

# Otago Region Economic Profile for Land and Water



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Cover image: early season growth on Misha's Vineyard (Cromwell) overlooking Lake Dunstan

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## Executive Summary

At a glance, Otago has plentiful land and water with few people living in the region, albeit uneven population distribution amongst locations. The region has 12% of the nation's total land area and around 23% of its lake surface area, with around 5% of New Zealand's population. However, looking closer, the proportion of highly versatile land is relatively low in Otago compared with New Zealand as a whole; and a good proportion of the Otago land that is suitable for primary production is relatively dry.

The people of Otago reside within five territorial authorities, each of which is unique in terms of things such as natural resources, demography, and economic structure. Yet, the region is connected by land and water, as well as trade, travelling, social relationships, and common culture.

Two themes emerged from profiling Otago's natural resources, economy, and community. One is the fundamental role natural resources play in the economy and servicing the needs and wants of local communities. Otago's land and freshwater enables, amongst other things, the production of food and fibre, attenuation of waste, building of communities, and supply of leisure and recreation.

The second theme is linked to the different natural endowments that various parts of Otago have, and defines the different challenges faced to enable natural resource protection and use, economic development, and community growth.

In general, inland parts of Otago (Queenstown Lakes District and Central Otago District) are drier and contain less versatile land; more conservation estate and lakes/streams; less intensive land use; and fewer communities are deprived of necessities (e.g., access to transportation and internet). Water availability and the pressure from rapid population growth are two of the key challenges facing these community.

Coastal Otago (Waitaki District, Dunedin City, and Clutha District) on the other hand, generally has more temperate climate and rainfall, more versatile land and higher percentage of intensive land use, and relatively more communities deprived of necessities. Water availability and quality, and population stagnation are some of the challenges facing the community.

In this report, an overview of Otago's land and freshwater resource is presented in Section 2. This section explores land and water's interaction with the economy, and specifically the connection with the primary sector. The subsections analyse Otago's land use map<sup>1</sup> and present information on the share of land use by land use type; introduce the concept of Land Use Capability (LUC) classes and compare Otago to New Zealand in terms of the distribution of classes; present Otago land use types by the LUC classes; and provide information on irrigated systems and land in Otago, as well as irrigation type by land use type.

Section 3 is about Otago people. The subsections discuss the region's demography and income; and present a brief summary of the uniqueness of each territorial authority in Otago in terms of its natural environment, demography, level of deprivation in the community, and environmental challenges.

Section 4 of the report describes the Otago Region's economy, with a focus on the sectors and industries that are characteristic of Otago and each territorial authority. This section also describes the largest

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<sup>1</sup> Data from Great South, 2022, which provides land use information in Otago for 2022.

changes in employment in the last ten years and international import risks linked to increasing uncertainty around the global supply of raw input materials and the availability of manufactured goods.

Section 5 focuses on the economic linkages, which are the impacts of activities occurring within one economic sector on other sectors within that economy. Key insights are discussed at the region-level and, for important linkages, at the territorial authority-level. They illustrate how each of the major sectors within the Otago Region support each other.

Section 6 provides concluding remarks and suggests areas for future study.

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## Glossary

*Industry* and *Sector*. Where the following text refers to an *industry*, it is referring to industry as per Statistics New Zealand's 109-industry classification used in the 2020 national input-output tables. Where the text refers to a *sector*, it is referring to a grouping of these industries. For example, the agricultural sector is comprised of (1) horticulture and fruit growing, (2) sheep, beef, cattle, and grain farming, (3) dairy cattle farming, (4) poultry, deer, and other livestock farming, (5) forestry and logging, and (6) agriculture, forestry, and fishing support services.

*Gross output* is all sales that an industry makes within a given accounting period.

*Value added* is comprised of most of the primary inputs excluding taxes on products. Value added represents the value above the raw material costs which consumers are willing to pay for a product or service. This extra value is achieved via the application of labour and capital (*e.g.*, manufacturing equipment and intellectual property), that is compensated for by wages, salaries, and business profits.

Employment is reported in units called *Modified Employment Counts (MECs)*. MECs are a modification of Statistics New Zealand's Employment Count (ECs) statistics. ECs only count employees of organisations but can include working proprietors who pay themselves a salary or wage. However, those owner-operators of businesses who take drawings from their business are not counted. Statistics New Zealand count business owner-operators separately as Working Proprietors (WPs). MECs adjust the EC figures using the WP figures to provide an estimate of the overall number of people who work in a business or area<sup>2,3</sup>. The use of the MEC measure also ensures consistency with the data sources and processes that are used by Market Economics Ltd in compiling the regional and sub-regional input-output accounts. More information about MEC measures is available upon request.

*Location quotients (LQs)* are an analytical statistic that measures a region's industrial specialisation relative to a larger geographic unit (usually the nation). An LQ is computed as an industry's share of a regional total for some economic statistic (this report uses employment (MECs)) divided by the industry's share of the national total for the same statistic. For example, an LQ of 1.0 in mining means that the region and the nation are equally specialized in mining; while an LQ of 1.8 means that the region has a higher concentration in mining than the nation., i.e.,

$$LQ_{r,i} = \frac{\frac{MEC_{r,i}}{\sum_i MEC_{r,i}}}{\frac{MEC_{NZ,i}}{\sum_i MEC_{NZ,i}}}$$

Where  $r$  is the area of interest (Otago Region or one of Otago's territorial authorities) and  $i$  is the industry of interest, *e.g.*, dairy product manufacturing.

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<sup>2</sup> The MEC approach, based on the IRD/ LEED data and applied by Market Economics Ltd since about 2003, is generally more robust than Census data, in terms of sector of employment and location of Geo unit. There are also other data sources for employment available from Statistics New Zealand such as the Household Labour Force Survey (HLFS) and the Quarterly Employment Survey (QES). These are sample surveys and therefore may provide less accurate employment measures due to potential sampling errors. Also, employee numbers will vary between data sources due to factors such as time of the year when employees are counted and varying coverage of both employees and industries.

<sup>3</sup> Stats NZ do not release WP counts at SA1 level due to confidentiality. We calculate WP numbers by sector reconciled with the TA totals to estimate WPs at SA1 level, and then combine with the EC data to calculate MECs.



# 1 Introduction

## 1.1 Background

The Otago Regional Council (ORC) is developing a new Land and Water Regional Plan (LWRP), set to be notified by June 2024. It will include settings of environmental ‘limits’ for water quality and water quantity, to give effect to the National Policy Statement for Freshwater Management 2020 (NPS-FM (2020)). Once operative, this new regional plan will guide a range of activities relating to land and water use in both urban and rural settings in Otago.

To understand the Otago economy and the socio-economic impact of the new plan, the ORC has partnered with iwi advisors, and collaborated with industry stakeholders and field experts, to develop an Economic Work Programme for the new plan, which includes five workstreams. This report is the fourth output from the Programme. Its purpose is to provide a profile of freshwater and land use in Otago, its people and their economy, and describe the economic linkages in the Otago regional economy, between key industries, among territorial authorities, and with other regions and the national economy.

The reports from the other workstreams of the Economic Work Programme characterise Otago’s rural sector, estimate the potential impact of land and water policies on rural businesses, provide stories of Otago’s catchment communities and their current efforts to manage land and water, and describe Otago’s regional Māori economy. Together with this report these outputs will inform an Economic Impact Assessment of the LWRP and provide a baseline understanding of the Otago economy.

## 1.2 An Otago regional economy

New Zealand’s regions are primarily determined by areas of water drainage into rivers, or catchments. The Otago region is made up of the catchments of two major rivers – the Clutha-Mata-au and the Taieri, starting in the high mountains in the central dividing range and flowing eastwards to the sea. A third river – the Waitaki – forms the northern boundary, however, much of its catchment lies in the adjacent Canterbury Region. The Otago Region’s character is therefore, to a large extent, determined by its catchments – the spatial arrangement of its land and water resources.

The region’s economy is the complex web of interactions and decisions that occur within its surface water catchments. The unique natural resources and cultural norms shape people’s livelihoods. However, economic activity does not occur solely within regional boundaries: a characteristic of regional economies is that they are generally very open with many linkages to both national and local levels.

In the case of Otago, the land and water in its catchments and the ecosystem services they provide are fundamental to the regional economy. They not only directly underpin the primary industries, which dominate the rural landscape, and their related processing industries, but also tourism, recreation, and urban domestic water supplies. The region’s land and water are of social and cultural significance and are important to the quality of life for all the communities of the region.

While the focus here is on what is usually thought of as ‘the economy’, with its market and non-market components, it is actually the second of two regional economies that co-exist in Otago (McIntyre, Timms-Dean, Moran, and Duncan, in press) The first is the Kāi Tahu economy, which is the subject of a separate report within the Economic Work Programme. According to McIntyre et al. (in press), the Kāi

Tahu economy operates as a system for managing economic activities within **te taiao** (the environment) through **tikaka** (customary lore and law relating to rights, values and practices) and **mātauraka** (knowledge and skills). Following colonisation and settlement, the second economy expanded and the first went through a long period of contraction and transition. Importantly for this report, the two regional economies intersect spatially. A key reason is that the Kāi Tahu economy revolves around seasonal practices associated with the gathering of food and resources spread across the whole region. The development of the modern Otago economy overlaid and was influenced by the pattern of trails and settlements.

The Otago Regional Council (ORC) and the five territorial authorities have statutory responsibilities for establishing and implementing a policy framework to ensure sustainable development of the region under the Resource Management Act (1991). The proposed Otago Regional Policy Statement (pORPS) articulates community visions for the state of the environment (land and water) of the region with the purpose of addressing the observed decline in water quality in some catchments and providing a decision-making framework to ensure sustainable development. The new Land and Water Regional Plan (LWRP) is a key implementation vehicle for the pORPS, by articulating environmental outcomes, setting targets and identifying actions and rules in relation to management of land and water.

In essence, the new LWRP aims to manage the use of freshwater and land to achieve environmental outcomes and in doing so it will likely have an important role in shaping the regional economy and economic outcomes. It is therefore necessary and logical to explore the relationships and linkages between regional economic activities and the region's land and water resources.

### 1.3 Purpose

The immediate purpose of this report is to profile three key aspects of the Otago economy:

1. the availability and use of land and water resources,
2. communities' work and income as well as level of deprivation, and
3. economic structure and linkages with reference to key industry sectors and their contribution to regional value added, export earnings and employment.

The information in this report will also be able to inform ongoing policy making at ORC, beyond the new LWRP, and provide a baseline for further studies.

It is only when the use of land and water resources is well understood and when the connections between land- and water-reliant primary sectors and other sectors within the economy are well understood, that the region's dependence on land and water, and the impact of changing/restricting land and water use can also be understood and managed to minimise impacts on the community and economy.

## 2 Otago's natural resources

### 2.1 Land

The Otago Region is the second largest region in New Zealand by land area (approximately 32,000 km<sup>2</sup> or 12% of New Zealand's land area, second to the Canterbury Region). The region stretches 480 kilometres along the South Island's eastern coast, from the Waitaki River in the north to Chaslands in the south, from the Otago Peninsula in the east, inland to the glacial lakes of Wakatipu, Wānaka and Hāwea, and along the Southern Alps and Mount Aspiring/Tititea National Park.

Otago boasts a vast range of landscape and climate. In general, the region's altitude drops from the west (inland) to the east (coastal) while the average annual temperature increases, except for some pockets in Central Otago where the land is flat, and the summers are hot and dry<sup>4</sup>. The driest areas in the region are in the central areas as well as the north-east tip of Waitaki area.

The region extends from the Southern Alps and the high rainfall beech and alpine areas of Mount Aspiring/Tititea National Park on the west boundary, to the dry inland Central Otago basins that encompass some of the best-known glacial lakes (Lakes Wakatipu, Wānaka, and Hāwea). These lakes form the headwaters of the Clutha River/Mata-au River, which then meanders through the south-east of Otago's wetter area (the Catlins) and reaches the coast near Balclutha where it emerges into the Pacific Ocean.

To the east of the drier inland area of Otago is the high valley of the Strath Taieri/Maniototo basin, which is in the centre-north of the region while the Taieri plain is in the centre-south (Pearson, 2022). The two are connected by the Taieri River that arises in the Lammerlaw Range in the south-east of Central Otago and reaches the sea at Taieri Mouth some 30 kilometres south of Dunedin.

To the south of the Waitaki River is the northern part of Otago, which is also the start of the eastern boundary of Otago – a spectacular coastline extending from south of the Waitaki River to Oamaru, then through Kakanui, Moeraki, Karitane, Waitati, the Otago Peninsula, Taieri Mouth, Kaka Point, and ending near Chaslands in the Catlins.

#### 2.1.1 Land use

Land use, or human use of land 'represents the economic and cultural activities (e.g., agricultural, residential, industrial, mining, and recreational uses) that are practiced at a given place' (EPA, 2022). As well as providing a general overview of land use in Otago, this analysis focuses on rural land use, as it is at the forefront of the changes that will be brought about by the new LWRP.

Figure 1 provides the land use map of Otago by detailed land use types and Figure 2 provides the share of the land use by land use type in Otago.

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<sup>4</sup> Pearson (2022) provided a comprehensive description of Otago's landscape (topography, geology, and Altitude), climate (temperature, precipitation, and climate change), and soils/soil drainage. See Moran (2022) <https://www.orc.govt.nz/media/13385/phase-1-farmers-and-growers-in-otago-report.pdf> for more details.

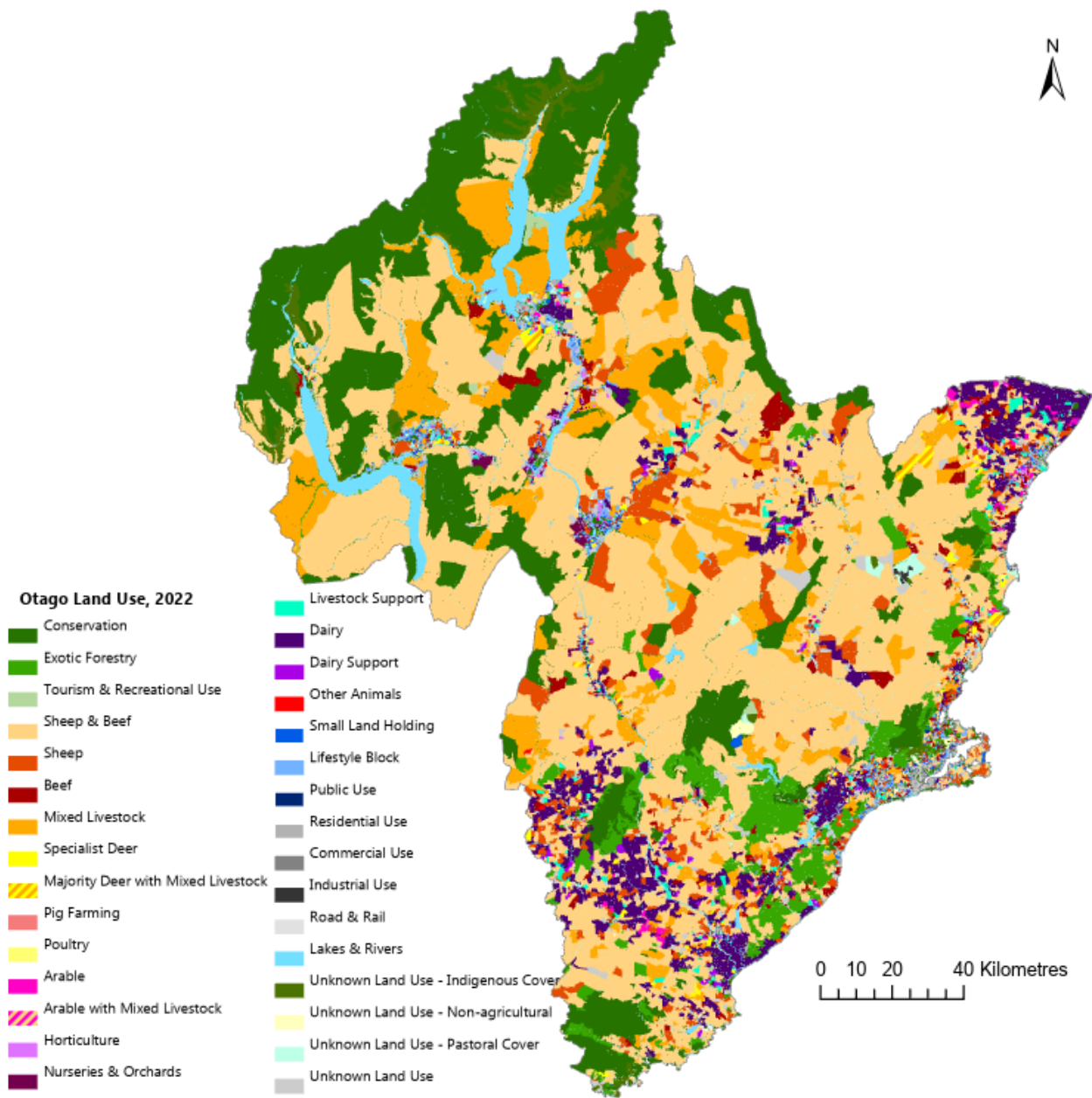


Figure 1. Land use map, Otago, 2022  
 Source: Data from Couldrey (2022)

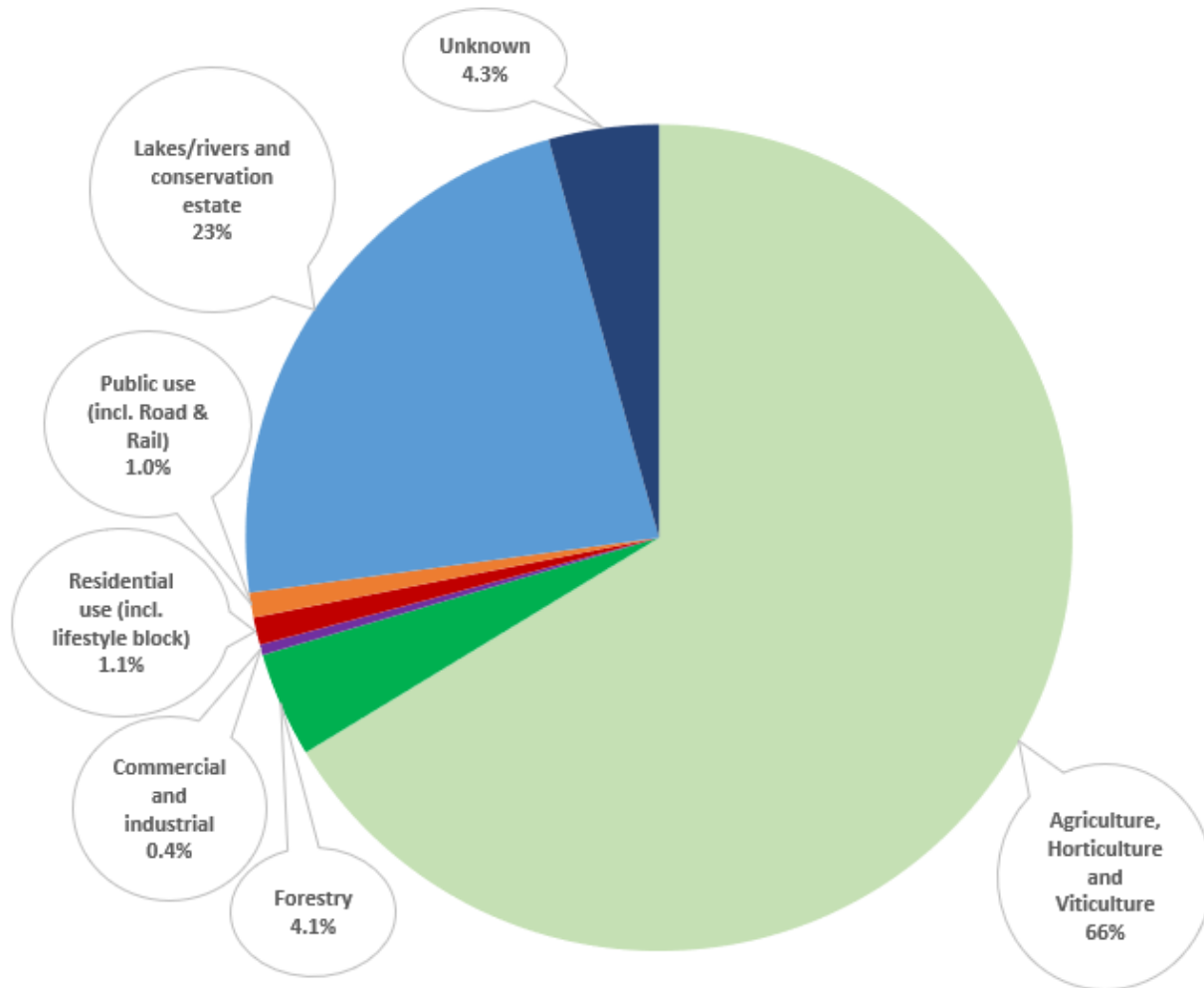


Figure 2. Land use share by land use type, Otago, 2022  
 Source: Data from Couldrey (2022)

Otago has some 3 million hectares of area. Nearly 700,000 hectares (nearly one quarter) are lakes, rivers, and conservation estate<sup>5</sup> mostly in the inland part of Otago in the Queenstown Lakes and Central Otago Districts. The rest of the region’s land use is distributed between primary production use (i.e., agriculture, horticulture, viticulture, and forestry) and urban/settlement centres (i.e., public land use, business properties, and residential properties).

