Waikato Regional Council Technical Report 2019/27

# Land use change diversification in the Waikato

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

Waikato
REGIONAL COUNCIL
Te Kaunihera ā Rohe o Waikato

Prepared by: AgFirst Waikato (2016) Ltd

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

October 2020

Document #: 15617806

Peer reviewed by:
Bala Tikkisetty

Date 9 March 2020

Approved for release by:
Mark Gasquoine

Date 9 March 2020

Independent
Agriculture
& Horticulture
Consultant
Network

# Land Use Change Diversification in the Waikato

## Prepared for Waikato Regional Council

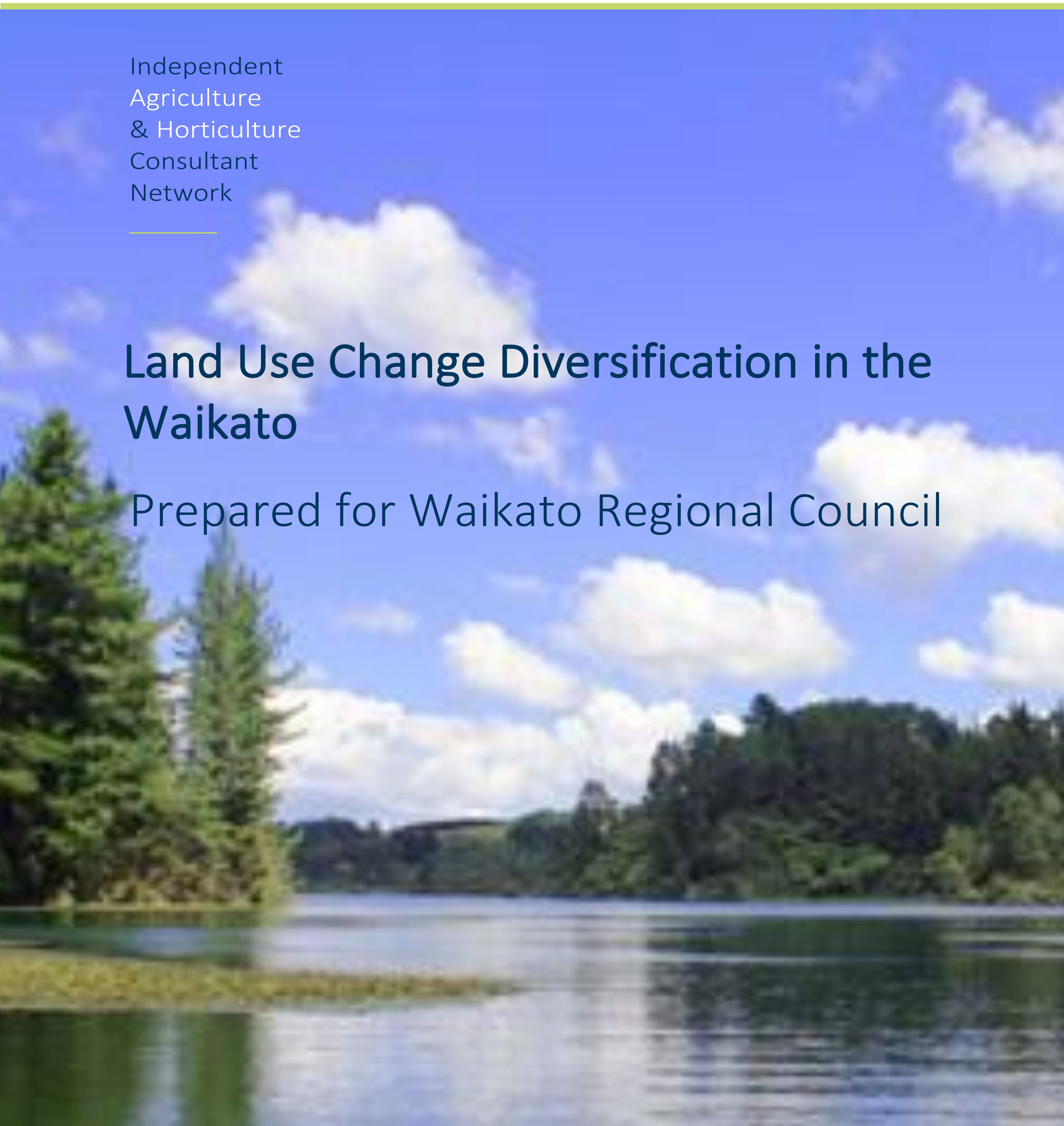


TABLE OF CONTENTS

AgFirst would like to acknowledge the assistance of Waikato Regional Council, in particular Bala Tikkisetty in the production of this report.

## 1.0 SUMMARY

This project has been developed in response to recent interest from Waikato landholders to diversify their businesses through land use change.

This report examines diversification options that involve both the development of part of an existing property or an option which involves the wholesale conversion to an alternative land use. The purpose is to provide a number of examples of what might be possible in terms of land use diversification and some of the considerations that should be made by a land owner prior to making a change.

Given that every farm is different, this report is not intended to provide advice at the level of due diligence for land use diversification, but rather to provide an initial benchmark and baseline that outlines some of the constraints for a range of development options.

### Drivers for Diversification

Drivers for diversification in pastoral farming can generally be categorised into the following:

1. Environmental regulation
2. Debt and financial compliance position
3. Industry negativity
4. Labour and business complexity

It is the report authors experience that these drivers for change are then embraced by a person or entity who is looking to make a change to either reduce risk or maximise financial return (economically driven), or whom are seeking to enter an area of activity that is more aligned to personal interests (interest driven). Within this analysis there is also an explicit requirement to lessen the environmental impact when regarding change in land use.

