Organic Wastes in a Circular Economy

Report by Nelson Tasman Climate Forum

Te Tauihu
Nelson Tasman Marlborough

Carlo Wiegand, Author
Robin Schiff, Editor and Revision
Joost van Rens and Barbara Robson, Revision

Liam Prince, Reviewer (Zero Waste Network)
Karen Driver, Reviewer (Nelson Tasman Climate Forum)

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Organic Wastes in a Circular Economy in the Top of the South (ToS)

1. Summary

There is movement happening in the space of organic wastes in the top of the South Island - Te Tau Ihu. The newly released 'The Top of the South (ToS) organic waste mapping study' looks at re-processing organic material with bioconversion technologies. According to the study, Insect Bioconversion Technology is seen as a solution to obtain higher value for some of the organic materials. The study has surveyed with good detail (including GIS database) the availability and types of organic wastes for the whole Te Tau Ihu and has concluded that there are 700,000 tonnes per annum of organic waste of which 189,000 tonnes go to landfill. The study has a focus on industrial organic waste, i.e. from businesses although it includes the expected residential food waste collection by councils.

This paper intends to expand the ToS organic waste mapping study and shine a light on existing and potential options to keep more organic waste out of landfill, and instead transition these material flows into a circular economy. The priority focus of this report is closing the loop of organic material and nutrient cycles.The prevention and reduction of organic wastes in the first place has a high priority but is beyond the scope of this report. The paper also looks at the policy context of industrial organic waste and guiding principles that should be observed.

This paper is produced by a group of Nelson Tasman Climate Forum members and aimed at stakeholders in the sector including producers of industrial organic waste, organic waste processors, Iwi, economic agencies and councils.

Key Findings:

- The primary goal must be zero organic waste to landfill to achieve a reduction of greenhouse gases, a circular economy and regenerative agriculture.
- There already is some key infrastructure to process organic waste in the Nelson/ Tasman region and some of it is in the process of expansion - i.e. bEartha in-vessel composter by Community Compost.
- A lot more organic waste processing capacity must be generated to deal with the large amount of organic waste going to landfill. Private and public-private partnerships are urgently needed to drive the diversion from landfill.
- In order to go full circle, there must be increasing substitution of organic fertilisers for conventional fertilisers.
- The largest amounts of organic waste identified in the Nelson-Tasman region are from pipfruit, hops, grapes growing and processing and waste from breweries and wineries. There are also wastes from forestry, fish and shellfish processing, some of which could be more challenging to process. Challenges are transport distances, processing, and required ratios for processing.

2. Situation

2.1. The Top of the South Organic Waste Mapping Study

In May 2022, the The Top of the South (ToS) organic waste mapping study was published[1]. The study was commissioned by the Marlborough Research Centre (MRC) and Plant and Food Security Solutions (FSS). It was managed by Plant And Food Research (PFR), the Economic Development arm of the Marlborough District Council (MDC) and the Nelson Regional Development Agency (NRDA).

The mapping of the Organic Waste Stream is a leap forward for the region on its way to a more circular and carbon-neutral economy. It allows agencies and businesses to do a stocktake and think about more suitable ways of dealing with local organic waste streams. The new data allows us to formulate guiding principles regarding how to deal with these wastes, and creates opportunities for new business collaboration. It also allows businesses to assess how they can reduce the waste in the first place.

In the ‘Organic Waste Management Solutions’ chapter, the ToS study loses its focus on enhancing the circular economy and instead showcases Insect Bioconversion Technology (IBT) as the only economically viable option. At the same time, the study also states that IBT will only be able to divert a portion of organic waste away from landfill and other disposal methods. The study identified 700,000 tonnes p.a. of organic wastes from the primary sector and processing (inclusive forestry) in the Top of the South region and 189,000 tonnes p.a. of that goes to landfill. For the Nelson/Tasman region the study has identified 292,000 tonnes p.a. of total organic wastes of which about 125,000 tonnes p.a. goes to landfill[2].

In this report we intend to show a range of options for dealing with organic wastes. We want to re-focus on the goal of creating a circular and carbon-neutral economy, with zero organic waste going to landfill.

A working group of the Nelson Tasman Climate Forum (NTCF) has produced this report. The NTCF is a community-led initiative guided by the goals and commitments in its charter to rapidly reduce the region’s greenhouse gas emissions. This working group has been in discussion with the Nelson Regional Development Agency (NRDA) regarding promoting solutions to reduce industrial organic wastes going to landfill. The discussions have been positive and have led to this report. This study has a focus on industrial organic waste, i.e. from businesses although it includes the expected residential food waste collection by councils.

[1] Macdonald John (2022) ‘Top of the South (ToS) organic waste mapping study report.’ Marlborough Research Centre (MRC).
https://www.mrc.org.nz/news/2022/5/23/top-of-the-south-organic-waste-mapping-study

[2] Based on information from John Macdonald, author of the ToS organic waste mapping study, the landfilled amount is proportional to the regions landfill sizes.

