Waikato Regional Council Technical Report 2018/55

Regional- and national-level economic impacts of the proposed Waikato Regional Plan Change No.1—Waikato and Waipa River Catchments

www.waikatoregion.govt.nz
ISSN 2230-4355 (Print)
ISSN 2230-4363 (Online)

Waikato
REGIONAL COUNCIL
Te Kaunihera â Rohe o Waikato

Prepared by:
Garry McDonald (Market Economics Limited)
Graeme J. Doole (University of Waikato)

This report was commissioned by the Technical Leaders Group for the Healthy Rivers Wai Ora Project
Report No. HR/TLG/2016-2017/4.5a

For:
Waikato Regional Council
Private Bag 3038
Waikato Mail Centre
HAMILTON 3240

August 2016

Document #: 8954531

Peer Reviewed by:
Bryce Cooper
(NIWA) Date December 2015

Approved for release by:
Ruth Buckingham Date December 2018

Disclaimer

This technical report has been prepared for the use of Waikato Regional Council as a reference document and as such does not constitute Council's policy.

Council requests that if excerpts or inferences are drawn from this document for further use by individuals or organisations, due care should be taken to ensure that the appropriate context has been preserved, and is accurately reflected and referenced in any subsequent spoken or written communication.

While Waikato Regional Council has exercised all reasonable skill and care in controlling the contents of this report, Council accepts no liability in contract, tort or otherwise, for any loss, damage, injury or expense (whether direct, indirect or consequential) arising out of the provision of this information or its use by you or any other party.

Regional- and national-level economic impacts of the proposed Waikato Regional Plan Change No. 1—Waikato and Waipa River Catchments

12 August 2016

Garry McDonald[1] and Graeme Doole[2]

[1] Director, Market Economics, Level 5 507 Lake Road, PO Box 331297, Takapuna 0740, Auckland.

[2] Professor of Environmental Economics, Department of Economics, Waikato Management School, University of Waikato, Private Bag 3105, Hamilton.

1. Introduction

The Healthy Rivers Plan for Change: Waiora He Rautaki Whakapaipai (HRWO) Project (www.waikatoregion.govt.nz/healthyrivers) will establish targets and limits for nutrients (N and P), sediment, and *E. coli* in water bodies across the Waikato and Waipa River catchments. Different targets and limits for these contaminants in waterways within this catchment will have diverse impacts on economic outcomes observed throughout the greater Waikato region. Accordingly, a central contribution of the Technical Leaders Group (TLG) to the HRWO project has been the development and utilisation of an economic model that integrates diverse information such that the size and distribution of abatement costs—across farm, catchment, regional, and national levels—associated with alternative limits and targets is predicted (Doole et al., 2015a, b).

The Collaborative Stakeholder Group (CSG) has proposed a policy to initiate improved water quality across the region, with most actions tied to reducing contaminant loss by the rural sector. The draft Waikato Regional Plan Change No. 1—Waikato and Waipa River Catchments (Proposed) (WRPC1) presented at CSG meeting #27 on 9 May 2016 sets out policies that aim to progressively reduce the concentrations of the four contaminants to meet Freshwater Management Unit (FMU) specific targets and associated values of water clarity and suspended algae (chlorophyll-a). The time frame for meeting these ultimate targets for water-quality improvement is 80 years, whereas the current Plan Change aims to ensure that the actions necessary to make a 10% step towards bridging the gap between the current and target states are implemented over the next decade. The target states that the Plan Change seeks to move towards are a key output of the HRWO process; these define goals of substantial improvement in water quality for swimming, taking food, and healthy biodiversity. This involves an improvement in water quality at all sites in the catchment, even if it is already meeting the minimum acceptable state. For further information on the elements of this aspirational state, see Doole et al. (2015a).

The policy mix contained in WRPC1 involves a number of diverse elements (Ritchie, 2016), given the size of the catchment, diversity of land-use sectors, number of contaminants considered, broad heterogeneity in contaminant loss, diversity of mitigation efficacy and cost, and spatial differences in water-quality limits. An additional consideration is that some gains in water quality brought about by this policy may potentially be offset through a proposed

policy that would allow for some future development of iwi land. The complexity of this context emphasises the importance of using predictive modelling to assess the implications of implementing WRPC1. The farm- and catchment-level implications of WRPC1 are set out in the comprehensive study of Doole et al. (2016). However, in contrast to the earlier assessments of Doole et al. (2015a, b), this report does not explore the regional- and national-level implications of the proposed policy mix. This is a deficiency since the regional- and national-level implications of broad-scale policies to reduce the intensification of rural and urban land-use in the Waikato can be significant (Doole et al., 2015a), especially given its size and the importance of this region in terms of agricultural production.

The primary objective of this analysis is to describe the regional- and national-level implications of the policy mix associated with WRPC1 under several different situations. The assumptions used to represent the policy mix are described in Doole et al. (2016). Moreover, that work describes the economic and water-quality implications of these scenarios at the farm- and catchment-level. This report goes a step further, using output from the catchment-level model as an input to an Input-Output (IO) model to identify the regional- and national-level impacts of the WRPC1 policy mix.

Section 2 describes the IO model and the scenarios explored within the model. Section 3 presents model output, with a summary of key findings. Section 4 concludes.

