Scaling-up, scaling-out & branching-out:

Understanding & procuring diverse organic materials management models in Aotearoa New Zealand

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Attributions

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Introduction

Summary

This report adds to current understanding of the scale, scope and nature of organics collectors and processors across Aotearoa, with a focus on composters. The report is primarily designed to support those at central and local government charged with making investment and procurement decisions in relation to the infrastructure and services for collecting and processing organic materials. We conducted a national survey of operators, with the results showing a lot of diversity in the sector. To develop a shared language to support decision-making on organics materials management, the report draws on international literature and the survey results to develop a simple taxonomy for distinguishing operators based on factors most relevant to procurability and scaleability. This taxonomy is then used to explore the various challenges, impacts and outcomes for each type of operator.

Background

Public and government interest in better managing 'organic materials'[1] in Aotearoa New Zealand is increasing in light of climate and waste reduction goals. In March 2023, central government announced that by 2030, territorial authorities must provide separate kerbside collections of organic materials for all households in urban areas across Aotearoa. Although some territorial authorities already provide organics collection and processing services, many do not and must now plan to do so. As such, these central government requirements have put both a timeframe and a spotlight on the need to fill current gaps in New Zealand's organics processing infrastructure and service delivery.

The subsequent procurement and investment decisions for organics collection and processing will influence the shape and nature of New Zealand's organic materials management system for decades to come. There is a window of opportunity to design the new system so as to harness co-benefits additional to diverting organics from landfill, such as soil remediation, local food supply enhancement, local climate change resilience and more. Balancing the need to meet central government timeframes (themselves connected to the urgency of addressing climate change), with the insights required to develop the most beneficial organic material systems and services possible, is critically important, and has motivated this research. While a spectrum of collection and processing options exist for local and central government to consider, it is currently difficult to identify and properly evaluate these options when planning systematic organics diversion due to key knowledge gaps:

1. A lack of national data on the full range of existing composting enterprises and practices.
2. No clear and consistent language to describe and distinguish the different models and processing options currently operating in Aotearoa New Zealand. This could mean some providers find themselves 'off the table' because their model is not well understood.
3. Uncertainty about how various models could be procured and integrated into an effective organics management ecosystem that maximises diversion alongside other critical social, economic and environmental outcomes.

1 We use 'organic materials' or 'organics' to refer primarily to food scraps and green (garden) materials that are generally framed as 'waste'. This limited definition focuses on organic materials commonly produced in households and businesses across Aotearoa, rather than broader definitions that include materials such as sewage sludge, timber, and agricultural wastes (manures and crop residues). We prefer the word 'materials' over 'waste' to recognise the inherent value of these resources.

Purpose

To begin to address these knowledge gaps, Zero Waste Network and Manaaki Whenua - Landcare Research conducted an online survey of organics processors and then analysed the results, in order to:

1. Stocktake the scale and scope of existing composting enterprises in Aotearoa New Zealand, and understand the challenges they face.
2. Develop a shared language to better categorise organics infrastructure to help inform policy, investment and decision making on organic materials management.
3. Identify the social, economic and environmental outcomes that different composting enterprises and practices can provide, and the challenges and opportunities.
4. Offer some high-level reflections on how local and central government could approach integrating a diversity of organics collectors and processors into future organics diversion contracts and investment strategies.

Findings and analysis

The online survey results indicate that organic materials management (primarily composting) is a growth industry characterised by a diversity of enterprises and practices that operate across different scales and sites. These different enterprises and practices are supported through a mix of fee-for-service and volunteer labour, and generate a wide variety of potential impacts. Key drivers for growth include the motivation to:

- Mitigate climate change
- Reduce waste
- Build soil
- Educate and shift people's (and societal) practices relating to organic materials away from a 'waste' mindset towards a view that recognises their value as resources.

The diversity of organics enterprises and practices has made it difficult to develop a shared language that clearly categorises and distinguishes the different approaches. A taxonomy of composting models is needed to support local and central government to plan and evaluate appropriately the different collection and processing options for organic materials. Overseas, research has contributed to developing such categories/taxonomies (c.f. Morrow and Davies, 2021; Slater and Aiken, 2014). Using our survey findings, we adapted these international categorisations to reflect the enterprises and practices currently operating in Aotearoa New Zealand. This new, Aotearoa New Zealand-specific taxonomy:

- Makes a clear distinction between composting clubs (e.g. voluntary and/or exclusive) and composting service providers. The latter are more clearly procurable to deliver local and central government organics services.
- Suggests that composting service providers should be distinguished based on their operating model, rather than on tonnage processed. This better supports procurement teams to evaluate providers based on multiple measures, including scalability, resilience and cost (see Figure 1).
- Identifies impacts from different operating models, alongside broader factors to consider when making investment and procurement decisions on organics infrastructure and services.

Figure 1:

Composting Service Providers	**Smaller geographic area serviced** e.g. town, small district, suburb(s)	**Larger geographic area serviced** e.g. regional or multi-regional
Single site	Single-site operator servicing a small geographic area → **Xtreme Zero Waste**	Single-site operator serving larger geographical distance → **Envirowaste Hampton Downs**
Distributed network	Network operator servicing a small geographic area → **Kaicycle**	Network operator serving larger geographical distance → **MyNoke**

We then worked with our taxonomy outlined in Figure 1 to develop an initial framework for assessing the impacts of various types of composting service providers. The report concludes by outlining some of the challenges operators face for establishing, sustaining and scaling their models. It also suggests some pathways forward for local and central government decision-makers to mitigate these challenges and create integrated organic materials management systems.

Report outline

- **Part 1** summarises the relevant survey findings that informed the development of the taxonomy.
- **Part 2** summarises approaches to categorising organics enterprises, practices and infrastructure elsewhere (in literature and legislation), and synthesises this with our survey results to propose a new taxonomy relevant to Aotearoa New Zealand.
- **Part 3** draws on the taxonomy to identify impacts from the different operating models, and broader considerations relevant to investment and procurement decisions on organics infrastructure and services.

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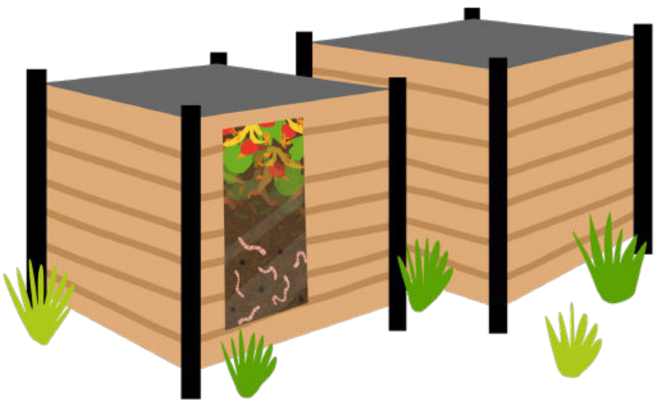


Part 1:

AOTEAROA NEW ZEALAND COMPOSTING SURVEY AND RESULTS

Aotearoa New Zealand must invest in organic materials management infrastructure and services to divert organic materials from landfills in order to meet climate change emissions reduction targets and ensure these materials are cycled back into local ecosystems for soil health and food production (Diprose et al., 2023; Climate Change Commission, 2021). Local and central government have begun to consider existing organics infrastructure, processing and service capacity, to determine what policies, procurements and investments are needed for New Zealand's organics management system to grow to divert the nation's organic materials. These considerations include efforts to understand which providers exist or could be supported to deliver the necessary services. To date, these considerations have focused on identifying processors whose models involve one site managing a large tonnage of organic materials, up to 150km away from where these materials are generated (Ministry for the Environment, 2022; Ministry for the Environment, 2023). Furthermore, a kerbside collection methodology is assumed to be the most viable option to achieve maximum diversion (Ministry for the Environment, 2022; Ministry for the Environment, 2023).

Such analysis has excluded a large number of organics processors and service providers across Aotearoa New Zealand whose infrastructure and methodologies for collecting and processing materials do not fit the above mould. To bring awareness to the full range of operators, Zero Waste Network and Manaaki Whenua - Landcare Research undertook to survey existing composting initiatives/enterprises in Aotearoa New Zealand to gather more robust and comprehensive information about the range of processors, including data about their operational models.

This Part describes the survey methodology and outlines the results, which were used to develop the taxonomy in Part 2.

Survey Methodology

The survey was conducted online via Qualtrics, and was open for approximately two months over October-November 2022. It included 74 questions[2], which were a mix of closed and open-ended questions, to capture the scale and nature of composting operations, operational challenges, and aspirations for the future. The survey was aimed toward anyone in Aotearoa New Zealand who operates, or is involved in, a collective or organised composting operation[3]. The survey was publicised through the Zero Waste Network, WasteMINZ, social media and various other networks and organisations.

A total of 41 participants responded, representing 41 composting enterprises across 59 sites from 14 regions within Aotearoa New Zealand[4]. Participants represented organics processing enterprises and practices associated with:

- Small to large scale composting/vermiculture service providers (including those operated by territorial authorities)
- Marae
- Urban farms
- Community gardens
- Schools and education facilities
- Composting equipment sellers
- Other community enterprises that include some form of collective composting

2 NB: participants were only asked relevant questions based on their previous answers.
3 The survey did not cover individual backyard composters or Sharewaste users.
4 Most of the survey questions were optional and depending on the participant's composting enterprise may not have been relevant or answered. Consequently, 41 participants did not answer every question. We use either percentages of participants, and/or total number of participants to report responses to questions in this section. The percentages do not always sum to 100 as most questions had an 'other' or 'not applicable' category, or participants were able to select multiple options to reflect the diversity of their enterprise's practices.

