



# Local study into local compost production

Live & Learn Environmental Education Tuvalu | 2020



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Tuvalu Food Futures is supported by the Australian Government and Implemented by Live & Learn Tuvalu



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Citation: McClean, A. (2020) Tuvalu Compost Feasibility Study, Live & Learn Environmental Education.

**Disclaimer**

This publication has been funded by the Australian Government through the Department of Foreign Affairs and Trade. The views expressed in this publication are the author's alone and are not necessarily the views of the Australian Government.

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# 1. EXECUTIVE SUMMARY

Tuvalu is the fourth smallest independent state in the world, and as a collection of low-lying atolls with low soil fertility, is particularly vulnerable to climate change associated impacts on the food security of its population. Furthermore, increased reliance on imported foods is leading to poor nutritional outcomes, and an increase in non-communicable dietary related diseases. In this context, compost production is seen as an important climate adaptation and food security strategy for both increasing soil fertility of more traditional land-based agriculture as well as being required to support the development of more innovative raised bed horticulture that is less vulnerable to saltwater intrusion from sea level rise. An example of this is award winning Biofilta “Food Cubes” currently being deployed in country by LLEE under the DFAT funded *Tuvalu Food Futures Project*.

The report explores the possibility for use of **‘incentivized models’ for compost production** with the intention of identifying any factors relevant to Tuvaluan community members or actors in the compost sector that will ensure benefits from development assistance is more effectively maintained over time. While creation of cash income opportunities from compost is a key ‘incentive’ in these models, other non-cash incentives are also explored, including reduced food insecurity, reduced labour burden from agricultural/compost making tasks and links to existing ‘incentives’ associated with traditional culture.

The **regulatory and legal context** around compost making remains limited. A number of key policy documents are in place, including the Integrated National Waste Policy and Action Plan. However, there is no national level strategy in place for developing compost production, no dedicated

budget allocation for this sector, and no licensing or regulatory requirement for the production of compost at a commercial scale within Tuvalu.

*Tuvalu has a strong culture of compost use through its traditional form of pulaka pit agriculture and decades of agricultural extension focussing on this at household level. Census data suggests that at least 48% of households across the country and 66% of outer islands households are engaged in agriculture of some variety. The vast majority of these households make use of a range of home-made compost types, with mixtures differing for pulaka farming, vegetables crops and fruit trees. A gender split between men and women regarding gardening and compost making activities seems to be in place in Tuvaluan households. Women are anecdotally more likely to be engaged in home vegetable production, but less likely to be involved in compost making – primarily due to the labour demands involved in cutting and collecting the feedstocks, and turning the piles.*

In general **demand for compost products** is strong, often outstripping supply both in Funafuti and in the outer islands. Survey data indicates that prices could be raised without reducing demand, and that a market probably exists for a broader range of higher quality products than is currently available.

The **market garden sector** is a key consumer of compost products, primarily through the Taiwanese Technical Mission to Tuvalu's (TTMT) vegetable production gardens on Funafala and Vaitupu islands. The Funafala garden consumes over half of the shredded palm mulch produced by the DoW on Funafuti, leading to periodic supply shortfalls for other customers. Individual market gardeners are very few in number, particularly on Funafuti, where reliance on shop bought food is high and the sale of vegetables for income is seen as a coping strategy for the poorest households, not in line with traditional island culture. However, developing this sector is an important long-term driver of demand for more compost products.

A number of **barriers to consumption and limits to demand** have been identified. Barriers to consumption (such as lack of compost supply in Funafuti and outer islands and the limited range of compost products available) generally seem to be more critical to resolve than limits to demand for compost (such as low engagement in horticulture/agriculture in Funafuti, low income from horticulture generally), which are more associated with the longer-term growth of the sector.

Barriers to consumption are readily addressed through increased volume and range of compost products, and should be seen as the first priority for investment. However, to address limits on demand for using compost products, **incentives for use of compost** have been identified that will need to be built into relevant government and donor community programs, including:

- Using compost to increase income from sales of vegetable produce
- Using compost for home vegetable production in order to reduce the household costs of shopping for fruit and vegetables
- Using compost for home vegetable production in order to increasing household food security and resilience to shocks
- Reducing the labour burden associated with compost making and vegetable gardening through either introducing simpler compost making methods or through providing cheap supply of ready-made compost products
- Linking to traditional Tuvaluan cultural motivations to increase demand for compost

While demand for compost is generally strong, **supply and production of compost** in Tuvalu is variable, and seen as more critical to address at this stage than issues relating to demand.

**Larger scale processing** of shredded palm waste is taking place in Funafuti by SWAT and on outer islands by Kaupules and supported by the DoW. Department data suggests that 400-500m<sup>3</sup> is produced a year in Funafuti and 50-100m<sup>3</sup> a year per outer island (depending on island population) where composting facilities are functioning. While these operations sell their product to the public, SWAT data indicates that they are not currently profitable. This however should not necessarily be seen as a problem. While it indicates there is much scope for improving the efficiency and profitability of this operation, the Government of Tuvalu and the donor community can justify subsidizing compost production as a legitimate investment in national food security. In this context the income stream from compost is a useful benefit but could definitely be increased.

The TTMT in particular uses SWAT mulch as a feedstock to produce a more complete compost product at its two garden sites on Funafala and Vaitupu. TTMT should be seen as a key technical partner in the development of a fledgling compost industry in Tuvalu who could possibly play the following roles in such development:

- Design input on any national and Kaupule level development of new compost products and production systems
- Training and support to staff producing compost within the DoW and the outer island Kaupules
- Assistance with design and implementation of testing and quality control procedures

The key current **limits on compost production identified include:**

- Lack of access to sufficient volume of feedstocks, where production is limited to the supply of green/brown waste collected from households (mostly palm fronds)
- Facilities are currently too small and inadequate
- Composting equipment is currently too small, limited range and rundown – particularly shredders
- Lack of adequate maintenance on existing equipment leading to regular breakdowns (particularly in the outer islands)
- Technical compost making skills in country are low, and access to training is limited
- Lack of testing and quality control
- Lack of available land and limited access to land for increased production (either by SWAT or households) and for harvesting of feedstocks.

Most immediate is the need for improved facilities and equipment for more reliable production – particularly shredders and their associated operations and maintenance systems. However increasing access to possible sources of feedstocks is also critical for any increase in production. Most available vegetation that could be harvested as feedstock for compost production in Funafuti is currently located on private, *kaitasi* or community land, with little incentive for landowners to collect it for processing.

A number of **opportunities to address limits on production** have been identified, including:

- Developing incentivized mechanisms for harvesting feedstocks – either paying individuals for inputs, tendering out supply of feedstocks or establishing plantations.
- Establishing small scale intensive piggeries to harvest manure for compost production
- Use of coconut husk to produce coco-peat – a high quality horticultural product
- Use of other specific ingredients to create higher quality compost products (based on current ACIAR research into Atoll Soil Fertility)
- Limited use of imported agricultural inputs to improve compost production such as EM4 and other composting bacterial inoculants
- More consistent testing of compost products
- Promotion of community level labour sharing arrangements

These opportunities come with some caveats however – harvesting of pig manure can lead to increased risk of disease, while unmanaged harvesting of natural resources for compost making

can lead to environmental degradation and land disputes with landowners. These will need to be appropriately managed in coordination with relevant government departments and key development partners.

**Recommendations** of this report are targeted at five key levels

- **Developing an integrated national level compost strategy** to coordinate national level partners and production, develop further links between Funafuti and the outer islands, and develop links between the compost and agricultural market chains.
- **Upgrading the SWAT compost production site on Funafuti** to increase quality, quantity and range of production through business planning, upgrading facilities, upgrading equipment, sourcing feedstocks, and investing in training and systems development.
- Re-establishing **outer island Kaupule level production** through partnering with Kaupules, upgrading equipment and establishing a robust and well-funded operations and maintenance system for composting equipment.
- **Working with households** on improved compost methods through extension, research and innovative technology such as Bioflta’s “Food Cubes”.
- **Working with Tuvaluan culture** to build community trust in improved methods of producing and using of compost, such as using existing “*fakafenua*” style labor sharing arrangements used on Nanumaea and Nanumanga as models to encourage increased collection of feedstocks and production of compost at a village level across the outer islands





## 2. INTRODUCTION

Tuvalu is the fourth smallest independent state in the world, and as a collection of low-lying atolls with low soil fertility, is particularly vulnerable to climate change associated impacts on the food security of its population.

The production of compost at household, local island and national level has been identified by DFAT, LLEE and others through the *Tuvalu Food Futures* project as a key strategy for improving soil health and supporting household food security.

In particular, there is a key need to produce compost in sufficient quality and quantity to support the rollout of Biofilta's innovative Food Cube 'wicking' garden beds through the TFF in Funafuti and the outer islands.

In response, this Compost Feasibility Study for Tuvalu, commissioned by LLEE under the DFAT funded *Tuvalu Food Futures* project will scope the current compost system and explore possibilities for incentivized models for improved production of compost at household, local government and national levels.

Specifically, the study aims to:

- Provide a detailed overview of current compost production and consumption patterns in Tuvalu including:
  - analysis of current knowledge of composting,
  - practices related to making and use of compost,
  - facilities and equipment,
  - links to the broader food security context and vegetable market chain
  - access to training and education,
  - key stakeholders,
  - land tenure, and
  - links to traditional culture.

- Present viable models with structured incentives for local compost production and provide overall recommendations for further investments in the compost sector.

This report will initially survey the social, environmental, policy and legal context within in Tuvalu as it relates to compost production and use. Findings are presented in three sections: the historical and current use of compost in country; the current demand for compost products and the current production of compost products. In these last two sections, key limits to supply and demand will be considered as well as opportunities for increasing both.

Recommendations are presented for a range of levels including: national level strategy; the capital Funafuti; outer islands/Kaupules; household level; and engagement with Tuvaluan culture. A range of technical data and summaries are included in appendixes.

The proposed use by LLEE of 'incentivized models' for compost production is intended as an approach that identifies any factors relevant to Tuvaluan community members or actors in the compost sector that can be used to ensure benefits from development assistance is more effectively maintained over time. While creation of cash income opportunities is a key 'incentive' in these models, other non-cash incentives are also explored, including reduced food insecurity, reduced labour burden from agricultural/compost making tasks and links to existing 'incentives' associated with traditional culture.



# 3. METHODOLOGY

## 3.1. Approach

The *Tuvalu Compost Feasibility Study* was originally planned to use a primarily qualitative social research approach to investigating the technical and social dimensions of compost production in Tuvalu, as well as examining the costs and benefits of likely models for future production.

However, the spread of COVID-19 virus in early 2020 altered the initially planned method for undertaking field work. No field trip was undertaken by the consultant, with all data collection instead being undertaken by the consultant remotely and the LLEE Tuvalu Team in country. Division of tasks was divided as per figure 1 below.

A number of areas were deemed not possible to complete remotely, in particular the cost benefit analysis aspects of the study. Instead a more brief examination of costs and benefits was undertaken remotely with findings drawn where possible, and areas for further research identified as needed. A broad approach to investigating costs and benefits was used, incorporating monetary, non-monetary, social and environmental costs and benefits. This approach was broadly effective in terms of allowing for consideration of the range of positive and negative impacts that could flow from these models, but still contains gaps due to the remote nature of the data collection.

FIGURE 1: RESEARCH TEAM ROLES AND RESPONSIBILITIES

External Consultant	LLEE Tuvalu Team
<ul style="list-style-type: none"> <li>• Develop Methodology, research tools and all formats required</li> <li>• Brief LLEE Tuvalu Team on research approach, methods/tools etc.</li> <li>• Undertake all Key Informant Interviews online via video conferencing and email.</li> <li>• Literature review</li> <li>• Data entry from questionnaires</li> <li>• Data analysis (questionnaires and interviews)</li> <li>• Report Writing</li> </ul>	<ul style="list-style-type: none"> <li>• Recruit research team</li> <li>• Deploy field level data collection questionnaires</li> <li>• Translation of research forms and questionnaire responses</li> <li>• Contribute to analysis of data collected in field work (together with consultant)</li> <li>• On ground logistics and follow up with interviewees and consultant.</li> </ul>

## 3.2. Data collection and analysis

A mixed approach of data collection was used, including literature review, interviews with key informants and household level questionnaires.