2. Regional economic effects of the proposed policy mix

2.1 Justification of the IO approach

IO models are the most widely-applied method for estimating the regional impacts of environmental policy, both in New Zealand and overseas. Additionally, they are one of the most popular economic methods applied globally (Miller and Blair, 2009), based on their clarity and descriptive capacity. These models study the flow of products, inputs, and sales between households and industries. Their primary advantage is that they describe the complex interdependency between different sectors within an economy, allowing the consideration of numerous flow-on relationships arising from a change in current economic activity. Accordingly, IO models provide a means to estimate the regional impacts of a given policy mechanism, based on the idea that an initial decrease in net revenue entering into a regional

economy—for example, in response to a change in milk production arising from reduced dairy-production intensity—will lead to a decline in subsequent spending in other industries within this economy, but the effect of these diminished contributions will dissipate over time due to the leakage of funds from the local economy (e.g. through expenditure outside of the region or through saving) (Mills, 1993). Such models have many benefits; namely, their ability to capture interrelationships between different sectors, low cost, and apparent simplicity, which helps to promote the clarity of their output. Also, the equilibrium structure of IO models is consistent with the steady-state approach employed in the catchment-level model employed throughout the HRWO process (Doole et al., 2015a, b, 2016).

Nevertheless, these frameworks have some limitations, particularly associated with the inclusion of price impacts, budget constraints, and technical change. The application of IO models is based on an explicit assumption that prices remain fixed, consistent with their equilibrium structure. However, an implication of this is that increased competition for scarce factors of production does not flow through to affect prices (Hughes, 2003). Also, the additional output associated with increased input use is assumed constant. These assumptions are highly stylised, but are justified in applied work based on their clarity, ease to deal with during computation, the inherent focus of these models on regional markets, and the complications associated with utilising more-detailed frameworks that do consider price feedbacks and varying returns to scale. Indeed, in relation to the last point, it is common that seeking to include price impacts through extending a model to become a computable general equilibrium framework or spatial decision support system will often lead to a downgrade in the amount of industry-level information that is included (Bess and Ambargis, 2013).

The decision to utilise an IO analysis within the HRWO process is also partially justified by the existence of the Waikato Region Multi-Regional IO Table, which was initially developed for the Waikato Regional Council Economic Futures Model (McDonald, 2010). The extension of a previous framework is more cost-effective than developing a framework from nothing, especially given that the existing framework has been applied previously and extension can take into account practices and principles that were learnt during its prior employment. This decision is also consistent with the time and budget constraints that face many limit-setting processes for water quality improvement in New Zealand, including the HRWO process. The adoption of an IO model has also allowed the seamless integration of the regional economic

model with the farm- and catchment-level models, such that the farm-, catchment-, regional-, and national-level implications of alternative limits can be ascertained in an integrated way.

Nevertheless, alternative methods exist that could be used within the HRWO process to explore the regional- and national-level implications of the proposed policy mix. Arguably, the most-valuable alternative would involve the development and application of a Computable General Equilibrium (CGE) model. Key reasons for adopting an IO, rather than a CGE, framework for use in this study are:

1. *Disaggregation*: The IO approach readily produces results that are disaggregated by study regions (in this case, the different FMUs, Waikato region, and New Zealand) and economic sectors (altogether 107 economic sectors or 'industries' are reported in the model, though results are aggregated to 17 key sectors for reporting purposes below). This provides important information on the distribution of economic impacts.
2. *Paucity of data*: Creation of a multi-regional CGE model that reports down to the level of each FMU would necessitate the construction of a Social Accounting Matrix (SAM) for the local area. There is a lack of information pertaining to inter-regional investment flows upon which to complete this task.
3. *Full analysis of 'circular flow of income'*: Although the approach used here is based on the IO format, a concerted attempt is made in this study to take full consideration of the 'circular flow of income' within an economy, much like an analysis based on a Social Accounting Matrix or CGE. Both 'backward' and 'forward' linkages are considered in the IO model applied here. Backward-linkage effects are those experienced by suppliers, or in other words, organisations situated up the supply chain. This includes, for example, the loss in demand for products of fertiliser manufacturers as a result of a reduction in farming intensity. Forward-linkage effects, by contrast, are experienced by those who purchase goods or are situated down the supply chain. This includes, for example, the loss in dairy-product manufacturing necessitated by a fall in the supply of raw milk from farms.
4. *Timeframe and budget*: It has been feasible to couple an IO-based model to the catchment-level model applied in the HRWO process, so as to produce a picture of FMU-, regional-, and national-level economic impacts, while keeping within the timeframe and budget of the project. In contrast, linking the catchment-level framework

to a CGE model would have been a major piece of work well beyond the scope of this project. Indeed, to date, this type of work has not been undertaken within New Zealand for the analysis of water-quality limits.

A broader discussion of available methods for regional- and national-level modelling and why the IO approach was chosen from among them is provided in Doole et al. (2015c).

More information regarding the IO model used in the HRWO process is provided in McDonald (2015).

2.2 Introduction to IO analysis

It is helpful to provide readers, particularly those not familiar with IO analysis, with a brief introduction to the IO framework. (Further information is provided in Miller and Blair (2009).) This introduction is provided below. The remaining sections of the methodology describe the way the different scenarios are incorporated into an IO framework (Section 2.3), including the major assumptions that are applied, and the scenarios explored in the policy mix (Section 2.4).

