TOP OF THE SOUTH ORGANIC WASTE MAPPING REPORT

Marlborough / Nelson / Tasman

A study to estimate the Organic Waste materials available within the region by volume and type, to consider possible future opportunities to upcycle their value utilizing bioconversion technologies with a collaborative regional strategy.

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John Macdonald - Food Security Solutions :Ltd

FOOD SECURITY SOLUTIONS LTD
Plant & Food Research
Rangahau Ahumāra Kai
MARLBOROUGH RESEARCH CENTRE
Te Rito Hiranga o Wairau
AGMARDT
FUTURE SHAPERS

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1. Executive Summary

The Top of the South (ToS) organic waste mapping study was commissioned by the Marlborough Research Centre (MRC), New Zealand as a starting point from which to develop regional strategies and multi-sector business opportunities to reduce and upcycle waste. The study was co-funded by MRC and the Agricultural and Marketing Research and Development Trust (AGMARDT) and managed by Plant and Food Research, Marlborough. Food Security Solutions Ltd. was contracted to conduct the research which was undertaken between November 2021 and January 2022. The study contacted 48 different stakeholders from a wide range of industries and local municipalities, of which 85% responded.

Results from the collated survey data from the ToS are:

- Total volumes of organic wastes are in excess of 700,000 T p.a. Excluding forestry slash the volume of material is three times higher than reported in earlier New Zealand Government's statistics on organic waste in the region.

- When forestry waste streams are included in the inventory, the distribution of available materials has a central point towards Havelock, Marlborough. Without forestry waste, Riverlands is a central location for organic waste material, predominantly from the viticulture industry. Seafood waste streams are evenly distributed across the region.

- The total waste volume contains interesting proportions of Carbohydrates (24%) and Protein (10%) for future bioprocessing projects to consider. The proteins largely comprise seafood and animal wastes, which will require further study as to their compatibility and suitability for upcycling.

- Waste material supply is steady throughout the year with the principal exception of grape marc from the viticulture industry. Further work and potential regional businesses will be required to stabilise grape marc and manage availability on an annual basis.

- Organic waste management is currently a significant cost to the ToS community which could be reduced by embracing a multi-sector upcycling strategy across the region.

Food Security Solutions Ltd is already managing upcycling projects based on insect bioconversion technology, both globally and within New Zealand. Results from this waste mapping process suggest that the ToS has sufficient volumes and mix of organic material to support such a project, subject to further detailed technical studies. If successfully implemented insect bioconversion technology could produce aquafeeds, pet foods and fertilisers - all with specific functional benefits – that would enhance the ToS circular economy.

Additional businesses within the region will have the opportunity to benefit from a new bioconversion initiative as it develops, to support the infeed supplies. This could provide several new opportunities for investment and employment within the region.

Sustainability, which includes a focus on improving environmental outcomes of waste management practices, is growing in awareness amongst key larger industries within the ToS region.

This study has identified interest and enthusiasm within the ToS business community to continue to engage in cross-sector sustainability initiatives to address their waste management challenges. Many have tried and failed previously to achieve sustainable solutions on their own and it is recognized that these challenges require a multi-sector approach to achieve meaningful industrial solutions.

2. Introduction

Three local authorities (Marlborough, Nelson and Tasman District Councils) oversee the Te Tau Ihu (the Top of the South = ToS) region. Collectively their waste minimisation plans[1,2] align with the Ministry for the Environment's New Zealand Waste Strategy[3] and specifically identify two objectives:

- improving the efficiency of resource use
- reducing the harmful effects of waste

Key industries in the ToS be they local (e.g. Kono[4]), large national (e.g. Zespri[5], Fonterra[6]) or multinational (e. g. Pernod-Ricard[7], Sogrape[8], Treasury Wine Estates[9] or Constellation Brands[10]) have clearly articulated sustainability goals. These goals invariably involve the development of more circular production systems that minimise and reuse or upcycle waste. Operationally, however, is it often difficult for individual companies or single sectors to make effective change in comparison with circular economy opportunities that span multiple and diverse industries[11].

Prompted by an approach from John Macdonald of Food Security Solutions (FSS), representatives from the Marlborough Research Centre (MRC), Plant and Food Research (PFR), the Economic Development arm of the Marlborough District Council (MDC) and the Nelson/Tasman Regional Development Agency (NRDA) met in October 2021 to discuss opportunities to add value to the diverse range of biological wastes produced in the ToS. It became apparent that a comprehensive inventory of the available bio-resources (waste streams) would provide a valuable starting point from which to develop regional strategies and multi-sector business opportunities to reduce and upcycle waste. MRC with matching co-funding from Agricultural and Marketing Research and Development Trust (AGMARDT) agreed to contract PFR, who in turn sub-contracted FSS to undertake the initial survey.

This report, the associated worksheets and data files present the results of the survey.

3. Brief and Deliverables

- To develop a database and map of major organic waste streams produced within the Marlborough, Nelson and Tasman regions from a range of sources within the community and industry.
- To record volumes per annum, types of materials with analysis, current methods and cost of disposal or use, as available.
- Each of the waste streams will have all available details collated and analysed to establish their volumes, seasonality, nutritional and commercial value (including logistics) from the point of origin.
- This study is not intended to be an exact inventory of all the organic waste produced in the ToS region. Volumes of materials supplied by participants are very often approximate estimates because of a lack of any measured/recorded data being available.

4. Objectives

- To create for the first time, an overview of all the "remaining raw materials" of biological origin (bio-resources) available within the ToS region.
- To collate these data into an interactive GIS map that will identify the types of material, their location and value, on an annual basis.
- Information from this study will be made available as a data resource, to be utilised to identify the most applicable future upcycling project options within the ToS region.
- To add value to these resources for the benefit of industry and the community, by improving the circular economy within the ToS.

5. Confidentiality

A sensitive subject matter, to be respected in order to achieve a better solution, for the benefit of all . . .

- Many of the respondents were reluctant to reveal the details of their waste streams and are seeking strict confidentiality for the data/information they have contributed.
- Some of the respondents are in competition with each other so they are naturally protective of their performance.
- Supplementary details collected during the study are available on request and will require a non-disclosure agreement signed between stakeholders.