### Waikato's Productive Land

Of the Waikato's 2.5 million hectares (ha) of land, approximately 1.3 million ha is productive agriculture. In terms of land use capability (LUC), the Waikato's presence of high-quality agricultural landscapes is highlighted with LUC Class 1 - 4 soils comprising approximately 37%, Class 5 and 6 approximately 38%, and Classes 7 and 8 approximately 21%. At a national level, the Waikato holds a significant proportion of these high-quality soils as shown in **Table 1** below. From a land use diversification perspective, this presents the opportunity for large amounts of land to be considered for a range of alternative land uses.

Table 1: Regional LUC Summary

| Land Use Capability Class | Region as a percentage of land use capability class | | | |
|---|---|---|---|---|
| | Waikato | NI | SI | NZ |
| 1-4 | 37% | 28% | 22% | 25% |
| 5-6 | 38% | 36% | 23% | 29% |
| 7-8 | 21% | 33% | 51% | 43% |

Source: LUCAS NZ Land use Map, NZLRI & Stats NZ.

## Project Scope and Methodology

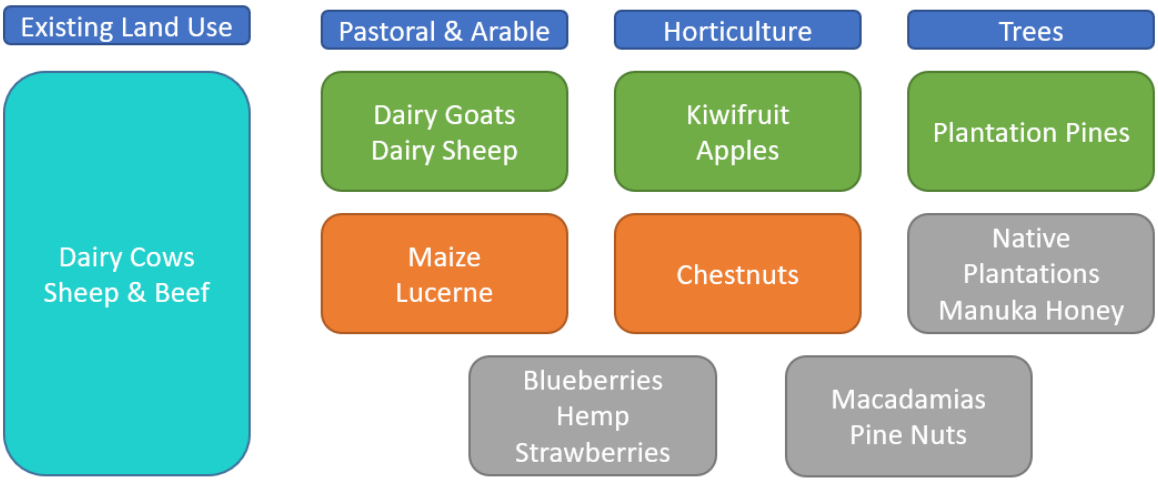
In determining the diversification scenarios to be analysed, the approach has been to select industries which are proven in a Waikato context and considered feasible from a biophysical, environmental (less impact on soil, water and air) and commercial perspective. From a commercial perspective, consideration focused on both the ability for the enterprise to make money and those which were capable of allowing the entry of a number of new producers without the market becoming over-saturated with the supply of the particular product.

On this basis, it was not intended to analyse all agricultural land use options, but rather demonstrate a range of potentially feasible and recognised agricultural industries for the Waikato. The steps and processes developed within this report to outline diversification options may be applied or substituted to a broader range of crops, horticultural and pastoral systems following the decision-making process outlined in **Section 9**.

This report seeks to show a range of diversification options, such as alternative dairy milking (sheep and goats) and arable crops (Maize and Lucerne) that could replace or be conducted on a large part of a farming platform, through to permanent horticulture and trees (kiwifruit, apples, chestnuts and forestry) that may take up a smaller proportion of an existing farm.

The purpose of this analysis is to identify the difference in investment and potential environmental impact. A landowner seeking diversification options not profiled in this assessment (e.g. blueberries, macadamias or hemp) could follow the methodology (**Section 9**) and approach outlined in this report, but to consider specific due diligence to their property and the preferred land use option. Presented in Figure 1 is a systematic diagram displaying the diversification scenarios and how additional options could be incorporated into the process.

Figure 1: Diversification and development process




## Approach to modelling

Economic, Risk and Environmental modelling has been carried out for a range of diversification options.

*Economic*

Quantitative modelling of the financial performance for a range of diversification options has been undertaken. This modelling provides a series of common metrics for economic comparison which have included:

- Net Present Value (NPV);
- Internal Rate of Return (IRR);
- Payback period;
- Total Capital; and
- Cash farm surplus per ha.

*Risk*

Qualitative assessment of the risk factors including consideration of the non-economic factors that could pose risk to a proposed development are listed below:

- Flexibility to further change, i.e. the permanence of the diversified land use.
- Water Usage
- Production Certainty, i.e. the commercial track record of the crop or land use in the Waikato.
- Labour
- Upskilling as it relates to the farmer learning new skillsets to make the diversified land use feasible

*Environmental*

To establish a reasonable baseline reference for both sheep and beef and dairy farm enterprises, a quantitative modelling assessment has been undertaken using OverseerFM. Nitrogen and phosphorus are modelled within OverseerFM to determine the environmental effect of an enterprise. Therefore, for this assessment, these contaminants are representative of an operations/enterprise's environmental performance. It is acknowledged that there are other key contaminants of issue, however it is not feasible to model them at a farm level.