At the core of any IO analysis is a set of data that measures, for a given year, the flows of money or goods among various sectors or industrial groups within an economy. These flows are recorded in a matrix or 'IO table' by arrays that summarise the purchases made by each industry (its inputs) and the sales of each industry (its outputs) from and to all other industries. By using the information contained within such a matrix, IO practitioners calculate mathematical relationships for the economy in question. These relationships describe the interactions between industries—specifically, the way in which each industry's production requirements depend on the supply of goods and services from other industries. With this information it is possible to calculate, given a proposed alteration to a selected industry (a scenario), all of the necessary changes in production that are likely to occur throughout supporting industries within the wider economy. For example, if one of the changes anticipated for a single FMU were to be a loss in the amount of dairy farming, the IO model would calculate all of the losses in output that would also occur in industries supporting dairy farming (e.g. fertiliser production, fencing contractors, farm-machinery suppliers), as well as the industries that, in turn, support these.

As with all modelling approaches, IO analysis relies on certain assumptions for its operation. Among the most important is the assumption that the input structures of industries (i.e. the mix of commodities or industry outputs used in producing output for a specific industry) are fixed. In the real world, however, these 'technical coefficients' will change over time as a result of new technologies being available, relative price shifts causing substitutions, and the introduction of new industries. For this reason, IO analysis is generally regarded as most suitable for short- to medium-term analysis, where economic systems are unlikely to change greatly from the initial snapshot of data used to generate the base IO tables. This further justifies the selection of this method, given that the catchment-level model applied in the HRWO process also represents a snapshot of reality that is based heavily on current prices, technologies, management practices, and knowledge of biophysical relationships.

2.3 Overview of impacts assessed

The study of economy-wide economic impacts in the modelling commenced with identifying six key categories of likely economic effects associated with the proposed options for water-quality improvement:

Changes to farming systems: backward linkage supply chain impacts. Attribute limits can encourage changes in land-management practices for farms within each FMU. Examples might include removing summer crops and replacing these with supplements and lowering fertiliser use. These measures result in changes to the purchasing patterns of farms, creating flow-on impacts through economic supply-chain linkages.

Changes to farming systems: forward linkage supply chain impacts. The changes in farming practices will also result in reductions to the overall output of farms. With less output (e.g. milk, wool, meat) produced per hectare, the supply to downstream processors (dairy manufacturers, meat processors, textile manufacturers, etc.) will be reduced, ultimately leading to a reduction in sales by these industries.

Conversion between land uses: backward supply chain impacts. In addition to changes in land management, the proposed scenarios will also likely result in changes in land use across the FMUs. This will create additional impacts for industries that would otherwise be involved in supplying goods and services to the existing farms. Businesses that are responsible for

providing direct inputs to the forestry sector (e.g. pruning contractors, accountants, etc.) will be positively impacted by conversion of land to forestry. Businesses involved indirectly in forestry supply chains (e.g. firms selling supplies to contractors) will also be positively impacted.

Conversion between land uses: forward linkage supply chain impacts. Similar to the forward-linkage effects resulting from changes in farming systems, the conversion of land from one use to another will result in changes to the supply of key products to downstream processors (for example, more timber to processors, but less raw milk to dairy product manufacturing if dairy land is replaced by forest production or vice versa).

Changes in incomes for land owners. For each of the scenarios evaluated, there will be changes in income for landowners in the form of wages/salaries and profits. This will cause changes in the expenditure patterns of these land owners; hence, creating impacts through the rest of the economy.

Outlays and revenues associated with land conversion. The conversion of land into different uses is associated with a set of discrete capital investments and other economic transfers. For land owners, these can be both outlays (e.g. construction of woolsheds, planting costs) and revenues (e.g. sale of Fonterra shares, sale of dairy herds). The income and expenditure patterns of land owners will have flow-on implications through the district, regional, and national economies.

Changes for wood and paper processing. Baseline FMU wood- and paper-processing input mixes were replaced with better data provided directly by Scion. This ensured that the latest available information on processing methods, unique to each FMU, was appropriately incorporated.

2.4 Scenarios assessed in the regional economic modelling

The modelling investigation is based around the simulation of four primary scenarios:

A. Simulation of the WRPC1 policy mix with *no* development of iwi land.
B. Simulation of the WRPC1 policy mix with *low* development of iwi land.
C. Simulation of the WRPC1 policy mix with *medium* development of iwi land.

D. Simulation of the WRPC1 policy mix with *high* development of iwi land.

These scenarios are hereafter referred to as Sc. A, Sc. B, Sc. C, and Sc. D, respectively. Land use is held constant at its baseline levels in the baseline scenario (Doole et al., 2015a). Rule 2 in the WRPC1 will prevent further development occurring through land-use change. Additionally, farm planning will seek to support business resilience such that the policy should not drive large shifts towards less-intensive enterprises through land-use change.

An exception to this general approach is a focus on the development of iwi land. Development is assumed to occur across two different types of iwi land:

1. Iwi land in the Central North Island. This involves areas of 2,167; 4,333; and 6,500 ha under the low, medium, and high levels of development predicted to occur over the next decade. These levels of development each constitute individual scenarios in the model.
2. Iwi land held under multiple ownership. This involves areas of 900; 1,800; and 2,700 ha under the low, medium, and high levels of development predicted to occur over the next decade. These levels of development each constitute individual scenarios in the model.

The level of development (i.e. no, low, medium, or high) that is simulated *is always the same* on these different types of iwi land. This means that different levels of development between iwi land that is located in the Central North Island or is subject to multiple ownership are not investigated. Development for iwi land is assumed only to occur on land blocks that are above 4 ha in size.

