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Economic costs of waste in Tonga

By Padma Lal and Lilieta Takau

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Acronyms

AusAID	Australian Agency for International Development
BCA	benefit–cost analysis
CSIRO	Commonwealth Scientific and Research Organisation (CSIRO)
CVM	Contingent valuation method
GEF	Global Environment Facility
ICWM	integrated coastal and watershed management
IWP	International Waters Project
MOH	Ministry of Health
NZAID	New Zealand Agency for International Development
SPREP	Secretariat of the Pacific Regional Environment Programme
SWMP	Solid Waste Management Project
TWSMP	Tonga Solid Waste Management Project
t	tonne
WSSD	World Summit on Sustainable Development
WTP	willingness to pay

Glossary

benefit–cost analysis	An economic analysis that compares an activity's benefits and costs over time, used to help decide if a project is worthwhile. Benefit–cost analysis can be useful when choosing between alternative options by comparing the net costs and cost ratios of each option.
best, high and low estimates	Results of sensitivity analysis are provided as best, high and low estimates when a number of parameters are varied at the same time. Best estimate is based on the set of parameter estimates judged to be the most realistic. Low and high estimates reflect varying key parameter values within the set range of values.
discount rate	The rate at which people discount earnings in the future. It also reflects people's preferences for goods and money now and in the future.
gross benefit	The measure of benefits, such as gross revenue, which does not reflect the cost associated with that activity. Gross benefit of improvement in waste management, for example, is the total benefit that people can expect from improvement. It does not include considerations of costs involved in improving waste management.
imputed cost	A cost estimate determined (imputed) when market price for the item does not exist. For example, the imputed value of loss in productivity caused by a person not working due to illness is equal to the wage foregone.
net benefit	The net value of the benefit of carrying out an activity. For example, the net benefit of improvement in waste management is equal to the benefit from improvements in waste management minus the cost of management-related activities.
present value	The value of a stream of future benefits (or costs) estimated using a discount rate and a mathematical formula.
primary data	Information and data directly collected by researchers, using techniques such as household surveys, waste audits and water quality tests.
proxy value	An estimate of a cost or benefit measure derived from indirect methods when a market does not exist for the good or service.
secondary data	Data derived from information supplied by other researchers, from published and unpublished government reports and or other sources.
sensitivity analysis	Sensitivity analysis involves repeating an analysis using different parameter values. It is carried out when there is a

	level of uncertainty associated with the information available. Each parameter value may be varied in turn and the analysis repeated, or the analysis may be carried out by varying a combination of parameters at the same time.
with-and-without analysis	A method used in benefit cost analysis to determine key values of direct and indirect effects associated with an activity. It allows the analyst to take into account changes that may have taken place in the absence of the activity. This is in contrast to before-and-after analysis, in which the with-project benefit and cost are compared with the before-project benefit and cost.

Acknowledgements

Many people in Tonga and the Secretariat of the Pacific Regional Environment Programme (SPREP) made it possible to complete this study. We wish to thank Sione Faka'osi, the Tonga International Waters Project Coordinator, whose dedication to the project and to the role of economic analysis in decision making made our work a lot easier to conduct and complete. The assistance provided by the director, deputy director and staff of the Department of Environment is also very much appreciated. Many government officials (listed in appendix 3) helped us to access unpublished information and data and patiently answered many questions. The Tongan households we interviewed were very helpful and their cooperation was critical. The staff from the AusAID-sponsored Solid Waste Management Project — Penny Dutton and John Gildea in particular — were most helpful to the project team. They also co-financed the waste audit survey and the household economic survey. We wish to thank Ms Rashmi Rita of the Fiji Land Information System, who helped design the Microsoft Access-based survey data forms and assisted with the data analysis. Review comments from Mark Rickett of SPREP and Stefan Hajkowicz of the Commonwealth Scientific and Research Organisation (CSIRO) are also much appreciated. Last, but not least, the staff of the International Waters Project Coordination Unit at SPREP (Drew Wright, Natasha Stacey and Paula Holland) deserve a special mention for their vision and their effort in trying to integrate the three pillars of sustainable development. While this has not always been easy, this economic project is a testament to their success in explicitly including economic considerations in their environmental projects. Thank you all.

Executive summary

The International Waters Project (IWP) aims to strengthen the management and conservation of marine, coastal and freshwater resources in the Pacific Islands region. It is financed through the International Waters Programme of the Global Environment Facility, implemented by the United Nations Development Programme, and executed by the Secretariat of the Pacific Regional Environment Programme (SPREP), in conjunction with the governments of the 14 participating independent Pacific Island countries.

Waste management is a major concern in Tonga. Waste is broadly divided into four key categories: solid waste, liquid waste (comprising human and animal waste), agrochemical waste and other waste. Each causes significant human health and/or environmental effects. Key concerns associated with solid and liquid waste include:

The impact of solid and liquid waste on human health, environment, fisheries and tourism is a major concern in Tonga.

- Mosquito-borne diseases such as dengue. With poor disposal solid waste becomes a breeding ground for mosquitoes, and dengue outbreaks are common.
- Water-borne diseases such as diarrhea, dysentery and other gastrointestinal illnesses and skin diseases caused by drinking water contaminated by human and animal waste.
- Environmental effects of increased nutrients in coastal waters and groundwater.
- Aesthetic effects of litter and indiscriminate dumping of solid waste in drains and waterways, and on public and unoccupied private land.

In response to the impact of solid waste on human health and the environment, the Tongan Government, with the help of the Australian Government, is developing a solid waste management facility on Tongatapu. To pay for the cost of running the new facility, the government is considering a user-pays system.

Economic impact costs of waste can be powerful information for advocacy and informed decisions.

To help the government better communicate the need for improved waste management to local and national decision makers, this project was commissioned by SPREP as part of the IWP in Tonga. The objectives of the economic analysis of waste in Tonga are to:

- estimate the economic cost of human health and environmental effects of the current level of solid and liquid waste management for Tongatapu, including the cost of any preventative measures taken by residents;
- estimate Tongan household willingness to pay (WTP) for an improved solid waste management system proposed by the Tonga-Australian Agency for International Development (AusAID) Solid Waste Management Project (SWMP); and
- compare the economic cost of solid waste pollution with the proposed average user fees under the SWMP (expected to open in October 2005 on Tongatapu).

Methodology

A with-and-without benefit–cost analytical framework is used to determine the economic costs. Waste is generated by humans as a byproduct of their consumption of goods and, because of their sheer existence, the gross benefits are the same whether waste is managed or not. The economic costs of waste are defined as the direct and indirect costs associated with waste management that could be avoided if better management services were provided. The economic costs of waste would depend, therefore, on the level and effectiveness of waste

management currently in place, and (i) the direct causal relationship between waste and impacts on human health and environmental and aesthetic values, (ii) indirect impacts on local fisheries and tourism, (iii) the value of foregone earnings of recyclable material sent to the rubbish dump, and (iv) the wider impact on the local economy. These costs may be borne by individuals or the government. A with-and- without benefit–cost analysis (BCA) in this situation is effectively an analysis of with-and-without costs associated with improvement in waste management.

This study estimates the effects on the Tongan economy of the following costs associated with solid and liquid waste:

- private health costs
- household preventative costs
- economic cost of human life
- health and preventative government costs
- cost to fisheries
- cost to tourism
- loss in foregone recycling earning
- foregone earnings from organic matter not composted
- aesthetic value of a clean environment.

A with-and-without benefit–cost analysis is the appropriate analytical method for estimating economic costs of poor waste management…

The gross estimate of potential direct savings Tonga can make — or losses that the country can avoid — with improved management is determined in this analysis. Market-based production and market pricing methods and non-market-based contingent valuation methods are used to estimate economic costs. A mixed methodology is used to collect relevant primary and secondary data, together with a stratified sample-based household survey. The results of the Tongatapu survey are extrapolated to apply to the country as a whole.

The estimates provided here are for gross estimates of potential savings Tonga can make, or losses that the country can avoid, with improved management. These gross cost estimates do not consider other costs, such as the economic cost of suffering, some ecological costs, or costs that may be expected in the delivery of management to improve the waste situation in Tonga.

Status of waste management

A Tongan household produces an average of one tonne of solid waste per year.

Management of solid and liquid waste is costing Tongans an estimated TOP 6.5 million per year. These are direct and indirect economic costs associated with residual wastes, given the current status of solid and liquid waste management in Tonga.

Solid waste

The household survey conducted in this study suggests that each Tongan household produces about a tonne (t) of solid waste per year. Extrapolating this to apply to the country as a whole, 16,194 rural and urban households produce about 16,400 t of waste per year, of which Tongatapu residents would account for 67%, or 11,000 t of solid waste. Of these wastes, garden and organic kitchen waste comprise about 65%, followed by diapers and recyclable materials such as beer bottles, aluminium cans, metals and polyethylene terephthalate (PET) bottles. Urban households produce about the same average volume of waste — 19 kilograms per week — as those in rural areas, although their waste differs in composition.

Individual households primarily undertake solid waste management with limited government- and private sector-organised collection and disposal services. Government-organised solid

waste collection is restricted to Nuku'alofa, Tongatapu and Neiafu, Vava'u. The weekly fee ranges from TOP 5 — or TOP 30 per month levied by the Ministry of Health (MOH) for a 'regular' collection — to a fee of TOP 8 per bin collection, charged by the private sector for ad hoc collection on demand.

Reuse, recycling and composting

Some reuse of solid waste and recycling for cash is currently practised. About 18% of households recycle items such as Royal Beer and other bottles, aluminum cans, aluminum and copper. The median income earned by households engaged in recycling is about TOP 10 per month per household — or TOP 120 per yea — while the average income reported is TOP 240. Villagers vary significantly in the level of recycling they conduct, and the level of income they earn. The range of income earned by those involved in recycling is from TOP 10–900 per household. In this study, a conservative estimate of the value of recycling is uses the median value of TOP 120 per household per year.

Eighteen per cent of Tongatapu residents recycle for cash, with median household earnings from recycling of about TOP 120 per year.

Composting

Sixty-five per cent of household waste can be composted, although only a few households appear to do this. Composting practices that are commonly conducted include throwing food cuttings and peelings from root crops, grass clippings and other greenery onto vegetable and flower garden beds. Very little conscious composting of organic matter occurs in Tonga, perhaps because there is lack of know-how about composting. The economic value of composted material could not be determined, however, because there is no market for it, nor was it possible to determine a proxy value.

Sixty-five per cent of household waste, or 12 kilograms per week, could be composted.

Human and animal waste

Human and animal waste are major environmental concerns. Tonga does not have a central reticulated human waste system and thus relies on household-based human waste management. Over three quarters of the households use septic tanks for human waste disposal, whereas a further 10% use flush pits and only 7% use traditional pit toilets. Poor maintenance of septic tanks (and in a few cases, poor design) results in significant groundwater contamination.

Animal waste is also a major source of pollution in Tonga. Given the importance of pigs in the Tongan culture, the average Tongatapu household owns between three and 14 pigs. With an average of five pigs per household, Tongatapu is estimated to have about 90,000 pigs. Most of these pigs are allowed to roam free despite a legislative regulation requiring that pigs be kept in pens. Households "manage" animal waste to a limited extent. Animal waste is either swept into a rubbish heap or dumped in nearby bush. It is still left open to the elements, however, and during rainy weather organic matter and bacteria enter the groundwater.

Human and animal waste are significant sources of groundwater contamination.

Residual effect of solid and liquid waste

Solid and liquid waste have a significant impact on human health as well as on the environment. It is the aesthetic effects of solid and liquid waste that cause the most concern to locals, although almost 50% of households reported suffering from waste-related illnesses such as diarrhoea and other gastrointestinal illnesses, dengue fever and skin infections. The aesthetic

effects of solid waste along the roadside and coastal beaches were also noted by tourists as an issue in a recent tourist exit survey, with some indication that the level of solid waste could discourage some tourists from returning to Tonga. Moreover, as a result of limited recycling of items such as beer bottles, aluminium cans and metal, the life of landfill sites is reduced. Leachate from solid waste dumps, along with human and animal waste, are important sources of organic matter and have high levels of nitrates and phosphates, causing eutrophication of coastal waters. Environmental outcomes of eutrophication include a decrease in biological diversity, impacts to coastal fisheries, and a decline in water quality.

Residual effects of poor waste management include human health effects, preventative measures by households and government, potential loss in recycling income, loss in fisheries and tourist earnings, and environmental aesthetic value.

The economic cost of pollution from solid and liquid waste

Tonga's total waste-related economic costs is estimated to be at least TOP 5.6 million per year (see Table A; see Figure A for distribution by category). The average cost per household borne by the government and individual households for waste-related impacts is estimated to be TOP 340 per year. This estimate reflects only the direct and indirect costs associated with human health and the opportunity cost of preventative measures taken by private households, government expenditure associated with the treatment of waste-related illnesses, loss in fisheries and tourism earnings, and the economic value of loss in amenity due to littering. A large part of the economic cost is borne by private individuals.

Economic cost of waste is about TOP 5.6 million a year, or about TOP 340 per household per year.

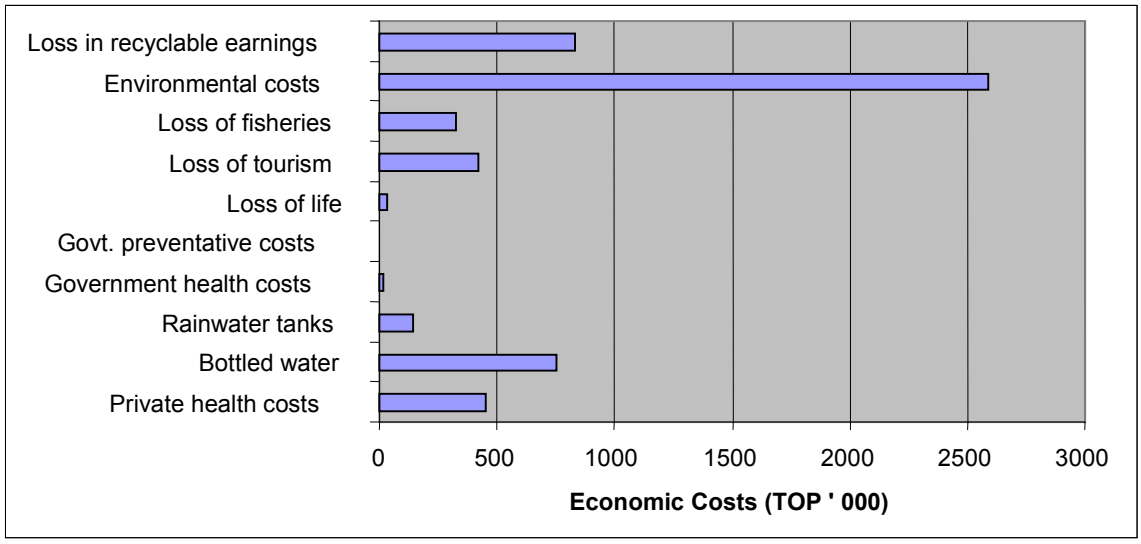

Figure A: Distribution of economic cost by category

The loss in environmental value is the most important economic loss. This is followed by the potential foregone earnings from recyclable products, and then the cost of bottled water (see Fig. A). Environmental costs reflect the economic value Tongan households place on a litter-free environment.

If key assumptions are varied, the total economic cost to the Tongan economy could be as high as TOP 8.6 million or as low as TOP 3.1 million. The cost per household per year could vary from as low as TOP 190–530. On the other hand, actual out of pocket financial costs to households vary from TOP 600,000 to TOP 2.9 million, in addition to the foregone earning of between TOP 400,000 to TOP 1.6 million from not recycling marketable waste.

The direct and indirect economic costs associated with solid waste alone (that is, excluding the

effects of liquid waste of human and animal origin) is estimated to be TOP 4 million per year (i.e. TOP 250 per household per year, or TOP 5 per week). Changing key assumptions, solid waste-related costs alone could range from TOP 2.3 million to TOP 5.5 million (i.e. TOP 140–340 per household per year, or TOP 2.80–6.50 per week). These figures (at least the lower estimates) are comparable to the expected cost-recovery charges under the Tongan-AusAID SWMP.

