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The Orari, Temuka, Opihi, Pareora (OTOP) Project – social community assessment phase 2 – Scenarios

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Summary

As part of the Canterbury Water Management Strategy (CWMS), the Orari, Temuka, Opihi and Pareora (OTOP) Zone committee will provide recommendations on regulatory and non-regulatory measures as an addendum to the already developed zone implementation programme. This report has been prepared by Landcare Research, at the request of Environment Canterbury, to underpin community consultation, and to support the assessment of different scenarios for the Zone.

The three water management scenarios examine what might happen in the OTOP zone under 1) the current pathway: current rules and plans under the current land use with the full implementation of regional plans and all farming activities operating at Good Management Practice (GMP), and a reduction in the volume allocated for water takes in over-allocated catchments; 2) In zone gains: improved management of the water currently available in the zone; and 3) New water: additional water is made available in the zone either on (a) a small scale or b) a large scale).

This report builds on the previous social community assessment of the OTOP zone (Kalaugher and Wright 2016) and is intended as a qualitative supplement to other work that is underway or already completed by Environment Canterbury. As such, it does not provide new quantitative data but rather seeks to bring together available outputs from other assessments and present a set of broader, emergent considerations as a basis for further discussion in the Zone committee and wider community.

Key findings and conclusions

In assessing the social implications of potential new regulations, it is important to consider not only the changes that would be made under the proposed scenarios, but other changes that may occur concurrently in the zone. These factors will also interact with one another, but much will depend on how policy changes are implemented. In most cases, the pressures identified could have either positive or negative effects, depending on the scenario:

- ***Effects on economic development***. Depending on the scenario, this could be either limiting, through stricter environmental regulations; or promote further agricultural growth and intensification through the availability of new water. Economic implications of the scenarios are more fully explored by BERL (2017).
- ***Increasing pressure on the farming community.*** Increased regulatory limits and higher standards of expected environmental performance will put pressure on the farming community and could negatively affect their wellbeing. However, OTOP farmers are experienced, well-educated, and engaged with the wider community. If expectations are agreed and realistic; and support (for example collaborative research) is provided where it is needed, such pressure could also stimulate positive innovation in the agricultural sector.
- ***Demographic changes in the zone.*** In particular, immigration patterns will likely be closely associated with changes in employment opportunities. Economic growth, particularly through the dairy sector, may bring an increase in migrant agricultural

workers. If such migrants are isolated and living in stressful conditions (see Kalaugher and Wright 2016), this may reduce the care and skill with which on-farm practices are carried out. However, economic growth may also increase the opportunities for young people to return to family farms in the zone.

- ***Community wellbeing.*** Perceptions of the distribution of costs and benefits may impact either positively or negatively on community cohesion. If the distribution is perceived as inequitable, this may polarise opinions and negatively affect the effectiveness of community groups. The high level of social capital evident in the OTOP zone may be one of its greatest assets, and needs to be at the core of strategies for policies affecting the future development of the zone. For example, there may be an opportunity to engage community groups in environmental monitoring through citizen science approaches. It is also important to bear in mind the health and well-being of individuals - both the mental health and wellbeing of farmers in the face of increasing pressure; and the importance of the long-term wellbeing generated through the relationship of people with their (healthy) environment.

1 Introduction

As part of the Canterbury Water Management Strategy (CWMS), the Orari, Temuka, Opihi and Pareora (OTOP) Zone committee will provide recommendations on regulatory and non-regulatory measures as an addendum to the already developed zone implementation programme. To support this process, Environment Canterbury has completed scenario assessments within the OTOP zone for three water management scenarios, as follows:

***Scenario 1: Current pathway*:** Assessing the implications of the current rules and plans under the current land use, including the implementation of Plan Change 5 with all farms operating at Good Management Practice (GMP) including compliance with stock exclusion rules and at least 80% irrigation efficiency.

***Scenario 2: In zone gains*:** More efficient management of existing water resources in the zone, including 90% irrigation efficiency. Management beyond GMP is required where surface water nitrates breach acceptable standards.

Scenario 3: New Water: New water enters the zone on either a small scale or large scale. Farms are expected to operate at GMP and 80% irrigation efficiency.

In follow up to the 2016 assessment of the current state of the OTOP community (Kalaugher & Wright 2016), this report has been prepared by Landcare Research New Zealand, at the request of Environment Canterbury, to provide the OTOP Zone committee with background and contextual information about the potential implications of the three water management scenarios for the OTOP community

2 Objectives

- To provide a qualitative assessment of the potential implications of the three water management scenarios for the OTOP community.
- To consider some of the contextual interactions between social and economic conditions in OTOP zone that will affect the outcome of these water management scenarios for the community.

3 Methods

The project uses desktop research methodologies, drawing on publicly available data as well as information provided by Environment Canterbury for the purpose of the assessment. It builds on the previous social community assessment of the OTOP zone (Kalaugher and Wright 2016) where we identified a set of themes with examples of indicators to help community, rūnanga, industry, and local authorities understand the implications of different future scenarios for the zone (see table 1). This assessment will be broadly based on these themes.

Table 1: Indicators identified for the OTOP zone (Kalaugher & Wright 2016)

Area of measurement	What needs to be measured	Examples of indicators
Community composition	The proportion of the community that is changing in composition, in order to understand changes to the zone	• School rolls • Employer data on migrants • Registration with migrant services • Census data (standard demographics including age) • Land use
Well-being of community	The well-being of farmers, the migrant community and the urban community should be monitored separately to identify trends in these groups	• School deciles, rural and urban • Health statistics – rural and urban. Obesity, mental health, alcohol intake. • Access to services • Employment data • Change in composition and number of sports clubs
Recreational quality	Trends in public use and enjoyment of recreational areas	• Swimmability in different rivers (safety and/or enjoyment scores) • Angling scores • Cyanobacteria levels
Farm environmental performance	The urban population, recreational water users and consumers of agricultural products are increasingly demanding accountability for environmental performance	• Amount of water used compared with similar enterprises • Change in water demand • Irrigation scheduling • Farm Environment Plans • Effluent management practices • Nutrient use
Farm economic performance	Trends in performance of farms in different sectors, to understand likely drivers of change	• Debt levels by sector • Profit by sector • Mixed operations
Cultural values	Values of particular significance to Māori	• Coastal erosion and wetland loss (areas) • Mahinga kai (indicator species selected in discussion with local kaumātua)
Community groups	Composition of catchment groups and connection with other groups. Engagement and activity levels	• Composition (diversity) of catchment groups • Connections with other groups • Perceptions of effectiveness
Adaptive capacity	Potential for and resilience to change	• Farmer attitudes (e.g. SRDM, see Brown 2015) • Farm structure (e.g. sharemilking arrangements, no. of migrant workers) • Diversity in secondary processing industries • Economic Diversification Index (EDI)

This report is intended as a qualitative supplement to other work that is underway or already completed by Environment Canterbury, including the cultural and economic reports in preparation, the 'Community Outcomes' set by the OTOP Zone Committee and the results of several workshops held in the zone to involve the community in developing appropriate management strategies through the Healthy Catchments Project.

As such, it does not provide new quantitative data but rather seeks to bring together the available outputs from other assessments and present a set of broader, emergent considerations as a basis for further discussion in the Zone committee and wider community.

4 Community concerns and aspirations

A summary of feedback from public workshops in September 2016 on the current state of the OTOP zone brought together information on community concerns, aspirations and proposed solutions for the zone[1]. Many of the concerns expressed related to the decline in water quality, including use of chemicals and lack of riparian margins in urban settings, as well as the loss of riparian vegetation, and, particularly from a cultural perspective, loss of wetlands. Water flows were also a source of concern, including over allocation of groundwater and changes to river dynamics.

Concerns were also expressed about the tools and approaches being used to address these problems; for example, the capacity of the OVERSEER® model, which is a long-term average model designed to compare management strategies, to represent fluctuating farm conditions. Modification of stop banks and rivers for bridge and town protection was also raised as a concern. In relation to equity, the community was worried about how the needed changes would be paid for. In particular, they voiced the need for care about restrictions on development and the need to provide for economic headroom.

Aspirations expressed by the community were also largely focussed on environmental and recreational quality, as well as on the need to provide for economic well-being and equity in terms of the distribution of costs and benefits. These aspirations have now been drawn together as the following Community Outcomes, set by the OTOP zone committee working with local people and stakeholders:

- All surface waterbodies safe for recreation and gathering mahinga kai.
- Increase recreational opportunities in the zone by ensuring appropriate management of river flows.
- Safe and reliable drinking water for community and domestic supplies both now and in the future.
- Increase the reliability of current irrigation in the zone.
- Increase the area of land irrigated in the zone.

[1] See the Healthy Catchments website: https://apps.canterburymaps.govt.nz/otop/otop.html

- Achieve ecosystem health and natural river mouth dynamics.
- Protect and enhance indigenous biodiversity Ki uta Ki Tai, particularly high naturalness areas, coastal lagoons, and wetlands and springs in the upper parts of catchments.
- Rectify loss and improve opportunities for mahinga kai gathering in the zone.
- Protect and enhance sites of cultural significance.
- Protect and enhance the natural character of the zone's braided rivers while providing a sufficient level of flood protection.
- Maintain and improve economic value in the zone and provide for community wellbeing

5 Current trends and driving forces

To provide a context for the assessment, it is important to consider not only the changes that would be made under the proposed scenarios, but also other changes that may occur concurrently in the zone and the interactions between the underlying drivers of change.