Primary production takes up around 70% of Otago’s total land use. A little over 2 million hectares of land (or two thirds of total land area) is used for agricultural production; quite a sizeable amount is either non-pastoral land or very low stocked pastoral land (Moran, 2022). The agricultural land consists mostly of dry stock and dairy production with some horticulture and viticulture properties. While dry stock land use is spread across the region, dairy production is more concentrated in the Clutha and Waitaki Districts. Horticulture and Viticulture operations in Otago are mainly centred around Central Otago with limited operations found in the Waitaki District and Dunedin City. Plantation forestry land use covers

<sup>5</sup> This type includes National parks, DOC Estate, Māori Trusts, and Queen Elizabeth II National Trust.

around 120,000 hectares (or 4% of the region) and is mainly concentrated in the coastal part of the region (Waitaki District, Dunedin City, and Clutha District).

Urban/settlement land use, i.e., public use (churches, schools, cemeteries, etc.), residential use and commercial/industrial land use, make up to around 2.5% of total land use. Further details of land use type by Otago's Territorial Authorities (TAs) can be found in ORC's Fresh Water Management Unit (FMU) and Rohe economic snapshots<sup>6</sup>.

### 2.1.2 Land use capability

Land Use Capability (LUC) classifications, part of the New Zealand Land Resource Inventory (NZLRI) tool, provide a rating for the ability of each parcel of land to sustain agricultural and forestry production, based on a mix of factors. These five main factors include soil, rock, slope, erosion, and vegetation cover (NZLRI, 2023 as cited in Lynn et al., 2009). LUC classifications also reflect climate, the effects of past land use, and the potential for erosion<sup>7</sup>.

There are eight LUC classes defined in the NZLRI: Classes 1 to 4 are generally suitable for all ranges of cultivation, Classes 5 to 7 tend to be suitable for pastoral farming and forestry, while Class 8 has severe limitations for primary production or forestry use<sup>8</sup>. Most Class 8 land in Otago occurs on conservation estate. LUC indicates the versatility of the land for potential production but does not explicitly consider the availability of water (either as precipitation or extraction).

Table 1 gives a description of the LUC classes and summarises the total land area in Otago as well as New Zealand in each class, while Figure 3 maps LUC distribution in the region. Otago has less LUC Class 1 and 2 land proportionally (i.e., 1.6%) compared with the New Zealand average (5.2%). As shown in Figure 3, Otago's LUC Class 1 and 2 land is mostly distributed in North Otago and the Taieri Plain. The LUC classes generally get higher (that is, the land becomes less versatile) from the east side of the region (coastal) to the west (inland).

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<sup>6</sup> Links to the snapshots are listed in the reference page of this report (Yang, Y., 2022a-f).

<sup>7</sup> The NZLRI maps soil and land resources of the entire country at a nominal scale of 1:50 000.

<https://soils.landcareresearch.co.nz/tools/nzlri-soil/nzlri-development/>

<sup>8</sup> For more details on Land Use Capability and LUC classes, see [https://ourenvironment.scinfo.org.nz/maps-and-tools/app/Land%20Capability/lri\\_luc\\_main](https://ourenvironment.scinfo.org.nz/maps-and-tools/app/Land%20Capability/lri_luc_main)

Table 1. Share of LUC classes, Otago vs NZ, 2022

Source: The New Zealand Land Resource Inventory, <https://iris.scinfo.org.nz/layer/48076-nzlr-land-use-capability-2021/>

LUC Class	Description	Land Area in Otago (ha)	Share of Otago (%)	Land Area in New Zealand (ha)	Share of New Zealand (%)
1	Land with virtually no limitations for arable use and suitable for cultivated crops, pasture or forestry	3,082	0.1	187,008	0.7
2	Land with slight limitations for arable use and suitable for cultivated crops, pasture, or forestry	47,249	1.5	1,201,129	4.5
3	Land with moderate limitations for arable use, but suitable for cultivated crops, pasture, or forestry	343,212	11	2,445,912	9.2
4	Land with moderate limitations for arable use, but suitable for occasional cropping, pasture, or forestry	431,418	14	2,779,538	11
5	High producing land unsuitable for arable use, but only slight limitations for pastoral or forestry use	44,468	1.4	208,875	0.8
6	Non-arable land with moderate limitations for use under perennial vegetation such as pasture or forest	1,010,105	32	7,478,558	28
7	Non-arable land with severe limitations to use under perennial vegetation such as pasture or forest	776,331	24	5,692,441	21
8	Land with very severe to extreme limitations or hazards that make it unsuitable for cropping, pasture, or forestry	437,566	14	5,810,206	22
0	Waters	95,443	3.0	790,076	3.0
<b>Total</b>		<b>3,188,874</b>	<b>100%</b>	<b>26,593,743</b>	<b>100%</b>

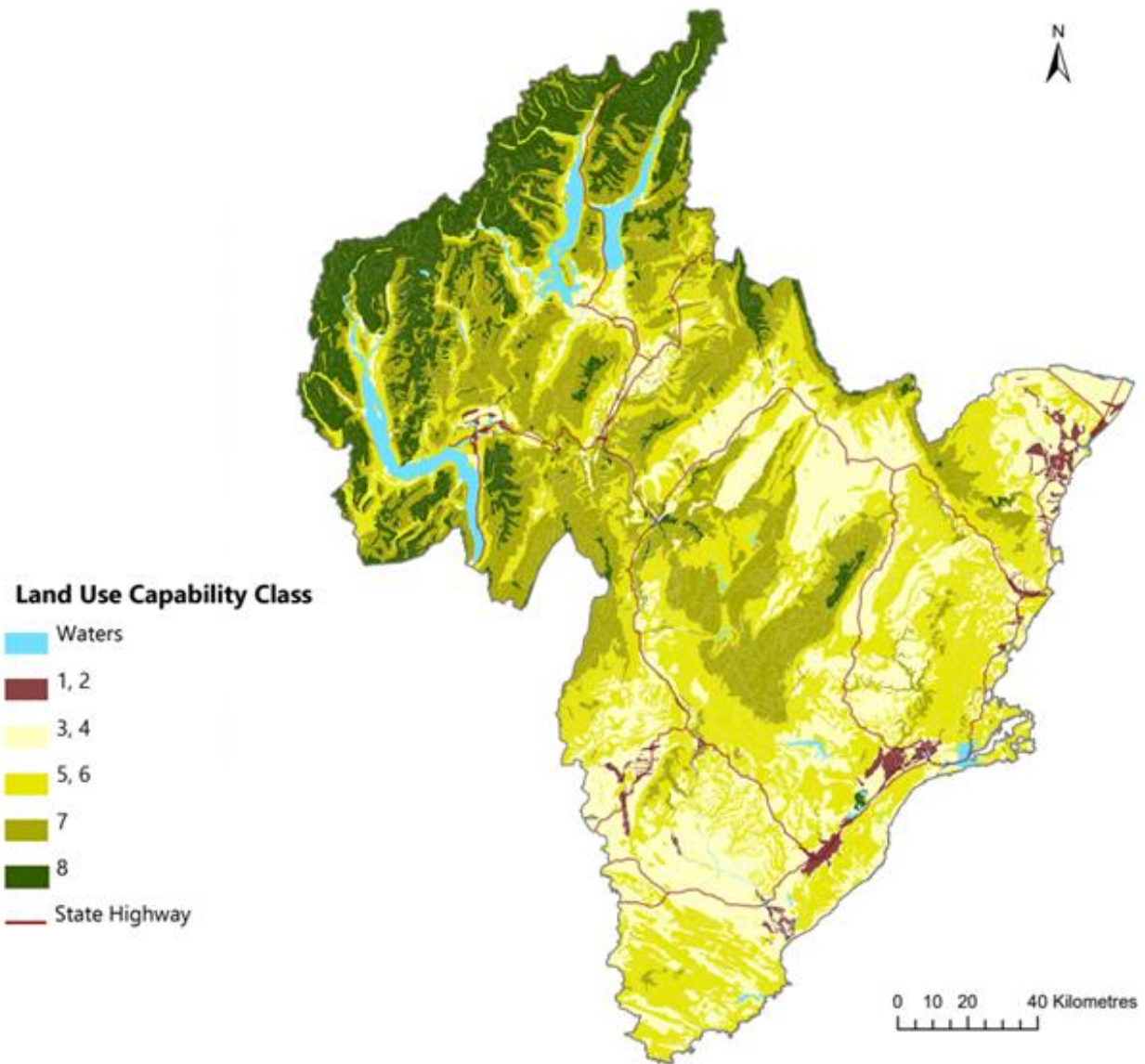


Figure 3. Map of Otago by LUC classes

Source: The New Zealand Land Resource Inventory, <https://iris.scinfo.org.nz/layer/48076-nzlr-land-use-capability-2021/>

One thing to note is that when rural sector participants make investment decisions, land use capability might be one of the criteria to consider. Other criteria might include water availability, product prices, proximity to the transportation centre, local environmental policies, or even personal preferences and expertise and family considerations. Therefore, there is likely to be a mismatch between optimal distribution of land use for agricultural production reasons alone, and optimal distribution of land use for a mixture of financial and lifestyle reasons. Further, some of the system conditions and relationships which individuals, families and communities consider when making decisions, such as prices of outputs and family choice/considerations, are dynamic, which then demands non-static and flexible measures.



### 2.1.3 Land use by different land use types

The majority of arable and dairy land uses in Otago are located on more versatile land (LUC 4 and below), followed by the horticulture industry (see Figure 54). About 45% of plantation forestry occurs on LUC 4 and below, which is higher than the national average of around 20% (see Figures 5 and 6). Sheep, beef and deer farming utilise less-versatile land.

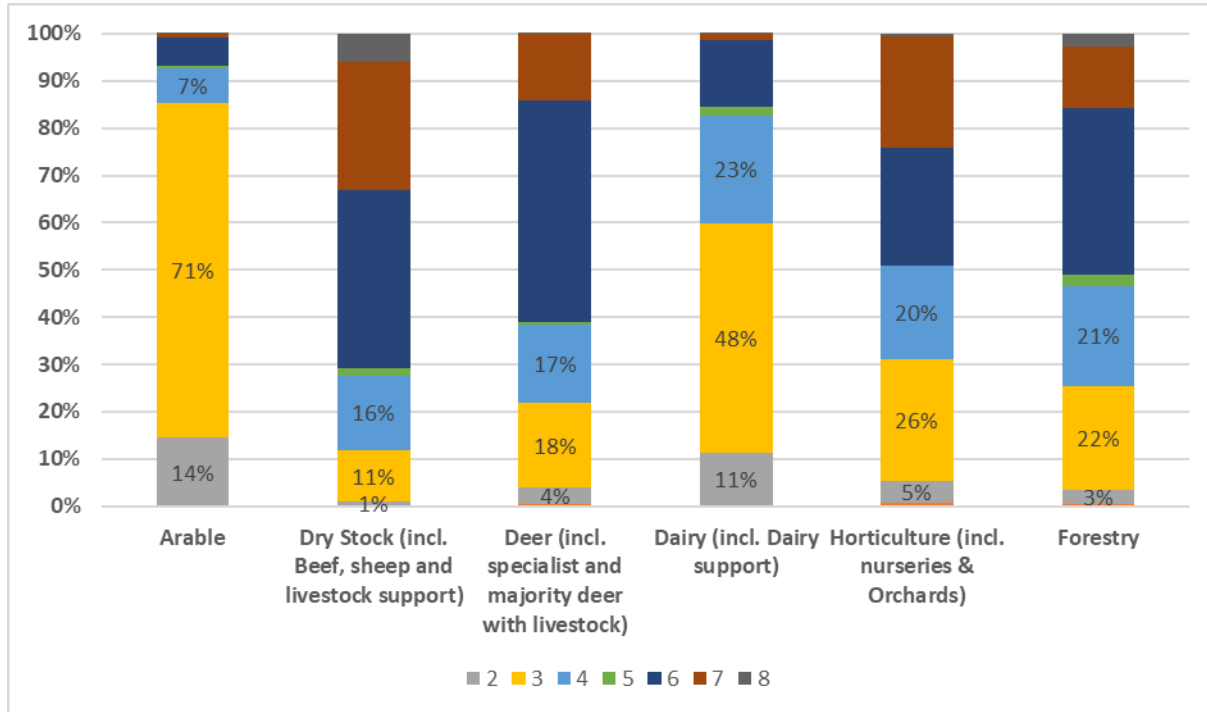


Figure 4. Otago land use type by LUC classes, 2022

Source: Data from Couldrey (2022)

According to the data in Figures 5 (Otago) and 6 (New Zealand), Otago features:

- Dry stock farming as the major land use for LUC Class 3 and above, as does New Zealand as a whole;
- More dry stock land use proportionally than New Zealand as a whole;
- Less dairy land use proportionally than Zealand as a whole;
- Less lifestyle block land use proportionally than Zealand as a whole;
- More forestry land use proportionally than Zealand as a whole; and
- More forestry land use located in LUC Class 4 and below, proportionally, than Zealand as a whole.

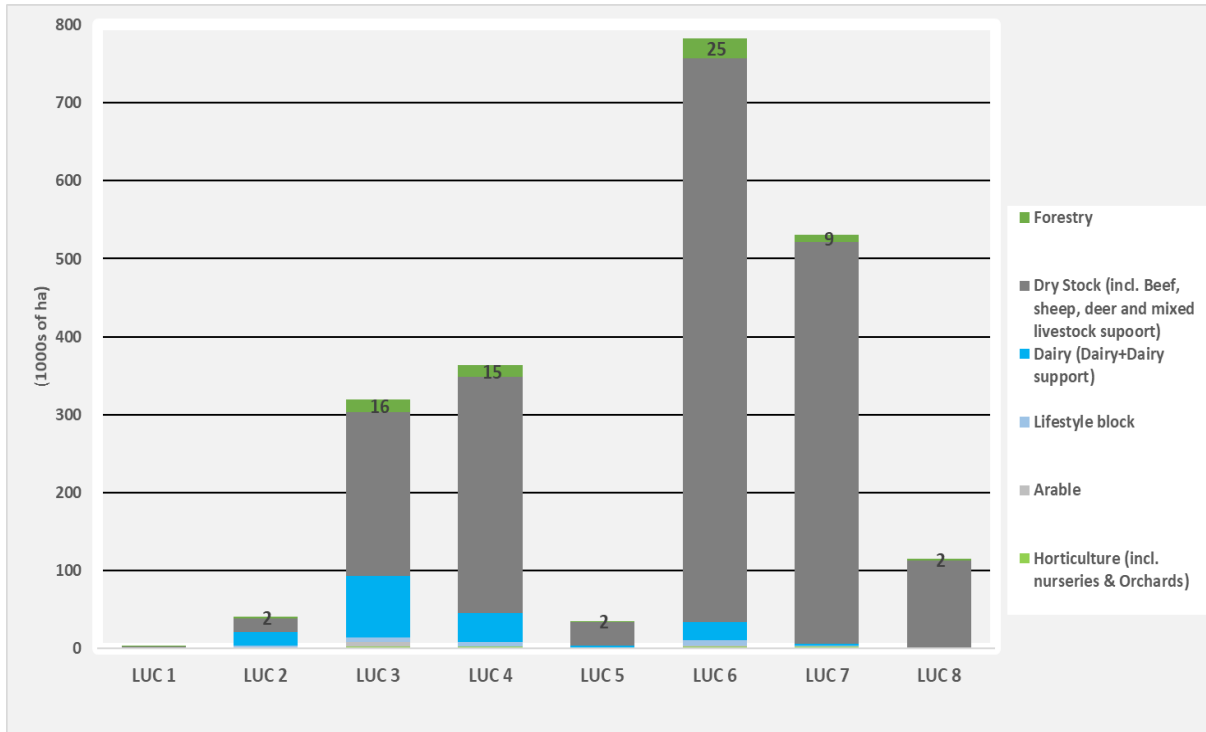


Figure 5. Otago land use classification area by selected land use type  
 Source: Data from Couldrey (2022)

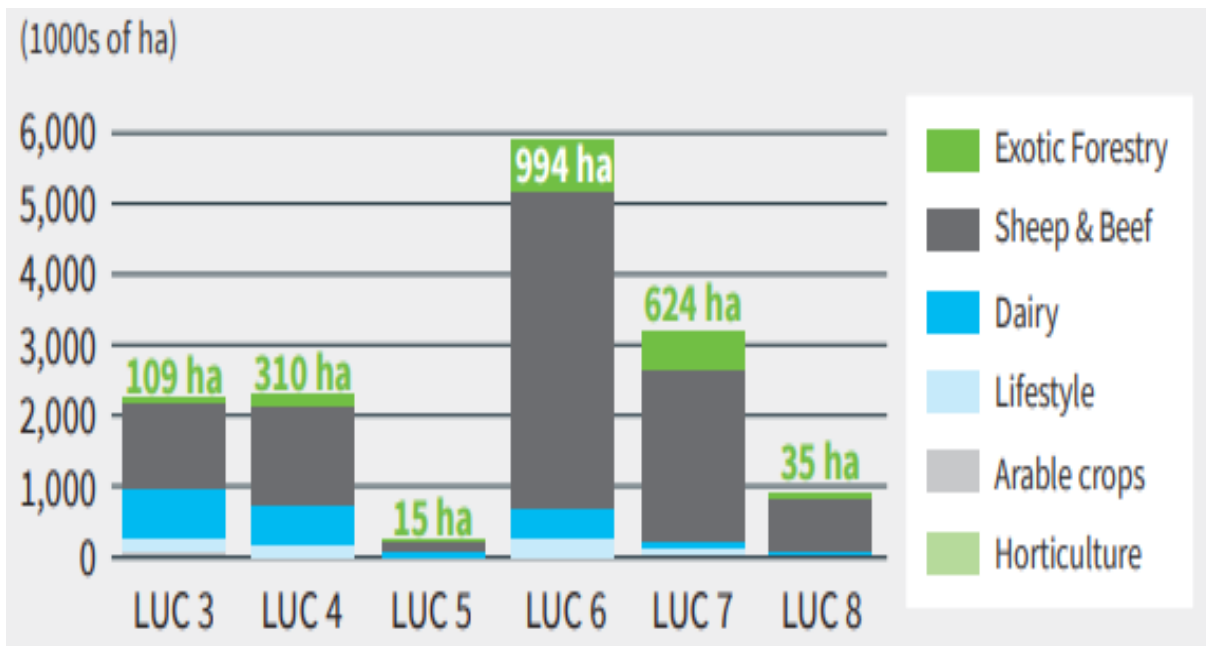


Figure 6. NZ land use classification area by selected land use type  
 Source: [https://www.nzfoa.org.nz/images/FGT\\_3704\\_Facts\\_and\\_Figures\\_202021\\_Web\\_FA1.pdf](https://www.nzfoa.org.nz/images/FGT_3704_Facts_and_Figures_202021_Web_FA1.pdf)

## 2.2 Water

Otago's lakes and rivers, wetlands, and estuaries are a prominent part of the region. Otago has many lakes of varying sizes, in total they make up to roughly 23% of New Zealand's lake surface area. While Lakes Whakatipu, Wānaka, and Hāwea are the three renowned lakes (in Queenstown Lakes District), Lakes Waipori and Waiholā (in Clutha District), Lake Hayes (in Central Otago); there are also constructed lakes Dunstan and Roxburgh and semi-constructed lake Onslow (all in Central Otago District) and many smaller lakes in the region.