Development of iwi land is assumed to consist of various actions:

- Areas of land use capability (LUC) class 1–4 are assumed to convert from forest to dairy. The new dairy activities that are simulated produce a level of leaching equivalent to the mean dairy farms found in the relevant FMU.
- Areas of LUC class 5–7 are assumed to convert from forest to drystock. The new drystock activities that are simulated produce a level of leaching equivalent to the mean drystock farms found in the relevant FMU.
- Areas of LUC class 8 are assumed to remain in plantation forest.

Areas of iwi land that potentially could be developed were identified using a variety of data sources. The model then determined where it was most profitable to convert existing land within the areas for development set within each scenario, given the implementation of the proposed policy mix.

The way that other elements of WRPC1 were represented in the HRWO catchment-level model is outlined in Doole et al. (2016).

The HRWO economic model involves the successive implementation of the catchment-level model and the IO model, with output feeding from the former into the latter. Standard practice in the assessment of environmental policy involves the comparison of a "without policy" scenario and a "with policy" scenario (Boardman et al., 2011; Pannell, 2015). The catchment-level implications of the "without policy" or "business-as-usual" case are outlined in Doole (2016). Catchment-level output from this application was entered into the IO model to determine the FMU-, regional-, and national-level implications of this scenario. Then, catchment-level output from the application summarised in Doole et al. (2016) was entered into the IO model to determine the FMU-, regional-, and national-level implications of the policy-mix scenarios. The results are reported for the WRPC1 runs below in Tables 1–6 (see Section 3); these are presented relative to the "business-as-usual" baseline.

3. Results and Discussion

The impact of each of the four scenarios (Sc. A–D) is ascertained, relative to the "business-as-usual" baseline described for the catchment in Doole (2016).

The following discussion focuses on information presented across 17 aggregated sectors in the regional and national economy, despite the fact that 107 individual industries are represented in the IO model itself (Doole et al., 2015a; McDonald, 2015).

Tables 1–4 present the changes in Value Added, employment, and international exports across each of the aggregated industries for each FMU, relative to the "business-as-usual" case. Table 5 presents these changes for the Waikato region as a whole, while Table 6 presents the predicted impacts for the national economy.

All employment results are measured by using Modified Employee Counts (MECs). Statistics New Zealand typically reports employment data according to the Employee Count (EC) measure. ECs are a head count of all salary and wage earners for a reference period. This includes most employees, but does not capture all working proprietors—individuals who pay themselves a salary or wage. The modified employment count or MEC measure is based on ECs, but includes an adjustment to incorporate an estimate of the number of working proprietors.

Table 1 presents the changes in Value Added, employment, and international exports for the Lower Waikato FMU across each of the aggregated industries, relative to the "business-as-usual" case. The impacts of WRPC1 are focused mainly on agricultural industries under all scenarios. The most-significant impacts on value added and employment are experienced in the sheep, beef, and arable industries, while lesser effects are felt across the dairy and horticultural sectors. However, the horticultural sector experiences the most-significant decline in international exports, given its high intensity in this FMU.

Table 2 presents the changes in Value Added, employment, and international exports for the Waipa River FMU across each of the aggregated industries, relative to the "business-as-usual" case. The most-significant impacts are experienced in the agricultural sectors again, but this time with dairy production experiencing the largest impacts in terms of value added and employment. There are also some small flow-on impacts experienced throughout the service industries associated with agricultural production, especially dairy-product manufacturing and retail. In particular, dairy-product manufacturing loses only a handful of jobs, but the value of international exports of these products decreases by around 4–10 million dollars (Table 2).

Table 3 presents the changes in Value Added, employment, and international exports for the mid-Waikato (Karapiro to Ngaruawahia) FMU across each of the aggregated industries, relative to the "business-as-usual" case. Employment falls in the horticultural, sheep, beef, arable, and dairy sectors. However, detrimental economic effects predicted for this FMU are mainly concentrated in dairy-product manufacturing and service industries, especially in the wholesale and retail trade sectors. This reflects the location of Hamilton—the main urban area in the Waikato region—within this FMU. Indeed, more than 100 jobs are lost within this FMU within each policy scenario. More than half of these job losses are predicted to occur in the retail, professional, and other-services sectors. The largest loss in value for international

exports occurs in the dairy-product manufacturing sector, with around 90% of any decrease across the FMU occurring in this industry.

Table 4 presents the changes in Value Added, employment, and international exports for the Upper Waikato (Karapiro to Taupo Gates) FMU across each of the aggregated industries, relative to the "business-as-usual" case. The WRPC1 is predicted to have significant detrimental impacts on value added and employment in the dairy sector but is predicted to lead to more jobs in forestry and wood and paper manufacturing, relative to the "business-as-usual" setting (Table 4). Indeed, 400, 284, 172, and 40 jobs are predicted to be lost in the dairy sector alone in Scenarios A, B, C, and D, respectively, relative to the "business-as-usual" case (Table 4). Additionally, 35, 25, 15, and 5 million dollars in value added is predicted to be lost in this sector in Scenarios A, B, C, and D, respectively, relative to the "business-as-usual" case. These findings reflect that while the economic impacts of the proposed policy mix are relatively benign at the catchment level (Doole et al., 2016), they are significant in the Upper Waikato FMU when compared to the "business-as-usual" case because of the significant economic benefits associated with broad-scale forestry-to-dairy conversion predicted to occur in the upper catchment in the absence of WRPC1.