5.1 Current state

In the current state social community assessment (Kalaugher & Wright 2016), a number of key themes emerged that provide insight into local drivers of social and economic change in the OTOP zone. These are summarised here to provide a background for the present assessment:

- **A long, proud, and diverse history as an agricultural zone**: The OTOP zone has been largely agricultural since the late 19th century, and has weathered many changes, including restructuring and removal of subsidies in the 1980s. The area is highly versatile and produces a mix of agricultural products that has varied over time with changes in markets and other relevant factors. The secondary processing industry has developed and changed over time, but always strongly centred on the port at Timaru.
- ***Economic growth and agricultural intensification:*** The OTOP zone has experienced significant economic growth over the past decade, due largely to the expansion and intensification of dairying, including an increase in the area under irrigation. Water quality issues are starting to have adverse effects on the relationship between farmers and the urban community. The change to dairy farming also brings with it different structures in the operation of a farm, including more permanent staff as well as casual workers, sharemilking arrangements, and often a different gender balance in roles. The expansion of dairying has also changed the dynamic of secondary processing industries in the area, including increasing dependence on Fonterra.
- ***Recreation and tourism:*** The Timaru district is often a stopping point for visitors to Tekapo and Geraldine on their way to or from Queenstown. Tourism is growing quickly and represents an area of opportunity. There is general appreciation of the waterways in the area and the recreational opportunities they provide. However,

increasing pressure on water quality and quantity is creating tensions that may focus on particular locations where water quality is poor.

- ***Demographic changes:*** Immigration to the area from both international and domestic sources is growing, creating an increasingly multicultural community and brings with it the challenges of a range of newcomers to the area, particularly migrant workers. In the previous assessment we noted in particular that the well-being of migrant dairy workers may be important to improving the environmental performance of dairy farms, as farm workers play a key role in on-farm outcomes. In addition, an increasing percentage of the population identify as Māori, and there is also increasing influence of Māori in resource management issues, for example, in promoting the creation of *Te Ahi Tarakihi Mataitai Reserve* at Caroline Bay. Demographic projections also suggest that the current trend of an ageing population in the Timaru area will continue.
- **Community wellbeing:** The area is relatively well serviced in terms of health and education, and school deciles and rolls are increasing, particularly in rural areas. *S*tatistics follow national trends of increasing obesity in younger people. Health statistics show a much higher level of diagnosed mental health issues than average in younger women in the zone.
- **Community spirit and social capital:** The OTOP zone has a long history of community spirit. Previous community assessments have indicated strongly that people are involved and value the cohesive, self-reliant nature of their communities. The farming community is experienced, well-educated, and engaged with the wider community. There is a strong sporting tradition in the area and farmers are most likely to be engaged with the community through sporting activities, as well as through schools. There is scope to improve farm environmental performance and farm decision makers in the zone exhibit a cautious openness to change. Successful examples already exist of collaborative groups that are working together to identify and overcome areas of tension in resource management. Examples included the proactive Opuha Environmental Flow Release Advisory Group (OEFRAG) and the catchment groups.

In our previous report, we noted that the main vulnerabilities in the area may stem from changes taking place in community composition, especially migration; from increasing reliance on the dairy sector and primarily, on one major secondary processor; from changes in the way farms are structured; and from the increasing reliance on irrigation to drive the local economy. For some of these factors, for example, the well-being of migrant workers on dairy farms, data gaps exist that may need to be addressed.

Notable assets the OTOP zone include a strong economy, community spirit, the growing influence of Māori values, and in particular, the OTOP zone's strong rural tradition and experienced farmers.

5.2 Drivers of change

In this report we use the Millennium Ecosystem Assessment definition of driver of change (MEA 2005; chapter 7) which is "any natural or human-induced factor that directly or indirectly causes a change in an ecosystem". Drivers may directly influence ecosystem

processes, or operate more indirectly, by causing changes to direct drivers (e.g. demographic changes). While these factors are largely beyond the scope of the current assessment, they are important contextual considerations to the scenarios presented. Based on the MEA (2005), community workshops and the previous social community assessment (Kalaugher & Wright 2016), some important drivers of change identified for the OTOP zone may include:

- ***Economic trends:*** As noted in the previous section, the OTOP zone has experienced significant economic growth over the past decade. To better visualize changes in economic trends over time and space, Figure 1 shows the distribution of median household income in both 2001 and 2013. Blank spaces represent meshblocks with no data. These maps are presented with data at the Census meshblock level, where darker areas represent higher income. Although there are no definite trends, the maps appear to show less dark areas in the 2013 map. However, the next two maps (Figure 2) show the change in median household income in the urban area around Timaru. Those maps illustrate an increase in dark areas from 2001 to 2013, suggesting that urban areas experienced income growth during that time. Overlaying currently irrigated areas with median household income (Figure 4) or the current deprivation index (Figure 5) does not show any clear relationship between these factors.
- ***Changes in wellbeing:*** The 2013 New Zealand Deprivation Index assigns a score between one and ten to areas based on census data (although there is also a version that uses survey data as an input), such as household income, homeownership, employment, and education, among others. It is intended to identify 'deprived' neighbourhoods based on socioeconomic status. The most recent version (2013) employs nine Census variables, and assigns values at the meshblock level[2]. Figure 3 shows the wider OTOP area as well as a more spatially explicit map of Timaru. In the wider OTOP map, the more rural areas appear to have fairly low deprivation scores, on average (indication low deprivation, or vulnerability). The Timaru area exhibits higher Deprivation Index scores, particularly closer to the coast.
- ***Climate change***: Climate change may impact a range of factors beyond direct temperature effects. In particular, it may significantly affect river flows during floods and droughts. National TopNet modelling under a high radiative forcing climate change scenario has indicated that low flows in Canterbury are likely to be negatively impacted, and occur earlier in the season. Under this scenario, mean discharge is likely to increase in the lowlands and East Coast areas and decrease in the mountains and uplands. Flow reliability is projected to decrease overall but improve in some East Coast areas, and flood risk is projected to increase (p 57, Rutledge et al. 2017). A modelled assessment of flood risk for Timaru under climate change also projected an increase in rain depths for 2030 and 2080, causing flood depths, flows, and volumes to increase (OPUS 2003).

[2] For a more detailed description of the deprivation index, as well as historical information and publications, see http://www.otago.ac.nz/wellington/departments/publichealth/research/hirp/otago020194.html. There is also a less spatially explicit version of the index that is based on survey responses.

- ***Changes in technology:*** Technology changes are ongoing and bring a number of opportunities as well as challenges. In particular, there are opportunities for efficiency increases though 'smart farming' approaches such as precision agriculture and environmental sensors. In order to take advantage of these technologies, skill in their use needs to keep pace with development.
- ***Rural-urban balance:*** Overall population trends in New Zealand have shown a strong growth in the urban population between 1886 and 2001, with a relatively stable rural population. However, in more recent years, the rural population has grown to over 600,000, and it has been suggested that more intensive dairying may be one of the major contributors to this trend (Polkinghorne 2017). Competition for land has been identified as a risk in the Timaru District, particularly the risk that residential growth may result in a loss of productive soils (Timaru District Growth Strategy).