Lakes Whakatipu, Wānaka, and Hāwea drain into Otago's Clutha River/Mata-Au, New Zealand's largest river by volume and second longest. The major rivers that feed into the Mata-Au include the Cardrona, Lindis, Shotover, Nevis, Fraser, Manuherikia, Teviot, Pomahaka, and Waiwera.

As well as providing for direct water use, the Clutha also accommodates two hydroelectric power stations<sup>9</sup>: the Clyde Dam and the Roxburgh Dam. The two power stations provide an estimated combined power supply of 865 MW to the New Zealand power grid. Most years, the Clutha power stations generate about 10% of New Zealand's gross electricity demand (Hunt, 2022). The Government is investigating options for a pumped hydro energy scheme at Lake Onslow<sup>10</sup> in Central Otago, and which is known as "Lake Onslow option"<sup>11</sup>.

The Taieri River catchment is another large catchment in the region. The Taieri River starts from the uplands of Central Otago and runs all the way across the Taieri Plain, where it joins Lake Waipori and Lake Waiholā then flows out to the sea at Taieri Mouth.

Some other examples of river catchments include the Pomahaka catchment, the Catlins, the Kakanui, Waianakarua, Shag and Waikouaiti Rivers in the northern part of the region, the Tokomairiro River drains between the Taieri and Clutha catchments.

Indeed, few places in Otago are very far from freshwater, including wetlands. Figure 7 the region's river network based on the River Environment Classification (REC), "a database of catchment spatial attributes, summarised for every segment in New Zealand's network of rivers." (NIWA, 2019). REC stream order 1 and 2 are streams with little upstream storage. Stream order 3 and 4 are tributaries. Stream order greater than 4 are main stems that have large upstream catchments with noticeable storage (Snelder *et al.*, 2010).

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<sup>9</sup> On the other hand, there are also concerns regarding the environmental and social impact of hydro dams in general, such as on water quality, Mahinga Kai, some fish species, food security, and greenhouse gas emissions. See for example, U.S. Energy Information Administration (2022), Fendt (2021), and NIWA (n.d.). The significance of these impacts do vary amongst the hydro schemes.

<sup>10</sup> This scheme "... could be anticipated to provide at least 5TWh of annual generation/storage. It is estimated to have a construction timeframe of 4-5 years, with commissioning and filling taking a further 2 years. At its construction peak, it is expected to create 3,500-4,500 skilled and semi-skilled jobs." <https://www.mbie.govt.nz/building-and-energy/energy-and-natural-resources/low-emissions-economy/nz-battery/lake-onslow-option/>

<sup>11</sup> <https://www.mbie.govt.nz/building-and-energy/energy-and-natural-resources/low-emissions-economy/nz-battery/lake-onslow-option/>

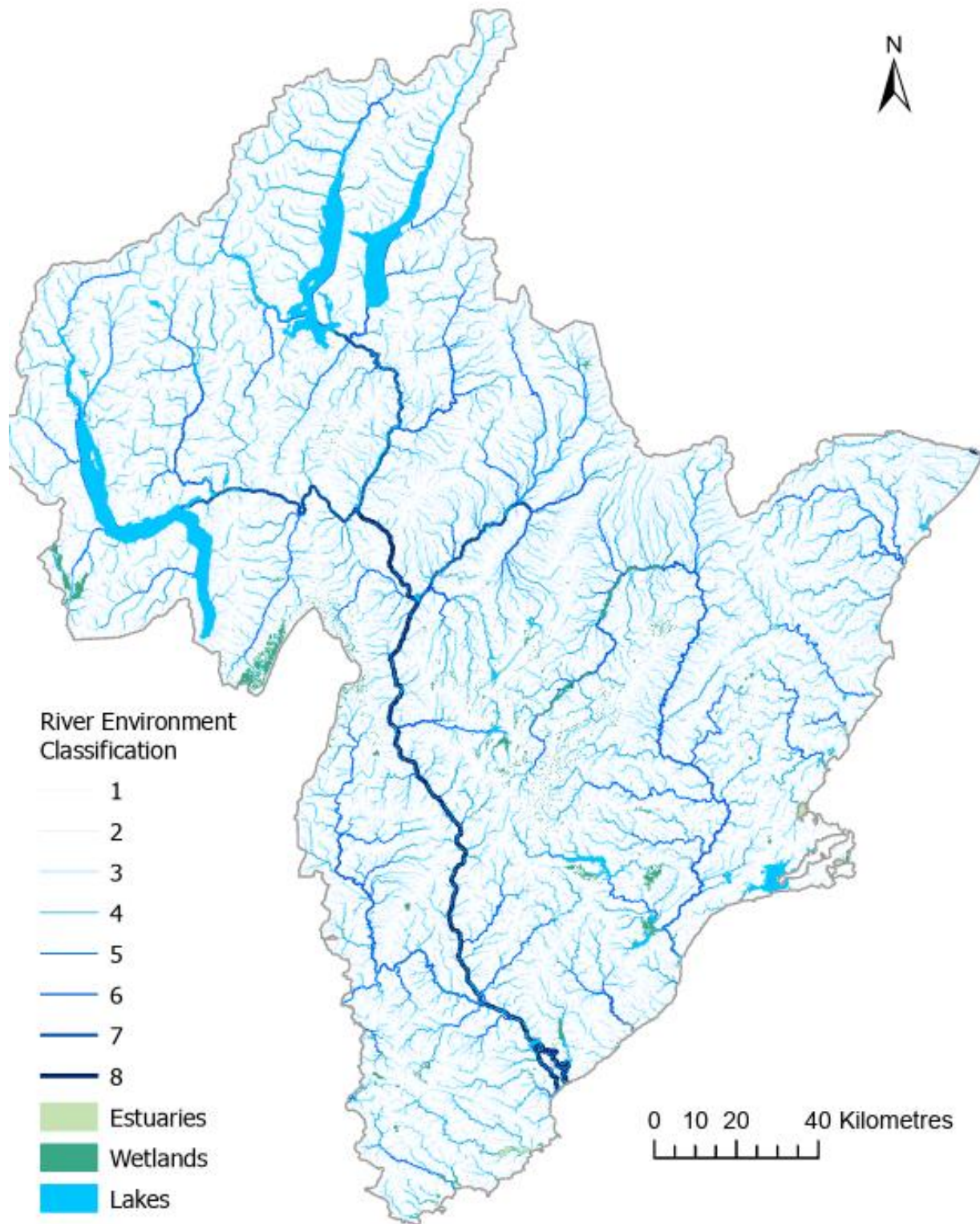


Figure 7. Otago's water systems  
 Source: NIWA River Environment Classification

The vital importance of freshwater is sometimes overlooked in New Zealand, perhaps partly because New Zealand is regarded as having a ‘low baseline water stress’ or is water-abundant according to Hofste *et al.* (2019). Apart from supporting all forms of life and ecosystem health, one of the many functions of water is to enable agriculture and forestry systems to provide food and fibre for human use. Agriculture and forestry systems may rely on natural hydrological and ecosystem processes to access water, or they may augment or alter these processes through irrigation and other technologies.

## 2.2.1 Irrigation

### 2.2.1.1 Overall

Figure 8 below provides a map of irrigated land in Otago and the types of irrigation used based on Aqualinc (2021)<sup>12</sup>. Most irrigation schemes are concentrated around North and Central Otago. The most common irrigation types in Otago are pivot (35%) and K-line/long lateral type (22%); they are followed by border dyke (9%) and wild flooding (7%). The remainder of irrigation types consist of gun, Roto Rainer, drip/micro, lateral, solid set, linear boom (10% all together) and unknown types (17%) (see Figure 8, which is based on Aqualinc (2021)<sup>13</sup>).

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<sup>12</sup> Note Aqualinc (2021) is based on a desktop update without field verification, engagement with irrigators, or scheme management or ORC staff other than to obtain input datasets. The authors recommended that before the dataset is used at a scheme or catchment scale there is a process of verifying the data to the level required for the intended purpose.

<sup>13</sup> Aqualinc (2021) used Aerial and satellite imagery method, which is likely to identify pivot irrigation type easier while border dyke/flood irrigation is challenging to discern using this method.

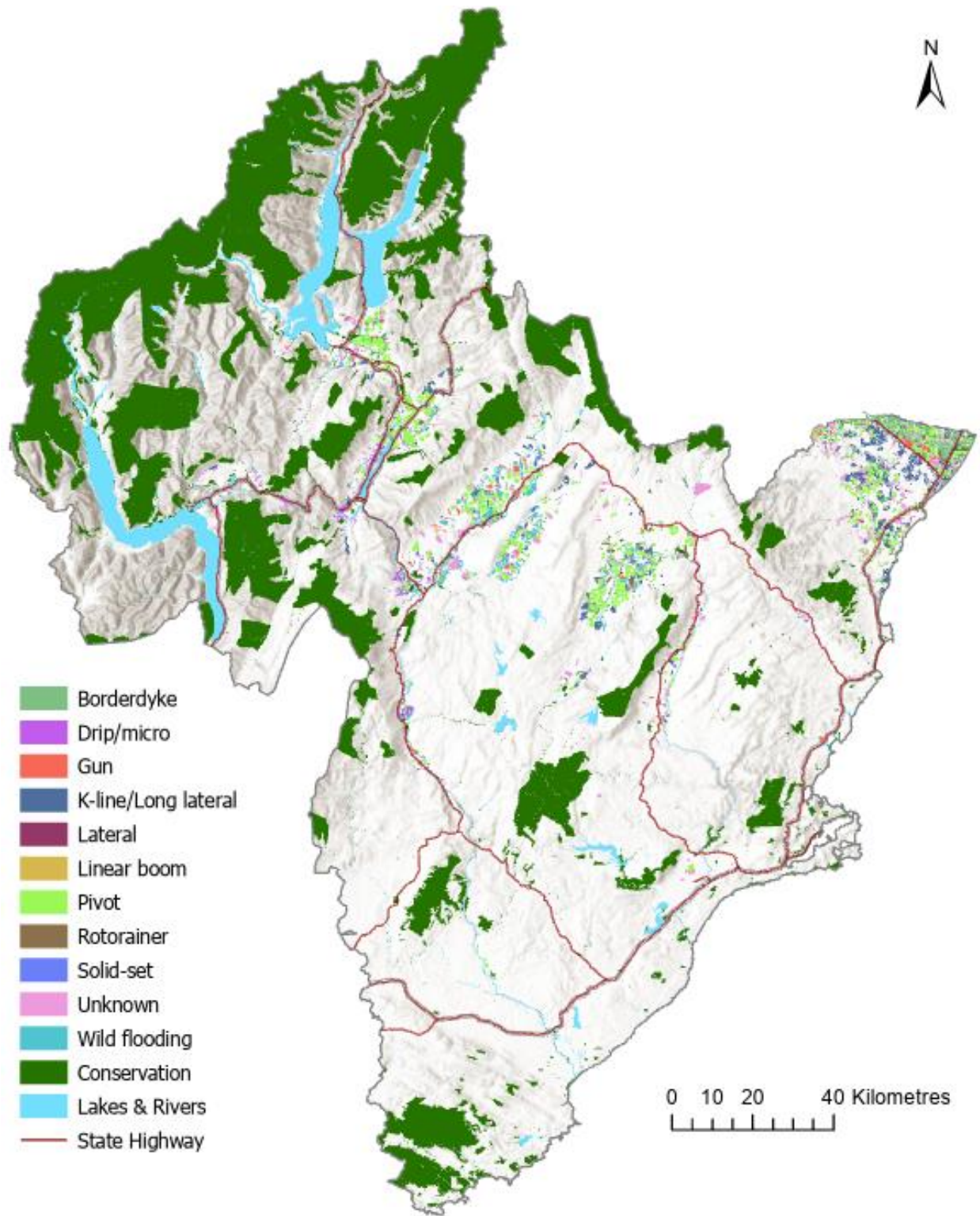


Figure 8. Otago irrigation map by irrigation type, 2021  
 Source: Aqualinc, 2021

### 2.2.1.2 By Land Use

The most common means of irrigation is by K-line, pivot, or Roto Rainers; all agriculture industries (except for horticulture and viticulture) have over half of the land irrigated by these methods. Horticulture (incl. nurseries and orchards) is by far the largest user of drip/micro irrigation (78%). Border dyke and wild flooding are less common but are still seen in all industries with varying intensity.

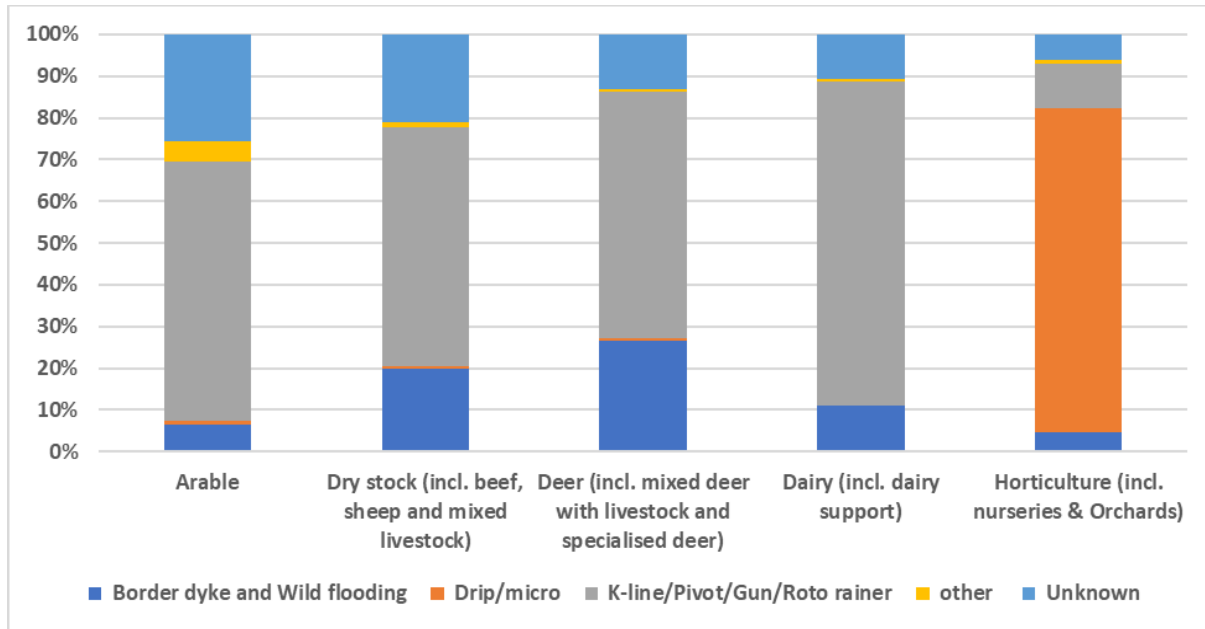


Figure 9. Otago share of irrigation type by selected land use type  
Source: Aqualinc, 2021 and Couldry, 2022

The reasonable irrigation water requirement estimation based on Aqualinc (2022)<sup>14</sup>, shown in Table 3<sup>15</sup>, highlights that different agriculture industries use irrigation differently. In terms of irrigation system application, irrigation on drystock farms is generally a small percentage of the total farm area - 3% for sheep and beef and 9% for deer farming. This is followed by dairy land use (25%), arable farming (31%), and horticulture (36%).

In terms of average water demand per hectare of irrigated land, horticulture uses around 4,500 m<sup>3</sup>/ha/annum. Deer farming uses 3,700 m<sup>3</sup>/ha/annum while sheep and beef farming and dairy

<sup>14</sup> ORC has engaged Aqualinc in 2022 to model reasonable irrigation water requirement by land use. The methodology used for the estimation can be found in <https://www.orc.govt.nz/media/4499/aqualinc-irrigation-guidelines-2015.pdf>.

<sup>15</sup> Aqualinc (2022) provided recommended seasonal volumes based on an average year; a one and two-year drought (80th percentile); a one in ten-year drought (90th percentile); and a maximum situation. Table 3 uses 'one in ten-year drought or 90th percentile', which is used in processing a water take application at the ORC.

farming uses around 2,800 m<sup>3</sup>/ha/annum<sup>16</sup>. A reasonable irrigation requirement value for arable land use could not be estimated due to this particular land use not being included in the Aqualinc (2022) report.

There are two points to note. First, irrigation water use does not represent the entire water use for these industries. It does not account for other water use on the farm such as stock drinking water or water used for shed washdown. It also does not capture discharges of contaminants (e.g., nutrients, and sediment). Secondly, the value gained from irrigation water use, measured by various metrics (e.g., employment, value-added, export revenue and number of people fed), is also not reflected.