2.2. Circular Economy and Government Policies

The goal for the region should be to close loops of nutrients, recycle the organic wastes locally and find an economically balanced way of doing so. Thus this needs a focus beyond the use and processing of organic wastes. It also needs to include evaluation of the local production processes from whence wastes come. The potential of reduction and prevention of organic wastes at their source should be investigated.

Agricultural and horticultural systems will need to be transitioned towards Regenerative Agriculture principles. The synthetic fertiliser inputs must be gradually replaced by locally made organic fertilisers to go full circle. Transitioning production methods to using organic fertilisers are increasingly being trialled and implemented.[3]

Even though there may be economic incentives to look for a better handling of organic waste, the methane emissions of organics in landfills continue to be a major problem for climate change. The government is moving into action on the issue. Central government is moving towards legislating 'Separation of business food waste'. The Ministry for the Environment consulted, in May 2022, on whether businesses should be mandated to divert their food/ organic wastes away from landfill[4].

The Climate Change Commission He Pou a Rangi Emissions Reduction Plan includes 3 necessary steps in their Action Plan: Enabling businesses to reduce food waste, Investing in organic waste processing and resources, and Requiring the separation of organic waste[5].

In regards to central government actions, the Office of the Prime Minister's Chief Science Advisor is currently leading a research project into Food Waste reduction that will look at combating food waste throughout the food system and capturing value through food rescue, upcycling, and recycling[6].

In this context, a wider framework for the processing of organic waste streams identified in the ToS organic waste mapping study should be established. The working group of the Climate Forum is working towards this goal and is making connections with stakeholders. In our view the Nelson Regional Development Agency (NRDA) is a key player in this. This report intends to contribute toward this goal by pointing out a wider range of potentially commercially viable opportunities for the environmentally beneficial use of organic waste streams in our region.

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[3] Nature-based Solutions. Catalysing Rapid Growth in Regenerative Agriculture with Mike Taitoko https://pureadvantage.org/catalysing-rapid-growth-in-regenerative-agriculture-with-mike-taitoko/

[4] https://environment.govt.nz/what-government-is-doing/areas-of-work/waste/transforming-recycling/#te-whakawehe-i-nga-para-kai-a-pakihi-separation-of-business-food-waste

[5] https://environment.govt.nz/assets/publications/Files/Aotearoa-New-Zealands-first-emissions-reduction-plan-Table-of-actions.pdf

[6] https://www.pmcsa.ac.nz/topics/food-rescue-food-waste/

2.3. Existing Industry Collaboration on Organic Wastes In New Zealand

There are recent examples of industry collaboration around organic wastes. For instance, Sustainable is Attainable is a project established in May 2019, by the South Canterbury Food Processors and Manufacturers Business Connection Group and led by Venture Timaru in collaboration with the University of Canterbury[7]. Twenty-two businesses in the food processing and manufacturing sector opted to be part of the Sustainable is Attainable research project. The Sustainable is Attainable project is now being replicated in Hawke's Bay.

In the Timaru Sustainable is Attainable project, it was shown that several businesses already produce compost onsite from their organic waste streams. The Timaru Resource Recovery Park also has a composting option for organic matter. Further research is underway to find ways to increase the value of composting, for example balancing nutrients in the compost by combining and blending multiple different waste streams.

Use as stock food is another option for the processing of organic by-products. The Sustainable is Attainable study recognises that some of the key obstacles to getting value from waste streams are coordination problems and high transport costs. To overcome these problems at a local level, there may be opportunities for companies to work together to reduce waste or add value to their respective waste streams. Some of the opportunities for collaboration identified in this project involve similar waste streams, while other opportunities create value by combining complementary waste streams.

Based on the data issued from Sustainable is Attainable, a vermicomposting operation is now being developed in Timaru. The plant will be run by MyNoke which already operates 6 plants and processes 250,000 tonnes p.a. of organic waste in the North Island[8]. Vermicompost is described further in detail below, and can process a wide range of organics and produces a premium soil conditioner and fertiliser called vermicast.

In Nelson, the group Businesses for Climate Action is offering businesses support to help them lower their carbon footprints through waste reduction. Businesses for Climate Action promotes business collaboration.[9]

2.4. Current Local Organic Waste Processing

The Nelson/Tasman region currently has two large sized plants operating windrows to process organic wastes. One is run by Greenwaste to Zero and the other by Wholesale Landscapes. The windrow processing technique is explained in chapter 4.1.1. Greenwaste to Zero processes about 6000 tonnes annually of which about 25% comes from primary industry businesses, the rest is received from gardening businesses and

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[7] Sustainable is Attainable South Canterbury and Hawke's Bay. Report August 2020 https://www.vtdevelopment.co.nz/news/media-releases/sustainable-is-attainable

[8] Michael Quintern, M. Morley, Bruce Seaton & R. Hamilton. 'How we transform industrial organic waste into vermicompost and champion environmental sustainability.' WIT Transactions on Ecology and The Environment, Vol 202, 2016, pp. 147-159. https://www.witpress.com/elibrary/wit-transactions-on-ecology-and-the-environment/202/35469

[9] https://businessesforclimateaction.co.nz/

households. Under its current resource consent conditions Greenwaste to Zero can't process food waste.[10] Wholesale Landscapes/ Azwood didn't provide any information about their operation but it is expected to be similar in size to Greenwaste to Zero, and potentially process a higher proportion of waste from primary industry businesses. Azwood is producing wood pellet fuel from selected forestry waste, with leftovers being composted by Wholesale Landscapes.