Limitations

We framed the survey using the term 'composting' as it was the most accessible term to describe the kinds of enterprises and practices we sought information about. However, we are aware that this may have discouraged some potential participants engaged in other forms of organics management. For this and other reasons, the survey results do not represent all the collective or organised composting and organics management operators occurring across Aotearoa New Zealand. Some potential participants informed the research team that they did not have time to complete the survey, did not want their operations to be included, and/or heard about the survey after it had closed. Based on feedback to the research team and our background knowledge, the operations most under-represented in the data are likely to be; organics processing facilities with large processing capacities, marae and iwi/hapū-led composting, schools and educational facilities and community gardens. Given these limitations, the data should be treated as underestimates given the information available. Notwithstanding these limitations, our taxonomy makes space for a diverse range of enterprises and practices and could be developed further.

Results

Enterprise structure, financing, jobs

The results show that composting activities are undertaken both for profit and not-for-profit (with various strategies for financing the activities), and that they generate employment opportunities.

Survey participants were asked to categorise the nature of their composting enterprise structure. The most common enterprise structures are:

- Non-profit (52.5%)
- For profit (22.5% - of which 15% are social enterprises, and 7.5% are not social enterprises)
- Other (25%) (includes composting taking place at schools, or managed by territorial authorities)

"In relation to questions on financing, 38% of participants noted that their enterprise charges a user fee for collection or drop-off of organic materials."

In terms of composting activities, 80% of participants manage or process compost 'on-site', with the remainder providing equipment sales, education, coordination of related initiatives (like food waste prevention, or managing composting services at customer locations such as vermiculture).

In relation to questions on financing, 38% of participants noted that their enterprise charges a user fee for collection or drop-off of organic materials. Table 1 shows average prices (NZD) for household kerbside pick-up and drop-off of organic materials based on data from participants who measure volume. Two participants' enterprises measured inputs in weight, pricing at $80 per tonne and $108 per tonne for drop-off respectively. One participant's enterprise charges $20 per month for unlimited drop-off.

In addition to the fee-for-service, participants noted other ways their enterprises are financially supported. The most common other income sources are:

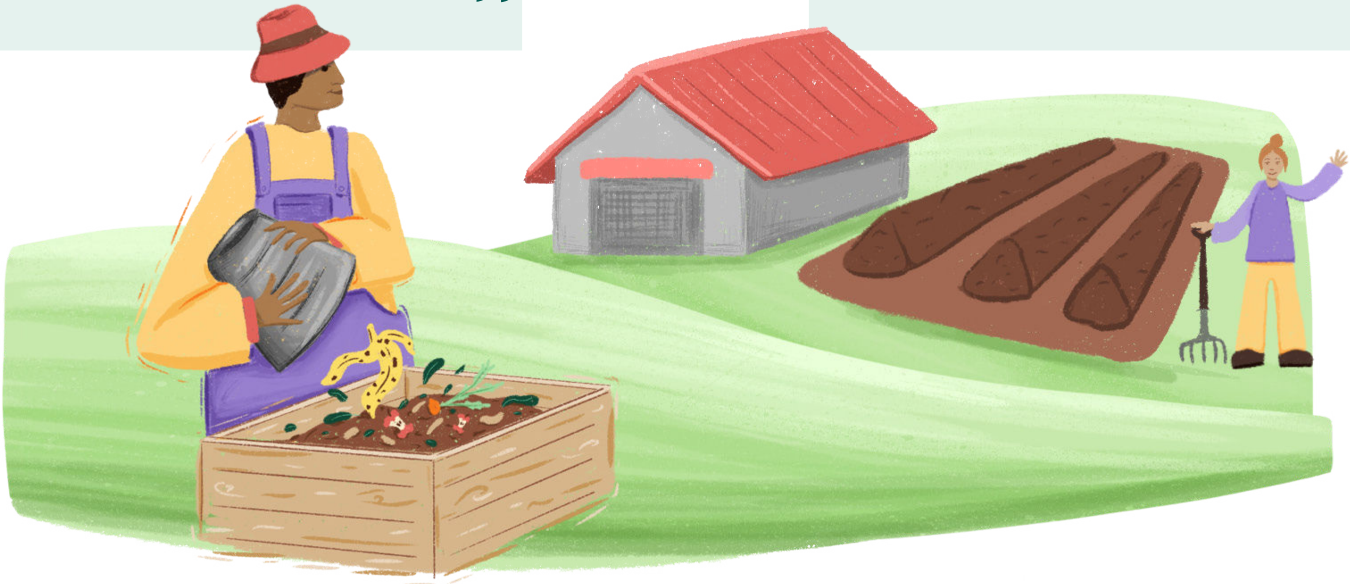
- Grants from council or other sources (34% of participants)
- Sale of compost or food grown with compost (25% of participants)
- Contract or procurement by large institution(s) (22% of participants).

Table 1: Collection and drop-off charges

	Kerbside pick-up	Drop off
Average price/litre	$0.81	$0.60
Median price/litre	$0.70	$0.61
Standard deviation	0.55	0.39

> ...47 full-time and 47 part-time employees are employed to work on organics processing during a typical week in Aotearoa New Zealand.

> ...enterprises coordinate a combined 125 volunteers each week, who contribute 234.5 total volunteer hours per week...



The survey asked participants whether their enterprise had experienced changes in funding since it began. Of the 25 participants who responded to this question, 12 noted no change, 8 reported new funding streams, 4 had received new start-up funding, 4 had experienced loss of funding (either through losing contracts, or inability to meet rising costs), and 3 had increased their self-reliance via other means. In terms of expected changes to income in the future, of the 24 participants who responded to this question, 9 intend to increase their self-reliance through a new product or service, 11 are seeking new funding sources (such as grants or contracts for service), 4 do not expect any changes, and 3 are planning on increasing fees for service[5].

The survey asked participants to estimate the annual monetary cost per 'household' to provide an organics processing service based on their enterprise's current operating model. This proved difficult to answer given the range of composting enterprise models and diversity of practices. Over half (54%) the participants who answered this question were unsure what the monetary cost would be. Twenty-one percent estimated the cost to be more than $151 per household per year, 14% estimated the cost to be between $51 and $150, and 11% estimated it to be less than $50. We note it is unsurprising that 54% of participants were unsure, given the high proportion of non-profit and 'other' composting enterprises represented in the survey. Most of these enterprises do not provide a 'fee for service', so would not be in a position to provide an estimate (nor may they wish to provide this kind of service for a fee). The wide range in estimates also reflects the diversity of practices and operations; further detail would be needed to adequately compare these. For example, does the cost include collection (pick-up), or only drop-off/delivery, what kinds of organic materials are included (e.g. 'compostable packaging'), what kind of processing technologies are used, what are the costs used for (e.g. human labour versus capital/plant), and what is the regularity of the service? The difficulty in responding to this question highlights the complexities involved in reliably costing fees for organics services.

The survey asked participants how many paid employees their enterprises supported. Across all the participants who answered this question, 47 full-time and 47 part-time employees are employed to work on organics processing during a typical week in Aotearoa New Zealand. Half the participants noted that their enterprise also provides unpaid volunteering opportunities to the wider community. Across these participants, their enterprises coordinate a combined 125 volunteers each week, who contribute 234.5 total volunteer hours per week, with an average of 1.9 hours per volunteer per week.

5 Note, some participants described more than one expected change to their future income, hence these numbers exceed 24.

Composting capacity, collection methods and processing

Capacity and end-markets/uses

Currently, no standardised national data collection method for organics processing exists. The inputs (organic material) and outputs (compost) are sometimes measured in weight, in volume, or not at all. Here, we have reported weight and volume separately because it is difficult to convert weight and volume measurements without knowing the density of the organic materials or compost.

Thirty participants (73%) track data on the organic materials they receive. Collectively, these participants received 216,953 tonnes[6], and 69,900 litres of organic materials in the last 12 months. Twenty participants (49%) track data on the amount of compost they generate. Collectively, these participants generated 3,148 tonnes, and 356,840 litres, of compost. These twenty participants did the following with the compost generated:

- 144 tonnes (4.5%) and 84,000 litres (23.5%) used on site
- 3,004 tonnes (95.4%) and 11,800 litres (3.3%) given away (or exchanged without money)
- 261,040 litres (73.1%) sold

Given the challenging and varied data collection methods, we anticipate that these numbers are a considerable underestimate of the collection and composting capacity of those surveyed[7].

Composting processing technologies and end-markets/end-uses

Participants were asked how many sites their organisation has - one, two, or three or more sites. Of those who answered this question, 16 (50%) have one site, 7 (22%) have two, and 9 (28%) have three or more sites. These findings show that there are multiple ways of arranging processing logistics (e.g. either at one or across more than one site.)

The following outlines the percentage of participant's enterprises who use particular composting processing techniques and technologies[8]:

- Box (62%)
- Worm farming/vermicomposting (56%)
- Windrow (29%)
- Bokashi (21%)
- Aerated static pile (19%)
- In-vessel (13%)
- SPICE (10%).

6 The majority of this is received by one participants' enterprise = 190,000 tonnes in the last 12 months.
7 Twenty-five percent of participants do not collect data about the amount of organic materials accepted and 50% of participants do not collect data on the amount of compost generated.
8 Participants could select more than one option, hence the percentages do not add to 100%.

