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Corresponding Author	Family Name	**Richards**
	Particle	
	Given Name	**Esther**
	Suffix	
	Division	
	Organization	Secretariat of the Pacific Regional Environment Programme (SPREP)
	Address	240, Apia, Samoa
	Email	sprep@sprep.org
Author	Family Name	**Haynes**
	Particle	
	Given Name	**David**
	Suffix	
	Division	
	Organization	Secretariat of the Pacific Regional Environment Programme (SPREP)
	Address	240, Apia, Samoa
	Email	

Abstract	The Pacific islands region is as large as it is diverse. Its 22 countries and territories with an estimated combined population of over 8 million extend over an area of 30 million square kilometers—almost a sixth of the earth's surface and three times larger than either the USA or China. Only two percent of this area consists of land mass in the form of about 7,500 islands and coral atolls, around 500 of which are inhabited. The geography of these varies greatly, and can range from large volcanic landforms with steep and mountainous terrain to tiny, low-lying, coral-based atolls (Secretariat of the Pacific Regional Environment Programme 2010).

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Solid Waste Management in Pacific Island Countries and Territories

Esther Richards and David Haynes

1 Introduction

The Pacific islands region is as large as it is diverse. Its 22 countries and territories with an estimated combined population of over 8 million extend over an area of 30 million km^2—almost a sixth of the earth's surface and three times larger than either the USA or China. Only two percent of this area consists of land mass in the form of about 7,500 islands and coral atolls, around 500 of which are inhabited. The geography of these varies greatly, and can range from large volcanic landforms with steep and mountainous terrain to tiny, low-lying, coral-based atolls (Secretariat of the Pacific Regional Environment Programme 2010).

The Pacific island countries and territories (PICTs) are generally classified into three sub-regions, namely, Melanesia, Polynesia, and Micronesia, based on their ethnic, linguistic and cultural differences. Across these three sub-regions, the land masses, populations, economic prospects, natural resources, and political systems can vary widely. A few general characteristics of PICTs are presented in Table 1.

Poor municipal solid waste management is a major threat to sustainable development in the PICTs, with potentially negative consequences on public health, environmental quality, water resources, fisheries, agriculture, tourism, trade, and other areas of national development (Secretariat of the Pacific Regional Environment Programme 2010).

The threats arising from poor solid waste management are made worse due to:

- Increasing rates of waste generation caused by economic and population growth;
- The limited availability of suitable land for landfills on small islands and atolls, exacerbated by customary land tenures, and "not-in-my-backyard" attitudes;
- The remoteness of many PICTs resulting in high capital and operating costs;

E. Richards (✉) · D. Haynes
Secretariat of the Pacific Regional Environment Programme (SPREP),
240, Apia, Samoa
e-mail: sprep@sprep.org

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Table 1 Population and size of pacific Islands

Country or territory[a]	Exclusive economic zone (km^2)[b]	Land area (km^2)[c]	population[c]	Density (people/km^2)[c]	2010 population growth rate (%)[c]
MELANESIA					
Fiji	1,260,000	18,273	847,793	46	0.5
New Caledonia (French Territory)	1,740,000	18,576	254,525	14	1.5
Papua New Guinea (PNG)	3,120,000	462,840	6,744,955	15	2.1
Solomon Islands	1,340,000	30,407	549,574	18	2.7
Vanuatu	710,000	12,281	245,036	20	2.5
MICRONESIA					
Federated States of Micronesia (FSM)	2,978,000	701	111,364	159	0.4
Guam (USA Territory)	218,000	541	187,140	346	2.7
Kiribati	3,600,000	811	100,835	124	1.8
Marshall Islands (RMI)	2,131,000	181	54,439	301	0.7
Nauru	320,000	21	9,976	475	2.1
Northern Mariana Islands (CNMI) (USA Territory)	–	457	63,072	138	−0.1
Republic of Palau	629,000	444	20,518	46	0.6
POLYNESIA					
American Samoa (USA Territory)	390,000	199	65,896	331	1.2
Cook Islands	1,800,000	237	15,708	66	0.5
French Polynesia (French Territory)	5,030,000	3,521	268,767	76	1.2
Niue	390,000	259	1,479	6	−2.3
Samoa	120,000	2,785	183,123	66	0.3
Tokelau (New Zealand Territory)	290,000	12	1,165	97	−0.2
Tonga	700,000	650	103,365	159	0.3
Tuvalu	1,300,000	26	11,149	429	0.5
Wallis and Futuna (French Territory)	–	142	13,256	93	−0.6
Totals	28,066,000	553,364	9,853,135	–	–

[a] This list excludes the Pitcairn Islands, which is a territory of the United Kingdom
[b] *Source* Data of member countries, Secretariat of the Pacific Community Applied Geoscience and Technology Division, 2013
[c] *Source* 2010 Pocket Statistical Summary, Secretariat of the Pacific Community, 2010

- The small and sometimes sparse populations which limit any potential economies of scale; and
- The limited institutional and human resources capacity, and the fact that solid waste financing has not kept pace with growth in waste quantities.

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1.1 Roles and Responsibilities

At the regional level, the Secretariat of the Pacific Regional Environment Programme (SPREP) is an inter-governmental organization that provides technical assistance to 21 PICTs in several priority environmental areas, including waste management and pollution control (Secretariat of the Pacific Regional Environment Programme 2011).

At the country and territory level, roles for solid waste management are sometimes divested to several agencies, or in some cases, one entity bears all the responsibility (see Table 2).

1.2 Regional Challenges and Priorities

While municipal solid waste management is one of the priority management issues for the Pacific region (Secretariat of the Pacific Regional Environment Programme 2011), it cannot be considered in isolation, given the limited human, financial and institutional resources available to many PICTs. Furthermore there are potential synergies to concurrently address multiple waste management issues. It is therefore worth articulating the other (mainly hazardous) waste management priorities, which have been identified by PICTs.

1.3 Asbestos

Construction materials such as cement-asbestos sheeting and roofing, which contain asbestos fibers, have been widely used in Pacific island countries for housing and other buildings, and even though health concerns have led to their phase-out, they are still found in many buildings.

The Pacific is subject to periodic catastrophic weather and geological events such as tsunamis and cyclones, which are highly destructive to built infrastructure and can give rise to asbestos waste. Building maintenance and replacement, and the gradual collapse and disintegration of disused buildings with asbestos materials, also create asbestos waste. As a consequence, asbestos containing materials are, or may become, a significant waste and human health issue in many Pacific countries and management and disposal of asbestos in the region is critical to the maintenance of long-term community health.