Community Compost is a medium sized operator using manual hot composting and in-vessel composting. Their second generation in-vessel composting machines will be launched soon. This is a revision of their first generation in-vessel composting machine, now with a greater capacity of 3-4m^3.[11] They provide services to households and businesses in the Nelson region and are predominantly focused on food waste.

Marlborough District Council is running a Greenwaste Acceptance Facility and Composting facility, processing around 4,000 tonnes annually. [12]

Probably the biggest limitation for these organic waste processing plants to attract further industrial organic waste, is transport costs. However, there are a lot of organic wastes produced in proximity to the operations. The biggest quantities available around the Richmond/ Brightwater area are pipfruit waste from packaging and processing facilities, waste from growers like pipfruit, hops, grapes and waste from breweries and wineries. More of these organic wastes could be processed by the existing composting plant infrastructure. The local waste streams are mostly carbohydrates but also contain large amounts of fibre and protein. Most of these wastes have the ideal moisture content for composting. Other waste such as forestry slash or shellfish could be more challenging to process.

There is plenty of scope for further organic waste processing infrastructure. This could either be existing operators upscaling or new operators entering the market. There are likely discussions of this kind already happening. Nelson City Council conducted a food waste collection trial in 2021/22 which was run by Community Compost. Multiple operators have lodged 'Expressions of Interest' regarding processing the food waste once the scheme becomes permanently established. However, as the Central Government has proposed to make such waste separation mandatory nationwide, Local Government is currently holding off starting the scheme until the Central Government direction is made more clear. In addition to Councils, Organic Waste processors and Business Associations, Iwi need to play an essential part in discussions regarding upscaling current facilities or building new ones. They may wish to advise on business aspects (i.e Kono[13]), land aspects and cultural dimensions, or become involved as collaborators. Our working group has begun reaching out to Iwi, via Tracey Williams, Resource Management Advisor -Te Tau Ihu, of the Ngati Toa Runanga, and have been encouraged by the response we received to our stated goal - Zero Organic Waste to Landfill.

[10] Conversation with Greenwaste to Zero representative.
[11] Conversation with Community Compost representative.
[12] https://www.marlborough.govt.nz/services/recycling-and-resource-recovery/greenwaste-acceptance-facility-and-composting
[13] Flaws B. 2020. Māori company Kono embraces regenerative agriculture as part of 500 year vision. Retrieved Jan. 2022 from: https://www.stuff.co.nz/business/farming/122241717/moricompany-konoembraces-regenerative-agriculture-as-part-of-500-year-vision

2.5. Materials identified in Nelson Tasman Area by the TOS Study

The TOS organic waste mapping study identified and surveyed 66 waste streams from 33 businesses in the Nelson Tasman region. They recorded what types of waste and how much of each type are available. Below are results focussing on the Nelson Tasman area[14]. The results include all recorded wastes if they are put into landfill, discarded on site, or further processed.

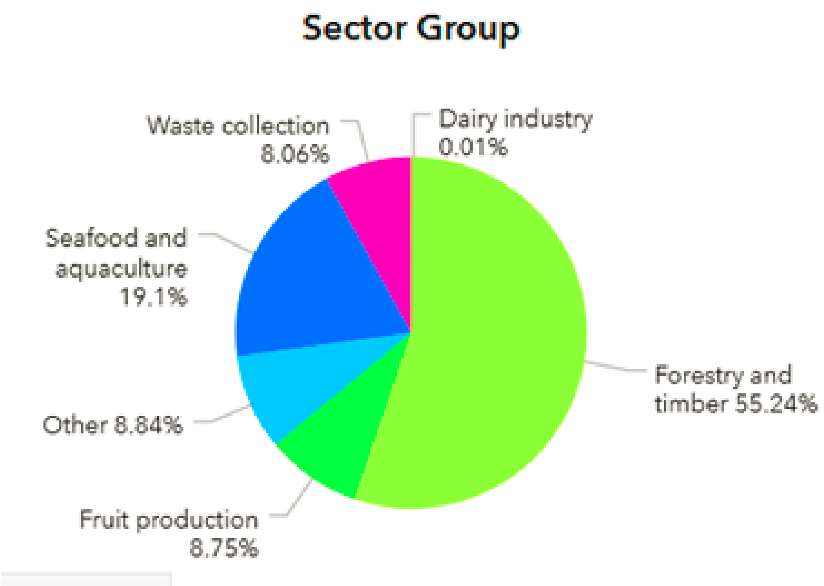

Figure 1: Sectors that produce Organic Wastes in The Nelson Tasman Region. The waste collection category is the planned residential food waste collection.