Table 5 presents the changes in Value Added, employment, and international exports for the whole of the Waikato Region across each of the aggregated industries, relative to the "business-as-usual" case. This scenario reflects the impact of the proposed policy mix on the FMUs studied within the HRWO process and those other districts within the Waikato but not incorporated within the HRWO (e.g. the Waihou catchment). WRPC1 is predicted to incur a cost of around $100 m annually when there is no iwi land development (Sc. A), with three-quarters of this falling on the dairy industry and around one-fifth coming from the sheep, beef, and arable sector. However, these costs are eroded with the intensification of iwi land, with high development of iwi land leading to a halving of the constituent cost. WRPC1 is also predicted to lead to a loss of around 940 jobs when there is no iwi land development (Sc. A), with around two-thirds of this arising in the dairy industry. Nevertheless, this falls to a loss of around 300 jobs with high iwi-land development. National exports are also predicted to fall as a result of WRPC1, with most impacts being felt in dairy-product manufacturing.

Table 6 presents the changes in Value Added, employment, and international exports for the whole of New Zealand across each of the aggregated industries, relative to the "business-as-

usual" case. WRPC1 without iwi-land development is predicted to decrease national value added by around $200 m nationally, with around half of this occurring in the dairy sector. This falls to $150 m, $120 m, and $80 m with low, medium, and high iwi-land development, respectively. High employment losses are observed across all sectors with no iwi-land development, except forestry and wood and paper manufacturing (Table 6). Nearly half of all jobs are lost in the dairy sector, while around one-tenth occurs in the sheep, beef, and arable sectors. Job losses still occur under the iwi-land development scenarios (Sc. B–D), but this intensification helps to offset those losses experienced in Scenario A. Indeed, 427, 805, and 1242 less jobs are lost under the low, medium, and high iwi-land development scenarios given that this intensification leads to greater vitality within the agricultural sectors, especially in the dairy farming and dairy-product manufacturing sectors. The greatest impact of WRPC1 on international exports is again almost exclusively observed within the dairy-product manufacturing sector.

Table 1. Regional economic impacts of the WRPC1 in the Lower Waikato (Ngaruawahia to Port Waikato) FMU, relative to the BAU scenario.

Industry	**Value added ($m)**				**Employment (MECs)**				**International exports ($m)**			
	Sc. A	**Sc. B**	**Sc. C**	**Sc. D**	**Sc. A**	**Sc. B**	**Sc. C**	**Sc. D**	**Sc. A**	**Sc. B**	**Sc. C**	**Sc. D**
Horticulture and fruit growing	-2	-2	-2	-2	-21	-21	-21	-21	-1.0	-1.0	-1.0	-1.0
Sheep, beef & grain	-7	-7	-7	-7	-47	-47	-47	-47	-0.3	-0.3	-0.3	-0.3
Dairy farming	-5	-5	-5	-5	-23	-23	-23	-23	0.0	0.0	0.0	0.0
Forestry	0	0	0	0	0	0	0	0	0.0	0.0	0.0	0.0
Other primary	0	0	0	0	1	2	2	2	0.0	0.0	0.0	0.0
Agriculture and forestry support	0	0	0	0	0	1	1	2	0.0	0.0	0.0	0.0
Meat and meat product manufacturing	0	0	0	0	-1	-1	0	0	-0.3	-0.2	-0.2	-0.1
Dairy product manufacturing	0	0	0	0	0	0	0	0	-0.3	-0.3	-0.2	-0.1
Wood and paper manufacturing	0	0	0	0	1	0	0	0	0.1	0.0	0.0	0.0
Other manufacturing	0	0	0	0	0	0	0	0	0.0	0.0	0.0	0.0
Utilities	0	0	0	0	0	0	0	0	0.0	0.0	0.0	0.0
Construction	0	0	0	0	6	6	6	6	0.0	0.0	0.0	0.0
Wholesale and retail trade	0	0	0	0	-2	-2	-2	-1	0.0	0.0	0.0	0.0
Transport	0	0	0	0	-1	-1	0	0	0.0	0.0	0.0	0.0
Professional and administrative services	0	0	0	0	-1	0	0	0	0.0	0.0	0.0	0.0
Local and central government	0	0	0	0	0	0	0	0	0.0	0.0	0.0	0.0
Other services	-2	-2	-2	-2	-13	-13	-13	-12	0.0	0.0	0.0	0.0
Total loss relative to baseline	-16.3	-16.2	-16.0	-15.9	-102.0	-99.8	-98.0	-96.0	-1.8	-1.7	-1.6	-1.5

Table 2. Regional economic impacts of the WRPC1 in the Waipa River FMU, reported relative to the BAU scenario.