In terms of demand for compost, approximately 50% of participants categorised demand for their compost as meeting expectations, while approximately 25% noted that demand is above or far above their expectations. Approximately 12% described demand being below or far below expectations, with the rest being unsure. These findings suggest that compost outputs are valued and demand is either at, or exceeding expectations for the majority of participants' enterprises.

> "...findings suggest that compost outputs are valued and demand is either at, or exceeding expectations for the majority of participants' enterprises."

Types and sources of organic materials and collection methodologies

The percentage of participant's enterprises who accept different types of organic materials is as follows:

- 84% accept fruit and vegetable scraps
- 72% accept garden/general green waste and other food scraps
- 63% accept paper towels, cardboard, and/or paper
- 41% accept compostable packaging and/or 'bioplastics'
- 31% accept animal products[9].

Participants' composting enterprises obtain organic materials from a variety of courses. Some organisations track data on these aspects, while others do not. Table 2 quantifies organic materials by source, over the last calendar year[10] for those participants who do track input sources.

Table 2: Breakdown of who provides organic materials to composting

Groups	% of participant's composting organisations who accept materials from each group	Total number of each group served	Organic materials contributed (tonnes)	Organic materials contributed (litres)
Households	66%	13,609	208	95
Hospitality businesses	50%	138	76	956
Workplaces	47%	158	76	0
Landscapers/ arborists	47%	41	24	288
Schools	47%	119	76	0
Food retail businesses	19%	4	73	0
Public institutions	19%	6	75	6
Marae	6%	1	unknown	unknown
Other	19%	11	3,256	0

9 1 participant noted that they also accept sludges and biosolids.

10 We asked participants about the total amount of organic materials they received, and output (compost) created. This was used to calculate the total tonnes and litres figure. We then asked respondents what percent of organic materials come from specific groups (e.g. households). Some respondents did not fill out this question, or could not confirm amounts for specific groups. Hence the total tonnes and litres in Table 3 does not match the overall total numbers outlined earlier. If the respondent did not provide both data points then it was excluded in Table 3.

> For kerbside collection, seven participants use trucks, four use non-electric cars, two use electric vehicles, and three use bicycles.

Organic materials are most often transported from the source to the composting facility through either kerbside collection or drop-off. Drop-off facilities are an alternative to individual collection services in which multiple users bring organic materials to a specified location, usually located at or near the composting facility. Containers at drop-off locations usually hold much larger quantities of organic materials than individual collection vessels, and reduce the need for collection infrastructure and logistics (e.g. vehicles, bins). For kerbside collection, seven participants use trucks, four use non-electric cars, two use electric vehicles, and three use bicycles. The largest vehicle collection fleet included eight trucks.

Table 3 shows the relative amounts of organic materials collected via these different methods over the last 12 months. The "Other" category is large (tonnes and litres) because of the contributions from a participant's enterprise that administers composting for commercial customers. Given the challenges and different approaches to data collection, we consider Table 3 to be a considerable underestimate of the volume and weight of materials collected and dropped off.

Land, relationships and co-located activities

Participants were asked about access to land and tenure. Of the 59 total sites represented by participants in the survey, 17 (29%) are located on privately owned land, 28 (47%) are on land owned and administered by a territorial authority, 11 (19%) are on land administered by the Crown (central government), and 3 (5%) are on Māori owned land. In terms of access arrangements, 9 sites (15%) rely on informal or verbal use agreements while 40 sites (68%) have formal written leases/use agreements. The remaining 10 sites (17%) have some other arrangement.

Participants noted that other activities were often occurring at their composting sites[11]. These co-located activities may or may not be administered by the composting enterprise. The most common co-located activities for the participants who reported these are:

- Community gardens (50%)
- Schools, kura, or educational institutions (34%)
- Food forest or silviculture (25%)

Table 3: Organic materials collection methods

Collection Method	Organics collected per year (tonnes)	Organics collected per year (litres)	Percent of total inputs by weight	Percent of total inputs by volume
Kerbside collection	30,475	0	14%	0%
Drop-off	8,652	5,500	4%	10%
On-site management	0	0	0%	0%
Other	176,832	49,400	82%	90%

11 This reflects research from the United Kingdom by Slater and Aiken (2014), who found composting was commonly co-located with other activities and services.

While composting activities were the focus of the survey, we also asked participants which other activities their enterprise undertook. The most common other activities or services included, based on participants who answered this question are:

- Education (73%)
- Event waste management (58%)
- Growing food (58%)
- Social programs (50%).

The survey asked participants to describe the kinds of relationships and connections their enterprise has with other groups and institutions. Participants described how they connect with other composting organisations through networks and organisations like Para Kore, WasteMinz, Enviroschools, Soil & Health Association, and Zero Waste Network, and more 'informal' networks like the Aotearoa Composters Whatsapp group. Some participants also described partnerships with their local council, Ministry for the Environment, and other placed-based groups in their region. Fifty-three percent of participants noted that they have some relationship with mana whenua through direct connections, and/or collaborative partnerships through Para Kore. Five percent of participants noted that they are, or represent, mana whenua. These results indicate an emerging network of actors who at times work together to achieve certain outcomes across different scales, with the potential for more collaboration. For example, one participant described how their enterprise:

"... works with both smaller community groups and larger composting plants where the organic waste is more beneficial to divert either to...or away from [their organisation]".

Impacts of organic materials management practices

The survey asked participants to describe impacts of their composting enterprises in their own words[12]. Table 4 provides a summary of self-reported impacts.

Some of the self-reported impacts - e.g. diverting waste from landfill and using compost to improve soil quality - apply to all composting enterprises regardless of their operating model or processing capacity. However, some of the impacts were specific to particular models, such as organisations that service smaller geographic areas. Some participants from these types of organisations described how their enterprises can help foster a sense of belonging and meaning for people who contribute their organic materials, as they know how these materials are processed, used and by whom. Furthermore, one participant described the social connections their composting can create:

"... people come along and chat while we are there, visit the gardens and it seems to bring so much interest and joy to people."

Another participant described how their compost operation helps welcome new residents to the community:

Table 4: Self-reported impacts of composting enterprises

Impact	Number of participants[13] (%)
Diverting organic materials from landfill	17 (51%)
Community empowerment and community building	16 (48%)
Enabling environmentally friendly lifestyles or work practices	13 (39%)
Enable growing of food	10 (30%)
Reduce waste disposal costs and/or generate income	10 (30%)
Create jobs and build skills/knowledge	9 (27%)
Help improve soil quality by retaining local resources (nutrients)	7 (21%)
Help reduce greenhouse gas emissions	6 (18%)

12 Asking participants to self-describe the impacts of their operations is consistent with well-established impact evaluation processes, such as Social Return on Investment (SROI) (c.f. Social Value International, N.D). For example, in SROI methods, the focus is on the value and/or impacts certain practices create for stakeholders. These values and/or impacts are communicated in their terms.

13 33 participants responded to this question, and participants were able to describe as many impacts as they chose, hence the summed percentages exceed 100%.

"... many people new to [town] enjoy coming to check out what we do as a part of assimilating into the [town's] community."

Some participants described how their composting enterprise enables people to take environmental focused action, especially when wider waste infrastructure is absent. For example, one participant described how restrictive rental rules get in the way of home composting and there is no council organics service in their area, but that their enterprise fills that niche:

"... students love that there is a place they can bring their food scraps for composting as most landlords don't allow composting in flats."

Participants also described how their enterprises can help to build resilience by keeping nutrient cycles local, especially as climate change impacts escalate. Given 69% of participants who compost on-site then use this compost on their site, a closed loop, local circular process is fostered. One participant described this as:

"... we enhance the resilience of our community - building local, closed-loop food systems to be more resilient to global shocks."

Other participants suggested that their local composting enterprises provide more environmental and social benefits without the harms of greenhouse gas emissions associated with single-site processors that transport materials long distances. These participants noted that using local organic inputs was less expensive than sending organic materials to landfill, or transporting it out of region for processing, while also helping to create 'local' jobs and income from selling compost. One participant described how distributed networked sites will be important moving forward to address both waste minimisation and provide alternative inputs to the horticulture and agriculture sectors:

"I went on the North Island composting tour with the Zero Waste Network and about half the participants were from district and regional councils. There was a degree of disappointment in the lack [of] options for medium scale, on-farm composting systems like ours given that most of these areas are mainly rural and the price of fertiliser is sky high."

Most participants described impacts of their enterprises that went beyond waste minimisation and diversion from landfill, and included social, environmental and economic impacts. Reflecting these more holistic impacts, nearly a third of participants' enterprises have begun since 2020 (coinciding with the beginning of the COVID-19 pandemic). Participants were asked what motivational drivers prompted the start of their compost operation (they were able to select more than one driver). The four most common motivational drivers are:

- Divert waste from landfill (84%)
- Take action on climate change (66%)
- Improve food security and soil health (63%)
- Community action or activism (59%).

Other motivations included: mana motuhake (Māori self-determination), creating employment opportunities, reducing chemical fertiliser use, and reaching students without access to composting facilities.

The survey asked participants to describe their aspirations for their compost enterprises. The responses indicate that many enterprises hope to grow and expand. Specific aspirations and actions include:

- Increasing compost-producing capacity
- Adding additional composting sites
- Recruiting new staff and volunteers
- Expanding education initiatives
- Refining composting methods and processes
- Using outputs to support food production and food security
- Increasing financial viability/stability
- Securing council procurement for their services
- Developing new partnerships with government funded institutions (e.g. schools, universities), commercial stakeholders and others.