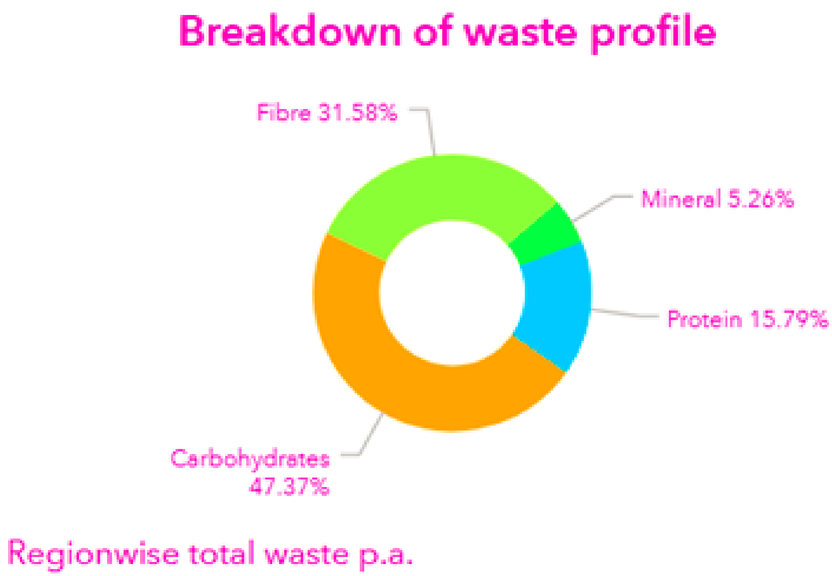

Figure 2: Breakdown of Organic Waste profile in The Nelson Tasman Region

[14] https://www.arcgis.com/apps/dashboards/9bebd1c41bf14f9b9a7e58881ea0b8c1

3. Guiding principles to be adopted

3.1. Waste Hierarchy

The waste hierarchy is a widely accepted guiding principle for waste reduction. A more specific Organic Waste Hierarchy has been developed by the Zero Waste Network based on similar overseas models. The Zero Waste Network hierarchy follows the same logic as the waste hierarchy while taking into account the ecological and social effects of the options. The Organic Waste Hierarchy is published by the Zero Waste Network in 'Organic Waste: A position statement', 2021 by the Zero Waste Network[15].