For the sheep and beef scenario, to practically allow the diversification options to be represented, it was decided that farming enterprises with some land capable for finishing or with an intensive grazing block should be modelled. This is largely due to the biophysical constraints of land for conversion.

A typical farm has been modelled for the dairy farm baseline. This is based on the assumption that a large proportion of Waikato dairy farms would have suitable land that could be converted into an alternative diversification option.

To provide an environmental comparison for the diversification options, a similar approach has been taken, whereby average production, yields, stock units and inputs have been assumed for each diversification option. Where available, industry specific data has also been used.

## Summary of results

### Economic Performance

The relative economic performance for a range of diversification options are considered in **Table 2** below.

Table 2: Analysis of economic performance

| Enterprise | NPV | IRR | Payback (years) | Total Capital | Cash farm surplus per ha | Area |
|---|---|---|---|---|---|---|
| Sheep and Beef | | | | | $388 | 127 |
| Dairy Farm | | | | | $2,444 | 571 |
| Dairy Goats | $1,645,697 | 10% | 8.5 | $4,637,250 | $10,410 | 60 ha development |
| Dairy Sheep | $1,156,721 | 12% | 7.5 | $1,587,500 | $4,947 | 60 ha development |
| Maize | $36,337 | 198% | 1 | $2,420 | $3,180 | per ha |
| | $2,249,401 | | 1 | $139,200 | - | 60 ha |
| Lucerne | $26,267 | 127% | 1 | $2,050 | $2,976 | per ha |
| | $1,576,014 | | 1 | $123,000 | - | 60 ha |
| Kiwifruit SunGold | $ 469,149 | 8% | 10.5 | $2,763,846 | $76,000 | 5 ha |
| Kiwifruit Hayward | -$122,264 | 5% | 13.5 | $1,262,310 | $28,000 | |
| Apples | $1,488,737 | 14% | 7.5 | $511,274 | $24,115 | 5 ha |
| Chestnuts | $155,125 | 9% | 12.5 | $352,000 | $9,850 | 10 ha development |
| Forestry (12%) farm Forestry | $29,879 | 24% | Income at year 28 (harvest) | $2,000 | - | Per ha |

* Sheep and Beef/Dairy is taken from the AgFirst modelled farms. Please note given that the diversification analysis has not factored the purchase or lease of land it is not possible to carry out investment analysis (NPV, IRR, Payback and Total Capital) for these baseline industries.

### Risk Matrix

The following risk matrix (**Table 3**) brings together the risk assessments carried out for each of the proposed diversification scenarios. These risk assessments were prepared based on AgFirst's professional experience and can be considered as subjective. It is worth noting that the higher the score the greater the diversification risk. Please note that a lower risk score does not indicate no risk and conversely a higher score does not indicate that the development is not feasible. Please note in **Table 3** below, a risk score of 1 is low risk and 5 high risk.

Table 3: Analysis of Risk performance

| Enterprise | Flexibility to Change | Water Usage | Production Certainty | Labour | Upskilling | Total Risk Score |
|---|---|---|---|---|---|---|
| Dairy Goats | 3 | 2 | 2 | 3 | 3 | **13** |
| Dairy Sheep | 2 | 2 | 4 | 3 | 3 | **14** |
| Maize | 1 | 1 | 1 | 1 | 1 | **5** |
| Lucerne | 1 | 1 | 3 | 1 | 1 | **7** |
| Kiwifruit | 4 | 4 | 2 | 4 | 4 | **18** |
| Apples | 4 | 4 | 4 | 4 | 4 | **20** |
| Chestnuts | 2 | 1 | 2 | 2 | 2 | **9** |
| Forestry | 5 | 1 | 2 | 1 | 1 | **10** |

### Environmental Performance

Modelling has been undertaken to broadly represent the various enterprises. As specified in **Section 2.1**, any change in land use will need to be that of a lower environmental impacting operation. The modelling results have been summarised in **Table 4** and indicate for the most, by changing from an existing dairy or sheep and beef enterprises to the proposed diversification options will be manageable. The results presented are losses based on the entire farming enterprise, and detailed assessment will need to be undertaken for block specific conversions. For example, a finishing or intensive grazing block are likely to have a higher N leaching value than a breeding block and therefore more flexibility with regards to diversification options.

Table 4: Summary of nutrient and greenhouse gas losses

| Enterprise | Nitrogen (kg N/ha/yr) | Phosphorus (kg P/ha/yr) | Methane ($CO^2$ Eq/ha/yr) | Nitrous Oxide ($CO^2$ Eq/ha/yr) | Total GHG ($CO^2$ Eq/ha/yr) |
|---|---|---|---|---|---|
| Dairy Farm | 30.0 | 0.6 | 7.3 | 2.5 | 9.8 |
| Sheep and Beef | 13.0 | 0.5 | 3.6 | 1.0 | 4.6 |
| Dairy Goats | 19.0 | 0.1 | Not reported | | |
| Dairy Sheep | 17.0 | 0.2 | Not reported | | |
| Maize | 6 \ 99 * | 0.1 | - | 0.8 | 0.8 |
| Lucerne | 8 | 0.1 | - | < 0.1 | < 0.1 |
| Kiwifruit (Gold) | 18 | 0.3 | - | 0.4 | 0.4 |
| Apples | 23 | 0.3 | - | 0.3 | 0.3 |
| Chestnuts | 12 | 0.1 | - | 0.1 | 0.1 |
| Forestry | 2.5 | 0.1 | - | - | - |

*Maize was modelled as two scenarios, immediately out of pasture and as a permanent crop

### A Process for Change

As part of this report, work has been undertaken to provide guidance to rural professionals and farmers who might be looking to diversify regardless of the enterprise. The following set of questions have been developed to prompt farmers to consider the range of matters that will affect the success of on-farm diversification. Further guidance to these questions is provided in **Section 9.0** of the report.

