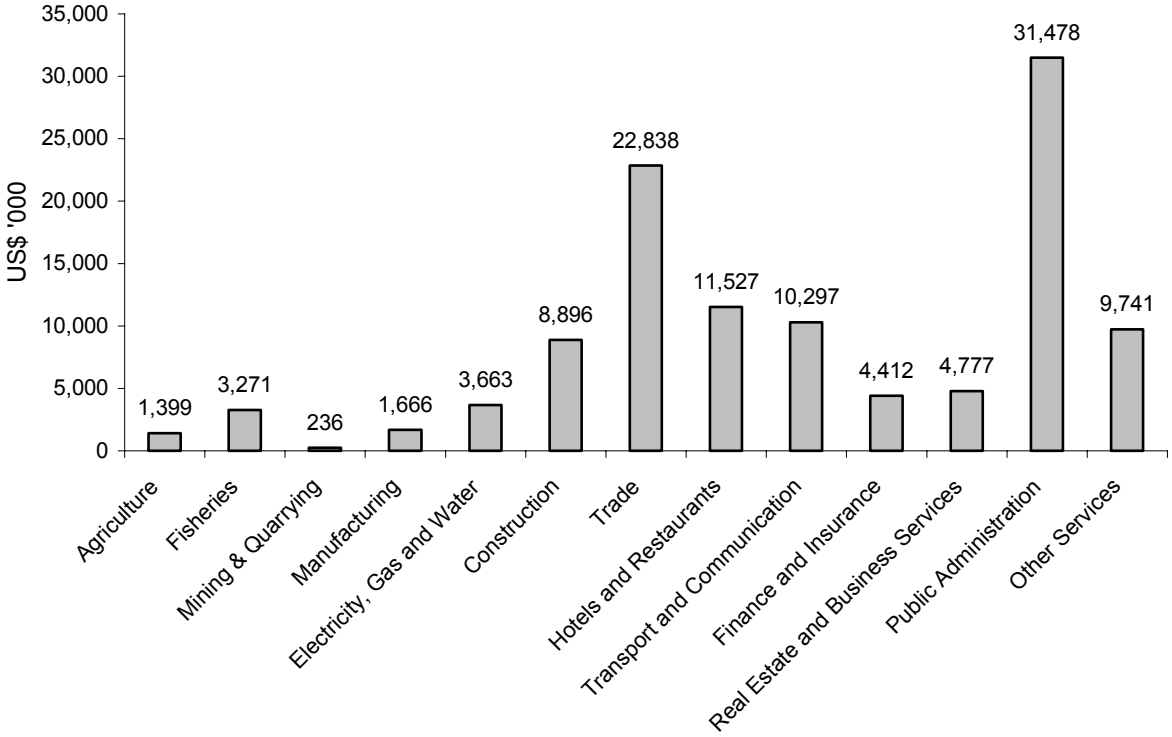


Figure 2 Palau's gross domestic product by industry sector in 2003

Palau is made up of 586 islands 10 of which are inhabited. It has a total land area of around 500 square kilometres. Around 80% of the land area is forested and the remaining 20% is covered by grasslands, croplands or urban development. Around

[4] 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.

[5] 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.

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 then restaurants and hotels. The majority of government revenues comes from taxation followed by the Compact of Free Association (COFA) funds.

The majority of Palauan people obtain their drinking water from rain supplies. The 2000 Palau Census (Ministry of Finance, 2003) found that residents obtain drinking water as follows[6]:

- 55% from rain supplies (*e.g.* rainwater tanks)
- 13% from public mains supply
- 10% from bottled water
- 3% from a mix of rain and bottled water

The mains water supply treatment and sewage treatment systems of Palau are described by The Micronesia Water and Wastewater Training Program[7]. 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.

The economic impact of watershed pollution through mains supply (*e.g.* health impacts, water filtration costs) is not covered in this report. This is for three reasons. Firstly, it is unclear whether watershed pollution in Babeldaob is significantly deteriorating mains supply water quality. Secondly, there is already a water filtration plant in place designed to remove sediments and bacteria prior to water entering the mains supply. Lastly, most of Palau's drinking water supply is from rainwater tanks which are unaffected by watershed pollution (but may be affected by drainpipes, gutters and tanks).