6. Methods

A survey approach was undertaken to conduct the study. Meetings between FSS and survey participants were conducted either face to face or virtually. The study was commenced in November 2021 and continued until late January 2022 with a wide collection of available data, from multiple sources as follows:

- District council databases of materials recorded being presented to regional landfills and any projects highlighted within the regional waste minimisation plans.
- Direct interviews and discussions with a wide range of enterprises throughout the region to understand the quantities and nature of their remaining raw materials.
- A total of 48 respondents were contacted and visited, as applicable, from all sectors of the business community and regional councils throughout the ToS region.
- NRDA circulated a request for engagement from regional members through their monthly newsletter.
- All data collected and information gathered has been included in a detailed worksheet to create the basis of this study.
- The scope of potential stakeholders has been sense checked with district council records of active businesses within the ToS region.
- The key operators and stakeholders in each sector have been included as respondents within this study where ever possible. The most senior contacts available within each organisation were the selected respondents.
- Industries have been classified utilising the New Zealand standards codes (ANZSIC06).
- Organic materials have been classified into five generic groups for the purpose of this study:
    - Carbohydrates - including apple pomace, grape marc, fruit and vegetable waste
    - Fats - including industrial fatty sludges and oils
    - Minerals - including calcium, shellfish and lime
    - Proteins - including animal wastes, seafood, yeast and dairy
    - Fibres - including wood and cellulose-rich, horticultural wastes, hop bines Other - miscellaneous materials.

The study has been presented in a manner to protect the stakeholders' privacy. The exact locations and addresses of respondents have not been identified and data have been grouped by the following regional localities: Stoke, Motueka, Nelson, Tasman, Appleby, Brightwater, Havelock, Kaituna, Picton, Tuamarina, Blenheim, Takaka, Richmond, Kekerengu, Upper Moutere, Riverlands.

Forestry has widespread locations throughout the region. For the purpose of mapping, Kaituna has been chosen as a central location for all forestry as it is one of the major processing sites for the industry. In reality, the forestry material will be sourced from a range of moving locations, subject to the forestry blocks being harvested at any chosen time.

7. Results

Significant volumes - majority fibres and carbohydrates

The study contacted 48 different stakeholders from a wide range of industries and local municipalities within ToS, of which 85% were interviewed or responded. The high response rate indicates interest and enthusiasm within the business community for the opportunity to engage in new collaborative sustainability initiatives to address their waste management challenges.

Respondents indicated that their waste streams have predominantly not been recorded with any accuracy and, until recently, monitoring of waste has not been a priority for most operations. Their core businesses have taken priority and "remaining raw materials" have been considered a challenge to manage rather than a value-add opportunity. However, with the increased obligation on industry to achieve sustainability targets, this opens new interest to find sustainable waste management solutions.

Key results from the survey are:

- The estimated total volume of organic waste materials in the ToS is in excess of 700,000 T per year.
- The volume of material uncovered by this survey is more than five times greater than reported by the New Zealand Ministry for the Environment (MfE) in 2010[3]. Even with the exclusion of the forestry slash the amount of material is three times greater than recorded in MfE statistics.

Total mix of organic waste in the ToS region

The tonnages of each major waste type class are shown in Figure 1. Fibre and Carbohydrates are the dominant waste classes followed by lesser amounts of Protein, Minerals and Fats.

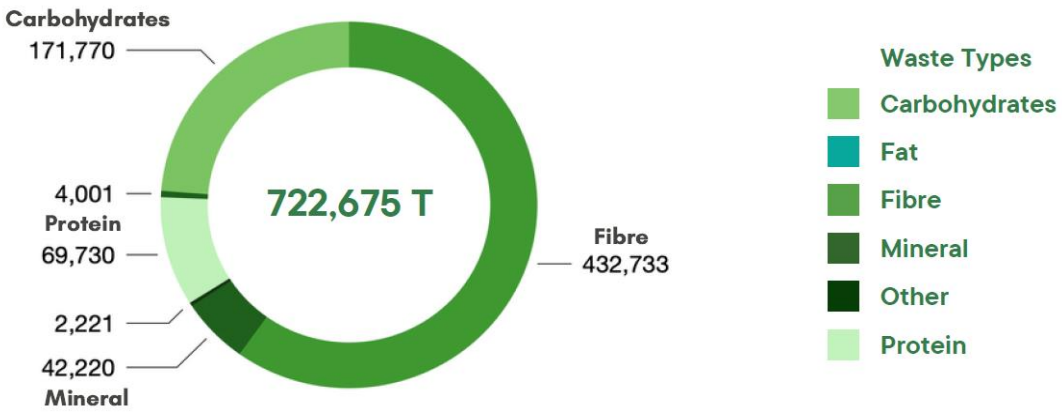

Figure 1. Total fresh weight tonnages and bio-waste types produced in the Top of the South. The coloured segments represent the proportions of each waste type.

For more information, please click on the bio-waste types produced in the Top of the interactive GIS Data Map here.

Composition analysis of materials

The proportional mix and indicative composition of the materials comprising each organic waste type are shown in Table 1. The breakdown of materials is diverse and appears balanced with a good range of waste types for future bioconversion projects to integrate into their planning models. However, not all the materials identified will have an upcycling opportunity. The largest source of organic waste type identified in the study is Fibre from forestry slash, timber milling, prunings and wood material from viticulture and horticulture. We have included this material in the total organic waste volume but how it might be uplifted and upcycled remains uncertain (refer Comments from Survey Respondents section on p. 16).

Table 1. Proportional mix and indicative composition of waste types available in the Top of the South

Organic Materials	% of Total	Composition
Fibre	60%	- majority timber - some horticulture
Carbohydrates	24%	- 71% vineyards - 16% food - 10% fruit
Protein	10%	- 80% animal sourced - 20% plant sourced
Mineral	5.2%	- Majority clean mussel shells
Fat	0.5%	- Industrial fats
Other	0.3%	- Miscellaneous
TOTAL	**100%**	

Carbohydrates, principally in the form of grape marc are the anchor waste material supported by large quantities of Fibre waste from forestry, viticulture and horticulture.

Proteins from animal and plant sources contribute to a good quality protein base, but at much lower volumes than Carbohydrates. Proteins are mostly from seafood/shellfish and animal processing waste streams. The balance is from non-plant sources such as brewery grains and wine lees.

Volumes and Distribution of Waste Types

A range of waste types are available across the ToS region (Figure 2). When volumes of materials are grouped by hub location (Table 2a) Richmond and Havelock waste types are dominated by Fibre. Riverlands (near Blenheim) is a hub for large volumes of both Fibre and Carbohydrates along with smaller amounts of Protein. Tasman agregates a smaller volume of total waste with a relatively even proportions of waste types.