17 semi-structured interviews with key informants were undertaken, 7 in Tuvalu and 10 in Australia and New Zealand (see appendix 8.6 for details).

Questionnaires were distributed to 60 households in Funafuti, Nukulaelae and Nanumanga islands. Forms were filled out by households themselves with limited assistance from LLEE field staff. In comparison to the originally planned qualitative focus groups discussions, this method was not considered ideal but was deemed the only method possible given the restrictions on travel in place due to the COVID-19 pandemic. 39 responses were gathered, with key demographics outlined below.

FIGURE 2: QUESTIONNAIRE RESPONSES DEMOGRAPHICS (N=39)

Category	Number	%
Total responses	39	100%
Men	14	36%
Women	25	64%
Funafuti (indigenous)	15	38%
Funafuti (immigrant)	14	36%
Outer islands (Nukulaelae)	9	23%

## 3.3. Compost specific terminology

The technical language related to compost can be at times complex and ambiguous. Specific terms can be used to convey a range of meanings in English both for technical professionals and lay people. This is similar in Tuvalu where the language around

compost is at times variable, reflecting a wide range in understanding of compost across the community. Therefore, a number of terms require clarification in order for this report to be read clearly. These include the methods and models of compost production, as well as a range of terms referring to the types of compost products being used. See figure 3 below for details.

FIGURE 3: COMPOST TERMINOLOGY AND DEFINITIONS

Term	Definition
Methods of compost production	the practical techniques used to turn compostable material into a composted product. All compost methods considered are listed in Appendix 8.3.
Models of compost production	The organizational/business structure used to implement the production of compost. All compost models considered are listed in Appendix 8.3.
Compost	An organic product that has been through biological transformation (aerobic and thermophilic) through the composting process.
Composting	The process whereby organic materials are microbiologically transformed under controlled conditions to achieve pasteurization and a desired level of maturity.
Pasteurization	A process whereby organic materials are treated to significantly reduce the number of plant and animal pathogens and plant/weed propagules.
Mature compost	Compost that exhibits a high degree of biological stability, ie: does not begin significantly biologically composting again under required conditions.
Australian standard Compost	Any mature composted product that meets tests for pasteurization, phytotoxicity and maturity required for commercial sale within Australia. Not considered to be relevant for the context in Tuvalu, used as reference only.

Term	Definition
<b>Screened Compost</b>	Composted product that has been passed through a screening process to remove large organic particles and foreign objects.
<b>Raw mulch</b>	Any shredded organic product (usually plant materials) that has yet to be composted and is safe for application in public as a surface treatment (excludes inorganic plastics/rock/cement/metals and unsafe organic materials such as animal carcass, raw manure etc).
<b>Pasteurized mulch</b>	Raw mulch that has been pasteurized to eliminate pathogens through a limited composting process.
<b>Composted Mulch</b>	Raw mulch that has been pasteurized and fully composted through a complete composting process.
<b>Fine Mulch</b>	Any mulch (raw/pasteurized/composted) that has been passed through a screening process to remove large organic particles and foreign objects.
<b>Coarse Mulch</b>	Any unscreened mulch (raw/pasteurized/composted)
<b>Potting Mix</b>	A controlled blend of mature screened compost and coarse sand specifically designed for growing plants in pots/containers. May be mixed with a range of fertilizers and other additives (such as seaweed, gypsum, rock dust, vermiculite, perlite, coco-peat, sphagnum moss etc) to produce a range of premium potting mixes and seed/cutting raising mixes.
<b>Coir/Coco peat</b>	The shredded, composted inner husk of coconuts. Commonly used as a replacement for the non-renewable peat moss in potting mixes. Has very high-water absorption properties.
<b>Composted Manure</b>	Any composted product that is composed mainly of animal manure.
<b>Dry litter manure</b>	A raw manure product mixed with dry leaves and/or straw. A common waste product from intensive livestock production.
<b>Liquid compost</b>	Compost in liquid form, either: <ul style="list-style-type: none"> <li>• Where regular mature compost has been added to water for application</li> <li>• Where the composting process has been achieved in a controlled liquid environment</li> </ul>
<b>Compost inoculant</b>	Any mix of bacteria commonly required for the composting process that is applied to a compost pile to begin or boost the composting process. Most commonly this is either a commercially available compost/soil bacteria in liquid form (such as EM4 or similar) or the use of mature compost to seed a new pile.
<b>Feedstock</b>	A technical term for compost ingredients, commonly used in large scale compost production.
<b>Green waste</b>	Commonly used to refer to any vegetation-based waste (fresh or dry), in this report it will instead be used to refer to fresh vegetation waste only, in line with its usage in Tuvalu.
<b>Brown waste</b>	Any dried vegetation waste.



# 4. CONTEXT

## 4.1. Country context

### 4.1.1. General Context

Tuvalu is a small island developing state, located approximately 1000km north of Fiji in the Pacific region. It's population of 10,645 people<sup>3</sup> is spread across 10 small atolls and reef islands, with a total land area of only 26km<sup>2</sup>. The population is primarily Polynesian but retains strong cultural and social links with nearby Melanesian Fiji and Micronesian Kiribati.

The fourth smallest economy in the world, Tuvalu is listed as a Least Developed State by the UN, due to the small size of its economy and limited scope for growth. Primary industries include commercial fishing and subsistence agriculture, with a relatively high number of families dependent on remittances from commercial fishing and income from employment in limited civil service jobs in Funafuti.

Immigration from the outer islands to the capital Funafuti has seen population densities 20 times higher there than in the outer islands, putting pressure on land and agricultural resources.<sup>4</sup> Outer islanders living in Funafuti are 80% of the population on the island, but as a group face a particular set of challenges, with limited access to land and high reliance on limited cash income to support themselves.<sup>5</sup>

Agriculture is declining in Tuvalu, particularly on Funafuti as the dependence on the cash economy grows. However, it is still the major form of economic activity in the outer islands, where subsistence agriculture is primarily traditional *pulaka* pit farming and the main cash crop is copra (processed coconut). Soil quality is generally poor, agricultural production is low and more than 90% of farming households are engaged in subsistence agriculture.<sup>6</sup>

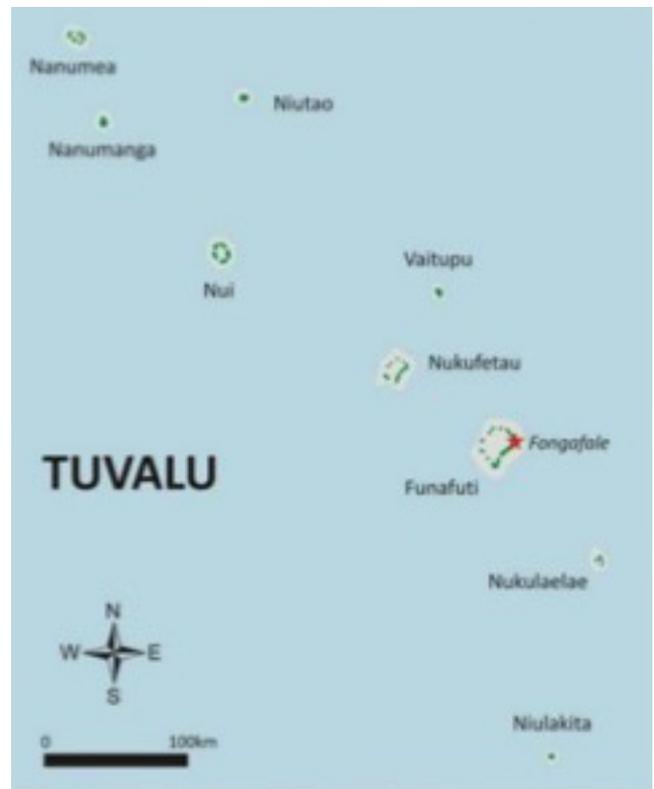


FIGURE 4: MAP OF TUVALU'S NINE ISLANDS (SOURCE: THAMAN ET AL, 2016)

### 4.1.2. Environmental and Climate Change Context

Located in the South Pacific Ocean near the equator, Tuvalu has a tropical maritime climate. Daily temperatures range between 25oC - 31oC with two main seasons recognized: cool/dryer season (April – October) and warmer/wet season (November – March). Annual rainfall ranges from about 2000 mm in the drier northern islands to 3500 mm in the wetter southern atolls<sup>7</sup>. Rainfall is very consistent even through the “dry season” with most households reliant on rainwater for drinking water, and experiencing water<sup>8</sup> stress if rain is less frequent than fortnightly.<sup>9</sup>

As a small island state with an average elevation of 1.83m above sea level Tuvalu is predicted to be one of the first nations to be affected by climate change, with impacts already evident.

Climate change projections for Tuvalu for the period to 2100 include:<sup>10</sup>

- El Niño and La Niña events will continue to occur in the future (very high confidence), but there is little consensus on whether these events will change in intensity or frequency;
- Annual mean temperatures and extremely high daily temperatures will continue to rise (very high confidence);
- It is not clear whether mean annual rainfall will increase or decrease, the model average indicating little change (low confidence), with more extreme rain events (high confidence);

- Incidence of drought is projected to decrease slightly (low confidence);
- Ocean acidification is expected to continue (very high confidence);
- The risk of coral bleaching will increase in the future (very high confidence);
- Sea level will continue to rise (very high confidence); and
- December–March wave heights and periods are projected to decrease slightly (low confidence)

Sea level rise is already having a significant impact on Tuvalu, with ocean inundation a common occurrence during high tides and cyclones. This has immediate impacts on the population and infrastructure as well as contaminating the islands’ limited ground water resources and effecting agriculture, particularly through salt intrusion in the country’s traditional sub surface *pulaka* pit form of agriculture.

At a policy level, climate change is seen by the Government of Tuvalu as a very high priority, with the following policies and strategies in place:

- Tuvalu Climate Change Policy (2012) <sup>11</sup>
- Tuvalu National Strategic Action Plan for Climate Change and Disaster Risk Management 2012–2016<sup>12</sup>
- National Adaptation Programme of Action (2007) Compost is seen in a number of sources as a important part of the climate change adaptation strategy for Tuvalu as it both supports soil fertility in land based agriculture, as well as being required for and raised bed agriculture/horticulture used to avoid the negative impact of salt water inundation of crops from sea level rise. <sup>13</sup>



FIGURE 5: FUNAFUTI ISLAND FROM THE AIR (SOURCE: FUNAFUTI KAUPULE)

### 4.1.3. National Food Security Strategy

Tuvalu faces a unique set of food security challenges, with a distinct split between its outer islands and the capital Funafuti. In the outer islands, reliance on subsistence agriculture is relatively higher but facing impacts from climate change, while in Funafuti where agriculture is almost absent, the population is highly reliant on imported foods and one or two local vegetable producers. The impacts of this are being seen in the decline of engagement in agriculture<sup>14</sup> and the rise of non-communicable diseases (eg: obesity, heart disease, diabetes)<sup>15</sup> and under nutrition (egg: iron deficiency anaemia) across the country.<sup>16</sup>

Food Security is a matter of national importance for the Government of Tuvalu and the donor community in country, with a number of actors currently focusing work on food security in-country, including:

- the Taiwanese Technical Mission to Tuvalu (TTMT) through the Department of Agriculture (DoA);
- The Australian Department of Foreign Affairs and Trade's (DFAT) *Tuvalu Food Futures Project* (TFF);

- the Australian Centre for International Agricultural Research's (ACIAR) *Improving soil health, agricultural productivity and food security on atolls* project; and
- the South Pacific Community's *Global Climate Change Alliance: Pacific Small Island States* (GCCA: PSIS)

Each of these actors have identified production of compost at various levels as a key component of addressing the role that poor soil quality plays in food security in Tuvalu.



## 4.2. Administrative and Legislative Context

### 4.2.1. National Government and Kaupules

Tuvalu is a parliamentary democracy that is administered at a national level by the national Government of Tuvalu and at an outer island level by nine *Kaupules* – the elected executive arm of traditional island assemblies called *Felakaupules*.

As a well-established traditional governance mechanism, the *Kaupules* have a high level of trust amongst the Tuvalu population, and strong links to culture and traditional landowners. They perform a range of local government functions including with relation to planning, local decision making, agriculture, waste management and education for younger age groups. The *Kaupules* are seen as the key local government body at island level, and therefore are an important partner for any compost production initiatives in the outer islands.