Although it has not been included here the economic impact of watershed pollution in Babeldaob may warrant further investigation.

[6] The remaining 19% is not stated.

[7] The website of the Micronesia Water and Wastewater Training Program is www.omip.org. Information on Palau's water and wastewater treatment plants is provided at this web address.

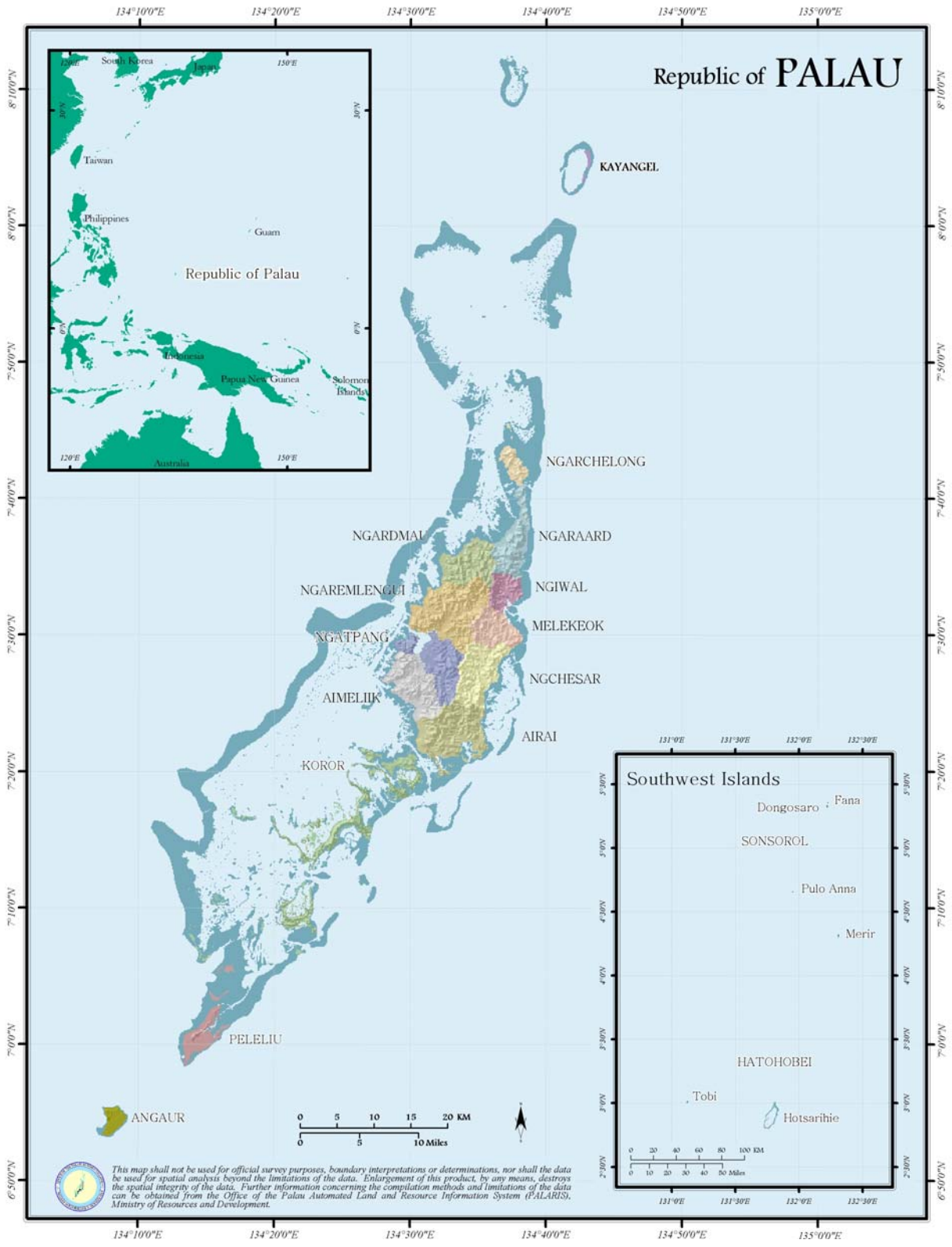


Figure 3 Location and map of The Republic of Palau (Source: Ministry of Resources and Development, Republic of Palau)

5.2 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 that could be avoided, reduced, re-used, recycled or composted leading to higher public waste disposal costs and the loss of potentially recyclable materials.
- Leachate run-off from waste dump sites causing damage to nearshore marine habitats which 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 run-off including sediments, fertilisers, pesticides and waste effluent.