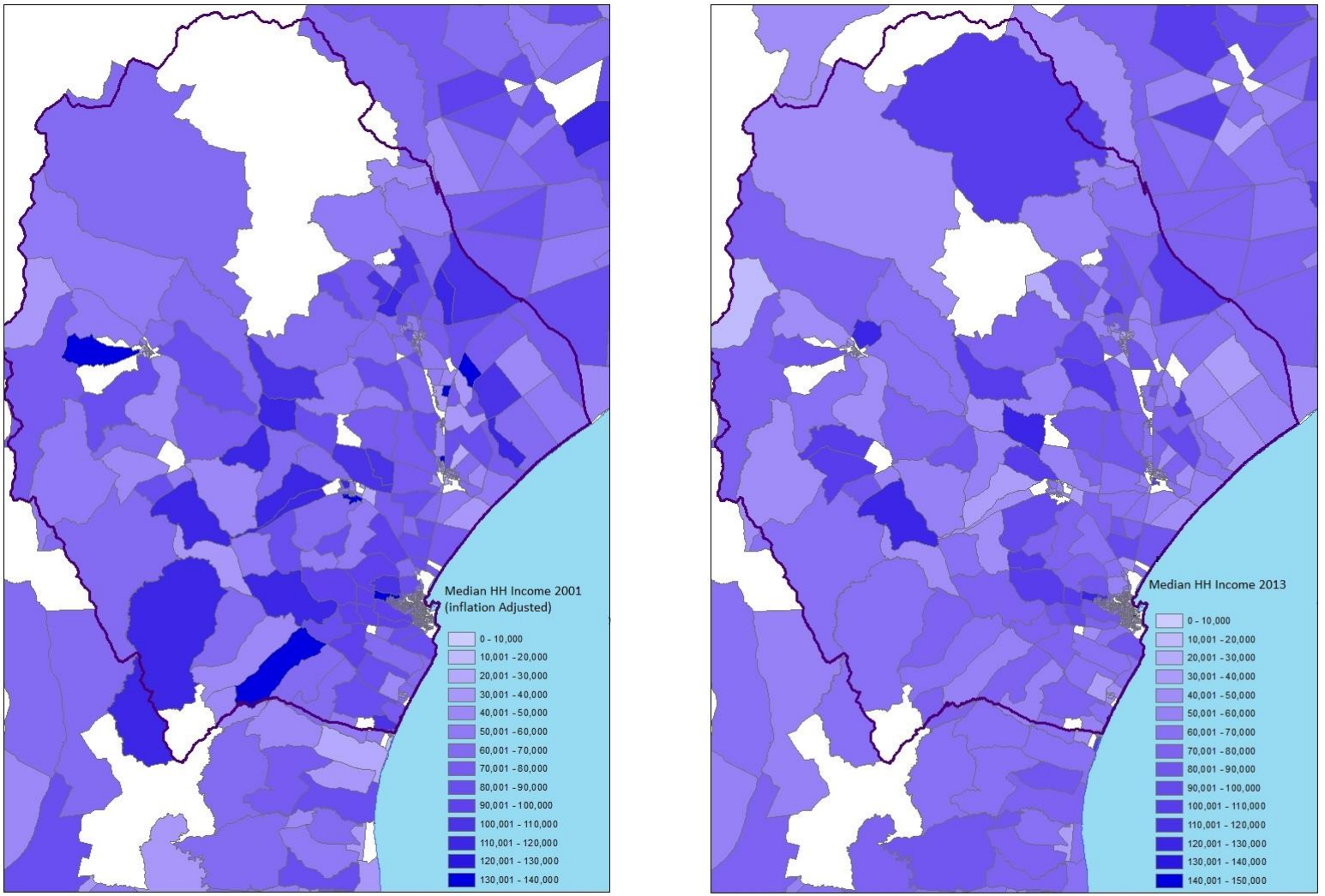

Figure 1: Spatial distribution of median household income for the OTOP zone based on census data from 2001 and 2013

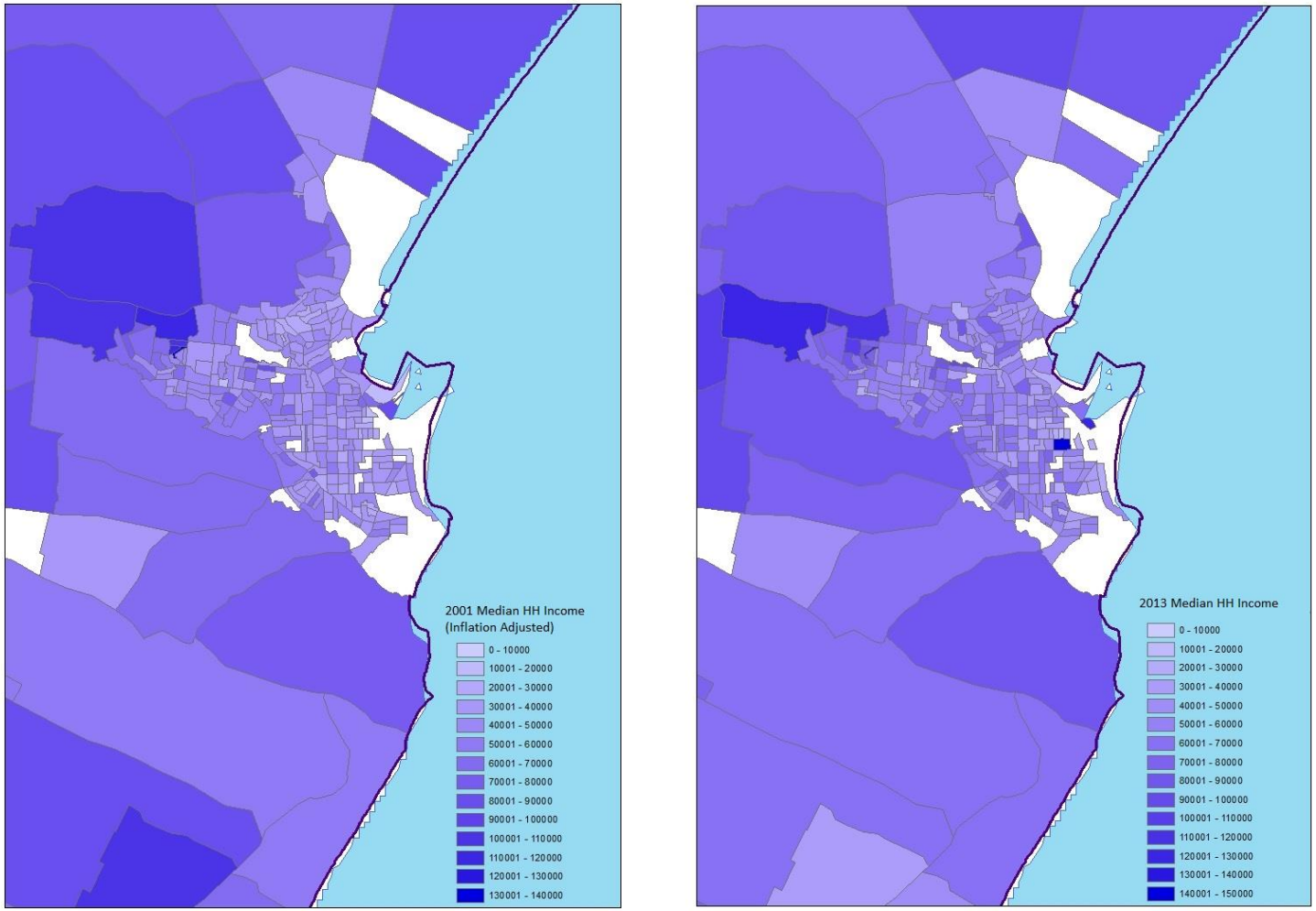

Figure 2: Median Household Income in Timaru

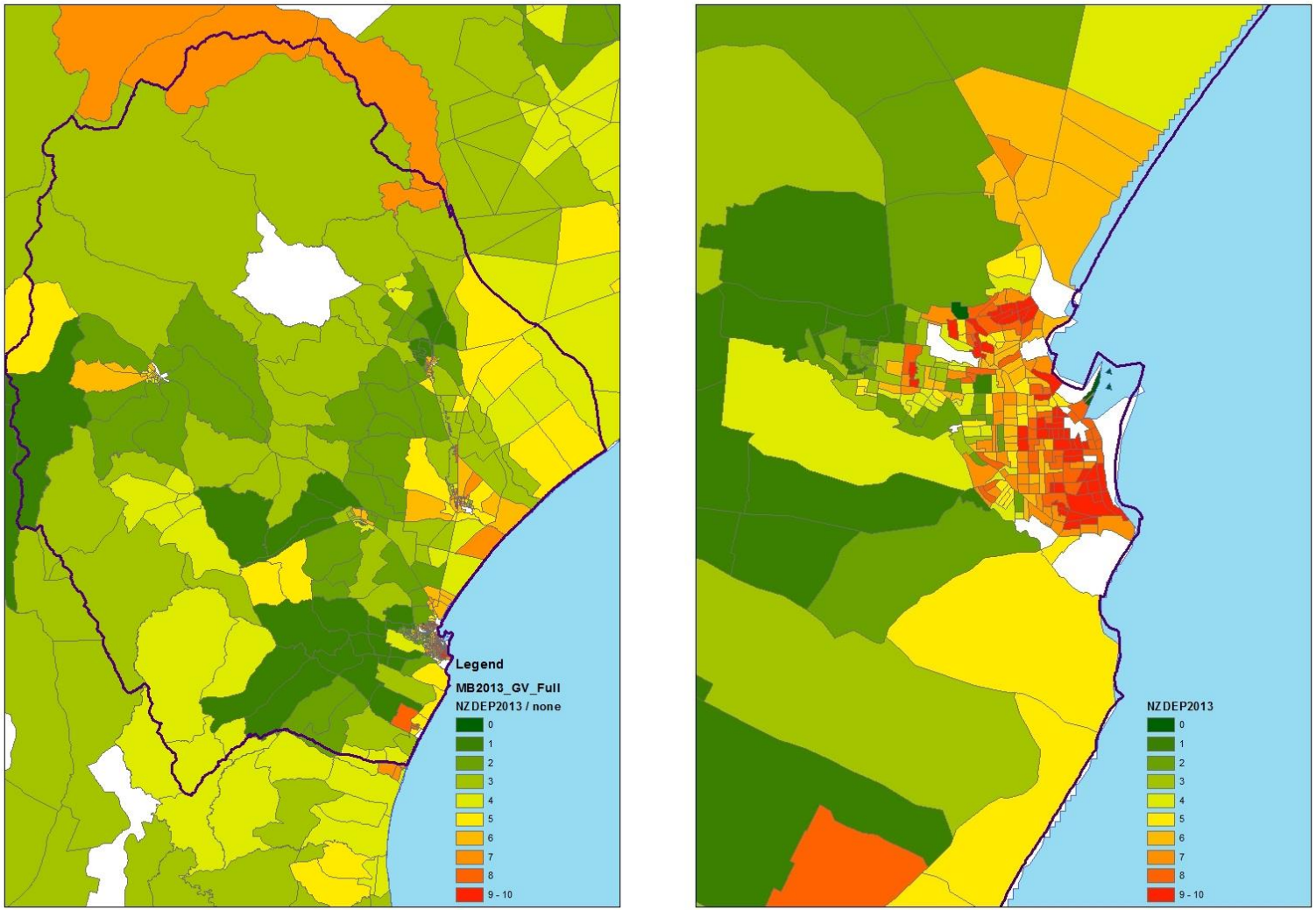

Figure 3: NZ Deprivation Index: OTOP Zone (left) and Timaru (right) (score of 10 indicates the most deprived areas)