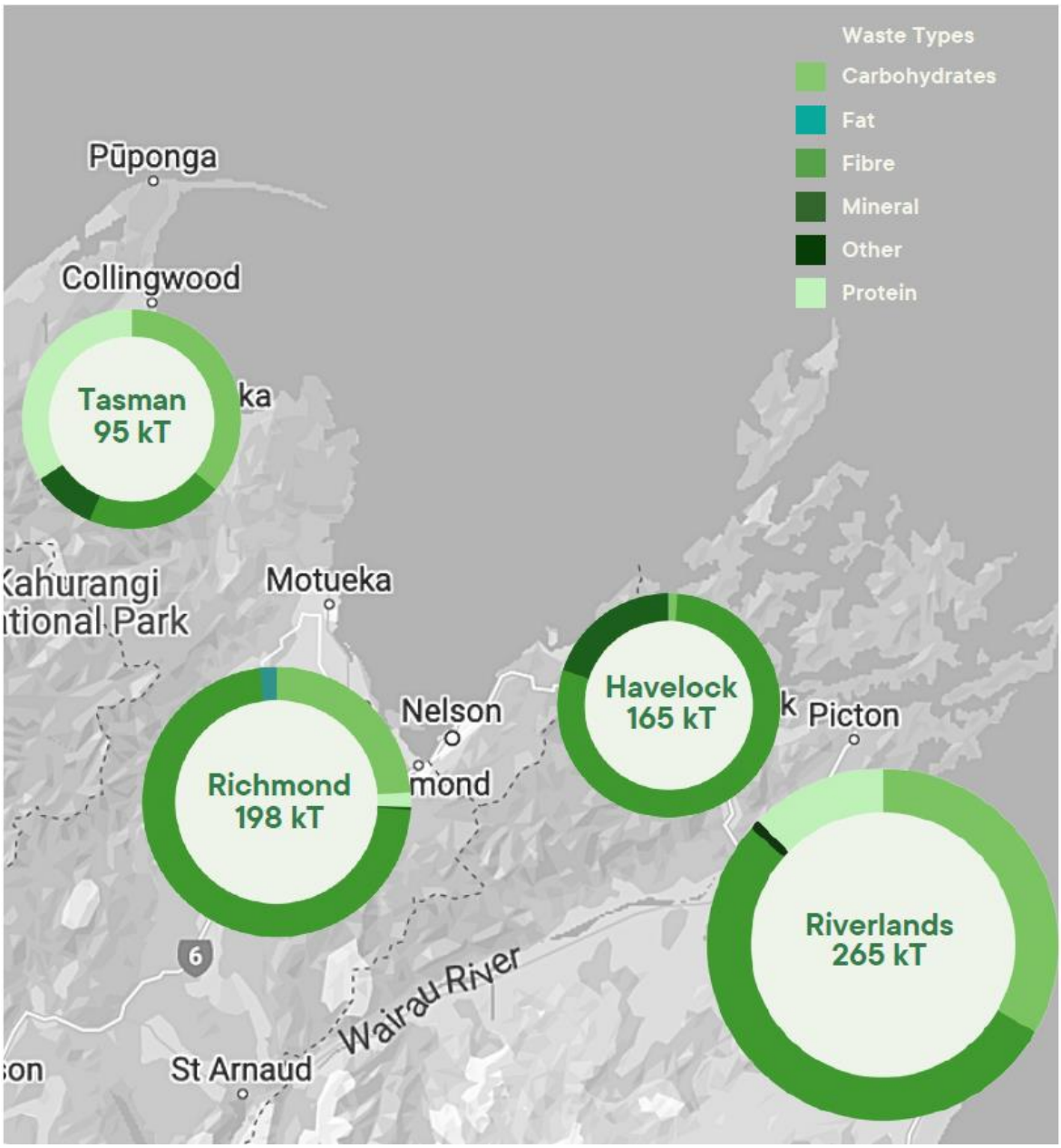

Figure 2. Fresh weight tonnages (kT = kilotonne) and waste types produced in four regional zones (Tasman, Richmond, Havelock and Riverlands) in the Top of the South. The diameter of each ring is proportional to the tonnage amount and the coloured segments within each ring represent the proportions of each Waste Type available in the surrounding locations.

Organic waste matrix

Table 2a. Summary of organic materials produced in the Top of the South by waste type and by location. All amounts are in tonnes.

Location	Hub Zone	Carbo-hydrate	Fat	Fibre	Mineral	Other	Protein	TOTAL
Appleby	Richmond	4,115	-	2,101	250	-	100	**6,566**
Blenheim	Riverlands	88,238	-	141,248	170	2,221	25,396	**257,273**
Brightwater	Richmond	2,182	-	120,000	-	-	24	**122,206**
Havelock	Havelock	2,080	-		32,500	-	200	**34,780**
Kaituna	Havelock	-	-	129,625	-	-	-	**129,625**
Kekerengu	Riverlands	-	-	5	-	-	-	**5**
Marlborough	Havelock	-	-	200	-	-	-	**200**
Motueka	Tasman	16,833	-	4	9,000	-	32,500	**58,337**
Nelson	Richmond	14,210	-	2,200	-	-	2,285	**18,695**
Picton	Riverlands		-		-	-	5,000	**5,000**
Richmond	Richmond	18,908	-	18,000	-	-	300	**37,208**
Riverlands	Riverlands	1	-	-	-	-	3,001	**3,002**
Stoke	Richmond	7,703	4,001	150	300	-	820	**12,974**
Takaka	Tasman	-	-	-	-	-	80	**80**
Tasman	Tasman	17,500	-	19,200	-	-	-	**36,700**
Tuamarina	Riverlands	-	-	-	-	-	24	**24**
TOTAL		**171,770**	**4,001**	**432,733**	**42,220**	**2,221**	**69,730**	**722,675**

Table 2b. Summary of organic materials produced in the Top of the South by waste type and by potential Hub zone. All amounts are in tonnes.

Hub Zone	Carbo-hydrate	Fat	Fibre	Mineral	Other	Protein	TOTAL
Havelock	2,080	-	129,825	32,500	-	200	**164,605**
Richmond	47,118	4,001	142,451	550	-	3,529	**197,649**
Riverlands	88,239	-	141,253	170	2,221	33,421	**265,304**
Tasman	34,333	-	19,204	9,000	-	32,580	**95,117**
TOTAL	**171,770**	**4,001**	**432,733**	**42,220**	**2,221**	**69,730**	**722,675**

Which industries produce the most organic materials?

Table 3. Summary of organic materials produced in the Top of the South by waste type and by industry. All amounts are in tonnes.