6 THE COSTS OF SOLID WASTE AND WATER POLLUTION TO PALAU

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.

6.1 Healthcare and illness costs

Consultations with doctors and epidemiologists from the Palau Ministry of Health, Bureau of Public Health, revealed that the diseases of 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). Part of the healthcare and lost labour productivity costs of these illnesses are included in the results for this study.

The potential impact of waste run-off through fish poisoning (ciguatera) was considered, but was not included because few cases are reported[8]. In 2004 there were zero 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 Typhus	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 run-off 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 dump fire in Koror of September 2004 (Figure 4).

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

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.

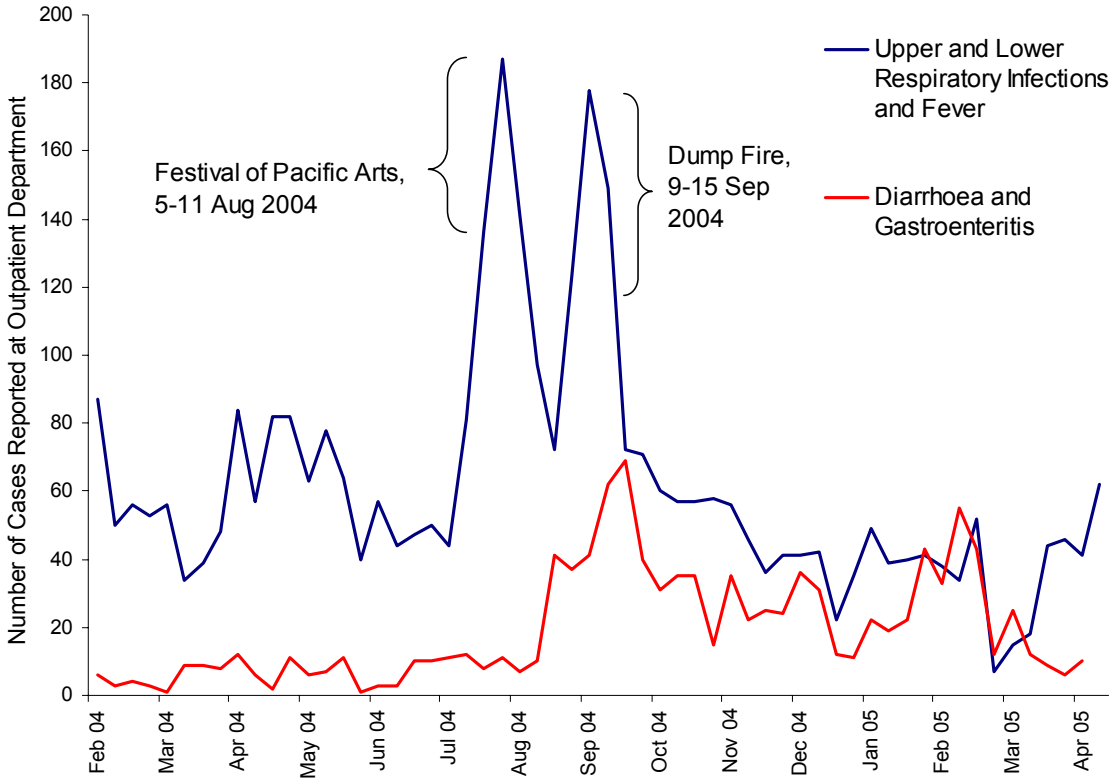


Figure 4 Increased respiratory infection, diarrhoea and gastroenteritis cases during the Koror national landfill dump fire in September 2004 (Source: Palau Ministry of Health, Public Health Epidemiology March 2005 – From Health Information System Data).

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: "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 US.