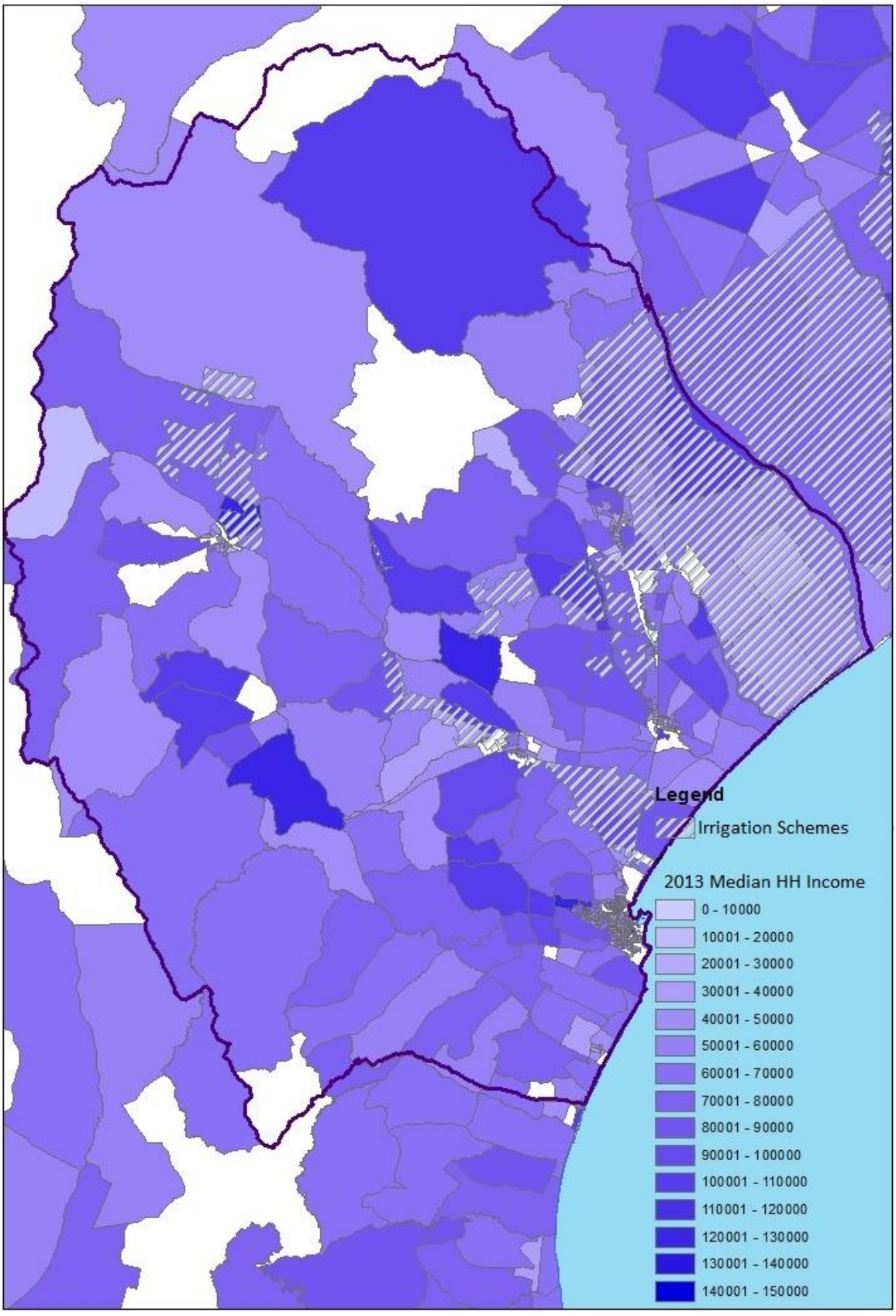

Figure 4: Median household income (2013) and current irrigation

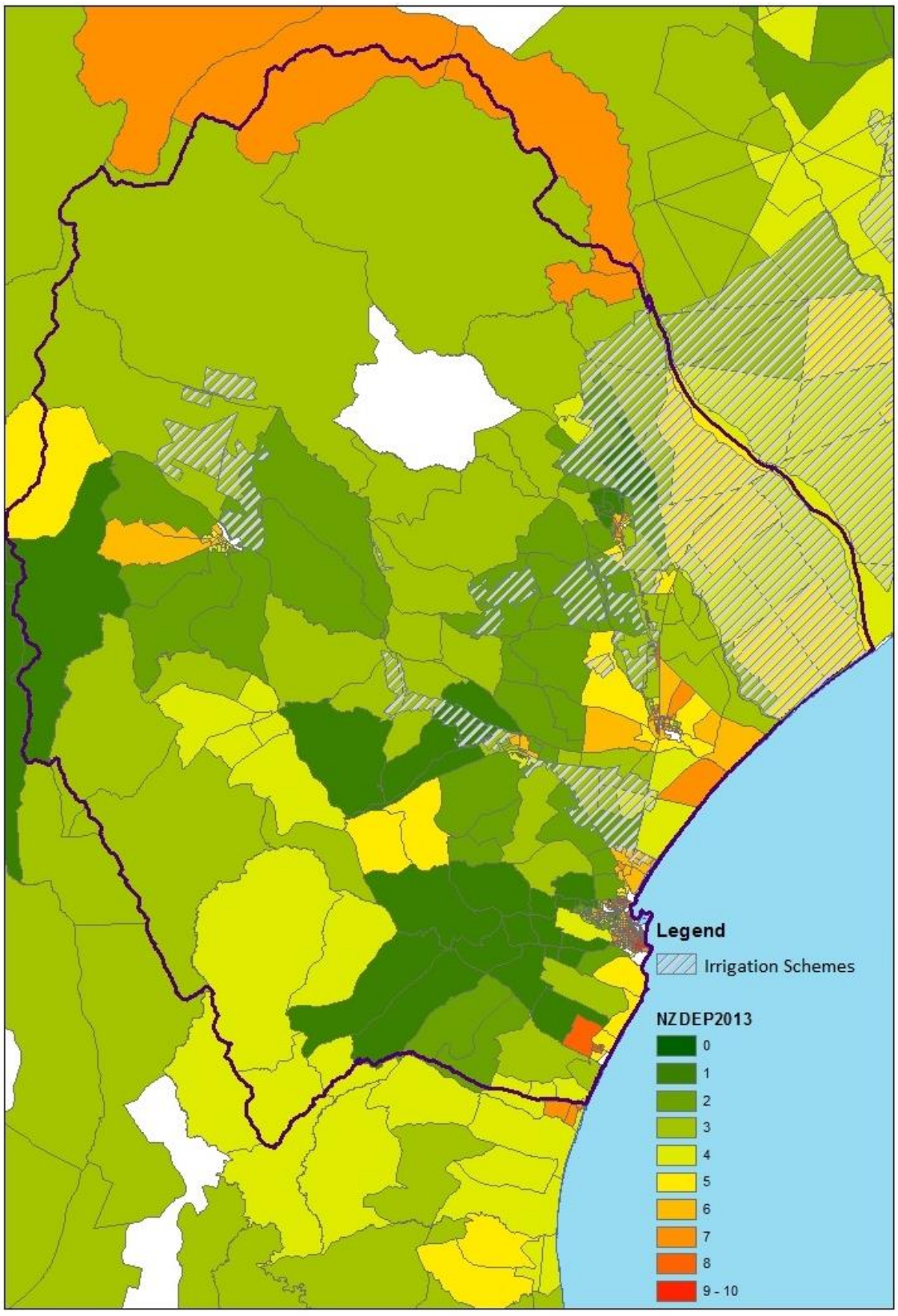

Figure 5: NZ Deprivation Index (2013) and current irrigation.

6 Scenarios assessment

This section provides a qualitative overview of anticipated social impacts under the three scenarios. Table 2 provides an overview and comparison of potential impacts under each of the themes identified in the previous assessment (Kalaugher & Wright 2016) as outlined in Table 1.

6.1 Scenario 1: Current pathway[3]

The current pathway scenario assumes the full implementation of all regional plans and all farming activities operating at Good Management Practice (GMP), including compliance with stock exclusion rules and at least 80% irrigation efficiency. In over-allocated[4] catchments, the volume allocated for water takes is reduced to 90% of current allocation and intensification is limited by constraints under planning rules. Otherwise, all land use activities, climate variability, available water and flow variability are assumed to remain unchanged. The exception is the reliability of supply is reduced in the Orari and Pareora from the introduction of higher minimum flows in accordance with the Pareora Catchment Environmental Flow and Water Allocation Regional Plan, and the Land and and Water Regional Plan for the Orari Catchment. These areas are currently overallocated catchments. The current pathways scenario does not bring all allocations down to the limits that have been set. Groundwater levels and stream flows are likely to continue to fall in the areas that remain overallocated.