Industry group	Carbo-hydrate	Fat	Fibre	Mineral	Other	Protein	TOTAL
Forestry and timber	-	-	249,800	-	-	-	**249,800**
Other	782	4,001	19,631	300	-	234	**24,948**
Waste collection	46,018	-	24,883	170	2,221	17,196	**90,488**
Seafood/aquaculture	2,080	-	-	41,500	-	42,852	**86,432**
Wine production	88,802	-	133,665	-	-	8,200	**230,667**
Vegetables	3,399	-	2,100	250	-	-	**5,749**
Meat industry	-	-	2,650	-	-	150	**2,800**
Fruit production	29,189	-	4	-	-	30	**29,223**
Dairy industry	-	-	-	-	-	168	**168**
Beer production	1,500	-	-	-	-	900	**2,400**
TOTAL	**171,770**	**4,001**	**432,733**	**42,220**	**2,221**	**69,730**	**722,675**

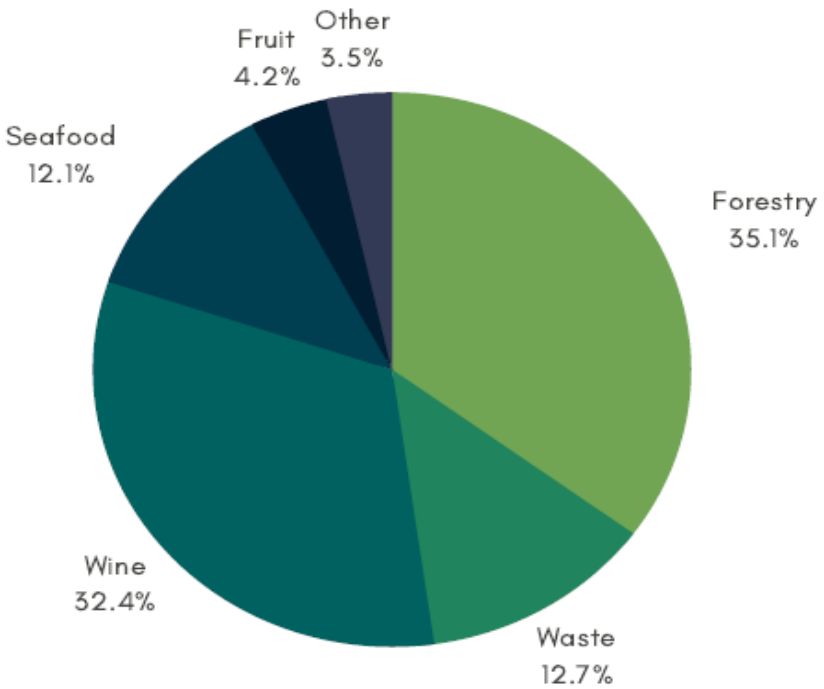

Figure 3. Proportional mix of major industry contributors to the total volume of organic materials.

Logistics

From the detailed list of locations and waste types (Table 2a) we have summarized data into three regional "hub" locations (Table 2b) that depending on the type of bioconversion envisaged would form possible logistics centres.

The distribution of the total organic waste volume is:

- Richmond 40% (this hub includes all locations from Nelson westward);
- Havelock 23% (including Kaituna) and;
- Riverlands 37% (all of Marlborough from Renwick eastward).

If Fibre from forestry operations is included in an eventual bioconversion process, Havelock would be the most likely epicentre of the organic waste logistics (Figure 4a).

If forestry waste is not included in a bioconversion opportunity, then Riverlands would become the most logical central point (Figure 4b).

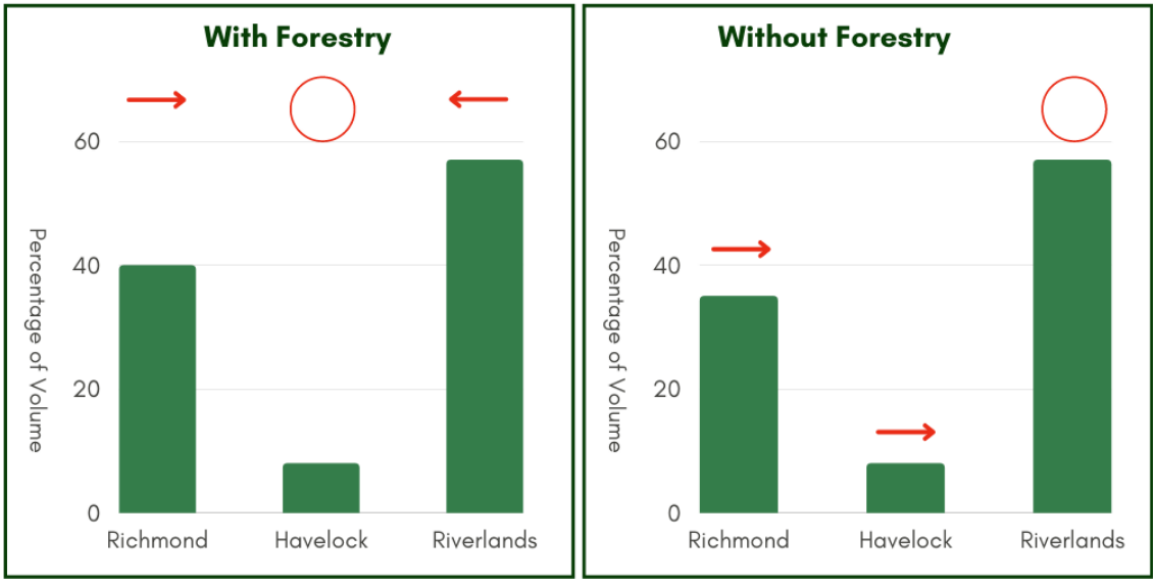

Figure 4a **Figure 4b**

Figure 4. Percentages of total organic materials by possible hub location for the total organic materials (a) and without forestry organic materials (b).

The ToS region is relatively compact with manageable distances between possible hub locations:

- Riverlands to Havelock 49 km
- Havelock to Richmond 88 km

All routes are well serviced and suitable for low to moderate volume passage of heavy trucks. Roading surface upgrades on routes other than State Highway 1 would probably be necessary if heavy truck volumes were substantially increased. In general terms distances between possible hub locations or between sources of organic materials are unlikely to compromise the economic viability of a bioconversion facility.

Where does the organic waste go?

The study respondents indicated a range of disposal methods for their organic materials. As would be expected the major proportion of Fibre from forestry, viticulture and horticulture is essentially abandoned where it falls. This represents 40% (266,000 T) of the total organic materials (Table 4).

Table 4. Proportion of total organic materials and waste tonnages by disposal method in the Top of the South.