Table A: Cost associated with solid and liquid waste in Tonga in 2005 (figures in TOP)

	High	Best	Low
Private health	811,176	454,344	115,851
Bottled water	1,098,711	749,898	374,949
Rainwater tanks	898,767	143,803	143,803
Government health	18,683	18,683	18,683
Government prevention	5,000	5,000	5,000
Loss of life	46,313	29,736	13,158
Loss of tourism	845,000	422,500	169,000
Loss of fisheries	406,250	325,000	162,500
Environmental	2,778,890	2,585,210	1,684,176
Loss in recycling earnings	1,664,338	832,169	416,084
Total	**8,573,127**	**5,566,343**	**3,103,205**
Average household costs	**529**	**344**	**192**

Key assumptions

High cost scenario: 100% of bottled water, 100% of rainwater tanks, 75% of dengue cases, and loss in civil servant labour productivity; all deaths involve civil servants; tourism assumed at a 15% decline; fisheries assumed at 10%; 100% of households recycle; all recyclable items (glass, aluminium, metals) are recycled.

Low cost scenario: 50% of bottled water, 16% of rainwater, 25% of dengue, loss in labour productivity from suffered by labourers only, tourism loss at 2%; fisheries loss at 4%; additional 25% of households practise recycling.

Best scenario: 50% of bottled water, 16% of rainwater tanks, 50% of dengue cases, one in four days loss in labour productivity; deaths involve both loss in productivity by equal proportion of civil servants and labourers; tourism assumed at 5% decline; fisheries assumed at 4%; additional 50% households recycled.

Economic costs of waste, household willingness to pay for improved solid waste management and the expected average user fee under the Tongan Solid Waste Management Project

With the support of AusAID, the Tongan SWMP Team has designed a solid waste collection and disposal system for Tongatapu. This is expected to cost TOP 1.8 million–2.2 million (SWMP Team, pers. comm., June 2005). This translates into a weekly fee of TOP 3.20–3.60 per household. This is within most households' estimated WTP value for improved management of waste. The average WTP for improved waste management is TOP 3.10, with most households (95%) willing to pay between TOP 2.80 and TOP 3.30 per week for improved solid waste management. The average WTP is, however, lower than the average economic costs associated with solid waste — TOP 2.80–6.80 per week — including the economic loss in aesthetic value.

If households practised recycling and earned an average recycling income of TOP 120 per year, with the introduction of the user fees for the collection and disposal of the solid waste, they would have a net financial cost of TOP 30 per year. If the economic value associated with a litter-free environment was to be taken into account, however, with the introduction of user

fees for regular waste collection at approximately TOP 3 per week, Tongan households could expect to have a net economic gain of about TOP 100 per year, or close to TOP 2 per week.

Tongans could thus not only benefit from improved waste management with reduced health effects and human suffering and less waste going to landfill, but they could also enjoy an aesthetically pleasing and clean environment that is free of litter. Each household could also contribute to the sustainable development of their nation by reducing, reusing and recycling solid waste, and disposing of only those wastes that are non-recyclable and non-reusable.

Concluding remarks

Tonga could make economic savings of approximately TOP 6.5 million through improved solid and liquid waste management nationwide. The estimates are based on some key assumptions about functional relationships between the nature and volume of waste and human health effects, waste and the coastal ecosystem and fisheries, as well as the effects of waste on tourism and the aesthetic value residents place on a clean environment. Given the paucity of scientific information, there is an urgent need to collect solid scientific information about the causal relationship between waste and its direct and indirect effects on fisheries, coastal ecosystems and human health. Despite this limitation, the economic values presented in this study can serve as a powerful advocacy tool to better target education and extension programs that advocate for reduction, reuse, and recycling of waste.

The results suggest that the Tongan Government could introduce a regular user pays collection and disposal system for solid waste, such as the one proposed under the Tongan–AUSAID SWMP. Even with the proposed level of user charges, households can not only avoid significant health costs and minimise expenditure on preventative measures, but they could even be economically better off if they engage in recycling for cash. Improved waste management could result in a win–win outcome for all: private households, the government and the country as a whole.

1 Introduction

The International Waters Project (IWP)[1] is a 7-year, USD 12 million initiative concerned with management and conservation of marine, coastal and freshwater resources in the Pacific islands region, and is specifically intended to address the root causes of environmental degradation related to trans-boundary issues in the Pacific. The project includes two components: an Integrated Coastal and Watershed Management (ICWM) component, and an Oceanic Fisheries Management component (the latter has been managed as a separate project). It is financed by the Global Environment Facility (GEF) under its International Waters Programme. The ICWM component is implemented by the United Nations Development Programme (UNDP) and executed by the Secretariat of the Pacific Regional Environment Programme (SPREP), in conjunction with the governments of the 14 independent Pacific Island countries: Cook Islands, Federated States of Micronesia, Fiji, Kiribati, Marshall Islands, Nauru, Niue, Palau, Papua New Guinea, Samoa, Solomon Islands, Tonga, Tuvalu and Vanuatu. The ICWM component focuses on integrated coastal watershed management, and supports national and community-level actions that address priority environmental concerns relating to marine and fresh water quality, habitat modification and degradation and unsustainable use of living marine resources through a 7-year phase of pilot activities, which started in 2000 and will conclude at the end of 2006.

The theme and location of each pilot project was selected on the basis of community and government consultation. Each project is expected to have adopted an interdisciplinary approach involving the three pillars — economic, social and environmental — of sustainable development. Each project is intended to address the root causes of degradation affecting one or more of four focal areas:

1. marine protected areas
2. coastal fisheries
3. freshwater resources
4. waste reduction.

1.1 Background—Tongan International Waters Project

The degradation of marine and fresh water quality has been identified as the main trans-boundary priority environmental concern for Tonga, and the most important source of concern is waste (Prescott 2006). All recent reviews of environmental issues in Tonga identified waste as a major concern (e.g. the Action Strategy for Managing the Environment; the 1997 Tonga Submission to IWP; and the Tonga National Assessment Report for the World Summit on Sustainable Development in 2000).

Waste is broadly divided into four key categories — solid waste, liquid waste (comprising human and animal waste), agrochemical waste and other waste — each with significant human health and/or environmental effects. Key concerns associated with solid and liquid waste include:

- mosquito-borne diseases such as dengue and filariasis. If poorly disposed of solid waste can become a breeding ground for mosquitoes, resulting in dengue fever outbreaks;
- the aesthetic effects of litter and indiscriminate dumping of solid waste in drains, waterways, on public and unoccupied private lands;
- water-borne diseases such as diarrhoea, dysentery and other gastrointestinal illnesses and

[1] IWP is formally titled Implementation of the Strategic Action Programme of the Pacific Small Islands Developing States.

skin diseases caused by drinking contaminated water; and

- environmental effects of increased nutrients in coastal waters and groundwater.

Past studies have highlighted several reasons for poor waste management in Tonga and identified a variety of actions, strategies and approaches that might be needed to address them (see appendix B). The root causes of these impacts are diverse and context-specific, requiring different management strategies at local and or national levels (SPREP 2002).

Under the IWP, Tonga adopted a two-pronged pilot project aimed at addressing waste management. The project aims to address issues at the local and national levels, targeting individual behavioural issues in order to minimise waste generation and encourage the reuse, recycling and sustainable disposal of residual waste. A particular focus is on root causes, including the lack of awareness of the waste problem, and the lack of knowledge of basic waste management issues (e.g. recycling, composting, reuse and safe disposal of solid and human waste).

At the local level, IWP uses a pilot project site, Nukuhutulu village, to demonstrate how waste problems could be addressed in an integrated manner. The IWP activities promoted at Nukuhutulu include community awareness, waste stream analysis, participatory problem analysis and the identification of local solutions. Among the community-based initiatives implemented are activities that promote the "three Rs": reduce, reuse and recycle. Community-based activities include composting of human waste, composting of organic garden and kitchen waste, and other locally suitable initiatives.[2]

Activities undertaken at both the local and national level by the Tongan IWP project include public education through radio and television programs, and community-based workshops on TOP ics such as composting. In addition, the project has analysed the economic issues surrounding waste management in Tonga, including making an assessment of the economic cost of the current waste situation. Together, the information should help underpin the government decision to develop and implement appropriate household and national waste management strategies. IWP has adopted this approach because individuals and governments tend to better respond to a situation when they understand that substantial financial costs result from taking no action.

The Tongan Government has decided to establish, with the help of the Australian Government, a solid waste management facility on island of Tongatapu. This is being supported through the Tonga-Australian Agency for International Development (AusAID) Solid Waste Management Project (SWMP), whose main purpose is to establish an environmentally sound and sustainable solid waste management system for Tongatapu. The project is based on the principles of solid waste collection, reduction and disposal of solid waste. A core component of the system is a regular waste collection and disposal system covering urban and rural households and business sector. While the funding options have not been identified, the waste collection and disposal service is expected to operate on a full cost recovery basis, with an average user charge levied on households and business communities. Information about economic costs currently borne by individuals and their willingness to pay (WTP) to have a clean environment is expected to help the government develop a charging policy for the Tongatapu solid waste management facility.

[2] Based on the lessons learned, a community-based national waste management strategy could be developed for the Tongan government, but this has not yet been identified as a possible way to extend the pilot project results beyond that community.

1.2 Objectives

The objectives of the economic study are to:

- increase awareness of the economic cost associated with solid and liquid waste impacts on human health and the environment, and borne by the people and the Government of Tonga;
- inform the Government of Tonga how much Tongan households may be willing to pay to have an environment free of litter, and the level of budgetary support that may be required;
- provide appropriate information to help mount an advocacy campaign to increase participation in the regular solid waste collection system and recycling of solid waste; and
- build local capacity in economic analysis.

1.3 Why do economic analysis?

Economic considerations play a major role in human decision making. When people have limited resources — including money, time, land or human resources — they are forced to compromise by using resources for one purpose rather than another; for example, governments may choose between spending money on waste management or on funding human health services. Similarly, where groundwater is polluted, individuals may decide that it is preferable to take preventive actions and buy bottled water rather than take the chance of getting sick.

Although such trade-offs may be implicitly made at the individual level, governments and communities can make more informed decisions by explicitly taking into account the benefits and costs that different options have on human wellbeing. For instance, when confronted with the problems resulting from waste, the Tongan Government may compare the benefits of improving waste management with the costs of introducing a new management system.

Benefit–cost analysis (BCA) can be used to support this form of decision making. BCA involves estimating and comparing gross economic benefits and costs associated with an activity. If the total benefit is greater than the total cost—that is, if the net benefit is greater than zero—then the activity is considered to be at least economically desirable because the society would be better off as a result of that activity. BCA may also be helpful when considering whether households or governments should invest in, or participate in, the new waste management activities rather than doing nothing. (For a discussion on the role of economics in resource and environmental management in the Pacific see Lal 1990; Orams 1999; Lal 2003; and Hajkowicz and Okotai 2006).

1.4 The scope of the study

The scope of this economic analysis is to:

- estimate the economic cost of human health and environmental effects of the current level of solid and liquid waste management for Tongatapu, including the cost of any preventative measures taken by residents;
- estimate Tongan household willingness to pay (WTP) for an improved solid waste management system proposed by the Tonga- AusAID SWMP; and
- compare the economic cost of solid waste pollution with the proposed average user fees under the SWMP (expected to open in October 2005 on Tongatapu).

The results of the Tongatapu case study are then extrapolated for the whole of Tonga. Details of the terms of reference of the study are provided in Appendix B.

2 Methodology

A number of steps were followed to determine the economic cost associated with the current level of waste management. First, the volume and nature of waste generated by rural and urban households was determined. Second, information about the direct link between household solid and liquid waste and their environmental and human health effects was obtained. Third, the costs associated with each direct and indirect effect were estimated, before determining the yearly aggregate and per household financial and economic costs of waste. Fourth, the household WTP for improved waste management was determined before comparing this with the average cost per household proposed under the TSWMP. Tongatapu was used as a case study and the results were extrapolated to cover the country as a whole.

A mixed methodology was used to collect relevant data required to determine the status of the waste problem in Tongatapu, and the impact of waste on human health and the environment. The methodology was also used to estimate the financial and economic costs associated with the current level of waste management in Tongatapu, and the household WTP for a clean environment through an improved waste management system.

2.1 Household survey

A household survey was conducted to obtain information on:

- socio-economic characteristics;
- the level and types of solid waste generated and recycled, and the disposal methods used;
- liquid (human and animal) waste generated and liquid waste disposal methods used;
- sources of drinking water, treatment (if any) and costs involved;
- incidences of waste-related water and vector-borne diseases in the family; and
- costs associated with avoiding diseases and the treatment of those affected.

The primary source of the household information was a survey of a stratified sample of urban and rural households using a pre-tested questionnaire. The questionnaire was designed in English and then translated into Tongan (see Appendix D) to obtain quantitative and qualitative information, including household WTP for improvements in waste management (discussed further in section 4).

Two villages were selected: one from urban and rural areas and one from dry and flooded areas. In each village, every fourth household was selected for interviews, giving a 25% sample. The recall method was relied on to obtain information from communities, together with a household waste audit. The detailed household survey, including the waste audit, was conducted in June 2005.

Household waste audit

A household waste audit was carried out to determine the difference in the volume and nature of solid waste generated by rural and urban households. Sixty-one households were selected: 40 rural and 21 urban (these households were selected from six villages chosen for the detailed household survey discussed below). Each household was given 50-liter plastic garbage bags to store all of their household rubbish for a week. At the end of the week, the bags were collected and the waste was weighed. Waste was then sorted into different categories, and each category of waste was weighed to determine the amount of different types of waste generated. The waste audit analysis was based on "waste audit methodology" (SWMP 2004).

2.2 Water quality

The extent of groundwater pollution was unclear, and detailed water quality data for each of the villages surveyed could not be accessed by the Tonga Water Board or the Ministry of Health. As a result, a sub-sample of households from those surveyed in the larger household survey was selected for water quality assessment to determine if there was any difference in the quality of groundwater between areas subject to flooding and the areas that remained dry during rainy periods.

The water assessment was carried out in six villages: two each from Nuku'alofa (central), Hanake (east) and Hihifo (west). Samples were also taken from Nukuhutulu (the IWP pilot site) and Hoi, where the SWMP team is carrying out trial collections.

Sampling was initially proposed for a dry period and during or immediately after heavy rains. This is because groundwater quality is expected to become heavily polluted after major rainfall, when runoff contributes to an increase in water pollution and increased leakage of septic tanks. For logistical reasons, however, dry weather samples could not be obtained.

Water samples were collected from three sources at each household:

1. raw groundwater
2. treated piped water
3. cement tank.

Table 1 Water assessment villages

District	Dry	Flood
Nuku'alofa (central)	Fasi	Halaovave
Hahake (east)	Nakolo Nukuhetulu	Ha'ateiho
	Hoi	
Hihifo (west)	Fo'ui	Kanokupolu
	Nukuhutulu	

Duplicate samples were collected for each of the sites and sent to the Tonga Water Board for testing within 24 hours of collection. Standard water sampling techniques were used to collect, fix and store water. The water samples were tested for coliform and *E. coli* contamination using the standard filtration method.

2.3 Secondary data

The primary data collected through the above surveys was supplemented with the use of secondary information obtained from a review of published and unpublished literature on waste and waste management in Tonga and from interviews with key government officials associated with different aspects of waste management. Much of the background information on waste in Tonga was obtained from published official census reports, annual reports and other unpublished literature, such as those from past AusAID and New Zealand Agency for International Development (NZAID) projects, student theses and peer-reviewed journal articles and conference proceedings.

The national-level qualitative and quantitative information was collected from government officials involved with waste, water, fisheries and environment management, and non-government organisations working with communities to promote waste management. A semi-structured questionnaire was used to collect primary data from various government stakeholders including the Ministry of Health, Ministry of Works, Ministry of Fisheries, and Ministry of Environment. Wherever possible, documents such as annual reports and special waste reports were also collected from the relevant ministries.

The Ministry of Health is the primary government source of waste-related data. Information collected from the Ministry of Health includes data on diseases commonly associated with solid waste and human and animal waste, human and solid waste-related preventative measures and costs, and costs associated with outpatient and inpatient treatments. Additional waste-

related information and health costs were also obtained from district nurses, local clinics and pharmacies. Data gathered from these sources include the number of incidences of waste-related diseases reported in a week, common medicine used and quantity of medicine used to treat each disease, and the price of medicine used. Limited information was also obtained from the Ministry of Environment, Ministry of Fisheries, Ministry of Public Works and the Tonga Water Board.

An open-ended interview format in a *talanoa (*discussion) session — but guided by a questionnaire — is usually found to be most appropriate when approaching villagers and non-government organisations. This puts them at ease and does not appear to be overly prying or intrusive. At the village level, information was sought about the nature of the village-based waste collection system (if any), the water treatment and supply system (if present) and their respective costs. Financial cost and price information of water and filtering devices were collected from villagers and commercial suppliers, and the retail prices of medicines were obtained from chemists in Nuku'alofa.