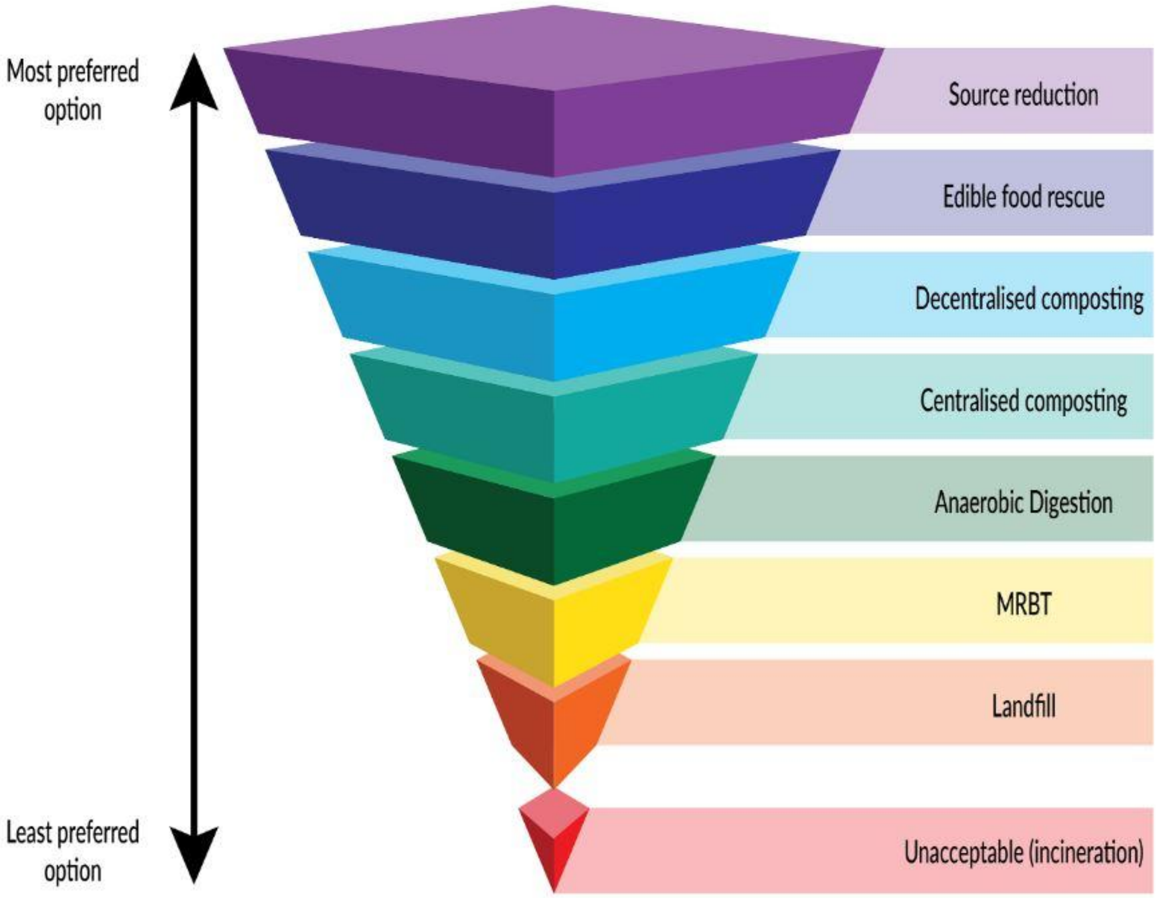

Figure 3: Waste Hierarchy for Organics. MRBT stands for Materials Recovery and Biological Treatment - a technique for contaminated organic waste streams

3.2. Technical, Economical and Social Considerations, and the Aspect of Climate Change

All technologies applied should be reviewed with regard to the following considerations. The evaluation needs to be done on a case by case basis, and is beyond the scope of this report.

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[15] Zero Waste Network Aotearoa (March 2021). Organic Waste: A position statement from the Zero Waste Network
http://zerowaste.co.nz/assets/Organic-Waste-in-Landfill_discussion-doc-2021.pdf

1. Technical feasibility: includes the land area required to implement the technology, the skills and capacity necessary to build and operate it, and the quantity and quality of waste feedstock that is available for use.
2. Economic feasibility: comprises the capital and operational costs of the treatment facility, as well as the revenue streams possible from sales of the products derived from waste by the specific treatment technology.
3. Social impact: considers aspects, such as job creation, as well as health threats that a technology may pose to the facility staff and the communities living or working nearby.
4. Climate change impact & resilience: Favourable are solutions that have the biggest impact in reducing emissions. Low tech solutions and solutions that don't require high up front investment costs and that are easily scalable, are likely to be more resilient in the long run.

4. Options for Organic Materials Processing

There are a variety of processing methods to recycle organic materials. The main composting techniques, as well as additional methods for processing organic materials, are described in the following chapter.

Composting methods emulate natural soil decomposition processes where the right ratios of carbon and nitrogen are maintained under controlled conditions. Anaerobic Digestion is a more technically involved technique in which Biogas is captured. In Insect Bioconversion Technology (IBT) insect larvae are grown, thereby transforming a specific mixture of organic wastes into insect larvae biomass; thus yielding increased protein. There's a further range of other processing techniques that happen in laboratories. End products can, for example, be biofuels or fertilisers.

4.1. Compost methods

Composting is a way of controlling the natural biological process that occurs in organic wastes, creating an organic fertiliser and soil conditioner. The resulting mixture is rich in nutrients and beneficial organisms, such as worms and fungal mycelium. Compost improves soil fertility in horticulture and farming systems. It reduces the financial costs associated with use of chemical fertilisers. Use of compost also reduces the carbon footprint when compared to using synthetic fertilisers. Compost is part of a regenerative circular system.

A 2013 report on municipal compost use on Canterbury farms showed potential for minimising the use of synthetic fertilisers (up to 40% reduction in the trial). The study shows that even with conventional farming practices, compost for agricultural use can be a vital tool in the shift towards regenerative methods.[16]

In the following chapters, the most common methods for processing larger volumes of organic materials are further presented.

4.1.1. Windrows

Windrows are long open-air triangular shaped piles and are the most common and basic composting method for medium and large-scale operations. Besides the 3 plants in the Top of the South, this method is also used in Christchurch, Timaru, Auckland and Wellington. The windrows size and shape enable large machinery to keep the piles aerated and hydrated. Windrows can also be modified and managed in ways that help speed up the process, reduce odour and improve water retention – e.g. the Gore™ Cover system used in Timaru.

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[16] Abie Horrocks et al. (Jan 2013). Compost SFF Final Report (2009–12): A report prepared for SFF Project 09/152: Sustainable use of municipal compost for the agricultural sector. Plant & Food Research, SPTS No. 7870. Retrieved from: https://www.envirofert.co.nz/uploads/Final-Report-on-Trial-2009.pdf

Windrow processing Profile[17]	
Processing Time	3- 6 months
Mass Reduction	35 – 40%
Labour needs	1 – 2 (<1 ton/day) 1 – 2.5 (> 1 ton/day)
Operating Temperature	Min: >0°C (big piles); Min: >15°C (small piles)
Land needs	180 - 300 m² per ton/day
Water needs	5 – 100 L/ton
Energy needs	30 – 55 kWh/ton
Examples	-Garden Orchard & Forestry waste -Vegetable waste -Fruit waste -Fish or meat waste -Animal manure
End Products	- Compost is a stable, dark brown, soil like material that improves soil structure and increases the nutrients availability in the soil. - Besides compost, other outputs produced are leachate, water vapour and CO_2.