Some participants noted that the recent shifts in central government policies on waste (specifically separate collection of organic materials for households) provided opportunities to scale out their existing distributed network:

"We would like to see localised hubs like ours all around our district. We think it is great the government wants to bring in food scraps pick ups across Aotearoa, but we want to keep it local here, not have a large commercial compost take it out of our district."

Reflecting the self-reported impacts, these aspirations and future actions extend beyond waste minimisation and diversion from landfill. They show how composting enterprises connect with a variety of concerns, including food security, resilience, climate change mitigation and adaptation, and education for social change. Taken together, these aspirations indicate a desire to scale-out existing processes via a distributed network approach (rather than only 'up', in terms of continuing to grow a single site), and in the process provide more services and develop peer support networks where successful approaches can be shared to help other compost enterprises start.

The following section of this report uses the survey findings to create a new taxonomy for organics processors in Aotearoa New Zealand. In Part 3, this taxonomy is used as a framework to understand how the various impacts discussed above constellate around different composting service provider models.

Part 2:
CATEGORISING COMPOSTING PRACTICES AND ENTERPRISES

The survey results indicate that organic materials management in Aotearoa New Zealand is characterised by a diversity of enterprises and practices that operate across different scales and sites. They are supported through a mix of fee-for-service and volunteer labour, and can generate a range of potential impacts. This variety of processors and models offers local and central government options when making policy, investment and procurement decisions in relation to organics. However, we currently lack a common language that would enable decision-makers to distinguish, compare and evaluate these options for the purposes of creating an integrated organic materials management system.

A growing body of local research is broadening our collective knowledge about organic materials and composting in Aotearoa. Recent studies have explored management and processing options (Prince, 2021), the significance of food waste (Office of the Prime Minister's Chief Science Advisor, 2022), the important role organic materials play in the life-sustaining and relational processes of soil, growing food, human-nature, and human-human connections (Diprose et al, 2023; Wing and Sharp, 2023), and connections between composting and Māori soil sovereignty and wellbeing (Hutchings and Smith, 2020; Pauling and Ataria, 2010). Taken together this work highlights the need to better manage organic materials, documents the diversity of organics diversion practices already occurring, identifies some impacts and outcomes of composting, and illustrates how composting intersects with other practices related to soil health, food production, human wellbeing, food sovereignty and Indigenous Māori understandings of 'waste' as a colonial-capitalist imposition. **However, it doesn't necessarily attempt to categorise composting practices nor support policymakers to identify various options and approaches for procuring organics diversion services.**

As a result, organics infrastructure mapping and procurement by central and local government has to date allocated disproportionate attention to single-site processors managing large tonnage. Diprose et al. (2023) suggest this focus stems from an assumption that these processors can divert larger amounts of organic materials, can more readily process 'problematic organics' and manage health and safety requirements, more easily fit within existing local/central government procurement processes, and are therefore generally seen as more viable "commercial" offerings. On the other hand, smaller processors are often labelled "community composters", and not generally considered easily scalable nor procurable. This **commercial-community dichotomy** currently used to categorise organic materials processors in Aotearoa New Zealand lacks nuance and has potentially unhelpful implications for how decision makers view a processor's viability, scalability and suitability to deliver organics diversion services. In particular, the "community composting" label does not adequately capture the range and diversity of models that characterise New Zealand's existing composting landscape, nor the way that these different models might 'scale'. Consequently, many processors with a procurable model may be effectively 'off the table' due to these misrepresentations.

> "…the "community composting" label does not adequately capture the range and diversity of models that characterise New Zealand's existing composting landscape, nor the way that these different models might 'scale'."

This report seeks to propose a more nuanced categorisation of organic material processors. To do so, we have undertaken a review of international literature on composting terminology, and have integrated this with insights from the survey results outlined in Part 1. Our proposed categorisation avoids use of the term "community" and instead distinguishes processors based on whether they are voluntary or in-house 'composting clubs' or pay-for-service 'composting service providers'. The latter are enterprises that charge for services and have paid staff (whether or not their enterprise is 'for profit'). We classify 'composting service providers' as more readily procurable, due to their commercial nature and ability to scale. Within the composting service provider category, rather than focusing on tonnage processed (the typical defining feature), we distinguish providers based on both their organisational structure (single-site or distributed network) and the geographical area their enterprises service. These factors have the most significant implications for costs and associated impacts (including system resilience).

International approaches to categorising composting service providers

A brief analysis of international literature highlights some notable terms and definitions given to organic materials management systems. We outline how they have been deployed, assess their strengths and weaknesses, and explain how we have approached them in creating a specific taxonomy for Aotearoa New Zealand.

Centralised versus decentralised

One of the most common distinctions in the literature is between **'centralised'** and **'decentralised'** organics processing models. In simple terms, they respectively refer to whether organics produced in any given area are processed by a singular, large-scale, 'centralised' facility, or by multiple facilities with varying processing capacities[14]. They therefore define the **logistical arrangements** that underpin a particular processing model.

Decentralised models have often been defined in contrast to centralised models. This is likely because centralised systems have tended to dominate organics service provision, due to attempts to maximise efficiency and achieve "economies of scale to reduce the overall cost of solid waste collection and provide a consistent level of service" (Pai, Ai & Zheng, 2019, p.2; see also Diprose et al., 2023). Defining one model in contrast to the other can create an unnecessary sense of fundamental tension or incompatibility. For example:

"Decentralized composting can be defined as a network of, or standalone processes, at the backyard, neighborhood or community level that divert and compost food waste ***that would otherwise be sent to be processed regionally****" (Pai, Ai & Zheng, 2019, p.2. Emphasis added).*

The Zero Waste Network (2021) has previously employed the terms 'decentralised' and 'centralised composting' in a position statement on organic waste. The terms were used to distinguish different layers of the food waste hierarchy, drawing on international examples and terminology (e.g. Platt, 2017). The position statement defined "decentralised composting" as "[c]omposting as close as possible to the source of organic waste to minimise transport and maximise availability of resource to be used locally. Usually small to medium scale" (p.9). It also defined "centralised composting" as "[a]dvanced technology with highly mechanized equipment" (p.10). These definitions focused less on the different logistical arrangements that distinguish decentralised and centralised models, and more on other factors, such as localisation and industrialisation. The paper also sought to distinguish decentralised composting from centralised composting based on outcomes, i.e. that decentralised composting leads to: better compost quality and contamination management, less automation and greater labour requirements, reduction in transportation costs, greater flexibility/scalability, greater regulatory barriers, and higher potential for poor management. However, these potential outcomes and features can be influenced by other factors as much as (if not more than) whether a composter is centralised or decentralised.

The tendency to define decentralised models by distinguishing them from predominant centralised models has led to definitions that bring in parameters superfluous to the essential meaning of 'decentralised'. This misrepresents and creates a misunderstanding of the diversity of operators that could fit within decentralised models and the role they can play in organics diversion ecosystems, while also making it difficult to accurately

14 This distinction is not specific to organic materials management nor even just waste infrastructure. However, the waste sector and organics management systems provide very clear examples of how this works.

quantify and assess critical system factors such as scalability, resilience and cost. These misunderstandings could be detrimental if centralised solutions are proposed in situations where a decentralised model might be more appropriate, cost-effective and fit-for-purpose. Two examples of successful but contrasting decentralised models are found in Besançon, France, and in large parts of Austria (see Prince, 2021, pp.9-10). The Besançon system consists of hundreds of small facilities, each attached to an apartment complex, and larger facilities for neighbourhoods without space for apartment facilities, across the city (Sybert, n.d.). The Austrian system utilises a wide variety of processing facilities, most of which are modest on-farm composting operations that source organics from nearby towns and cities (Amlinger, 2012, p.9; Favoino and Giavini, 2020, p.21; Salmenperä, 2021, p.4; Amlinger et al., 2009; Kisliakova, 2005, p.31).

Because the terms centralised and decentralised are often defined in conjunction with other factors such as material flow distances, processing capacity/scale of facilities, output quality etc., we have opted not to use these terms in our taxonomy. **Instead, we simplify the concepts by using the terms 'single-site' and 'distributed network' to describe the essential difference in logistical arrangements (i.e. whether the model relies on more than one site or not).**

Scale

'Scale' is a common distinction applied to organics processing facilities. Scale usually refers to processing capacity, although there are no international or national standard definitions of what constitutes 'small', 'medium' and 'large-scale'. For example, some literature places any 'full-scale facility'[15] with an annual processing capacity of less than 5,000 tonnes in the smallest-scale bracket (BioCycle, 2017; Goldstein, 2019), while others suggest anything above 500 tonnes is 'large-scale' (Slater and Aiken, 2014, p. 1092)[16] or in the largest-scale bracket (SPREP, 2020, p.5). Some literature uses 'households served', rather than tonnage processing capacity, as a measure of scale (CPHEEO, 2018). Additionally, scale typically only refers to the processing capacity of a single site or facility, rather than the capacity of distributed networked sites, revealing both an inherent bias toward single-site/centralised models, and an assumption that processing capacity is always a static, unchangeable feature, rather than something that some models may be able to increase or decrease, as needed.