Where official records were not available, this research relied on information recalled by government officials and villagers. Data had to be triangulated wherever possible and as necessary. Differences, when found, were cross-checked and verified using secondary information or information from other stakeholders familiar with waste in Tonga.

Using the results of these interviews and data collected from other sources, typical impact models associated with different categories of effects were constructed for typical categories of different types of waste. These models were then be used to estimate the financial cost associated with the impacts of solid and liquid waste on urban and rural Tongans and the economic costs of inadequate waste management.

2.4 Solid Waste Management Project average cost

Financial data on the expected costs associated with the proposed collection and disposal facility for Tongatapu proposed under the Tonga-AusAID SWMP was obtained from the SWMP team. They have identified different waste collection scenarios and different forms of user charges; the most likely scenario, as identified by the SWMP team, was compared with the WTP estimates derived in this study in order to identify alternative user charges policy options.

The results presented here are thus based on national statistics (where available), together with detailed rural and urban household-based data collected for Tongatapu. Where information was not readily available, expert opinion has been relied on. To give a more robust basis for decision making by the Tongan Government, alternative scenarios are also considered to provide upper and lower ranges of the economic cost of waste. The estimates provided here are for gross estimates of potential savings Tonga can make — or losses that the country can avoid — with improved management. These cost estimates do not reflect considerations of the costs that would be expected in the delivery of management to improve the waste situation in Tonga.

3 Results — waste in Tonga

The Kingdom of Tonga comprises 176 islands, ranging from high volcanic to low coral terrain. Thirty-six of the islands are inhabited. The islands are divided into five divisions, with a population of 97,784 (at the time of last census in 1996), residing in 16,914 households. Two thirds of the households are in the Tongatapu Division (see table 2). Nuku'alofa, the capital of Tonga, is located on the main island of Tongatapu.

Within each of the districts there are some villages considered to be "urban" in lifestyle, with a relatively higher level of consumerism than rural villages. About 40% of the households live in urban centers and the rest live in villages scattered around the islands.

Table 2: Distribution of Tongan households by division

Division	Number of households (1996 census)		
	Urban	Rural	Total
Tongatapu	5,998	4,798	10,796
Vavau	618	2,110	2,728
Ha'apai	249	1,220	1,469
Eua	208	612	820
Niuas	0	381	381
Total	**7,073**	**9,121**	**16,194**

Source: (Department of Statistics (Tonga) 1999)

Waste is a major problem in Tonga and pollution from solid, human and animal waste and their associated human health and environment impacts are among key environmental concerns in the country (SPREP 2002). There is some difference between both the volume and composition of waste generated by urban and rural households, as discussed below.

3.1 Solid waste production

Based on the results of the household waste audit, an average household in Tongatapu is estimated to produce about a tonne (t) of solid waste per year. Statistically, there is no difference between the volume of waste produced by urban households and that of rural households. Tongatapu residents are estimated to produce a total of 11,000 t of waste annually. Assuming residents on other islands have similar consumption patterns, it is estimated that about 16,400 t of waste is produced annually in Tonga, of which Tongatapu residents would account for 67%.

Garden and organic kitchen waste comprise about 65% of waste, followed by diapers and recyclable materials such as beer bottles, aluminium cans, metals and polyethylene terephthalate (PET) bottles. Total recyclable material accounts for about 75% of the weight of total household waste. This suggests that, with a strong recycling program, it would be possible to reduce the amount of waste going to the landfill by almost 75%, increasing the life of the existing landfill sites. The volume of waste going to landfill may be further reduced if households also used cloth diapers, which make up about 12% of all household waste (see Fig.1).

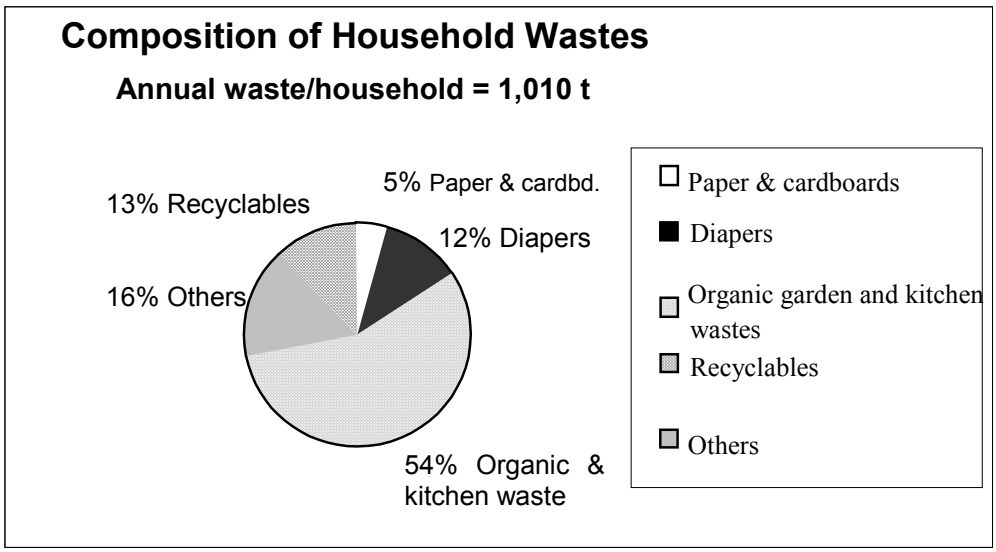

Figure 1: Composition of household solid waste, 2005

Source: Household Economic Survey, June 2005

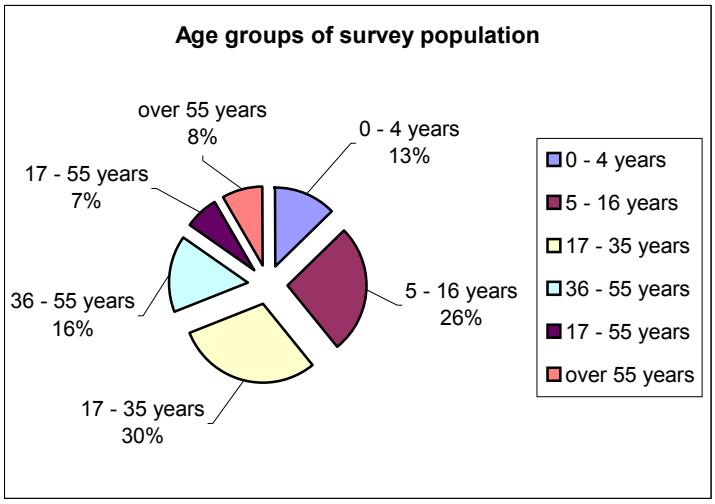

Figure 2: Population by age distribution

Source: Household Economic Survey, June 2005

Urban households produce about the same average volume of waste as those in rural areas, although the waste differs in composition. Urban households produce 20.6 kilograms (kg) of waste per week, compared with 18.7 kg of waste per week produced by rural households.[3]

One of the main reasons for a difference between rural and urban households stems from a higher number of diapers (16% of household waste) used by urban households (compared with 9% in rural households). Rural households, on the other hand, also produce proportionately more garden and organic waste (see Table 3).

The volume and nature of waste per household also depends on the number of individuals in the family and their age distribution, and particularly on the number of children under four years of age. In the survey population, the average household has six people with about 13% of the population below four years of age. Only 8% of the population is over the age of 55 (see Fig. 2).

On average, the households surveyed revealed that diapers comprise about 12% of the total waste generated per household. Of those households with babies, the majority (89%) used disposable diapers, costing an average of TOP 20 per week. Only 3% of households used cloth diapers exclusively, while 8% used both. The use of disposable diapers may be a sign of changing lifestyles as well as household wealth and education (Box 1).

Other solid waste

Other types of solid waste — in addition to household solid waste — are produced in Tonga. Construction and demolition waste typically comprise a range of waste products including soil, waste concrete, steel scraps, wood offcuts, sawdust, waste bricks, sheet metal offcuts, cladding offcuts, and various types of waste packaging including steel strapping, plastic, paper and cardboard. Agricultural solid waste primarily includes waste vegetation matter generated during the farming activities. This material is usually managed on-site by burning and consequently has little impact on centralised community waste management services and facilities. Agricultural waste also includes some hazardous materials such as unused insecticides and herbicides (and their containers). There is also solid waste that is commonly

[3] This is slightly higher that an earlier estimate of 18.3 kg of waste reported in 2004, where no distinction was made between urban and rural households (SWMP 2004).

classed as "special waste" because of its characteristics and the need for special handling, treatment and disposal. Car batteries, for example, which contain lead and acid, need special care when being disposed of. According to Prescott (2006), data on volume and type of chemical and other hazardous waste is not readily available, because most industrial operators do not keep records; records of special waste are also lacking.

Table 3: Average weekly waste generated per rural and urban household

	Rural		Urban		All	
Waste category	kg	%	kg	%	kg	%
Paper and cardboard	0.587	3.1	1.423	6.9	0.888	4.6
Diapers	1.714	9.2	3.258	15.8	2.271	11.7
Organic kitchen	2.601	13.9	1.505	7.3	2.206	11.4
Garden waste	9.340	50.1	6.837	33.2	8.437	43.6
Glass	0.515	2.8	1.069	5.2	0.715	3.7
PET plastic	0.347	1.9	0.606	2.9	0.441	2.3
Polyethylene	0.104	0.6	0.079	0.4	0.095	0.5
Other plastic	0.883	4.7	1.483	7.2	1.099	5.7
Aluminium	0.314	1.7	0.497	2.4	0.380	2.0
Other metal	1.419	7.6	1.878	9.1	1.585	8.2
Textiles	0.297	1.6	0.706	3.4	0.444	2.3
Hazardous	0.029	0.2	0.092	0.4	0.052	0.3
Construction	0.012	0.1	0.011	0.1	0.011	0.1
Other	0.497	2.7	1.156	5.6	0.735	3.8
Total	**18.659**	**100.0**	**20.601**	**100.0**	**19.359**	**100.0**

Source: Household Economic Survey, June 2005

Other types of special waste include:

- medical waste from hospitals, clinics and laboratories;
- sludge from waste water treatment plants and septage from septic tanks;
- slaughterhouse and animal waste, offal and food waste;
- quarantine waste;
- shipping solid waste; and
- hazardous household waste (oil-based paints, pesticides, herbicides, batteries, household cleaners, tyres and batteries).

Box 1: Household characteristics

Tonga is ranked fifty-fourth in the world in terms of its human development index, with a per capita gross domestic product of USD 1,602 (UNDP 2005). According to the 2005 Household Economic Survey, almost a quarter of all households have a fortnightly income of under USD 100, with the majority (58%) earning between USD 200 and USD 400 per fortnight — or USD 5,200 to USD 10,400 per year. Seventy per cent of households have family members that were engaged in income-generating activities or employment either on a full-time or part-time basis. The other 30% of households are dependent on migrant workers for remittance or relatives within Tongatapu for financial support.

High levels of household income also reflect a high literacy rate: 98.9% (UNDP 2005). Over 41% of households had at least one person who had a tertiary education (see Fig. 3). Better education and higher income also mean increased consumerism and changing lifestyles, including the increased use of disposable diapers.

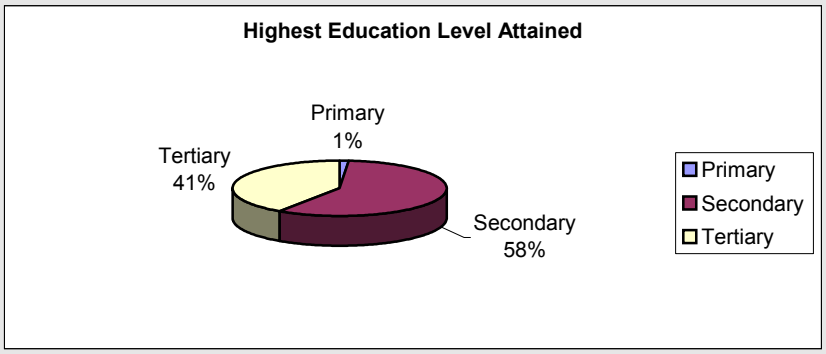

Figure 3: Distribution of education level in Tongatapu

Source: Household Economic Survey, June 2005

Almost 95% of the households using disposable diapers cited convenience or the ease of use as their main reason for using them, and 16% of the households noted it was father's preference. The use of disposable diapers reflects changing lifestyles, a changing social structure (with fathers becoming more involved with looking after babies), and increased consumerism. On average, families who used disposable diapers spent about USD 20 per week — or USD 1,040 per year — and the average income is about USD 8,800 a year.

Source: Household Economic Survey, June 2005 and UNDP 2005

3.2 Solid waste management

Solid waste management is primarily carried out by individual households, although limited service is provided by local governments and private companies. Based on the household survey results, the visual impact of waste is the main concern for Tongan residents and burning of solid waste is the preferred management method. Residents commented that they preferred burning because it is easier than other methods of disposal.

Seventy five per cent of homes burn their rubbish, with a small number (7%) burying their rubbish in their back yard. Many homes dispose of their rubbish in their own bush allotment. Only about 7% of households on Tongatapu take their waste to the local dump, while 4% use a waste collection system. A small proportion of households (1%) reported indiscriminate dumping of waste on public land. Households near mangroves see disposal of solid waste in mangroves as an important reason to reclaim the land for alternative use. These results are similar to those reported in the 1996 census and in the IWP survey of their pilot study site, Nukuhutulu.

Government-organised solid waste collection is restricted to Nuku'alofa, Tongatapu and

Neiafu, Vava'u. Although weekly collections are scheduled for Nuku'alofa, these are not regularly used by the residents. In the first six months of 2005, only about 12% of the urban households where waste collection services are provided reportedly used these services. This is lower than reported in 2003, when it was estimated that 25%, or 1011 households, used services provided by the government (Sinclair 2000:20). One of the reasons for the decline could be the irregularity in the collection service provided by the Ministry of Health. The Ministry owns and operates only one collection truck, which has been subject to regular breakdowns (Mr Matafahi, pers. comm. May 2005).

Tonga also has private sector involvement in solid waste management. On Tongatapu, Waste Management Ltd provides regular collection services for residential and business premises, using an open-deck collection truck. It has nearly 200 registered customers and charges a fee of TOP 8 per bin per collection. This fee is much higher than the fee levied by the Ministry of Health, which charges TOP 5 per week, or TOP 20 per month for a "regular" weekly collection.[4] The private company, however, arguably provides a more flexible collection system, with the collection service provided to meet individual demand. They also sort waste and separate glass and other recyclable material recycles. PET plastic bottles are incinerated and organic matter is composted. The rest of the waste is disposed of at the Tukutonga dump.

In rural villages, there is no regular government-operated collection service. Garbage collections at the village level, where they exist, are organised by the village council. These are mainly event-based; for example, for the occasion of village household site inspections by the Ministry of Health.

During the survey period, the SWMP team ran a trial solid waste collection service in three villages: Fo'ui, Nakolo and Hoi. The main purpose of the trial was to assess the response rate of households to regular collection services and to determine the average quantity of waste that a household may produce. In Hoi and Fo'ui, the SWMP team also organised recycling collections of cans and plastic bottles.

It is important to note that not every household in these villages participated in the trail. This suggests that the concept of regular collections may take time for people to get used to. Furthermore, those households that did participate noted the positive difference that regular collection made to the aesthetic appeal of their villages. This is consistent with the results of the IWP household economic survey where, as discussed below, the aesthetic effects of waste is reported as the primary concern.

Reuse and recycling

There is some reuse and recycling of household waste. About one third of households reported reusing items such as plastic bottles, glass bottles and cardboard boxes. The recycling concept is not commonly understood, although is becoming gradually accepted as a means of reducing waste. A little over half of the households (57%) understood what was mean by the term recycling, although less than half of these (only 40%) actually practised recycling. Earning income was the main reason for recycling, and mainly items that generated income — Royal Beer and other liquor bottles, aluminium cans, aluminium and copper — were recycled. Of the recyclable items, Royal Beer bottles were the most popular, with 35% of the households recycling them. This was followed by metals of different types (copper was recycled by 22%, aluminium by 19%, and steel by 7%; aluminium cans were recycled by 16%). About 1% of the households collected PET bottles. The reasons for the popularity of beer bottles and metal for recycling could be that they are more commercially valuable. Consequently, the commercial

[4] The service is very irregular because the collection truck periodically breaks down and households are often left without any collection service.

recycling companies — Atenisi, GIO Scrap Steel, and Crystal Recycling — offer home collection services.