Destination of waste materials by volume	% of Total	Volume (T)
Landfill - mixed	26%	189,000
Animal feed	8%	61,000
Land spread - vineyards	17%	123,000
Compost - vineyards/hops	11%	80,000
Other - abandonded mostly forestry	37%	267,000
TOTAL	100%	720,000

The second largest disposal method was landfill (189,000 T) comprising 26% of the total volume and representing a significant cost to the communities, councils and industries (refer pp. 14-15). Land spreading is widely used by viticulture and horticulture (123,000 T) while animal feed was less preferred as a disposal method (61,000 T).

With 77% of the stakeholders selecting abandon, landfill and land spreading these three options represent the biggest opportunities to divert or capture organic materials (total of 578,000 T) towards upcycling.

Which industries spend the most disposing of their waste?

The study identified that approximately 189 kT of organic materials is being sent to landfills. The estimated cost to the community Table 5), industries and district councils is approximately $26 M based on an estimated landfill gate fee plus transport/contractor costs of $ 140/T. The mussel industry would appear to carry the major cost of organic materials disposal as most of the Fibre and Carbohydrate produced from the timber and wine industries remains where it is produced or is returned to land. Disposal costs for these operations are difficult to identify because they occur under permitted activity rather than consent regulations where a more comprehensive monitoring regime applies.

Table 5. Estimated costs to major industry groups of organic wastes disposed to landfills.

Source of industry organic waste	Volume to landfill (T)	Disposal cost (@$140/T)
Seafood	84,500	$11.8M
Forestry	21,000	$2.9M
Wine	12,000	$1.7M
Waste collection	46,000	$6.4M
Other	25,500	$3.5M
TOTAL	**189,000**	**$26M**

The valorisation of the organic waste resources.

As different to cost, some organic materials identified in the survey have a notional value that can sometimes be quantified. Value can fall into two categories:

- Nuisance value: Materials which are considered to be "nuisance waste" by their stakeholder owners. These materials have a zero value under current market settings and are either abandoned, delivered by the producer or collected by the user. Table 4 shows that 266,000 T of organic material is currently abandoned and therefore considered a nuisance value material with a zero value. An additional 203,000 T goes to land spreading or composting which is often chosen because of limited alternative options. Depending on stakeholder circumstances composting/land spreading can add a cost or a bring benefit. In some cases, there is a short term benefit for soil regeneration but after time too much of a single organic material (e.g. grape marc) can create a soil imbalance and will become a nuisance value. Consents for land spreading are becoming increasingly restrictive due to the environmental impacts. Valuing the environmental and wider benefit of composting/land spreading is beyond the scope of this study and for current purposes a nil value has been used.

- Revenue Earners: Materials which accrue some value to their owners and are currently sold often to pig, dairy or deer farmers as supplementary animal feeds. Prices usually range between $10 - 40 /T and organic materials are usually collected on a daily basis at the site gate from where they are produced. Our study shows 61,000 T of material goes to animal feed (Table 4) which usually gives the stakeholder a minimal return of $10 - 40/T. Based on the upper price this could generate revenue of approximately $2.4 M. In addition, our study has identified a small quantity of bespoke material which has found a premium market generating revenue of approximately $4 M making a total of $6.4.

The difference between the estimated cost of the organic wastes from Table 5 ($26 M) and the above estimated value of $6.4 M indicates a cost of organic waste disposal to the ToS communities of approximately $20 M.

8. Comments from Survey Respondents

The survey process has allowed us to gain many insights from experienced industry professionals and local authority representatives on current opportunities and challenges with upcycling waste in the ToS. We have presented these comments in a synthetic but not critiqued or reviewed form.

Aquaculture and fishing

ToS has large and established aquaculture (mussels and salmon) and fin-fishing industries. Mussel shells are a major waste stream from aquaculture as approximately 25% of harvest weight is unused. Shells mostly go to stockpiles/landfill but ground shells are also used as a soil conditioner on farms, orchards and vineyards. The composition of mussel shells is well documented (90% Ash as calcium carbonate; 5% Protein; 5% Carbohydrate) but waste streams from the sector can also include Blue mussels, seaweed and algae which can make up 5% of the total sea harvest. If Government objectives are met, NZ Aquaculture is predicted to grow to a NZD 3 Billion industry by 2035 which is an increase of 500%[15]. Production growth will not only greatly increase organic waste streams produced but will also require huge increases in aquafeed supplies.

Most of the waste produced from fish processing is currently rendered and converted into a 10% protein fish meal for export to Asia at commodity prices. Rendering is messy and expensive to run with high energy requirements and expensive real estate costs close to the wharfs. Additional volumes of fish waste are dumped at sea due to low return options and space constrictions in boats. Industry would be highly receptive to alternatives that streamline the processing of waste and improve commercial returns.

Fruit production

A respondent reported that Nelson/Tasman produced 152,360 T in 2021 which was 26% of the national (apple) crop at a production rate of 61 T/ha, one of the highest in the world. Strong growth in apple production is predicted[13]. Packhouse waste which is included in our study figures was estimated at 15% - 20% of the harvest weight making regional a total of 23 – 30,000 T of waste. This estimate does not, however, account for an unknown proportion of the apple crop that is shipped to packhouses in Hawkes' Bay.

A large proportion of the apple crop is left on the ground or in the trees. The shutdown of the Cedenco® juicing plant in Nelson has probably also contributed to greater volumes of low grade fruit not being manually harvested. If viable to collect these fruit would contribute a significant increase to the amount of bio-waste available. Collection of unharvested apples would require development of new mechanisation technology which could create spin-off business opportunities. One large orchard estimated at 60 T/ha which suggests that 50% of the total crop is left on the ground or tree (i.e. 150,000 T for the region). This tonnage is not included in the survey volumes. Fruit thinned in the early season (that doesn't meet minimum spray withholding periods) or windfalls are an additional source of organic material estimated at 10-15 T/ha or 25,000 T for the region also not included within this study.

Respondents highlighted the need for more research into upcycling orchard bio-wastes which, in addition to the materials already described, would include prunings, wood from redeveloped orchards as well as leaf and fibre paper board from packhouse operations.

8. Comments from Survey Respondents

Viticulture and winemaking

Marlborough produces 97% of the winegrapes in ToS and the majority of the grape processing is centred in or near the Riverlands industrial estate on the outskirts of Blenheim. Grape marc quantities vary with tonnages and press extraction rates but typically represent 13-20% of the grape harvest which was has been as high as 330,000 T from approximately 29,000 ha in Marlborough. This equates to 43-66,000 T per annum of marc. Final moisture content and whether the marc contains sugar or ethanol depends on the wine style being produced but 90% of Marlborough's production is Sauvignon blanc white wine for which the marc is fresh (unfermented). The marc is produced in a concentrated 6 week period from mid-March to late April. Vineyard areas are predicted to grow (principally Sauvignon blanc) at current rates (3% p.a.) for the foreseeable future[12] which would put yield in 2030 at approximately 400,000 T of grapes giving 70-80,000 T of marc. In smaller vineyard + winery properties land spreading or composting of grape marc is manageable but this practice becomes increasingly difficult with larger volumes or when winery processing is off-vineyard.