Land use type	Total irrigated land (ha)	Total land use (ha)	Percentage of the land that is irrigated (%)	Irrigation Water demand (m3)	Average water demand per ha irrigated land (m3/ha)	Average water demand per ha total land use (m3/ha)
Arable	2,566	8,178	31	n/a*	n/a	n/a
Dry stock (incl. beef, sheep, and mixed livestock)	63,562	1,895,701	3.4	183,558,641	2,888	97
Deer (incl. mixed deer with livestock and specialised deer)	1,840	19,646	9.4	6,785,241	3,687	345
Dairy (incl. dairy support)	40,233	163,597	25	110,763,533	2,753	677
Horticulture (incl. nurseries & orchards)	4,033	11,091	36	18,136,266	4,497	1,635

\* A reasonable irrigation requirement value for arable land use was not included in the Aqualinc (2022) report.

Table 2. Estimated reasonable irrigation water use by land use type, 2022

Source: Data from Aqualinc, 2022

<sup>16</sup> Caution needs to be exercised when using the irrigation and water demand estimates in this section. Water demand is calculated as a product of irrigated area and reasonable annual water demand for the particular plant in particular area, which are both estimates.



### 3 Otago Residents in the five territorial authorities (TAs)

#### 3.1 The region's demography and income

Otago had an estimated resident population of 246,700 people (approx. 4.8% of New Zealand's population) in 2022<sup>17</sup>. Compared to the New Zealand average, the Otago Region had more people aged 65+ years and fewer aged under 14. The total dependency ratio in Otago (0.50) is currently lower than the New Zealand average (0.54). The ratio suggests that in Otago roughly 2 working-age (15-64-year-olds) people support one person of non-working age. However, this ratio is forecast to increase to roughly 0.6 by 2048, meaning 20 working-age people would be supporting 12 non-working age people (Table 3 below).

Table 3. Summary of Otago demographic stats  
Source: Stats NZ

People	Year	Otago	New Zealand
Population	2022	246,700	5,122,600
Share of population : 0 - 14 years		16%	19%
15 - 39 years		36%	34%
40 - 64 years		31%	31%
65 years +		18%	16%
Projected population growth 2018-2048		0.7%	0.9%
Dependency ratio*:	2022	0.50	0.54
	2048	0.61	0.62

\* The ratio between non-working age to the working-age population; the higher the ratio, the more the non-working age population compared to the working-age population.

Otago generated approximately \$15 billion of regional Gross Domestic Product (GDP) in 2022, which accounted for 4.2% of New Zealand's total GDP that year. In terms of labour force indicators, in 2022, Otago has a slightly lower labour participation rate (67%) than the New Zealand average (69%); Otago also has a lower unemployment rate (2.8%) than the New Zealand average (3.3%); the Youth NEET rate (15-24-year-olds Not in Education, Employment, or Training) in Otago is also lower (9%) than the New Zealand average (12%) (Table 4).

Otago's median annual household income (\$74,357) is below the national median (\$89,127). Despite the lower average house value, median disposable income after housing cost in Otago is also lower than the national median (Table 4).

<sup>17</sup> Stats NZ Subnational population estimates: at 30 June 2022 (provisional).

Table 4. Summary of Otago work and income stats  
Source: Stats NZ and REINZ<sup>18</sup>

Work and income stats	Date	Otago	New Zealand
GDP	2022	\$15,336m	\$361,299m
GDP per capita	2022	\$62,518	\$70,617
Total Employment	Jun-2022	137,700	2,821,000
Employment rate	Jun-2022	67%	69%
Unemployment rate	Jun-2022	2.8%	3.3%
Labour force participation rate	Jun-2022	69%	71%
NEET (15-24 year olds Not in Education, Employment, or Training) rate	Jun-2022	9.0%	12%
Median annual household income	2021	\$74,357	\$89,127
Average house value	Sep-2022	\$665,000	\$811,000
Median household equivalised disposable income after-housing-costs	2021	\$30,190	\$33,090

### 3.2 Otago's five TAs

There are five territorial authorities (TAs) in Otago: three coastal and two inland. The coastal TAs are Waitaki District, the northern most district in Otago that straddles both the Canterbury and Otago Regions; Dunedin City to the south of Waitaki, and Clutha District, the southernmost district in Otago. The two inland TAs are the Central Otago District and Queenstown Lakes District.

Just over half (130,400) of Otago's residents are based in Dunedin City; around 20% (49,500) of residents live in Queenstown Lakes District; and a further 27% of the population live in the Central Otago District, Clutha District and Waitaki District<sup>16</sup>.

<sup>18</sup> From various sources - Stats NZ, Regional gross domestic product: Year ended March 2022 (provisional); Stats NZ, Labour Force Status by Sex by Regional Council (Annual-Jun); Stats NZ, Youth NEET by Regional Council by Age (Annual-Jun); Stats NZ, Household income and housing-cost statistics: Year ended June 2021; and REINZ, <https://static1.squarespace.com/static/5ce1fd700bf20400017d3a30/t/6345c95988825d7a829d09d9/1665517942100/REINZ+Monthly+Property+Report+-+September+2022.pdf>

The map (Figure 10) below provides a map of Otago’s five TAs, the major lakes and rivers, major townships<sup>19</sup>, as well as showing indications of the level of deprivation in these communities through the University of Otago’s New Zealand Deprivation Index. The index estimates the relative socio-economic deprivation of an area. The current version of the index is derived from the 2018 Census and combines census data relating to income, home ownership, employment, qualifications, family structure, housing, access to transport and communications, and access to internet. In the Deprivation Index, decile 1 represents areas with the least deprived scores while decile 10 represents areas with the most deprived scores.

The map shows that most Otago communities are located around the lakes and rivers throughout the region. And in general, inland Otago has lower deprivation scores (is less deprived of necessities) compared to coastal Otago. Furthermore, rural areas have lower deprivation scores compared to town centres<sup>20</sup>.

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<sup>19</sup> Based on stats NZ population grid based on population estimates for 2018 for Statistical Area 1.

<sup>20</sup> More detailed information on the deprivation scores at a finer scale can be found in ORC’s area economic snapshots; links to the snapshots are listed in the reference page of this report (Yang, Y., 2022a-f).

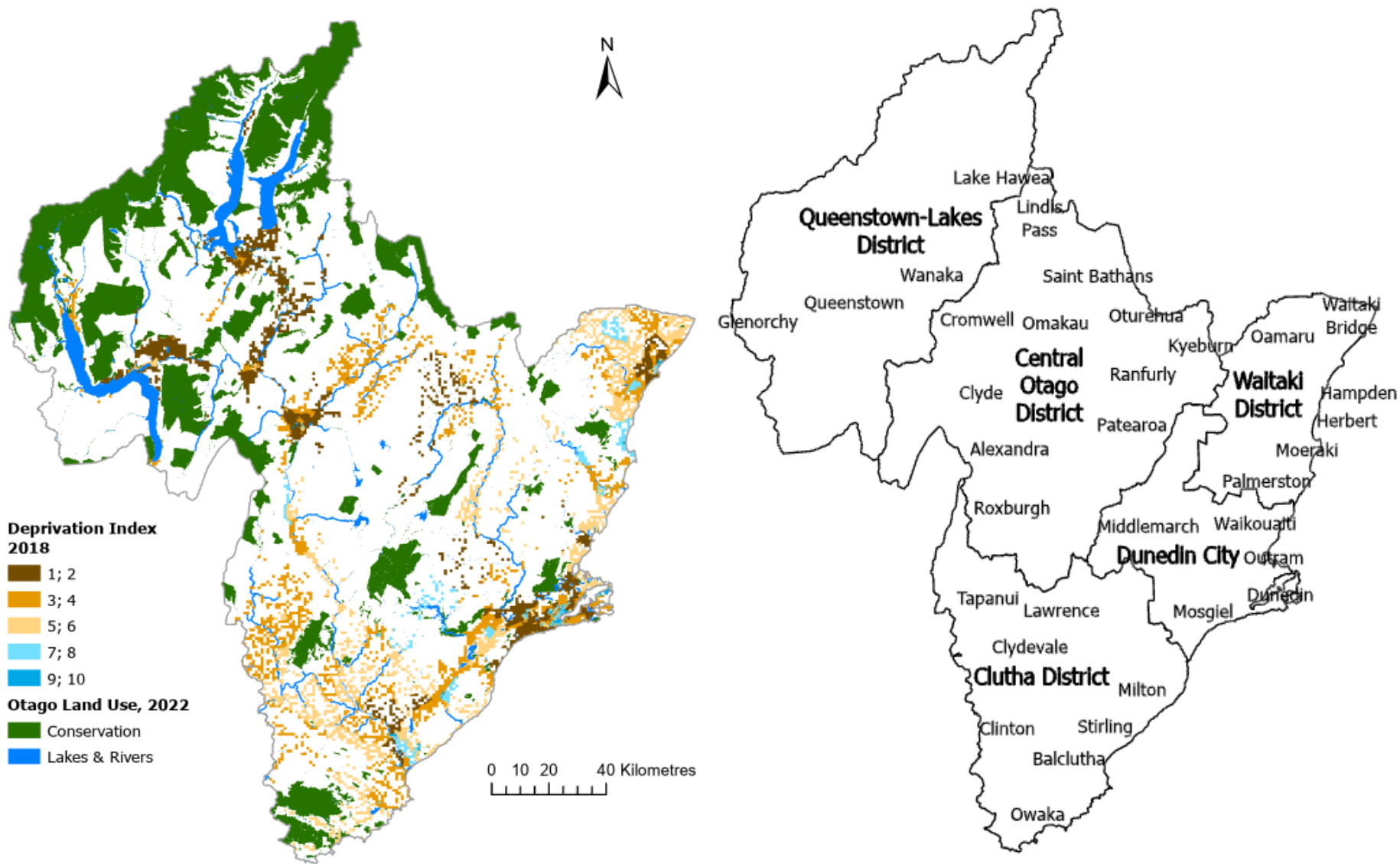


Figure 10. Map of Otago TAs, townships, and level of deprivation in the communities

**Queenstown Lakes District** (2022 estimated population 49,500<sup>17</sup>), the most inland district in Otago, is known for its beautiful scenery; it has nearly half of Otago's lakes/ivers and conservation estate and the lowest proportion of rural land use amongst all TAs in Otago (43%). The three most populous towns in the district, Queenstown, Wānaka and Lake Hāwea, are located on the foreshores of three renowned lakes: Lake Whakatipu, Lake Wānaka, and Lake Hāwea, respectively. The natural scenery has made Queenstown Lakes a popular tourist destination for both domestic and international visitors.

The district experienced substantial population growth pre-COVID, adding around 5,000 people (including 4,200 more people from net migration) from July 2018 to June 2020<sup>21</sup>. This equated to 8.9% of the district's population and is also the highest percentage increase of any TA in New Zealand over that period. This growth trend is expected to continue, with 1.6% annual average population growth (i.e., the second highest annual growth rate in the country) projected out to 2048<sup>22</sup>.

Queenstown Lakes' residents are, overall, more affluent; more areas in this district have relatively low levels of deprivation compared to the rest of the region (Figure 10 above<sup>23</sup>). There are some district level variances. For example, Queenstown Central areas have the highest deprivation scores of between 6 and 8; Queenstown East areas have deprivation scores between 2 and 6; most areas in Wānaka have a deprivation score of 4 and under; and the deprivation scores for most areas in Arrowtown are 3 and below.

Population increase, both from residents and visitors, in the district has brought with it economic growth, as well as challenges. There has been increasing pressure on natural resources and infrastructure, such as drinking water demand and wastewater treatment, requirements for more land for residential and commercial buildings, as well as increasingly unaffordable housing.

**Central Otago District** (2022 population 25,500<sup>17</sup>) Queenstown Lakes' neighbour to the east, is well-known for its outdoor activities (e.g., biking, hiking, and camping), as well as Pick Your Own fruit in the orchards and winery tours in the vineyards. The major towns in the district are Alexandra, Cromwell, Roxburgh, Clyde and Ranfurly. Like Queenstown Lakes, Central Otago also had a rapidly increasing population pre-COVID, adding 8.3% more residents (or around 2,000 people) between July 2018 and June 2020. Around 1.2% population growth is projected per annum between 2018 and 2048 in the district, the fourth highest growth rate amongst all the TAs in New Zealand<sup>22</sup>.

There are some variations in community deprivation levels. The rural communities in Central Otago generally have a deprivation score of 4 and above. The larger townships in the district, such as Cromwell, Clyde, and Roxburgh, have varying deprivation scores between 1 and 7.

There are two challenges facing Central Otago. First, population aging. Although population growth is projected out to 2048, the projected increase of the senior population (65+) is much faster than the younger population. The dependency ratio of Central Otago is estimated to grow from 0.63 in 2022 to 0.85 in 2048.

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<sup>21</sup> Stats NZ Subnational population estimates: at 30 June 2021.

<sup>22</sup> Stats NZ Subnational population projections: 2018 (base) – 2048; medium level population growth is used.

<sup>23</sup> More socio-economic details of the district can be found in ORC's area economic snap shots; links to the snapshots are listed in the reference page of this report (Yang, Y., 2022a-f).

Secondly, the drier climate and the effects of climate change provide less certainty to the water supply, including for rural activities. Careful management of land and water resource might be especially challenging and essential given that the district produces the majority of Otago Region's fruit and wine grapes and the majority of the country's stone fruit.

**Dunedin City** (2022 population 130,400 or a little over half of Otago's population<sup>17</sup> is the administrative centre of Otago; it is the second largest city in the South Island after Christchurch. Population growth in Dunedin was the slowest in the region at 1.2% between July 2018 and June 2020<sup>21</sup> lower than the national average of 1.9% over that period. Slower population growth is also projected, with an average annual rate of 0.3% between 2018 and 2048, well below the national average of 0.8%<sup>22</sup>.

In terms of the level of deprivation in the community, in the Dunedin City area, the closer an area is to the Octagon the higher the deprivation score. Similarly, the data for the Mosgiel area (including Allanton, Brighton, Outram and Wingatui) shows that neighbourhoods closer to the centre of Mosgiel generally have higher deprivation scores. Most areas on the Otago Peninsula have deprivation scores under 5 with pockets of areas scoring above 7. The towns, including Middlemarch, Waikouaiti, Karitane, Waihola and Milton generally received high deprivation scores, of 7 and above, except for Karitane, which scored 2.

Dunedin City's population growth has been slow and the residential population during school and university terms is inflated by the transient tertiary student population. Furthermore, aging infrastructure and housing stock (especially in the city centre) hinders the standard of living.

**Waitaki** (2022 population 24,000<sup>17,24</sup>) to the north of Dunedin is the only district in the South Island that crosses regional boundaries – the south-east side of the district is part of the Otago Region while the north-west side is in the Canterbury Region. Oamaru is the main town in Waitaki District, where visitors are attracted to the architecture of the Victorian Precinct, built using locally quarried limestone. Population growth in Waitaki (1.7% between 2018 and 2020<sup>21</sup> has been lower than the national average of 1.9%; and a slower population growth than the national average is projected at an average annual rate of 0.3% between 2018 and 2048<sup>22</sup>.

Some parts of Waitaki District have high deprivation scores. Oamaru has more areas with deprivation scores between 10 and 6 than between 5 and 1. The area with the lowest deprivation score in Waitaki is around the outskirts of Oamaru, especially around Weston. Hampden, Kakanui, and Palmerston all have deprivation scores between 10 and 6.

**Clutha District** (2022 population 18,650<sup>17</sup>, the southernmost district in Otago, is well known amongst Otago locals for its unique scenery. Balclutha is the administrative centre of the district; the major towns and settlements are focal points for the surrounding local communities. These include Milton, Kaka Point, Owaka, Pounawea and Lawrence. The Catlins (located in the southern part of the district) is a popular short holiday destination for Otago residents.

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<sup>24</sup> This is the total population of the Waitaki District. The area in Canterbury region (Aviemore, inland water Lake Ohau, and Dansey's Pass) has a population of around 1,800 people in 2018 and is projected to grow to around 2,000 people by 2048.

Population growth in Clutha (1.1%) between 2018 and 2020 was lower than the national average of 1.9%<sup>21</sup> and very little population growth is projected, at an average annual rate of 0.1% between 2018 and 2048<sup>22</sup>.

There are higher deprivation scores in a large part of the district. Owaka has a deprivation score of 8. Balclutha, Lawrence, Kaitangata, and Clinton have higher deprivation scores – between 6 and 10. Tapanui and Benhar-Stirling have mid-range deprivation scores – between 3 and 7. Kaka Point and Pounawera are the two main townships that have lower scores – of 5 and 3 respectively.

Both Waitaki District and Clutha District have similar challenges. First, both districts are experiencing low population growth/stagnation as well as population aging. Furthermore, both districts focus heavily on rural businesses and manufacturing, which have higher impact on the environment. Last, there are more communities that are more deprived of necessities compared to other TAs in the region.

## 4 Economic summary of the Otago Region

This section provides an overview of the Otago Regional economy, structured around profiles of key economic sectors. The term ‘sector’ is used here to refer to a grouping of economic industries as defined in the Australian and New Zealand Standard Industrial Classification (ANZSIC), 2006 (Revision 2.0) - see glossary. The report also includes a section describing the dependence of the Otago economy on imported goods and services.

Sectors focused on within this economic summary were chosen based on their strong dependence on water supply as a critical input, their high specialisation within Otago and/or a territorial authority, or their significant contribution to the region’s international export earnings.

Key sectors examined are (1) agriculture (including horticulture and viticulture)<sup>25</sup> and forestry, (2) metal ore and non-metallic mineral mining, (3) agricultural product processing, (4) electricity generation and on-selling, (5) construction, and (6) tourism-related industries. The tourism-related industries sector (6) consists of industries that all have a high level of international export sales to visiting consumers, i.e., tourists. For example, accommodation, food and beverage services, air and space transport, travel agency and tour arrangement services, and sports and recreation services. The proportion of these types of industries that serve international visitors rather than local populations varies between territorial authorities. In addition, this section also includes tertiary education and health care services as additional sectors of interest in Otago.

The ordering of the sectors in this economic summary is based on the level of economic activity of each sector, measured in terms of gross output, with the sector producing the highest regional gross output described first. For clarity, we also include a list (see Appendix A) of specific industries from the ANZSIC 2006 system that appear within the discussion of each sector.

All employment estimates provided in the economic summary below use the Modified Employment Count (MEC) measure, which is described in the Glossary.

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<sup>25</sup> Horticulture and viticulture are subdivisions under the Agriculture division in the ANZSIC06 classification system.

The value added and trade information provided in this economic summary, and in Section 5, are sourced from regional and sub-regional input-output accounts. Further information on the derivation of the input-output accounts is provided in Appendix B.

Exports include goods that are transported abroad for consumption overseas, as well as goods and services that are consumed in New Zealand by foreign tourists. Exports are important to an economic system as they are a source of demand for goods and services over and above that demanded by local industries and population. They also generate foreign earnings which ensure that, in turn, New Zealanders can purchase goods and services from abroad.