In general, this scenario is likely to have only a small economic impact, although the reduced reliability of supply in the Rangitata-Orton and Pareora catchments may have some negative impacts on farmers (see table 10, p21 BERL 2017) in more localised areas. In addition, the strong economic growth seen over the past decade may slow with restrictions on further expansion and intensification of dairying. Flow-on effects may include a slowing of the influx of migrant labour into the area.

The current planning requirements are unlikely to make a significant improvement in environmental quality[3]. This lack of improvement along with the reduced reliability of water supply in some areas may promote dissatisfaction, particularly in the urban community. This may lead to a polarisation of views, which could negatively impact on the work of community groups and social cohesion in the OTOP community. The extent of the impact will be influenced by how communication processes are managed, and the support offered

[3] Scenario information described in this section is drawn from the Healthy Catchments Project Public Workshops November 2016 presentation on Scenario One: Evaluating the Current Pathways. https://apps.canterburymaps.govt.nz/OTOP/images/OTOP%20Current%20pathways%20presentation%20_Nov%202016.pdf

[4] Over-allocated catchments refer to those catchments where the consented water takes exceed the water available for irrigation under increased minimum flow requirements.

to farmers by council and industry organisations during the implementation of the current regional plans and the move towards full GMP adoption by the farming community.

6.2 Scenario 2: In zone gains[5]

This scenario is focussed on better management of current resources, including increasing irrigation efficiency to around 90%, and reducing race losses from irrigation schemes such as Rangitata South to improve the reliability of water supply and reduce both ground and surface water abstraction in the area.

In addition, farmers in Rangitata-Orton, Levels plains and Ashwick Flat are required to go beyond GMP to reduce loss of N (by 30-40%, 28%, 9% respectively[6]) and protect drinking water quality. Modelling shows that going beyond GMP for these areas is likely to improve average nitrate levels in groundwater, but some hotspots remain. In this scenario, the Opihi and Temuka catchments groundwater abstractions will be assessed against calculated stream depletion effect using the methodology in the Land and Water Regional Plan. This slightly improves low flows but reduces supply reliability.

On-farm practices will be the focus of changes in the catchment for the in-zone gains scenario. Pressure to move beyond GMP, potential increases in debt levels to implement these practices, and higher expectations for water-use efficiency will likely be a source of significant stress and financial pressure for farmers in some areas. Combined with a reduction in the reliability of water available, increases in stress and impacts on mental health are likely. It is important for this scenario to identify areas where the greatest farm management changes will be required, such as Rangitata-Orton and Levels plains, and specifically consider the vulnerability and adaptive capacity of farmers in those areas (for example debt levels, involvement in catchment and support groups).

There is potential for ongoing water quality issues in the lower catchment to increase both polarisation of views and conflict within and among catchment groups. Recognition of and support for farmers going beyond GMP by both Council and industry support organisations, as well as other local initiatives to improve water quality (e.g. catchment groups, Talbot Forest Working Group, the Orari River Protection Group) may be an important factor in the success or otherwise of this scenario. Additional support for farmers could also take the form of collaborative research on locally appropriate management solutions for reducing

[5] Scenario information described in this section is drawn from the Healthy Catchments Project Public Workshops presentations on Alternative Pathways https://apps.canterburymaps.govt.nz/OTOP/images/OTOP%20May%20public%20workshops%20presentation%20In-zone%20gains%20and%20New%20Water.pdf

[6] These figures have been updated from the original scenario descriptions to reflect recent information provided to the OTOP Zone Committee in S. Hayward & M. Scott, Water quality issues and options for groundwater and surface waterways of the Timaru freshwater management unit (FMU), memorandum to D. Clark & C. Davison, 18 August 2017.

nutrient leaching (e.g. appropriate pasture and fodder crop species) and managing under water restrictions (e.g. water storage, water sharing arrangements).

Implementation of GMP and practices beyond GMP, as well as investment in the required infrastructure, will depend on the decisions and abilities of people managing and working on farms. For this reason it is also important to consider the influence of farm management structures, such as farm manager and sharemilking arrangements, and the availability of and support for skilled agricultural workers. Potentially, improvements in environmental quality and on farm management practices could have positive flow on effects in efficiency of resource use (e.g. improved water use efficiency), and create new opportunities in added value products (e.g. initiatives like that of Taupō beef) and in tourism (e.g. Agritourism).

6.3 Scenario 3: New water[3]

This scenario explores the potential for new irrigation in the OTOP zone, on a small scale or large scale. Under the small-scale irrigation scenario, existing consented schemes would source new water from the Rangitata and Waitaki rivers, resulting in irrigation of approximately an additional 1700 ha in the Orari and Temuka catchments. As with other scenarios, farms are expected to operate at GMP. The large-scale irrigation scenario builds on the small-scale option and also draws on new water supplied from alpine rivers. The new water would irrigate an extra 15,010 ha, split between 11,710 ha of new irrigation area and 3,300 ha of stream depleting groundwater being replaced by high reliability alpine water. This water is not currently consented and the actual source of the new water and related planning processes or environmental impacts is not considered in this assessment.

New irrigation is usually accompanied by a shift to more intensive land use. The increased availability of water will improve the security of supply and may increase economic growth, especially in dairy and horticulture. It is expected that replacing existing surface and groundwater fed irrigation with water from new sources will improve control of water flows and as a result, provide some environmental benefits such as improved low flows. However, the additional irrigated areas increase the risk to water quality, particularly in the Opihi and Pareora catchments. The new water is expected to result in further land use intensification, more nitrate in surface and groundwater and an increased risk of Phormidium (cyanobacteria). In Timaru, the risk to drinking water may also increase, as well as the risk for recreational purposes such as swimming.

For the new water scenarios, an important consideration will be where expansion and intensification is likely to occur and where the most economic gains can be made with the least environmental impact. Figure 6 shows the Land Use Classification (LUC) map for the OTOP zone. Lynn et al. (2009) describe the classification in more detail, where class 1 land is the most productive and versatile, with classes 1–4 considered most suitable for arable cropping.

BERL (2017) have indicated for this zone the following current gross margins in $/ha for different land uses:

- Arable cropping or seed production: $1,900 (dryland) and $5,500 (irrigated);

- Dairy: $1,315 (dryland) and $3,732 (irrigated);
- Beef cattle or sheep: $149 (dryland) and $550 (irrigated);
- Mixed sheep and beef: $393 (dryland) and $1,056 (irrigated);
- Deer: $362 (dryland) and $1,095 (irrigated);
- Grazing: $149 (dryland) and $550 (irrigated);
- Vegetable and fruit growing: $3,442 (dryland) and $4,392 (irrigated).

Figure 6 shows that the areas indicated for the increase in new irrigation for both scenarios occur largely on very versatile land, particularly in the small-scale scenario where the greatest increase is south of Timaru. The large-scale scenario expansion is indicated at a higher altitude and further upstream, suggesting environmental impacts under this scenario may be more widespread.

The likely positive economic effects of this scenario may provide opportunities beyond the direct benefits to farmers. Particularly on highly versatile land, more irrigated dairy and, particularly, an increase in horticulture and arable/seed production may provide employment opportunities and support growth in secondary/support industries. This may also affect the composition of the OTOP community by encouraging more young people to stay in the area or return to the area after university. Higher value production from highly versatile land may also reduce the risk of expansion of lifestyle blocks onto these areas.

The expected intensification of agriculture as a result of the new water is likely to require more labour and will likely result in more migrants coming to the area as agricultural workers. As discussed in Kalaugher and Wright (2016), a number of challenges are associated with more migrant workers. In particular, migrant workers in rural areas can easily become isolated from support services. Under this scenario employment issues on farms may require particular attention. The level of skill and care of agricultural workers can directly affect the practical implementation of GMPs on farm.

The anticipated negative effects on water quality under this scenario may have both direct and indirect negative impacts. A decline in water quality for drinking and recreation may have a negative impact on tourism in the area, although tourism is currently focused mainly in the upper catchments. It may increase tension between the rural and urban community, and also Māori, potentially affecting the effectiveness of catchment groups.

Indirect effects on human health, particularly mental health and well-being, are difficult to measure. However, it has been suggested (e.g. Keniger et al. 2013; Speldewinde et al. 2009) that there is an important link between human well-being and the natural environment.