Grape prunings are an additional bio-waste stream which are estimated at 4T per hectare across 30,000 ha equating to 120,000 T p.a. Mechanised techniques for stripping and mulching canes from the trellis currently exist making collection of this material feasible if there was a higher value end-use. Pruning tonnages are therefore included into the study even though current disposal is almost entirely land spreading.

Broken CCA (Copper-Chrome-Arsenic) treated posts from vineyards are producing a large amount of problematic bio-waste that is often stockpiled on-vineyard. Pyrolysis and other disposal options have been explored by industry but to date no viable solutions have been identified except for repurposing the broken (used posts) into shorter fence posts for farming.

Hops and brewing

The recent growth in the Brewing and Hops industries coincides with an upswing in micro-brewing which has created a boutique focus and pride in production excellence. Breweries report good growth and expect their production to double in 5 years. Consequently the NZ Hop industry is also growing rapidly with a strong sustainability strategy which includes seeking Carbon Credits and sequestering options. The recent and rapid industry growth has meant little focus on upcycling waste streams. Respondents indicate that more research is required especially with respect to producing biodegradable/compostable options for strings and other trellis material that is currently harvested with the hop bines.

Vegetables

Similar to the hop growers vegetable producers reported frustration with waste from plastic strings and clips used in glasshouse horticulture which forces bio-waste to go to landfill as it cannot be composted. Respondents identified a research need to develop string and clip options from biodegradable materials.

8. Comments from Survey Respondents

Forestry

In addition to bark and saw-dust produced from timber milling the forestry sector produces a very large amount of "slash" material that is left on-site after logging operations. Respondents placed this volume at approximately 15% of the lumber harvest. Some work is being done to use timber waste to produce biofuel but a large opportunity exists for the slash which is mostly abandoned on site in the forests. Technology for the collection of this bio-resource largely exists and could be implemented if a higher value end-use could be found. As the slash is widely dispersed across the ToS regions we have arbitrarily chosen Havelock/Kaituna as a central location for mapping purposes in this study.

Urban

Nelson City Council has been conducting a pilot study collecting household food waste in a new bin collection program at a rate of 5.36 kg of waste per bin per week. The trial has had an 85% positive response rate and, with Council approval, is expected to soon be introduced to 22,000 households in Nelson and then extended to 26,000 households in the Tasman District. This will produce approximately 13,000 T of food waste per annum which will be new organic material available for upcycling and included in this study. Population and economic growth is also expected for the region[17]. Further research into toxin and packaging screening along with the optimal end use applications will be required to enable this new resource to be diverted from the landfill.

General

Other anecdotal information from industry respondents suggested that increased cleaning requirements for COVID-19 compliance is generating much more paper towel waste and that organic plastic is a new bio-material that is growing in waste volume. Industries are questioning what they should be doing with this material and how to dispose of it in a useful circular manner.

Some ToS industries have attempted to add value to their waste streams but these initiatives have mostly not eventuated because working in isolation usually means that only a narrow range of materials (in intermittent volumes) is available. These hurdles are even greater if new technology or substantial investment is required. Stockpiling and composting of bio-wastes is sometimes unsightly and smelly which can generate concerns amongst adjoining properties or communities.

Seasonality

Seasonal fluctuations will require managing

Bio-conversion plants require constant and consistent nutritional in-feed in order to operate all year round. Seasonality of the production of organic materials is therefore an important consideration for bio-conversion feasibility.

The seasonal availability of most materials is reported as being fairly consistent throughout the year with the major exception of grape marc (and possibly prunings) from viticulture. For other crops there will be changes in fruit and vegetable varietals throughout a season but variations in nutritional content will not make a significant difference to the total material profile, therefore have been itemised collectively in Figure 5.

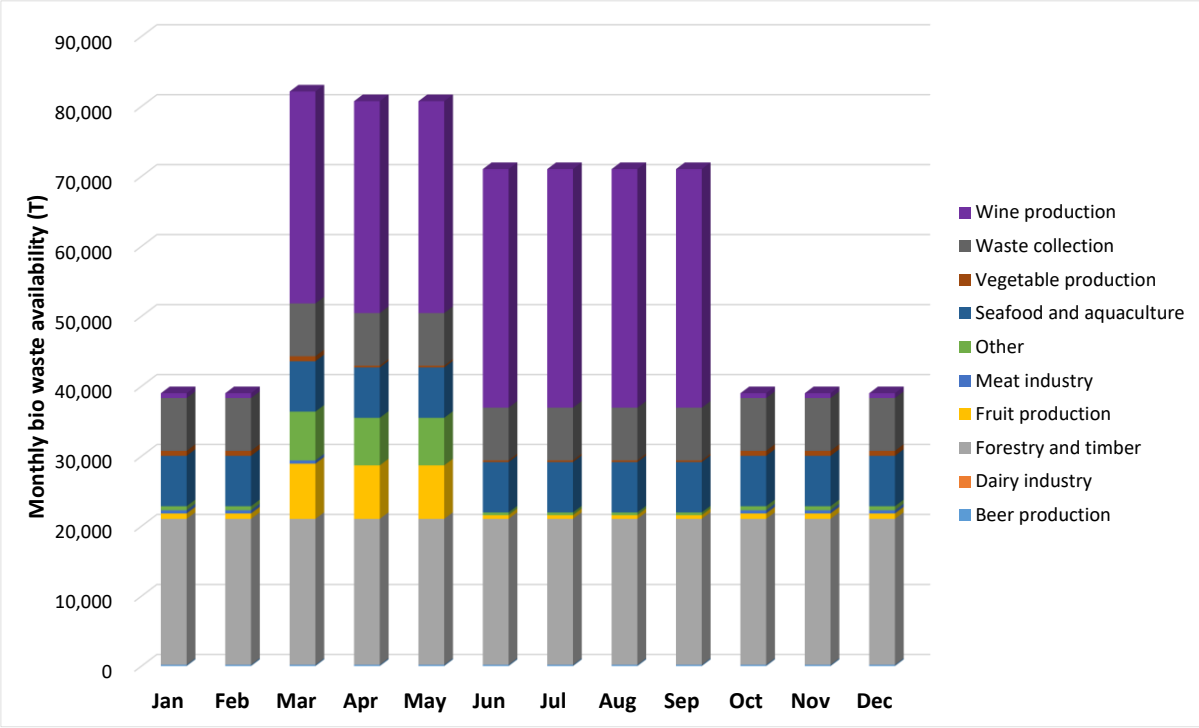

Figure 5. Seasonal volumes by waste type produced by industry groups in the Top of the South.