Employment and other economic data in this and the following section is provided for 2020. Again, this is due to the information being derived from the regional and sub-regional input-output accounts, which in turn are based on the latest available national input-output table from Statistics New Zealand for the year ending March 2020. Besides matching to the input-output tables, by using 2020 information (rather than say statistics that may be available for 2021), we avoid using data that is for an economy significantly disrupted by the international COVID-19 pandemic and not reflective of more long-term trends.

Before looking at specific sectors in the following subsections, Table 5 presents a summary of the key sectors for the entire Otago Region. Collectively the key sectors account for 55% of gross output, 44% of value added, 79% of all export income (“Export share” as labelled in Table 5 and subsequent tables represents an industry’s contribution to the Otago Region’s total export earnings), and 48% of employment.

*Table 5. Economic profile of key sectors in the Otago Region*

<b>Industry</b>	<b>Gross output</b>	<b>Value added</b>	<b>Export share</b>	<b>Employment 2020 (MECs)</b>	<b>Employment 2011 (MECs)</b>
Construction	\$4,300m	\$1,300m	0.5%	14,000	9,500
Agriculture	\$2,500m	\$1,100m	9.8%	12,000	12,000
Tourism-related industries	\$2,200m	\$1,000m	19%	19,000	14,000
Agricultural product processing and manufacturing	\$2,100m	\$420m	38%	5,200	5,200
Electricity generation and on-selling	\$1,600m	\$440m	0.2%	350	300
Healthcare services	\$1,100m	\$680m	0.4%	8,800	7,000
Tertiary education	\$700m	\$500m	4.9%	5,000	5,300
Metal ore and non-metallic mineral mining	\$540m	\$290m	6.2%	740	570
Other	\$13,000m	\$7,400m	21%	70,000	59,000
<b>Total</b>	<b>\$28,000m</b>	<b>\$13,000m</b>	<b>100%</b>	<b>140,000</b>	<b>110,000</b>

Note: Totals may not add due to rounding

The following subsections provide further information on the individual industries that make up each sector, as well as information and statistics specific to Otago region’s territorial authorities. These statistics highlight each territorial authority’s specialties. As a broad overview, Waitaki and Clutha



Districts are highly specialised in drystock and dairy cattle farming, food manufacturing, and plantation forestry. Central Otago District has a focus on horticulture and fruit growing. Queenstown Lakes District has a highly developed tourism sector; while Dunedin City has large tertiary education and healthcare industries.

The majority of these industries cannot be sustained or developed without the use of land and water resources. Section 2 of this report provides some insight into the land and water use of primary industries. Agriculture, horticulture, and forestry utilise large quantities of land for production and depend on services provided by terrestrial and freshwater systems for waste removal. The sector also has high 'consumptive use' of water not only because water is incorporated into products and crops, but also because agriculture and forestry systems enhance evaporation and transpiration thereby withdrawing water from freshwater and surface water systems.

Other sectors such as mining, construction, and tourism, are all also reliant on land and water use in various ways. Mining depends on the presence of mineral deposits and water for various processing steps, while the tourism-related industries and construction sector are driven by demands from international and domestic visitors and new residents, many of whom are drawn to the magnificent landscapes in the area and opportunities for recreation, including within and around lakes and rivers.

#### 4.1 Construction

Over the period 2011 to 2020, parts of the Otago Region have greatly increased in popularity as lifestyle living destinations, including to New Zealanders from outside the Otago Region and overseas immigrants and investors. The region's population has increased significantly, especially in proportion to its 2013 population. Census figures for 2013 and 2018 count population growing from 168,000 to 188,000 with a net immigration of 25,800 people. In large part to meet the corresponding demand for housing, the construction sector has also greatly increased in size from 9,500 MECs to 14,000 MECs, a 50% increase (Table 6). To accommodate population growth, not only do residential buildings need to be constructed, but also infrastructure and commercial and industrial buildings to accommodate the provision of services (retail, food, health care, schools, etc.). The growth in the construction sector is also due to the growth in the tourism sector as described in the following section.

Table 6. Economic profile of the construction sector in the Otago Region

Industry	Gross output	Value added	Export share	Location quotient	Employment 2020 (MECs)	Employment 2011 (MECs)
Residential building construction	\$1,300m	\$280m	0.0%	1.1	3,300	2,000
Non-residential building construction	\$590m	\$85m	0.1%	1.3	950	690
Heavy and civil engineering construction	\$990m	\$330m	0.0%	1.3	2,600	1,700
Construction services	\$1,400m	\$590m	0.4%	1.0	7,400	5,200
<b>Total</b>	<b>\$4,300m</b>	<b>\$1,300m</b>	<b>0.5%</b>	<b>-</b>	<b>14,000</b>	<b>9,500</b>

The Central Otago District experienced the third largest population growth of across all TAs in New Zealand in percentage terms (22%) between the 2013 and 2018 censuses. The size of the construction sector reflects this population growth with 1,900 MECs of employment, \$590 million in gross output, \$180 million value added and relatively high location quotients for construction industries (Table 7).

Table 7. Economic profile of the construction sector in Central Otago District

Industry	Gross output	Value added	Location quotient	Employment 2020 (MECs)	Employment 2011 (MECs)
Residential building construction	\$150m	\$33m	1.1	390	290
Non-residential building construction	\$78m	\$11m	1.5	130	82
Heavy and civil engineering construction	\$190m	\$64m	2.1	510	510
Construction services	\$160m	\$67m	1.0	850	520
<b>Total</b>	<b>\$590m</b>	<b>\$180m</b>	<b>-</b>	<b>1,900</b>	<b>1,400</b>

Population growth has been even higher in Queenstown Lakes District, with the TA experiencing the largest percentage change in population growth of any TA in New Zealand. Again, the construction sector (and its constituent industries) reflects this population growth with employment increasing in size from 2,400 MECs in 2011 to 4,800 MECs in 2020, a 100% increase (Table 8). Out of the 109 industries used to classify the economy (i.e., of all industries as defined by the *SNZ input-output (IO) table industry name* categories in Table A1), residential building construction is the district's largest industry by gross output (\$590 million) with a location quotient of 2.1. This location quotient means that the residential construction industry's share of employment in Queenstown Lakes District (4.59%) is 2.1 greater than residential construction industry's share of employment nationally (2.22%). Construction services is the second largest industry (\$550 million gross output) in the district, with a location quotient of 1.4.

Table 8. Economic profile of the construction sector in Queenstown Lakes District

Industry	Gross output	Value added	Location quotient	Employment 2020 (MECs)	Employment 2011 (MECs)
Residential building construction	\$590m	\$130m	2.1	1,500	700
Non-residential building construction	\$160m	\$23m	1.5	260	98
Heavy and civil engineering construction	\$130m	\$43m	0.7	370	130
Construction services	\$550m	\$230m	1.4	2,600	1,400
<b>Total</b>	<b>\$1,400m</b>	<b>\$420m</b>	<b>-</b>	<b>4,800</b>	<b>2,400</b>

The construction sector in Dunedin City is notable as it contains two of the City's largest industries, heavy and civil engineering construction (fifth largest), and construction services (fourth largest).

Construction services is the largest by gross output (\$590m) and value added (\$240m). The sector employs a large number of people, 6,000 MECs in 2020 which grew from 4,400 MECs in 2011 (Table 9).

Table 9. Economic profile of the construction sector in Dunedin City

Industry	Gross output	Value added	Location quotient	Employment 2020 (MECs)	Employment 2011 (MECs)
Residential building construction	\$450m	\$99m	0.8	1,200	750
Non-residential building construction	\$170m	\$24m	0.8	270	360
Heavy and civil engineering construction	\$530m	\$180m	1.4	1,400	720
Construction services	\$590m	\$240m	0.9	3,100	2,500
<b>Total</b>	<b>\$1,700m</b>	<b>\$540m</b>	<b>-</b>	<b>6,000</b>	<b>4,400</b>

## 4.2 Agriculture and forestry

Agriculture (including Horticulture and Viticulture) and Forestry play an important role in the Otago economy. As a sector it accounts for employment of 12,000 MECs and gross output of \$2.5 billion, \$1.1 billion value added, and 9.8% of the region's international export revenue (Table 10).

Table 10. Economic profile of the agriculture, horticulture, and forestry sector in the Otago Region

Industry	Gross output	Value added	Export share <sup>1</sup>	Location quotient	Employment 2020 (MECs)	Employment 2011 (MECs)
Horticulture and fruit growing	\$150m	\$62m	1.9%	1.6	3,000	2,500
Sheep, beef cattle, and grain farming	\$1,200m	\$530m	2.2%	2.2	3,700	4,100
Dairy cattle farming	\$410m	\$200m	0.1%	1.0	2,000	1,900
Poultry, deer, and other livestock farming	\$120m	\$39m	1.2%	1.0	440	470
Forestry and logging	\$270m	\$81m	3.6%	1.0	330	340
Fishing and aquaculture	\$49m	\$18m	0.6%	0.5	120	150
Agriculture, forestry, and fishing support services	\$290m	\$130m	0.2%	1.3	2,500	2,200
<b>Total</b>	<b>\$2,500m</b>	<b>\$1,100m</b>	<b>9.8%</b>	<b>-</b>	<b>12,000</b>	<b>12,000</b>

<sup>1</sup> Note that exports only consider finished products. For example, dairy cattle farming has a low value of exports because the industry mainly produces raw milk and cattle, both of which undergo further processing to new products before export.

Within the Otago Region’s agricultural sector, sheep, beef cattle, and grain farming is the largest industry with \$1,200 million in gross output and \$530 million in value added and is particularly regionally significant with a location quotient of 2.2. Horticulture and fruit growing<sup>26</sup> is also a regional specialty with a location quotient of 1.6. Dairy cattle farming, poultry, deer and other livestock farming, and forestry and logging also contribute large amounts, but with more concentration in particular TAs as described in Tables 11, 12, and 13 below.

The bulk of Otago’s horticulture and fruit growing industry sits within the Central Otago District with 2,600 MECs of employment, \$110 million in gross output, and \$47 million in value added. This sector is estimated to export 59% of its produce overseas. Sheep, beef cattle, and grain farming is the second largest of all Central Otago District’s 109 industries with \$250 million in gross output, and \$110 million in value added. This industry is estimated to export 17% of its output to other TAs within the Otago Region, and 37% to the Canterbury Region mainly for processing. The ‘Other’ category groups together all other industries within the TA and sector in question.

Table 11. Economic profile of the agriculture and horticulture sector in Central Otago District

Industry	Gross output	Value added	Location quotient	Employment 2020 (MECs)	Employment 2011 (MECs)
Horticulture and fruit growing	\$110m	\$47m	12	2,600	1,800
Sheep, beef cattle, and grain farming	\$250m	\$110m	3.8	750	630
Poultry, deer, and other livestock farming	\$17m	\$6m	1.3	68	100
Agriculture, forestry, and fishing support services	\$130m	\$59m	5.5	1,200	1,000
Other	\$58m	\$21m	-	120	130
<b>Total</b>	<b>\$560m</b>	<b>\$240m</b>	<b>-</b>	<b>4,700</b>	<b>3,700</b>

Sheep, beef cattle, and grain farming, dairy cattle farming and poultry, deer, and other livestock farming are of particular regional importance to the Waitaki District with location quotients of 3.4, 4.2, and 2.3, respectively (Table 12). Sheep, beef cattle, and grain farming and dairy cattle farming are the Waitaki District’s fourth and sixth largest of all industries by gross output, respectively. The sheep, beef cattle, and grain farming industry is estimated to export 53% of its output to the Canterbury Region.

<sup>26</sup> Horticulture and fruit growing consists of the following industries at the ANZSIC 6 digit level: Nursery production (under cover), Nursery production (outdoors), Turf growing, Floriculture production (under cover), Floriculture production (outdoors), Mushroom growing, Vegetable growing (under cover), Vegetable growing (outdoors), Grape growing, Kiwifruit growing, Berry fruit growing, Apple and pear growing, Stone fruit growing, Citrus fruit growing, Olive growing, Other fruit and tree nut growing.

Table 12. Economic profile of the agriculture and horticulture sector in Waitaki District

Industry	Gross output	Value added	Location quotient	Employment 2020 (MECs)	Employment 2011 (MECs)
Sheep, beef cattle, and grain farming	\$170m	\$70m	3.4	450	540
Dairy cattle farming	\$130m	\$64m	4.2	620	560
Poultry, deer, and other livestock farming	\$24m	\$8m	2.3	80	90
Forestry and logging	\$44m	\$13m	1.1	27	12
Agriculture, forestry, and fishing support services	\$25m	\$11m	1.3	190	160
Other	\$17m	\$7m	-	120	160
<b>Total</b>	<b>\$410m</b>	<b>\$170m</b>	<b>-</b>	<b>1,500</b>	<b>1,500</b>

The agriculture sector in the Clutha District accounts for 3,600 MECs of employment, \$980 million gross output, and \$420 million value added. Sheep, beef cattle, and grain farming, dairy cattle farming, and forestry and logging all have significantly high location quotients (14, 6.5, and 7.2 respectively). Sheep, beef cattle, and grain farming is the second largest of all industries in the district with 1,800 MECs and \$580 million gross output (Table 13). Six percent of this industry's output is estimated to be exported to other Otago TAs with a further 50% going to the Canterbury Region. Dairy cattle farming is the area's fourth largest industry overall, with 931 MECs and \$200 million gross output. Ninety-three percent of dairy cattle farming output is estimated to be exported to the Southland Region. Forestry and logging is the seventh largest industry in the Clutha District, with 180 MECs and \$120 million gross output.

Table 13. Economic profile of the agriculture and horticulture sector in Clutha District

Industry	Gross output	Value added	Location quotient	Employment 2020 (MECs)	Employment 2011 (MECs)
Sheep, beef cattle, and grain farming	\$580m	\$250m	14	1,800	2,100
Dairy cattle farming	\$200m	\$97m	6.5	930	1,000
Forestry and logging	\$120m	\$35m	7.2	180	190
Agriculture, forestry, and fishing support services	\$67m	\$31m	4.6	660	590
Other	\$13m	\$4m	-	60	250
<b>Total</b>	<b>\$980m</b>	<b>\$420m</b>	<b>-</b>	<b>3,600</b>	<b>4,200</b>

### 4.3 Tourism-related industries

The Otago Region increased significantly as a tourist destination between 2011 and 2020 with significant growth in the number of people employed in tourism-related industries. As explained at the beginning of Section 4, the industries considered collectively as tourism-related industries are accommodation, food and beverage services, air and space transport, travel agency and tour arrangement services, and sports and recreation services. These service industries that derive a significant portion of their income

from outside the region via interregional and international exports (i.e., tourism) together account for 19,000 MECs of employment, \$2.2 billion in gross output and \$1.0 billion in value added (Table 14). Altogether, the tourism-related industries accounted for 19% of the region's international exports. Roughly one third (31%) of the sector's outputs are consumed locally, another third (34%) by visitors from other regions of New Zealand, and the remaining third (34%) by visitors from overseas.

Table 14. Economic profile of tourism-related industries in the Otago Region

Industry	Gross output	Value added	Export share	Location quotient	Employment 2020 (MECs)	Employment 2011 (MECs)
Accommodation	\$830m	\$420m	9.9%	3.7	6,000	4,600
Food and beverage services	\$820m	\$370m	5.0%	1.2	9,200	6,800
Air and space transport	\$150m	\$44m	1.7%	0.8	320	170
Travel agency and tour arrangement services	\$120m	\$64m	1.1%	4.1	1,100	590
Sport and recreation services	\$330m	\$130m	1.0%	1.6	2,600	2,000
<b>Total</b>	<b>\$2,200m</b>	<b>\$1,000m</b>	<b>19%</b>	<b>-</b>	<b>19,000</b>	<b>14,000</b>

Many of the largest industries in Queenstown Lakes District are those associated with tourism. Accommodation, food and beverage services, air and space transport, travel agency and tour management services, and sport and recreation services all have relatively high location quotients. The five industries presented in Table 15 account for employment of 10,000 MECs of which approximately 6,600 MECs can be attributed to visitors from outside of the Queenstown Lakes District.

Table 15. Economic profile of tourism-related industries in Queenstown Lakes District

Industry	Gross output	Value added	Location quotient	Employment 2020 (MECs)	Employment 2011 (MECs)
Accommodation	\$530m	\$270m	9.8	3,900	2,600
Food and beverage services	\$350m	\$160m	2.2	3,900	2,400
Air and space transport	\$110m	\$30m	2.5	230	110
Travel agency and tour arrangement services	\$94m	\$49m	13	840	360
Sport and recreation services	\$180m	\$70m	4.0	1,600	1,000
<b>Total</b>	<b>\$1,300m</b>	<b>\$580m</b>	<b>-</b>	<b>10,000</b>	<b>6,500</b>

Dunedin City also has relatively large tourism-related industries (Table 16).

Table 16. Economic profile of tourism-related industries in Dunedin City

Industry	Gross output	Value added	Location quotient	Employment 2020 (MECs)	Employment 2011 (MECs)
Accommodation	\$200m	\$100m	1.9	1,500	1,500
Food and beverage services	\$330m	\$150m	1.0	3,700	3,100
Air and space transport	\$41m	\$12m	0.5	90	52
Travel agency and tour arrangement services	\$19m	\$10m	1.3	170	150
Sport and recreation services	\$110m	\$42m	1.0	750	740
<b>Total</b>	<b>\$700m</b>	<b>\$320m</b>	<b>-</b>	<b>6,200</b>	<b>5,500</b>

#### 4.4 Agricultural product processing and manufacturing

Agricultural product processing is perhaps the region's most important sector in terms of international exports, accounting for 38% of the region's exports, and this occurs despite dairy product processing having a relatively low location quotient of 0.5 (Table 17). The sector is estimated to earn \$420 million in value added and employ 5,200 MECs. Meat and meat product processing and dairy product processing are the region's ninth and seventh largest industries respectively, by gross output.

Table 17. Economic profile of the agricultural product processing sector in the Otago Region

Industry	Gross output	Value added	Export share	Location quotient	Employment 2020 (MECs)	Employment 2011 (MECs)
Meat and meat product manufacturing	\$830m	\$150m	16%	1.7	2,800	2,800
Dairy product manufacturing	\$910m	\$140m	19%	0.5	400	240
Seafood processing	\$14m	\$5m	0.2%	0.1	30	30
Fruit, oil, cereal, and other food product manufacturing	\$120m	\$38m	1.1%	0.6	940	1,100
Beverage and tobacco product manufacturing	\$130m	\$37m	1.3%	1.0	420	360
Wood product manufacturing	\$140m	\$40m	0.6%	0.6	610	800
<b>Total</b>	<b>\$2,100m</b>	<b>\$420m</b>	<b>38%</b>	<b>-</b>	<b>5,200</b>	<b>5,200</b>

With the Alliance Group's Pukeuri Plant, Oamaru Meats, and Whitestone cheese factory, meat and meat product manufacturing is the second largest industry in Waitaki District. Dairy product manufacturing is the third largest industry. The meat and meat product manufacturing industry accounts for employment of 1,300 MECs (Table 18).