The average income earned from recycling by the 18% of all households that do so is approximately TOP 20 per month per household, or TOP 240 per year (see Table 4). Villagers, however, varied significantly in their level of recycling; their level of income from recycling ranged from TOP 10–900 per year. The higher amounts earned by some households suggest (but this could not be confirmed) that these households may have recycled materials — particularly metal — accumulated over a matter of years, so the higher amounts could not be regarded as *average* yearly household income. Because of the large variations, a median estimate is more appropriate to use. Excluding the extraordinary amounts over TOP 400, the median value of recycling is TOP 120 per year, which is similar to the average household earnings (TOP 128).

Table 4: Income earned from household waste recycling (TOP)

Village	Total income per household
Fasi	229
Fo'ui	96
Ha'ateiho	181
Hala'ovave	283
Hoi	176
Kanokupolu	280
Nakolo	375
Average	**240**
Median	**120**

Source: Household Survey, June 2005

Given the current rate of participation in recycling, Tongatapu residents in 2005 are estimated to have earned a gross income of up to about TOP 235,200 from recycling beer bottles, aluminium and metal. The officially recorded export value of recycled aluminium and metals for 2004 is TOP 170,000, which reflects an almost ten-fold increase over the previous year (Bureau of Statistics, pers. comm., May 2005).

Composting

Sixty-five per cent of household waste is garden and kitchen organic matter, which can be composted. This generates approximately 8 t of compostable waste each year, but only about 20% of Tongan households engaged in any composting in 2005. Composting practices commonly in use include throwing food cuttings and peelings from root crops, grass clippings and other greenery onto vegetable and flower garden beds. Very little conscious composting of organic matter occurs in Tonga, however, perhaps because there is lack of understanding of the practice. The concept of systematic composting of waste is a recent introduction, with only about half of households (56%) indicating that they understood what composting is about. Less than half, however, actually practiced composting; of those who did compost, about a third (i.e. one sixth of the total) use proper composting bins. Almost half of these households are from the IWP pilot test site of Nukuhutulu, where composting has been supported with awareness and education activities. Of those that did not practice composting, the reason noted most commonly was a lack of understanding of how to set up the composting bins. This suggests there is scope to reduce the amount of solid waste through increased education and demonstration of composting.

3.3 Liquid waste

Liquid waste pollution from human and animal sources has two main effects:

1. bacterial contamination of the environment; and
2. increased nutrient levels in the environment.

Bacterial contamination triggers concerns about human health, whereas an increase in the organic matter from human and animal waste can lead to environmental concerns. The contamination of Tonga's groundwater is a key concern. This is because Tonga has no rivers

or streams, making groundwater the country's main source of water for domestic use. Past studies have shown close links between the quality of sanitation systems and groundwater pollution of wells (Crennan 2001; Falkland 2002).

Human waste

Tonga does not have a central reticulated human waste system and thus relies on household-based human waste management. Over three quarters of the households use septic tanks for human waste disposal. A further 10% use flush pits, and only 7% of households use traditional pit toilets. Poor maintenance and, in a few cases, poor design of septic tanks are identified as the reasons for groundwater contamination.

Table 5: Septic Tank Clearance

Frequency of clearing	%
More than once per year	1
Once per year	11
Once in 2 years	4
Once in 3 years	1
Once in 5 years	20
Once in 7 years	7
Once in more than 7 years	15
Never	**41%**

Source: Household Economic Survey, June 2005

While the desludging of septic tanks is recommended at least once every five years, over 63% of households have not desludged their septic tanks in the past five years (see Table 5). As a result, septic tank leaks are common, causing local contamination of groundwater (water quality issues are discussed in detail below).

Animal waste

Animal waste is also a significant source of pollution in Tonga. Given the cultural importance of pigs in Tongan culture, almost every household keeps several pigs. A Tongatapu household may own three to 14 pigs (see Table 6). With an average of five pigs per household, this results in an estimated 90,000 pigs kept in Tonga. Most of these pigs are allowed to roam freely. Although Tonga has legislation requiring the containment of pigs, this is rarely enforced. Similarly, dogs — of which there are an average of two per household, or about 33,000 dogs nationwide — are also a health hazard. They rummage through solid waste lying around in yards and land allotments, and are believed to be a source of some waste-related diseases, particularly in children.

Table 6: Animals kept per Tongatapu household

Village	Households	Pigs	Dogs	Chickens	Pigs per household	Dogs per household
Fasi	80	222	125	404	3	2
Fo'ui	20	133	78	76	7	4
Ha'ateiho	90	309	160	755	3	2
Hala'ovave	43	287	78	324	7	2
Hoi	20	111	43	120	6	2
Kanokupolu	20	286	50	175	14	3
Nakolo	20	157	38	54	8	2
Nukuhutulu	20	160	37	143	8	2
Total	**313**	**1,665**	**609**	**2,051**	**5**	**2**

Source: Household Economic Survey, June 2005

There is limited management of animal waste, if any. Households do "clean up" after their

animals and practice some form of management (see Table 7), but the collected animal waste is generally swept into a rubbish heap or dumped in nearby bush, and thus still left to the elements. During rains, organic matter and bacteria are washed into the groundwater.

3.4 Water

All households have access to groundwater, either through the local water supply, the village water supply or their own wells. Piped treated water is available to all households in the Nuku'lofa area through the Tonga Water Board; however, the village water supply is generally untreated, or treated only when water is found to be have a high coliform count. This is infrequent because village water is not tested regularly (Mr S Tuiono, Vaini District Officer, pers. comm. April 2005). In any case, most households do not use groundwater for drinking.

Table 7: Commonly used disposal methods for animal wastes

Method	%
Burn when dried	15
Bury with soil	10
Compost	1
Leave as is	8
Throw to bush	3
Sweep to rubbish heap	63

Source: Household Economic Survey, June 2005

Groundwater is generally contaminated with coliform and *E. coli* bacteria from human and animal waste. The Ministry of Health was not willing to release the results of its regular water quality assessment in key locations around the island (a reason for this unwillingness was not given). In order to understand the extent of contamination, the Department of Environment carried out water quality assessment in support of this economic analysis at two locations (one from a dry area and another from an area subject to flooding) in each of the eight villages surveyed in this study.

The results of the water quality assessment carried out by the IWP team in June 2005 confirmed that almost all the piped water had bacterial counts (*E. coli* and coliform) greater than the World Health Organization (WHO)-recommended values of less than 1 per 100ml of water (see Table 8). Those villages susceptible to regular flooding (Fo'iui, Ha'ataiho, Hoi, Kanakupolu and Nakolo) had higher bacterial counts. These were much higher than the WHO standards, as well as being higher than in the nearby dry areas.

This is important because, although groundwater may not be the main source of drinking water, it is used by all households for general household purposes. Most of the households (78%) noted the taste and odour of tap water as the main reason for not drinking piped groundwater. This was regardless of whether the water was treated. Nevertheless, only 16% of the respondents mentioned health reasons for not drinking ground or piped water. Most households did use groundwater for washing and bathing purposes.

Table 8: Village bacterial counts (per 100ml)

	Rainwater tank	Village, urban water supply	Piped groundwater
Fasi	0	0	0
Fo'iui	0	2	15
Ha'ateiho	0	0	27
Hala'ovave	0	n/a	0
Hoi	0	0	14
Kanokupolu	0	4	8
Nakolo	0	0	11
Nukuhutulu	0	2	1

Source: Household Economic Survey, June 2005

Rain water is the main source of drinking water in both urban and rural areas. Almost 90% of households use rainwater for drinking, which was found to be within the stipulated WHO standards. About 25% of households bought bottled water, purchasing on average 3.5 litres of water per household per week and spending

approximately TOP 10.60 per week. Imported water sales in Tonga have increased over time and have now reached 350,000 litres retailing at around TOP 1.1 million.

3.5 Formal waste management

Formal management of waste by the Tongan government is somewhat piecemeal and ad hoc, with several government agencies involved, depending on the specific issue of concern. The main concerns with the current solid waste management include littering, human health effects and the impact on the coastal ecosystem. Similarly, there is concern over liquid waste contaminating groundwater because of poor human and animal waste management. The nuisance factor associated with wandering and free ranging pigs and dogs is also regarded as a concern by the government. Because of such concerns, several government agencies are involved in the management of solid and liquid waste, with each operating under their respective legislations (see Table 9).

Table 9: Government authorities involved in waste management

Types of waste	Sources	Management authority
Liquid waste		
Human waste	Pit toilets, septic tanks	Ministry of Health (health) Ministry of Works (infrastructure)
Animal waste	Free roaming animals (pigs, dogs, etc.)	Ministry of Police (nuisance)
Solid waste		
Household (solid) waste: biodegradable (e.g. green waste, paper) and non-biodegradable (e.g. aluminium cans, plastics, class bottles)	Household	Ministry of Health (health) Ministry of Works (infrastructure)
Other waste		
Hazardous and special waste	Agricultural chemicals, oil	Ministry of Agriculture (farm management)
	Batteries (e.g. from vehicles, mobile phones)	Tonga Water Board (pollution)
	Hospital	Ministry of Health (health)

Source: Compiled from Prescott 2006.

Solid waste

The primary responsibility for solid waste rests with the Ministry of Health under the amended *Public Health Act 1913* and the Public Health (Refuse Dumping Ground) Regulation. These and other Tongan laws make substantial provisions for waste management, but implementation is limited and enforcement is lax (Powell 2006a).

The Ministry of Health (MOH) provides a regular collection service for the Nuku'alofa and Va'vau regions. They also manage the local landfill sites at Popua and Neiafu. In addition, private waste collection services are also provided by the private sector, complementing the services provided by the government. The current dump sites in Nuku'alofa and Vava'u are in mangrove areas with open pit dumping, with no prior sorting and very little on-site management. Domestic animals (e.g. dogs, pigs and cats) commonly scavenge at the dumps, as do people. There is very little, if any, enforcement of the formal regulations.

When passed the (now draft) Environment Management Bill and Environment (Littering and Dumping of Waste) Regulation are expected to provide comprehensive waste management regulation. There is also a proposal to establish a waste authority to help coordinate the efforts

of different agencies. This authority is expected to be vested with responsibilities either (i) under its own Act, (ii) by delegation of authority to apply and enforce provisions of the Public Health Act, or (iii) by a combination of these approaches (Powell 2006). Its effectiveness will certainly be determined by the degree to which officials enforce the relevant regulations.

The Ministry of Health occasionally undertakes limited spraying to control mosquitoes, often after an outbreak of dengue has been reported.

Liquid waste

The Ministry of Works operates septic tank pump trucks for the Ministry of Health and disposes of sewage sludge under the Ministry of Health's supervision. While the Ministry of Health is responsible for the monitoring the effectiveness of septic tanks, this monitoring is almost non-existent. Consequently, septic tanks are not maintained, seldom desludged and are susceptible to regular leaks, particularly after heavy rain. As noted earlier, many septic tanks are not cleaned even once in five years.

Water quality

The quality of water is managed by the Ministry of Health under the Public Health Act. The Ministry of Health is expected to regularly monitor water quality in both town and rural water supplies, but this does not always happen (Mosese Fifita, Health Inspector, Ministry of Health, pers. comm., 16 March 2005).

The Tonga Water Board, acting under the *Water Board Act 1966* and Regulations, supplies treated groundwater to urban residents of the Nuku'alofa region. The Water Supply Regulations set out the various functions of the Tonga Water Board and stipulates that the selling of water is prohibited, as is the wasteful use of water (Gazette 1963 and 1984). Fouling or damaging of public water supplies is also prohibited under the Act. Enforcement is inadequate, however, and the penalties for breaching these measures are minimal. Furthermore, the treatment of water appears to be inadequate, as indicated by the number of piped water samples found by this study to have bacterial counts greater than the WHO standard for drinking water.

The jurisdictions of the Ministry of Health, Ministry of Agriculture and Fisheries and Ministry of Works all include minimising the effects of pollution on coastal areas; there appears to be no mechanism in place to coordinate the actions of the ministries with respect to various aspects of pollution control, however, and in practice there is little if any control on pollution when it comes from different sources. Enforcement is minimal and penalties are inadequate (see Table 10).

In conclusion, although households and government agencies carry out some waste management, the general level of household waste management is inadequate. There is also a lack of coordination between different agencies mandated to look after aspects of solid and liquid waste management and pollution control. Where legislation exists to regulate individual household solid waste generation and disposal activities, the regulations are generally not monitored and enforced. The monitoring of water quality is limited and enforcement of rules regarding septic tank and toilet standards are virtually non-existent.[5] Consequently, the costs of the residual solid and liquid waste on human health and the environment are significant. Some of these costs are what private individuals actually pay for out of their pockets. In addition to out-of-pocket financial costs, there are also hospital and medical costs borne by the government. Society may also bear externality costs of pollution, for example on coastal ecology and fisheries. All of these costs are included in economic cost estimations.

[5] A recent review of environmental legislation provided a number of recommendations regarding harmonisation of waste management legislation (see Powell 2006a).

4 Economic costs of solid and liquid waste pollution

Economic costs of poor waste management are defined as the direct and indirect costs associated with the current level of waste management that could be avoided if better management services were provided. Economic costs therefore depend on the level and effectiveness of waste management currently in place, including the amount of recycling of recyclable waste, the direct causal relationship between waste and its impact on human health and environment, and aesthetic values, as well as the indirect impact on local fisheries yields and tourism, and the wider flow-on impact on the local economy. These costs may be borne by individuals, the government or society as a whole.

4.1 Economic cost estimation — the methodology

A with-and-without BCA was conducted to assess economic costs of waste in Tonga. A with-and-without analysis refers to the difference between the economic net benefits of the current situation of waste management (the with-waste scenario) and the economic net benefits of the alternative situation of improved management (the without-waste scenario) (see Sinden and Thampapillai 1995 for a discussion on with-and-without analysis).

Solid waste is generated by humans because of their consumption of goods of some type, while liquid waste is a product of human existence. It is assumed that there is no change in their lifestyle and thus the direct benefits (utility) of consuming the goods are constant, regardless of whether waste is managed. A with-and-without BCA in such a situation is, therefore, effectively a with-and-without analysis of costs; that is, the BCA reduces to an analysis of economic costs with waste (i) without improvements in waste management and (ii) with improvement in waste management.

In the with-waste scenario, the direct economic costs of waste include costs associated with human health effects of poor waste management, including hospital costs, the costs of private doctors' fees and medicine, the value of human life (in the event of deaths), and the cost of human suffering. It also includes the costs of measures taken to prevent health problems, such as the collection of rain water to avoid the use of groundwater, the purchase of bottled water in order to minimise the risk of catching water-borne diseases, and preventative measures taken by the government, such as spraying villages for mosquitoes. The with-waste costs also include the loss in potential earnings from not recycling, indirect costs of the loss in coastal fisheries, loss in tourism earnings and non-market values associated with the loss in environmental amenity.

The without scenario used in the BCA assumes that waste management is improved in a way that makes economic costs negligible. In this case, the economic cost of poor waste management is the sum of :

- private health costs;
- preventative costs;
- economic cost of human life;
- health and preventative government costs;
- aesthetic value of a clean environment;
- cost to fisheries;
- cost to tourism;
- foregone earnings from recyclable material sent to the dump; and
- foregone earnings from organic matter not composted.

Table 10: With- and without-costs categories

Costs **with** current state of waste problems	Costs **without** waste problems, or negligible or zero impacts
Direct costs	
• Treatment of diarrhea, dengue and skin diseases, including transportation costs to the hospital or private doctors, doctors' fees, if any, and the cost of medicine	• Nil private costs
• Financial costs of health services borne by the government	• Nil government expenditure on waste-related illnesses
• Economic value of loss of human life attributable to waste	• no loss of human lives
• Economic cost of human suffering	• Loss of human life and human suffering avoided
• Private costs associated with preventative measures: cost of rainwater tanks, filters, and bottled water	
• Costs of government's preventative actions	• No preventative measures needed
• Foregone earnings from recyclable waste going to the dump	• No recyclable material is sent to the dump
• Potential economic value of composted organic matter	• No organic matter going to the dump
Indirect costs	
• Economic value of the loss in fisheries	• Loss of fisheries and environment avoided
• Economic loss of tourism due to reduced number of international tourists	• No loss to the tourism industry
• Economic value of aesthetic benefits associated with clean environment	• aesthetics restored

To determine the economic cost of waste, it is first important to determine the causal relationship between waste and its impact on human health, tourism, fisheries and environmental aesthetics. Market values are then assigned to these impacts using one or more of the methods in Box 2, and the data collected using mixed methodology (see appendix B).