Approximately 50% of the available Carbohydrates this is grape marc which constituting large volumes and challenging seasonality peaks. The hop (bines) season is also narrow (March – May) and is included in the "Other" category in Figure 5.

The seafood industry works throughout the year generating reasonably consistent volumes of high Protein materials. Meat Industry processing peaks from October to April while dairy is constant throughout the year. While these industries produce relatively small volumes they represent important contributors to the available Protein.

Contributions to the circular economy

Meeting sustainability objectives amongst all stakeholders within the region has recently become a driving factor in the management of organic waste streams and presents opportunities for multiple upcycling projects within the region.

As discussed in the introduction, many of the leading stakeholders interviewed within the ToS were very committed to embracing the sustainability options that were available to them. This can improve their own access to markets and meet corporate sustainability objectives.

In addition, a consequence of achieving sustainability objectives can open access to new sustainable funding options.

The opportunity to engage in a sustainable waste management solution, in addition to already existing initiatives throughout production processes, could be the final step to elevating businesses to gold status within the sustainability STARS®, or similar, programmes.

The leading industries striving to achieve equivalent "gold status" in the ToS region appeared to be viticulture, pipfruit, seafood and hops, closely followed by forestry and horticulture.

9. Organic Waste Management Solutions

Organic waste management has become a global subject for communities to address in order to reduce waste and improve environmental outcomes. Hawaiian author K. Surendra[18] published a comprehensive summary of insect bioconversion research worldwide that cited nearly 300 scientific publications indicating strong and recent research interest. Swiss author N. Zoppini[14] has compared five well known organic waste management technologies currently available and concluded a range benefits and constraints as follows:

- Composting - cheap to build, creates low value soil conditioners, environmentally challenging with odour and leachates.
- Incineration - expensive to build, high energy consumption, emits toxic fumes into the environment but can consume a wide range of materials.
- Anaerobic Digestion - expensive to build, produces Methane which can be captured and used as energy source.
- Landfill - expensive to build and manage, creates many public compliance issues, produces methane and potential leachate, environmentally challenging.
- Insect Bioconversion Technology (IBT) - expensive to build, creates new employment and investment opportunities, positively contributes to the circular economy, produces high value outputs for the aquafeed, pet food, poultry and fertiliser markets to create a long term profitable and sustainable business.

Amongst the five technologies evaluated Zoppini (Figure 6) identified that Insect bio-conversion, if feasible, is a very favourable option because it is the only process that can produce benefits the environment while being financially profitable[14, 16, 18].

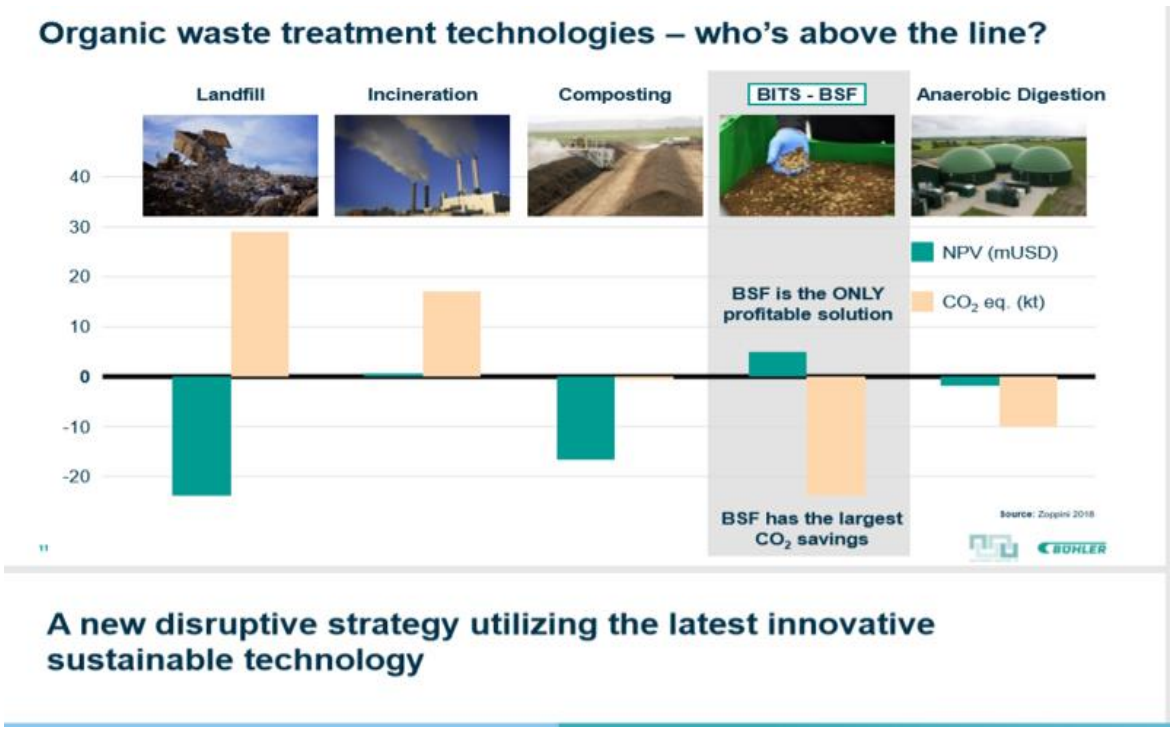

Figure 6. Zoppini N 2018. Organic Waste Treatment Technologies - Who's above the line?. University of Zurich/Bühler Group.

Pre-Treatment

As discussed in the Seasonality section bioconversion technology projects typically require constant and consistent nutritional in-feed. This means that seasonally produced waste and some waste types will require pre-treatment to stabilise their storage and nutritional properties.

Pre-treatments processes are varied but often involve drying and/or milling organic wastes. Pre-treatment processes for insect bioconversion are designed to prepare organic materials into a consistent format of scale, texture and stability to ensure regular and optimum nutrient accessibility to the insects throughout the year. Due to the seasonality and the high volumes of grape marc in the Marlborough region, combined with the perishability of this material, a pre-treatment process will be required to stabilize this resource. The challenge is to manage a very large scale of material over a short few months before the material decomposes. An Industrial drying operation may be the solution but only useful if the nutrient value of the marc is maintained. Further research work is required on an industrial scale to develop this opportunity and ensure its commercial viability.

Mussels and seafood materials will also require pre-treatment, in order to upcycle their potential. Some preliminary pre-treatment research has been undertaken and results are promising.