Scale is also used in conjunction with other terms to describe specific aspects of processing facilities that may reflect socioeconomic purpose, enterprise structure, and/or location. For example, 'commercial', 'community', 'regional', 'neighbourhood', and 'home' - followed by 'composting' or 'organics processing facility'. While these other terms may refer to the average processing capacity of the facility, they can also create confusion and invoke pre-existing assumptions. Such terms also often overlap with descriptions of either centralised and decentralised models. For example, 'large-scale', 'regional' and 'commercial' facilities are commonly associated with centralised models, and 'small-scale', 'home' and 'community composting' facilities are commonly associated with decentralised models. Sometimes these terms are used interchangeably in the literature, for example:

"Decentralized composting, also known as community composting, refers to a community-scale network in a specific neighborhood that diverts and composts biowaste in a controlled operative environment" (Bruni et al., 2020).

The range of definitions that invoke some aspect of scale and connect this to other factors (socioeconomic purpose, enterprise structure, and/or location) can conflate quite separate factors. For example, commentators might use a processor's location as a stand-in for explaining their scale and/or their socioeconomic purpose, e.g. "community" = small-scale and voluntary, whereas "regional" = large-scale and commercial. This is problematic because scale, socioeconomic purpose, enterprise structure, and location are independent variables; one does not automatically predetermine the other. Terminology that implies dependence can perpetuate assumptions, e.g. that distributed networked systems are not easily scaleable or are not commercial, without a proper assessment of a particular processor's business or operational models. If applied to a single

15 "...a municipal or commercial facility equipped to receive and process organic waste streams arriving by truckload volumes from generators and haulers on a year-round basis. This is in contrast to "captive" and "community" composting sites, which BioCycle defines as follows:
- Captive: Only compost organics from own facility; utilize compost on-site. No outside materials accepted.
- Community: Small-scale operation that enables community members to manage organic material on a neighborhood scale, e.g. at a community garden or urban farm. Accepts feedstocks, e.g., food scraps from off-site. Seeks to keep organics in a closed loop (e.g., neighborhood), from source of feedstocks to use of compost" (Goldstein, 2019).

16 In the context of a study on 'community composting'.

facility, we consider scale one among multiple factors describing that facility's attributes. If applied to multiple sites in a distributed network, it simply describes the collective capacity of that network.

For these reasons, we do not consider scale a critical determiner of model type. However, we do see a model's approach to increasing its processing capacity in relation to its logistical arrangements as relevant. For example, if a model manages increased tonnage by growing the size of a single-site or expanding the number of sites within a network. We refer to this as 'approach to scalability'.

"Community"

The word 'community' is often used to describe a wide range of composting activities, enterprise models, processing capacities and more. It is often used as a stand-in for the purpose or business model of the composting activity. For example, it may denote a primarily non-commercial 'hobbyist' model, reliant on volunteers and perhaps attached to other voluntary activities, such as a community garden. The most precise definitions of 'community composting' facilities can be found in legislation in some jurisdictions, where such facilities are prescribed by parameters such as the maximum footprint or processing capacity, and the proximity of organic materials received, to which regulatory exemptions apply. For example, in Italian legislation, the definition of community composting is a facility which has a processing capacity of no more than 130 tonnes per annum (TPA), and is located within one kilometre of contributing users (ReteAmbiente, 2023). In California, the Department of Resources, Recovery and Recycling (2020, p. 54) defines 'community composting' as a facility in which "the total amount of feedstock and compost on-site at any one time does not exceed 100 cubic yards and 750 square feet".

However, general usage of the term 'community composting' varies widely in its applications and meanings. For example, in an analysis of the UK community composting sector, Slater and Aiken (2014) found there were:

"...a range of organizations engaged in composting that are highly differentiated by a mix of activities, size and scale. ...there does not appear to be a community of organizations sharing a similar meaning system but rather a series of subgroups some of which may link more coherently to other adjacent fields" (p. 1097).

The authors even suggest that composting as an activity "may not be a strong unifying characteristic" of groups that typically fall under the label 'community composting', and that the notion of community composting as a coherent sector or field is best understood as "under construction" and only "partially institutionalized" (p. 1098). The authors conclude that attempting to compare community composting enterprises, subjecting them to standardised forms of performance measurement, and even efforts to promote them collectively could be problematic and misleading. In an effort to demonstrate the variability of community composting groups, the authors propose a five-part framework to categorise different types of initiatives/enterprises, ranging from the volunteer-driven to the service providers with paid staff. These five types are differentiated based on the scale, activities, source of material, employment, location and other features of initiatives. To view Slater and Aiken's five-part framework, see Appendix 1.

In this report, **we avoid characterising processors using the term 'community composting' for its lack of clarity and precision.** In relation to distinguishing processor business models, we adopt some of Slater and Aiken's framing, specifically their **"composting club"** vs **"composting service provider"** categories, as these help to distinguish between commercial and non-commercial business models for the purpose of procurement. However, we define these two categories using different parameters to the five-part framework, and we also see Types II (land activities), III (social activities) and IV (3Rs) as capable of falling within either a composting service provider model or a composting club model.

Proximity and localism

The interchangeability of terms such as "decentralisation", "community" and "small-scale" in the literature highlight that proximity of processing/composting facilities to the source of organics is a key feature among the definitions quoted above (including the Italian legislation and Zero Waste Network definition) and multiple other definitions. The following example even cites the importance of the 'proximity principle' to decentralised models, which is defined as:

"Any source separation and composting scheme for organic household waste and green waste which implies not more than approximately 30 km distance between the point of collection and the composting plant (proximity principle). This figure is

an approximation. In sparsely populated areas with a distance of more than 30 km from the next settlement this would mean that it should consider to install its own small-scale composting plant" (Amlinger et al., 2009, p.110).

Proximity (which is sometimes referred to as local/ism) is relevant to consider because the distance material inputs have to travel has flow-on implications for cost and other impacts. Adhikari et al. (2010) modelled the financial costs and GHG emissions of four organics materials management system scenarios: "BAU (most organics going to landfill with 80% gas capture - Base Scenario), modest organics diversion rates relying on "centralized" composting facilities (Scenario 1), ambitious organics diversion relying on "centralized" facilities (Scenario 2), and a distributed network model with zero landfilling (90% of organics processed by 'home composters' and 'community composting centres (CCC)' - Scenario 3)". The study assumed that Scenario 3 does not require a collection system, and home composting and CCC are 'on-site' treatment systems. This analysis was applied to four country groups: high GDP European countries, low GDP EU countries, the EU as a whole, and Canada. The results showed that Scenarios 1 and 2 would increase costs and Scenario 3 would reduce costs compared to the Base Scenario, while Scenario 3 offers the greatest GHG emissions reductions (1048-1049).

Given the relevance of proximity, we have incorporated the **size of the geographical area serviced** as an important factor in categorising composting processors. We see this factor as **distinct from the difference between distributed network and single-site models** (there are cases where the former might service a wide geographic area, whilst the latter might service just one township). We have avoided use of the vague "community" moniker to denote proximity because, as previously noted, this term does not necessarily help to communicate the role that providers for a small geographic area might play in procured organics services. We emphasise that geographical area serviced does not automatically translate to the distance materials travel within a system, but allows for this to be considered when comparing particular models.

A taxonomy of composting for New Zealand

In the following section we build on the discussion of the literature above and the survey responses to create a refined framework for categorising composting enterprises and practices in Aotearoa New Zealand. As we are writing this report in the context of coordinated national and local attempts to build an effective organics materials management system for Aotearoa New Zealand, our focus is on developing a taxonomy that supports policy, investment and procurement decisions relating to composting service provision, and so procurability and approach to scalability receives greater focus here than in the international literature.

We consider Slater and Aiken's framework (Appendix 1) a useful blueprint for distinguishing compost processors, particularly its use of the terms 'compost clubs' and 'composting service providers' to distinguish in-house or purely voluntary models from pay-for-service enterprises. However, their framework focuses on 'community compost groups' only, and differentiates them primarily based on tonnage processed per annum, associated activities and labour model. We consider all potential processors and distinguish them based on logistical arrangements, geographic area serviced, and the business model the group adopts, as these are more relevant to New Zealand's composting landscape as a whole, procurability and approach to scalability.

Table 5 summarises the discussion of common terms in the literature and how we are adapting them for clarity for the purposes of this report. *Please note: our use (or not) of the following terms should not in any way be interpreted as commentary on the nature of enterprises who have chosen to use such terms, e.g. ("community" or "club"), in their names. The name of an enterprise does not dictate whether they would be classified as a composting club or a composting service provider within our taxonomy.*

Table 5: Summary of our adaptations of terms from the literature

Terms in literature	Definition summary	Alternative terms used in this report
Centralised vs decentralised	Logistical arrangement of processing facilities	Single-site vs distributed network
Scale	Processing capacity	Approach to scalability
Community	A diverse range of typically smaller-scale composting initiatives distinct from large-scale 'industrial' facilities	Avoid use of 'community'. Distinguish business models based on composting clubs vs composting service provider
Proximity & localism	Distance between source of organic material and processing facilities	Geographic area serviced
Composting clubs vs composting service providers	Slater and Aiken's five-part framework distinguished based on tonnage processed, material source, labour model, location.	Composting clubs vs composting service providers, distinguished based on business model.

> "In our view, composting service providers are procurable options for council organics diversion, whereas composting clubs are less obvious candidates for procurement (but could still be supported in other ways)."

Our proposed taxonomies are set out in Table 6 and Figure 1. Table 6 focuses on distinguishing organics processors based on their business/service model, differentiating composting clubs from composting service providers, to categorise attributes related to processors' purpose, and business, labour and finance models.