Table 2 Reported cases for waste related illnesses in Palau

Illness	2000	2001	2002	2003	2004	Percent of 2004 cases avoidable with effective waste management[2]
Scrub typhus[3]	MD[1]	MD	MD	MD	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. MD is missing 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 ('US$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

6.2 Avoidable public waste disposal

Even with highly effective waste management strategies involving avoidance, recycling, composting and reuse there will clearly be some amount of waste put into landfill in Palau. This cost estimate covers only that portion which 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 stages were involved in estimating the annual cost of disposing 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). 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 kilograms per person per day in Koror assessed in a 2004 survey by the State Government (Solid Waste Management Office, 2004)[9].
2. Non-domestic waste generation by hotels, restaurants, bars and retailers of 1,948 tonnes for Palau based on data reported by Golder Associates (1999). It is assumed that with 70% of Palau's population Koror produces 1,354 tonnes 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. Multiplying the populations by waste generation rates and adding non-domestic waste generation yields annual waste generation for Koror of 2,695 tonnes and for Palau of 3,875 tonnes[10].
4. Annual costs of rubbish collection with garbage trucks including operating (US$24,000), labour (US$49,000) and capital upgrades (US$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 US$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 US$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 US$87 per tonne. This gives total annual costs of waste disposal for Palau of US$338,000. Given

[9] The 1999 Integrated Solid Waste Management Plan (Golder Associates, 1999) estimates per capita waste generation for Palau residents at 1 kg per person per 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 at 0.25 kg per person per day. The Koror State Government survey results have been used in this study as they are more up to date and are based on a survey of Palau (as opposed to extrapolation from other countries).

[10] The per capita waste generation for Palau is assumed equal to the per capita waste generation of Koror which contains 70% of Palau's population.

that 30% is avoidable the national value of avoidable costs from waste generation is estimated at US$101,000 per annum.

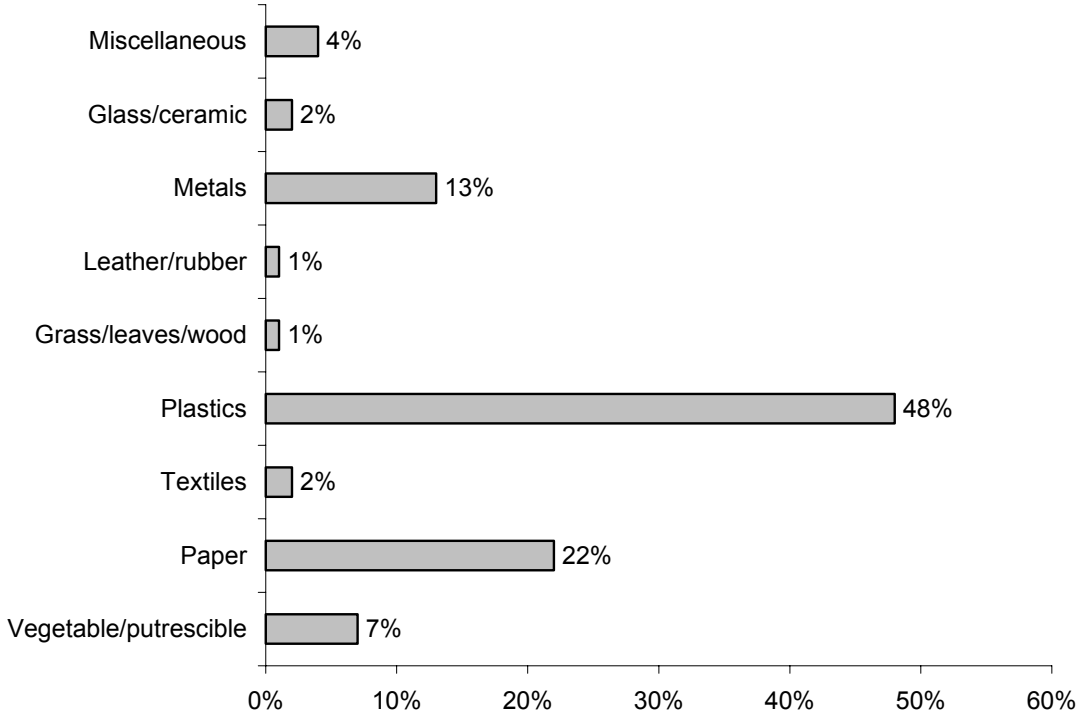


Figure 5 Waste stream for Koror, Palau (source: Solid Waste Management Office of Koror State Government)

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

Item	Cost (US$/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%.