A regional asbestos waste management strategy (Secretariat of the Pacific Regional Environment Programme 2011) provides background information and guidance on the health risks associated with asbestos exposure and on best practices in asbestos handling, and presents an integrated framework to progressively assess, stabilize, collect and dispose of asbestos containing materials in the Pacific.

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Table 2 Waste Management Roles and Responsibilities in PICTs

PICT	Coordinating agency[a]	Monitoring agency[b]	Agency for waste management services[c]
American Samoa	American Samoa Environmental Protection Agency	American Samoa Environmental Protection Agency	American Samoa Power Authority
Cook Islands	National Environment Service	National Environment Service and Ministry of Health	Ministry of Infrastructure and Planning
Fed. States of Micronesia	Office of Environment and Emergency Management	Environmental Protection Agency for each State	Department of Transport and Infrastructure in each State
Fiji	Department of Environment	Department of Environment	Municipalities
French Polynesia	Department of Environment	Department of Environment	Municipalities
Guam	Guam Environmental Protection Agency	Guam Environmental Protection Agency	Department of Public Works
Kiribati	Ministry of Environment, Lands and Agricultural Development	Ministry of Environment, Lands and Agricultural Development	Municipalities
Marshall Islands	Office of Environmental Planning and Policy Coordination	RMI Environmental Protection Agency	Majuro Atoll Waste Company
Nauru	Department of Commerce Industry and Environment	Department of Commerce Industry and Environment	Nauru Rehabilitation Corporation
New Caledonia	Departments of Environment (Provincial)	Departments of Environment (Provincial)	Municipalities
Niue	Department of Environment	Department of Environment	Department of Environment
Northern Mariana Islands	Division of Environmental Quality	Division of Environmental Quality	Department of Public Works
Palau	Environmental Quality Protection Board	Environmental Quality Protection Board	Bureau of Public Works (Ministry of Public Infrastructure, Industries and Commerce), and State Governments
Papua New Guinea	Department of Environment and Conservation	Department of Environment and Conservation	National Capital District Commission (for Port Moresby only)
Samoa	Ministry of Natural Resources and the Environment	Ministry of Natural Resources and the Environment	Ministry of Natural Resources and the Environment

(continued)

Table 2 (continued)

PICT	Coordinating agency[a]	Monitoring agency[b]	Agency for waste management services[c]
Solomon Islands	Environment and Conservation Division (Ministry of Environment, Climate Change and Disaster Management)	Environment and Conservation Division (Ministry of Environment, Climate Change and Disaster Management)	Environmental Health Department (Ministry of Health and Medical Services), Municipalities
Tokelau	Department of Economic Development, Natural Resources and Environment	Department of Economic Development, Natural Resources and Environment	Department of Economic Development, Natural Resources and Environment
Tonga	Ministry of Environment and Climate Change	Ministry of Environment and Climate Change	Tonga Waste Management Authority (Tongatapu only), Ministry of Health
Tuvalu	Ministry of Internal Affairs	Solid Waste Agency of Tuvalu	Kaupule (Island Council)
Vanuatu	Department of Environment	Department of Environment	Municipalities

Notes
[a] Entity with primary responsibility for strategic planning and policy development
[b] Lead entity that regulates environmental quality
[c] Entity that is directly engaged in delivering waste management services (collection, disposal, etc.)

Particularly important is the focus on adoption of minimum occupational health and safety guidelines for workers and citizens involved in asbestos handling operations, either as a routine operation or as part of an emergency response scenario.

Adoption of national asbestos management policies by Pacific island countries will also ensure that the regional transport of waste asbestos is controlled through relevant protocols to ensure its safer transport and disposal.

1.4 Electrical and Electronic Waste

Due to the demand for newer technology, the life span of electrical and electronic products is progressively decreasing. Consequently, older and outdated items such as computers, printers, photocopy machines, television sets, washing machines, radios, and mobile phones are becoming obsolete and being discarded in large quantities and at increasing rates worldwide.

The extent of the electrical and electronic waste (E-waste) problem in the Pacific has not been comprehensively documented, however the limited

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information available indicates that the use of electrical and electronic equipment is increasing significantly on an annual basis in PICTs. E-waste contains hazardous but also valuable and scarce materials such as metal and alloys, which can be recovered and recycled. Proper management and disposal of E-waste is therefore important to the long-term protection of local and regional Pacific environments.

A regional E-waste management strategy (Secretariat of the Pacific Regional Environment Programme 2012) provides background information on the health risks associated with E-wastes and provides guidance on best practice in E-waste handling and disposal options through an integrated framework to progressively collect, store and dispose of E-waste in the Pacific region. The development and adoption of national E-waste policies will establish a framework for the Pacific that improves management of E-waste and promotes and enforces responsible E-waste management. This framework is expected to incorporate extended producer responsibility, mandatory recycling fees charged at point of sale and/or import taxes or tariffs to effectively finance eventual recycling of all imported electrical and electronic goods.

1.5 Health Care Wastes

Health care waste is a by-product of modern health care. A majority of health care waste is similar to domestic waste, although a small fraction is infectious and/or hazardous and requires special treatment. This waste fraction includes sharps, blood, body parts, chemicals, pharmaceuticals, medical devices and radioactive materials.

Poor management of health care waste potentially exposes health care workers, waste handlers and the community to potential infections, toxic effects and injuries. The extent of the health care waste problem in the Pacific has not been comprehensively documented, but the limited information available (United Nations Environment Programme Division of Technology, Industry and Economics 2012) indicates that quantities of the waste are increasing significantly on an annual basis in Pacific island countries due to increasing population numbers and improved health services.

Proper management and disposal of health care waste is important for the long-term protection of local and regional Pacific environments and for the protection of public health. A draft regional health care waste management strategy released in 2013 (Secretariat of the Pacific Regional Environment Programme 2012) provides background information on the health risks associated with health care waste and provides guidance on best practice in health care waste handling and disposal options including an integrated framework to collect, store (where necessary) and dispose of health care waste in the Pacific region. Development and adoption of national health care waste policies will establish a framework for the Pacific that improves management of health care waste and promotes and enforces responsible health care waste management.