Various national departments provide services at island level including agricultural extension through the DoA, and waste management services (including brown waste shredding) through the DoW. Historically provision of these services and management of associated sites on the outer islands has moved between the *Kaupules* and these departments depending on availability of resources (see section 5.1.3 below).

### 4.2.2. Waste management regulation and licensing

There is currently no licensing or regulatory requirement for the production of compost at a commercial scale within Tuvalu.<sup>17</sup>

However, the Waste Operations and Services (WOS) Act 2009 and Environmental Protection Act 2008 (see below) do provide a broad legal framework for the management of solid waste in Tuvalu, with some relevance to the compost making sector, and the Integrated Waste Policy and Action Plan provides key operational direction in the broader sector.

The Solid Waste Authority (SWAT) under the DoW is responsible for coordinating the work of all those involved in the waste sector, including:<sup>18</sup> developing national SWM strategies;

- acting as sector regulator, including management of compliance and performance of all waste management operations in Tuvalu;

- supporting waste management operators in a communicative and cooperative manner by providing necessary technical expertise;
- reporting to the government on the national waste management program; and
- promoting community education and awareness on solid wastes.

The SWAT also runs the solid waste management site in Funafuti and on each of the outer islands, which each include a composting facility for production of shredded mulch from household green waste.

Under the Falekaupule (Local Government) Act 1997, the *Kaupules* have the primary responsibility for providing solid waste collection services to households and businesses, while green waste and other recycling collection is provided by SWAT.<sup>19</sup>

### 4.2.3. Environmental protection, conservation and pollution regulation

Land and sea resources are limited and fragile in Tuvalu, so particular consideration should be given to their protection in any initiatives to increase large scale organic waste processing in country.

Under the Environmental Protection Act 2008, the Department of Environment (DoE) is responsible for ensuring the proper regulation, monitoring, and control of solid wastes to minimize its impact on environmental quality. The DoE is mandated to regulate waste collection and disposal systems and set operational standards by applying guidelines for waste management operations within Tuvalu.<sup>20</sup> This would be of particular importance with regards to ensuring the safe operation of any proposed community piggeries on Funafuti (see section 5.3.3. below), or compost production facility using pig manure or similar hazardous waste.

DoE's responsibilities also include promoting composting and recycling activities and raising public awareness on waste management issues.

The Conservation Areas Act (2008) and Foreshore Licence Regulation (2008) under the Foreshore and Land Reclamation Act (2008) allow for the protection of designated conservation areas and regulation by *Kaupules* of the removal of sand, soil and rocks from foreshore areas. While neither of these currently apply to removal of vegetation from outside of designated conservation areas, these could provide a framework for ensuring the protection of natural resources in the instance of increased harvesting of vegetation/seaweed for compost production feedstocks.

#### 4.2.4. Land Context and Legal Framework

The land context in Tuvalu with relation to agriculture and production of compost is complex, involving traditional and modern notions of land ownership. It is being further complicated by extremely limited available land (less than 26km<sup>2</sup> across the country) and increasing problematic issue of a lack of access to land due to inter island immigration to the capital Funafuti.

Traditionally, land ownership in Tuvalu is managed through the *Kaitasi* system, where extended families are recognized as jointly owning land, represented by a nominated family representative. Each outer island has slightly different arrangements,<sup>1</sup> with village land often being seen as shared community land, and at least two islands (Nanumea and Nukufetau) also recognizing other types of communal land.

The Tuvalu Native Lands Act (2008) provides the national framework for regulation of land ownership in Tuvalu, recognizing private titles, traditional ownerships through the *Kaitasi* system, community/communal land as well as *Felakaupule* and state jurisdiction over land and sea areas and leasing arrangements. The act outlines ownership rights, and arrangements for securing these rights for landowners under the act, including the sharing of profits/benefits from activities undertaken on traditional, communal and leased land.

This notion of fairly sharing profits from shared/leased land is a particularly important issue in Tuvaluan life, with a number of examples of land disputes demonstrating its particular relevance to the agriculture and compost making sector:

- The high number of tenants leasing houses on Funafuti (predominantly immigrants from the outer islands) are typically only given rights under their lease to make use of the area within 3m of their house.<sup>21</sup> This restricts their access to land for horticulture or other livelihoods activities, and also restricts access to vegetation outside this area for use in compost making, leading directly to higher dependence on shop bought food and associated health issues. Removal/over-use of trees/vegetation within this area for compost making is also a potential area for conflict between tenant and landlord, placing a further limit on compost production at household level.

- The successful Nukufetau Women's Initiative ran agricultural activities for nearly 20 years from the 1970s, generating income for members. This was disbanded however in the early 1990s, despite its success, due to concerns from village chiefs that profits generated by the group on communal land was not being appropriately distributed to the community.<sup>22</sup> This example demonstrates something of importance within Tuvaluan culture of the principle of ensuring all that landowners are able to share in profits/benefits from their land (family or communal or otherwise).
- Most available vegetation that could be harvested as feedstock for compost production in Funafuti is currently located on private, *kaitasi* or community land, with little incentive for landowners to collect it for processing. This is further complicated by instances of family representatives under the *kaitasi* system occasionally being incorrectly treated as private landowners under the Native Lands Act. Such instances contribute to a concentration of decision-making power in the hands of fewer landholders, confusion over ownership rights, and lack of clarity about appropriate decision-making processes for harvesting natural resources.<sup>23</sup>

Land is therefore a complicated issue that will need to be treated with consideration and based on proper consultation with affected parties.



FIGURE 6: ADDING COMPOST TO TARO GARDENS IN THE OUTER ISLANDS (LLEE)

<sup>1</sup> Kaitasi is a Funafuti specific term, other islands use different terms for their traditional land tenure systems, although they essentially function in very similar ways.



## 5. FINDINGS

### 5.1. Historical Use of Compost in Tuvalu

#### 5.1.1. Traditional pulaka pits

Tuvalu has a strong traditional culture of compost making through its traditional system of *pulaka* pit agriculture. The *pulaka* or giant swamp taro (*Cyrtosperma murkusii*) is grown across the Pacific and while it is no longer the main staple of Tuvaluan households, it forms a very important part of island culture in Tuvalu and is highly revered.

*Pulaka* are commonly grown in excavated pits or *pela*, dug 1-2m deep through the limestone bedrock to access the fresh water lens below.<sup>24</sup> Artificial

soil is built up in these pits through application of traditional compost called *kaiao* made from a range of dry and fresh leaves, swampy soil and sometimes other ingredients also. Field level questionnaires show that traditional *pulaka* pit farmers are familiar with a wide variety of compost ingredients (see figure 6 below), although methods and recipes are often closely kept within families, so exact ingredients used may vary.

This farming method is currently in decline,<sup>25</sup> and while it is still common in the outer islands it has almost entirely disappeared on Funafuti,<sup>26</sup> where pressures of land availability and salt intrusion into *pulaka* pits threatens its ongoing use.



FIGURE 7: GIANT SWAMP TARO GROWING IN A PULAKA PIT ON FUNAFUTI ISLAND (LLEE)

### 5.1.2. Household compost production

Household compost production for a range of uses is very common across Tuvalu, primarily based on the population's existing familiarity with *pulaka* pit compost making. 85% of household questionnaire respondents (n=39) reported making and using compost at home, for vegetable gardening (51%), traditional agriculture (35%), and agroforestry crops (31%).

A number of agricultural development projects have provided extension support and training to households for improved compost production, going back as far as the 1970s, including:<sup>27</sup>

- 1970s: DoA established demonstration gardens and extension services on all outer islands
- 1980s: Save the Children & UNICEF home garden project
- Late 1990s: SPC & EU funded agriculture project on composting for atolls, which promoted the popular PRAP "fast composting" method, using a mix of soil, manure, green leaves, dry leaves and coconut husk applied directly to trenches for underground composting and rapid 2-week processing time before planting. This is now the preferred method taught by DoA extension staff.
- 2000-2010: EU funded DSAP program which promoted a similar method to PRAP (mostly based on research in Kiribati), but with increased green leaf content, 8 week production time and higher labour requirement than PRAP, mostly in turning compost regularly.
- 2013-2015: – SPC and EU funded Climate change Adaptation Project
- 2003 – present: the Taiwanese Technical Mission to Tuvalu (TTMT) has provided technical training DoA staff, including in household and demplot composting methods.

### 5.1.3. Municipal and National level projects

A number of larger scale compost production sites have been in operation in Tuvalu in recent years, and at smaller scales going back to the 1970s.

The DoA has been producing its own compost on site at demonstration plots (demplots) on outer islands since establishment in the 1970s. Methods used are the PRAP method and open piles, with production primarily for their own use on site. Many of the demplots were taken over by the *Kaupules* to ensure day to day management, with ongoing occasional support from DoA extension staff dependent on funding.

Since 2003, the TTMT has provided technical assistance to the DoA, including the establishment of 2 vegetable production sites on Funafuti and Vaitupu island where it produces its own compost using shredded palm waste from SWAT and pig manure (see section 5.2.1 below for details).

The DoW 's SWAT established green waste processing facilities on Funafuti in 2013 with EU funding to purchase a commercial chipper/ shredder. SWAT collects yard waste from households (primarily dried palm fronds and mixed leaf litter) and processes it into a partially composted shredded mulch product for sale to household and institutional customers.

Similar smaller green waste processing operations have also been in place in the outer islands from as early as 2010. DFAT funded smaller commercial chippers for use by the *Kaupules* to process similar household yard waste into shredded mulch. However, issues with maintenance has led to regular breakdowns in this service, leading to it being taken over by SWAT in 2016. There are some indications this may be temporary arrangement, as the Tuvalu Integrated Waste Policy and Action Plan stipulates this service as the responsibility of the *Kaupules*.<sup>28</sup>

## 5.2. Current Compost Demand and Consumption

### 5.2.1. Compost Consumer Profiles

#### Traditional *Pulaka* Farmers

As referred to above, *pulaka* farming is a very important part of traditional island culture in Tuvalu, and is highly revered. It is still very common in the outer islands where around 50% of households still grow this crop, but is almost dying out on Funafuti, where it is grown by fewer than 1% of households (see figure 2 below). *Pulaka* farmers always make their own compost, using a very specific mix of green leaves, dry leaves soil and sometimes other ingredients. Recipes and methods for making *pulaka* compost are closely guarded within families and the winner of the largest *pulaka* competitions at traditional island festivals called *nafa* are highly esteemed. It is not expected that *pulaka* farmers will engage in the purchasing of compost for their *pulaka* pits. Instead interventions in this area should focus on the preservation and improvement of *pulaka* cultivation for nutritional and cultural ends.

#### Subsistence Vegetable Gardeners

Around half of Tuvaluan households engage in some level of agriculture (see figure 2 below) with over 90% of the crops grown being used for subsistence purposes.<sup>29</sup> Agriculture in general is more common in the outer islands than in Funafuti where immigration is high and access to land extremely limited. Tree crops such as banana, coconut, breadfruit and toddy are generally more common than vegetable crops. However, vegetables such as pumpkin and sweet potato are still grown by almost half the households in outer islands.

The compost types used for tree crops and vegetable gardening differ. Vegetable gardeners use a homemade compost either based on the DoA methods or use a traditional compost in their vegetable gardens. A small number report using the DoW 's shredded mulch as a feedstock to make this compost. For tree crops, a coarse mulch made of green and dried leaves is piled around the trees and left to breakdown into humus naturally. Again, a small number report using the DoW 's shredded mulch as a feedstock to make this compost.

Key informant interviews backup the questionnaire evidence showing that these groups (vegetable and tree crop growers) are prepared to pay for shredded mulch as an input on subsistence vegetable and tree crop production, even though these households do not gain income from the production.



FIGURE 8: A TUVALUAN FRAMER ADDING TRADITIONAL COMPOST OR 'KAIAO' TO HIS PULAKA (GIANT SWAMP TARO) ON NUKULAEALAE ISLAND (LLEE).

Figure 4 below shows the percentage of households Funafuti and the outer islands that grow the most common vegetable and tree crops. This reflects the potential number of households who may hold interest in purchasing shredded mulch.