6.3 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 of around 12 litter wardens by the Koror State Government. The annual salary costs for these personnel in 2004 was US$75,075. It is assumed that 30% of these costs would be avoidable with effective waste management. This is the same level of waste entering landfill that could be prevented considered feasible by waste management staff (Section 6.2). This results in avoidable costs of litter collection of US$22,522.

6.4 Environmental Health Vector Control (Mosquito 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 till 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 US$17,000 .

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

Item	Cost US$ per year
Salary (4FTE & 1 PTE)	72,634
Equipment	
ULV Sprayers (US$8,000 x 2)	16,000
Vehicle upgrades	2,364
Supplies Mosquito Larvacides (Altosid) Pesticides/Insecticides (Mortein, Cislin) Rodenticides (Hawk) Dengue test kits Leptospirosis test kits Mosquito traps Rat traps Hand-held sprayers Backpack sprayers	28,329
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

6.5 Loss of nearshore fish catch

Palau's nearshore fisheries provide for a catch of reef fish, lobsters, crabs and in some years trochus. These fish are both consumed on a subsistence basis and sold at market. Records on the market value and total catch of these fish are available from 1999 to 2003 (Ministry of Finance, 2003).

Whilst Palau's fisheries are considered to be sustainable and healthy (The Environment Inc, 2003), it is believed that populations and harvests per unit of fishing effort for some species are in decline in some locations. 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:

- In the 2003 Resource Use Study of Palau it is stated 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" (The Environment Inc, 2003; p15).
- 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; p63).
- A comparison of the total reef yield over two five year periods (1992-1996) and (1997-2001) shows a decrease of 38 metric tonnes 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. 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. They do not include the loss of fish resources from overfishing – only 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 populated States). In these two States a 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 terrestrial sourced pollution. Koror and Airai have the highest populations in Palau with more development (roads, residential 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 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 US$3.06/kg for reef fish, US$11.19/kg for crabs, and US$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 US$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 (US$/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 further exploration to determine whether the above estimates are realistic. There is potential for a very large economic impact of pollution through fisheries damage. The estimates given in this report provide only very rough approximations of the loss in fish value resulting from terrestrial pollution.

6.6 Mangrove timber loss

Palau has a total mangrove habitat area of 4,700 hectares (Metz, 2000). Some solid waste dumps in Palau occur on or near mangrove habitats. This can damage the mangrove habitat either by pollutant run-off or direct clearance. Two main economic impacts result from mangrove habitat damage, namely the loss of fish catch and the

loss of mangrove timber. The economic impact on nearshore fisheries is covered in section 6.5. This section considers the loss of timber value.

Data on the area of mangrove loss is only available for a few states (Table 8). However, those states for which data are available are also the most heavily populated with the higher development pressure. 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 it is assumed that 50% of mangrove loss results from solid waste dumps and pollution.

Table 8 Mangrove loss in Palau[1]

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

1. Data Source: The Environment Inc (2003) Resource Use Study

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

From these data the lost value of mangrove timber can be estimated in the vicinity of US$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.* revising the area of mangroves destroyed higher or increasing the timber value) the loss of mangrove timber value resulting from solid waste is a minor cost impact.

6.7 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 included.

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 the Federated States of Micronesia. This study assumes that 4.2% of the waste entering all dumps in Palau is aluminium which equates to roughly 163 tonnes (based on current waste generation estimates).

The local market price for aluminium scrap metal, paid by the recycling company to local collectors, is US$0.05 per kilogram. 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 US$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, however a market in Palau for these scrap products was no identified. The absence of such markets is most likely due to the high costs of shipping.

6.8 Lost tourism income

Records for visitor and tourist arrivals are available for Palau from 1998 to 2004 (Figure 6) from the Office of Planning and Statistics, Ministry of Finance[11]. 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. The is an expectation that tourist arrivals will continue to increase, however there is much uncertainty. Palau's tourism industry is sensitive to global issues such as terrorism, diseases epidemics and natural disasters.