4.2 Private human health-related costs

The human health costs of waste include health and preventative costs borne by private individuals and the health service, as well as preventative costs borne by the government.

Private health costs

There are three broad categories of water-related diseases arising from poor waste management. These are:

1. dengue fever;
2. gastrointestinal diseases such as gastroenteritis and diarrhea; and
3. skin infections such as fungal infections.

Gastroenteritis, dysentery and diarrhea are all water-borne and sanitation-related illnesses directly linked to human and animal waste. Dengue, on the other hand, is one of the vector-borne diseases directly associated with poor solid waste management (Dr Toakase Fakakovikaetau, pers. comm., March 2005). Of these, only dengue and gastrointestinal cases are officially reported by the government (see Table 11), although skin infections were reported in the household survey.

Box 2: Valuation techniques used in this study

The value a person places on a good or service reflects the amount that person is willing to pay for it rather than go without it. For example, the household survey results in this study indicated that households were concerned about the aesthetic effects of littering in their villages. The value that people associate with having an aesthetically more pleasing environment — free of litter — would then be reflected in the amount that people would be willing to pay for a waste collection service that eliminated littering. Where markets exist, the market price reflects a person's WTP for improved waste management systems, and this can be used to determine the economic costs of waste. Where markets do not exist, a proxy measure has to be determined using one of several valuation methods.

Market valuation

Market valuation methods include the use of market-based cost and price information to determine losses households incur due to health problems, lost production and lost earnings. This economic analysis used the following market valuation methods:

Preventative and mitigating expenditure

The costs incurred by households to reduce the risk of getting sick from drinking contaminated water are used in this study as a proxy for the cost associated with polluted water due to waste contamination. The cost of purchasing bottled water and rainwater tank plus filters, for example, are used as a proxy for the waste-related cost of human health. The government may also incur costs associated with, for example, mosquito control. Market costs are also included in the preventative expenditure estimates. Despite such preventative measures being taken by individual households and the government, a number of cases of water-borne diseases directly attributable to poor waste management are reported, resulting in additional health costs.

Human health cost

The economic cost of getting ill because of poor waste management was estimated using actual costs incurred by the person. The cost associated with coming down with diarrhea from waste-contaminated water includes the cost of transport to the doctor, the doctor's fees, the cost of medicine needed to treat the disease, and any loss in income the person experiences if diarrhea causes the person to stay away from work. The approach was used to estimate the cost of acquiring skin diseases, and dengue caused by mosquitoes that breed in waste that was poorly disposed of.[6]

In addition to out-of-pocket financial costs, there are also hospital and medication costs borne by the government. In some cases, poor waste management-related dengue resulted in villagers not being able to get to work and, in extreme cases, deaths were also reported. To determine the economic cost of loss in productivity (regardless of whether the person was paid for the time away from work) and loss in lives, the production method was used.

Production method

This method measures the loss in the value of production due to loss in productivity and/or loss of lives. The loss in productive time was estimated as the wage rate and number of days away from work. The value of the loss in human life due to dengue or any other waste-induced illnesses was also estimated using the market pricing method. In this method, the present value of future loss in income from the death of a person is used as a proxy for the value of human life.

The production method was also used to calculate the value of the loss in coastal fisheries due to pollution and eutrophication. Similarly, if poor environmental effects led to a decline in tourist numbers, the loss in gross value of the tourist expenditure was measured using the production method. Market prices and quantities can be used to estimate the impact of waste on the tourist industry and the coastal fisheries, assuming a direct causal relationship between waste and tourist numbers and waste

[6] Market price is used in this study as a proxy for economic value. (See Perkins 1994 for further discussion on the relationship between financial and economic values.)

and coastal fisheries is known to exist.

Foregone earnings

Recyclable material that is not recycled is a wasted resource. This is because people may have earned income or produced more goods had they recycled. The value of the economic loss of not recycling can be estimated by calculating the earnings foregone. Ideally, the total gross value of foregone earnings is the export value of the potential volume of recyclable material. It was not possible, however, to obtain this information from exporters because of the confidential nature of this information. Instead, a second-best estimate of the recycling value was made using the value of earnings that the households would have earned had they sold their recyclable material to the local recycling companies.

Non-market valuation

A number of non-market valuation techniques can be used to estimate the economic value of goods and services that are not directly bought and sold in the market. These techniques include what is known as revealed preferences methods, such as travel cost and hedonic pricing, and expressed preference methods, such as contingent valuation method and choice modelling. The contingent valuation method was used in this study to estimate household WTP for improved waste management (see Hanemann 1988; Freeman 1991; and Carson et al. 2003 for details on the different methods).

Contingent valuation

This method relies on people's ability to express their WTP for an improved environmental amenity such as waste collection and disposal. Using this method, people are asked to express how much they value a clean environment by directly asking them how much they would be willing to pay for improved management services to achieve it. This can be done using open ended questions such as, 'How much are you willing to pay for [a specified increment of environmental improvement]?' Alternatively, people can be asked discrete questions about whether they are willing to pay a specified amount, and then calculating the average WTP estimate for the improvement (see Box 3). This measure is used as a proxy for the non-market aesthetic value associated with no waste.

Non-market-based techniques, because of their hypothetical nature, can have several sources of bias but all efforts were undertaken in this study to minimise bias through a carefully designed questionnaire (See Freeman 1993; and Carson et al. 2003 for information on non-market valuation and bias).

Table 11: Reported cases of selected notifiable diseases, 1999-2003

Disease	**District**	**Year**				
	Tongatapu	2003	2002	2001	2000	1999
Bacillary dysentery	4	9	8	0	5	10
Gastroenteritis	117	175	637	216	750	958
Amoebic dysentery	4	4	0	0	0	0
Dysentery unclassified	9	9	9	0	178	0
Diarrhoea (infants only)	852	1035	1396	1452	1893	1588
Diarrhoea (adults only)	850	1285	1273	1459	1596	1286
Dengue	192	194	0	0	0	0

NB 50% of gastrointestinal diseases, 100% of skin diseases and 100% of dengue cases are assumed to be attributable to waste (see text for explanation).

Source: Government of Tonga 2003

Box 3: Discrete contingent valuation method

In this study, the discrete contingent valuation method (CVM) was used to estimate the average value households place on improvement in waste management resulting in a clean environment free of litter.

In the discrete CVM, households were divided into several groups. Analysts explained the nature of the proposed improvement in waste management proposed under the SWMP: for a fee, each household's waste would be removed weekly and the current littering problem minimised. Each respondent was then asked to give a discrete yes or no answer to a question such as, 'Are you willing to pay a specified sum — $*x* per week — for a service that will result in a cleaner environment?' At this stage, two alternative approaches could be followed.

In the first, the yes or no answers are recorded, and later analysed using a Logit model to estimate an average WTP for improved waste management. Logit analysis is carried out using mathematical software called STRATA.

In the second approach, an iterative process is used, combined with the discrete choice method. In this case, the respondent is asked, 'Are you willing to pay a specified sum — $*x* per week — for a service that will result in a cleaner environment?' If the respondent accepts the first bid offer, the question is repeated using the next value up. If the respondent rejects the first bid value, they are asked if a specific lower amount would be acceptable. This process is repeated several times until the respondent changes their answer. The highest value to which the respondent answered yes is the maximum value the respondent places on the proposed waste management improvement strategy.

For either method, this study's bid categories were determined using the results of a pilot open-ended CVM survey. The pilot survey gave an idea of the range of values people may place on the collection and removal of their household waste. Most of the respondents gave WTP estimates ranging from TOP 2 to TOP 8 per week, with only two respondents willing to pay TOP 10. A very small number of households gave zero values (these respondents indicated that they were not willing to pay anything because they can take their waste directly to a landfill site). Three bid categories were chosen to identify household WTP: TOP 2, TOP 4 and TOP 6 per week. It is important to note that those who gave the higher values appeared not to have a firm understanding of the concept of money because there appeared to be no logical relationship between (a) their expressed WTP and their ability to pay (income level), or (b) their WTP and their lack of concern about the effects of poor waste management. To explicitly address this issue, the WTP question was immediately preceded by a question about their weekly food bills and transport costs to contextualise the question. In the iterative bidding method, higher values were nonetheless possible through the iterative bidding process.

Formally reported cases reflect only those cases with severe symptoms or situations in which individuals would have gone to a hospital or to a private doctor for treatment. These formally recorded figures may also include foreign tourists, who either went to the local doctor or a hospital for treatment. In many instances, locals and tourists may get medication directly from a pharmacy or try home remedies, as is often the case with skin infections. This is one of the reasons that skin diseases do not feature in the officially reported records but were commonly reported during the Household Economic Survey.

Twenty eight per cent of households reported incidences of skin irritations and fungal skin infections such as Dhani and ringworm. These infections lasted an average of 10 days per incidence. Similarly, 17% of households reported cases of gastrointestinal illness lasting about four days. Seven per cent of households had at least one person with dengue, lasting an average of eight days (see Table 12). No cases of typhoid, fish poisoning or food poisoning were reported in 2005. A total of 8,485 cases of waste-related infections were reported, which lasted a total of 67,300 days.

Table 12: Households that reported incidences of waste-related diseases

	Proportion of households that reported diseases (%)	Number of Tongan households affected	Average days ill per reported case	Total number of days ill
Dengue	7	1,086	7.5	8,175
Gastrointestinal disease	17	2,794	3.8	10,710
Skin infection	28	4,605	10.5	48,427

Source: Household Economic Survey, June 2005

Not all of these cases could be directly attributed to poor waste management and a number of assumptions were made to reflect this reality when estimating the health costs discussed in the next section. The assumptions are later relaxed in the sensitivity analysis to determine the upper and lower bounds of the likely economic costs associated with poor waste management.

Human health costs

Waste-related gross health costs borne by private individuals are estimated to be about TOP 506,200 per year. This is based on the assumption that 50% of gastrointestinal diseases and all cases of skin diseases are directly attributable to poor water quality. Such an assumption was made because most households drink rainwater rather than piped groundwater, and all diarrhea cases cannot be directly attributed to the drinking of fecal-contaminated groundwater. Furthermore, some of these diseases may also be due to poor sanitation and hygiene and, to some extent, transmitted by pigs and dogs. On the other hand, dengue cases are attributable to poor solid waste management because poor waste disposal provides a breeding ground for mosquitoes that spread the dengue virus; however, not all mosquitoes can be eradicated with improved waste management. It is assumed in this study that through an improvement in waste management the chance of contracting dengue will be reduced by 75%.

Under these assumptions, a household would have to spend an average of TOP 1.74 per year on skin infections, TOP 0.54 on gastrointestinal illness and TOP 3.84 on dengue — or a total of TOP 6.00 per household for waste related illnesses — on going to the hospital, a private doctor and or on medication bought from pharmacies (see Table 13).[7] [8]

In addition, people suffering from dengue fever and gastrointestinal diseases are likely to miss work, leading to a loss in productivity. This is a loss to the employers who have to pay salaries while employees are off work. It is also a loss to self-employed workers because they are unable to produce income when they are sick. It is assumed that each person would have stayed away from work one in every four days when they reported gastrointestinal or dengue fever problems. The loss in productivity is measured in terms of the average daily wage of a labourer and civil servant.

Preventative costs

Some householders use rainwater tanks and bottled water for drinking purposes rather than using groundwater as supplied by the government, village or their own wells. Almost every household surveyed reported to have a rainwater tank, but only 16% of households noted that

[7] Not every household will have these diseases but these averages were estimated based on all households, including those that did not report. The average cost to sufferers would, therefore, be much higher.

[8] This is comparable to the imputed out-of-pocket cost of TOP 6.22 per outpatient reported by Tongan National Health. The figure is based on total outpatient cost, adjusted for diagnostic and other costs that do not apply in normal waste-related illnesses (Government of Tonga 2004, table 33).

they did not drink tap water or groundwater because of health concerns. Assuming that 16% of the households in Tonga had installed rainwater tanks for health reasons — and these are directly attributable to the effects of liquid and solid waste — the total cost of a rainwater tank purchase as a preventative measure is estimated to be TOP 143,803. This is also based on the assumption that each cement tank costs TOP 1800 and lasts for 25 years. In addition, these households would have spent an average of TOP 2 per filter per tank per year.

Table 13: Private health costs of poor waste management (in TOP)

	Tongatapu medical costs	Tongatapu loss in labour productivity	Total Tongatapu health costs	Tongan direct medical costs	Tongan loss in labour productivity @TOP 22/day*	Total Tongan health costs
Skin	39,728	0	39,728	59,592	0	59,592
Gastro	2,932	156,514	159,445	4,398	234,771	239,168
Dengue	14,125	89,598	103,723	21,187	134,398	155,584
Total	56,784	275,978	337,471	92,239	413,967	454,344

* minimum laborer's wage rate

In addition, 25% of households in Tongatapu regularly purchased drinking water. The average volume of drinking water purchased is 3.5 litres per household per week. Each household surveyed spends an average of TOP 10.70 per week — or TOP 3.14 per litre — on bottled water. The average annual volume of imported water for the years from 1999 to 2003 was 350,000 litres (consumed in homes and offices). The total retail value of bottled water is thus estimated to be TOP 1.5 million, 95% of which is consumed in Tongatapu. Assuming only 50% of this water is consumed for health reasons, the cost of bottled water attributable to waste is TOP 74,898.

As noted above, financial costs borne directly by households are only one component of the total costs associated with solid and liquid waste. Other costs include the economic value of loss of human life, costs borne by the government for health services, and the loss in aesthetic value caused by littering, as well as environmental effects on the ecosystem.

Cost of loss of human life

Waste-related diseases have caused some loss of human life. In 2003, six lives were lost due to dengue fever, and one person died from extreme diarrhea. The latter case has not been included in this analysis because it is unclear whether the diarrhea was due to the impact of waste or to poor sanitation.

Economic cost of human life is estimated in terms of the present value of the foregone earnings in the future.[9] The value of foregone earnings is calculated to give an annual loss in earnings. If it is assumed that half of those who died may have worked as highly trained civil servants, and the rest as labourers, the expected annual loss to the economy in foregone earnings from the loss of lives would be an estimated TOP 29,736.

[9] Some economists are reluctant to place an economic value on human life. It is included in this study only to emphasise the fact that loss of human life does not only have emotional costs but that there are also economic costs. This is not to say that a human life is worth only in terms of what a person can earn.

Total private health-related costs

The residual financial cost of solid and liquid waste borne is expected to be TOP 1.4 million (see Table 14). This is based on several assumptions, as discussed above, which are later relaxed in the sensitivity analysis to determine the upper and lower bounds of the likely economic costs associated with waste.

Table 14: Private costs borne by Tongan households

Category	Cost (TOP)
Private health costs	454,344
Bottled water	749,900
Rainwater tanks	143,800
Total	**1,348,045**
Private cost per household per year	**83**

4.3 Government health costs

The Tongan Government provides basic health care, the costs of which are borne by the health budget. It also takes preventative measures against illnesses in the form of spraying for mosquito control. This cost is borne by the Ministry of Health, with support from WHO.

The average cost associated with outpatient treatment from waste-induced illnesses borne by the Tongan Government is estimated to be TOP 6.22 per household per visit and TOP 16.83 per inpatient case (Government of Tonga 2004).[10] Assuming the number of reported cases in 2005 is similar to those reported in 2003 (more recent statistics were not available at the time of this study), the government is expected to incur approximately TOP 18,683 for 192 cases of dengue and 50% of the 1832 cases of gastrointestinal illness assumed to be linked to poor waste management. The annual budget for village spraying for mosquito control was estimated to be TOP 5000, excluding the Ministry of Health staff cost (Niu Fakakovikaetau, Ministry of Health, pers. comm. March 2005).

4.4 Potential loss from not recycling

In this study, the median value of TOP 120 per household per year is used to estimate the opportunity cost of not recycling, assuming that only a proportion of households actually change their habits and begin to recycle. Experiences from other countries suggest that not every household is likely to be engaged in recycling, even with a massive education campaign. Assuming 50% of the non-recycling households were to be engaged in recycling, the best estimate of gross loss in the economic value of recycling prevented is expected to be approximately TOP 830,000. This is most likely to be an underestimate, since not all recyclable waste would have been recycled by recycling households.

4.5 Impact on the tourist industry

Tourism is the most important foreign exchange earner for Tonga. In 2004, 41,208 tourists visited Tonga. Of this number, holiday visitors comprised about 41%, followed by family and friends of Tongans living abroad (40%). Eleven per cent of the tourists were business travelers.