**FIGURE 9: HOUSEHOLDS ENGAGED IN AGRICULTURE BY CROP TYPE**

	HH Total	HH growing cash crops <sup>2</sup>	HH growing subsistence crops <sup>3</sup>	HH growing tree crops <sup>4</sup>	HH growing Pulaka
<b>Funafuti</b>	849	82 (9.7%)	20 (2.4%)	263 (31.0%)	11 (1.3%)
<b>Outer Islands</b>	777	81 (10.4%)	280 (36.0%)	515 (66.3%)	383 (49.3%)
<b>Total</b>	1626	163 (10.0%)	300 (18.5%)	778 (47.8%)	394 (24.2%)

Data sourced from Tuvalu Census 2017<sup>30</sup>

### Market Vegetable Gardeners

The local cash market for vegetables in Tuvalu is very limited. National survey data suggests that at best only 7%-8% farming households report growing the most commonly sold vegetables (cucumber and pumpkin) for the purpose of selling.<sup>31</sup> These crops are more commonly grown in Funafuti than subsistence vegetable crops, perhaps indicating that a very small number of gardeners there occasionally sell some of what they grow. Anecdotally however this is very uncommon and looked upon as a necessity of the very poor.

In general, not enough data about market gardeners is available in any of the sources reviewed or field data collected, probably because so few households engage in this activity. However, this is an important group in the overall compost value chain, both as a potential growth market for commercially available compost products and as a potential driver of demand for these products.

It is assumed that small market gardeners (where they exist at all) are currently making, buying and using compost in a similar fashion to subsistence vegetable gardeners, because they are most likely just subsistence farmers who occasionally sell their crop. If they are to develop into more market gardeners proper, it can safely be assumed that they will need access to a higher quality, screened mature compost product than is currently commercially available in country. It may be possible that they will eventually be willing to pay for it (or its constituent ingredients if they wish to make it themselves on site), and most likely at a higher price than is currently the case, particularly if income from vegetables increases in the future.

A number of limits to the development of the local vegetable market currently exist, and are discussed more fully in section 5.2.3. below.



**FIGURE 10: A TYPICAL RURAL HOME IN TUALU, SHOWING TREE CROPS INCLUDING: BREAD FRUIT, BANANA, COCONUT AND PANDANUS (LLEE).**

2 Based on census data for most commonly grown cash crop, cucumber.  
 3 Based on census data for most commonly grown subsistence crop, taro.  
 4 Based on census data for most commonly grown fruit tree crop, banana.

## Ministry of Agriculture Demonstration Plots

As recorded above, the Ministry of Agriculture established demonstration gardens on each of Tuvalu's islands as part of their extension work in the 1970s. These gardens have served as training centers, demonstration sites, and production plots at various times over their history. Many now are only sporadically used, with Ministry of Agriculture extension staff often lacking the funds to be able to travel to the outer islands to implement their activities.

These sites periodically order shredded mulch to make compost from either the DoW on Funafuti or from the Kaupules on the outer islands. However, their requirements vary as activity levels at their sites fluctuate, and as their training program varies throughout the year.

## The Taiwanese Technical Mission to Tuvalu

The Taiwanese Technical Mission to Tuvalu (TTMT) has established two horticultural production sites on Funafuti (the "Garden of Friendship") and Vaitupu (the "Garden of Hope") islands since its mission began in 2003. These gardens are both the largest local supplier of fresh fruit and vegetables to the local market in Tuvalu, and also the largest consumer of compost, ordering 45m<sup>3</sup> of shredded mulch every 2-3 months from the DoW in Funafuti. They use this to produce 8-10 tonnes of high quality mature compost a month at their Funafuti site, by mixing it with pig manure and possibly imported ammonia.

TTMT has the highest technical expertise in compost production and quality control available in Tuvalu. It plays an important role both within the Ministry for Agriculture in the technical training support they provide to extension officers, as well as being the most important source of fresh fruit and vegetables available within the country. However, they have so far declined to sell the compost they make in bulk and would probably be unwilling to buy improved compost products from the DoW were such products available (as they can make it themselves). TTMT currently takes up a large proportion of the available shredded mulch supply from the DoW leading to fluctuations in the availability of this product at times.

TTMT should be seen as a key technical partner in the development of a fledgling compost industry in Tuvalu rather than a supplier of compost products (see section 5.3.1. below). It can also play a key ongoing role in providing a constant high level of demand for shredded mulch to the DoW and high-quality vegetable production – both of which will be necessary to support the development of a commercial compost and vegetable industry in Tuvalu.

## Institutional Consumers

A number of local institutions currently purchase shredded mulch from the DoW (the hospital, the University of the South Pacific, schools etc). Anecdotally some of this mulch is used raw for amenity landscaping and some is made into compost on their site. Consumption patterns and volumes are not known, but interview responses suggest that were supply more reliable these customers may well buy product regularly.

In the outer islands, schools with gardens also occasionally procure shredded mulch from the Kaupules or Department of Waste. However, these gardens are small, and it is not known if there is any likelihood of increased uptake of these products were production improved.

## Biofilta Food Cubes

As referred to above, The Australian Department of Foreign Affairs and Trade, along with Live and Learn Environmental Education and Biofilta, have introduced Biofilta Food Cubes into Tuvalu as an innovative approach to addressing climate change and food security in the country. They are essentially a modular "wicking bed" (or bottom watering) type garden bed technology.

Currently there are 400 "Food Wall" gardens (0.25m<sup>2</sup> stackable units) and 80 "Food Cube" gardens (1m<sup>2</sup> units) delivered in country by Biofilta. Of these, the Food Walls have been distributed primarily to 40 households in Funafuti, most of whom continue to use them (although not all). The 80 Food Cubes have been deployed as a community scale production site at Funafala, however only 30 are currently in use due to lack of available compost/ growing medium to fill them.

These units represent a very good opportunity to address a number of climate and land related issues leading to food insecurity in Tuvalu, however the lack of available compost is currently a barrier to their rollout and is the catalyst for this consultancy.



FIGURE 11: BIOFILTA 'FOOD WALLS' BEING USED FOR HOME VEGETABLE PRODUCTION (LLEE)

## 5.2.2. Compost Consumer Numbers, Volumes and Pricing

### Volume Estimates

Estimating volumes of compost currently used and purchased within Tuvalu is very difficult given the nature of data collection that was possible due to COVID-19 restrictions.

Estimates of the volume of compost purchased based on sales data from the DoW suggest a conservative figure of 400-500m<sup>3</sup> of compost being purchased annually on Funafuti.<sup>32</sup> Department staff report this figure could be higher if production volumes were higher and more consistent with customers often required to pre-order or wait to purchase product.

To estimate volumes for the outer islands, production estimates from Nukulaelae island were used. Here rough estimated from Kaupule staff suggest approximately 1m<sup>3</sup> produced in a normal week, giving potentially 40-50m<sup>3</sup> consumed per year - a relatively small volume. Given that Nukulaelae is a small island of 57 households (compared to an average of 97 across all outer islands), consumption is likely higher on larger islands with more households - similar to production (see section 5.3.1 below).

### Consumer Numbers and Consumption

A little over half of the raw mulch produced annually by the DoW on Funafuti is consumed by the TTMT garden, who purchase 300 bins (approx. 45m<sup>3</sup>) every 2-3 months. The rest is purchased by a mix of other institutional consumers (see above) and household consumers (ratio unknown).

The TTMT gardens therefore represents a very significant and reliable customer providing certainty of sales for any future expansion of the Department's operation. However currently the volume of mulch it orders leads to supply shortfalls to other customers, as overall supply is limited by feedstocks (see below) and TTMT's consumption patterns are large and infrequent compared to other customers.

Questionnaires with farmers/gardeners on Funafuti (n=30) show that approximately 29% of gardeners using compost sourced it from the DoW as shredded waste. The percentage is slightly higher for vegetable gardeners (35%, n=14), the most common group within this consumer group. While this is a very small sample, so not reliable, were this data figure extrapolated across the country, this would mean a current market of approximately 127 households purchasing compost (figure 3). This should be balanced by various sources reporting that demand for compost is higher than supply, so numbers could in fact be higher than this.

FIGURE 12: ESTIMATED HOUSEHOLD COMPOST CONSUMER NUMBERS

Location	Estimated number of households who engage in vegetable production	% vegetable growing households that purchase compost
Funafuti	82	35% (n=28.7)
Outer Isl <sup>33</sup> ands	280	35% (n=98)
<b>Total</b>	362	1 <sup>34</sup> 26.7

The Figure above shows that currently around a third of households on Funafuti and outer islands grow vegetables, and of those only a third purchase compost. Interviews in both Funafuti and the outer islands confirm demand for this product is often greater than supply indicating both the number of households purchasing and total volume of compost purchased could be higher if supply limit were resolved.<sup>35</sup>

### Pricing

The price of compost is currently \$2.00 per 150L bin or \$13.33/m<sup>3</sup> at the DoW in Funafuti.

High demand indicates that prices could be set higher than they currently are, a fact confirmed in survey data also, where almost 30% of respondents (n=23) across Funafuti and Nukulaelae said they were prepared to pay more for compost than they currently do.

No reliable market survey data exists to guide new pricing, but a conservative increase to a price of \$2.50 - \$3.00/150L or \$16.66-\$19.95/m<sup>3</sup> could be potentially trialed once supply limits are addressed.

A separate pricing structure could also be considered were a higher quality screened and mature compost product to be produced on site.

### 5.2.3. Limits on demand and barriers to consumption

A number of barriers to consumption and limits to demand have been identified. Barriers to consumption<sup>5</sup> generally seem to be more critical to resolve than limits to demand<sup>6</sup>, which are more associated with the longer-term growth of the sector.

#### Barriers to consumption

**Lack of compost supply in Funafuti** is a key limit to increased consumption of compost in Funafuti, where demand is often greater than the available supply.<sup>36</sup> Larger customers often pre-order to ensure availability, and smaller customers are at times required to wait for available supply in order to purchase. This is primarily the result of limited supply of feedstocks and processing facilities (see section 5.3.3 below).

**Lack of compost supply in outer islands** is also a key limit to increased consumption of compost in the outer islands, where demand is anecdotally greater than the available supply.<sup>37</sup> Traditional and household composting is much more common here, so it is less of a critical gap, and appears to be directly related to the function and upkeep of existing DoW and Kaupule shredders on the outer islands (see section 5.3.3 below).

The **Limited range of compost products available** prevents further uptake by consumers. The only product available for purchase is the Department of Waste’s shredded mulch – no mature compost product or specialty products (eg: screened compost, coco-peat, potting mix etc) are available for purchase. Many consumers are aware of the benefits of mixing pig manure with shredded mulch to make a more complete mature compost product. Some consumers are also willing to pay more for compost than they currently do (see section 5.2.2 above) indicating a potential market for this product produced at scale.

#### Limits on demand

**Low engagement in horticulture/agriculture in Funafuti** is a key factor limiting household demand for compost products in Funafuti. This is a complicated issue that has a number of contributing drivers, including: the declining interest of youth in agriculture as a career; overall small arable land area available and poor quality soils; lack of land access to the high number of outer island immigrants in Funafuti; and the relative availability of paid employment compared to the outer islands leading to reliance on employed family members for support. This complex set of issues is already being addressed by DFAT’s *Tuvalu Food Futures* Food Security program in Tuvalu, and so will not be addressed in any further detail here. This study will assume that any success in the TFF would increase the number of households engaged in agriculture and therefor increase demand for compost products.

5 Defined as any factor that impedes a customer’s ability to purchase compost without effecting their demand for the product.

6 Defined as any factor that reduces a consumer’s motivation (or demand) for purchasing compost products.

**Low income from horticulture** is probably a limit to demand for compost, although must be qualified by interview and questionnaire responses confirming that many gardening households are happy to pay for shredded mulch, even if they are using it for subsistence production (ie: no income gained from production).<sup>38</sup> The key contributing issues here appear to be a very limited local market for vegetable producers both in the outer islands and in Funafuti (which is primary supplied by TTMT); the lack of reliable transport for outer islanders wishing to transport produce to market in Funafuti; little fresh fruit and vegetables being sold in local supermarkets; and the importation of fresh fruit and vegetables from Fiji for hotels and the tourism sector.

#### 5.2.4. Opportunities for increasing demand – incentives

This study is focused on exploring incentivized models for compost production in Tuvalu. Research findings have identified a number of incentives that could be used to increase demand for compost at a number of levels.