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1.6 Regional Initiatives

Waste management in the Pacific region is undergoing a transformation. Beginning in the early to mid 2000s, and with consistent support from the Japan International Cooperation Agency (JICA), there was an emphasis on strategic planning for municipal solid waste management with the adoption of the Pacific Regional Solid Waste Management Strategy (Secretariat of the Pacific Regional Environment Programme 2006) and a number of country solid waste management strategies and action plans. This occurred concurrently with investments by JICA and other development partners to deal with waste management across the Pacific islands, including investments in medical waste management facilities, new landfills, waste minimization activities (including the 3Rs—Reduce, Reuse, Recycle; and household composting), and institutional reforms to improve the efficacy of waste management services.

Within recent times, SPREP has partnered with JICA to implement a US$10 million 5-year (2011–2016) project namely the Japanese Technical Cooperation Project for Promotion of Regional Initiative on Solid Waste Management in Pacific Island Countries (J-PRISM). This project aims to strengthen the human and institutional capacity base in 11 Pacific island countries to manage solid waste in a more effective manner. Specific national project outputs have been tailored to each country's needs and priorities.

Complementing the J-PRISM project is the *Agence Française de Développement* (AFD) Regional Solid Waste Management Initiative for €1 million implemented by SPREP—which has a component to deliver a technical, train-the-trainer style waste management course for Pacific islanders. Together, these two projects will increase the human technical capacity to deliver a cleaner Pacific region. A particular focus is on developing capacity for waste minimization such as the 3Rs, as well as waste collection, and waste disposal. The AFD Project will also develop a program for waste oil management across the region.

Fundamental change in waste management practices is likely to be sustained if such change occurs at the community level. For this reason, it is important to engage at the community level to increase capacity and adjust behaviors and attitudes. Each PICT conducts its own awareness and education programs to effect such changes. At the regional level, SPREP simultaneously undertakes broad-reaching regional campaigns to support and strengthen national efforts.

One such campaign was SPREP's Clean Pacific 2012 Campaign (Secretariat of the Pacific Regional Environment Programme 2012), the goal of which was to provide opportunities to enhance awareness of, and support actions for good waste management and pollution prevention policies and practices. Support for grass-roots actions for waste management under this campaign has provided the region with a range of new, community-based case studies to learn from, and provided successful models to replicate in other communities. These included activities such as composting, waste reduction, recycling, litter prevention, and better waste

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disposal solutions which help to maintain a clean environment and help control pollution.

Even with the progress being made through these regional initiatives and other national programs, solid and hazardous waste management remains an ongoing and escalating priority problem for the region.

2 Waste Generation and Composition

The specific municipal solid waste quantities and composition generated by selected PICTs are shown in Table 3. In general terms, the waste stream in many PICTs is dominated by organic (decomposable) waste accounting for 50 % or more of the waste stream. This reflects the largely agricultural-based economy in many PICTs. High dependence on imported goods, increasing economic development, and increasing participation in global trade also contribute to shaping the municipal waste stream, and in all likelihood contributes to increasing proportions of packaging waste (including glass, paper, plastics, metals).

3 Collection and Transportation

Historically, the waste collection systems in many PICTs were characterized by inconsistent and unreliable services—caused by the shortage of appropriate collection equipment, poor management, a shortage of trained personnel and financial resources, and limited availability of supporting infrastructure and equipment such as transfer stations and public bins.

Waste collection programs typically cover the main urban areas, with limited service in the rural areas and less populated outlying islands. The 2011 characteristics of the waste collection system in selected PICTs are presented in Table 4.

With the focused intervention of aid agencies and development partners such as the Japan International Cooperation Agency (JICA), the European Union, the New Zealand Aid Programme, and the Australian Agency for International Development (AusAID), the waste collection and transportation systems in the PICTs are steadily improving.

4 Waste Minimization (Reduce, Reuse, Recycle)

The constraints on waste management resources in the Pacific region demand that waste minimization (reduction, reuse, and recycling) strategies be employed in order to reduce residual wastes requiring final disposal and support more effective and efficient utilization of available resources. However, there are currently only a

Table 3 Waste generation statistics in selected PICTs

Waste component	Municipal Solid Waste composition (%) in selected PICTs				
	Fiji (Nadi Town and Lautoka City combined)[a]	Niue (Alofi) (household waste only)[b]	Samoa (Apia) (household waste only)[c]	Solomon Islands (Honiara)[d]	Vanuatu (Port Vila)[e]
Glass and ceramics	4.1	3.1	2.2	0.7	10.0
Metals	1.9	13.2	8.8	8.5	8.7
Organic matter					
Kitchen waste	33.2	27.7	3.8	47.1	43.6
Grass, leaves	37.2		38.7	2.6	
Paper and cardboard	12.5	9.4	7.2	17.5	12.9
Plastics					
Films	5.8	8.0	6.5	16.8	11.7
Other	1.7	12.6	6.5		
Rubber and Leather	0.1	0	0	0.4	0
Textiles	1.2	0.4	6.8	2.1	0.8
Others	2.3	25.6 (Diapers: 16.3 %)	19.5 (Diapers: 15.1 %)	4.3	12.3 (medical waste: 6.3 %)
Totals	100.0	100.0	100.0	100.0	100.0
Unit waste generation rate (kg/person/day)	1.50	0.31	0.38	0.95	0.97
Average waste density (kg/liter)		0.083	0.160	0.366	0.257
Reported methodology	8-day direct sampling of 86 randomly selected households and commercial businesses during dry and wet seasons	7-day direct sampling of 15 randomly selected households	7-day direct sampling of 40 randomly selected households	7-day direct sampling of 21 randomly selected households and 7 commercial businesses	Three 3-week surveys of waste arriving at landfill

Source

[a] 3R Promotion Manual, Fiji Department of Environment, November 2011

[b] Draft Niue National Solid Waste management Plan, Niue Department of Environment, 2010

[c] Solid Waste Characterization and Generation Study 2012—Vaitele, Division of Environment and Conservation, Ministry of Natural Resources and Environment, 2012

[d] Honiara Waste Characterization Audit Report 2011, Honiara City Council and the Environment and Conservation Division, 2011

[e] Draft Solid Waste Management Plan for Port Vila Municipal Council, Japan International Cooperation Agency, 2008

Table 4 Waste collection service characteristics in selected PICTs, 2011

PICT	Access to regular solid waste collection service in urban areas (% of population)	Frequency of household collection service per week in urban areas (number)
Cook Islands	100	1
FSM	Chuuk State: 20 Kosrae State: 70 Pohnpei State: 60 Yap State: 50	1
Kiribati	35	1
Nauru	100	1
Niue	100	1–3
Palau	100	1
RMI	80–90	1
Samoa	100	1–2
Solomon Islands	60 (Honiara)	1
Tonga	73	1
Tuvalu	80	1–2
Vanuatu	>50 (Port Vila)	3

Source Pacific Infrastructure Performance Indicators 2011, Pacific Regional Infrastructure Facility, September 2011

small number of policies that directly support waste minimization in the Pacific region—all of which favor programs that encourage return of waste for recycling. Specifically, FSM, Fiji, Kiribati, and Palau have enacted beverage container deposit legislation, which offers a full or partial refund of a deposit imposed on plastic and aluminum beverage containers at the time of purchase.