- Is the principal reason for diversification financial or other?
- Why is your business considering diversification?
- What financial capacity does the farming business have to make a land use change or to diversify
- What are the activities of farming that you like most, what do you like least and why?
- Who are all the stakeholders in the diversification decision? Have they all been involved in the consideration?
- Where do you see your involvement in the value chain starting and or stopping?
- Through reflection do the stakeholders in the business possess the skills to make the business work, or if not held is there a strong desire to learn them?
- What is the farming businesses appetite for complexity? Is there a desire to grow the business with more moving parts and staff?

## 2.0 DIVERSIFICATION: WHY NOW?

Drivers for diversification in pastoral farming can generally be categorised into the following core categories:

1. Environmental impacts
2. Debt and financial compliance position
3. Industry negativity
4. Labour and business complexity

It is our experience that these drivers for change are then embraced by a person or entity who is looking to make a change to either reduce risk or maximise financial return (economically driven), or whom are looking to change to enter an area of activity that is more aligned to personal interests (interest driven). In general terms, these two types of diversifiers are at present motivated by the following.

### 2.1 Environmental Impacts

Environmental compliance is being cited increasingly by farmers as a reason for considering diversification. For many farmers, it is not a case of not supporting the increased focus on improved environmental outcomes, but rather the costs associated with system upgrades, and the sense of uncertainty around the level of change required to meet mid to long term environmental regulations.

Notwithstanding the increasing demands for improved environmental outcomes, pastoral agriculture, particularly the dairy industry, has made significant recent contributions. These changes have required major capital infrastructure investment.

While recognising the degree of change that has already taken place, further change will be required to improve environmental outcomes. There is major regulatory reform currently underway within the Waikato and Waipa catchments currently through the Proposed Waikato Regional Plan Change 1 (PWRPC1) – Healthy Rivers Plan Change 1, and it is anticipated that other catchments will soon follow. This plan change sets policy and rules in accordance with the National Policy Statement (NPS) for freshwater to manage the key contaminants (nitrogen, phosphorus, sediment and *E.coli*) to water.

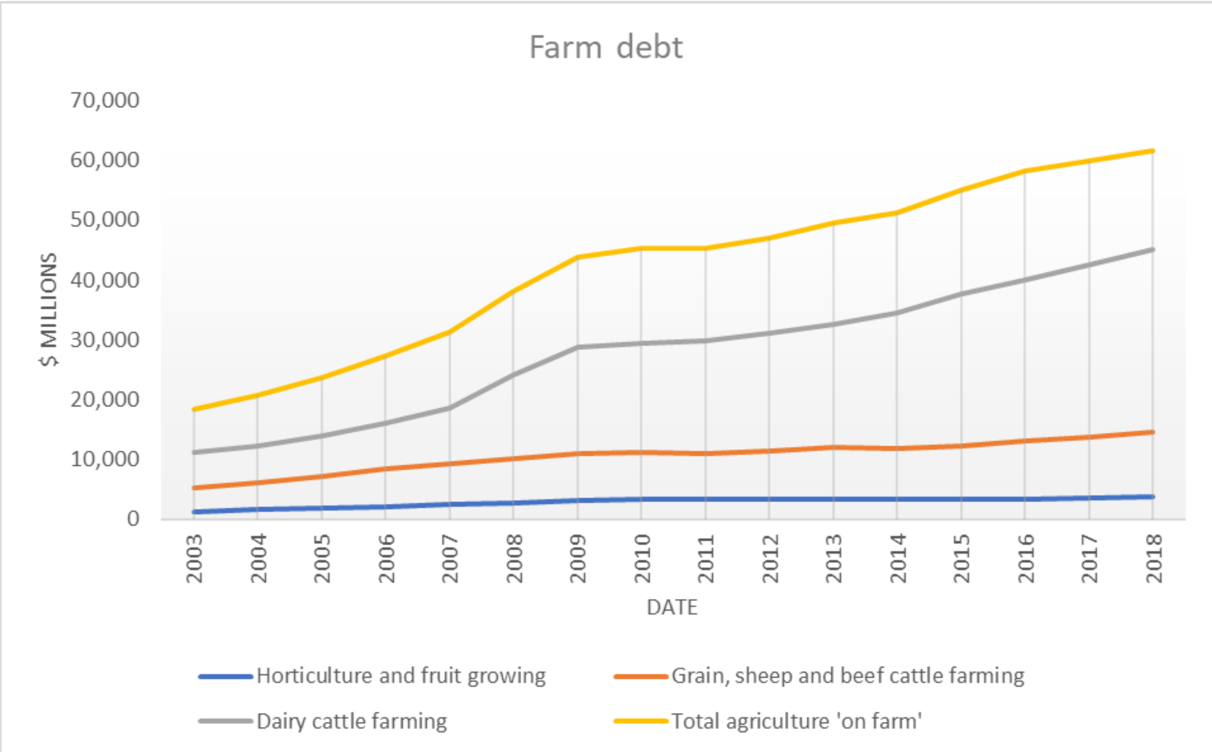
Land use diversification scenarios modelled in **Section 6** of this report have been selected on the basis of "improved" environmental impact. This definition of environmental impact was restricted to nutrient losses to water and GHG emissions to the atmosphere as these contaminants can be modelled and predicted within OverseerFM. The remaining contaminants identified in the NPS will be manged through Farm Environment Plans (FEP). Notwithstanding this, any decision to diversify should be cognisant of the other environmental impacts associated with the proposed land use.