Table 18. Economic profile of the agricultural product processing sector in Waitaki District

Industry	Gross output	Value added	Location quotient	Employment 2020 (MECs)	Employment 2011 (MECs)
Meat and meat product manufacturing	\$380m	\$70m	10	1,300	1,300
Dairy product manufacturing	\$270m	\$43m	1.9	110	91
Other	\$50m	\$15m	-	280	270
<b>Total</b>	<b>\$700m</b>	<b>\$130m</b>	<b>-</b>	<b>1,700</b>	<b>1,600</b>

There are five food manufacturing plants located within Lower Clutha or within 100 kilometres of most urban areas within the Rohe. They are Silver Fern Farms' Finegand meat processing plant (Lower Clutha), Fonterra's Stirling cheese factory (Lower Clutha), Duncan South's venison processing plant (Mosgiel, Dunedin), Fonterra's Edendale milk processing facility (Southland), and Alliance Group's meat processing plants (Lorneville and Mataura Southland). Both food growing and food processing require water resources as an input into production and as means of disposing of waste products.

With the Silver Fern Farms Finegand plant and the Fonterra Stirling plant, dairy product manufacturing and meat and meat product manufacturing are among the largest industries in Clutha District in terms of gross output with \$620 million and \$380 million, respectively. The wood product manufacturing industry also accounts for a substantial amount of economic activity (\$38 million gross output) in Clutha District (Table 19).

Table 19. Economic profile of the agricultural product processing sector in Clutha District

Industry	Gross output	Value added	Location quotient	Employment 2020 (MECs)	Employment 2011 (MECs)
Meat and meat product manufacturing	\$380m	\$71m	11	1,300	1,100
Dairy product manufacturing	\$620m	\$98m	4.6	260	140
Wood product manufacturing	\$38m	\$11m	1.8	130	250
Other	\$6m	\$0m	-	9	11
<b>Total</b>	<b>\$1,000m</b>	<b>\$180m</b>	<b>-</b>	<b>1,700</b>	<b>1,500</b>

The beverage and tobacco product manufacturing industry accounts for the majority of the agricultural product processing sector in the Central Otago District (\$44 million gross output, Table 20). In turn, most of the associated employment in this category (at the 4-digit ANZSIC06 level), relates to wine and other alcoholic beverage manufacturing (140 of 150 MECs).



Table 20. Economic profile of the agricultural product processing sector in Central Otago District

Industry	Gross output	Value added	Location quotient	Employment 2020 (MECs)	Employment 2011 (MECs)
Beverage and tobacco product manufacturing	\$44m	\$12m	3.1	150	230
Other	\$31m	\$7m	-	160	180
<b>Total</b>	<b>\$74m</b>	<b>\$19m</b>	<b>-</b>	<b>320</b>	<b>410</b>

#### 4.5 Electricity generation and on-selling

Electricity generation and on-selling is the Otago Region's largest industry with \$1.6 billion in gross output and \$440 million in value added (although as per the sector definitions in this report, it is only the fifth largest sector). The industry is also a regional specialisation with a location quotient of 1.5. However, the industry employs only a relatively small number of people, 350 MECs in 2020 which grew from 300 MECs in 2011 (Table 21). A relatively large share of the industry's economic activity also comes from transactions made with itself.

Table 21. Economic profile of the electricity generation and on-selling sector in the Otago Region

Industry	Gross output	Value added	Export share	Location quotient	Employment 2020 (MECs)	Employment 2011 (MECs)
Electricity generation and on-selling	\$1,622m	\$435m	<1%	1.5	348	301

Electricity generation and on-selling is the largest industry in Central Otago District with \$720 million in gross output and \$190 million in value added. However, again, the industry only employs a relatively small number of people, 91 MECs (2020), within the district (Table 22).

Table 22. Economic profile of the electricity generation and on-selling sector in Central Otago District

Industry	Gross output	Value added	Location quotient	Employment 2020 (MECs)	Employment 2011 (MECs)
Electricity generation and on-selling	\$720m	\$190m	3.4	91	85

#### 4.6 Health care services

Linked to the University of Otago, one of New Zealand's two main institutions for training of medical professionals, health care services<sup>27</sup> is also an important sector for the Otago region. The sector

<sup>27</sup> Note that the health care sector includes the 'Hospitals' and 'Medical and other health care services' industries, but not the 'Residential care services and social assistance' industry

accounts for 8,900 MECs of employment, gross output of \$1.1 billion, and value added of \$680 million (Table 23).

Table 23. Economic profile of the health care services sector in the Otago Region

Industry	Gross output	Value added	Export share	Location quotient	Employment 2020 (MECs)	Employment 2011 (MECs)
Hospitals	\$580m	\$410m	0.1%	1.1	4,900	3,900
Medical and other health care services	\$500m	\$270m	0.3%	0.8	4,000	3,100
<b>Total</b>	<b>\$1,100m</b>	<b>\$680m</b>	<b>0.4%</b>	<b>-</b>	<b>8,900</b>	<b>7,000</b>

Similar to the tertiary education sector, the majority of the healthcare services sector (Dunedin Hospital and the University of Otago Medical School), is located within Dunedin City with 6,700 MECs of employment, \$840 million gross output, and \$530 million value added (Table 24).

Table 24. Economic profile of the health care services sector in Dunedin City

Industry	Gross output	Value added	Location quotient	Employment 2020 (MECs)	Employment 2011 (MECs)
Hospitals	\$510m	\$350m	1.9	4,200	3,400
Medical and other health care services	\$330m	\$180m	1.0	2,500	2,000
<b>Total</b>	<b>\$840m</b>	<b>\$530m</b>	<b>-</b>	<b>6,700</b>	<b>5,400</b>

#### 4.7 Tertiary education

Tertiary education is another sector in which Otago has a regional specialty (location quotient of 2.2). The University of Otago is New Zealand's oldest and one of its most prestigious universities. The Otago Polytechnic (now merged into the new national mega polytechnic Te Pūkenga) and The Southern Institute of Technology (SIT) are also important tertiary education providers here. The sector accounts for employment of 5,000 MECs, gross output of \$700 million, value added of \$500 million and brings in 4.9% of the region's international export earnings (Table 25).

Table 25. Economic profile of the tertiary education sector in the Otago Region

Industry	Gross output	Value added	Export share	Location quotient	Employment 2020 (MECs)	Employment 2011 (MECs)
Tertiary education	\$700m	\$500m	4.9%	2.2	5,000	5,300

The bulk of the tertiary education sector is located within Dunedin City. The University of Otago, Otago Polytechnic, and supporting organisations are situated there with 4,900 MECs of employment, gross output of \$650 million, \$460 million in value added, and a location quotient of 4.5 (Table 26).

Table 26. Economic profile of the tertiary education sector in Dunedin City

Industry	Gross output	Value added	Location quotient	Employment 2020 (MECs)	Employment 2011 (MECs)
Tertiary education	\$650m	\$460m	4.5	4,900	5,200

#### 4.8 Metal ore and non-metallic mineral mining

The Oceana Gold Macraes gold mine in the Waitaki District accounts for the majority of the metal ore and non-metallic mineral mining sector in the Otago Region. This sector comprises of 740 MECs (570 MECs in 2011) and a location quotient of 4.4 for the Otago Region (Table 27). This is second largest location quotient for the metal ore and non-metallic mineral mining and quarrying industry for any region in New Zealand behind the West Coast region with a location quotient of 7.7.

Table 27. Economic profile of the metal ore and non-metallic mineral mining sector in the Otago Region

Industry	Gross output	Value added	Export share	Location quotient	Employment 2020 (MECs)	Employment 2011 (MECs)
Metal ore and non-metallic mineral mining and quarrying	\$540m	\$290m	6.2%	4.4	740	570

#### 4.9 Largest increases in employment

Table 28 lists industries within TAs with the 20 largest changes in employment between 2011 and 2020. Over half of the top 20 are in Queenstown Lakes, driven mainly by population growth and growth in tourism and tourism-related industries. Dunedin-City also features strongly in the list of top 20 industry increases. Given the large population base and large base size of many of the industries within Dunedin, it is not surprising that several of the growing industries make the top 20 list.

Two of the 20 industries with the largest gains in employment are agricultural-based, which are the horticulture and fruit growing in Central Otago District and meat and meat product manufacturing industry in Clutha District.

Table 28. Largest gains in employment by TA and industry grouping of selected industries, 2011 to 2020

Rank	Territorial Authority	Industry	Employment gain (MECs)
1	Queenstown Lakes District	Food and beverage services	1,500
2	Queenstown Lakes District	Accommodation	1,400
3	Queenstown Lakes District	Construction services	1,200
4	Queenstown Lakes District	Residential building construction	830
5	Dunedin City	Hospitals	830
6	Central Otago District	Horticulture and fruit growing	720
7	Dunedin City	Heavy and civil engineering construction	670
8	Dunedin City	Food and beverage services	640
9	Dunedin City	Construction services	610
10	Queenstown Lakes District	Sport and recreation activities	520
11	Queenstown Lakes District	Travel agency and tour arrangement services	470
12	Dunedin City	Residential building construction	430
13	Dunedin City	Medical and other health care services	430
14	Queenstown Lakes District	Advertising, market research and management services	340
15	Central Otago District	Construction services	330
16	Queenstown Lakes District	Recreational, clothing, footwear, and personal accessory retailing	300
17	Queenstown Lakes District	Rental and hiring services (except real estate); non-financial asset leasing	290
18	Clutha District	Meat and meat product manufacturing	230
19	Queenstown Lakes District	Heavy and civil engineering construction	230
20	Dunedin City	Road transport	230

#### 4.10 International import risks

With increasing uncertainty around the global supply of raw input materials and the availability of manufactured goods, prices of imported commodities could increase. This subsection highlights key imports that the Otago Region, and New Zealand more broadly, rely on. Recent global events, particularly the global pandemic and the Russia-Ukraine war, help to illustrate that there can be security concerns when local production chains depend on the supply of import of commodities for their operation. Table 29 reports key international industrial imports highlighting a selection of industries that are particularly dependent on those imports.<sup>28</sup>

<sup>28</sup> The figures in Table 29 are derived from Market Economics' regional supply and use tables as described in Appendix B. In relation to diesel, petroleum, and other petroleum products, it is worth noting that New Zealand's sole oil refinery has just recently ceased operation meaning that the import of manufactured petroleum products is now significantly higher than in Table 29. In terms of import reliance, access to petroleum products was already heavily dependent on imports prior to the refinery closure due to the need to import raw oil for manufacturing from overseas.

Table 29. International industrial import values for a selection of commodities and industries that import large proportions of those commodities for Otago

Commodity	Industry	Domestic supply <sup>1</sup> (2020 NZ\$)	Import value <sup>2</sup> (2020 NZ\$)	Percentage imported from overseas (%)
Diesel	Total across all industries	76m	62m	45
Other petroleum products (besides petroleum and diesel)	Total across all industries	39m	31m	44
	Air and space transport		10m	
Basic chemicals; plaster and lime, other paper, and paperboard products	Total across all industries	61m	52m	46
Fertilisers and pesticides	Total across all industries	97m	48m	33
	Sheep, beef cattle, and grain farming		28m	
	Dairy cattle farming		11m	
Pharmaceutical products	Total across all industries	34m	47m	58
	Sheep and beef farming		12m	
	Dairy cattle farming		8m	
	Hospitals		10m	
	Medical and other health care services		11m	
Steel products, semi-finished metal products	Total across all industries	92m	52m	36
Structural metal products and other fabricated metal products	Total across all industries	252m	84m	25
	Residential building construction		13m	
	Non-residential building construction		13m	
	Heavy and civil engineering construction		9m	
	Construction services		15m	
Motor vehicles, trailers, and semi-trailers; bodies (coachwork)	Total across all industries	7m	58m	89
Medical equipment	Total across all industries	0m	37m	100
	Hospitals		20m	
	Medical and other health care services		13m	
Engines	Total across all industries	0m	36m	100
General industrial machinery	Total across all industries	14m	75m	84
	Construction services		35m	

<sup>1</sup> Note that domestic supply includes goods imported into Otago from other regions of New Zealand

<sup>2</sup> Note that these import values do not identify the ports through which the imports have come into New Zealand

In terms of overseas imports, notable future risks are increased costs for fertilisers and pesticides, and for fuel for machinery and transport.

Ongoing supply chain disruptions caused by the COVID-19 pandemic, disruption to international trade associated with the Russia/Ukraine war and other geopolitical tensions, and the potential for a global recession, are all risks that may hinder the local tourism sector from returning to pre-pandemic overseas visitor levels, particularly given the discretionary nature of tourism spend. At the same time, those risks are also associated with global food shortages (Caprile and Pichon, 2022), and likely increases in agriculture commodity prices. These trends suggest that, at least in the near to medium term, the agricultural sector will continue to play an important role in New Zealand's export trade and foreign revenue generation.

## 5 Economic linkages

In an interconnected economic system, the activities occurring within one economic sector ultimately (through complex production chains or 'value chains') impact on other sectors within that economy. These impacts are known as linkages. There are two types, forward linkages refer to sales of goods and services to customers while backward linkages refer to purchases of goods and services from suppliers. A single sale between two industries is a forward linkage for the seller, and a backward linkage for the purchaser. Two industries can be linked via forward and backward linkages, even when there is no direct sale and purchase of goods/services between the industries, as long as the industries are involved in the same production chain.<sup>29</sup>

Industries also depend on consumers as the ultimate source of demand for the goods and services they produce. Within national economic accounting, the final consumption of goods and services is generally split into categories that include consumption by households, consumption for the purposes of creating capital (i.e., assets that will be used for producing more goods and services now and in the future), and export sales.

To illustrate the nature of economic linkages occurring within the Otago Region economy, two figures have been produced in Section 7.1 and 7.2 below. The first describes linkages at the whole-of-region level, while the latter drills down to linkages within and between TAs within Otago. The data required for drawing these diagrams has been derived from regional and sub-regional input-output tables for New Zealand (refer to Appendix B).

Ideally, the data in the regional and sub-regional tables would all originate from surveys and official statistics. This is not however possible, as limited economic information is produced at the regional and TA scales. Thus, the regional and sub-regional tables have been derived from a top-down process, involving splitting national level economic accounts into regional level accounts, and then subsequently splitting again into TA-level accounts.

The splitting or disaggregation process uses known information on the location of economic activities, proxies for the relative size and scale of activities (e.g., employment, agriculture production statistics), and estimates of trade based on a gravity model (see Appendix B for further information). Given the

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<sup>29</sup> For example, industry A has a forward linkage to industry C if industry A sells to industry B, and industry B then sells to industry C.

derived nature of the data, the figures below are not intended to capture every nuance and linkage of the Otago economy, but rather broadly illustrate the nature and relative scale of economic linkages.

### 5.1 Region-level economic linkages

Figure 12 illustrates the linkages between all industries in the Otago Region. For the purposes of the diagram, the industries have been aggregated to 40 categories (refer to Appendix A). Key industries included in the economic summary above are coloured purple, while remaining industries are coloured green.<sup>30</sup> The arrows depict the two largest sales exchanges and the two largest purchase exchanges with other industries. Arrows between key industries are coloured blue with arrow width corresponding to the magnitude of the exchange. Arrows indicating exchanges between non-key industries are of uniform width and do not correspond to the magnitude of exchange. Any transaction less than \$5 million is omitted from the diagram and while almost all industries have some level of exports, only those greater than \$44 million are depicted.

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<sup>30</sup> Healthcare and education industries are not included as 'key' industries in the diagram given the lesser use of water by these industries compared with other industries, coupled with moderate industry size. These industries were however included in the economic summary given their special role in the Dunedin economy and the relatively high export earnings derived by education.

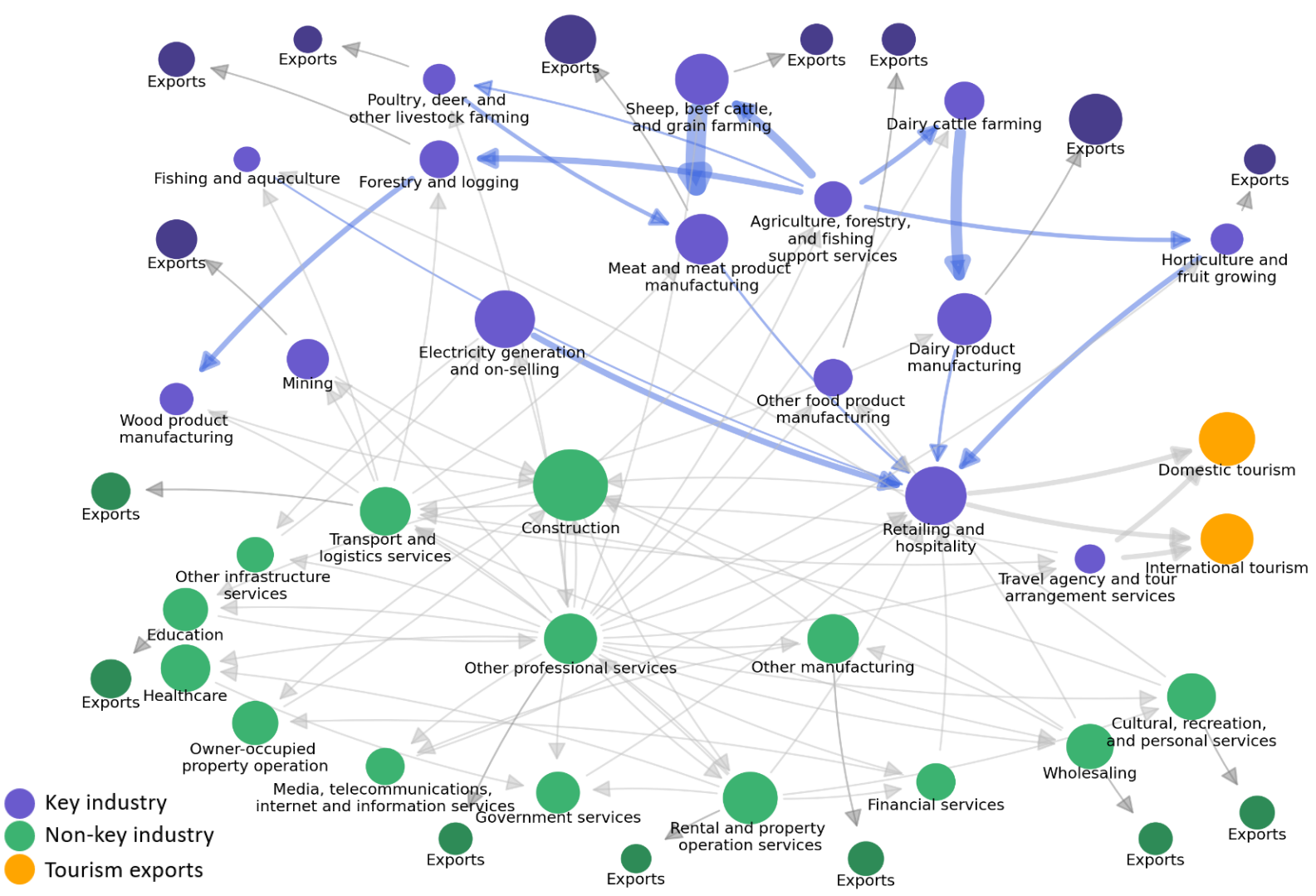


Figure 11. Otago Region economic linkages for all industry sectors.