4.1.2. In-Vessel Composting

In-Vessel Composting (IVC) involves composting organics in an entirely enclosed vessel in which the temperature and airflow can be controlled. The vessel produces little to no odour. Hence enclosed systems can process materials that are more difficult/problematic to process in windrows. The process is also reliably fast. However, it does not produce quality usable compost on its own – the compost usually requires further maturation.

Community Compost Nelson are rolling out their second generation of in-vessel composter bEartha 2 which is fully integrated in a shipping container. The small footprint of the operation can allow it to have multiple decentralised plants that reduce the need for trucking materials around.[18] Living Earth in Christchurch uses an IVC tunnel in an initial 7-10-day step that 'pasteurises' food waste before it is mixed with green waste and matured in windrows outdoors. In-Vessel Composting requires the construction of a technical facility and thus has higher capex costs than windrow systems.

[17] Zabaleta I., Mertenat A., Scholten L. and Zurbrügg C. (2020) Selecting Organic Waste Treatment Technologies. SOWATT. Eawag: Swiss Federal Institute of Aquatic Science and Technology, Dübendorf, Switzerland https://www.eawag.ch/en/department/sandec/projects/mswm/sowatt-selecting-organic-waste-treatment-technologies/

[18] https://be2.communitycompost.co.nz/

In-Vessel Composting Profile[17]	
Processing Time	2 – 3 month
Mass Reduction	35 – 50%
Labour needs	1 (<1 ton/day) 1 – 2 (> 1 ton/day)
Operating Temperature	Non-heated vessels - Min.: >0°C (big vessels) or >15°C (small vessels) Heated vessels - Min: non-influential
Land needs	85 m² per ton/day
Water needs	5 – 60 L/ton
Energy needs	165 – 190 kWh/ton or none (manual)
Examples	- Garden trimming - Fruit waste - Vegetable waste - Fish or meat waste - Animal manure
End Products	- Compost is a stable, dark brown, soil like material that improves soil structure and increases the nutrient availability in the soil. - Besides compost, other outputs produced are leachate, water vapour and CO2.

4.1.3. Vermicomposting

Vermicomposting (worm farming) is highly scalable and can be done on an industrial scale. Vermicomposting also has the potential to process organic wastes that are difficult or unable to be composted using conventional methods (e.g. liquid wastes such as farm manure and effluent, food processing sludges and by-products, sewage sludge and cardboard and paper including organic contaminants). Earthworms reduce the waste volume by 80% with no odour or steam due to vermicomposting being a cold process.Vermicast, the end product, are the mature earthworm castings and are a sought after soil conditioner improving soil structure, biological diversity and activity and humus levels.

MyNoke offers large-scale vermicomposting services across NZ and currently processes as much as 250,000 tonnes of organic waste per year.[19]

19 https://www.powerfarming.co.nz/news-item/power-farming-partner-with-mynoke-for-healthier-soils-and-a-better-environment

Vermicomposting Profile[17]	
Processing Time	4 - 6 months
Mass Reduction	65 – 80%
Labour needs	1 – 2 (<1 ton/day) 1 – 2 (> 1 ton/day)
Operating Temperature	- Min: 1°C - Optimal:10 – 30°C - Max: 38°C
Land needs	300 – 580 m² per ton/day
Water needs	5 – 40 L/ton
Energy needs	30 – 55 kWh/ton
Examples	- Vegetable waste - Animal manure - Fruit waste - Fibre - Sedimentation and sewage sludge
End Products	- Vermicompost is a stable, dark-brown, granular, soil-like material that has shown to have higher levels of nutrients than compost. - Liquid vermicast extract (worm-tea) from the worm bins can also be used as fertiliser. - The worms are rich in protein and can be used as animal feed.

4.2. Anaerobic digestion

Anaerobic digestion (AD) decomposes organic matter in an enclosed, oxygen exclusive and low heat-treated environment. Anaerobic digestion occurs naturally in some soils and in lake and oceanic basin sediments, where it is usually referred to as ‘anaerobic activity’. While composting emulates natural soil decomposition and as a gas mainly produces carbon dioxide, anaerobic digestion produces mostly methane. It is an expanding technology both overseas and with a first plant currently built in New Zealand. Advantages of this method to process organic waste are seen in it producing ‘renewable’ energy - biogas, and the remaining organic matter, known as ‘digestate’, can be used as an organic fertiliser. Generally the plants are large, requiring high Capex to establish. Additionally, long distance transport of the organic waste is usually necessary.

Anaerobic digestion is starting up gradually in NZ, but is already widespread in places like Europe. Auckland Council recently signed a 20-year contract with Ecogas to send food scraps from its kerbside collections to a large-scale AD plant currently being built in the central North Island. This is the first of its kind in NZ, but Ecogas sees potential to build up to 20 facilities around NZ in the next 10 years.

4.2.1. By-products of AD

Biogas - the AD process metabolises a large proportion of carbon from the feedstock to produce methane/ CH_4 . This biogas is widely recognised as a renewable source of energy, being one element of the carbon cycle. It provides GHG emissions reductions if used in place of fossil fuels.