Industry	Value added ($m)				Employment (MECs)				International exports ($m)			
	Sc. A	Sc. B	Sc. C	Sc. D	Sc. A	Sc. B	Sc. C	Sc. D	Sc. A	Sc. B	Sc. C	Sc. D
Horticulture and fruit growing	0	0	0	0	-3	-3	-3	-3	0.0	0.0	0.0	0.0
Sheep, beef & grain	-4	-3	-3	-3	-38	-21	-21	-19	-0.2	-0.1	-0.1	-0.1
Dairy farming	-6	-6	-6	-6	-49	-46	-46	-44	-0.1	-0.1	-0.1	-0.1
Forestry	0	0	0	0	0	-1	-1	-1	0.0	0.0	0.0	0.0
Other primary	0	0	0	0	1	1	2	2	0.0	0.0	0.0	0.0
Agriculture and forestry support	0	0	0	0	-6	-4	-3	-1	0.0	0.0	0.0	0.0
Meat and meat product manufacturing	0	0	0	0	-3	-2	-2	-1	-1.2	-0.9	-0.6	-0.3
Dairy product manufacturing	-2	-2	-1	-1	-8	-6	-5	-3	-10.5	-8.2	-6.2	-3.8
Wood and paper manufacturing	0	0	0	0	0	0	0	0	0.1	0.0	0.0	0.0
Other manufacturing	0	0	0	0	0	0	0	0	0.0	0.0	0.0	0.0
Utilities	0	0	0	0	0	0	0	0	0.0	0.0	0.0	0.0
Construction	0	0	0	0	7	7	8	8	0.0	0.0	0.0	0.0
Wholesale and retail trade	0	0	0	0	-5	-5	-4	-4	0.0	0.0	0.0	0.0
Transport	0	0	0	0	-1	-1	-1	0	0.0	0.0	0.0	0.0
Professional and administrative services	0	0	0	0	-1	-1	0	0	0.0	0.0	0.0	0.0
Local and central government	0	0	0	0	-2	-2	-2	-1	0.0	0.0	0.0	0.0
Other services	-2	-2	-2	-1	-17	-15	-14	-13	0.0	0.0	0.0	0.0
Total loss relative to baseline	-15	-14	-13	-12	-126	-97	-91	-79	-12	-9	-7	-4

Table 3. Regional economic impacts of the WRPC1 in the mid-Waikato (Karapiro to Ngaruawahia) FMU, reported relative to the BAU scenario

Industry	**Value added ($m)**				**Employment (MECs)**				**International exports ($m)**			
	Sc. A	**Sc. B**	**Sc. C**	**Sc. D**	**Sc. A**	**Sc. B**	**Sc. C**	**Sc. D**	**Sc. A**	**Sc. B**	**Sc. C**	**Sc. D**
Horticulture and fruit growing	0	0	0	0	-21	-21	-21	-21	-0.2	-0.2	-0.2	-0.2
Sheep, beef & grain	-1	-1	-1	-1	-10	-10	-10	-10	0.0	0.0	0.0	0.0
Dairy farming	-1	-1	-1	-1	-2	-3	-4	-9	0.0	0.0	0.0	0.0
Forestry	0	0	0	0	0	0	0	0	0.0	0.0	0.0	0.0
Other primary	0	0	0	0	0	0	1	1	0.0	0.0	0.0	0.0
Agriculture and forestry support	0	0	0	0	-1	1	2	4	0.0	0.0	0.0	0.0
Meat and meat product manufacturing	-1	0	0	0	-5	-4	-3	-2	-1.8	-1.4	-1.0	-0.6
Dairy product manufacturing	-6	-5	-3	-2	-21	-16	-12	-7	-27.0	-20.8	-15.0	-8.4
Wood and paper manufacturing	0	0	0	0	1	1	0	0	0.3	0.2	0.1	0.0
Other manufacturing	0	0	0	0	-3	-2	-1	1	0.0	0.0	0.0	0.0
Utilities	0	0	0	0	-1	-1	-1	0	0.0	0.0	0.0	0.0
Construction	0	0	0	0	2	2	3	3	0.0	0.0	0.0	0.0
Wholesale and retail trade	-1	-1	-1	-1	-21	-18	-15	-13	0.0	0.0	0.0	0.0
Transport	0	0	0	0	-4	-3	-2	-1	0.0	0.0	0.0	0.0
Professional and administrative services	-1	0	0	0	-12	-8	-5	-1	0.0	0.0	0.0	0.0
Local and central government	0	0	0	0	-5	-4	-4	-3	0.0	0.0	0.0	0.0
Other services	-5	-4	-4	-3	-60	-53	-48	-42	0.0	0.0	0.0	0.0
Total loss relative to baseline	-16	-13	-11	-8	-162	-139	-119	-100	-29	-22	-16	-9

Table 4. Regional economic impacts of WRPC1 in the Upper Waikato (Karapiro to Taupo Gates) FMU, reported relative to the BAU scenario.

Industry	Value added ($m)				Employment (MECs)				International exports ($m)			
	Sc. A	Sc. B	Sc. C	Sc. D	Sc. A	Sc. B	Sc. C	Sc. D	Sc. A	Sc. B	Sc. C	Sc. D
Horticulture and fruit growing	0	0	0	0	-1	-1	-1	-1	0.0	0.0	0.0	0.0
Sheep, beef & grain	-6	-5	-4	-3	-12	5	28	44	-0.1	0.1	0.3	0.5
Dairy farming	-35	-25	-15	-5	-400	-284	-172	-40	-0.7	-0.5	-0.3	-0.1
Forestry	5	3	1	0	56	38	20	1	1.5	1.0	0.5	0.0
Other primary	0	0	0	0	0	0	0	0	0.0	0.0	0.0	0.0
Agriculture and forestry support	0	0	0	0	-7	-4	1	6	0.0	0.0	0.0	0.0
Meat and meat product manufacturing	0	0	0	0	-1	0	0	0	-0.2	-0.2	-0.1	0.0
Dairy product manufacturing	-2	-1	-1	0	-6	-5	-3	-1	-8.6	-6.3	-4.1	-1.5
Wood and paper manufacturing	5	3	2	0	34	23	12	1	10.1	6.9	3.5	0.2
Other manufacturing	0	0	0	0	1	1	1	0	0.0	0.0	0.0	0.0
Utilities	0	0	0	0	1	0	0	0	0.0	0.0	0.0	0.0
Construction	0	0	0	0	4	5	5	5	0.0	0.0	0.0	0.0
Wholesale and retail trade	0	0	0	0	-8	-6	-4	-2	0.0	0.0	0.0	0.0
Transport	0	0	0	0	0	0	0	0	0.0	0.0	0.0	0.0
Professional and administrative services	0	0	0	0	1	1	1	0	0.0	0.0	0.0	0.0
Local and central government	0	0	0	0	-1	-1	-1	0	0.0	0.0	0.0	0.0
Other services	-4	-3	-2	-1	-40	-29	-20	-10	0.0	0.0	0.0	0.0
Total loss relative to baseline	-37	-27	-19	-9	-379	-257	-134	4	2	1	0	-1

Table 5. Total economic impacts of the WRPC1 in the Waikato Region, reported relative to the BAU scenario.