These other environmental impacts can be obvious, such as increased water use, or less obvious, such as real or perceived impacts such as spray drift (associated with horticulture), odour associated with stock permanently housed indoors (e.g. goats) or noise associated with some horticulture frost protection methods (i.e. helicopters, wind fans).

## 2.2 Debt and Financial Position

A second driver for diversification and land use change at present, is the tightening position of the banks towards rural debt, dominated by dairy. **Figure 2** shows how dairy debt has increased relative to debt across the other primary industries. As presented in **Figure 3**, debt per kilogram of milk solids (kgMS) has increased from approximately $10 per kgMS in 2004 to over $24 per kgMS in 2018.

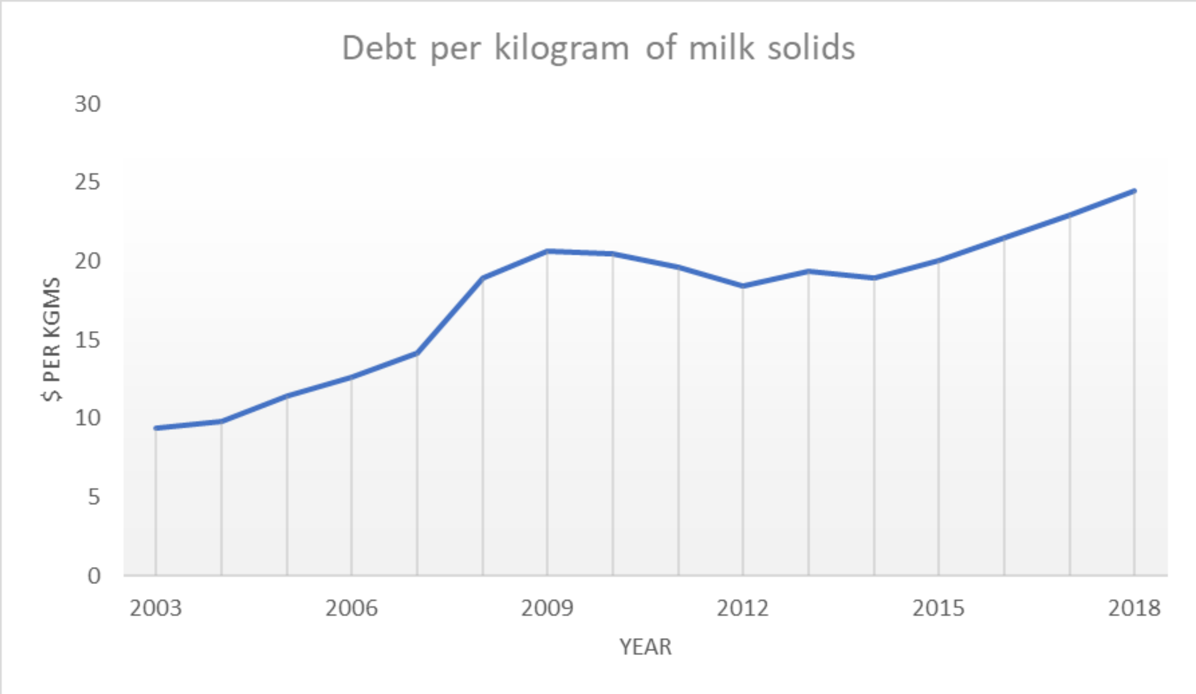
Figure 2: Farm debt




Source: Reserve bank, DairyNZ Economic Survey

In response, banks are actively looking at mechanisms to reduce their risk by focusing more on cashflow profitability rather than supporting capital gain only business models.

Figure 3: Debt per kgMS




Source: DairyNZ Economic Survey

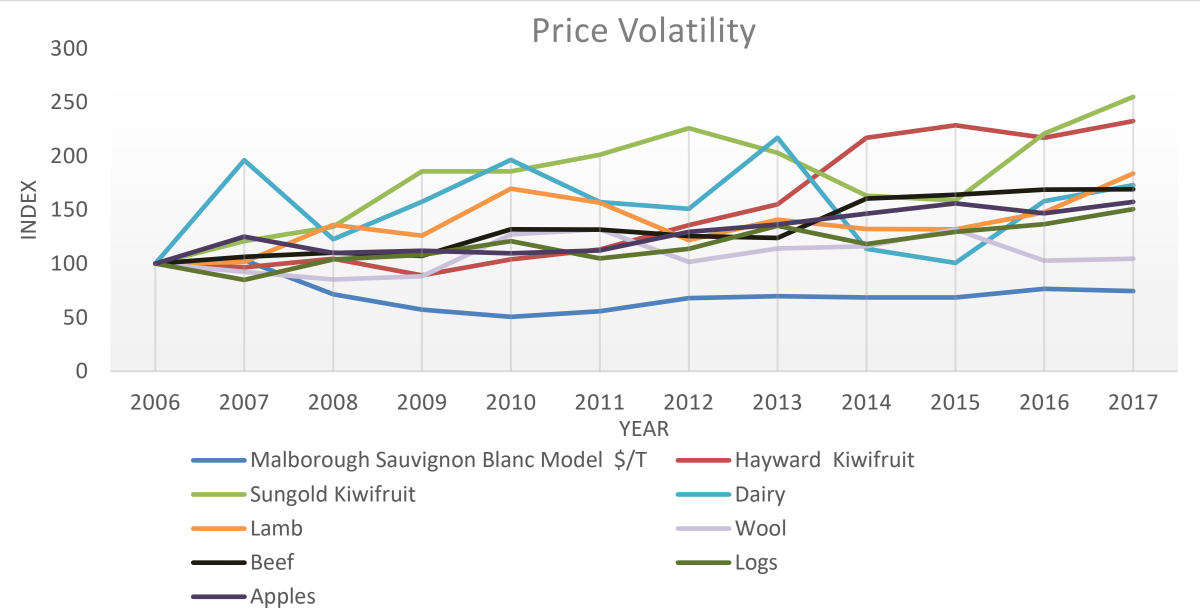
Dairy businesses in particular are the focus for risk mitigation by the banking industry, with an increasing requirement for principal and interest repayments. As a result, attention is directed to drawings and other personal expenditure, creating a sense for some farmers that they are under pressure, creating a driver to consider diversification.