Notes: (1) Size of circle corresponds to root of industry output, smallest circle = \$32m, largest circle = \$3,000m (2) Circles shaded darker indicate exports (3) Width of blue arrows corresponds to trade value, smallest width arrow = \$4m, largest width arrow = \$290m.



The key linkage illustrations show how each of the key sectors within the Otago Region support each other.<sup>31</sup> We can see, for example, that the agriculture, forestry and fishing support services industry is highly connected with other industries in the agriculture and forestry sector. Horticulture and fruit growing receives 18% of its inputs from this support services industry, while sheep, beef cattle and grain farming receives 8% of its inputs, dairy cattle farming 10% of its inputs, and forestry and logging 24% of its inputs. Not surprisingly, wide arrows also exist between industries within the agriculture and forestry sector, and industries in the agriculture product processing sector reflecting that the existence of processing businesses and operations depend on the continued supply of raw materials from agriculture and forestry. Interestingly there is also quite significant trade and connection between regions, with for example some 59% of the inputs to dairy product manufacturing in Otago estimated to be sourced from Southland.

The forward and backward linkages of industries in Figure 11 can provide an indication of the magnitude and direction of the flow-on impacts from land and freshwater use constraints. For example, all else being equal, if constraints on freshwater use lead to restricted production and output of the sheep, beef cattle and grain farming industry, we would expect to see fewer inputs to sheep/beef/grain farming being purchased from agricultural support services and fewer products supplied to the meat and meat product manufacturing industry for processing. This reduced output of sheep, beef cattle and grain farming as well as by meat product manufacturing would also lead to less demand for transport and logistic services and professional services, and a reduction in export revenue. The negative impact on income for employees working in these industries could lead to less spending and thus reduce purchases on retail and hospitality and other goods and services used by households.

## 5.2 Territorial authority-level economic linkages

Figure 13 illustrates some of the key linkages in more detail at the territorial authority level. In addition to water dependent key industries, this diagram also includes industries that are distinctive to each territorial authority, e.g., tertiary education and hospitals in Dunedin. This figure includes final demand consumption categories to illustrate the relative sizes of the consumption base in each Territorial Authority. The linkages between each industry and consumption category shown are those that are greater than \$40 million.

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<sup>31</sup> Note that these figures exclude inputs from compensation of employees, operating surpluses, taxes, and subsidies.

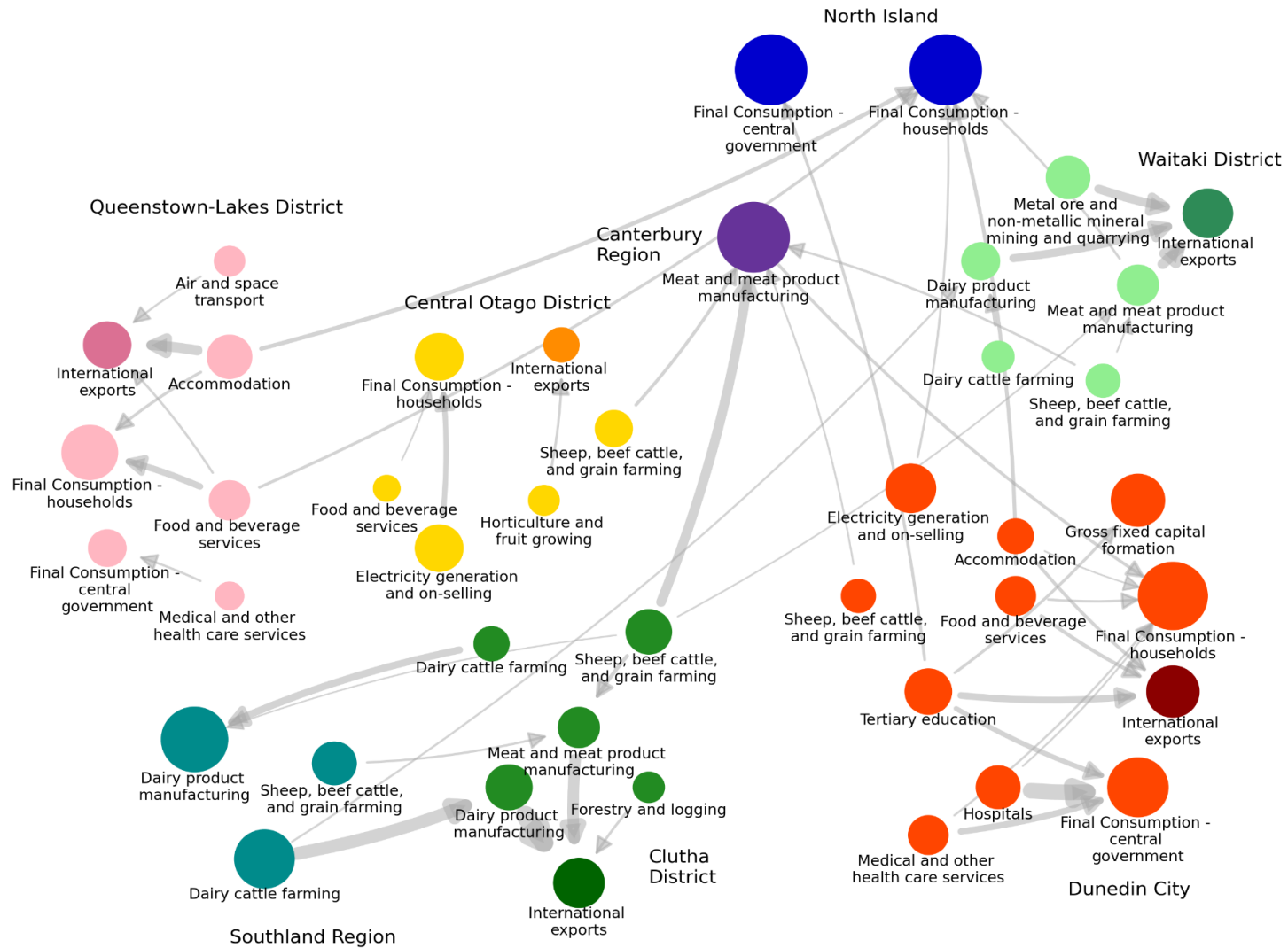


Figure 12. Key economic linkages at the Territorial Authority level

Notes: (1) Size of circles corresponds to square root of industry output, smallest circle = \$58m, largest circle = \$3,900m (2) Circles are grouped into colours to distinguish between TAs and regions (3) Circles shaded darker highlight indicate international exports (4) Arrow width corresponds to trade value, smallest width arrow = \$40m, largest width arrow = \$490m.

Figure 13 illustrates that while trade within each territorial authority is substantial, there is comparatively limited trade between territorial authorities in Otago. The only linkage that is greater than \$40 million is \$45 million of output from the sheep, beef cattle, and grain farming sector in Clutha District to the meat and meat product manufacturing industry in Waitaki District. Statistics New Zealand travel to work data (see Appendix C) also indicates that only small numbers of people travel between TAs for work purposes. There are, however, substantial transfers of goods between Otago TAs and the Canterbury and Southland Regions associated with the movement of agricultural products to processing facilities.

Exports are an important source of income for the region (as well as New Zealand as a whole). Clutha district generates exports of some \$490 million from dairy product manufacturing, \$64 million from forestry and logging, and \$290 million from meat and meat product manufacturing, while Waitaki District generates exports of \$210 million from dairy product manufacturing, \$270 million from meat and meat product manufacturing, and \$230 million from metal ore and non-metallic mineral mining and quarrying. A smaller but still substantial export value of \$64 million is generated by horticulture and fruit growing in Central Otago District.

Service industries are the major export earners in Dunedin City and Queenstown Lakes District. Exports of \$84 million and \$260 million are estimated to be generated by the accommodation industry in two territorial authorities respectively. Exports of food and beverage services are also estimated at \$93 million and \$59 million respectively. Dunedin also has a major export revenue of \$180 million from tertiary education.

Altogether, Figures 11 and 12, along with Table 5, emphasise that tourism and rural land production strongly underpin the structure of the Otago economy. These are activities in which Otago exhibits a comparative strength and concentration when compared to the rest of New Zealand, and the activities also provide most of Otago's export earnings, 19% and 54% (73% in total). Importantly, the services and values that are most needed from terrestrial and freshwater systems to support these activities are also different between the activities. While activities based around rural land production strongly depend on consumptive uses of water and waste assimilation services, tourism is highly connected to the provision of recreational values and the spiritual and contemplative values provided by landscapes.

It is likely that trade-offs will arise, as policies and actions to support one set of economic activities may not support, and indeed may negatively impact on, the operation of other activities. Hence, careful consideration will be required when designing policies that manage water and land conservation and the economic development goals of tourism, agriculture, mining, construction, and the various interconnected services that support workers and populations.

## 6 Concluding remarks and future work

This report characterised the current status of Otago's land and water resources, the region's people and community, and the economy. It also illustrated how the land and water resources are used in the primary sectors as well as how the primary sectors are connected with the rest of the sectors in Otago's economy.

The findings from the report are perhaps not far from our preconceptions: that water and land resources are essential in producing primary goods, and that no sector/industry stands alone – the economy is a network with inputs and outputs flowing in all directions. Further, Otago TAs are different in the natural resources they have and the challenges they face.

In the longer term, we suggest updating and developing this report every three years, to reflect the changes within the Otago community, its resources (e.g., both land and water use), and the wider natural/social/economic environment. We also suggest investigating how other sectors/industries (e.g., the mining sector and the utility sector) use water and land resources. Once the 2023 census data is published it will be possible to gain some insight into how the pandemic has impacted Otago's economy. Lastly, we recommend looking at how climate change is likely to impact on our land and water resources, driving changes in the productivity of land and the livelihoods of people.

## Appendix A: Sector and industry classification

The Statistics New Zealand 2020 input-output table 109 industry classification is an aggregation of the ANZSIC06 industry classification. At the highest level of detail, Statistics New Zealand classify businesses use a 1 letter and 6 numerical digit classification code (although the 4 digit codes contain the same information). The following table provides concordances that match each sector as named in Section 6 to the corresponding industries in the input-output tables, as well as the detailed industry codes from the ANZSIC06 classification.

Table A1. Comparison of sector and industry classifications

SNZ IO code	SNZ input-output (IO) table industry name	Key Sector Designation	Figure 12 Aggregation	ANZSIC06 4 digit class codes
1	Horticulture and fruit growing	Agriculture and horticulture	Horticulture and fruit growing	0111-0139
2	Sheep, beef cattle, and grain farming	Agriculture and horticulture	Sheep, beef cattle, and grain farming	0141-0159
3	Dairy cattle farming	Agriculture and horticulture	Dairy cattle farming	0160
4	Poultry, deer, and other livestock farming	Agriculture and horticulture	Poultry, deer, and other livestock farming	0171-0199
5	Forestry and logging	Agriculture and horticulture	Forestry and logging	0301, 0302
6	Fishing and aquaculture	Agriculture and horticulture	Fishing and aquaculture	0201-0203, 0411-0419
7	Agriculture, forestry, and fishing support services	Agriculture and horticulture	Agriculture, forestry, and fishing support services	0420-0529
8	Coal mining	n/a	Coal mining	0600
9	Oil and gas extraction	n/a	Oil and gas extraction	0700
10	Metal ore and non-metallic mineral mining and quarrying	Metal ore and non-metallic mineral mining	Metal ore and non-metallic mineral mining and quarrying	0801-0990
11	Exploration and other mining support services	n/a	Professional and technical services	1011-1090
12	Meat and meat product manufacturing	Agricultural product processing and manufacturing	Meat and meat product manufacturing	1111-1113
13	Seafood processing	Agricultural product processing and manufacturing	Seafood processing	1120
14	Dairy product manufacturing	Agricultural product processing and manufacturing	Dairy product manufacturing	1131-1133
15	Fruit, oil, cereal, and other food product manufacturing	Agricultural product processing and manufacturing	Fruit, oil, cereal, and other food product manufacturing	1140-1199

16	Beverage and tobacco product manufacturing	Agricultural product processing and manufacturing	Beverage and tobacco product manufacturing	1211-1220
17	Textile and leather manufacturing	n/a	Textile and clothing manufacturing	1311-1334
18	Clothing, knitted products, and footwear manufacturing	n/a	Textile and clothing manufacturing	1340-1352
19	Wood product manufacturing	Agricultural product processing and manufacturing	Wood and paper manufacturing and printing	1411-1499
20	Pulp, paper, and converted paper product manufacturing	n/a	Wood and paper manufacturing and printing	1510-1529
21	Printing	n/a	Wood and paper manufacturing and printing	1611-1620
22	Petroleum and coal product manufacturing	n/a	Chemical product manufacturing	1701-1811
23	Basic chemical and basic polymer manufacturing	n/a	Chemical product manufacturing	1812-1829
24	Fertiliser and pesticide manufacturing	n/a	Chemical product manufacturing	1831, 1832
25	Pharmaceutical, cleaning, and other chemical manufacturing	n/a	Chemical product manufacturing	1841-1899
26	Polymer product and rubber product manufacturing	n/a	Chemical product manufacturing	1911-1920
27	Non-metallic mineral product manufacturing	n/a	Mineral and metal product manufacturing	2010-2090
28	Primary metal and metal product manufacturing	n/a	Mineral and metal product manufacturing	2110-2222
29	Fabricated metal product manufacturing	n/a	Mineral and metal product manufacturing	2223-2299
30	Transport equipment manufacturing	n/a	Machinery manufacturing	2311-2399
31	Electronic and electrical equipment manufacturing	n/a	Machinery manufacturing	2411-2439
32	Machinery manufacturing	n/a	Machinery manufacturing	2441-2499
33	Furniture manufacturing	n/a	Furniture and other manufacturing	2511-2519
34	Other manufacturing	n/a	Furniture and other manufacturing	2591-2599
35	Electricity generation and on-selling	Electricity generation and on-selling	Electricity generation and on-selling	2611-2619
36	Electricity transmission and distribution	n/a	Electricity transmission and distribution	2620-2640
37	Gas and water supply	n/a	Gas and water supply	2700, 2811

38	Sewerage and drainage services	n/a	Sewerage and drainage services	2812
39	Waste collection, treatment, and disposal services	n/a	Waste collection, treatment, and disposal services	2911-2922
40	Residential building construction	Construction	Construction	3011, 3019
41	Non-residential building construction	Construction	Construction	3020
42	Heavy and civil engineering construction	Construction	Construction	3101, 3109
43	Construction services	Construction	Construction	3211-3299
44	Basic material wholesaling	n/a	Wholesaling	3311-3339
45	Machinery and equipment wholesaling	n/a	Wholesaling	3411-3499
46	Motor vehicle wholesaling, including parts	n/a	Wholesaling	3501-3505
47	Grocery, liquor, and tobacco product wholesaling	n/a	Wholesaling	3601-3609
48	Other goods and commission based wholesaling	n/a	Wholesaling	3711-3800
49	Motor vehicle retailing, including parts	n/a	Retailing	3911-3922
50	Fuel retailing	n/a	Retailing	4000
51	Supermarket and grocery stores	n/a	Retailing	4110
52	Specialised food retailing	n/a	Retailing	4121-4129
53	Furniture, electrical, and hardware retailing	n/a	Retailing	4211-4232
54	Recreational, clothing, footwear, and personal accessory retailing	n/a	Retailing	4241-4259, 4272-4279
55	Department stores	n/a	Retailing	4260
56	Pharmaceutical and other store based retailing	n/a	Retailing	4271
57	Non-store and commission based retailing	n/a	Retailing	4310, 4320
58	Accommodation	Tourism-related industries	Accommodation	4400
59	Food and beverage services	Tourism-related industries	Food and beverage services	4511-4530
60	Road transport	n/a	Logistics services	4610-4623
61	Rail transport	n/a	Logistics services	4710, 4720
62	Water transport	n/a	Logistics services	4810, 4820
63	Air and space transport	Tourism-related industries	Logistics services	4900
64	Other transport	n/a	Logistics services	5010-5029
65	Postal and courier services	n/a	Logistics services	5101, 5102

66	Transport support services	n/a	Logistics services	5211-5299
67	Warehousing and storage services	n/a	Logistics services	5301, 5309
68	Publishing (except internet and music publishing)	n/a	Communication and information services	5411-5420
69	Motion picture and sound recording activities	n/a	Communication and information services	5511-5522
70	Broadcasting and internet publishing	n/a	Communication and information services	5610-5700
71	Telecommunications services	n/a	Communication and information services	5801-5809
72	Internet service providers, web search portals and data processing services	n/a	Communication and information services	5910-5922
73	Library and other information services	n/a	Communication and information services	6010, 6020
74	Banking and financing; financial asset investing	n/a	Financial services	6210-6240
75	Life insurance	n/a	Financial services	6310
76	Health and general insurance	n/a	Financial services	6321, 6322
77	Superannuation and individual pension services	n/a	Financial services	6330, 6411
78	Auxiliary finance and insurance services	n/a	Financial services	6419, 6420
79	Rental and hiring services (except real estate)	n/a	Leasing and real estate services	6611, 6619, 6631-6639
80	Non-financial asset leasing	n/a	Leasing and real estate services	6620
81	Residential property operation	n/a	Leasing and real estate services	6711
82	Non-residential property operation	n/a	Leasing and real estate services	6712
83	Real estate services	n/a	Leasing and real estate services	6720
84	Owner-occupied property operation	n/a	Owner-occupied property operation	n/a
85	Scientific, architectural, and engineering services	n/a	Professional and technical services	6910-6925
86	Legal and accounting services	n/a	Professional and technical services	6931, 6932
87	Advertising, market research, and management services	n/a	Professional and technical services	6940-6962
88	Veterinary and other professional services	n/a	Professional and technical services	6970-6999
89	Computer system design and related services	n/a	Professional and technical services	7000
90	Travel agency and tour arrangement services	Tourism-related industries	Professional and technical services	7220



91	Employment and other administrative services	n/a	Professional and technical services	7211, 7212, 7291-7299
92	Building cleaning, pest control, and other support services	n/a	Professional and technical services	7311-7320
93	Local government administration services	n/a	Government	7530
94	Central government administration services	n/a	Government	7510, 7520, 7551, 7552
95	Defence	n/a	Government	7600
96	Public order, safety, and regulatory services	n/a	Government	7540, 7711-7720
97	Preschool education	n/a	Education	8010
98	School education	n/a	Education	8010-8024
99	Tertiary education	Tertiary education	Education	8101, 8102
100	Adult, community, and other education	n/a	Education	8211-8220
101	Hospitals	Health care services	Healthcare	8401, 8402
102	Medical and other health care services	Health care services	Healthcare	8511-8599
103	Residential care services and social assistance	n/a	Healthcare	8601-8790
104	Heritage and artistic activities	n/a	Culture and recreation	8910-9003
105	Sport and recreation services	Tourism-related industries	Culture and recreation	9111-9139
106	Gambling activities	n/a	Culture and recreation	9201-9209
107	Repair and maintenance	n/a	Culture and recreation	9411-9499
108	Personal services; domestic household staff	n/a	Culture and recreation	9511-9539
109	Religious services; civil, professional, and other interest groups	n/a	Culture and recreation	9540-9603

# Appendix B: Methodology for generating regional and sub-regional input-output tables

This appendix describes the process used by Market Economics Ltd to generate regional and sub-regional input-output tables for New Zealand. From these tables it is possible to obtain a variety of economic metrics, including industry value added, industry output, exports and imports, and the value of trade between regions and sub-regions. Employment is not a metric contained directly in the input-output tables, but employment data is used in deriving the tables.