**Increasing income from sales of vegetable produce** through development of a small-scale market gardening industry should be seen as an important mechanism for increasing demand for compost products in Tuvalu. The links between the compost value chain and the fresh fruit and vegetables value chain are key to ensuring the long-term growth of the agricultural sector in Tuvalu and flow on effects for driving demand in compost products. A market chain analysis for this sector is already planned as part of DFAT's *Tuvalu Food Futures* program and the Government of Tuvalu has plans for the development of an Agricultural Sector Plan and a pricing study as part of its *Tuvalu Agriculture Strategic Marketing Plan 2016–2025*.<sup>39</sup> The existing Tuvalu Coconut Industry Roadmap could be a useful model here. If realised these should provide a pathway for the development of demand for compost from the small-scale agricultural sector in Tuvalu. However, it should be noted this is a long-term investment strategy, unlikely to show results in the short term.

**Reducing the household costs of shopping for fruit and vegetables** is a key incentive for many households already engaging in vegetable gardening – particularly in Funafuti where reliance on market purchased food is high. By producing their own vegetables at home, less expenditure of vegetables for daily consumption is required by the household. Continuing to use technologies such as Food Cubes and other small-scale intensive household

vegetable production methods will help to engage these households in gardening and increase demand for compost products. Outer islanders leasing in Funafuti should be a key target group here with high need for low land use gardening technologies and high incentive to purchase compost products even if they make no income from vegetable production.

**Increasing household food security and resilience to shocks** is a similar incentive for engaging in household food growing, particularly in the outer islands where store purchased food is comparatively less common than on Funafuti. Demand for compost products on Nukulaelae already is higher than supply (see above) and is probably also the case on other islands. The impact of the COVID-19 crisis on transport and delivery of imported food into Tuvalu has underlined how reliant the population is on this food source and how much of a need there is for reducing this reliance through household food production (among other strategies).

**Reducing the labour burden associated with compost making and vegetable gardening** is a key strategy for addressing commonly reported reasons for disengagement in food growing. A range of options are available to increase the demand for compost through labour saving approaches including:

- Promotion of quick composting methods and microbial additives (such as EM4 or similar) to reduce production times and improve the quality of produce.
- Availability of affordable, good quality, consistent supply of mature compost product (using palm waste and pig manure) at Funafuti and on the outer islands. This will provide other options for sourcing compost than only household production, particularly for women who typically engage in gardening, but less so in compost making due to the labour requirement.
- Use of labour sharing groups (traditional and otherwise) to increase the availability of compost at village level, with reduced labour requirements. See section 5.3.1 below for examples).

**Linking to traditional Tuvaluan cultural motivations** as a means to encourage engagement with traditional agriculture as well as growing and eating traditional foods is an important strategy for increasing demand for compost making and use at household and community level. LLEE is already engaging in this area though it's food security programs. See section 6.5 for further recommendations on approaches to use in this area.

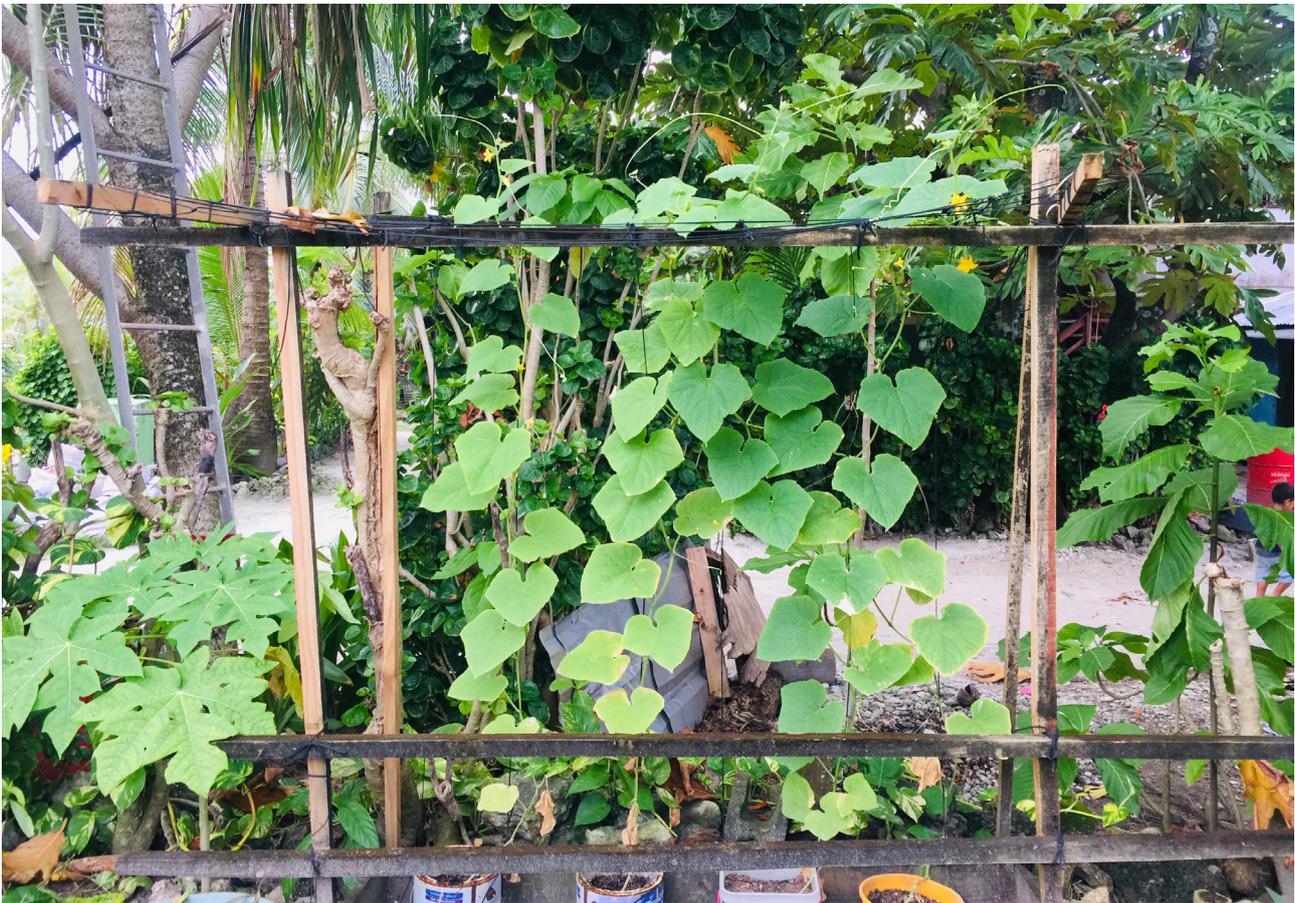


FIGURE 13: A HOME GARDEN ON FUNAFUTI

## 5.3. Current compost supply and production

### 5.3.1. Summary of compost producers

Due to the small number of actors involved in the compost sector in Tuvalu, many are both consumers and producers. The following sector may therefore be somewhat repetitive. Where possible supply and demand are addressed separately, but in some cases overall is unavoidable.

#### DoW Funafuti Depot

The Department of Waste's depot at Funafuti is the largest producer of compost product in the country, producing 5-7m<sup>3</sup> of product a week (or approximately 400-500m<sup>3</sup> per year) and up to 10m<sup>3</sup> following storms when more feed stock is available. This facility produces a partially composted shredded mulch and uses an open pile composting system, on bare ground, turned every 2 weeks.

Feedstocks are sourced from daily pickups of household yard waste from around Funafuti, by 2 DoW collection crews.<sup>40</sup> This is stockpiled and shredded 2-3 times a week (1-2 shredder operating hours at a time). The feedstock is a mix of fresh and

dry leaves and branches, with the main ingredient being dry coconut palm. This is a low nutrient feedstock, that is difficult to process in small or poorly maintained chippers due to its fibrous and acidic nature.<sup>41</sup> To manage this, the depot stuff currently cut off and stockpile thicker coconut frond stems for burning. This is a good practice for reduced wear and tear on machines, but could be improved by use of turning the remaining woody waste into biochar rather than simply burning it.

Equipment used:

- Chipper (Hansa C30 27hp 7" diesel chipper) – age and running hours unknown, estimated 10yrs old. This is the smallest diesel chipper in the Hansa range.
- Backhoe loader (CAT 432F2 8.5T diesel loader)
- 2x flatbed trucks (make, model and age unknown) used for waste pickup

Maintenance on these machines is provided by a mix of the DoW and Department of Works, including regular servicing, diesel maintenance, hydraulic servicing and the specialized area of chipper blade sharpening on a bench sharpener (the skill level of engineers in country needs verification).



**FIGURE 14: HANSA C-30 SHREDDER AT SWAT DEPOT FUNAFUTI (PHOTO COURTESY OF DOW)**

This is a very basic facility, producing one type of compost product, with the following limits:

- Lack of available feedstock currently limits production to 5-7m<sup>3</sup> per week.
- Limited range of feedstocks means only shredded mulch products are available.
- Lack equipment means higher quality compost products cannot be produced (screened compost, potting mix etc).
- Composting open piles on bare ground exposes the product to salt intrusion during flood events, leading to high pH and salt levels

- Lack of available land area may be a future limit on production.
- Little/no testing and quality control means consistency of production is not assured.

The depot is capable of producing more product than it currently does, with availability of feedstock being the key limit. Following storms, production increases significantly as the volume of green waste brought in from households increases, and this is usually taken up by customers without long oversupply issues.

A cost estimate analysis of this operation is not possible as detailed data was not available given the nature of the consultancy. Furthermore, it is run as part of the DoW and many costs are subsidized by or shared with other operations in the Department, including:

- Fuel and servicing costs for the shredder
- Staff costs for collecting and processing green waste
- Vehicle running costs for collection
- Admin overheads

Discussion with the department confirm that it is likely that the overall costs are higher than the income generated from sales, reported as \$8000-\$10,000 p.a. Rough estimates of the business costs indicate they could be 4 times the reported income,<sup>42</sup> meaning if this operation were a private business it would not be profitable in its current form.

This however should not necessarily be seen as a problem. While it indicates there is much scope for improving the efficiency and profitability of this operation, the Government of Tuvalu and the donor community can justify subsidizing compost production as a legitimate investment in national food security. In this context the income stream from compost is a useful benefit but could definitely be increased.

## Taiwanese Technical Mission to Tuvalu Gardens

The Taiwanese Technical Mission to Tuvalu produces the highest quality compost in country, at its Funalala and Vaitupu garden sites. They produce 8-10 tonnes a month (est. 110-130m<sup>3</sup> per year) of mature compost product, using the following methods:<sup>43</sup>

- Ingredients are a mix of shredded mulch (purchased from the Department of Waste), pig manure (purchased from local households at \$20/bucket) and possibly imported ammonia to assist the composting process.
- Open bays x5 (dimensions 10x3m, concrete lined)
- Equipment used bobcat loader (Funafala) and a shredder (Vaitupu)

TTMT uses this compost for their own vegetable production to supply local markets, but have so far declined to supply their mature compost product in bulk to supply the local market.<sup>44</sup>

TTMT has the highest technical expertise in compost production and quality control available in Tuvalu - they are the only producers to undertake testing and quality control, using an onsite germination test, commonly used to test for general plant toxicity.<sup>45</sup>

As noted in section 5.2.1. above, TTMT should be seen as a key technical partner in the development of a fledgling compost industry in Tuvalu rather than a supplier of compost products to the local market. Pending agreement with the TTMT's Head of Mission, their agronomists could possibly play the following roles in such development:

- Design input on any national and Kaupule level development of new compost products and production systems
- Training and support to staff producing compost within the DoW and the outer island Kaupules
- Assistance with design and implementation of testing and quality control procedures



FIGURE 15: SHREDDED PALM WASTE STOCKPILED AT SWAT DEPOT FUNAFUTI

## Outer Islands

Shredded waste is being produced on each of the outer islands by the Department of Waste, in a similar (but smaller scale) open pile fashion to in Funafuti. This was historically managed by the Kaupules (starting from around 2010) but in more recent years has been taken over by the DoW following persistent machine breakdowns and difficulties servicing machines.

As noted already, production estimates from Nukulaelae suggest approximately 1m<sup>3</sup> produced in a normal week, or potentially 40-50m<sup>3</sup> produced per year - although production is reportedly more sporadic than in Funafuti.<sup>46</sup> Production is tied to collection of household green waste collection (similar to Funafuti). Given that Nukulaelae is a small island of 57 households (compared to an average of 97 across all outer islands) this production figure could reasonably be assumed to be potentially higher on most other islands.