In essence, a composting service provider charges a pay-for-service fee and processes materials that are mostly (if not wholly) generated off-site. In contrast, composting clubs are projects serviced wholly or primarily by volunteers and/or which exist as an internally-funded on-site solution to a particular organisation's organic materials (such as hospitals, schools, or a business managing their business waste on-site). In this sense, the term "club" can encapsulates both hobbyist models and models that are exclusive to the site on which they are located. In distinguishing composting clubs and composting service providers, a not-for-profit status is not generally determinative; the key factors are whether a processor charges to deliver a regular service, has paid staff, and processes mostly materials generated off-site.

In our view, **composting service providers are procurable options for council organics diversion, whereas composting clubs are less obvious candidates for procurement** (but could still be supported in other ways). This distinction helps policymakers to understand which service providers can be considered in the design of effective organic materials management systems.

Table 6: Categorising composting business models

Broad Category	Composting clubs	Composting Service Provider
Description	Includes provision of composting facilities (generally processing, not collection or sale of compost) that is not procurable. Tend to take place at: • Community gardens • Public facilities (schools, universities, hospitals, tertiary education providers, corrections facilities) • Marae • Community centres Usually compost processing is provided as an ancillary activity to the primary activity or purpose, or it is an internally-funded in-house system exclusively for processing the organic materials generated on-site.	Includes composting services (collection, processing, and sale of compost) and products provided by an organisation or company that is procurable. This includes composting equipment and materials. May be provided as a standalone service (e.g. just collection or processing), or part of a suite of waste management services from collection through to sale/distribution of compost. Wholly or primarily manages organic waste that has been generated by third-parties who are off-site to the processing facility.
Business Model (Enterprise)	• Not for profit • May not be a legally constituted entity • Generally does not provide a 'procurable' service for general public	• Not for profit • Social enterprise • For profit • Cooperative • Legally constituted entity
Labour	Generally volunteer based workers or employees of the organisation that has established the in-house system	Generally wage/salaried workers
Finance	• Primarily operate through volunteer labour or the employees of the organisation that has established the in-house system • May draw on some Council, philanthropic, or other funding for certain aspects (e.g. materials, training of volunteers, signage)	• Operate by charging a fee for service/goods • May draw on some Council, philanthropic, or other funding for certain aspects (e.g. access to sites, training, signage, support for co-located activities)
Examples	Composting at community gardens, e.g. Innermost Gardens, Wellington Institutional onsite composting (e.g. school and marae based composting)	• Living Earth, Christchurch • MyNoke (various locations) • City to Farm, Auckland • Hamilton Organic Centre • Why Waste (various locations) • Xtreme Zero Waste, Raglan • Kaicycle, Wellington • Biorich, Napier • EnviroWaste, Hampton Downs • Community Compost, Nelson

> Rather than focusing on the tonnage processing capacity and using terms such as "large", "medium" or "small" scale, or "community", "centralised" or "decentralised", we have opted to distinguish processors based on their logistical arrangements, with a matrix that focuses on whether they are a distributed network (decentralised) or a single-site (centralised), and the geographical area serviced.

Figure 1 focuses on distinguishing the procurable composting service providers in order to understand the range of processing options available for policy, procurement and investment decisions. Rather than focusing on the tonnage processing capacity and using terms such as "large", "medium" or "small" scale, or "community", "centralised" or "decentralised", we have opted to distinguish processors based on their logistical arrangements, with **a matrix that focuses on whether they are a distributed network (decentralised) or a single-site (centralised), and the geographical area serviced.**[17] These factors have a greater bearing on scalability, cost and resilience (all key issues for procurement decisions and investment strategies) than tonnage processed alone.

We emphasise that the different categories of the matrix are neutral classifiers used for the purposes of distinguishing providers. As will be discussed in the final Part of this report, the overall impact of a particular model depends on the interaction of various factors. For example, a single-site operator can be fit-for-purpose for a particular community, while servicing a wide geographic area can be an approach to increasing processing capacity for a network operator (e.g. scaling out rather than up).

Figure 1:

Composting Service Providers	**Smaller geographic area serviced** e.g. town, small district, suburb(s)	**Larger geographic area serviced** e.g. regional or multi-regional
Single site	Single-site operator servicing a small geographic area → **Xtreme Zero Waste**	Single-site operator serving larger geographical distance → **Envirowaste Hampton Downs**
Distributed network	Network operator servicing a small geographic area → **Kaicycle**	Network operator serving larger geographical distance → **MyNoke**

17 For the purposes of this taxonomy, we do not quantify the distances that qualify as "small" or "large".

Part 3:
IMPACTS AND BROADER CONSIDERATIONS

This Part presents a framework (Table 7) of anticipated impacts of different operating models, based on our taxonomy, survey results and literature review. We also summarise the challenges survey participants face to establishing, sustaining and expanding their operations, and the kinds of support that would increase capacity and capability. We conclude by highlighting broader considerations to be considered when making policy, investment and procurement decisions about organics infrastructure and services.

Potential impacts of composting models

Generally, the primary goal of organic materials management at a policy/strategic level is to maximise diversion of organic materials from landfill, often measured through processing capacity. On its own, this measure does not provide a holistic assessment of circularity and can overlook other important factors, such as the energy/resources needed to collect and transport organic materials (inputs) and outputs (compost), wider socio-economic impacts (Morrow and Davies, 2021), and the extent to which systems are achieving the 'closed loops' needed to transition to a more circular economy (Mourad, 2016; Thyberg and Tonjes, 2016). Different methods of diverting organics can have a stronger or weaker role in generating other circularity impacts, e.g. reducing waste and emissions, regenerating nature and operating within social and planetary boundaries. Our proposed taxonomy offers a way to compare this wider range of anticipated impacts, including:

- Organic waste diversion from landfill/ability to increase processing capacity
- System resilience and diversity
- Proximity, low GHG emission system, and connection between organic material producers and processors
- Building soil/reducing contamination/supporting food resilience
- Job creation and quality

Organic waste diversion potential and processing capacity

The processing capacity of single-site operators is simpler to measure and the pathway to expanding capacity has clearer precedent, especially in Aotearoa New Zealand. However, there are cases where increasing processing capacity is not relevant, or where capacity can be increased in different ways. For example, a single-site operator with modest processing capacity can adequately service all households in a small geographic area (e.g. Xtreme Zero Waste in Raglan), negating the need to truck food waste out of that town to a larger processor. Alternatively, network operators can increase processing capacity by adding multiple new sites to their network (scaling-out rather than scaling up), thereby increasing capacity while maintaining proximity and system resilience (discussed below).

> "Different methods of diverting organics can have a stronger or weaker role in generating other circularity impacts, e.g. reducing waste and emissions, regenerating nature and operating within social and planetary boundaries."

A network 'scaled-out' approach can enable duplication of low-cost infrastructure, requiring less capital expenditure than scaling up one site with expensive industrialised processes (Pai et al., 2019). However, the scale-out approach requires access to multiple sites and this may be costly and difficult to arrange and administer. Additionally, planning rules may make it easier to obtain resource consent for one site with larger processing capacity than multiple networked sites. However, this depends on the scale and intensity of processing, and the specific planning rules in the relevant territorial authority/region (Diprose et al., 2023).

System resilience and diversity

Our survey findings suggest that system resilience is of increasing concern, with nearly one third of composting enterprises beginning since 2020 (coinciding with the start of the COVID-19 pandemic). Some participants specifically noted that disruptions to food supply and waste management associated with the pandemic were drivers for starting distributed composting operations that serve smaller geographic areas, as these were viewed as having greater resilience. As climate change and other associated disruptions increase over the coming years, the resilience of waste management systems will become even more important to consider.

> "As climate change and other associated disruptions increase over the coming years, the resilience of waste management systems will become even more important to consider."

Resilience researchers suggest that increasing the resilience of infrastructure involves three related capabilities; "providing absorptive capacity so that the network can withstand disruptions, providing adaptive capacity so that flows through the network can be accommodated via alternate paths, and providing restorative capacity so that recovery from a disruptive event can be accomplished quickly and at minimum cost" (Turnquist and Vugrin, 2013, p. 104). Distributed networks are likely to require a longer and more complex process to establish and procure than single-site operators, but would be far more resilient to disruptions as they have in-built redundancies that provide more absorptive, adaptive and restorative capacity.

For example, in Christchurch, the city's kerbside organics collections are all processed at one single-site: the Council-owned organics processing (composting) plant in Bromley, operated by Living Earth. Following odour complaints, this site is slated to close, and a new facility established elsewhere, if smell mitigation technology cannot be implemented. The example illustrates the inability of the site to adapt to changing community expectations and restore itself following a disruption. The impacts caused by the closure in the absence of alternative site/s will be significant: the landfilling of thousands of tonnes of organic waste, with associated landfill levy costs and increased GHG emissions implications; the odour problem being distributed across the city as food scraps would be handled by transfer stations with inadequate facilities to do so; and the potential for further erosion of social licence for composting in the wider community (c.f. Law, 2022).

Furthermore, an organic materials management system that applies a network approach or opts for multiple single-site operators that each service a smaller geographic area can generate beneficial diversity and utilise a variety of processing technologies that are suited to different material inputs or land availability. In other words, such approaches can increase absorptive capacity and provide adaptive capacity. For example, network operators such as MyNoke establish nodes to process particular organic materials close to source (e.g. paper mill waste) or establish on-farm set ups.