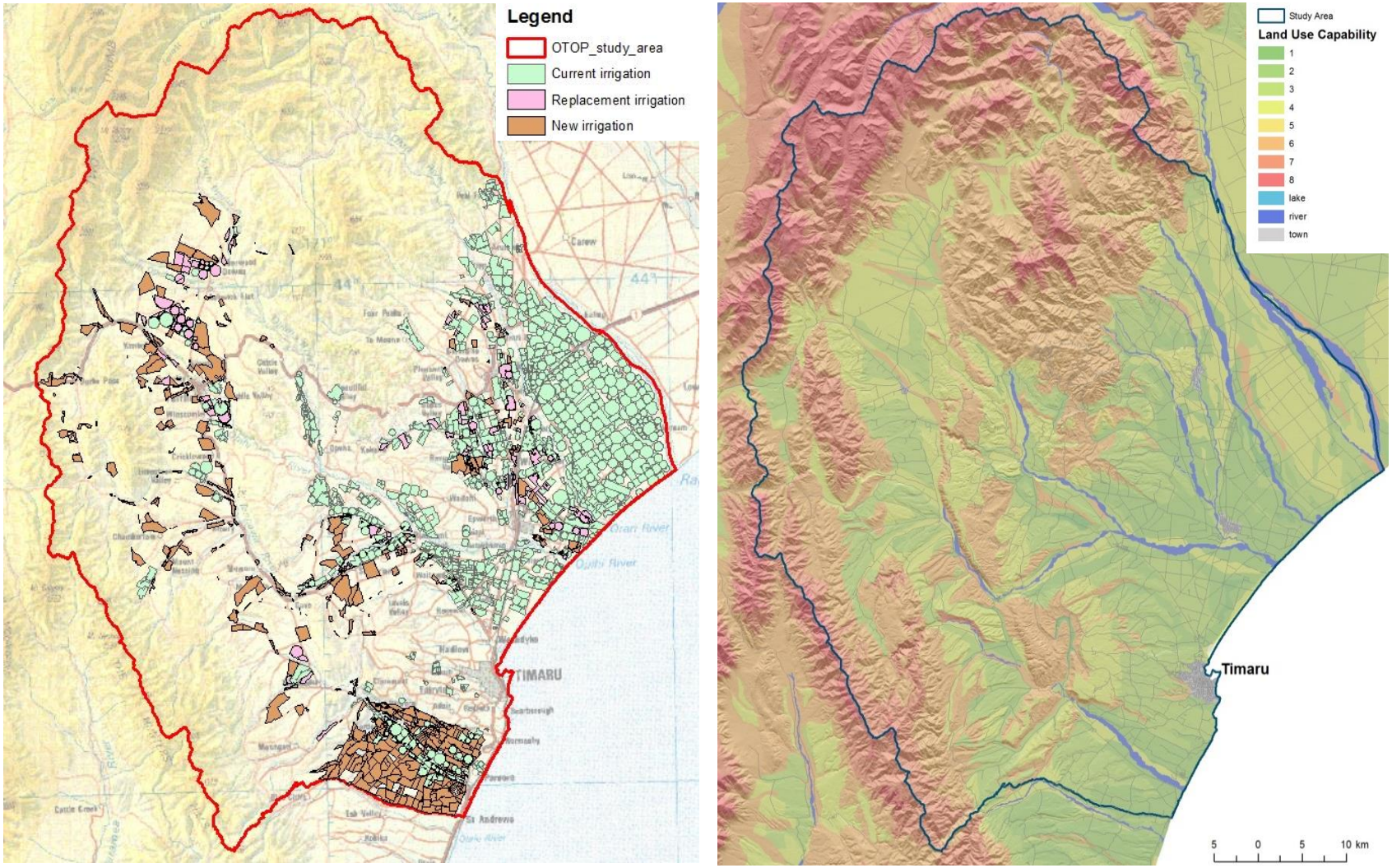

Figure 6: Land use capability map of the OTOP zone. Source: Manaaki Whenua Landcare Research 2000.

Table 2: Overview of potential impacts of the three scenarios, in relation to the themes identified in Kalaugher & Wright (2016)

	Current state (see Kalaugher & Wright 2016)	1. Current pathways	2. In-zone gains	3. New water
Community composition The proportion of the community that is changing in composition.	General trends show the OTOP population growing slowly, largely through immigration, and at the same time aging. Economic growth has been a driver of immigration, for example to work on dairy farms. School rolls have highlighted increasingly diverse communities. The distribution of migrant workers is closely related to localised economic opportunities. For example, migrants in the McKenzie district tend to work in the hospitality industry; the Waimate district employs many Chinese immigrants in agricultural work.	Current trends are likely to continue under this scenario, although limitations on further expansion and intensification of dairy farming may slow the rate of change in trends such as immigration.	Current trends likely to continue and potentially slow as per current pathways. Environmental improvements may potentially lead to increased opportunities in tourism. This may attract more young people to the area and require additional labour in the hospitality industry.	The new water scenario may drive further economic growth especially in dairy and horticulture, and migration trends are likely to move faster than other scenarios as a result, with a greater need for agricultural workers. Economic growth may also attract more young people to the area and result in youth seeing more opportunities in agriculture.
Well-being of community The well-being of farmers, the migrant community and the urban community should be monitored separately to identify trends in these groups	Strong economic growth over the past decade has been reflected in employment growth, with all sectors showing a steady increase in employment. The percentage of the population who own their own home has dropped since the 2001 census. School rolls have increased and the decile rating of schools has risen, particularly in rural areas. Migrants face many challenges, e.g. in	This scenario will likely maintain and potentially improve the zone's economy and employment. Negative impacts on wellbeing may stem from lack of improvement in environmental quality. For example, dissatisfaction of the urban community and Māori community, and increasing polarisation of	Will likely maintain and potentially improve the zone's economy and employment. Efforts made by farmers to improve environmental performance may improve rural/urban relationships, particularly where farmers go beyond GMP. The combination of very high expectations around efficiency, the need to go beyond GMP and reduced reliability of flows may	Increased irrigation provides economic benefit within the zone, including areas outside of the catchment receiving water. Reduction in environmental quality may have social impacts. In particular, negative impacts on drinking water quality in Timaru, and Phormidium affecting recreational water quality may increase the dissatisfaction of the urban community and increasing polarisation of views, resulting in a loss of social capital.

	Current state (see Kalaugher & Wright 2016)	1. Current pathways	2. In-zone gains	3. New water
	settling and accessing services. Some areas have high nitrate levels in the water: Lowland streams, (lower Orari) and groundwater in some areas (Ashwick Flat, Lower Orari, Levels Plains.	views, resulting in a loss of social cohesion.	be a significant source of stress for farmers in some areas. Positive impacts on human health may occur through improvements in environmental quality.	Indirect negative impacts on human health may also occur as a result of loss of environmental quality, e.g. reduced activity levels and connectedness with the natural environment. Potential increase in unskilled migration may increase pressure on resources available and challenges to the migrant community. Tourism may be negatively impacted through reduction in environmental quality.
Recreational quality Trends in public use and enjoyment of recreational areas	Many recreation opportunities in OTOP are freshwater-based, including walking, tramping, boating, kayaking, swimming, hunting, fishing, whitebaiting, rafting, camping and picnicking. The Rangitata, Orari and Opihi rivers are particularly popular fishing spots. The Timaru district has a relatively low provision of sports and recreational land, and the Parks Strategy (Kelly 2011) recommends increasing this area. However, the Timaru District Growth Strategy suggests that the ageing population may mean demand for active sports may decrease, and other recreation opportunities may be required such as gardens and gentle walking tracks.	This scenario maintains water quality in areas where it is currently good and provides some improvement at some sites with poor water quality. However, there is little overall improvement in recreational water quality under this scenario. It is considered highly unlikely under this scenario that all surface waterbodies will be safe for recreation and gathering mahinga kai.	Flows remain similar to Current Pathway, with continued low flows and dry reaches. It is suggested that community outcomes for recreation and mahinga kai are still unlikely to be met due to *E. Coli*. However, on-farm improvements may have positive flow on effects for other areas which have not been accounted for in the modelling. Upper catchment water quality and quantity remain good, and N-loss reductions beyond GMP improve average nitrate levels in groundwater.	Impacts on recreational water quality are likely to be negative overall, with increased risk of Phormidium affecting recreational water quality in many areas, particularly for swimming. Replacing existing surface and groundwater-fed irrigation should provide some environmental benefits in terms of flows and groundwater recharge.

	Current state (see Kalaugher & Wright 2016)	1. Current pathways	2. In-zone gains	3. New water
	Dry summers and lack of high flows have contributed to issues with cyanobacteria and algal growth, and many popular recreation spots have issues with algal blooms that affect swimming and fishing.			
Farm environmental performance The urban population, recreational water users and consumers are increasingly demanding accountability for environmental performance	Agricultural industry support organisations and some irrigation schemes have developed approved templates for farm environment plans. There are 172 dairy farms in the OTOP zone requiring farm plans, of which 94 have been completed or are underway with DairyNZ. IrrigationNZ suggests there is considerable scope for improvement in irrigation efficiency. Formal irrigation manager training is a requirement of Farm Environment Plan process. Of 302 dairy herds in South Canterbury, 63% are owner operated and 37% are run by sharemilkers. Data from the Survey of Rural Decision Makers (2015) indicates there is a much higher proportion of a seasonal/casual worker than permanent staff.	The current pathways scenario assumes all farms will operate at GMP, producing a 5–15% improvement in key water quality indicators. Support from the council and agricultural industry, for example collaborative research and sharing information and examples of successful implementation of good management practices, may be required to bring all farms in the area up to GMP, and bring irrigation efficiency up to a minimum 80%.	This scenario demands a high level of investment and management and it is therefore even more important to consider the influence of farm structure (e.g. sharemilking arrangements) and employment arrangements. All farming in Rangitata-Orton zone will be expected to go beyond GMP (30-40%). Increased investment in research into locally appropriate solutions may be required, as well as support for farmers under this scenario. IrrigationNZ has suggested that 90% irrigation efficiency may be unrealistic as a general target (Steve Breneger, 13 September2017, pers. comm.).	New irrigation is usually accompanied by a shift to more intensive land use. This scenario is positioned for agricultural expansion and increased intensification and as such, may incentivise quantity of products over quality. There will be less regulatory pressure to improve water use efficiency under this scenario, and more water available overall. However, investment in new irrigation infrastructure may contribute to improved water use efficiency. Increasing intensification and the accompanying demand for additional labour may also reduce the quality of labour available. Economic opportunities may also attract educated youth back to family farms.
Farm economic performance Trends in performance of	Economic growth in OTOP has been driven primarily by increases in dairy production. In the 2014/15 season South Canterbury dairy farms produced an average 1,347	An economic assessment (BERL 2017) has suggested that under this scenario, total water availability in currently irrigated areas	Investment and new infrastructure will likely be required of farmers to achieve the required improvements,	Increased irrigation provides economic benefits for farmers. New infrastructure and expansion of dairying will likely increase debt levels.