Current chippers being used are the Vermeer BC600XL (27hp 7" diesel chipper), the smallest chipper in the Vermeer range and no longer in production. The chipper on Nukulaelae is 2012 model logging 5097 machine hours (very high), showing visual signs of wear and is likely in need of replacement. These machines are shredding dry coconut fronds (a very difficult material to shred) and likely are working with blunt blades, increasing the wear on the diesel engine.

An audit of age, machine hours and condition of all outer island machines should be undertaken to assess likely remaining useable lifetime, and to develop a plan for replacing machines as needed. The DoW should be assisted to upgrade shredder maintenance programs to the outer islands (see section 6.3 below).



FIGURE 16: VERMEER BC-600XL CHIPPER AT NUKULAEAE

## Cooperative and Communal Compost Making

Communal compost making does not appear to be common in Tuvalu, with *pulaka* pit farming and vegetable gardening being primarily household activities. However, two examples exist of communities undertaking shared compost making to reduce the labour burden associated with this activity:<sup>47</sup>

- On Nanumaea island, villages work together in a traditional fashion to collect ingredients for compost (green leaves, dry leaves etc) from communal land. The actual compost making however is done separately in individuals' own *pulaka* pits.
- On Nanumanga island, farmers are working together in clans to make compost in each other's *pulaka* pits. This is considered a recent, and not very traditional arrangement.

There is not a readily accepted term for these arrangements in Tuvaluan language, with the commonly used term for communal sharing "*fakangamua*" often being used to refer to communal land rather than shared activities, and has difficult associations in Funafuti where land issues and immigration are a source of tension. The less common term "*fakafenua*" (meaning "working together as an island") is perhaps more appropriate, but also less often used, particularly on Funafuti and less traditional islands closer to the capital.

Whilst this is not a major focus of this study, these arrangements could be used as a model to promote increased compost production at community level in the outer islands. LLEE has already developed a case study on one such example of these groups in Nukulaelae in early 2020.<sup>48</sup>

## Household Level Compost Producers

As noted above, Tuvalu has a strong culture of composting, based on traditional compost methods used in *pulaka* (giant swamp taro) farming. Census data suggests that at least 48% of households across the country and 66% of outer islands households are engaged in agriculture of some variety.<sup>49</sup> Questionnaire data (n=39) suggests that 72% of these farmers use traditional compost recipes for a range of applications. This represents a significant broad level of experience in making and using compost within the country that can be used as a basis for initiatives focused on increasing the quality and quantity of compost and household level and above.

Questionnaire data also shows that these compost makers are familiar with a wide range of feedstocks and ingredients

The Australian Centre for International Agricultural Research (ACIAR) is already undertaking research into the use of diverse feedstocks in household compost making to address soil nutrient deficiencies through its *Soil Health for Atolls* project.<sup>50</sup> Findings from this research will be used to assist Tuvaluan farmers through a training and extension approach to improve the quality of their compost and soil health. This is an important element in the broader *Tuvalu Food Futures* food security program, but can also be used to identify key ingredients that could be used at a Kaupule or national level to produce higher quality compost at scale, tailored to meet identified soil nutrient deficiencies in Tuvalu.

FIGURE 17: HOUSEHOLD QUESTIONNAIRE DATA - INGREDIENTS USED IN HOME-MADE COMPOST (N=39)

Ingredient	Respondent (numbers)	Respondent (%)
a. Dry leaves	23	59%
b. Fresh leaves	14	36%
c. Coconut husks	17	44%
d. Spoiled fruit or vegetables	7	18%
e. Other garden waste:	3	8%
f. Pig manure	18	46%
g. Manure from other animals:	2	5%
h. Food scraps	4	10%
i. Seaweed	1	3%
j. Fish waste	1	3%
k. Ash	2	5%
l. Soil	10	26%
m. Other	5	13%

A gender split between men and women regarding gardening and compost making activities also seems to be in place in Tuvaluan households. While questionnaire data shows that both men and women share *pulaka* farming activities, women are anecdotally more likely to be engaged in home vegetable production, but less likely to be involved in compost making – primarily due to the labour demands involved in cutting and collecting the feedstocks, and turning the piles.

### 5.3.2. Limits and barriers to increased on supply and quality

A number of limits on supply are currently evident in the compost production system at present.

**The lack of access to feedstocks** is the most immediate limit on the amount of compost that the DoW is able to produce at national and outer island level. Collection is currently based on daily pickups of household yard waste, and production levels are limited to this supply. After storms this increases with more yard waste from fallen trees/ foliage being collected, showing that the current production system can process higher volumes when needed, and the market can absorb higher volumes of product. There is little public land where the Department can collect green waste without needing permission from or compensation for a landowner. There is also no commercial industry (such as arborists or landscapers) creating a waste stream of green waste as there would be in a larger urban location. Creative solutions will be required to develop workable mechanisms for gathering the most readily available organic waste products that could be composted (such as pig manure, coconut husk, non-palm green waste, seaweed, etc).

**Facilities are currently too small and inadequate** to manage a significant increase in production volumes, or types of compost products. More land area will be required to scale up larger windrows, and concrete pads, bays and possibly a production shed may be required if higher quality production at scale is to be achieved. Concrete lined pads and bays are particularly important to protect compost from salt contamination during flood events.

**Equipment is currently too small, limited range and run DoW n** to be used for any scale up of production volumes, product range or quality control regime. Shredders at Funafuti and on the outer islands are at the end of their useable life, and mostly the smallest size in their manufacturers' range. No screens, turners, packaging equipment or testing equipment is currently in place.

**Lack of maintenance on existing equipment** is an issue for the effectiveness of these machines, particularly in the outer islands. Regular quarterly maintenance is being delivered by the DoW in Funafuti and possibly the outer islands also. There is some evidence it is not as regular as recommended by the manufacturers. The critical areas of daily checks and regular blade sharpening may not be happening to the required standard leading to increased wear on these machines. Blade sharpening in particular is a specialized area of work. Training input and improved Operations and Maintenance support for the Department in these critical areas will improve the life and function of these machines.

**Technical compost making skills in country are low** at a national and local government level, primarily focused on production of low quality shredded mulch. Significant capacity building in compost production and management will be needed to increase production volumes, range of products, and quality control. TTMT already has skills and experience in this area that can be of use.

**Lack of testing and quality control** will be a future limit on improving the quality and consistency of compost product in country. Simple testing can take place regularly on site for basic production parameters (eg: pH, moisture, temperature, contamination, plant toxicity, particle size), with more technical testing (eg: nutrient content, pathogen testing, etc) being delivered by soil laboratories in Fiji or elsewhere. TTMT could also potentially provide some degree of technical support here, particularly with regards to testing production parameters.

At a household level the **labour burden associated with compost making is** perceived to be high, leading to either disengagement with compost making or repeated requests for "fast composting methods" such as PREP or similar (see section 5.1.2. above). As noted above some communities are also using labour sharing methods to address this, but this is not common. Given the gendered nature of this split (see section 5.3.1. above), addressing the labour burden women feel in making compost assist with increased demand as well as supply, as women are more of then the gardeners than men.

### Land Issues

The **lack of available land** in Tuvalu in general, and issues of **access to land in Funafuti** in particular present some direct limits on the production of compost, particularly regarding access to feedstocks. The land context in Tuvalu is complex, as in many developing nations, with the Tuvalu Native Lands Act (2008) recognizing private titles, traditional ownerships through the *Kaitasi* system of extended

family land ownership, community/community land as well as *Felakaupule* and state jurisdiction of land and sea areas. This is further complicated by significant immigration from the outer islands to the capital creating tensions relating to land access, leasing and sharing of profits from this land on Funafuti. Tenants in Funafuti have access to 3m of land around their house, outside which they cannot use any land, nor harvest any materials for compost making or horticulture.

This is a complex issue that is beyond the scope of this study to explore fully. However, it is a basic principle of property ownership under the Tuvalu constitution that landowners must have the right to decide upon and benefit from any produce or profit from their land. Any initiative to increase the harvesting of compost feedstocks must be done in partnership with or with the permission of landholders – individual, family, communal or otherwise.

Incentivized schemes for collection and processing are crucial here to address this issue in a constructive rather than regulatory fashion (see section 5.3.3 below). The basic approach here is to create incentives for landowners (cash or in kind benefits) to harvest and provide their organic waste or natural resources to the DoW for making into compost.

This approach will not necessarily solve however the issue of outer islanders living in Funafuti not being able to harvest compost materials due to lack of land. The provision of cheap, good quality compost through the DoW will continue to be the best solution to this issue, particularly when combined with small scale intensive gardening approaches such as the Biofilta Food Cubes being used by LLEE.

### 5.3.3. Opportunities for improved supply (quality, quantity, consistency) of compost products.

A number of key opportunities have been identified for improving the quality, quantity and consistency of compost production in Tuvalu.

Using **incentivized mechanisms for harvesting feedstocks** is seen as a real possibility for addressing the under supply, particularly where this is caught up in issues of land access and potentially land dispute. This could include:

- paying for feedstocks from individual collectors (in cash or in compost)
- tendering out provision of feedstock to landowner groups or Kaupules

- collecting/purchasing feedstocks from other industry waste streams (pig manure from piggeries, coconut husk from future copra processing businesses, fish waste from fishing industry etc).
- Producing feedstocks specifically for compost production through plantations or similar projects (either as a government initiative or privately owned for supply to the department under contract)

The most likely feedstocks for collection might include:

- increased coconut palm waste
- freshly cut vegetation (targeted on species based in ACIAR research)
- piggery waste (see below)
- coconut husks (see below)
- seaweed (although collection and processing is complicated)
- Human waste – currently being pumped out to sea. This can be safely turned into compost but requires a high technical ability to do so safely.

Three important caveats must be considered in relation to this approach:

- Further research into land ownership and consultation with landowners and their representatives (eg: the Kaupule Councils) will need to be undertaken to ensure appropriate strategies for collection are developed and foreseeable issues avoided.
- Strategies must be put in place to ensure that any initiatives to harvest feedstocks do not create an inadvertent negative environmental impact through over harvesting of natural resources (eg: vegetation, seaweed etc).
- Not all feedstocks are of equal value in compost production, so purchase price would need vary based on the availability, quantity required and relative nutrient value of the feedstock. Clear communication to suppliers would be required regarding differing purchase price of feedstocks ensure any industry investment from groups or individuals is well targeted.

The use of **small scale intensive piggeries to harvest manure for compost production** is a very promising area that should be further investigated. The DoW has been trialing a small scale dry litter system for several years with modest but promising results.<sup>51</sup> Further rollout of the dry litter method would allow for more efficient collection of manure, provide public health and environmental benefits through better management of excrement.

Census data shows that 76% of households own pigs, with 3722 pigs on Funafuti alone.<sup>52</sup> However being so distributed, collection is not straightforward or efficient for large scale production. Waste from a medium sized community piggery (450 pigs) could double the weekly feedstock input by volume into the Department of Waste, giving a much higher quality mature compost product and 20% higher production output volumes.<sup>53</sup> Better management of pig manure through more centralized and regulated piggeries may well also provide the additional benefit of addressing issues of water pollution in Funafuti's central lagoon.

There are health risks<sup>54</sup> associated with handling, transporting, stockpiling and composting pig manure, particularly in large volumes.

A number of proposals are already being considered by the government and donor community in this area, for both the outer islands and Funafuti, and for just pig management as well as biogas production. This should be seen as a key area for developing the composting system in Tuvalu.

Existing **community level labour sharing arrangements** appear to show some promise for possible ways to increase compost production at village level. See section 5.3.1. above for discussion, and section 6.5 below for recommendations relating to this topic.

**Use of coconut husk to produce coco-peat** or coir is another area with good potential. This is an existing abundant waste stream that can make a high quality, highly water absorbent potting mix or additive to compost. Many farmers are already familiar with it also (see figure 4 above). There is currently no incentive to collect coconut husk so incentivized schemes (above) would need to be trialed for this product. Processing also requires some care to avoid damage to shredders. Despite these challenges this is a good prospect for future compost product development.

**Use of other specific ingredients to create higher quality compost products** is another promising area that is already being explored through ACIAR's *soil Health for Atolls* research project. Results from this research could be used to target collection for specific ingredients (Pisonia leaves, Chaya leaves, iron shavings, ash etc) to address known soil deficiencies in Tuvalu's atoll soils (potassium, iron, copper etc).<sup>55</sup> As noted above, results from work at household level could be brought up into national level composting systems to improve products produced by the DoW also.