Digestate - Digestate is sometimes separated into its solid and liquid portions. Digestate is high in organic nutrients such as nitrogen, phosphorus, potassium and others, and thus deemed suitable for use as an agricultural fertiliser and/or soil amendment. Because digestate derived organic fertiliser can be used to offset the use of synthetic fertilisers, it can reduce agricultural emissions and is better for soil health than mineral fertiliser. However, there are multiple environmental harms that can result from using digestate fertiliser, such as nitrate run-off and NOx emissions. The digestate can be composted first which can mitigate the environmental harms.[20]

AD is an expensive technological solution. But AD is likely a suitable processing solution for steady industrial organic waste streams and waste streams that are difficult to compost. They are used extensively by the food processing industry, i.e. breweries for example in Scotland.

Profile Anaerobic digestion[17]	
Processing Time	10 - 40 days
Mass Reduction	0 – 20% (depends if water is considered)
Labour needs	1 (<1 ton/day) 1 – 2 (> 1 ton/day)
Operating Temperature	- Min: 15°C - Optimal: 25 – 30°C - Max: 40°C
Land needs	100 – 530 m² per ton/day
Energy needs	30 – 55 kWh/ton
Examples	- Vegetable waste - Animal manure - Fruit waste - Fish or meat waste
End Products	- Biogas is a carbon neutral gas fuel, composed of CH4 (55–60%), CO2 (35–40%) and "impurities", such as hydrogen sulphide, nitrogen, oxygen and hydrogen. - The digestate is rich in nitrogen and can be utilised in agriculture as a nutrient fertiliser or organic amendment.

[20] Gilbert J, Ricci-Jürgensen M.,Ramolal A.,(2021) SWA Report 2 Benefits of Composts and Anaerobic Digistable. https://www.iswa.org/biological-treatment-of-waste/?v=8e3eb2c69a18

4.3. Re-processing to obtain higher value

Creating new materials and products from bio-waste has seen a large growth. There are various ways for creating new materials and products from biomass, including organic waste. In New Zealand, the Bioresource Processing Alliance (BPA) co-funds and undertakes research and development projects with companies by using the expertise of partner organisations (AgResearch, Scion, Plant & Food Research and Callaghan Innovation) and universities. Organic wastes are converted into valuable products such as chemicals, nutraceuticals, biofuels, food and feed ingredients, biomaterials or fibres. A lot of these processes are still in their infancy and require a supply of stable feedstock to run efficiently.

4.3.1. Insect Bioconversion Technology (IBT) with Black soldier fly

Insect Bioconversion Technology (IBT) with black soldier fly processing is an emerging technology in organic waste treatment. It involves the use of the larvae of the Black Soldier Fly (BSF), *Hermetia illucens*, to biologically transform the organic waste into insect larvae biomass and a treated organic waste residue. Larvae consist of ±35% protein and ±30% crude fat. This insect protein is a potential feed resource for chicken and fish farmers.
The BSF larvae feed on biowaste and develop until the stage of pupation, and are harvested before pupation. Under controlled conditions (28 °C, 75% relative humidity), the total development from egg to adult lasts 20–35 days. As a fly, they survive for one week, during which they focus on reproducing. In the fly state, they do not eat and, therefore, also do not transmit diseases.

Waste reduction of up to 80% (on a wet weight basis) has been demonstrated. The residue, a substance similar to compost, contains nutrients and organic matter. A high waste-to-biomass conversion rate of up to 25% (on wet weight basis) is possible.[18]

Profile Black soldier fly (BSF) processing[17]	
Processing Time	14 days (lifecycle of the larvae)
Mass Reduction	50 – 80% Waste to biomass conversion 25%
Labour needs	3 (<1 ton/day) and: 1 – 2 workers per additional ton/d 1 additional worker every 5 tons
Operating Temperature	Adequate: 15 – 47°C Optimal: 28 – 32°C
Land needs	50 m² for nursery and 100 m² per ton/day
Energy needs	90 – 105 kWh/ton or none (manual)
Examples	- Vegetable waste - Fish or meat waste - Fruit waste - Animal manure

End Products	- Larvae: the harvested prepupae contain 40% crude protein and 30% fat and residues. The grown larvae are suitable as a (partial) replacement of fish meal in animal feed. - The residue still contains valuable nutrients and might be used as a soil amendment after a maturation phase (composting).

4.3.2. Further Re-Processing Options

There are further emerging technologies to process organic waste materials. Listed here are the headlines of international development from 'Bio-waste in Europe — turning challenges into opportunities'.[21]

Ethanol fermentation
Ethanol is commonly produced by fermenting biological material and it is considered one of the most important liquid biofuels. In New Zealand, biodiesel has been produced from tallow (a meat processing by-product) or waste cooking oil, while bioethanol is produced from whey (a dairy industry by-product). New Zealand uses a very small amount of biofuel in its transport fleet.[22]

Production of volatile fatty acids
VFAs are short-chain fatty acids that are used in various applications, for example in the production of biofuels or bio-based plastics and in the biological removal of nutrients from wastewater.