Proximity, GHG emissions and community connection

Reducing the distance organic materials travel to processing facilities can reduce costs and GHGs (as noted in Part 2), and can also increase a sense of connection between producers of the organic materials and processors (Morrow and Davies, 2021; Slater and Aiken, 2015). In many cases it will also mean that outputs (e.g. compost) travel shorter distances as well. Generally speaking, these outcomes are more easily achieved by providers servicing a smaller geographical area, as this model guarantees proximity. Therefore, as geographical area expands, the distance that material inputs travel must be considered if GHGs are to be reduced and the connection maintained between the processor and the community from where inputs come. We note that this can be achieved through a network operator model, where a large geographic area is serviced, if individual sites in the network are located closer to the sources of the organic inputs (e.g. MyNoke

> Drop-off systems were also found in our survey to be significantly cheaper to operate than collection systems. However, socio-economic equity and accessibility also need to be considered for drop-off.

or Compost Connection). This enables the efficiency gains of one operating enterprise, but the diversity and resilience gains of multiple smaller operators.

Operators who service a smaller geographic area are more likely to be able to utilise low-emissions collection methodologies and vehicles, such as bikes (e.g. Community Compost and Kaicycle) and drop-off systems rather than collections (e.g. Easy Earth, Kaicycle or Besançon in France). Drop-off systems were also found in our survey to be significantly cheaper to operate than collection systems. However, socio-economic equity and accessibility also need to be considered for drop-off. For example, some people may not be able to drop off organics due to physical mobility, geography, time constraints or other factors.

Compost quality, soil remediation, supporting food resilience

While larger scale, single-site operator enterprises may have greater processing capacity, these systems can also require more formalised procedures and costly technologies to manage contamination and safety, which can be ineffective and may actually generate more surplus and waste (Mourad, 2016; ICF Incorporated, 2021, pp.11-19). In contrast, the smaller volumes processed by operators servicing a small geographic area enables higher levels of screening for contamination. Similarly, a network approach generally allows for input volumes to be spread over multiple sites (depending on the capacity of individual sites), generating similar results.[18]

Operators that maintain greater connection between communities generating materials, end-users and processors can also enable more beneficial flows of inputs and outputs (Diprose et al., 2023). For example, Xtreme Zero Waste in Raglan can tailor communications specific to their community to minimise contamination, while network operators or those servicing smaller geographic areas can support more targeted utilisation of outputs to achieve beneficial outcomes. For example, the Austrian system of supporting a network of farmers to process city-sourced food scraps that they can use on-farm instead of fertiliser is enabled through a network approach to processing. A similar model is being pursued by a range of initiatives in Aotearoa, such as City to Farm (North Auckland), Kaicycle (Wellington), 20:20 Compost (Christchurch), Community Compost (Nelson), Grow Space (Auckland), and many others, who use compost outputs for their own food production. Processors who use their outputs also have a greater incentive to produce high quality outputs and mitigate contamination.

> Operators that maintain greater connection between communities generating materials, end-users and processors can also enable more beneficial flows of inputs and outputs.

18 Other factors, particularly the sources and types of materials collected and accepted by processors, are likely to present greater contamination risks and management requirements than the differences between models in our taxonomy

Job creation and quality

Job creation can be measured in different ways. These include relatively simple measures like the number of full-time jobs created, or more qualitative measures such as the quality or nature of the work, recruitment and retention measures, and benefits of jobs to the wider community and economy. Generally, single-site operators that process more tonnage from a larger geographic area also tend to have higher levels of mechanisation and investment in machinery and technology. In other words, they require proportionally more investment in capital expenditure (CapEx = buildings, equipment, machinery and vehicles) rather than operational expenditure (OpEx = employee salaries, rent and utilities).

Over-investing in CapEx can create risks of maladaptation and sunk investment (especially in a climate changing world), whereby the infrastructure may no longer be fit-for-purpose or have unintended adverse effects, but is either maintained due to the initial costs, or written off as a loss. Similarly, investment in CapEx will generally mean less investment in OpEx, which has implications for the local economy. While there is limited research on job creation and quality in relation to organics management, literature suggests that network operators servicing smaller geographic areas tend to create more diversified and valued jobs, provide employment and volunteer opportunities for disadvantaged groups, and foster working practices that connect people to nature through decomposition processes (Slater and Aiken, 2014; Diprose et al., 2023; Morrow and Davies, 2021).

A framework to assess impacts of different organics enterprises

Table 7 draws on our survey results and the literature-informed discussion above to identify how enterprise attributes affect anticipated impacts, challenges and considerations, and provides examples from Aotearoa New Zealand. The anticipated impacts will depend on other contextual factors. However, Table 7 provides a starting point for key aspects to consider when making investment decisions about organics infrastructure.

Table 7: Anticipated impacts and challenges/considerations for different enterprises

	Small geographic area serviced	Large geographic area serviced
Single-site	Single-site operator serving small geographical distance	Single-site operator serving large geographical distance
Anticipated positive impacts and benefits	+ Keeps organic materials local (both inputs and outputs) + May be easier to manage contamination/produce higher quality outputs + Local jobs + More likely to foster community engagement and connection + Lower input transport costs and associated GHG emissions, as materials travel shorter distance and increased opportunity to use low-emissions transport methods such as bikes or smaller vehicles + May be able to process a wide range of organic inputs (but depends on method) + Limited transport of materials may improve overall system resilience + May be easier to obtain regulatory approvals (resource consent) than networked sites (but depends on scale, intensity and planning rules)	+ Regional jobs + May experience economies of scale in processing capacity + May be able to process a wide range of organic materials (but depends on method) + May be easier to procure under current approaches + May be easier to obtain regulatory approvals (resource consent) than multiple distributed network sites (but depends on scale, intensity and planning rules)
Challenges/ considerations	– Reliance on a single-site may reduce overall system resilience – May be harder to procure under current approaches, particularly if multiple providers might be required – May experience community opposition (but depends on scale, intensity and location)	– Less likely to foster community engagement and connection (can perpetuate 'out of sight out of mind' waste mentalities) – Reliance on a single site may reduce overall system resilience – Transporting materials a longer distance may reduce overall system resilience – Highest input transport costs and potential transport GHG emissions – May experience community opposition (but depends on scale, intensity and location) – Contamination more challenging to manage

	Small geographic area serviced	Large geographic area serviced
Distributed network	Network operator serving small geographical distance	Network operator serving large geographical distance
Anticipated positive impacts and benefits	+ Keeps organic materials local (both inputs and outputs) + May be easier to manage contamination/produce higher quality outputs + Local jobs + Can foster community engagement and connection + Limited transport of materials may improve overall system resilience + Lowest input transport costs and associated GHG emissions, as materials travel shorter distance and increased opportunity to use low-emissions transport methods such as bikes or smaller vehicles + Reliance on multiple networked sites may increase overall system resilience (ie. may have high network redundancy) + May be easier to integrate some sites in high-density urban contexts and/or co-locate with food production	+ Regional and/or local jobs + May experience economies of scale in processing capacity + May be able to process a wider range of organic inputs (depends on method) + Reliance on multiple networked sites may increase overall system resilience (ie. may have higher network redundancy) + Can restrain the distance materials travel, preserving community connection and reduced transport costs/emissions, even as service expands geographically + May enable tonnage to be spread across sites, enabling greater control of contamination and higher quality outputs + May be easier to co-locate some sites with food production
Challenges/ considerations	– May not process as wide a range of organic inputs (but depends on method) – May be harder to procure under current approaches because may be perceived as more complex – May be harder to obtain regulatory approvals (resource consent) than a single site (but depends on scale, intensity and planning rules)	– May be harder to obtain regulatory approvals (resource consent) than a single site (but depends on scale, intensity and planning rules – Ability to restrain distance materials travel or how tonnage is managed depends on number/location of sites relative to the source of inputs – Could be harder to procure under current approaches because may be perceived as more complex

Challenges

Participants described a number of challenges to establishing, sustaining and growing their organic processing operations:

- Access to land and security of tenure
- Regulatory requirements and rules/policies relating to organics processing
- A lack of standardised national data collection processes for organic materials (both inputs and outputs)
- A lack of standardised national guidance on managing inputs, especially in relation to contamination (including chemicals and potentially hazardous substances, like PFAS)
- Pest control

Very few of the survey participants own the land upon which they operate. More than half of the sites represented by survey participants are owned or administered by local or central government. When asked, 19% of participants described feeling either 'not at all confident' or only moderately confident in their continued ability to use or access land. This lack of security related to the ability to conduct composting activities on available land is compounded by regulatory requirements and planning rules that are another barrier for some enterprises. Nearly 20% of participants noted that they required resource consent[19] for their composting enterprise, while 10% were unsure whether they needed resource consent. Those participants who had obtained resource consent reported spending between $0 - $250,000 on the process.[20] We note that these challenges are particularly critical for network operators whose approach to increasing processing capacity tends to be based on increasing the number of sites rather than the capacity of individual sites; therefore, the costly process of securing and maintaining access to land is a barrier to the network composting service provider models and therefore also the positive impacts that their approach to managing organic materials can bring.

Participants described how the lack of standardised national data collection processes for organic materials (both inputs and outputs) affects their ability to measure and evaluate impact. As noted earlier, approximately

> "…19% of participants described feeling either 'not at all confident' or only moderately confident in their continued ability to use or access land."