Despite the success demonstrated by these programs, other PICTs seem to lack the political will to adopt similar programs. The challenge in the coming years will be to continue the dissemination of these and other waste minimization success stories and to encourage their adoption by PICT governments.

4.1 Waste Reduction

Waste reduction initiatives in the region often take the form of national and regional education and awareness programs encouraging responsible consumer behavior, such as a 2006 regional campaign promoting the reduction of plastic bag consumption and the use of reusable shopping bags (Secretariat of the Pacific Regional Environment Programme 2006). SPREP's Clean Pacific 2012 Campaign (Secretariat of the Pacific Regional Environment Programme 2012) (discussed earlier) is another example of a regional campaign, which recently targeted grassroots actions towards waste minimization and better waste management.

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For the majority of PICTs, organic waste often accounts for over 50 % of the domestic waste stream (Secretariat of the Pacific Regional Environment Programme 2010), which makes composting an attractive waste reduction solution.

4.2 Composting

Organic waste composting is generally encouraged at source (*i.e.* at the household level) in order to reduce the management (collection, transportation, and disposal) costs of organic waste, and to produce a beneficial soil additive to support subsistence farming. Recovering the nutrient content of waste organic materials through composting (rather than locking it away in landfills and dumpsites) is particularly crucial to small atoll states such as Kiribati, Marshall Islands, Tokelau, and Tuvalu.

The soils on these atolls are typically alkaline with low levels of certain micronutrients essential for plant growth and health (iron, manganese, copper and zinc). Furthermore, since soil fertility depends on the amount of accumulated organic material (Morrison 1990), any organic material locked away permanently in landfills and dumpsites is unavailable to contribute to improving the soil fertility.

The expected improvement in soil conditions and crop health from the application of compost can potentially reduce reliance on imported food crops, and (with appropriate promotion) contribute to healthier lifestyles. Furthermore, the diversion of organic waste from dumps and landfills reduces leachate toxicity and reduces leachate treatment costs.

For these reasons, organic waste composting is a major component of the J-PRISM project (2011–2016), where pilot programs are being (or will be) implemented in Kiribati, Marshall Islands, Palau, Samoa, Solomon Islands, and Vanuatu. Pilot composting projects will also be undertaken in the Cook Islands and Niue commencing in 2013, under a 5-year project (2013–2018) funded by the Global Environment Facility (GEF) and implemented by the United Nations Environment Programme (UNEP), entitled *Pacific POPs Release Reduction through Improved Management of Solid and Hazardous Wastes* (United Nations Environment Programme 2012).

Several demonstration projects for composting have also been completed under the Development of Sustainable Agriculture in the Pacific (DSAP) Project (Secretariat of the Pacific Community 2009), which involves 16 PICTs, namely Cook Islands, Federated States of Micronesia, Fiji, French Polynesia, Kiribati, Nauru, Niue, Palau, Papua New Guinea, Marshall Islands, Samoa, Solomon Islands, Tonga, Tuvalu, Vanuatu, and Wallis and Futuna. Composting demonstration and pilot programs have also been initiated by the Taiwan Missions in the Taiwan-allied countries (Fiji, Kiribati, Marshall Islands, Palau, Papua New Guinea, Solomon Islands, and Tuvalu) as part of their technical assistance program for horticultural crop development.

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Some of the challenges going forward in organic waste composting include establishing steady demand for the compost, minimizing the duplication of past efforts, building on successful initiatives, and developing mechanisms to support accurate recording and reporting of waste diversion rates.

4.3 Waste Reuse

Reuse activities are driven by local entrepreneurs in each country and typically involve repairing goods (e.g., computers, television sets, radios, printer cartridges) to make them usable again, or modifying items to use for a different purpose (e.g., using tires as decorative planters; empty containers for water storage; empty bottles cut to make drinking glasses, or crushed for aggregate). This informal reuse industry provides a vital service by reducing the waste that goes to landfills, but there is very little accurate information at present about the size of this reuse sector in the Pacific Region. A SPREP project (2012–2014) funded through the United Nations Strategic Approach to International Chemicals Management (SAICM)

Table 5 Recycling activities in PICTs

Recycling activity	PICT	Markets for recyclables
Aluminum cans	CNMI, Cook Islands, Fiji, Guam, Kiribati, Niue, Palau, PNG, RMI, Samoa, Solomon Islands, Tokelau, Tonga, Vanuatu	Australia, California-USA, New Zealand, Korea
Scrap metal (ferrous metal)	Cook Islands, Fiji, Niue, Palau, PNG, RMI, Solomon Islands, Tonga, Vanuatu	Australia, China, Hong Kong, Mauritius. India, Turkey, Korea, Indonesia
Paper/cardboard	Cook Islands, Fiji, Palau, Tonga	Australia, Local, New Zealand, Korea
Glass	CNMI, Cook Islands, Palau, Tonga	Local
Plastics (includes foam)	CNMI, Cook Islands, Fiji, RMI, Samoa, Tonga	Australia
Lead-acid batteries	CNMI, Cook Islands, Fiji, Kiribati, Niue, Palau, PNG, RMI, Samoa, Tonga, Vanuatu	Australia, China, New Zealand
Used oil	CNMI, Cook Islands, Fiji, Palau, Tonga, Vanuatu	Fiji, Indonesia, Nauru, New Zealand, Philippines
Tires	CNMI, Fiji, PNG, Tonga	Indonesia, Malaysia, Korea, Vietnam
Electrical and electronic waste (E-waste)	Cook Islands, Kiribati, Tonga	New Zealand, Singapore
Organic waste (composting)	Cook Islands, Fiji, Palau, RMI, Samoa, Tokelau, Tonga, Tuvalu	Local

Source Pacific Regional Solid Waste Management Strategy 2010–2015, Secretariat of the Pacific Regional Environment Programme 2010

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program is investigating options for, and feasibility of reusing the electrical and electronic wastes in-country in the Cook Islands, Kiribati and Samoa.