Production of biohydrogen
Organic waste can also be used to produce hydrogen (H2), valuable as a source of clean energy, for which demand has increased considerably in recent years.
Conventional methods for the production of H2 are expensive because of the high energy requirements. There are also biological methods for producing H2, in which organic waste can be used as feedstock.

Production of hydrosolate
Fish Hydrolysate is produced by processing fish waste into fertiliser/ biostimulants. This is currently happening in New Zealand. A product example is Fish IT.[23]

[21] European Environment Agency, 2020: Bio-waste in Europe — turning challenges into opportunities. https://www.eea.europa.eu/publications/bio-waste-in-europe
[22] https://www.mbie.govt.nz/building-and-energy/energy-and-natural-resources/energy-generation-and-markets/liquid-fuel-market/biofuels/
[23] https://fishit.co.nz/blog/fish-hydrolysate-a-better-way-to-grow/

Table 1 Emerging technologies in organic waste management: main opportunities and challenges. Adapted from Bio-waste in Europe – turning challenges into opportunities.

Technology	Opportunities	Challenges
Bioethanol production	Organic waste can serve as a sustainable alternative feedstock for the production of bioethanol — an important liquid biofuel.	High processing costs and the heterogeneous nature of bio-waste creates challenges for industrial-scale bioethanol production.
Producing volatile fatty acids (VFAs) through anaerobic digestion of bio-waste	VFAs have a wide range of possible high-value end uses. Extraction of VFAs from organic waste can be more sustainable than the conventional approach of deriving VFAs from fossil fuels through chemical synthesis.	The most important challenges include optimising the operational parameters for VFA production and cost-effective separation of VFAs from digestate.
Production of biohydrogen	Hydrogen demand is increasing and there is a need for sustainable methods for producing it.	Low substrate conversion efficiency and low yield.
Recovery of phosphorus	Efficient recovery of phosphorus from organic waste can reduce the dependence on limited geological resources.	Further technical development is needed to minimise operational costs and improve the quality and predictability of the fertilisers produced.
Pyrolysis	Pyrolysis provides the possibility of transforming low-energy density materials into high-energy density biofuels.	Making pyrolysis economically viable remains a challenge.
Gasification	A flexible technology that can be adapted to treat various materials. The gas produced can be used as a fuel or for producing chemicals.	The main challenges are finding solutions to deal with heterogeneous feedstocks, maximising syngas yield, optimising gas quality and process efficiency and decreasing production costs.
Hydrothermal carbonisation	Converts organic waste into hydrochar that can be used as a solid fuel or soil improver or be further processed into activated carbon.	Further technical development is needed for industrial-scale applications.
Production of animal feed	Direct use as animal feed, or potential small-scale organic waste treatment methods to turn organic waste into insect protein and lipids.	Potential legal barriers for using organic waste as feedstock to create animal feed, for example black soldier fly larvae technology.

5. Conclusions and Recommendations

This paper and the 'Top of the South (ToS) organic waste mapping study' have shown that there are large amounts of organic wastes currently going to landfill in the Top of the South, Te Tau Ihu. There are now only a few processing facilities in or near the region that can divert organic wastes from landfill. The overarching goal must be zero organic waste to landfill to achieve a reduction of greenhouse gases, a circular economy and regenerative agriculture.

Therefore, although there is significant potential to reduce waste to landfill in the region by diverting organic wastes, this can only be achieved to any large extent by the establishment of additional facilities in the region. Any facility that is established would need to be suitable for the organic waste streams that have been identified in the TOS study, and would need to address the local uptake of the end product. The goal for the region should be to close loops of nutrients and recycle the organic wastes locally. There is room for a mix of processing techniques where some new technologies like Black soldier fly (BSF) processing, and techniques that are established in other parts of New Zealand, such as vermicomposting among others, have their place.

Recommendations:

- One major action that will have a direct impact on diverting more organic wastes from landfill is the development and operation of more organic waste processing facilities.
- In order to make progress in that direction, the initiation of a round table process is proposed. This could happen along the lines of the 'Sustainable is Attainable' format to get producers of organic wastes working together with waste processors, Councils and economic development agencies. The economic development agencies are well positioned to start such an initiative, provided they are adequately resourced to do so by Councils. Businesses for Climate Action could also be a good local entity to carry out this work, with support and funding leveraged from central or local government through Nelson Regional Development Agency, Tasman District Council and Nelson City Council.
- The economic development agencies could lead the strategic coordination of increasing the establishment of additional processing facilities in the region. The result should be new private and public-private partnerships. In particular, it will be important to consider the proposed processing facilities' options around collections and transport. The whole system's environmental and social impacts and costs of proposed solutions need to be assessed and optimised. Solutions that need big infrastructure built might not be as resilient as smaller decentralised systems. Local based solutions may be a better fit to build resilient local communities rather than having all the infrastructure in one place.
- Councils currently have limited involvement and overview of the industrial organic waste streams, but are likely to be mandated by Central Government to provide residential food waste collections. As part of the review of the Joint Waste Management and Minimisation Plan (JWMMP) of Nelson and Tasman, goals should be set to minimise and ultimately end industrial organic wastes going to landfill.

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