According to the Tourist Visitors Bureau, tourists are estimated to have spent about TOP 26 million, with leisure tourists contributing 34%, or TOP 8.5 million.[11] The highest spending visitor category was those visiting friends and relatives, who contributed about TOP 12 million

[10] Estimated from the proportion of total health costs reported for the country, proportion of the cost borne by the government and the percentage of government costs spent on outpatient services, medical supplies, and administration costs.

[11] This is lower than the $49 million reported in the draft 2005 Tourist Bureau Survey report. The Annual Report of the Tourist Visitors Bureau reported $26 million. The contribution of leisure tourism is based on the adjusted Tourist Visitors Bureau data.

to the local economy.

Holiday tourists to the Pacific generally place considerable value on environmental aesthetics. The natural beauty of Tonga and the friendliness of the Tongan people are the two main attractions for holiday visitors (Tongan Visitors Bureau 2005). During a survey conducted in 2004–2005, 55% of tourists commented on, among other things, the amount of rubbish in the Nuku'alofa town area and along the waterfront (Malelupe Vunipola, Tongan Visitors Bureau, pers. comm. September 2005). Other issues raised included poor service in restaurants, and difficulty negotiating the island and the town center because of a lack of street signs and signs explaining different tourist sites.

As noted by Hajkowicz and Okotai (2006), factors that determine visitor numbers are complex and it is often difficult to separate the effect of any one factor. It is particularly difficult when the issue is not regarded as significant enough to warrant some drastic action. The impact of waste on tourism was not raised as an issue during stakeholder consultation in February 2005. Tonga's natural beauty is one feature that attracts tourists to Tonga. Tonga does not currently have the problem facing Majuro, where cruise ship operators have given notice that they will bypass Majuro because of "visible solid waste pollution on the land and coastal waters" (Rogers 2003: 13). Similarly, unlike in the case of the Cook Islands, no disease outbreaks have been reported in Tonga that are directly associated with poor waste and which may act as a deterrent to tourists. In the Cook Islands, a major eye problem, Takitumu Irritant Syndrome, was reported in 2003. This infection is associated with an algal bloom caused by high nutrients from poorly managed animal and human waste. The disease was seen to have potentially serious consequences for the Cook Islands tourism industry, particularly because this industry contributes about half of the country's gross domestic product (Hajkowicz and Okotai 2006).

In the case of Tonga, the impact of waste on the tourism industry specifically is likely to be small. It is possible that some tourists may not return, however, because of their concern about waste. The Tongan Visitors Bureau claimed that at least a third of the leisure tourists (who actually commented about poor waste management), may not revisit because of their concern about waste. In the absence of any empirical evidence, this study has assumed (in discussion with the staff of the Department of Environment) that the effect of waste on the tourism sector is nominal (5% at most). Under this assumption, Tonga could have lost TOP 845,000 in gross tourism expenditure. If the waste problem is not addressed, it is possible this figure could increase.

4.6 Economic costs to coastal fisheries

The indiscriminate disposal of liquid and solid waste affects coastal ecosystems such as mangroves local beaches and coastal fisheries, causing a decline in fisheries output (Prescott 2006) (see appendix A). The Fanga'uta Lagoon in Tongatapu, which is the main area targeted by commercial fisheries, is a highly polluted environment; key features include decreasing water quality, high levels of nitrate and phosphate, and coliform counts exceeding international standards for recreational use and seafood consumption (Prescott 2006). Some trace metals were also found. Much of the pollution has been caused by the direct dumping of solid waste, including items such as diapers and kitchen waste, as well as land runoff. These pollutants negatively affect coral growth, stimulate algal growth, and affect coastal fisheries (Kaly 1998, 2001a; 2001b). A decline in fish yields has been observed in Fanga'uta Lagoon, with total fisheries catches estimated to have declined by 40–50% compared to ten years ago; current yield is 18–20 t per year. Some species such as *ngatala* (groupers), *Koango* (emperors) and *kanahe* (mullet) are no longer found in the lagoon, or are seldom caught.

It is difficult, however, to attribute the decline in fisheries yields entirely to waste, because there is little information available on the impact of indiscriminate waste disposal on fisheries and coastal ecology. Similarly, the direct or indirect environmental effects of pollution from

human and animal waste are not known. Limited scientific information (Morrison 1998; Morrison 1999; Prescott 2001a; TEMPP 2001; TEMPP 2001) and some anecdotal evidence suggest that pollution from human and animal waste is one of the causes of the high nutrient levels in the lagoon and coastal waterways. The high organic content in effluent discharges from leaking septic tanks has caused algal, mossy growth around villages and in coastal areas.

Spiller (2001) reported a decline in fisheries catch of 300 t, valued at TOP 650,000; this represents a 60% decline in fisheries catches between 1985 and 1994, with the decline believed to be largely due to the effect of pollution and overfishing. The Fisheries Department suggests that if 20% of the catch decline is attributable to the effect of liquid waste-related eutrophication, then 8% of the overall decline in fisheries could be attributed to waste-related pollution. This would put the value of the loss in fisheries output at TOP 325,000.

Poor water quality is also believed to cause fish poisoning, or ciguatera. There were 35 cases of ciguatera reported in 2003. It is not clear, however, what the actual cause of ciguatera is. Several factors are believed to have been the cause of a ciguatera outbreak: sediment runoff, human and animal waste and climate change. Although other researchers have assumed that a proportion of ciguatera is caused by land-based pollution (see, for example, Hajkowicz and Okotai 2006)[12], in Tonga, even anecdotal evidence supporting the incidence of ciguatera linked to human, animal or solid waste pollution is not available, nor could the fisheries officers provide any reasonable estimate of the likely relationship (Ulunga Fa'anu, Deputy Director, Fisheries Department, pers. comm., September 2005). The link between waste and ciguatera is tenuous, particularly when there are other changes also occurring in the ecosystem. As a result, these values were not included in this valuation exercise. It is acknowledged, however, that solid- and liquid-based pollution affects the coastal ecosystem, and that the associated costs should be included in economic valuations when better information becomes available.

4.7 Non-market value of environmental aesthetics

One of the main concerns expressed by Tongans with respect to poor solid waste management is the aesthetic effects. Almost 48% of the surveyed households identified the visual effects of littering to be their main concern, followed by 37% who noted general environmental effects as their main concern. Only 15% of households were concerned about human health effects of household waste littered around the villages. International tourists also commented on the visual effect of solid waste lying on roadsides and in coastal areas (Tonga Tourist Bureau 2005). Health effects were generally not mentioned. This is not surprising considering that the human health effects of solid waste are indirect and generally not easily recognised. The human health effects of solid waste arise largely from vector-borne diseases such as dengue, hepatitis and filariasis. Poor disposal of soiled disposable diapers, as noted earlier, is also a source of gastrointestinal illness. Bacteria are transmitted via wandering pigs and get into solid waste, and germs are passed via pigs' contact with humans, particularly children (Moses Fifita, pers. comm., March 2005). Such effects are indirect and people do not usually associate such illnesses with poor solid waste management.

Willingness to pay

The national value of a clean environment resulting from regular solid waste collection and disposal is estimated at TOP 2.6 million. This is based on an average household WTP of TOP 3.10 to have solid waste collected and disposed of. The 95% confidence limit of WTP per household is TOP 2.80–3.30. This was estimated using the iterative discrete CVM modeling approach. This approach gave a lower value than the estimate derived using the Logit model

[12] This may be a reasonable assumption for the Cook Islands because the researchers were interested in estimating the economic costs associated with poor watershed management, which includes sediment run-off, waste and the eutrophication effects of nutrient run-off.

(see Box 4). Furthermore, it is not surprising that the Logit model-derived estimate is greater than the iterative process or values derived from open-ended CVM. Other studies have also found such a difference, and this has been attributed to potential bias introduced through the bid offer (Jakobsson and Dragun 1996).

Box 4: Logit modelling results

Logit regression involves estimating the probability that a person will say yes to a bid value WTP, given the values of the independent variable using the formula:

$$In\left[\frac{\Pr(Y)}{1-\Pr(Y)}\right] = \beta_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4$$

In the above equation, Pr(Y) is the probability of a positive WTP (that is, a *yes* response), where Y=1 and 1–Pr(Y) is the probability of a negative WTP, where Y=0. The ratio $\frac{\Pr(Y)}{1-\Pr(Y)}$ is called the odds ratio (Gujarati 1999) and the log of this odds ratio is known as the Logit model.

The model can be rewritten as: $Y_i = \beta_1 + \beta_2 X_{2i} + \beta_3 X_{3i} + \beta_4 X_{4i} + u_i$ or

$Y(0,1) = \alpha + \beta_1$ (bid value) $+ \beta_2$ (income) $+ \beta_3$ (age) $+ \beta_4$ (edu) $+ \beta_5$.

Where Y_i is the dependent variable for the '*i*th' person, X_{2i} and X_{3i} are the independent explanatory variables and β coefficient of X. In this study, the explanatory factors considered are bid value, income, education, flooding (wet or dry), and location of village (urban or rural).

The distribution of the estimated values of the Logit model lies within the upper bound of 1 and lower bound of 0. Psuedo R^2 measures the proportion of the variance of dependent variable explained by the regression.

The Log Likelihood = –84, at a 95% confidence interval.

The R^2 in this analysis was 20%. According to Mitchell and Carson (1989), R^2 greater than 0.15 or 15% indicates that the data is theoretically valid and reliable, whereas Bennett and Block (1991) regarded R^2 in the range of 0.2–0.4 as adequate.

The average WTP estimate, using the Logit analysis, is TOP 4.78 per household per week.

Y (0,1)= –0.71+0.72 (7.6) Education*+0.001 Income (2.45)*+0.28 rural/urban (0.9)+0.006 Drywet (0.02); R^2=0.21 (figures in brackets are the absolute *z* values).

The WTP amount expressed by Tongan households is statistically correlated with their ability to pay (income) and the highest level of education in the family. This is not surprising because people's ability to pay would influence how much they are willing to spend on a service. Furthermore, having higher education also implies greater awareness of the potential impact of poor waste management. On the other hand, the household's location — that is, whether in an urban or a rural area — did not affect people's WTP. This suggests that, waste being a fundamental issue, there is a minimum amount that households will be willing to pay regardless of where people live. On the other hand, people's WTP was not influenced by the likelihood of flooding — that is, in wet or dry villages. Flooding could be expected to be a determinant because people's expressed WTP would be affected by their concern about health: people in flood prone areas are prone to greater health effects such as gastrointestinal diseases and skin diseases because their septic tanks are regularly flooded, contaminating the nearby areas and groundwater. As noted above, however, the main concern in Tonga is the aesthetic effect of waste rather than health effects.

4.8 Summary of economic costs associated with solid and liquid waste

Tonga's total waste-related economic cost is estimated to be at least TOP 5.6 million per year (see Table 15). The average cost per household borne by the government and individual households for waste-related impact is estimated to be TOP 350 per year. This estimate reflects only direct costs associated with human health, the cost of preventative measures taken by private households, government expenditures associated with treatment of waste-related illnesses, loss in fisheries and tourism earnings, foregone income of not recycling waste for which there is a domestic market, and the economic value of loss in amenity due to littering. A large part of the economic cost is borne by private individuals.

Table 15: Costs associated with solid and liquid waste in Tonga, 2005 (TOP)

Category	High	Best	Low
Private health costs	811,176	454,344	115,851
Bottled water	1,098 711	749,898	374,949
Rainwater tanks	898,767	143,803	143,803
Government health costs	18,683	18,683	18,683
Government preventative costs	5,000	5,000	5,000
Loss of life	46,313	29,736	13,158
Loss of tourism	845,000	422,500	169,000
Loss of fisheries	406,250	325,000	162,500
Environmental costs	2,778,890	2,585,210	1,684,176
Loss in recycling earnings	1,664,338	832,169	416,084
Total	**8,573,127**	**5,566,343**	**3,103,205**
Average household costs	**529**	**344**	**192**

Key assumptions

High cost scenario: 100% of bottled water, 100% of rainwater tanks, 75% of dengue cases; loss in civil servant labor productivity; all deaths involve civil servants; tourism assumed at 15% decline; fisheries assumed at 10% decline; 100% of households recycle all recyclable items (glass, aluminum, other metals).

Low cost scenario: 50% of bottled water, 16% of rainwater tanks, 25% of dengue cases; loss in labor productivity suffered by laborers only; tourism loss at 2%; fisheries loss at 4%; additional 25% of households practice recycling.

Best scenario: 50% of bottled water, 16% of rainwater tanks, 50% of dengue losses; one in four days loss in labor productivity; deaths involve both loss in productivity by equal proportion of civil servants and laborers; tourism assumed at a 5% decline; fisheries assumed at a 4% decline; additional 50% of households recycle.

The loss in environmental value is the most important economic loss, followed by the potential foregone earnings from recycling. After this comes the potential loss to tourism, purchase of bottled water and private health expenditures.

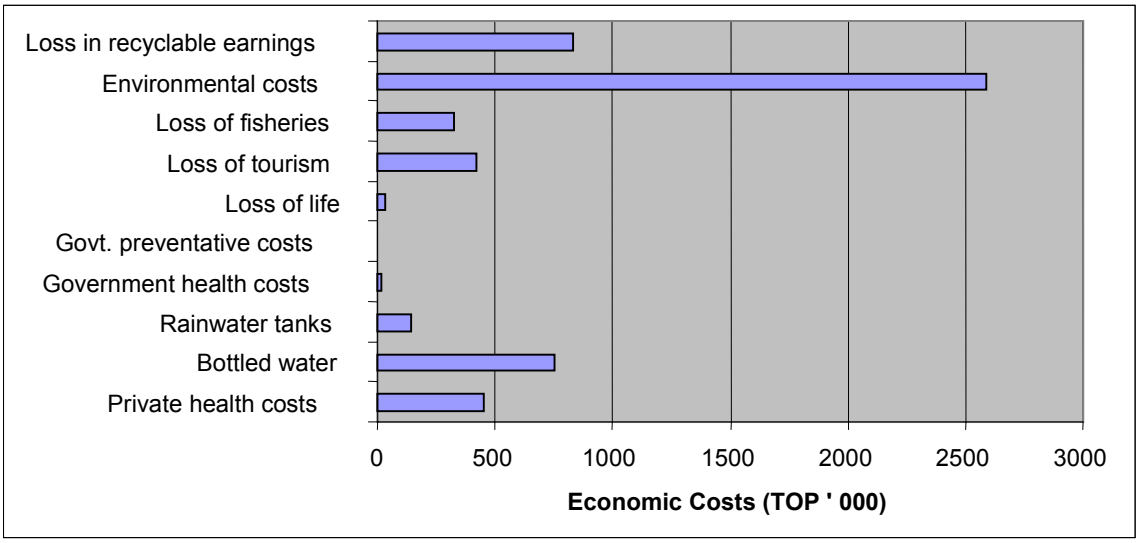

Figure 9: Distribution of economic cost by category

Solid waste-related costs

Direct and indirect economic costs associated with solid waste alone (that is, excluding the effects of liquid waste of human and animal origin) is estimated to be TOP 4 million: TOP 250 per household per year, or TOP 5 per week (see Table 16).

Table 16: Economic costs associated with solid waste only, 2005 (TOP)

Category	High	Best	Low
Total private health cost of solid waste	155,584	133,519	51,861
Government expenditure	n/a	14,342	n/a
Loss of amenity	2,778,890	2,585,210	1,684,176
Loss of tourism	845,000	422,500	169,000
Loss of fisheries	0	0	0
Loss of human life	46,313	29,736	13,158
Loss in recycling earnings	1,664,338	832,169	416,084
Total economic costs	**5,490,125**	**4,017,475**	**2,334,280**
Average household cost	**339**	**248**	**144**
Per week cost	**6.50**	**4.80**	**2.80**

The above estimates reflect only partial costs because some pertinent scientific information was not available. This made it harder to estimate the economic costs associated with these impacts. The estimates provided here thus are merely indicative. When more detailed scientific relational information becomes available, these economic cost estimates must be revised. In order to provide decision makers with more robust information, sensitivity analysis, using high and low estimates of key parameters, is reviewed below.

4.9 Sensitivity analysis

The economic cost estimate of TOP 5.6 million is based on several assumptions (see listing in Table 15). By varying these assumptions, economic costs could be as high as TOP 8.6 million or as low as TOP 3.1 million, with per household estimates varying from TOP 190–530 per household. Direct out-of-pocket financial costs to households vary between TOP 0.6–2.8 million.

4.10 Comparison between total economic cost of waste, households' willingness to pay and the expected average user fee under the Solid Waste Management Project

The total economic cost of losses from poor waste management in Tonga establishes a valuable basis for considering the feasibility of the new waste management system proposed under the SWMP.