FIGURE 18: COCONUT HUSKS PILED UP AROUND HOMES IN FUNAFUTI (LLEE)

**Use of woody waste to produce Biochar** at the SWAT site is a further product with good potential. It can readily be produced in batches to suit availability of woody waste, using 'intermediate technology' type equipment (some training would be required). While not a standalone compost product itself, it would significantly increase the quality of potting mixes and composts it is added to.

### What is Biochar?

Biochar is a specific type of charcoal, used as a soil amendment in organic agriculture. Its benefits include increased soil carbon, soil bacteria and humic acids, as well as the ability to retain water and sequester carbon in the soil through its production process.

Biochar is produced in a low oxygen combustion process called 'pyrolysis', a process readily undertaken with low-tech kilns up to highly controlled industrial production. It is produced from a range of biomass inputs, with timber, green waste and crop residues commonly used.

See: <https://www.biochar-international.org/>  
For further details

**Imported agricultural inputs** could also play a role, if used judiciously so as not to impact on Tuvalu's environment and limited ground water resources. Liquid microbial inoculants such as EM4 and similar compost bacteria inoculants would be very safe and beneficial in improving the speed of composting and quality of the final product. These products are commonly used in commercial compost production facilities, as well as at household level throughout Asia, can be easily manufactured at household level also, and would meet the common request for "fast composting methods" from farmers and gardeners. Such inoculants would also be a low cost way or improving quality of larger scope compost production at national and Kaupule level. The TTMT also anecdotally uses ammonia to achieve similar results in its composting processes. This is a non-organic product but also acceptable method for improving compost production processes, if used judiciously, and possible impacts on the water-table of over-use is considered and managed.

Introducing **more consistent testing of compost products** is a key part of improving overall product quality and consistency for large scale composting operations – primarily the national level facility at Funafuti. A range of possible tests is outlined in figure 5 below, starting from simpler on site tests, leading to more advanced off site laboratory testing if required by upgraded facilities. TTMT already undertake some on site testing and would be a valuable partner in increasing capacity in this area.

FIGURE 19: POSSIBLE COMPOST TESTING PARAMETERS

Testing Stage	Test Parameter	R <sup>56</sup> results
During production (on site)	Moisture	Ensure adequate conditions for aerobic composting
	Temperature	Ensure pasteurization
	Physical contamination	Ensure free of debris
Finished product (on site)	Ph test	Ensure neutral acidity levels
	Germination test	Check for plant toxicity
	Maturity	Ensure composting is completed
	Particle size	Quality control (screened products only)
Finished product (laboratory test)	Nutrient content (various)	Ensure adequate NPK and micronutrients for intended use.
	Pathogen testing	Ensure safe for human use
	EC test	Salt content



## 6. RECOMMENDATIONS

### 6.1. Integrated National Level Compost Strategy

Many of the basic elements required for compost production in Tuvalu are already present at national, outer island and household levels. However, each of these elements face challenges and limits to their effectiveness, leading to underproduction at most levels.

There is particular scope to address these challenges through an integrated national level compost strategy, that would allow various actors to jointly address the issues the sector faces. This strategy could include the following:

#### Coordinate National level production

- Facilitate a national level compost forum to bring together actors, develop strategies and build support for a shared strategy to increase quality, range and consistency of product being produced in country.
- Identify links to existing policies and programs, such as The Tuvalu Strategic Agriculture Marketing Plan (2016-25), the Tuvalu Food Futures
- Agree roles and potential contributions of key national level actors in the sector: the DoW, Department of Finance, TTMT, Funafuti Kaupule, the donor community (LLEE, DFAT, ACIAR and others).
- Scope and cost plans to upgrade the national DoW facilities for compost production (see below) to increase volume.

- Discuss and develop strategies for incentivizing collecting of feed stocks, production of compost and development of industries that might create demand for compost (such as the small-scale horticultural market).
- Develop plans as a matter of priority for the coordination of the existing DoW facility with proposed small to medium scale piggeries for biogas and manure production by various proponents. This is a key opportunity requiring national level coordination to ensure its success.

#### Links Between Capital and Outer Islands

- Clarify the lead actor to provide compost production on the outer islands for future support and partnership. The national Waste Policy stipulates this is the Kaupules, however a lot of current capacity is provided by the Department of Waste.
- Develop coordinated and funded program through the DoW for providing maintenance and servicing support to composting equipment on the outer islands (see below).

## Links between compost market and agricultural market

- Undertake market chain analysis of the vegetable market in Tuvalu, including existing and future links to compost production at all levels (national, TTMT, Kaupule, household)
- Support the development of local market gardeners and associated industry services (eg: producers associations, extension, markets, storage, transport, etc) as a possible strategy for growing the demand for compost products. The Tuvalu Coconut Industry Roadmap, Tuvalu Copra Co-operative Society and Tuvalu Coconut Traders Co-operative could be used as models here.<sup>57</sup>
- Possible provision of subsidies to any compost consumers using product to support agricultural production, in order to assist in developing more demand for products.

## 6.2. Upgrade the DoW Compost Production Site – Funafuti

The existing DoW Facility at Funafuti requires upgrading to meet existing demand and provide greater quality, quantity, range and consistency of compost products. While this is clearly the responsibility of the Government of Tuvalu through the Department of Waste, there may be roles to play for partners from the donor community including LLEE. Overall however this should include the following:

## Business planning

Any investment should be based on appropriate scoping and long-term business planning.

Recommendations include:

- a more detailed evaluation and profitability analysis of the current operation to identify areas for increased efficiency and investment
- Development of a 3 to 5-year business plan to outline planning required for increased scale and production volumes. This could also include scope for investigating models for donor funding tied to income or production targets to incentivize efficient operation of the new facility.
- Trial scaled up operation by having local projects (such as LLEE and others involved in the Tuvalu Food future project) pre-order compost product required for their projects in bulk. This will provide a both trial of new procedures/products and a cash injection into the new facility.

## Facilities

Existing facilities will require expansion and upgrades to increase production volumes. Upgrades could be undertaken in a staged manner as follows:

1. Improved Existing Facility – focused on improved mulch production only, and increased volumes using the existing facility.
2. Upgraded Facility – focusing on production of mature compost (as per TTMT’s existing systems), at increased volumes, probably at a new or expanded location.
3. Major Upgraded Facility – large scale production of a wide range of products, at a new location, with significant upgrade to facility and equipment.

Facility Upgrade Level	Site Requirements	Equipment Requirement	Testing
<b>Improved Existing (shredded mulch)</b>	Utilize existing site Min 200m <sup>2</sup> production area (concrete pad or lined bays)	Shredder (75hp) Backhoe	Temperature pH
<b>Upgraded Facility (mature compost)</b>	New site? Min 500m <sup>2</sup> production area (concrete pad or lined bays) Additional concrete lined stockpiling area required	Shredder (150hp) Compost screen Backhoe	All parameters (see below)
<b>Major Upgrade (range of mature compost products)</b>	Increased site area Specialized covered, concrete lined production shed (1000m <sup>2</sup> +) Additional concrete lined stockpiling area required	Horizontal grinder (400hp) Compost screens Windrow turner Backhoe	All parameters (see below)

## Shredders and Processing Equipment

Shredders have been identified as a key barrier in the consistent running of the existing system and will be a key part of any future system. Recommendations for shredders and processing equipment are as follows:

- Undertake an audit of all DoW shredders (for age, machine hours, condition) in Funafuti and the outer island machines to assess likely remaining useable lifetime, and to develop a plan for replacing machines as needed (recommended models in figure 8 below).
- Upgrade the existing shredder at the DoW (as per figure 8) to allow for increased production volumes.
- Progressively upgrade shredders on the outer islands according to the result of the machine audit.
- Scope and fund a reliable and robust shredder maintenance program for the outer islands (see section 6.3 below).

FIGURE 20: RECOMMENDED SHREDDER SPECIFICATIONS

Locations	Materials	Specs	Example Models
Outer islands	Palm, leaves and timber up to 250mm	8-10", 50-75hp, diesel, drum chipper	Vermeer BC 1000 Hansa C40
Dep Waste Funafuti	Palm, leaves and timber up to 500mm	15-20" 120-170hp diesel drum chipper	Vermeer BC 1500*
Dep Waste Funafuti	Mixed materials (major upgrade scenario only)	400HP horizontal grinder (mixed materials)	Vermeer HD 4000

\* This is a high air flow model designed for processing palm waste



FIGURE 21: COMPOST WINDROWS AT THE NCBA COMPOST FACILITY, TIMOER-LESTE. THIS FACILITY IS COMPARABLE TO THE RECOMMENDED "MAJOR UPGRADE" ABOVE (PHOTO A. MCCLEAN)

## Sourcing Feedstocks

Increased range and volumes of feedstocks will need to be sourced to allow for increased production volumes and range of products.

Key recommendations include:

- Develop plans for coordination with proposed small-medium scale piggeries on Funafuti to allow easy collection of pig manure for use in producing composted manure/palm waste at the DoW depot on Funafuti (see section 5.3.3 above for discussions regarding piggery development and possible links here).
- Undertake research and consultation with the Department of Lands, landowners and their representatives (eg: the Kaupule Councils) to develop strategies for harvesting available feedstocks (vegetation etc) for compost making.
- Trial purchasing of feedstocks from individual collectors (in cash or in compost)
- Trial tendering out provision of feedstock to landowner groups or Kaupules as a commercial contract.
- Undertake research and coordination with the department of Environment to develop safeguards and community messaging to ensure that any initiatives to harvest feedstocks do not create an inadvertent negative environmental impact through over harvesting of resources.

## Training and Product/systems Development

A significant investment in training and support to DoW will be required. This could potentially be provided as part of TTMT's existing technical mission, or by a third-party consultant or waste management contractor.

Recommended focus areas for training and system development should include:

- Development of more varied products, including (in order of priority):
  - Improved composted mulch (similar to existing, improved quality)
  - mature, screened compost (by incorporating pig manure)
  - composted coco-peat (as standalone product or mixed into mature compost)
  - biochar (to make productive use of existing waste stream of uncompostable woody waste from palms)
  - potting mix (optional – only if required by local horticulture industry)
- Development of tailored compost recipes to increase product quality and address known soil nutrient deficiencies (building on research results from ACIAR's *Soil Health for Atolls* project)
- More efficient processing and operational procedures
- Introduction of improved testing for quality control and product consistency.
- Work health safety
- Public health safety (particularly regarding use of manure)



## 6.3. Outer Island Local Government Level Production

Production of compost on the outer islands at local government level has been going on since around 2010, but with inconsistent results and inadequate machine maintenance. Improving these facilities, and particularly the maintenance systems required to support them is an important part of ensuring soil health and food security in the outer islands. Opportunities for incentivized schemes here are less apparent, however engagement with agriculture is already comparatively high in the outer islands, so the need for these schemes is less critical here. Recommendations for the improvement of these operations includes:

### Management and Partnerships

- Clarify the lead actor to provide compost production on the outer islands (previously Kaupules, now Department of Waste) for future support and partnerships.

### Sites and Equipment

- Upgrade existing facilities to ensure concrete lined bays are available for processing, stockpiling and protecting shredded mulch from salt intrusion.
- Undertake an audit of all DoW shredders (for age, machine hours, condition) in Funafuti and the outer island machines to assess likely remaining useable lifetime, and to develop a plan for replacing machines as needed (recommended models in figure 8 above).
- Begin upgrading outer islands shredders as per results of machinery audit.

## Operations and Maintenance

The establishment of a funded program to have skilled maintenance staff from DoW regularly provide on-site servicing and support to local operators is critical to the success of composting operations in the outer islands. This should build on or partner with the existing, but underfunded DoW maintenance program. This program should include:

- Train and support key maintenance position(s) based in Funafuti with responsibility for upkeep of all DoW shredders in country (currently 8-9 units).
- Establish and ongoing relationship with either a machinery supplier or training provider to provide ongoing training support to this program in all aspects of machine maintenance (diesel engines, hydraulics, blade sharpening, damage repairs etc).
- Manage stock of spare parts and consumables required for operations, and ordering of replacements as needed.
- Train local operators in the daily and weekly operations and maintenance (annual training).
- Provide minor and major servicing, and minor blade sharpening on site for all machines.
- Manage delivery of blades to Department of Works engineers (Funafuti) for major blade sharpening requirements.
- Maintain relationships with suppliers and other mechanics/specialists as needed to support ongoing operation of equipment, and annual training from suppliers as needed.
- Undertake major repairs under direction from supplier or suitable qualified mechanic.
- Concerted effort to establish simple and robust systems for maintaining records and logs of all servicing, repairs, etc.