Forestry and timber organic waste streams may also require some form of pre-treatment. Added complexity would come with the processing of broken treated vineyard and fence posts which contain arsenic and chromium. Treated timber may prove to be too difficult to manage in a practical manner with currently available technology.

Pre-treatment operations will each offer additional business opportunities within the region to enable the utilization of each material into a collective resource bank of material suitable for upcycling.

10. Opportunities

Options to consider

In addition to the methods of managing organic waste discussed in the preceding section additional bio-resource upcycling business opportunities have been identified during the interviews conducted in this study. Some of these opportunities relate to the production of feed materials for an IBT and others are more suited for new biofuel opportunities. These include:

- Nutraceutical extraction from targeted organic materials.
- Biofuel production
- Wood / Timber bioconversion and upcycling

Compared to these processes insect bioconversion technology utilising the black soldier fly would appear to be a frontrunner. IBT brings the highest benefit to the environment including CO_2 reduction and has the potential to be the most commercially profitable of all the options currently available. Significant research and operational case studies are available to support this technology, many of which are detailed in published research[18].

IBT projects have recently been launched in France and the Netherlands and there will be many more facilities emerging globally. Food Security Solutions Ltd. is managing upcycling projects based on insect bioconversion technology, both globally and within New Zealand. In the author's opinion, New Zealand, and especially the ToS, is well positioned to embrace this innovative technology because the available mix of organic materials identified by this study appears, superficially at least, able to support the development of a financially profitable and environmentally beneficial IBT project.

The protein meal outputs of an IBT project have proven to be of benefit to the aquaculture industry in Europe with improved growth rates and health outcomes for fish[16]. There is a strong argument that similar circular benefits could accrue in the ToS. Locally produced insect protein meal would provide a new resource to potential NZ Aquafeed producers (substituting imported feeds) and current pet food manufacturers.

Other circular benefits of IBT include secondary production of highly functional fertilisers and soil regeneration materials. These can be re-invested back into the region's soils.

There are however some constraints. To produce a high-value protein meal for animal feed, an IBT project needs a range of nutrient in-feeds of which uncontaminated protein can often be a key limitation. In the absence of large-scale dairy, brewery and grain industry bio-resources in the ToS, there is an apparent shortfall in plant-based protein as most animal protein sources are likely cross-contaminated with faecal material which will create compliance issues. However, it is possible that grape marc and/or other plant-based carbohydrate sources will have enough primary amino nitrogen substrates to overcome this deficit. New research (and associated funding) into both the protein content of the infeed materials and the target end-use requirements (e.g. protein meal as an aquafeed ingredient) will be essential to confirm the economic and technical viability of an IBT project.

The mix of available bio-resources is specific to the ToS and although it may have some protein limitations, there is a large excess of volume to work with. A standard sized IBT project will require a minimum 50,000 T of wet waste per annum as infeed and this study has identified ca. 700,000 T within the region. However not all this material will be available or necessarily suitable, but within the overall pool there should be a sufficient quantity of selected materials. An IBT project is modular[16] so can be built to a range of scales in modular units from 50,000 T upwards. There is nevertheless an excess of materials that could support many other upcycling projects.

10. Opportunities

Additional spin-off opportunities

- This study has also identified alternative uses and peripheral value-added processes, which have the potential to support economic growth and reduce the environmental impacts of waste in the ToS. These include:
- Pre-treating grape marc on an industrial scale.
- Stabilising wine lees.
- Engineered methods for capturing wasted apples left abandoned in orchards.
- Separation of string and plastic clips from hop production and horticulture greenhouses. This has IP potential to solve a global problem.
- Rockwool management options from horticultural sites.
- Process to utilise abandoned forestry slash, vineyard/orchard wood and prunings and leaf waste from packhouses.
- Collection of food waste from hospitality industry sites and council collection bins, removal of packaging and toxin screening.
- Processing and stabilising seafood and animal wastes as an upcycling alternative to rendering.
- Processing mussel shells to present in an accessible format for bioconversion.
- Capturing additional seaweed from mussel waste for upcycling.
- Processing of paunch grass and lamb pelts to stabilise and present in an accessible format for bioconversion.
- Paper towel and packaging board collection and processing.
- Industry collaboration to collect all waste from breweries/distillers to add value to spent grain and yeast.
- Processing plant waste, including roots and soil, from nurseries and research centres
- Capturing and processing "at sea" waste from the seafood industry including mussel mix, seaweed and algae.

11. Conclusions

ToS has the opportunity to upcycle undeveloped resources

There was high interest in the study and its outputs and the majority of participants were willing and forthcoming with information. Most companies did not keep detailed records of their waste streams, which made rigorous data collection difficult. A global push by producers and a pull from consumers and communities is forcing many industries to take a more proactive strategy towards circularity, which underpinned the wide stakeholder interest in this study.

Industries and communities in the ToS region, from Blenheim to Tasman inclusive, produce a diverse range of bio-resources. This study has identified approximately 700,000 T of organic materials potentially available for upcycling throughout the region which is an amount more than three times greater than historical government statistics.

The study results suggest that the ToS is well positioned to embrace IBT technology because the available mix of organic materials appears broadly suitable, with excess volume in a relatively compact geographical area.

In considering insect diets (for the production of higher value animal feeds) there is an apparent shortfall in plant-based protein. However, it is possible that grape marc and/or other plant-based carbohydrate sources will have enough primary amino nitrogen substrates to overcome this deficit. New detailed analysis will be required to understand the exact regional compositions and accessibility of nutrients that could be utilized in any upcycling bioconversion project.

Many of the bio-resources have a steady production flow throughout the year. The major exception is fruit waste (including grape marc) Carbohydrate which is highly seasonal with production confined to the February to April period.

The largest source of organic waste type identified in the study was Fibre from forestry slash, timber milling, prunings and wood material from viticulture and horticulture. There is a large opportunity to upcycle this material but additional research will be required to establish its value and assess processing options.

Some of the organic materials are of known composition and are relatively easy to work with and some are of unknown composition and will require additional research into their potential. To retain their value when presented to a bioconversion project many materials will require pre-treatment processes which will create additional business opportunities for the region.

Taking into account the cost and value of the materials, the current net cost to the community for organic waste management is approximately $ 20 M. There is an opportunity to develop mutual benefit for all parties through upcycling of organic waste materials bringing cost savings to the community.

In summary, the Top of the South has an undeveloped opportunity to add value to the organic waste materials within the region. The annual availability and mix of materials have the potential to support the development of financially profitable, environmentally beneficial and highly circular bioconversion projects.

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