	Current state (see Kalaugher & Wright 2016)	1. Current pathways	2. In-zone gains	3. New water
farms in different sectors, to understand likely drivers of change	milksolids/ha and 395 milksolids/cow. Cows were milked an average 6 days longer than the NZ average.	will drop by around 4% This is expected to reduce Direct gross margins and Value chain GDP by about 2 percent of the current levels with similar levels of employment reductions (BERL 2017) Reliability of water supply decreases in the Orari and Pareora. This may negatively impact farmers in these areas in dry periods.	potentially increasing debt levels. Increased emphasis on GMP, leadership in some areas to achieve beyond GMP and potentially, the accompanying investment in upskilling staff may have positive flow-on effects in other areas, such as improved water management efficiency or increased utilisation of smart farming technologies. Improving farm environmental performance beyond GMP may create opportunities in high value products and/or agritourism.	This scenario may also increase competition for land.
Cultural values Values of particular significance to Māori (N.B. Separate cultural reports have been completed or are in preparation and available on the Healthy Catchments website).	The proportion of the community identifying as Māori has increased slightly. Māori values are closely associated with the wellbeing of the environment. Particular concerns identified include the wellbeing of mahinga kai species, wetland loss and coastal erosion.	While this scenario may protect and enhance existing indigenous biodiversity, it will not improve some areas of greatest concern to Māori such as mahinga kai.	Some improvements in environmental quality, e.g. improved mahinga kai, and more wetlands created. Any increase in tourism could potentially have flow on effects for Māori interests such as the Te Ana Rock Art Centre.	Despite some benefits from improved control of water flows, environmental effects are likely to be negative overall, particularly for drinking water and recreational water quality from the likely increase in nitrates in water. This is likely to be a source of concern to Māori.
Community groups Composition of catchment groups and connection with other groups. Engagement and	A number of community groups are actively working together to improve environmental outcomes for the zone (e.g. catchment groups, Talbot Forest Working Group, the Orari River Protection Group). Sports clubs also play a key role in the	Local on-the-ground actions have the opportunity to provide some improvement in water quality and habitat. However, if there are no clear improvements and	Increased pressure on farmers to perform beyond GMP may increase tensions in some catchment and other community groups, if the burden of changing farming practices is felt to be unfair or unsupported.	Expansion and/or intensification of agriculture may result in polarisation of the rural/urban community if there is associated environmental degradation.

	Current state (see Kalaugher & Wright 2016)	1. Current pathways	2. In-zone gains	3. New water
activity levels	social structure of the OTOP zone.	community goals are not met, this may gradually increase tension within the community. Much will depend on perceptions of effectiveness and equity.		
Adaptive capacity Potential for and resilience to change	There are several indicators that the OTOP community has a strong capacity to adapt to change. The zone has a long and diverse history as an agricultural zone. The area is highly versatile and the mix of agricultural products has changed over time according to markets and other factors. In recent years, dairying has expanded quickly. South Canterbury dairy farms are performing very well in both production and indicators such as somatic cell count. The area also has a very strong community spirit and a range of highly engaged community groups, including active marae and involvement in sports clubs.	Limits on dairy growth may lead to economic diversification, potentially leading to diversification in secondary processing industries.	If pressure to improve performance beyond GMP in hotspot areas is accompanied by appropriate support for farmers, it could potentially incentivise innovative solutions and value-added products. Providing appropriate support would require an in-depth understanding of localised challenges and any barriers that may exist to change – for example, access to research and technology, financial or labour issues. High standards for irrigation efficiency (90%) may promote expansion of the industry around irrigation technology.	Economic benefits in time may increase the ability of farmers to invest in improvements to their farms. New opportunities will likely be provided through increased water availability including diversified land uses, which may contribute to improved community resilience. Increased water availability will likely be a driving force for further economic development in the zone. However, increased pressure on natural resources may be unsustainable in the long term and eventually require tightening of environmental standards. Investment in infrastructure for more intensive agricultural operations including irrigation technology may create path dependencies. For example, debt incurred to pay for such infrastructure will reduce flexibility to change to a different land use in future.

7 Discussion and conclusions

The previous section provided some specific issues for consideration in the context of the proposed water management scenarios. However, from a social community perspective, much will depend on how the proposed changes are implemented, the effectiveness of practices to improve environmental quality, and the perceived equity and the distribution for any resulting new opportunities.

7.1 Farm environmental performance

In all scenarios, expectations for farm environmental performance increases. These expectations vary depending on the scenario and where the improvements are to occur. Some environmental performance expectations, such as the requirement for 90% irrigation efficiency, may be considered unachievable by some farmers and primary industry support organisations such as IrrigationNZ. In addition, the requirement to go beyond GMP in some areas will increase pressure on farmers in those areas. The development of agreed GMPs[7] was a long, intensive and important process. Any requirement for farmers to go beyond these industry-agreed GMPs needs to be carefully considered and accompanied with appropriate technical and potentially financial support.

In addition, concerns have been raised in community meetings around the use of the OVERSEER® model, with farmers emphasising that the model was originally intended as a tool for farmers to improve performance, rather than a monitoring instrument. Particularly in areas where farmers are expected to improve performance beyond GMP, the use of OVERSEER® may prove controversial. It will be important to openly discuss the way in which this tool is used.

There are New Zealand examples where strict nitrogen limits have stimulated innovation. For example, the Taupō cap-and-trade scheme for nitrogen prompted the established of Taupō Beef[8]. Taupō Beef is commanding a premium price for high quality beef produced in a farming system specifically designed to reduce nitrogen losses. Such examples highlight the potential for high end agricultural products marketed both on quality and environmental performance. There are also examples, such as the Starborough–Flaxbourne area in Marlborough[9], that have sought new knowledge and subsequently been transformed by management practices to improve water use efficiency and combat erosion. However, it is important to note that in these cases, a strong external driver has been present. In Taupō, a

[7] http://files.ecan.govt.nz/public/pc5/MGM_Technical_Reports/Industry_Agreed_Good_Management_Practices_MGM_2015.pdf

[8] https://www.taupobeef.co.nz/

[9] http://www.landcare.org.nz/Regional-Focus/Nelson-Office/Starborough-Flaxbourne

new regulation and in Marlborough, several consecutive years of drought drove the technical innovations.

As noted in Kalaugher and Wright (2016) agriculture in the OTOP zone has weathered many changes in the past, is highly versatile and produces a mix of agricultural products that has varied over time with changes in markets and other relevant factors. The secondary processing industry has also developed and changed over time. A number of indicators suggest OTOP farmers may be well positioned to be at the forefront of nutrient management innovation in New Zealand. Data from the most recent Survey of Rural Decision Makers (Brown 2015) suggests that farm decision makers in the zone are very experienced. Compared with the rest of New Zealand, there appear to be a higher proportion of farmer decision-makers in the Timaru, Mackenzie, and Waimate districts whose family have been on the land for three or more generations (Brown 2015, see Kalaugher & Wright 2016). This suggests they are likely to have both a strong sense of place and a good understanding of the changes already experienced in the zone. They are also well-educated compared with the general population (Kalaugher & Wright 2016).

Much research has gone into farming practices to reduce nutrient leaching in recent years – for example, the P21 programme[10] – with some promising results, in particular around the use and management of different pasture and crop species. It is important to note that many of these innovative practices are not yet represented in the OVERSEER® model. In order to stimulate the innovation required, it will be important to build flexibility into the new rules to accommodate innovative farming practices, new learnings and place-based successes.

Actual implementation of management practices on farms, as well as investment in the required infrastructure will depend on the decisions and abilities of people managing and working on farms. In areas identified as nutrient hotspots, it may be valuable to work directly with farmers to understand their specific capacity and limitations or bottlenecks such as level of debt servicing, the influence of farm management structure (e.g. sharemilking arrangements), or the availability of skilled labour.

Once these locally specific issues are understood, collaborative research would be beneficial to jointly identify and implement locally-appropriate solutions, as well as identifying new potential economic opportunities – for example, in agritourism or high value products. Support for farmers in these areas from catchment and/or community groups will also be important in maintaining and building community cohesion and reducing stress on farmers.