4.4 Waste Recycling

Waste recycling in the Pacific islands context generally refers to the collection, compaction and shipping of recyclable waste to a recycling facility that is usually located off-island (Secretariat of the Pacific Regional Environment Programme 2010). Various waste recycling activities are being undertaken in PICTs (Table 5), some of which are supported by policies such as container-deposit legislation in the case of beverage containers. In other cases, the absence of sympathetic government policies means that private sector operators rely solely on the economic value of the recyclable materials to support their operation; as such they are more susceptible to fluctuations in the global price of recyclable materials compared to those who operate with the support of government policies.

Two major technical obstacles to cost-effective waste recycling in PICTs are the lack of national recycling and re-processing facilities, and the comparatively small quantities of recyclable waste, which make it uneconomic to transport materials elsewhere for recycling and reprocessing. Some recyclers have also had their shipment of recyclable materials rejected at the port of import due to quarantine violations, which has hampered the development of the recycling sector in those localities. These obstacles are compounded by the absence of a regionally oriented or coordinated recycling mechanism.

The feasibility of establishing such a regional mechanism was investigated by JICA through a 10-month study conducted in 2012. Specifically, the aim was to assess the feasibility of establishing Reverse Logistics and Recycling Ports for five Pacific island countries (Fiji, Samoa, Tonga, Tuvalu, and Vanuatu) (The Overseas Coastal Area Development Institute of Japan 2012).

Reverse Logistics refers to the transportation system for collection of used products and materials and moving those products and materials to remanufacturing points for recycling and/or reuse purposes. Recycling Ports complements the function of reverse logistics, and refers to a terminal for processing and storing recyclable materials that require environmentally-sensitive treatment (The Overseas Coastal Area Development Institute of Japan 2012).

The JICA study focused on bulky wastes (vehicles, white goods, E-waste, furniture, etc.) having the potential to be recycled ("recyclable waste goods"), as well as on recycled waste materials—materials actually processed from the recyclable waste goods (e.g. scrap metal, aluminum and steel cans, plastic bottles, paper, and cardboard).

The preliminary report of the JICA study highlighted a number of barriers related to recycling of bulky wastes and reverse logistics, and proposed several improvement measures including expansion of the collection coverage of recyclable waste goods, improved working standards and conditions at the recycling

companies, enhancing the domestic demand for recycled waste materials, adoption of supportive government policies, formation of a water transportation network for recyclable goods, mechanisms for alleviating high freight costs, and improvement in information provision to ensure compliance at import ports.

5 Treatment and Disposal

The overwhelming proportion of municipal solid waste in PICTs is disposed of on land by way of dumps and landfills, with a small component composted and recycled. However, this method of disposal compounds one of the greatest challenges for many PICTs, which is the availability of suitable land for waste disposal.

Coral atolls such as Kiribati, Marshall Islands, Tokelau, and Tuvalu have very little land space with many competing uses (housing, public infrastructure,

Table 6 Modes of municipal solid waste disposal in PICTs

PICT	Mode of municipal solid waste disposal (Donors involved in original construction and/or rehabilitation are in parentheses)
American Samoa	Anaerobic landfill on Tutuila Island
Cook Islands	Anaerobic landfill on Rarotonga and Aitutaki (Asian Development Bank)
FSM	Semi-aerobic landfill on Kosrae (JICA); Controlled dumpsites on Pohnpei and Yap[a]; Open dumpsite on Chuuk
Fiji	Anaerobic Landfill in Suva (European Union); Controlled dumpsite in Lautoka (JICA)
Guam	Anaerobic landfill with gas management facilities
Kiribati	Controlled dumpsites on South Tarawa (New Zealand Aid Programme)
Nauru	Open dumpsite
Niue	Open dumpsite
Northern Mariana Islands	Anaerobic landfill with gas collection on Saipan
Marshall Islands	Controlled dumpsite on Majuro[a] (JICA); Open dumpsite on Ebeye
Palau	Semi-aerobic landfill in Koror State[a] (JICA)
Papua New Guinea	Open dumpsites in Port Moresby[a] and Kavieng
Samoa	Semi-aerobic landfill on Upolu (JICA); Controlled dumpsite on Savaii
Solomon Islands	Open dumpsites in Honiara[a] (JICA)
Tokelau	Open dumpsites on Fale, Atafu, and Nukunonu Islands
Tonga	Anaerobic landfill on Tongatapu (AusAID, Asian Development Bank), Controlled dumpsite in Vava'u[a] (JICA)
Tuvalu	Open dumpsite on Funafuti (European Union)
Vanuatu	Semi-aerobic landfill in Port Vila[a] (JICA)

Notes

[a] These dumpsites are being improved under the JICA/SPREP Japanese Technical Cooperation Project for the Promotion of Regional Initiative in Solid Waste Management in Pacific Islands Countries (J-PRISM)

farming), and their permeable coral soils contribute to the transfer of pollutants from dumpsites and other above-ground sources of pollution to their underlying freshwater lens.

The availability of suitable land is also an issue throughout the Pacific region because the vast majority of land is held under customary tenure (Wilson 2013), which places ownership with communities or family groups. In most countries, customary tenure accounts for more than 80 % of the total land area (Making Land Work 2008). Where a landfill is to be sited on communal or family land, negotiating a land lease can be a lengthy and complex process, in terms of obtaining consent, and agreement on appropriate compensation, particularly where negative perceptions over past operations of waste disposal sites exist, and because customary land has significant cultural, spiritual, environmental, and economic value (Making Land Work 2008).

Despite the challenges, several PICTs, assisted by donors, have upgraded urban dumpsites or have closed polluting dumpsites and constructed new facilities. The various modes of waste disposal in the PICTs are shown in Table 6. Improving waste disposal facilities and practices is also the focus of the J-PRISM project in the Federated States of Micronesia, Palau, Papua New Guinea, Solomon Islands, Tonga and Vanuatu.