## 2.3 Market Volatility

In **Figures 4** to **6**, the price volatility for a range of farm gate metrics ($ per tonne of produce, orchard gate returns, milk price, log price, and cents per kilogram of milk solids) have been indexed and compared between 2006 and 2017. Critically for the Waikato region, despite all commodities exhibiting a degree of volatility, it is dairy which has shown the greatest price volatility over the analysis period meaning dairy farmers have had less certainty than other primary producers as to the prices received for goods produced. This uncertainty differs from commodities such as Marlborough Sauvignon Blanc and Wool which despite not showing strong growth have shown more consistent, albeit lower, returns over the analysis period.

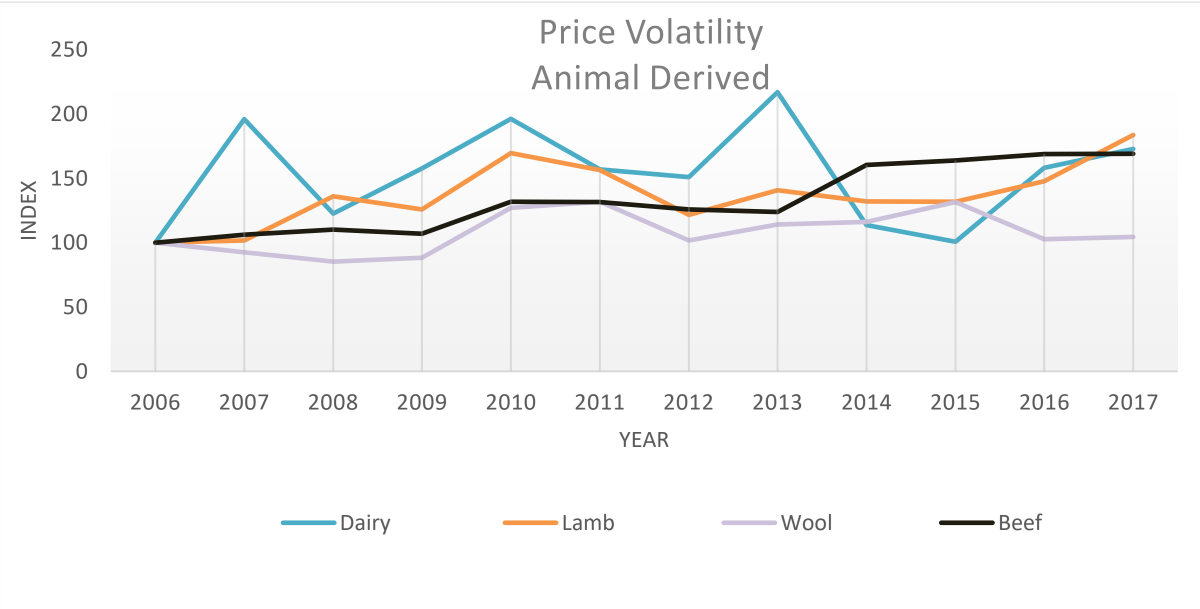
In these Figures, the various commodities have been indexed against themselves based at a set date (2006). This allows a comparison of their rate of change, or how they have varied over the time period, giving a good indication of their volatility. Having the same starting index (i.e. 100), it also allows for comparison across the commodities.