7.2 Water flows in the zone

One of the key recurring themes in community consultation is the need for greater security in water availability, and the need to provide for future economic growth. Small-scale water storage is currently in use on some farms, but requires investment and provides only a

[10] https://www.dairynz.co.nz/about-us/research/pastoral-21/

short-term and localised solution. It may be beneficial to consider options for improved management and sharing of existing water resources not only at the farm scale but at zone level.

The success of the Opuha Environmental Flow Release Advisory Group (OEFRAG) in improving management of waters supplying the Opuha and Opihi rivers indicates that there is considerable potential for collaborative approaches to water management. The Above Dam Irrigators Group has also noted[11] that flow sharing has been voluntarily practised by farmers taking from the South Opuha for around 15 years. The diversity of water sources in the zone, including groundwater and four major rivers, suggests there may be potential to improve security of supply through improved coordination of supply and demand from different sources; and mechanisms such as water sharing arrangements (Steve Breneger, 13 September 2017, pers. comm.). To achieve this, one of the most important factors would be the relationship between the different water schemes operating in the zone. It may be beneficial to consider options for incentivising collaboration between the different schemes.

7.3 Community well-being

Community well-being is at the heart of all considerations when planning for the future of the OTOP zone. Many of the factors discussed above, such as economic factors and potential demographic changes, will directly and indirectly affect the well-being of people in the OTOP.

For migrants to the OTOP zone, as discussed in Kalaugher and Wright (2016), key issues are social isolation and access to amenities and services. Employers have been identified as a key resource both for understanding and improving problems facing migrant workers.

Indirect effects on human health, particularly mental health and well-being, are difficult to measure and causal links difficult to establish. However, it has been suggested (e.g. Keniger et al. 2013; Speldewinde et al. 2009) that there are important links between human well-being and the natural environment, and indirect negative impacts on human health may occur as a result of loss of environmental quality. For example, Albrecht et al. (2007) gave the term “solastalgia” to mental distress that occurs with environmental degradation.

For Māori, cultural interconnectedness with the environment lends a particular significance to this issue. A greater number of residents identify as Māori than a decade ago. This is potentially a factor of ‘ethnic mobility’ or increasing reconnection with Māori ancestry, rather than a direct result of increasing birth rates (Rarere 2012).

Also important to mental health are the connections between people, networks, norms and trust, often described as social capital (McKenzie et al. 2002). Despite the challenges, these issues need to be included in considerations of the future development of the Zone: The

[11] https://apps.canterburymaps.govt.nz/OTOP/images/Above%20Dam%20Irrigators%20presentation.pdf

South Canterbury District has a high level of diagnosed common mental disorders, particularly evident in younger women, and during the period 2009–2013 had significantly higher suicide rates than the national average[12].

7.4 Catchment groups and local solutions

The OTOP zone has an engaged community and active catchment groups, representing a clear opportunity to involve the community in finding local-level solutions to environmental issues. These catchment groups and the zone committee clearly feel strongly about improving the environment while maintaining a thriving economy. Many concerns voiced in the community workshop related to monitoring of waterways and the need for improved data. One way to harness the potential inherent in such a high level of engagement may be to develop environmental monitoring programmes in which the community participate (Storey et al. 2016, Peters, 2016). There are examples of such programmes in other parts of New Zealand including the Auckland WaiCare programme[13]. Recently, Landcare Research has also worked to develop a mobile App to facilitate the monitoring of cultural values, initially for a Waikato Iwi. In many cases farmers have valuable local knowledge and this kind of monitoring exercise can help facilitate collaboration between different parts of the community with potential to involve groups such as Marae, schools, farmers, sports clubs and the urban population.

8 References

Albrecht G, Sartore G-M, Connor L, Higginbotham N, Freeman S, Kelly B, Stain H, Tonna A, Pollarg G. 2007. Solastalgia: the distress caused by environmental change. Australasian Psychiatry 15: Suppl 1:S95-8

BERL 2017. OTOP Scenario Economic Assessment. Technical report. October 2017. Wellington, BERL.

Brown P 2015. Survey of rural decision makers. Landcare Research Ltd. www.landcareresearch.co.nz/srdm2015 DOI: 10.7931/J28913S8

Maré D; Alimi O, Poot, J. 2015. Revisiting income inequality within and between New Zealand's regions: Analysis of 1986-2013 Census data. Presentation to Pathways conference, Wellington, 24 July 2015. Retrieved 24 October 2017 from http://www.caddanz.org.nz/massey/fms/caddanz/3_%20Dave%20Mare%20Income%20Inequality%20Pathways_20150720.pdf?98E1E04AD7AA562EE81860056C89EDAD

Environment Canterbury 2013. The Canterbury Water Management Strategy. Zone Supplement for Ōrari-Ōpihi-Pareora Zone 2013–2014. http://ecan.govt.nz/publications/Plans/oop-water-supplement.pdf (accessed 25 September 2016)

[12] http://www.health.govt.nz/publication/suicide-facts-deaths-and-intentional-self-harm-hospitalisations-2013

[13] https://waicare.org.nz/Home.aspx

Kelly J 2011. Parks Strategy 2012 to 2022. Xyst report for Timaru District Council. Xyst Ltd.

Keniger LE, Gaston KJ, Irvine KN, Fuller RA 2013. What are the benefits of Interacting with nature? International Journal of Environmental Research and Public Health 10: 913–935; doi: 10.3390/ijerph10030913

Lynn IH, Manderson AK, Page MJ, Harmsworth GR, Eyles GO, Douglas GB, Mackay AD, Newsome PJF 2009. Land use capability survey handbook – a New Zealand handbook for the classification of land, 3rd edn. Hamilton, AgResearch; Lincoln, Landcare Research; Lower Hutt, GNS Science. 163 p.

Landcare Research, Manaaki Whenua 2000. NZLRI Land Use Capability. URL: https://lris.scinfo.org.nz/layer/48076-nzlri-land-use-capability/ (accessed 23 May 2017).

McClintock W, Taylor N, McCrostie Little H 2002. Social assessment of land use change under irrigation. Working Paper no. 33, November 2002. Available: http://www.tba.co.nz/pdf_papers/2002_wp_33_land_use_change.pdf (accessed 25 September 2016).

McCrostie Little H, Taylor N 2001. Social and economic impacts associated with irrigated land use change. Proceedings of Seventh Annual Conference of the New Zealand Agricultural and Resource Economics Society (Inc.), Blenheim, July 2001. AERU Discussion paper No 148. Canterbury, Lincoln University.

McKenzie K, Whitley R, and Weich, S. 2002. Social capital and mental health. British Journal of Psychiatry181: 280–283. 10.1192/bjp.181.4.280

OPUS 2003. Climate change case study: flood risk arising from future precipitation changes in Gleniti, Timaru. Prepared for the NZ Climate Change Office (Ministry for the Environment) by OPUS International Consultants Limited in conjunction with Timaru District Council, December 2003. http://www.mfe.govt.nz/publications/climate-change/climate-change-case-study-flood-risk-arising-future-precipitation. Accessed 23 September 2017.

Peters, M. 2016. An Inventory of citizen science initiatives, resources and learning opportunities in New Zealand. A report prepared for the NZ Landcare Trust, Hamilton, New Zealand. p. 55

Polkinghorne, J. 2017. A New Zealand Local Population Database. Retrieved 24 October 2017 from http://on-cue.co.nz/John%20Polkinghorne.pdf

Rarere MA 2012. The determinants of tribal population growth in the New Zealand census. Masters thesis. University of Waikato.

Rutledge DT, Ausseil A-GE, Baisden T, Bodeker G, Booker D, Cameron MP, Collins DBG, Daigneault A, Fernandez M, Frame B, Keller E, Kremser S, Kirschbaum MUF, Lewis J, Mullan B, Reisinger A, Sood A, Stuart S, Tait A, Teixeira E, Timar L, Zammit C (2017). Identifying Feedbacks, Understanding Cumulative Impacts and Recognising Limits: A National Integrated Assessment. Synthesis Report RA3. Climate Changes, Impacts and Implications for New Zealand to 2100. MBIE contract C01X1225. 84pp.

Sandifer PA, Sutton-Grier AE, Ward BP 2015. Exploring connections among nature, biodiversity, ecosystem services, and human health and well-being: Opportunities to

enhance health and biodiversity conservation. Ecosystem Services 12: 1–15. http://dx.doi.org/10.1016/j.ecoser.2014.12.007

Speldewinde P, Cook A, Davies P, Weinstein P 2009. A relationship between environmental degradation and mental health in rural Western Australia. Health & Place15(3): 880–887.

Storey RG, Wright-Stow A, Kin E, Davies-Colley R, Stott R. 2016. Volunteer stream monitoring: Do the data quality and monitoring experience support increased community involvement in freshwater decision making? Ecology and Society 21(4):32. https://doi.org/10.5751/ES-08934-210432

Timaru District Stormwater Strategy 2018–2048. An integrated approach to urban stormwater management. Document #1078874

NZIER 2014. Water management in New Zealand: a road map for understanding water value. NZIER public discussion paper Working paper 2014/01, March 2014. ISSN 1176-4384 (accessed 25 September 2016).