The proposed solid waste collection and disposal system for Tongatapu is expected to cost TOP 1.8 million–TOP 2.2 million (John Gideon, SWMP Team, pers. comm., June 2005). This translates into a weekly fee of TOP 3.20–3.60 per household (see Table 17), which is less than the economic costs associated with solid waste only (see Table 16). This fee is greater than the average household WTP of TOP 3.10.[13] If one considers only the operating costs, the average cost recovery fee will be TOP 2.60–3.10 per week, which is closer to what the average household is willing to pay. These fees and the average WTP are, however, lower than average economic costs associated with solid waste of TOP 3.60–9.00 per week per household, including the loss in aesthetic value.

Table 17: Projected operating cost of AusAID-Tongan Solid Waste Collection and Disposal System (Tongan pa'anga)

	2005/2006	2006/2007	2007/2008	2008/2009	2009/20010
Management, operation and maintenance	1,482,253	1,565,326	1,655,824	1,697,638	1,740,146
Depreciation	325,173	342,703	342,703	372,752	372,752
Total costs	**1,807,426**	**1,908,029**	**1,998,527**	**2,070,390**	**2,112,898**
Average cost per household	**167**	**177**	**185**	**192**	**196**
Full cost recovery AC	**3.20**	**3.40**	**3.60**	**3.70**	**3.80**
Full cost recovery minus depreciation	**2.60**	**2.80**	**3.00**	**3.00**	**3.10**

Source: John Gideon, SWMP Team 2005, pers. comm., May 2005

Effects of recycling

With the introduction of a waste collection and disposal fee of TOP 2.60–3.10 per household per week, a household could expect to have an out-of-pocket expense of only TOP 30 per year, assuming the household practiced recycling of products for which there was a local market. Tongatapu households that engaged in waste recycling could expect to earn about TOP 120 from recycling beer bottles, aluminum cans and selected metals.

On the other hand, if the economic value of improvements in aesthetics were considered, Tongatapu residents could expect to be economically better off by about TOP 110 per year, even if they had to pay the average fees proposed under the Tonga–AusAID SWMP in Tongatapu. This assumes, of course, that the households practised recycling. Improved waste management can not only benefit Tongans by reducing health effects and human suffering, and reducing the amount of waste going to landfill, but it can also provide an aesthetically pleasing and clean environment that is free of litter, and prevent loss of life. Each household can contribute towards the sustainable development of their nation through reducing, reusing and recycling solid waste.

[13] The 95 per cent confidence limit is TOP 2.80–3.30 per household per week.

5 Conclusion

The economic cost of residual pollution from poor solid and liquid waste management in Tonga is estimated to be TOP 5.6 million per year, or TOP 350 per household. This estimate is based on partial analysis and reflects direct health costs borne by the people and the Tongan Government, and the financial costs of preventative measures taken by households to avoid health effects of drinking contaminated groundwater. It also reflects the indirect costs of a loss in fisheries output and a loss in tourism earnings due to pollution, economic value of lives lost due to dengue, and non-market economic value placed by Tongans on litter-free clean environment. In addition, it reflects the foregone earnings from not recycling materials for which local markets exist.

The estimates are based on some key assumptions, which were made because of the paucity of scientific information, particularly about the relationship between the nature and volume of waste and human health effects, waste and the quality of the coastal ecosystem and fisheries, as well as waste and tourism and the aesthetic value placed by on a clean environment. A key policy implication is, therefore, an urgent need to develop robust scientific information about the causal relationship between waste and its direct and indirect effects on fisheries, coastal ecosystems and human health.

The results suggest that Tonga could avoid economic loss if solid and liquid waste management were improved and individual households changed their waste management behavior. The economic valuation information could be used as a powerful advocacy tool in encouraging changes in individual behavior. It can be used to better target education programs and extension programs on waste reduction, reuse and recycling. The results also suggest that the government should consider adopting a regular, user-pays collection and disposal of solid waste, such as the program implemented under the Tongan–AusAID SWMP. Even with the proposed level of user charges, households can not only avoid significant costs in terms of human health and minimise expenditure on preventative measures, but they can also be financially better off, if households engage in the recycling of waste for cash.

Appendix A: Sources and nature of pollution in marine and coastal areas of Tonga

Waste from different sources of pollution causes many different problems. The empirical information about such impacts is not well known, however, as summarised in Table A.1 below. Some of these wastes have direct impact on the coastal ecosystem, although the exact functional relationship is not known.

Table A.1: Sources of pollution and impacts on coastal resources

Biological indicators	Status	Pressures and potential impacts	Source(s) of information
Corals	Only 10–20% alive	Heavy sedimentation and poor water quality have killed off patch reefs and their associated fisheries	Kaly (1998, 2001b)
Seagrasses	All seagrass beds in the lagoon are under stress and patchy in distribution Up to 100% cover by epiphytes	Heavy sedimentation, high nutrients and high turbidity are stressing seagrasses, which are important habitats for fish and affect the productivity of the lagoon	Kaly (1998, 2001b)
Mangroves	High human impact Massive clearance and only narrow strip around the capital and villages with few remaining intact areas	Reduction in mangroves leads to loss of fisheries, habitats, foreshore protection and stabilisation and resources for building, crafts and medicines	Ellison (1998), Prescott (2001a and 1992)
	Land allocation and fragmentation	Most of the mangrove area between Nukuhetulu and Veitongo has been assigned for allotments. Losing this area of mangroves is likely to lead to major further damage to an already stressed lagoon.	Ministry of Land and Natural Resources Land Records, Ellison (1998)
	Die back problem	Large area of mangrove dieback from Pea to Mu'a	Ellison (1998)
	Pig damage	Damage to mangrove ecosystems, particularly the growth of young trees	Ellison (1998)
Fisheries	Declining	Many of the fish, shellfish and jellyfish are affected	Spiller (2001), Kaly (1998)
	Fish kill in the lagoon	Several species of silver biddies, tilapia and crabs were washed up on the shore, from the National Centre to Veitongo, during November 1998. Similar events have happened before. Most recent fish kill in a different area in brackish lakes in Sopu, west of Nuku'alofa; tilapia and eels were floating dead during December 2001	

Biological indicators	Status	Pressures and potential impacts	Source(s) of information
Shellfish	No major contamination by metals	Concentrations of trace metals expected to cause health problems are either below the detection limits (<2 mg/kg of dry weight) or similar to values for shellfish in uncontaminated areas elsewhere; however, it was recommended that due to increasing urbanisation and industrialisation, such studies should be carried out on a regular basis (every 1–2 years) and other health problems such as microbiological contamination should be investigated on a regular basis.	Morrison (2000)

Several different causes have been identified. These include:

- lack of waste management policy and planning, and of waste management regulation;
- poorly constructed and run waste disposal depot [Tukutonga/Popua], which would have a detrimental affect on the adjacent coastal waters, due mostly to lack of funding and equipment;
- high level of indiscriminate dumping and burning of solid waste, leading to pollution of air, land and waters;
- little use of household waste collection service despite the low cost;
- little use of secure garbage bins or containers by many premises, leading to littering;
- lack of information on waste generation and characteristics;
- non-biodegradable waste, such as plastics and cans used in packaging;
- little re-use and recycling facilities and opportunities in rural areas;
- high potential to compost organic component of solid waste stream, with plenty of application on local agricultural lands which have a relatively low organic content; and
- disposal of motor vehicles is a problem, with no real disposal option resulting in indiscriminate dumping as the most common practice.

Solid waste re-use and recycling faces the following challenges:

- lack of focus on waste management hierarchy;
- perceived lack of economic viability;
- long distance to recycling markets;
- need to focus on local re-use and markets; and
- control over incoming materials and products (for example, via taxes, tariffs and duty).

Source: (Morrison 1999)

Appendix B: Terms of reference

The Strategic Action Programme for the International Waters of the Pacific Small Island Developing States (SAP/IWP) involves 14 participating Pacific Island Countries: Cook Islands, Federated States of Micronesia, Fiji, Kiribati, Marshall Islands, Nauru, Niue, Palau, Papua New Guinea, Samoa, Solomon Islands, Tonga, Tuvalu and Vanuatu.

The IWP is intended to address the root causes of degradation in Pacific island international waters. It is intended to do this through the use of regionally consistent, country-driven, targeted actions that integrate development and environment needs.

Under the IWP in Tonga, a pilot project has been established to address waste. At the community level, the project is hosted by Nukuhetulu village which provides a case study for addressing waste locally in Tonga. A number of activities have already occurred under the IWP in Tonga including community awareness meetings, waste stream analysis and participatory problem analysis.

To support the work of the IWP in Tonga, an economic evaluation of waste in Tonga is to be conducted. The economic evaluation is intended to assess the losses to the Tongan economy incurred as a result of waste. Where possible, a monetary estimate of the contribution will be determined. However, where relevant data and information are lacking, the evaluation will deliver a qualitative assessment of the economic values involved that can still be used by the Tongan government to inform resource management. In this case, the study will also identify other data required to make decisions in the future.

The major objectives of the evaluation are:

- to provide information for IWP Tonga to highlight the importance of addressing waste through the IWP or other current or future initiatives (advocacy);
- to explore methods, procedures and other issues associated with the economic evaluation of natural resources in Pacific Island Countries;
- to assist in resource management and planning:
    - provide a context for the waste management activities conducted in Tonga, especially (but not limited to) those activities conducted under the IWP;
    - to provide baseline values/descriptions for environmental activities conducted in country.

Focus of the economic evaluation

The economic evaluation will target economic goods and services affected by waste in Tonga. For instance, the evaluation may cover goods and services such as but not limited to:

- water quality;
- fisheries; and or
- tourism.

Phases of the evaluation

The evaluation will occur in two phases. Phase 1 will reflect a scoping exercise in which existing information which is relevant to the economic evaluation of waste in Tonga will be collected and synthesised from an economic perspective. Phase 2 will reflect the actual economic evaluation of waste in Tonga. Phase 2 activities will include a specific capacity building element in which local assistants – research assistants – will participate in evaluation activities with a view to enhancing local abilities to understand, interpret and conduct evaluation excises in the future.

Outputs

The outputs from the economic evaluation will be:

- presentations to the IWP Tonga national coordinator and lead agency, the national task force (NTF, including Project Development Team) and Local Project Committees (if appropriate) at meetings arranged by the national coordinator. The presentations will involve preliminary findings, outline remaining investigations/work to be undertaken and input from meeting attendees into the remaining work as relevant;
- a report on the economic cost of waste in Tonga, outlining sectors affected by waste, activities undertaken, method (s) used to collect and analyse the necessary data, key findings and any recommendations; and
- improved local capacity to prepare for and or conduct economic evaluations of natural resources in the future.

Appendix C: People consulted

Name	Organisation
'Asipeli Palaki	Department of Environment
Dr Lucien	Ha'ateiho Clinic
Dr Malakai 'Ake	Public Health, Ministry of Health
Dr Seini Kupu	Infectious Diseases
Dr Toakase Pele	Paediactrics, Vaiola Hospital
Elevisi Fonua	Ministry of Works
Emily Esau	Tonga Trust
Emily Esau	Tonga Trust
Heimuli Likiafu	Ministry of Agriculture, Forestry and Fisheries
Inspector Mosese Fifita	Environmental Health
Inspector Niu Fakakovikaetau	Environmental Health
Lee and Roger Miller	Waste Management Ltd
Lepa Mafi	Tonga Water Board
Lineni 'Akau'ola	Ana 'Akauola's clinic
Lupe Matoto	Department of Environment
Malakai Vakasioula	Water Board
Malakai Vakasiuola	
Malelupe Vunipola	Tonga Visitors Bureau
Mele Lupe Vunipola	Tongan Visitors Bureau
Melenaite Mahe	Vaiola Pharmacy
Michelle Satui	Central Planning
Monalisa Tukuafu	Aloua Ma'a Tonga
Monalisa Tukuafu	Aloua Ma'a Tonga
Ofa Tu'ikolovatu	GIO Scrap Steel Recycling
'Ofiu 'Isama'u	Environment Health, Ministry of Health
Paea Kolo	Crystal Recycling
Pau Likiliki	Fisheries Department
Paula Taufa	BP
Pisila Matafahi	Ministry of Works
Taimani 'Akimeti	Fasi Pharmacy
Tofavaha Tamo'ua	AusAID
'Ulungaa Fa'anunu	Fisheries Department
Viliami Ika	World Bank Hospital Project, Ministry of Health
Viliami Mahe	Department of Environment
Penny Dutton	
John Gildea	
Sonia Chigrin	
Talita Helu	Solid Waste Management Team

Appendix D: Pre-tested household survey questionnaire

Introduction:

Thank you for agreeing to be part of this survey. This survey is conducted by the International Waters Programme, Department of Environment as part of their International Waters Project. As you may be aware, The Tongan IWP project is about waste and waste management. (Enumerators will have with them the flyer, *DOE 2005: Tonga International Waters Project* on the IWP project, in case villagers are interested in more information.)

The main purpose of this survey is to obtain from the individual households information about the:

- costs of waste disposal and collection, if any
- costs of waste-related human health effects (such as water-borne diseases, vector infectious diseases), including costs associated with doctors visits, medicine, and hospitalisation, if any
- costs associated with measures taken by individual households to mitigate or reduce the chances of having health effects associated with household waste and water pollution.
- how much they may be willing to pay for improvement in solid waste management for a clean environment (that is, free of rubbish lying around) and minimisation of human health effects associated with poor waste disposal.

Instructions:

- Fill in the answers for each question.
- Some answers require you to:
  - circle the appropriate response
  - provide estimates or averages
  - write the answers in words.

Enumerators Only

Village Name ……..... **Household No.** ……

Enumerator name……..... **Respondent Gender:** **Female/Male**

Date …….....

A. Household Details

1. Are you the head of the household? Yes/No

1a. If not, then what is your position in the household?

.....

.....

2. Number of people in household: ..…….

2a. Fill in the following table indicating number of people in each age range in your household.

Age (yrs)	Number
0-4	
5-13	
14-35	
36-55	
>55	

3. Highest level of education in the family

a. Primary e. Secondary f. Tertiary

4. Number of people employed (self or external employment). Indicate if unemployed.

#_____Full Time #_____ Part Time#_____ Casual

#_____ Unemployed

5. Which income range would best describe your household's total income fortnightly?

a. $100 or under

e. $100–$300

f. $300–$500

h. $500–$700

i. $700–$900

k. $900–$1100

l. over $1100

(If casual employment than ask for their total annual income)

6. In your opinion which of these is a priority concern about waste in Tonga (tick only)?

a. littering and looks bad

e. effect on human health

f. effect on environment

E. Household Waste Generation and Disposal

7. What do you store your household rubbish in? For each storage method write down the number of each used in a week.

No./Week

a. plastic bags .....

e. cardboard boxes .....

f. rubbish bin/ drum .....

h. coconut baskets .....

i. no storage—direct disposal to dump

Hazardous Waste

8. What do you understand about hazardous waste?

.....

.....

.....

(Enumerator: to record whatever the villager says, even if not right answer given.)

(Data entry: convert this to note if villagers understands about hazardous waste—Yes/No)

9. For each of the hazardous waste you have at home, tick or fill in the disposal method used.

Types of hazardous waste	**Disposal Method**			
	Burn	Bury	Safe package and store in the house	Other—specify
01. batteries				
02. liquid medication such as cough medicine or solution for cuts				
03. pills/tablets				
04. paint/turpentine				
05. tyres				
06. petrol/kerosene/oil				
07. car batteries				
08. sprays (e.g. mortein)				
09. fertilizers/pesticides				
10. asbestos				

Diapers

10. Do you have a baby in the household? Yes/No (*if no continue to Q11)*

10a. If yes, how old are the babies who use diapers? Years i. …….. months i……..

ii…… ii……..

10e. Please indicate the types of diapers you use

a. cloth

e. disposal

f. both

10f. Please indicate the number of diapers you use per week.

a. Cloth .....

e. Disposal .....

10h. How many cloth diapers have you got? #.....

10i. How much did you pay for this many cloth diapers? $.....

10k. Why do you use cloth diapers?

a. cheaper than disposable diapers

e. chances of getting rash lower

f. reuse for subsequent children

h. environmental reasons

i. other—specify.....

10l. What is the cost of diapers in a week? $.....

10m. Why do you use disposable diapers? (Circle what the villagers say)

a. time saving (from washing)

e. ease of use

f. lower frequency of changing diapers

h. father's preference

i. Other—specify.....