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

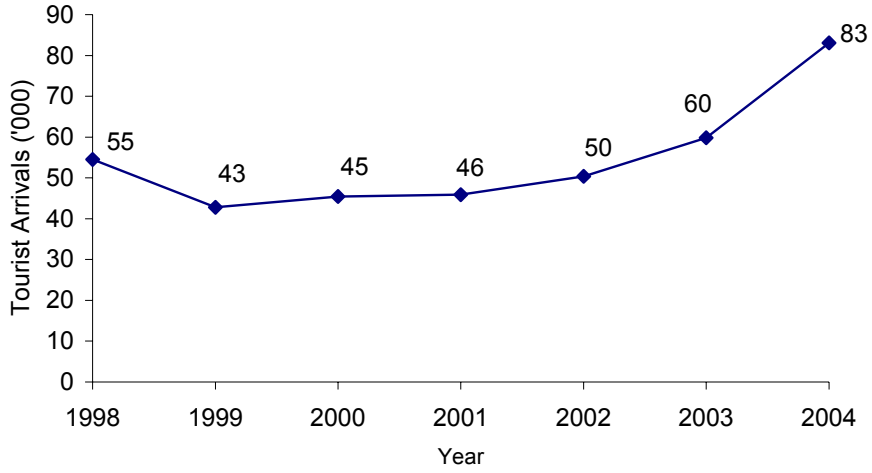


Figure 6 Tourist arrivals (Data source: Ministry of Finance, Office of Planning and Statistics)

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) provides estimates of 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).

The question of how many additional tourists choose another destination over Palau due to concerns about environmental quality, in particular solid waste and water pollution, is difficult to answer. Tourist choices are driven by many factors of which environmental quality is but one. There does not exist a readily available dataset or survey result that provides a definitive answer. Rather estimates of the percentage loss are 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.

Whilst 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 high levels of satisfaction with the quality of snorkelling and dive sites. This is partly because the dive sites are mostly located 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. Whilst 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 an additional 2.0% of tourist arrivals would be possible in the absence of solid waste related pollution in Koror and Airai States. The low and high estimates are 0.0% and 5.0%. Therefore, the low estimate removes the tourism impact altogether. Even though these represent small percentage variations the cost impacts are significant. For 2004 the best estimate is a gross value of US$1,902,000 for lost tourism income.

Table 9 Tourist value lost if an additional 2% of visits were possible without pollution

Home Country	Value added to Palau per visit (US$/visitor)	Number of tourist arrivals 2004	Total value added (US$000 per year)	Additional tourists in absence of pollution	Lost opportunity (US$000 per year)
United States	911	4,794	4,367	96	87

Japan	698	23,411	16,341	468	327
Europe	889	1,199	1,066	24	21
Taiwan	154	38,175	5,879	764	118
Other	670	30,450	20,402	609	408
Totals		98,029	48,055	1,961	961

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.

6.9 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

	('000 US dollars per year)		
Cost categories	Best Estimate	Low Estimate	High Estimate
Healthcare and illness costs	697	669	745
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**	**803**	**3,501**
As percentage of GDP	**1.6%**	**0.7%**	**2.9%**
Cost per household	**0.51**	**0.22**	**0.95**

The cost of waste related pollution to Palau is estimated between US$0.8 to US$3.5 million per year. The best estimate is US$1.9 million per year which is 1.6% of gross domestic product and imposes annual costs of US$0.51 per household.

The best estimate is particularly sensitive to two assumptions made in consultation with experts. Firstly, the number of tourists lost to Palau due to waste related pollution is assumed at 2% of tourist arrivals in 2004 which equates to 1,961 tourists. Secondly, 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 tonnes 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.

7 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 alongside the financial impacts listed above in policy formulation and decision making. Some of the main non financial impacts of pollution in Palau include:

- The loss or damage to biodiversity.
- Loss of recreational amenity (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.

8 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 US$38 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, 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) 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.

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 more waste is avoided, reduced, re-used or recycled (in that order) rather than disposed into landfill.