See appendix 8.7 below for further operations and maintenance details.

## 6.4. Working with Households

Composting at household level is widespread in Tuvalu and should be the focus of continued support for direct food security benefits. It should be a key area of focus for any national level compost strategy developed (see above). Recommendations include:

- Support ongoing extension to farming households around improved compost making techniques through the DoA, *Tuvalu Food Futures* program and similar.
- LLEE should utilize local farmers with existing compost making skills as community field staff and “champions” to support any rollout of food cubes or similar activities to the outer islands, to ensure experienced on ground support is available to project beneficiaries.
- Continue to support and implement the findings of ACIAR research into improved compost recipes to identify key ingredients for addressing soil nutrient deficiencies.
- Introduce safe organic imported/replicable compost ingredients such as EM4, to assist with improved household compost production and meet the demand for “quick composting methods”.
- Target *Food Cubes* for use with outer islander families living in Funafuti, to address food security for this vulnerable group and to foster increased household demand for compost products.

## 6.5. Working with Tuvaluan Culture

Engaging with Tuvaluan culture has been identified as a key mechanism for developing community trust in improved methods of producing and using of compost. Recommendation include:

- Continue to promote traditional foods and engage with traditional *pulaka* pit agriculture in food security programs/activities related to making and using compost at all levels (household, local government, national).
- Promote the “*fakafenua*” style labor sharing arrangements used on Nanumaea and Nanumanga as models to encourage increased collection of feedstocks and production of compost at a village level across the outer islands.
- Trial introduction of new categories/prizes at traditional competitions or “*nafa*” to increase community engagement with compost making, horticulture and related activities. Initial discussion with outer islands communities by LLEE suggests that this approach could possibly be successful.



FIGURE 22: BIOFILTA 'FOOD CUBES' ON FUNAFUTI



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# 8. APPENDIXES

## 8.1. Summary of Compost Consumers

Consumer	Location	Number	Consumption Pattern	Currently Pays
Traditional Farming Households	Funafuti	11	Does not purchase compost	\$0
	Outer Islands	383	Does not purchase compost	\$0
Home Vegetable Gardeners	Funafuti	82	<sup>58</sup> 29% of respondents report purchasing from Dep Waste, using approx. 150L/month	\$2 per 150L
	Outer Islands	280	<sup>59</sup> Unknown	\$2 per 150L
Home tree crop gardeners	Funafuti	263	Very few buy compost for tree crops	\$2 per 150L
	Outer Islands	515	Very few buy compost for tree crops	\$2 per 150L
Taiwan Mission to Tuvalu	Funafuti	1	Pre-order 45m <sup>3</sup> every 2-3 months (est. 15-20m <sup>3</sup> /month)	\$13.33/m <sup>3</sup>
	Vaitupu	1	Assumed that they do not purchase, as they own their own shredder.	\$0
Dep Agriculture Demplots/Nurseries	Funafuti	2	unknown	-
	Outer Islands	8	unknown	-
Schools, hospital, university, others	Funafuti		Occasionally purchase	\$2 per 150L
	Vaitupu	1	Unknown	-
Food Cubes	Funafuti	80	Looking to purchase 15m <sup>3</sup> to fill remaining 50 food cubes.	\$13.33/m <sup>3</sup>
Food Walls	Funafuti	400	Purchased an estimate 5-10m <sup>3</sup> mulch to make compost to fill food walls already	\$2 per 150L

## 8.2. Summary of compost Producers

Producer	Number	Location	Method	Product	Volume Produced	Sale Price
<b>Traditional Farmers</b>	394*	All islands, Less common on Funafuti	Traditional	Traditional kaiao compost (like humus)	-	NA
<b>Home Vegetable Gardeners</b>	300*	All islands	PREP	Home compost	-	NA
<b>Home tree crop gardeners</b>	778*	All islands	Mulching	mulch	-	NA
<b>Dep. Waste SWAT</b>	1	Funafuti	Open pile	composted mulch (coarse)	400-500m <sup>3</sup> per year	\$2/150L or \$13.33/m <sup>3</sup>
<b>Dep. Waste SWAT – Outer Islands</b>	7		Open pile	composted mulch (coarse)	40-80m <sup>3</sup> per year (each island)	\$2/150L
<b>Dep. Agriculture</b>	1	Waituku	PRAP	compost	-	NA
<b>Taiwan Mission to Tuvalu</b>	2	Funafuti, Vaitupu	Open pile in lined bays	Mature compost	110-130m <sup>3</sup> per year	NA

\*Based on Government of Tuvalu (2017a) Population and Housing Census, Central Statistics Division Ministry of Finance, Economic Planning and Industries Funafuti, Tuvalu, p.42.

### 8.3. Summary Of Compost Production Methods And Models Considered

This report defines a composting “method” as the practical techniques used to turn the compostable material into a composted product, and a composting “model” as the organizational structure

used to implement the production of compost. Models and models considered in this study are below.

Methods of Compost Production	Models of Compost Production									
	Subsistence	Cottage industry	Communal production	Cooperative business	Small-med commercial	Large commercial	Municipal production	National Government production		
Small open piles (static or turned)	✓	✓	✓	✓						
Pyramid Method (aerated static pile)	✓	✓	✓	✓						
Windrows (turned)			✓	✓	✓	✓	✓	✓		
Windrows (static aerated)			✓	✓	✓	✓	✓	✓		
Pit/trench Composting (small)	✓	✓	✓	✓	✓	✓	✓	✓		
Trench Composting (large/industrial)				✓	✓	✓	✓	✓		
Compost Bins (small)	✓									
Powered Composting units					✓	✓	✓	✓		
In vessel composting (Med-lge)									✓	✓
Compost bioreactors									✓	✓
Biogas digester (small)	✓								✓	✓
Biogas digester (industrial)				✓	✓	✓	✓	✓		
Compost tumblers (manual)	✓									
Compost tumblers (Powered)				✓	✓	✓	✓	✓		
Compost tumblers (industrial)				✓	✓	✓	✓	✓		✓
Liquid Compost	✓									
Vermicomposting	✓	✓	✓	✓	✓	✓	✓	✓		

## 8.4. Summary of island contexts

	Funafuti (total)	Funafuti (funafala)	Nanumea	Nanumaga	Niutao	Nui	Vaitupu	Nukufetau	Nukulaele	Niula kita
Population (resident)	6,238	-	475	444	541	553	898	553	283	18
HH	849	-	105	93	116	97	187	112	57	10
Island Group	Central	Central	North	North	North	Central	Central	Central	South	South
Distance to capital	-	16km	464km	402km	337km	266km	128km	111km	116km	254km
Land Area (km <sup>2</sup> )	2.4km <sup>2</sup>	-	3.9km <sup>2</sup>	3.0km <sup>2</sup>	2.5km <sup>2</sup>	2.8km <sup>2</sup>	5.6km <sup>2</sup>	3.0km <sup>2</sup>	1.8km <sup>2</sup>	0.4km <sup>2</sup>
Reef island or atoll?	Atoll	-	Atoll	Island	Island	Atoll	Atoll	Atoll	Atoll	Island
HH trad ag	1%	1%	49%	49%	49%	49%	49%	49%	49%	49%
HH vegetable gardening	2%	2%	36%	36%	36%	36%	36%	36%	36%	36%
HH fruit tree gardening	31%	31%	66%	66%	66%	66%	66%	66%	66%	66%
Land tenure type	Extended family - Kaitasi	Extended family - Kaitasi	Extended family - sim. to Kaitasi							
Soil fertility	poor	poor	poor	poor	average	good	good	average	good	average
Shredders (incl owner)	1 (SWAT)	1 (Dep Ag)	1 (SWAT)							
Vegetable market	1	0	0	0	0	0	1	1	0	0
Dep Agr de mplot	1	1	1	1	1	1	1	1	1	1

## 8.5. Key Informant Interviews

Interviewee Name	Position/Organisation
Joe Manteit	DFAT
Sally Asker	Insight Sustainability (LLEE consultant)
Teuleala Manuella-Morris	LLEE Tuvalu Country Manager
Geoffrey Dean	University of Tasmania
Itaia Lausaveve	LLEE Tuvalu board, and (ex DoA Government of Tuvalu)
Miriam Taukeiei	Department of Waste, Government of Tuvalu
Taualo Penivao	Secretary, Funafuti Kaupule
Leata Loleni	Secretary, Nukulaelae Kaupule
Pesega Lifuka	Department of Waste, Government of Tuvalu
Roy Luo	Taiwanese Technical Mission to Tuvalu
Marc Noyce	Biofilta Australia
Mark Wallace	Vermeer WA NT
Nigel Dobier	Vermeer Australia
Kevin Laherty	Able Trees, Alice Springs, NT
Richard Kenyon	Remote Area Tree Services, Darwin NT
Martin Vogel	Hansa New Zealand
James Burns	Morbark Australia

## 8.6. Shredder Purchasing and Maintenance Program considerations

In order to meet the recommendations related to purchasing and maintaining new shredders for national and local government (outer island) level compost production, the following details should be considered.

### Purchasing and Warranty Considerations

- The Department of Works is designated as being responsible for advising on the specifying of any waste management machinery under the Tuvalu Integrated Waste Policy and Action Plan.<sup>60</sup> Any decisions to purchase equipment should be made in consultation with DoW according to protocols laid out in the policy.
- As much as possible, purchase one brand, to ensure ease of ordering spare parts, and better manufacturer support.
- Select equipment supplier based on reputable brands who have existing supply chains and support systems in place in the Pacific, eg: Vermeer, Hansa.
- Select and size equipment models based on capacity to process required material (dry palm fronds), and similarity of machine components. A fleet of all diesel chippers with similar blade sizes and cutting disk/drum mounts will be easier to maintain than a mix of different models.
- Confirm suppliers ability to uphold warranty requirements in country. Most suppliers will meet warranty requirements by sourcing qualified mechanics in country or in Fiji to undertake works under the supplier's direction, and at the supplier's cost.
- At time of purchase a stockpile of commonly required spare parts should be purchased, particularly cutting blades, which can be time consuming to have sharpened in remote locations.

### Training

- Most reputable suppliers will provide 2-3 days in country training and support upon purchase, as part of the purchase price.
- Additional training can also be supplied at additional cost (either hourly rate or disbursements only, depending on supplier).

### Blade Management

- Blades are a critical element in shredders – do not run a shredder on dull blades, it adds wear to the machine
- Shredders are designed to process timber. The following rules should be adhered to in order to preserve blades:
  - No palm logs to be processed through standard airflow or disk mounted chippers
  - No non timber/palm products to be processed. More diverse products should be processed through a mixed materials horizontal grinder or similar.
  - Servicing and washdown must be adhered to, particularly when shredding palm.
- Major blade sharpening must be undertaken on a bench grinder, by a suitably skilled engineer. If not available in country, training or sharpening services can be sought through most suppliers.

## Summary of Expected Shredder Servicing Tasks<sup>61</sup>

Service Type	Delivered by	Tasks
<b>Daily Checks</b>	Local operator	All safety checks Check fluids, filters, belts etc. Wash DoW n after use (particularly important when shredding palms)
<b>Weekly Checks</b>	Local operator	Grease all points
<b>Minor Service (3 months)</b>	Dep Waste Mechanic	Diesel engine service Check and tension all belts, nuts, bearings
<b>Major Service (12 months)</b>	Dep Waste Mechanic	Hydraulic system service Diesel engine service Replace filters, belts, fluids etc as needed.
<b>Minor Blade Sharpening (3 months)</b>	Dep Waste Mechanic	Contact sharpen blades on site.
<b>Major Blade Sharpening (6 months)</b>	Dep Works Engineers	Remove blades to be bench sharpened by skilled engineer.
<b>Blade Replacement (12 months or as needed)</b>	Dep Waste Mechanic	Replace blades once tolerance is too low.

This is a generic list based on several sources. Manufacturer recommendations for maintenance periods should be adhered to for any equipment purchased.

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