Figure 4: Price volatility



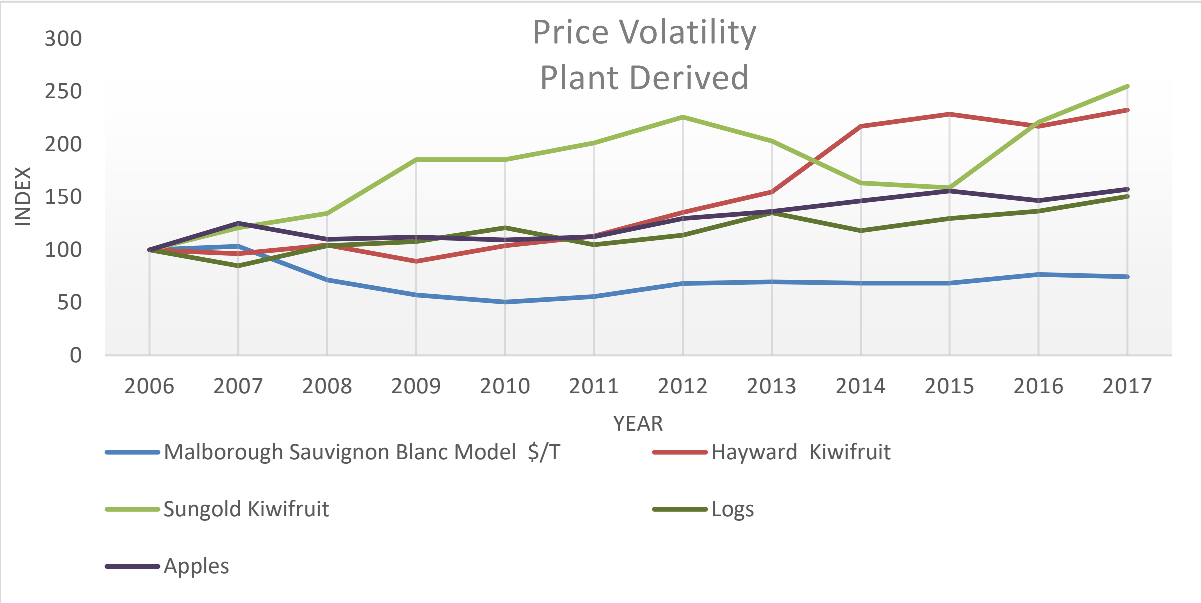

Source Zespri; ANZ, Ministry for Primary Industries, Pers. Comms Phil Journeaux, Beef and Lamb New Zealand Economic Service and DairyNZ Economic Survey.

Figure 5: Price volatility - animal derived




Source: DairyNZ and Beef & Lamb New Zealand

Figure 6: Price volatility - plant derived




Source Zespri; ANZ, Ministry for Primary Industries, Pers. Comms Phil Journeaux.

## 2.4 Industry Negativity

Despite the financial outlook in the primary industries being relatively promising, with high beef and lamb prices forecast and firming milk prices, the primary industries have a flatness and negativity at present, as reported in several media reports. This can be perceived negativity, however, with the strengthening voice of social media platforms, they are difficult to be ignored.

## 2.5 Labour and Business Complexity

Labour and the inability to attract suitably reliable, keen and trainable labour is often a business constraint across the primary industries.

Complexities associated with managing labour often drives farmers to consider less labour-intensive business methods. This consideration can often exacerbate the stress associated with running the farm business and farming entities may want to look at an option where labour is significantly reduced.

## 3.0 WAIKATO LAND USE AND NATURAL RESOURCES

The Waikato consists of 2.5 million hectares (ha) of land. Of this, agriculture comprises approximately 1.3 million ha (56%), native forest and scrub 613,000 ha (25%), exotic plantation forestry 315,000 ha (12%) and 'other' land (e.g. mountains, urban) 145,000 ha (6%)[1].

In terms of land use capability (LUC) (see **Figure 7**), the Waikato's presence of high quality agricultural landscapes is highlighted with LUC Class soils 1 - 4 comprising approximately 918,000 ha (37%), Class 5 and 6 approximately 930,000 ha (38%), and Classes 7 and 8 approximately 520,000 ha (21%). As presented in **Table 5** and **Figure 7**, the Waikato holds a significant proportion of these high-quality soils compared to the broader North and South Island and regional scales. Therefore, this reinforces the importance of the agricultural sectors in the Waikato and how valuable this resource is.

Table 5: Regional LUC Summary

| Land Use Capability Class | Region as a percentage of land use capability class | | | |
|---|---|---|---|---|
| | Waikato | NI | SI | NZ |
| 1-4 | 37% | 28% | 22% | 25% |
| 5-6 | 38% | 36% | 23% | 29% |
| 7-8 | 21% | 33% | 51% | 43% |

Source: LUCAS NZ Land use Map, NZLRI & Stats NZ.

LUC is an important consideration for due diligence of land use diversification. Put broadly LUC provides guidance to the capability of the land resource for sustained production, which can be matched to the requirements of a particular crop or farming enterprise. **Table 6** below provides an indication as to how LUC and land use relate.

## 3.1 Land Use Capability

The LUC is defined as a systematic arrangement of different kinds of land according to those properties that determine its capacity for long - term sustained production. Capability is used in the sense of suitability for productive use or uses after taking into account the physical limitations of the land.

Table 6: How LUC and land use relate [2]

| LUC Class | Arable cropping suitability | Pastoral Grazing suitability | Production forestry | General Suitability |
|---|---|---|---|---|
| 1 | High ↓ | High ↓ | High ↓ | Multiple land use |
| 2 | | | | |
| 3 | | | | |
| 4 | Low | | | |
| 5 | Unsuitable | | | Pastoral or forestry land |
| 6 | | | | |
| 7 | | Very Low | Low | |
| 8 | | Unsuitable | Unsuitable | Unsuitable |

LUC Classes 1-4 are suitable for arable cropping (including vegetable cropping), horticultural (including vineyards and berry fields), pastoral grazing, and tree crop or production forestry. Classes 5 to 7 are not suitable for arable cropping but are suitable for pastoral grazing, tree crop or production forestry, and in some cases vineyards and berry fields. Class 8 land is unsuitable for grazing or production forestry and is best managed for catchment protection and/or conservation.

[1] LUCAS NZ Land use Map 1990, 2008,2012 (v016) NZLRI Land Use Capability, Statistics NZ

There are four physical limitations recognised in the LUC subclasses that limit land use, which are:

- Erodibility – where susceptibility to erosion is the dominant limitation.
- Wetness – where a high water table, slow internal drainage, difficulty/high cost to drainage required and/or flooding constitutes the dominant limitation.
- Soil – where the dominant limitation is within the rooting zone. This can be due to shallow soil profiles, subsurface pans, stoniness, rock outcrops, low soil water holding capacity, low fertility, salinity or toxicity.
- Climate – where the climate is the dominant limitation. This can be summer drought, excessive rainfall, unseasonal or frequent frost and/or snow, and exposure to strong winds or salt spray.

## 3.2 Traditional Waikato Land Uses

As shown in **Figure 7** and described in **Section 3.0** above, agriculture dominates the high-quality soils of the region. The dominant agricultural land uses of the region are further described below.