The current approach taken by most PICTs, supported by the J-PRISM project and SPREP is to implement the Semi-aerobic Landfill Method (also known as the Fukuoka Method). When managed properly, the Semi-aerobic Landfill is a cost-effective and speedy method of stabilizing waste with high organic (biodegradable) content (Chong et al. 2005).

The Semi-aerobic Landfill Method is a sanitary landfill method in which leachate and landfill gas are continuously removed from the waste mass through a system of leachate collection and gas venting pipes. With proper design and placement of the pipes, the decomposing waste generates heat, which creates convection currents that draw the ambient air through the network of ventilation pipes located throughout the waste mass. The resulting semi-aerobic condition in the waste mass improves the stabilization process and the leachate quality due to the increased aerobic microbial activity, and releases carbon dioxide compared to the methane released under anaerobic conditions. This is critically important as methane is 21 times more potent as a greenhouse gas than carbon dioxide (over a 100-year period) (Global Warming Potentials 2013).

In many cases, a leachate recirculation system is also installed, whereby the leachate is collected in a pond and re-circulated into the waste layers. The waste mass serves as a biological filter, improving the quality of the leachate after each cycle. Leachate is further treated in the leachate collection pond through mechanical aeration to increase microbial activity, and also by passage through a compact wetland before ultimately being discharged into the environment (Kouji 2007).

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Table 7 Solid waste management legislation in PICTs

PICT	Legislation
American Samoa	Environment Quality Act
Cook Islands	Environment Act (2004) (Rarotonga); Public Health Act 2005; Sewerage Regulations 2008
FSM (Chuuk)	CSL Public Law 02-94-01; Littering Law CSL- 191-33; Recycling Law
FSM (Kosrae)	Kosrae State Constitution, Article 2; Kosrae State Code, Title 13, Section 13.506; Kosrae State Code, Title 13, Section 530; Kosrae State Code, Title 7, Chapter 22
FSM (Pohnpei)	Constitution of Pohnpei, Article 7, Section 1; State Law 3L-26-92, Pohnpei Environmental Protection Act; Solid Waste Regulations 3/30/95; Pohnpei State Law No 6L-66-06
FSM (Yap)	YSL #4-4 Yap State Public Service Corporation; Recycling Program Law (2008); Recycling Program Regulations (Dec 2008); Recycling Finance Law (2009)
Fiji	Waste and Pollution Regulations 2008; Litter Promulgation 2008; EIA Regulations 2007; Environmental Management Act 2005; Public Health Act; Fijian Affairs Act; Municipal Council Byelaws
Guam	Solid Waste Management and Litter Control Act; Guam Environment Protection Agency Act; Guam Environmental Pollution Control Act
Kiribati	Special Fund (Waste Material Recovery Act 2004; Environment Act 1999
Marshall Islands	Conservation Areas Act 1978; National Environmental Protection Act 1984; Public Health Act; Majuro Local Government Ordinance; Littering Act 1982
New Caledonia	New Caledonia Act 1999
Northern Mariana Islands	Resource Conservation and Recovery Act; Litter Control Act 1989; Safe Drinking Water Act; Solid Waste Management Act
Niue	Environment Act 2003; Public Health 1982;
Palau	Public Law 1-58; Palau National Code 34, subsection 1004; Recycling Law RPPL 7-94; Environmental Quality Protection Act; Solid Waste Management Regulations
Papua New Guinea	Marine Pollution Bill (draft); Environment Act 2000 and regulations; Organic Law on Provincial and Local Level Government; Public Health Act; National Capital District Commission Act
Samoa	Waste Management Act 2010; Land, Surveys and Environment Act 1989
Solomon Islands	Environment Regulation 2008; Environment Act 1998; Shipping Act 1998; Agriculture Quarantine Order 1995; Ports Act 1990; Environmental Health Act 1980
Tokelau	Marine Pollution Regulations 1990; Marine Pollution (Dumping and Incineration) Regulations 1982; Marine Pollution Act 1974;
Tonga	Waste Management Act 2005 (Tongatapu); Public Health Act 2008
Tuvalu	Waste Operation and Services Act 2009; Environment Protection Act 2007; Marine Pollution Act 1991; Public Health Act and Regulation 1926
Vanuatu	Waste Operations and Services Bill; Environment Management and Conservation Act Cap. 283 (2002); Bio-security Bill (draft);

Source Pacific Regional Solid Waste Management Strategy 2010-2015, Secretariat of the Pacific Regional Environment Programme, Apia, Samoa, 2010

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6 Legal Framework

Legislation in selected PICTs containing provisions relevant to municipal solid waste management is summarized in Table 7. Some countries have enacted specific laws addressing municipal solid waste management, while in others, broad Environment Acts have been adopted. However, there are still a few PICTs that rely on Public Health Acts for waste regulation, which usually contain inadequate provisions to deal with the complex nature of today's municipal solid waste stream (Secretariat of the Pacific Regional Environment Programme 2010).

In cases where legislation has been enacted, non-compliance is often reported and attributed to low levels of public awareness. There is also limited human and financial capacity within many PICTs to enforce the legislation. This can be compounded by an uncoordinated approach where regulation is spread among a number of agencies without clearly defined roles and responsibilities, lack of consolidated legislation, and social pressure exerted in small communities, where enforcers may be associated with, or related to offenders.

7 Impacts of MSW on Greenhouse Gas Emissions

The Pacific islands region as a whole is estimated to account for 0.03 % of the global emissions of carbon dioxide from fuel combustion despite having approximately 0.12 % of the world's population (Hay and Sem 1999). The specific contribution from the waste management sector has not been assessed, but it is not unreasonable to assume that this would constitute a minute fraction of the region's total emissions.

Low greenhouse gas emissions notwithstanding, the Pacific islands are committed to demonstrating leadership in reducing greenhouse gas emissions through a number of measures including engaging in the Clean Development Mechanism and other carbon-market mechanisms (Secretariat of the Pacific Regional Environment Programme 2011).

The Semi-aerobic Landfill contributes to reductions in greenhouse gas emissions from the waste management sector since the degradation of waste under semi-aerobic conditions favors the production of carbon dioxide over the more potent methane gas. This landfill method (also categorized as passive aeration) is accredited as a new emission-reduction method under the Clean Development Mechanism of the United Nations Framework Convention on Climate Change (UNFCCC) (United Nations Framework Convention on Climate Change (UNFCCC) 2013), and presents a new generation of opportunities for Pacific islands to improve the safe management of waste while simultaneously demonstrating leadership by reducing greenhouse gas emissions.