We begin by providing a very broad summary of the three steps involved and then, as the first two of the three steps are described in detail in other technical documents, the remainder of this appendix is devoted to providing further details on the third step.

## B.1 Summary of steps required to generate the regional and sub-regional input-output tables

The national level input-output tables and associated tables (including supply and use tables, imports into industry table) are produced relatively infrequently by Statistics New Zealand. The latest available tables were published in December 2021 and are for the year ending March 2020. Instead of starting directly with the national input-output table (termed the ‘inter-industry transactions table’ by Statistics New Zealand) and disaggregating this to a multi-regional input-output table, the first two steps disaggregate the national supply and use tables to multi-regional supply and use tables, then transform the multi-regional supply and use tables into a multi-regional input-output table (see Figure B1). Overall, the process for deriving the multi-regional input-output tables is complex, relying on a range of data sources and involving many steps. Market Economics Ltd first completed this task for supply and use tables for the year ending March 2007, and the disaggregation of the tables for the year ending March 2020 has been completed recently. Full details of the process are contained in the technical report by Smith *et al.* (2015).

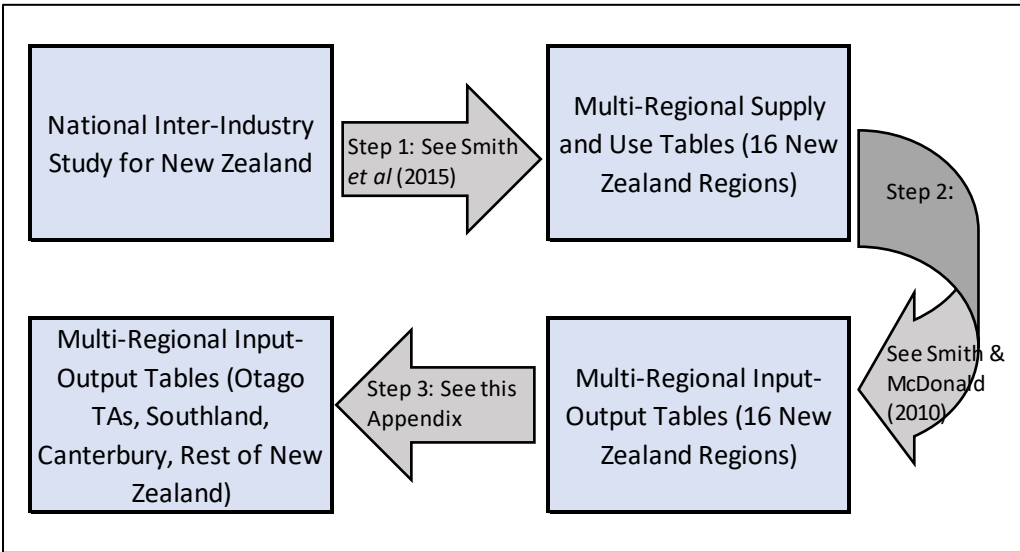


Figure B1: Generation of Regional and Sub-Regional Input Output Tables.

### 1. Disaggregate national level supply and use tables into regions

The first step in generating the regional and sub-regional input-output tables is to disaggregate the national level supply and use tables into regions corresponding with the regional council boundaries. We use the supply and use tables because they contain information on the specific commodities (goods and services) used and produced by industries. This allows us to use, where available, spatial information on commodity production as part of the disaggregation process (for example, from mining and agricultural production statistics), thus leading to better estimates of production and industry structure at the regional level.

### 2. Translate multi-regional supply and use tables to multi-regional input-output tables

The second step translates the multi-regional supply and use tables to multi-regional input-output tables and uses what is termed the 'fixed industry sales structure' assumption. Refer to the textbook by Miller and Blair (2009), as well as the paper by Smith and McDonald (2011) for further information on the difference between supply and use tables and input-output tables, and the methods and assumptions used to translate between these tables.

### 3. Disaggregating multi-regional input output tables to distinguish Otago TAs

The third and final step involves disaggregating further the Otago components of the multi-regional input output table to distinguish each of the separate TAs within Otago. The details of this process are described in the remainder of this appendix.

## B.2 Generating the sub-regional input-output table

To generate the multi-regional input-output table with Otago TAs specified separately (also referred to as a sub-regional input-output table) we:

- (1) take cells within the multi-regional input-output table for New Zealand that pertain to the Otago Region and disaggregate these into sub-regions (i.e., territorial local authorities) within Otago; and
- (2) aggregate cells within the table that pertain to regions other than Otago, Canterbury or Southland to derive the aggregated study areas of 'Rest of South Island' and 'North Island'.

Since the process required for task (2) is straightforward, the remainder of this appendix focuses on describing just task (1). We begin by setting out the symbols applied in the mathematical equations used in this appendix and the data requirements. We then outline each of the modelling steps required for the disaggregation.

### B.2.1 Explanation of symbols used

#### Variables

$d$  distance (/impedance) variable

<i>E</i>	employment
<i>GO</i>	gross output
<i>IO</i>	IO table variable
<i>P</i>	gross output per employee (MEC)
<i>q</i>	q coefficient
<i>Q</i>	q value
<i>s</i>	supply share
<i>S</i>	supply variable
<i>share</i>	share variable (subscripts describe variable that is subject to share)
<i>u</i>	use coefficient
<i>U</i>	use variable

### **Subscripts**

<i>1<sup>st</sup> est</i>	first estimates for the target variable in optimisation problem
<i>2<sup>nd</sup> est</i>	second estimates for the target variable (i.e., target solution) in optimisation problem
<i>ANZSIC06</i>	denotes industry categorisation by ANZSIC06 standard (approximately 491 industry types in total)
<i>fd</i>	final demand category
<i>IO109</i>	denotes industry categorisation by Statistics NZ categorisation of industries in input-output tables. The ANZSIC06 categorisation maps to the IO109 categorisation with a many-to-one mapping
<i>is</i>	industry, supply
<i>iu</i>	industry, use
<i>pi</i>	primary input category
<i>r</i>	region (using regional council boundaries)
<i>sa</i>	study area. Study areas correspond to territorial authorities. Where a territorial authority sits across two regional councils, e.g., Waitaki, the study areas are also split, e.g., Waitaki in Otago and Waitaki in Canterbury. This also means that study areas map to regions with a many to one relationship, i.e., for variable $x$ , $\sum_{sa} x_{r,sa} = x_r$
<i>sas</i>	study area, supply
<i>sau</i>	study area, use

### B.2.2 Data requirements

The following data is required to generate the sub-regional input-output table:

- Multi-regional input-output for New Zealand as generated by Steps 1 and 2 (Figure B1).
- Employment by territorial authority by ANZSIC06 industry
- Gross output by ANZSIC06 industry (at national level)
- Transport cost between Otago territorial authorities.

### B.2.3 Steps involved in disaggregation

Four major steps are necessary for disaggregating the multi-regional input-output table, each are described below.

#### 1. Calculate relative industry size shares for each territorial authority

The first step is to calculate the proportion of regional economic activity for each industry, that will be allocated to each of the territorial authorities. In other words, the size of an economic industry within a territorial authority, relative to the economic industry in the whole of the region. These proportions, or shares, are calculated based on employment within each industry within each territorial authority (MEC's by ANZSIC06 industry category), and on estimates of the level of output per employee within each of the study areas (calculated from gross output and employment statistics from the 2020 Annual Enterprise Survey). The calculations are first undertaken at detailed ANZSIC06 industry classification, and then aggregated to the 109 industry classification used in the input-output tables based on the following mathematical equations:

$$GO_{sa,ANZSIC06} = P_{ANZSIC06} \times E_{sa,ANZSIC06}$$

$$GO_{sa,i_{IO109}} = \sum_{i_{ANZSIC06} \rightarrow i_{IO109}} GO_{sa,i_{ANZSIC06}}$$

$$share_{r,sa,i_{IO109}} = \frac{GO_{r,sa,i_{IO109}}}{\sum_{sa} GO_{r,sa,i_{IO109}}}$$

The equations are written generally to apply to all regions within the non-disaggregated table. In the last equation, the study areas that are summed in the denominator are only those that belong to the same New Zealand region as the subject study area. Thus, for cells that do not relate to Otago, the shares will always equal 1 (i.e., only the Otago components of the table are to be disaggregated).

#### 2. Calculate total supply and use constraints for disaggregation of each cell in the input-output table

To help explain the disaggregation process, Figure B2 depicts a simplified example of a multi-regional input-output table consisting of just two regions (Otago and Rest of New Zealand), two industries (Ind1

and Ind2) and one final demand category (FD). For this simplified example, we assume that Otago must be split into two territorial authorities (TA1 and TA2). The diagram demonstrates that cell  $a$  in the original table becomes split into four cells in the disaggregated table ( $a_{1,1}$ ,  $a_{1,2}$ ,  $a_{2,1}$ ,  $a_{2,2}$ ). Similarly, cell  $b$  in the original table becomes split into two cells ( $b_1$  and  $b_2$ ) while cell  $c$  is also split into two cells ( $c_1$  and  $c_2$ ).

Original Input-Output Table			Otago	Otago	Rest of NZ	Rest of NZ	Otago	Rest of NZ
			Ind 1	Ind 2	Ind 1	Ind 2	FD	FD
Otago	Ind 1		a					
Otago	Ind 2							b
Rest of NZ	Ind 1						c	
Rest of NZ	Ind 2							

Disaggregated Input-Output Table			Otago	Otago	Otago	Otago	Rest of NZ	Rest of NZ	Otago	Otago	Rest of NZ
			TA1	TA1	TA2	TA2	Ind 1	Ind 2	FD	FD	FD
			Ind 1	Ind 2	Ind 1	Ind 2					
Otago	TA1	Ind 1	$a_{1,1}$		$a_{1,2}$						
Otago	TA1	Ind 2									$b_1$
Otago	TA2	Ind 1	$a_{2,1}$		$a_{2,2}$						
Otago	TA2	Ind 2									$b_2$
Rest of NZ	Ind 1								$c_1$	$c_2$	
Rest of NZ	Ind 2										

Figure B2. Simplified Example of Input-Output Table Disaggregation

When disaggregating each cell, it is assumed that each industry's total supply and use of goods and services described by the original cell is based on the relative size of that industry (as calculated by the shares in step 1). To explain further using the simplified example above, let us assume that the value of cell  $a$  in the original table is \$4 million and that 10% of Ind1 in Otago is contained in TA1 and 90% in TA2. This would mean that the total supply by Ind1 in TA1 to Ind1 in both TA1 and TA2 (i.e., cells  $a_{1,1}$  plus  $a_{1,2}$ ) is equal to \$0.4 million. Similarly, the total use by Ind1 of goods and services supplied by Ind1 in both TA1 and TA2 (i.e., cells  $a_{1,2}$  plus  $a_{2,2}$ ) is equal to \$3.6 million. These known cell sums corresponding to total supply and use become constraints in the optimisation problem which is described further below.

When splitting final demand categories into multiple final demand categories for each territorial authority (e.g., disaggregating cell  $c$  in Figure B2) the relative territorial authority shares are derived from Statistics New Zealand data on population and household income for each study area.

Mathematically the process for deriving the supply and use constraints is described below:

#### Supply industry to use industry

$$share_{rs,sas,ru,sau,is,iu} = share_{r,sa,i_{IO109}} \times share_{r,sa,i_{IO109}}$$

#### Supply industry to final demand

$$share_{rs,sas,ru,sau,is,fd} = share_{r,sa,iO_{109}} \times share_{r,sa,fd}$$

**Primary input to use to use industry**

$$share_{ru,sau,pi,iu} = share_{r,sa,iO_{109}}$$

**Primary input to final demand**

$$share_{ru,sau,pi,fd} = share_{r,sa,fd}$$

**Supply industry to use industry**

$$IO_{rs,sas,ru,sau,is,iu} = IO_{r,is,iu} \times share_{rs,sas,ru,sau,is,iu}$$

**Supply industry to final demand**

$$IO_{rs,sas,ru,sau,is,fd} = IO_{r,is,fd} \times share_{rs,sas,ru,sau,is,fd}$$

**Primary input to use to use industry**

$$IO_{ru,sau,pi,iu} = IO_{r,pi,iu} \times share_{ru,sau,pi,iu}$$

**Primary input to final demand**

$$IO_{ru,sau,pi,fd} = IO_{r,pi,fd} \times share_{ru,sau,pi,fd}$$

**Supply industry constraint**

$$S_{rs,sas,is,constraint} = \sum_{sau,iu} IO_{rs,sas,ru,sau,is,iu}$$

**Use industry constraint**

$$U_{ru,sau,is,iu,constraint} = \sum_{sas} IO_{rs,sas,ru,sau,is,iu}$$

**3. Derive first estimates of disaggregated input-output table cells**

First estimates of the values in each of the disaggregated cells are based on a so-called gravity modelling approach (Eiselt and Marianov, 2011, p. 423). The gravity model assumes that the size of trade from a supplying industry to a demanding industry will be positively impacted by:

- The total quantity of goods and services that are being supplied by the supplying industry;
- The total quantity of goods and services being demanded by the demanding industry;
- The inverse of the impedance to trade between the supplying industry and demanding industry.

Q-coefficients are parameters used in the gravity model to capture relative impedance in trade between industries sited at different locations. We have used travel distance between territorial authorities as the cost variable in calculating the Q-coefficients, but more complex measures could be used.

Overall, the first for each of the disaggregated cells are calculated according by the equations:

$$Q_{sas,sau,is,iu} = \frac{S_{sas,is}U_{sau,iu}}{d^2}$$

$$q_{sas,sau,is,iu} = \frac{Q_{sas,sau,is,iu}}{\sum_{sas,sau,is,iu} Q_{sas,sau,is,iu}}$$

$$IO_{sas,sau,is,iu,1^{st}est} = IO_{is,iu} \times q_{sas,sau,is,iu}$$

#### 4. Solve optimisation model

The final step is to compile and solve the optimisation model that generates the sub-regional input-output table. In summary, the optimisation model takes the first estimates of the disaggregated cell values (from Step 3) and finds a solution that is as close as possible to these first estimates, while meeting the supply and use constraints (from Step 2).

The optimisation model is specified as:

$$\text{minimize} \left( \frac{IO_{sas,sau,is,iu,2^{nd}est} - IO_{sas,sau,is,iu,1^{st}est}}{IO_{sas,sau,is,iu,1^{st}est}} \right)^2$$

Subject to the constraints:

$$\sum_{sau,iu} IO_{sas,sau,is,iu,2^{nd}est} = IO_{sas,is}$$

i.e., The sum of the second estimates by use region and use industry must sum to the total industry supply for each study area of the disaggregated table values calculated in Step 2.



$$\sum_{sas, is} IO_{sas, sau, is, iu, 2^{nd} est} = IO_{sau, iu}$$

i.e., The sum of the second estimates by use region and industry must sum to the total industry use for each study area of the disaggregated table values calculated in Step 2.

$$\sum_{sas \rightarrow rs, sau \rightarrow ru} IO_{sas, sau, is, iu, 2^{nd} est} = IO_{rs, is, ru, iu}$$

i.e., The sum of the second estimates sum to the regional level (i.e., non-disaggregated) IO table.

The values,  $IO_{sas, sau, is, iu, 2^{nd} est}$ , constitute the sub-regional input-output table.

### B3 Limitations and opportunities for further development

This appendix describes a top-down methodology for deriving a sub-regional level input-output table with more than 1 million elements that provide an overall view of the economy. However, it may miss some subtle nuances and idiosyncrasies of local supply chains. This section describes some limitations of these derived figures and how they might be refined in future.

The optimisation algorithm in the final step can limit the accuracy of the numbers for very small transactions between industries. In the future we will also trial alternative optimisation and balancing procedures (e.g. RAS (Lee, 2014)).

A significant component of the figures in the sub-regional IO table are derived from data specified at the national level, and average relationships at the national level. National averages are less likely to be representative at the regional or sub-regional level when the region/sub-region is dominated by just a few businesses or one major business rather than a 'population' of businesses. For example, the export figures in Table 27 are dominated by a single business (Macraes gold mine). Some caution therefore needs to be exercised when interpreting the derived data.

The impedance values used in the gravity model calculations are the travel distances between TA centres. The gravity model could be improved by using more detailed data such as travel times, known freight flow data, route capacity, contracts in place, existing transport runs from milk tankers, and other information available from industry. Such data can be incorporated by improving the first estimate values or adding additional constraints to the optimisation model.

## Appendix C: Statistics NZ travel to work data

Table C1 shows the number of people living in each territorial authority and the territorial authority they travel to for work. The cells highlighted in yellow contain the number of people who travel between different territorial authorities for home to work trips where at least either the origin or destination territorial authority is located within the Otago region.

Table C1. Travel to work data.

Live in \ Work in	Timaru District	Mackenzie District	Waimate District	Chatham Islands Territory	Waitaki District	Central Otago District	Queenstown-Lakes District	Dunedin City	Clutha District	Southland District	Gore District	Invercargill City
Tasman District	0	0	0	0	42	0	0	0	0	0	0	0
Nelson City	0	0	0	0	6	0	0	0	0	0	0	0
Marlborough District	0	0	0	0	0	0	0	0	0	0	0	0
Kaikoura District	0	0	0	0	0	0	0	0	0	0	0	0
Buller District	0	0	0	0	0	0	0	0	0	0	0	0
Grey District	0	0	0	0	0	0	0	0	0	0	0	0
Westland District	0	0	0	0	0	0	0	0	0	0	0	0
Hurunui District	0	0	0	0	0	0	0	0	0	0	0	0
Waimakariri District	0	0	0	0	0	0	0	0	0	0	0	0
Christchurch City	0	0	0	0	0	0	0	0	0	0	0	0
Selwyn District	0	0	0	0	0	0	0	0	0	0	0	0
Ashburton District	18	0	0	0	0	0	0	0	0	0	0	0
Timaru District	18,210	21	0	0	0	0	0	0	0	0	0	0
Mackenzie District	30	2,172	0	0	27	0	0	0	0	0	0	0
Waimate District	219	0	2,505	0	39	0	0	0	0	0	0	0
Chatham Islands Territory	0	0	0	249	0	0	0	0	0	0	0	0
Waitaki District	0	12	42	0	7,959	0	0	36	0	0	0	0
Central Otago District	0	0	0	0	0	9,321	315	0	0	0	0	0
Queenstown-Lakes District	0	0	0	0	0	57	19,455	0	0	0	0	0
Dunedin City	0	0	0	0	102	0	0	45,120	60	0	0	0
Clutha District	0	0	0	0	0	0	0	192	7,248	0	108	6
Southland District	0	0	0	0	0	0	6	0	0	12,087	168	1,098
Gore District	0	0	0	0	0	0	0	0	30	81	4,623	51
Invercargill City	0	0	0	0	0	0	0	0	0	444	0	20,349

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