10n. How many elderly people in the household who use diapers? _____

10ng. How many diapers do they use in a week? _____

10o. What is the cost of adult diapers in a week? _____

10h. How do you dispose of used diapers?

a. burn

e. bury

f. take to Popua dump

h. take to bush allotment

i. indiscriminate dumping (bush/sea)

k. regular rubbish collection

l. other – specify.....

Animal Waste

11. Fill in the number of animals you keep at home and tick the appropriate cell to indicate where they are kept.

Animal	Number	Containment status		
		Contained in pen/shed	**Contained but occasional release**	**Free roaming**
Pig				
Dog				
Chicken				
Horse				
Goat				
Duck				

Cat				
Cow				

12. How do you dispose of the animal waste?

a. bury with soil

e. throw to the bush

f. rubbish heap

h. burn when dried

i. leave it as it is

k. compost

Human waste

13. What type of latrine system does your house have?

a. Pit without flush *(answer Q14)*

e. Pit with flush *(answer Q 14)*

f. Septic tank *(answer Q15)*

14. If you have a pit system, how often do you need to dig a new pit?

a. once every 5 years or less

e. once every 5–10 years

f. once over 10 years

Continue to Q 17 on waste disposal methods

15. If you have a septic tank system, how many times did it overflow in the last 12 months?

a. every time it rains (*if answer is (a) cont. to Q16e)*

e. once a year

f. more than once a year

16. What is the main reason for the septic tank overflowing?

a. old and leaking

e. poorly designed

16a. If age is the reason for septic overflow, how old is your septic tank?

a. less than 5 years

e. 5–10 years

f. over 10 years

16e. How often do you have the septic tank cleared?

a. once a year

e. once in two years

f. once in 5 years

h. once in 7 years

i. once over 7 years

k. never

Waste Disposal Methods

17. What types of waste disposal methods do you usually use, and how often you use this method in a week or month?

Disposal method	**# in a week**	**# in a month**
a. Burning		
e. Burying		
f. Take to Popua dump		
h. Take to bush allotment		
i. Indiscriminate dumping (bush, sea)		
k. Regular rubbish collection		
l. Other—specify		

18. In your opinion, what waste disposal method do you think is best for the environment and people? Why?

.....

.....

.....

Garbage Collection Services

19. Do you have regular garbage collection in your area? *yes/no (if no cont. to Q20)*

19a. If yes, do you use it? *yes/no (if no cont. to Q20)*

19e. Which collection service do you use?

a. Ministry of Health

e. Waste Management Ltd

f. Other—specify.....

19f. How much do they charge? $.....

19h. How often do you use the collection service?

a. Once a week

e. Other—specify.....

19i. How satisfied are you with your current waste collection service?

a. very dissatisfied

e. dissatisfied

f. satisfied

h. highly satisfied

19k. What is the main reason for your level of satisfaction in Q19i?

a. costs

e. unreliability

f. improper collection (some waste dropped, and left behind)

Recycling

20. What do you understand about recycling?

.....

.....

.....

(Enumerator to write down whatever respondent says even if not correct.)

(Data entry—convert this to answer the question if the respondent understands what is recycling—Yes/No)

21. Do you **reuse** any of the following items:

a. glass

e. plastic bottles

f. aluminium cans

h. steel

i. copper

k. aluminium

l. food cans

m. other metals

n. paper/cardboard

ng. plastic bags/plastic wrappers

22. Do you **recycle** any of the following items:

a. glass

e. plastic bottles

f. aluminium cans

h. steel

i. copper

k. aluminium

l. food cans

If you do not recycle continue to Q 23, if you recycle continue with Q22a.

22a. Do you use the services of any of the following recyclers (please circle):

a. Atenisi Institute

e. Crystal Recycling (Paea Kolo)

f. GIO Scrap Steep Recycling (‘Ofa Tu’ikolovatu)

h. Waste Management Ltd

i. Royal Beer

k. Other—specify.....

22e. What are some of the benefits to you of recycling?

.....

.....

.....

22f. Of the items that you recycle, which of them do you earn income from?

.....

.....

.....

22h. How long did you collect your recyclable material before selling?

..... months

22i. How much did you earn from your last recycle trade $.....

Composting

23. What do you understand about composting?

.....

.....

.....

(Enumerator to write down whatever respondent says even if not correct.)

(Data entry—convert this to answer the question if the respondent understands what is recycling—Yes/No)

24. Do you compost your organic (green waste and kitchen) waste? Yes/No *(if No cont. to Q27)*

25. What method do you use?

a. throw in the garden/bush

e. proper composting

26. What is the main reason why you do not compost?

a. don't know how

f. don't have garden

h. too much effort

F. Water Source and Supply

27. What is the source of your drinking water?

a. rainwater

b. Tonga Water Board piped water

c. village piped water supply

d. well water

e. bottled imported water

28. Do you buy bottled water? Yes/No *(if No cont. to Q29)*

28a. How many bottles do you buy a week? Indicate the volume size of the bottles you buy.

Number of bottles i..... size of bottles i.....mls

ii..... ii.....mls

iii..... iii.....mls

28e. What is the total cost of bottled water for your household, **per week**? $.....

29. Do you have your own rainwater tank? *Yes/No (if No cont. to Q31)*

29a. How often is your rainwater tank cleaned in a year? .....

29e. How many hours does it take to clean your rainwater tank? .....hrs

29f. For your rainwater tank do you:

a. use filters Yes/No

e. water treatment Yes/No

f. boil water Yes/No

29h. If you use filters or water treatment indicate the number of filters used and/or treatments done in a year.

i. filter .....

ii. water treatment .....

29i. What is the cost of each item?

i. filters $...../filter

ii. water treatment S...../treatment

30. If not drinking piped village or TWB water, why?

a. smell and taste of treated water

e. not available in area

f. fear of health effect

h. other …….

31. What do you use piped (ground) water for? Please circle indicated responses.

a. washing

e. bathing

f. drinking

h. watering the garden

i. general cleaning and household purposes

32. If you use piped water, what is your average water bill each month? $.....

33. In a day, what is the regular number of hours of water supply?

a. 24 hours

e. between..... to.....

34. What is your level of satisfaction with piped water supply (all aspects of it)?

a. very dissatisfied

e. dissatisfied

f. satisfied

h. highly satisfied

(If highly satisfied go to Q 35)

34a. If you are not satisfied with the current of water supply what is the **main** reason?

a. because it makes you sick

e. costs too high

f. taste and smell

h. limited access hours

H. Waste-related waterborne and vector infectious diseases

Separate the costs into cash and inkind costs.

35. Has anyone in your household suffered from any of these listed diseases since the beginning of this year?

- Diarrhoea, Dysentery, Dengue, Typhoid, Ringworm, Scabies, Boils, White spot

Yes/No *(if no cont. to Q36)*

35a. How many adults, children and infants in your household suffered, if at all, from any of the above illnesses? How many days did the disease last for each sick person in the family? How much did the family spend for treatment (include cost for transportation, consultation, and medication)?

Fill out the answers to the above questions by filling in the appropriate table cells.

Note: In administered survey identical tables (see following page) provided for each of the following disease groups:

A. DENGUE FEVER

B. DIARRHEA, DYSENTRY, GASTROENTERITIS

C. SKIN INFECTIONS: SCABIES, RINGWORM, WHITE SPOTS, BOILS

D. TYPHOID

Code for Treatment Outlets: 00: Traditional Medicine,01: Vaiola Hospital/District Health Centre, 02: Private Clinics/Doctors, 03: Pharmacy/Shop, 04: No treatment sought, 05: Other – please specify

Adults								
# Persons	# total sick days	Treatment Outlets						$ treatment
		00	01	02	03	04	05	
Adult 1								
Adult 2								
Adult 3								
Children								
# Persons	# total sick days	Treatment Outlets						$ treatment
		00	01	02	03	04	05	
Child 1								
Child 2								
Child 3								
Child 4								

Infants (0-2 years)								
# Persons	# total sick days	Treatment Outlets						$ treatment
		00	01	02	03	04	05	
Infant11								
Infant 2								
Infant 3								

I. Participation in cleanups

36.This year, did you or any member of the family participate in any community cleanup activities or other voluntary cleanups? Yes/No

K. Willingness to pay

You may be aware that the Tongan Government and AusAID is developing a new collection and waste disposal system, including a new dump site at Tapuhia, Vaini. This new dump site is expected to operate from October of this year (2005).

Household garbage will be collected weekly for all villages in Tongatapu. For the first 6 months of the new landfill's operation, garbage will be collected from the Nuku'alofa area only. This will be followed by the inclusion of all other villages. They too will have regular once a week collection. Each village will have a scheduled collection at a fixed time and day of the week.

When the new national collection system is implemented, you may be asked to pay for collection and disposal on a regular basis.

37. What is your household's expense on:

a. food $_____/ week b. transport $ _____/ week

Set I.

38. Would you be willing to pay $2/week on the collection and disposal of your household garbage?*Yes* __ (Go to Q 39) *No*__ (Go to Q 40)

39. If yes, would you then pay $4/week? ____

40. If not, then would you pay $1/week?____

41 If not then how much would you be willing to pay? _____ $...../ week

42. If you are not willing to pay anything, explain why not.

Set II.

38. Would you be willing to pay $4/week on the collection and disposal of your household garbage? *Yes* __ (Go to Q 39) *No*__ (Go to Q 40)

39. If yes, would you pay $6/week ____

40. If not, then would you pay $2/week?___

41 If not, then how much would you be willing to pay?_____

42. If you are not willing to pay anything, explain why not.

Set III.

38. Would you be willing to pay $6/ week on the collection and disposal of your household garbage_ Yes __ (Go to Q 39) *No*__ (Go to Q 40)

39. If yes, would you then pay $8/week? ____

40. If not, then would you pay $__4___/ week.

41 If not then how much would you be willing to pay? _____

42. If you are not willing to pay anything, explain why not.

References

Bennett, J. and Block, W. eds. 1991. Reconciling economics and the environment. West Perth, Australia: Australian Institute for Public Policy.

Carson, R., M. Hannemann, R. Koppi, R. Mitchell, S. Presser and P. Rudd. 2003. Contingent valuation and lost passive use: damage from the Exxon Valdez oil spill. Environmental and Resource Economics 25: 257-286.

Crennan, L. 2001. Integration of social and technical science in groundwater monitoring and management. Groundwater pollution study on Lifuka, Ha'apai, Tonga, IHP-V Technical Documents in Hydrology, No. 43. Paris: UNESCO.

Department of Statistics (Tonga). 1999. Tonga Population Census 1996: Household Analysis. Nukua'lofa, Tonga: Statistics Department, Kingdom of Tonga.

Ellison, J., 1998. 'First report on development of mangrove environmental management plan for Tongatapu', Tonga Environmental Planning and Management Strengthening Project (TEMPP), Nukualofa, Tonga.

Falkland, T. 2002. A synopsis of information relating to the quality of freshwater and watershed issues in the Pacific region. IWP Technical Report 2002/02. Apia, Samoa, South Pacific Regional Environment Programme.

Freeman, A. M. 1993. The Measurement of environmental and resource values: theory and methods. Washington, DC: Resources for the Future.

Freeman, A. M. 1991. Valuing environmental resources under alternative management regime. Ecological Economics 3(3): 247-256.

Government of Tonga, 2003. Report of the Minster of Health for the year 2003, Ministry of Health, Nukualofa.

Government of Tonga, 2004. Tonga National Health Account, 2001/2002, Ministry of Health, Nukualofa.

Gujarati, D. 1999. Essentials of econometrics. Singapore.

Hajkowicz, S. and P. Okotai. 2006. An economic valuation of watershed pollution in Raratonga, Cook Islands. IWP-Pacific Technical Report no. 18. Apia, Samoa: SPREP.

Hanemann, W. M. 1988. Economics and the preservation of biodiversity. In BioDiversity. E. O. Wilson (ed.). Washington DC: National Academy Press.

Jakobsson, K.M. and Dragun, A.K., 1996. Contingent Valuation and Endangered Species, Ecological Economics, Cheltenham, UK.

Kaly, U. 2001a. Tuvalu waste management project, ecological audit of Funafuti landfill: marine baseline surveys & assessment of site suitability. Funafuti, Tuvalu: AusAID Waste Management Project.

Kaly, U. L. 2001b. Status of Fanga'uta Lagoon, Tonga: monitoring of water quality and seagrass communities 1998-2000. Nuku'alofa, Tonga: Department of Environment.

Kaly, U. L. 1998. Monitoring training and lagoon baseline survey manual: case study - monitoring of Fanga'uta-Fangakakau Lagoon System. Nukualofa, Tonga: Department of Environment.

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

Lal, P. N. 2003. Economic valuation of mangroves and decision-making in the Pacific. Oceans and Coastal Management. 40(9-10): 823-844.

Mitchell, R.C. and Carson, R.T., 1989. Using Surveys to Value Public GOods: The Contingent Valuation Method, Resources for the Future, Washinton, DC.

Morrison, J. 1998. First Report of Environmental Chemist Advisor. TEMPP WP No. 15. Nuku'alofa, Tonga: Department of Environment.

Morrison, J. 1999. Report of Environmental Chemist Advisor. TEMPP WP No. 20. Nuku'alofa, Tonga: Department of Environment.

Morrison, J. 1999. Report of Environmental Chemist Advisor. Nukualofa, Tonga: Department of Environment, Nuku'alofa, Tonga.

Morrison, J., 2000. 'Report of Environmental Chemist Advisor', Tonga Environment Planning and Management Strengthening Project (TEMP), Department of Environment, Nuku'alofa, Tonga, Nukualofa, Tonga.

Orams, M. B. 1999. The economic benefits of whale watching in Vava'u, the Kingdom of Tonga. Albany, New Zealand: Massy University at Albany.

Perkins, F. C. 1994. Practical cost benefit analysis: basic concepts and applications. Melbourne: Macmillan.

Powell, G.. 2006. Analysis of environment-related legislation. IWP-Pacific Technical Report no. 32. Apia, Samoa: Secretariat of the Pacific Regional Environment Programme.

Powell, G. 2006a. Inventory of Tonga's Environment-Related Laws. IWP-Pacific Technical Report no. 31. Apia, Samoa: Secretariat of the Pacific Regional Environment Programme.

Prescott, J. 2006. Profile of institutional elements of the environment sector in Tonga of relevance to the International Waters Programme: An update of the first project coordination unit country visit. IWP-Pacific Technical Report no. 46. Apia, Samoa: Secretariat of the Pacific Regional Environment Programme.

Prescott, N., 2001a. State of the Environment of Tonga. Nukualofa, Tonga: Department of Environment.

Prescott, N. 2001b. Environmental Management Plan for Fanga'uta Lagoon System. Nuku'alofa, Tonga: Department of Environment, Government of Tonga.

Prescott., N. 1992. Country Report on mangrove ecosystem in the Kingdom of Tonga. In Proceedings Seminar and Workshop on integrated research on mangrove ecosystems in Pacific islands region II, ed. T. Nakamura. Tokyo: Japan International Association for Mangroves.

Rogers, N. 2003. Case study on the application of traditional environmental management practices, knowledge and values to solid waste management on Majuro Atoll. Majuro, Marshall Islands: Asian Development Bank.

Sinclair, K. M. 2000. Solid waste characterisation study and management plan for Nuku'alofa, Tonga. Country Report. Nukua'lofa, Tonga, South Pacific Regional Environment Programme and the European Union.

Sinden, J. A. and D. J. Thampapillai. 1995. Introduction to Benefit-cost Analysis. Melbourne: Longman.

Spiller, G., 2001. 'Community Fisheries Monitoring Programme', Tonga Environmental Planning and Management Strengthening Project (TEMP), Nukualofa, Tonga.

SPREP. 2002. Review of priority environmental concerns in Tonga (draft). Apia, Samoa: SPREP.

SWMP. 2004. Nuku'alofa waste audit. Technical Bulletin (1).Nukualofa, Tonga: Solid Waste

Management Project.TEMPP. 2001. Environmental management plan for Fanga'uta Lagoon system, Part 1 Plan. Nuku'alofa, Tonga: Department of Environment.

TEMPP. 2001. Environmental management plan for Fanga'uta Lagoon system, Part 2 Plan. Nuku'alofa, Tonga: Department of Environment.

Tonga Tourist Bureau 2005. Tourist expenditure survey. Nuku'alofa, Tonga: Tourism Bureau of Tonga.

Tongan Visitors Bureau 2005. Tourist Visitors Survey (Draft). Nukualofa, Tonga.

UNDP 2005. Human development report: international cooperation at the cross roads — aid, trade and security in an unequal world. New York: United Nations Development Program.