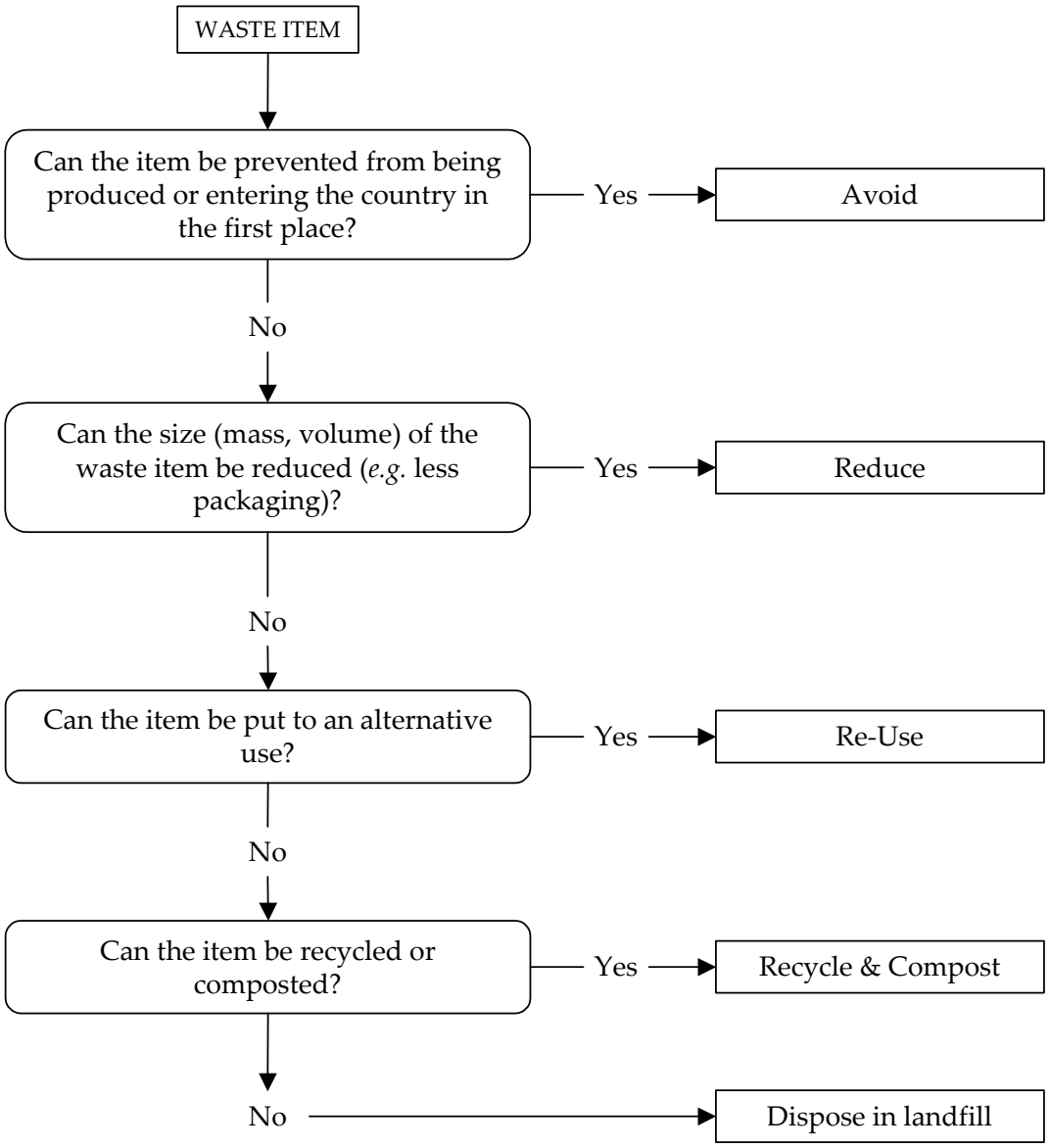


Figure 8 The waste avoidance, reduce, re-use, recycle and dispose decision hierarchy

Policy levers such as taxation incentives, disincentives, subsidies, education and awareness may be used to increase waste avoidance, reduce, re-use, recycling and composting. However, there will continue to be a requirement for 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 underpinning science and datasets are improved. However, policy makers cannot wait for a '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.