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Table 8 Potential climate change impacts on waste disposal sites

Change in climate	Impacts
Increased temperatures and extreme heat events	• Accelerated decomposition of organic waste • Higher rate of evaporation—more concentrated leachate • Increased problems with odor and vectors • Increased risk of landfill fires
Increased wet season rainfall	• Increased leachate generation • Flood risks and increased contamination of surrounding environment from leachate • Increased likelihood of anaerobic waste decomposition and increased landfill gas (methane, carbon dioxide) generation
Decreased dry season rainfall	• Increased dust issues • Increased risk of landfill fires

8 Impacts of Climate Change on MSW Management

The adverse and long-term effects of climate change present significant risks to the sustainable development of PICTs and threaten the very existence of some (Secretariat of the Pacific Regional Environment Programme 2011). Climate change impacts such as increased sea level rise, increased rainfall, and increased cyclone intensity can damage waste management infrastructure leading to pollution, which increases the man-made stresses on natural systems such as coral reefs and mangroves and undermines the adaptive capacity and resilience of these natural systems. Furthermore, adverse weather events typically generate disaster waste, which must be safely managed to minimize further adverse environmental and public health impacts.

Potential climate change impacts on waste disposal sites in the Pacific may include those listed in Table 8. Impacts such as increased leachate generation, dust issues, and inundation from floods and storm surges, will exacerbate existing poor operating conditions. Building adaptive capacity within the waste management sector to cope with climate change impacts is therefore an important facet of responding to climate change.

To this end, SPREP with the assistance of the AusAID International Climate Change Adaptation Initiative (ICCAI) is implementing a project in Fiji to integrate climate change adaptation planning into the waste management sector (AdaptWaste Project). The target site is a dumpsite in the town of Labasa on Vanua Levu, the 2nd largest island in Fiji. The dumpsite is an ideal demonstration site for adaptation in the waste management sector since the Labasa area faces the direction from which most cyclones arise, and is susceptible to river flooding, and storm surge inundation.

The anticipated outcomes of the AdaptWaste Project include strengthened capacity within the local council and national government for adaptation planning in the waste management sector, rehabilitated waste disposal site with waste

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diversion programs to better cope with climate change impacts, national guidelines for climate-related disaster waste management, and enhanced public awareness.

8.1 Waste-to-Energy

There is also a growing interest amongst Pacific island communities in exploring waste-to-energy options to potentially reduce dependence on the importation of diesel generator fuel. This interest is being driven primarily by international companies promoting proprietary waste-to-energy technology. A project under development by the Asian Development Bank, also seeks to potentially implement waste-to-energy schemes for the Cook Islands, Palau, Marshall Islands, and Vanuatu.

With the many challenges facing the PICTs (outlined earlier), and an agreed regional goal of adopting cost-effective and self-sustaining solid waste management systems (Secretariat of the Pacific Regional Environment Programme 2010), the Pacific region must take a cautious approach to the adoption of high-tech solutions, particularly those relying heavily on foreign expertise and supplies. All proposals (including those put forward by the Asian Development Bank and other development partners) should be fully investigated from a technical and financial perspective and within the context of possible contradiction with existing waste reduction philosophies, strategies, and programs currently supported in the Region.

9 Local Case Studies

9.1 Waste Minimization and Recycling Promotion in Fiji (Singh 2012)

Fiji with a population of 850,000 largely depends on the importation of goods and materials from the developed countries. Due to its geographical isolation and relatively small recycling market, it is very difficult to recycle waste within Fiji. In addition, finding a suitable landfill site is quite difficult considering local land issues and customary rights.

The Government of Fiji therefore recognized the need to strengthen the capacity of two municipalities—Lautoka City (population of 45,000) and Nadi Town (population of 12,700)—and the Department of Environment (DOE) to promote waste minimization, and embarked on a 42 month technical cooperation project (2008–2012) with JICA entitled “Waste Minimization and Recycling Promotion Project in the Republic of Fiji Islands” (3R Project).

The project scope included: (i) conducting baseline surveys to assess the existing situation and issues relating to solid waste management; (ii) developing Solid

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Table 9 Baseline waste management data of Lautoka City and Nadi Town, Fiji

Parameter	Lautoka city	Nadi town
MSW Generation (ton/day)	48.1	22.4
Household waste generation rate (g/person/day)	432	374
Recycling rate (%)	8.1	2.8
MSW generation rate per person (g/person/day)	1,098	1,902
Budget for solid waste management (Fiji Dollars)	1.06 million (20 % of council's total budget)	1.15 million (28 % of council's total budget)
Highest composition of waste (%)	Grass and wood: 37.4 Kitchen organic waste: 30.1	Grass and wood: 36.7 Kitchen organic waste: 36.4

Waste Management Plans for the two municipalities based on baseline data; (iii) implementing pilot projects to examine the applicability, sustainability and expandability of waste minimization practices such as home-composting, market waste composting, Clean Schools program, separate collection for recyclables, and green waste collection and chipping; (iv) improving the operation and management of the Vunato Disposal Site in Lautoka; (v) developing a wide range of educational tools, which were utilized for extensive awareness raising to citizens through house to house visits, and community meetings; and (vi) expanding viable pilot projects to other areas based on the validity and lessons learnt from the pilot projects.

The key data obtained through the baseline surveys are summarized in Table 9. These results subsequently informed the design of several pilot projects aimed at promoting the 3Rs, including separate collection of recyclables, promotion of home composting, development of market waste composting, green waste collection and recycling, and a Clean Schools program.

As a result of the 3R Project, the total recycling rate was increased from 8.1 % to 10.3 % in Lautoka City and from 2.8 % to 18.3 % in Nadi Town as of October 2011. Concomitantly, the waste disposal volumes from 2008 to 2011 have decreased by 7.8 % in Lautoka City and 38.6 % in Nadi Town.

There were many lessons learned during this project including:

- The importance of learning from others; project staff were able to learn firsthand from the successful experience of Shibushi City in Japan, which contributed to the encouragement and commitment of counterparts to the project implementation.
- The mechanism of joint weekly meetings, which contributed significantly to monitoring and stimulating the progress of the project activities, and also to promoting mutual understandings and friendly working relationships between the two municipalities involved.
- The significant role that all stakeholders can play, in particular the community members in the pilot project communities. The Matavolivoli 3R Pilot Project Committee members in Nadi gained a wealth of experience in practicing the 3Rs

and were effectively utilized as 3R promoters by the Nadi Town Council during the expansion of 3R activities to other communities.