25% of participants' enterprises do not measure the amount of organic materials accepted and 50% do not measure the amount of compost generated. These participants described various reasons for this, including: lack of standardised measurements and systems, and lack of time, personnel, and funding. Some participants noted that there was little point collecting data on these aspects unless national guidance was provided to ensure everyone was measuring the same thing using similar methods. Some participants noted that they did not have the resources and expertise to develop their own data measurement practices, and given the lack of national guidance they were not in a position to prioritise this.

Participants also raised concerns about the lack of national guidance on managing organic inputs and contamination. Contamination is difficult to quantify and there is currently no agreed national definition of what 'contamination' refers to in Aotearoa New Zealand for organic materials. To address this grey area in the survey, we asked participants to describe levels of contamination qualitatively. Fifty-six percent of participants described their inputs as having 'no, or a little contamination', 16% experienced 'a moderate amount', and 3% reported 'a lot'. The most common contaminants are plastic, compostable packaging, 'wrong inputs', and chemicals (like pesticides). Participants manage contaminants through: sorting by hand, preventative measures such as signage, and the pre-screening of inputs prior to acceptance (e.g. only accepting green waste if it is not in contact with pesticides). While participants have developed practices to reduce contamination, some noted that providing more national guidance and research on contamination of inputs would help provide certainty and support wider education of the general public.

19 Resource consents are required by a territorial authority or unitary/regional council for any activity that is either not permitted, or exceeds permitted activity standards in a district or regional plan.

20 The one participant who reported no costs noted it was because their operation was a 'trial' and the territorial authority did not require a resource consent.

> Some participants noted that to scale out and expand their impact they needed more sustainable funding models, rather than short-term or one-off grants.

Participants noted that pest (mammal) management is a concern when composting, with 69% of participants controlling pest mammals on their sites. Of those 69%, the majority use traps (91%), almost half design their composting materials to keep pests out (45%), over a third use poison (36%) and almost a fifth hunt pests (18%). For the 31% of participants who do not actively manage pests, they noted that they do not have these mammals on site.

Support needed

The challenges described above identify additional support that could help composting enterprises. In response to a question specifically about what support is needed, participants described two key things:

1. A national composting network
2. Sustainable funding models.

Nearly all the participants who answered this question suggested that some kind of national network is needed to support composting. Participants suggested this network could:

- Advocate for composters' interests
- Collate and share resources, knowledge, and good practice to build the community of practice
- Provide guidance on how compost enterprises can access and secure council procurement
- Provide guidance on how to meet regulatory requirements (resource consents, bylaws)
- Contribute to developing standard measurement metrics and common compost quality certification.

Some participants noted that to scale out and expand their impact they needed more sustainable funding models, rather than short-term or one-off grants. Some suggested that these shifts would also require central and local government to revise their investment approaches to waste infrastructure and associated cost benefit analysis. For example;

"... localised composting initiatives are typically under-resourced and find it hard to access funding, especially for operational costs which are heavy. Action further up the waste hierarchy tends to be a lot heavier in OpEx than CapEx.... localised composting services will never be the cheapest to councils - because the additional positive outcomes, including those beyond the waste lens, are not priced in (so the true value is greater), and neither are the externalities of commercial operations (so the true cost is greater)." (non-profit compost enterprise)

Implications for organics policy, procurement and investment

The qualitative survey responses discussing the challenges some operators face and the support needed highlights both the tension and potential opportunity presented by central and local government action to incentivise, procure and invest in collection and processing services for organic materials. On the one hand, this drive increases contractual and investment opportunities for composting service providers, which would provide a pathway to long-term financial sustainability for successful tenderers and funding recipients. On the other hand, if procurement processes and investment priorities only favour some of the four types of composting service providers identified in our taxonomy, this could lead to some providers being shut out of the market. This, in turn, would mean that society misses out on the positive impacts associated with those models.

Increasingly, organics researchers suggest there is no 'one-size fits all' approach to an effective organics material management system (c.f. Diprose et al., 2023; Prince, 2021). Rather, geography, context, and a variety of socio-economic factors need to be considered and will shape the most suitable organics management options for a specific community and region. In addition, any organics diversion system must consider how it adheres to and actively embeds the zero waste hierarchy and food waste hierarchy, including how its design can complement, rather than compete with, actions to prevent, reduce and reuse/redistribute food and other organics.

Our taxonomy provides a matrix to ensure central and local government are aware of the various options, and their associated impacts. We suggest that decision makers use our taxonomy to assess what proportion of contracts/investment they are allocating to which model type and then seek to address any imbalances to ensure a well integrated organics material management system that delivers as many positive impacts as possible. Some organics processing technologies will only apply to certain parts of the taxonomy. For example, anaerobic digestion is currently only feasible at single site models that process large amounts of material due to the costs of the infrastructure. However, this need not be an either/or situation - different models or parts of the taxonomy can also work together to build a connected organics management system that serves different purposes. For example:

- Pai et al., (2019) modelled the potential share of organics diversion that 'household/backyard' and 'community scale' composting ('decentralized composting') could achieve for the city of Chicago, alongside large-scale regional processing facilities. The results show that "decentralized composting" (using public parks only as 'community scale' composting sites) could divert 27% of residential food waste in Chicago, leading to cost savings and GHG emissions reductions for the City.
- The Austrian system has followed a general hierarchy of options that prioritises home composting, providing a collection service where home composting is not possible, and favouring agriculture composting operations that service a relatively small geographical area. Larger facilities have filled the remaining capacity gaps. This has led to a wide variety of organics processing facilities that work in an integrated, complementary system: as of 2012, nearly 1 million tonnes of organic materials were processed by 454 facilities across Austria, 292 of which were on-farm facilities (collecting and processing material from urban areas) with an average processing capacity of 1,100 t per site, 89 were 'municipal' facilities (2,700 t per site average), and 73 were 'industrial' facilities (5,900 t average) (Amlinger, 2012, p.9).
- Adhikari et al (2010) modelled the cost and GHG emissions reductions that could be achieved in a scenario in which 10% of organics are processed in 'centralized composting facilities', 60% by home composting, and 30% in 'community composting centres', which were greater reductions than scenarios relying on 'centralized composting facilities' alone.
- Morrow and Davies (2021) show how distributed networked composting processing sites across New York work in conjunction with residential kerbside collections to maximise socio-economic benefits (including jobs and social cohesion) that help reconnect people with nature through composting.

Conclusion

There are a variety of enterprises working to transform organic materials into compost across Aotearoa New Zealand in community gardens, schools, marae, not-for-profit and for-profit businesses, and resource recovery centres. These enterprises enable people and communities to shift toward greater local circularity and reduce greenhouse gas emissions. Given composting often happens alongside other activities (food growing, education, recycling, retail, and social programs), impacts could grow with further investment and more stable funding and procurement that values and factors them into procurement processes. Understanding the existing diversity and impacts of composting operations in Aotearoa New Zealand provides an important first step to help inform future policy and investment decisions to expand and replicate existing operations.

To help inform future investment in, and procurement of, organics infrastructure and services, we emphasise the importance of ensuring that decision-making adequately considers all the potential operators and works to create the appropriate mix of services to create a well-integrated organics material management system that maximises impacts and avoids over-reliance on one type of model or a small handful of providers.

To lay the groundwork for this type of decision-making, we offer two tools:

1. A taxonomy of composting enterprises that:
    a. Distinguishes between procurable (composting service providers), and non-procurable (composting clubs) composting enterprises[21]; and
    b. Distinguishes the procurable composting service providers in terms of their logistical arrangements, i.e. whether they are a single-site operator or networked, and the size of the geographical area they service.
2. A framework that identifies and compares anticipated impacts from the different procurable composting service providers that may exist within an organic materials management system.

We anticipate these two tools could help bring about a future where organic materials management decisions in Aotearoa New Zealand are evaluated and prioritised not just by the tonnes/volume diverted from landfill at the lowest cost, but by additional outcomes including: system resilience and diversity; transport emissions; community connection; local quality job creation; and soil restoration and compost generation for nutritious food production to support wider transitions in the horticulture and agriculture sectors.

21 While this may seem obvious, discussion across Aotearoa to date has tended to conflate smaller scale composting enterprises (regardless of whether they offer a fee for service) as 'community providers', which then impacts whether they are viewed as viable procurement options by Councils and others.

Appendix 1: Five-part framework to categorise Community Compost Group Types (from Slater and Aiken, 2014, p.1095)

	Scale	Main Activity	Source of material for composting	Staff and/or volunteers	Rural/urban/ suburban	Other
Type I: composting clubs	Micro/very small (<5 tpa**)	Composting	Householders bring to site	Volunteers	Rural	May run composting clubs***
Type II: land activities + composting	Small (<30 tpa)	Land use + education	On-site + householders bring to site	Mainly volunteers, small number of staff	Rural/urban	Training + education programmes
Type III: social activities + composting	Small (<30 tpa)	Services for disadvantaged + marginalized individuals	Collect from householders + householders bring to site	Staff + volunteers	Rural/urban	Training + education programmes
Type IV: 3Rs* + composting	Small (<30 tpa)+ medium (30-100 tpa)	Waste reduction, reuse + recycling	Collect from householders, commercial + householders bring to site	Staff + volunteers	Urban/ suburban	May receive recycling credits from local authority
Type V: composting service providers	Medium (30-100 tpa) + large (>1000 tpa)	Composting	Collect from householders, commercial, parks and gardens + householders bring to site	Staff + possibly volunteers	Suburban	May have service agreement or contract with local authority

*Note: *3Rs = waste reduction, reuse & recycling, **tpa = tonnes per annum, ***Composting clubs where householders pay a small fee to deposit waste and receive compost*

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