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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: THE INTERNATIONAL WATERS PROGRAM

The International Waters Project (IWP) is funded by the Global Environment Facility and executed by the South Pacific Regional Environment Programme (SPREP) in partnership with 14 Pacific Island countries. The objective of the project is to help participating countries improve the management of their environment and coastal resources. The IWP will attempt to do this by supporting 'pilot' projects in each participating country. These pilot projects will assist countries (communities and governments) to identify and address the "root causes" of environmental degradation and to design and implement possible solutions at the local and national level. Community based activities may include low tech solutions to addressing environmental degradation while national level activities may involve activities that have a broader or more strategic focus.

Under the IWP in Palau, a pilot project has been established to address *waste*. The 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 the IWP in Palau including community awareness meetings.

The next stage in supporting the IWP is to conduct an economic evaluation of IWP related waste in Palau.

APPENDIX C: VALUATION TECHNIQUES

This is an extract from a valuation study in the Cook Islands by Hajkowicz and Okotai (2005). Alternative techniques to CSA which have not been applied in this study are described as follows.

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 US$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 US1,416 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 US$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 D: SUMMARY TABLE OF VALUATION TECHNIQUES

This is an extract from Hajkowicz and Okotai (2005).

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 US$ 10,000 to 6.5 million/hectare for reefs; US$ 3000-510,000/ha for mangroves; and US$ 9000-680,000/ha for seagrasses and US$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 US$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 US$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.
	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.
Revealed preference	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 US$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.
	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.
Other	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 US$14-$55 billion annually, with a mean estimate of $32 billion.

Note: References are listed in Section 9.

APPENDIX E: PERSONS CONSULTED

Ministry of Health

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   Ministry of Health

2. Julie Erb Alvarez, MPH
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3. Joanne M. Sengebau-Kingzio
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4. Rosemary Kiep
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Ministry of Resources and Development

1. Theo Isamu
   Director, Bureau of Marine Resources
   Ministry of Resources and Development

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   Bureau of Public Works, MRD

Koror State Government

1. John Ngiraked, Jr.

   Chief, Solid Waste Management Office

   Bureau of Public Works, KSG

2. Joyce Kyota

   Director of Finance

   Koror State Government

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The Environment, Inc

1. Ann Kitalong
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1. Asap Bukurrow
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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 F: ADDITIONAL HEALTH COST DATA

These costs and impacts were estimated in consultation with pharmacist, doctor and epidemiologist from the Palau Ministry of Health. All prices are in 2004 US dollars.

Illnesses related to waste and pollution

Diseases	Cases reported in 2004	Portion attributable to waste & pollution	Adjusted cases
Scrub typhus	5	30%	1.5
Dengue fever	22	75%	16.5
Leptospirosis	10	80%	8
Gastroenteritis	709	10%	70.9
Respiratory infections	2501	15%	375.2

Pharmaceutical treatments

Pharmaceutical products	Average Cost Per Patient
Scrub typhus	$32.00
Dengue fever	$38.49
Leptospirosis	$133.18
Gastroenteritis	$288.00
Respiratory infections	$320.56

Time away from work and hospital accommodation

Diseases	Average time-off work (days)	Average time in hospital (days)
Scrub typhus	15	5.0
Dengue	20	5.0
Leptospirosis	15	7.5
Gastroenteritis	3	2.0
Respiratory infections	4	2.0

Hospital accommodation cost (US$/day)	$500

Labour prices and working population

Labour cost	$/hr	$/day
Imputed cost of labour	2.88	23.04
Number of working-age persons	14,241	

APPENDIX G: 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 US$ per kilogram.

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 fish catch decline (kg/fisherman/year) due to pollution	50%	25%	85%
Portion of mangrove loss attributable to waste dumping	50%	30%	60%
Value of mangrove land for timber habitat (1996 US$/year/hectare)	533	426	640
Scrub typhus - percent caused by pollutuion	30%	10%	35%
Dengue - percent caused by pollutuion	75%	50%	90%
Leptospirosis - percent caused by pollutuion	80%	50%	90%
Gastroenteritis - percent caused by pollutuion	10%	7%	15%
Respiratory infections - percent caused by pollutuion	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 KERBSIDE TRASH CAN

An average cost of a typical kerbside 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 kilograms of waste.

Cost category	$US
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 of US$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', thereby excluding sedimentation from these estimates.
- Tourism loss also results from sedimentation of diving and snorkelling locations. This is less because most dive/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