One of the major challenges of the project has been the difficulty in bringing about behavioral change amongst citizens since the 3R concept is a new one and requires voluntarily participation of the citizens to embrace 3R's. Hence, it is expected that the planned enactment of 3R legislation would compel the citizens to engage and practice 3Rs.

In conclusion, the 3R Project is a success story for the Pacific region, wherein vital equipment has been procured and various educational tools, guides, plans and manuals have been developed to assist in promoting and sustaining 3R practices. The technical capacities of the staff from the municipalities (Lautoka City and Nadi Town) have also been greatly developed to support the expansion of 3R practices throughout Fiji and the Pacific region into the future.

10 Towards sustainable waste management financing in French Polynesia (Ebelewicz 2012)

French Polynesia is an Overseas Territory of France with a substantial degree of autonomy. It consists of five main island groups scattered across five million square kilometres and is located midway between Australia and South America (Central Intelligence Agency 2013).

French Polynesia has a resident population of 250,000, and an estimated 200,000 tourist arrivals annually. Increasing goods imports driven by an increasing population have resulted in increasing quantities of garbage generation. Despite the implementation of waste management programs and waste treatment efforts, the problem remains significant in urban areas and in areas of high human visitation (Gabrié et al. 2007).

In relative terms, the management of solid waste is considered to be significantly more technologically advanced in the main island of French Polynesia (Tahiti) than in other Pacific island countries. The current waste management system is operated under contract by a semi-public company, *Société Environnement Polynésien*, and includes:

- a two-bin system for residential waste collection consisting of a grey bin for general waste and a green bin for recyclables, which are further sorted at a Materials Recycling Facility;
- a recycling and transfer center in Motu Uta for direct re-loading of municipal solid waste, and sorting and bailing of recyclable materials (developed at a cost of US$ 5 million (excluding land acquisition costs));
- waste transfer facilities at Punaauia Municipality and Moorea island;

- a fully lined engineered landfill site located in Paihoro, with leachate collection and treatment (aeration and filtration) facilities, developed at a cost of US$6.7 Million (land acquisition costs excluded); and
- a landfill compaction vehicle which achieves a high waste compaction density of 1,000 kg/m^3.

These systems, while being technically and environmentally sound, required financial subsidies by the Government of France for construction and involve high ongoing operating costs, which are currently subsidized.

The cost for solid waste management was previously covered by a 50 % contribution from the French Polynesia Government (financed through a 2 % environmental tax on all imported goods), a 25 % contribution from 12 of the 13 Municipalities involved, and a 25 % contribution from an inter-municipality equalization fund that included a contribution from the Government of France. These funds were used to engage the managing company, *Société Environnement Polynésien,* to establish and operate the environmentally friendly waste treatment processes.

However, the inter-municipality equalization fund was discontinued in 2009, and the contribution from the French Polynesia Government will be phased out between 2012 and 2017. Consequently, the total cost (100 %) of waste management (collection, treatment (recycling), and landfilling) will become the responsibility of each of the 12 municipalities in 2017, to be ultimately financed from user-pay (household) charges.

A new partnership of Municipalities (*Syndicat Mixte*) is to be esablished to replace the role of the *Société Environnement Polynésien*. Ideally, the proposed partnership should include all Municipalities, however, at the time of writing, Faa'a Municipality remains independent and provides its own collection service (unsorted waste) and operates its own municipal landfill. The partnership will be autonomous in managing the services, and will be able adjust rates to achieve full cost recovery. Municipalities will have to systematically increase the household waste charge over a five-year period (2012–2017) to the level required to achieve full cost recovery, otherwise the current solid waste management system operating in Tahiti is unlikely to be sustainable with the present level of household charges.

In 2012, the *Agence de l'Environnement et de la Maîtrise de l'Energie* (*ADEME*—a French Agency responsible for Energy and Environment) was in the process of reviewing the current system of solid waste collection and recycling in French Polynesia, and assessing the cost/benefit of recycling to the island's population, because the unit cost was thought to be potentially disproportionate to the benefits. The outcomes of this review will not only guide improvements in the waste management financing situation in French Polynesia, but will also be an instructive case study for the Pacific region on achieving financial sustainability in municipal solid waste management.

While the waste management systems established by the managing agency in Tahiti are technically and environmentally sound (if not yet financially self-sustaining), many of the smaller, sparsely populated French Polynesian islands

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face similar waste management problems as other Pacific island countries due to the lack of space and the contamination risk to freshwater lenses located at shallow depths (Gabrié et al. 2007).

On these islands, efforts are also being made to establish systems for the collection of bulky and hazardous wastes such as motor vehicles, used oil (lubricants), lead acid batteries, tires, cars and dry cell batteries, with future plans to collect other recyclables such as plastics, cans and paper.

11 Summary

The Pacific islands face many solid waste management challenges as a consequence of their physical and geographic characteristics, economic development and specific cultural practices. Climate change, legacy hazardous waste issues, and emerging priorities in hazardous waste management add to those challenges. However, with the assistance of donors and development partners through various regional and bilateral initiatives, progress is steadily being made to improve solid and hazardous waste management policies, systems and practices throughout the region.

The challenge for the future lies in sourcing seed-financing to enable the adoption of self-sustaining and cost-effective systems that will contribute to preserving and restoring the integrity of the Pacific environment for future generations.

12 Defining Terms

Clean Development Mechanism: A provision under the Kyoto Protocol of the United Nations Framework Convention on Climate change under which emission-reduction projects in developing countries can earn certified emission reduction credits. These saleable credits can be used by industrialized countries to meet a part of their emission reduction targets under the Kyoto Protocol, while the revenue from the sales can be used by the developing countries to implement emission-reduction projects.

Customary tenure: A system of land ownership, where land rights are managed by indigenous communities or family groups according to their unique processes, which are linked to underlying social and spiritual belief systems.

Semi-aerobic Landfill (or Fukuoka Method): An engineered, sanitary landfill that contains a network of leachate collection pipes and gas venting pipes, which facilitate the passive aeration of the waste layers by natural convection induced by the heat of the decomposing waste.

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