Industry	Value added ($m)				Employment (MECs)				International exports ($m)			
	Sc. A	Sc. B	Sc. C	Sc. D	Sc. A	Sc. B	Sc. C	Sc. D	Sc. A	Sc. B	Sc. C	Sc. D
Horticulture and fruit growing	-3	-3	-3	-3	-46	-46	-46	-45	-1.2	-1.2	-1.2	-1.2
Sheep, beef & grain	-18	-16	-15	-14	-119	-82	-57	-35	-0.7	-0.4	-0.1	0.1
Dairy farming	-56	-44	-33	-20	-563	-423	-292	-139	-0.8	-0.6	-0.4	-0.2
Forestry	5	3	1	0	59	40	20	1	1.5	1.0	0.5	0.0
Other primary	1	1	1	1	6	7	8	10	0.0	0.0	0.0	0.0
Agriculture and forestry support	-1	0	0	1	-18	-9	2	13	0.0	0.0	0.0	0.0
Meat and meat product manufacturing	-2	-2	-1	-1	-19	-14	-9	-4	-7.3	-5.4	-3.6	-1.6
Dairy product manufacturing	-18	-14	-10	-5	-60	-46	-32	-17	-80.4	-60.9	-43.0	-22.1
Wood and paper manufacturing	5	4	2	0	41	28	14	0	10.9	7.4	3.7	0.2
Other manufacturing	0	0	0	0	-4	-2	-1	1	-0.1	-0.1	-0.1	-0.1
Utilities	0	0	0	0	-2	-1	-1	-1	0.0	0.0	0.0	0.0
Construction	1	1	1	1	18	20	21	23	0.0	0.0	0.0	0.0
Wholesale and retail trade	-2	-2	-1	-1	-48	-39	-32	-24	0.0	0.0	0.0	0.0
Transport	-1	-1	0	0	-7	-6	-5	-3	0.0	0.0	0.0	0.0
Professional and administrative services	-1	0	0	0	-14	-10	-5	0	0.0	0.0	0.0	0.0
Local and central government	-1	-1	-1	0	-10	-8	-7	-6	0.0	0.0	0.0	0.0
Other services	-15	-12	-10	-8	-152	-128	-109	-87	0.0	0.0	0.0	0.0
Total loss relative to baseline	-106	-86	-69	-50	-938	-720	-531	-314	-78	-60	-44	-25

Table 6. Total economic impacts of the WRPC1 across New Zealand, reported relative to the BAU scenario.

Industry	Value added ($m)				Employment (MECs)				International exports ($m)			
	Sc. A	Sc. B	Sc. C	Sc. D	Sc. A	Sc. B	Sc. C	Sc. D	Sc. A	Sc. B	Sc. C	Sc. D
Horticulture and fruit growing	-4	-4	-3	-3	-80	-71	-65	-59	-1	-1	-1	-1
Sheep, beef & grain	-24	-20	-18	-16	-196	-141	-98	-56	-1	0	0	0
Dairy farming	-80	-62	-45	-26	-769	-580	-402	-195	-1	-1	0	0
Forestry	7	5	2	0	68	46	23	1	1	1	0	0
Other primary	1	1	1	2	0	4	7	11	0	0	0	0
Agriculture and forestry support	-4	-2	-1	1	-78	-47	-12	25	0	0	0	0
Meat and meat product manufacturing	-4	-3	-2	-1	-37	-28	-19	-9	-11	-8	-5	-2
Dairy product manufacturing	-28	-21	-15	-8	-105	-80	-56	-29	-119	-90	-63	-32
Wood and paper manufacturing	8	5	3	0	69	46	23	0	14	9	5	0
Other manufacturing	-8	-7	-5	-4	-83	-71	-61	-49	-4	-3	-3	-3
Utilities	-2	-2	-2	-1	-5	-4	-3	-3	0	0	0	0
Construction	0	0	1	1	5	10	14	19	0	0	0	0
Wholesale and retail trade	-8	-6	-5	-3	-142	-114	-92	-65	0	0	0	0
Transport	-5	-4	-3	-2	-54	-43	-34	-23	0	0	0	0
Professional and administrative services	-8	-6	-4	-2	-127	-95	-66	-33	0	0	0	0
Local and central government	-3	-3	-2	-2	-36	-30	-25	-19	0	0	0	0
Other services	-33	-27	-22	-16	-311	-256	-210	-156	0	0	0	0
Total loss relative to baseline	-193	-154	-120	-80	-1880	-1453	-1075	-638	-120	-93	-69	-39

4. Conclusions

The draft Waikato Regional Plan Change No. 1—Waikato and Waipa River Catchments (Proposed) (WRPC1) presented at CSG meeting #27 on 9 May 2016 set out policies that aim to progressively reduce concentrations of nitrogen, phosphorus, sediment, and microbes to meet Freshwater Management Unit (FMU) specific targets and associated values of water clarity and suspended algae (chlorophyll-a). The time frame for meeting these ultimate targets for water-quality improvement is 80 years, whereas the current Plan Change aims to ensure that the actions necessary to make a 10% step towards bridging the gap between the current and target states are implemented over the next decade.

The farm- and catchment-level implications of WRPC1 are set out in the comprehensive study of Doole et al. (2016). However, this work did not explore the FMU-, regional-, and national-level implications of the proposed policy mix. The primary objective of this analysis has been to fill this gap using the IO model described in McDonald (2015). This current research is important, given that the economic implications of broad-scale policies to reduce the intensification of rural and urban land-use in the Waikato can be significant (Doole et al., 2015a), especially given its size and the importance of this region in terms of agricultural production. Results are reported relative to the "business-as-usual" scenario described by Doole (2016).

Model output shows that the proposed policy mix will have a significant negative impact on income, employment, and exports within agricultural industries in the Waikato region and those sectors that provide services to them. These impacts are further magnified when connections with industries across the nation are considered. The negative economic outcomes associated with improved water quality are perhaps unsurprising given that in the Waikato region contaminant loss from agriculture is a key cause of water-quality decline (McDowell and Wilcock, 2008), agricultural production is a key source of income and jobs (Doole et al., 2015a), much intensive agriculture is present in the catchment, and there is a distinct lack of profitable mitigation activities across the range of agricultural enterprises and contaminants considered within the HRWO process (Doole, 2015; Doole and Kingwell, 2015). The scale of these losses is also somewhat further exacerbated, given that significant intensification and associated increases in income are predicted to occur in the absence of the WRPC1.

Nevertheless, while this analysis shows that the economic impacts of WRPC1 are likely negative for most primary sectors, the proposed policy mix is predicted to achieve significant improvements in water quality across the catchment (Doole et al., 2016).

Acknowledgements

The primary authors of this report are Garry McDonald and Graeme Doole, who have led the development and application of the primary framework applied in this study. However, this work represents a significant effort invested by many people across many organisations, and we acknowledge their tireless effort in helping us in its development.

References

Bess, R., and Ambargis, Z.O. (2013), *IO models for impact analysis*, U. S. Department of Commerce, Washington D. C.

Boardman, A.E., Greenberg, D.H., Vining, A.R., and Weimer, D.L. (2011), *Cost-benefit analysis*, Pearson, New York.

Doole, G.J. (2015), *Description of mitigation options defined within the economic model for the Healthy Rivers Wai Ora project*, Healthy Rivers Wai Ora report HR/TLG/2015-2016/4.6, Hamilton.

Doole, G.J., and Kingwell, R.S. (2015), 'Efficient economic and environmental management of pastoral systems: theory and application', *Agricultural Systems* 133, pp. 73–84.

Doole, G.J., Elliott, A.H., and McDonald, G. (2015a), *Economic evaluation of scenarios for water-quality improvement in the Waikato and Waipa River catchments: Assessment of first set of scenarios*, Healthy Rivers Wai Ora report HR/TLG/2015-2016/4.1, Hamilton.

Doole, G.J., Elliott, A.H., and McDonald, G. (2015b*), Evaluation of scenarios for water-quality improvement in the Waikato and Waipa River catchments: Assessment of second set of scenarios*, Healthy Rivers Wai Ora report HR/TLG/2015-2016/4.2, Hamilton.

Doole, G.J., Elliott, A.H., and McDonald, G. (2015c), *General principles underlying the development of the Healthy Rivers Wai Ora economic model*, Healthy Rivers Wai Ora report HR/TLG/2015-2016/4.7, Hamilton.

Doole, G.J. (2016), *Evaluation of scenarios for water-quality improvement in the Waikato and Waipa River catchments: Business-as-usual assessment*, Unpublished Healthy Rivers Wai Ora report, Hamilton.

Doole, G.J., Quinn, J.M., Wilcock, B.J., and Hudson, N. (2016), *Simulation of the proposed policy mix for the Healthy Rivers Wai Ora process*, Healthy Rivers Wai Ora report HR/TLG/2016-2017/4.5, Hamilton.

Hughes, D.W. (2003), 'Policy uses of economic multiplier and impact analysis', *Choices* 2, pp. 25–30.

McDonald, G. (2010), *Waikato River Independent Scoping Study, Appendix 31: Economic modelling*, NIWA, Hamilton.

McDonald, G. (2015), *Economic impacts of the Healthy Rivers Wai Ora initiative—Freshwater Management Unit, regional, and national Assessment*, Healthy Rivers Wai Ora report HR/TLG/2015-2016/5.1, Auckland.

McDowell, R.W., and Wilcock, R.J. (2008), 'Water quality and the effects of different pastoral animals', *New Zealand Veterinary Journal* 56, pp. 289–296.

Miller, R.E., and Blair, P.D. (2009), *IO analysis: foundations and extensions*, Cambridge University Press, New York.

Mills, E.C. (1993), 'The misuse of regional economic models', *Cato Journal* 13, pp. 29–39.

Pannell, D.J. (2015), *Ranking environmental projects*, University of Western Australia School of Agricultural and Resource Economics Working Paper 1506, Perth.

Ritchie, H. (2016), *Modelling the Collaborative Stakeholder Group policy mix*, Waikato Regional Council, Hamilton.