### *3.2.1 Dairy*

Dairy farming has been an important component of the Waikato economy for many decades, and its importance has increased over time with the conversion of sheep and beef land and production forestry into dairy farms.

Land use for dairying in New Zealand increased 42%, from 1.8 million ha to 2.6 million ha between 2002 and 2016. The Waikato had one of the largest increases in land area used for dairying (up 35%), between 2002 and 2016, with land taken out of productive forestry and conversions from sheep and beef.

In 2018 the Waikato region had 4,000 dairy herds and 1.5 million milking cows, compared with 4,900 dairy herds and 1 million milking cows in 2000. The value of milk production to the regional economy in 2018 was $3.2 billion, from 500 million kilograms of milk solids produced. 29% of New Zealand's dairy herds are in the Waikato, as well as 27% of New Zealand's milk production.

### 3.2.2 Sheep and Beef

Beef cattle numbers have decreased across New Zealand by 28% since 1994 (from 5 million to 3.6 million). Sheep numbers decreased by 44% with national numbers reducing from 49.5 million to 27.5 million between 1994 and 2017.

Recent land use change in the Waikato reflects this national trend with land used for sheep and beef decreasing by 22% from 2002 to 2016 as a result of dairy conversions.

### 3.2.3 Goat Milking

The Waikato region has a well-established dairy goat industry, with the majority of the dairy goat farms in New Zealand located in the Waikato largely as a result of the Dairy Goat Co-operative (DGC) being based in Hamilton.

DGC has worked to achieve a well-established dairy goat industry in the Waikato, resulting in New Zealand being one of the leading international manufacturers of goat milk powder for infants and young children, despite production from New Zealand being globally insignificant in terms of the proportion of global goat milk solids produced.

### 3.2.4 Kiwifruit and other 'permanent' Horticulture

Kiwifruit is well established in nearby regions such as the Bay of Plenty and Northland. In the Waikato pockets of kiwifruit can be found on generally free-draining soils around Hamilton, Cambridge, Te Awamutu, Pirongia and Ohaupo. Like a range of other horticultural activities including apples, pears and persimmons, kiwifruit are sparsely located across the region rather than being the dominant land use as they are in the Bay of Plenty, and as pipfruit and vineyards are in parts of the Hawke's Bay for instance.

### 3.2.5 Production forestry

In the Waikato region, forestry contributes to nearly $280 million, 20% of the national forestry GDP. The Waikato region has the single largest area of plantation forest of any region in New Zealand, at 330,000 hectares, which equates to 27% of the North Island total area of production forestry, or 19% of the New Zealand total.

## 4.0 RESEARCH METHODOLOGY AND GUIDANCE TO RESULTS

### 4.1 Selection Criteria

In terms of determining the enterprises to be analysed, the approach has been to select industries on the following basis:

1. **Biophysically Feasible**
   The diversification scenario involves crops that are known to grow in the Waikato region given the climate and soil. Horticulture (nuts, kiwifruit and apples) and cut and carry enterprises (maize, lucerne and dairy goats) are limited to easy slope classes to allow tractor access. Apples and kiwifruit are further limited by a requirement for free draining soils to get year-round machinery access. Both Kiwifruit and apples require irrigation which in the Waikato River catchment may be a significant constraint. Kiwifruit and apples require shelter and may require frost protection at various times of the year. These can be costed into a development dependent on its location and micro-climate and are not considered to be significant constraints.

2. **Commercially Feasible**
   Diversification scenarios, with the exception of chestnuts[2], have been selected with an established value chain, i.e. where if a farmer was to produce a product and was to meet various standards they have a known market.

3. **Environmentally Feasible**
   Due to recent regulatory changes with the Healthy Rivers – Plan Change 1, there are now strict controls over land use changes. It is now a non-complying activity to intensify land within the Waikato and Waipa catchments for land parcels greater than 4.1 ha. Intensifying includes:

   - From woody vegetation to farming activities; or
   - Any livestock grazing other than dairy farming to dairy farming; or
   - Arable cropping to dairy farming; or
   - Any land use to commercial vegetable production is a non-complying activity.

   To intensify land use within the Waikato and Waipa catchments therefore will require a resource consent and significant technical investigation, and justification to demonstrate to the Council that the loss of contaminants from the proposed land use will be equal or

[2] The rationale for selecting chestnuts was to provide a second diversification option to forestry which could be developed on land with LUC below 4 and critically to provide a land use option which does not require additional water to product a crop.

less than that from the existing land use. While these rules do not currently apply to the entire Waikato region, it is likely that there will be future land use change constraints and regulations specified over the rest of the region. This is reinforced by recent central government actions looking to restrict land use change to more intensive activities, across the rest of the country.

In the context of selecting the scenarios for modelling, consideration was made to ensure that the per ha nutrient and contaminant losses were no greater, and hopefully lower than typical dairy or sheep and beef operations. This constraint resulted in commercial market gardening for vegetables including potatoes and onions being disregarded.

Consideration initially was not given to constraints around water allocation from a water access perspective or other environmental considerations such as spray drift or changing visual amenity to a region dominated by pastoral rather than horticultural. Comment is however provided within this report as to the impact associated with a varying water take.

4. **Scalable**
   In selecting enterprises for diversification the approach was to select crops or farming enterprises where it was considered that a number of new entrants could enter the market without creating an over-supply of product, thereby depressing the price.

## 4.2 Representative Options

This modelling has not sought to analyse all agricultural land use options, but rather aims to demonstrate a range of potentially feasible and recognised agricultural industries for the Waikato. The steps and processes developed within this report to outline diversification options may be applied or substituted to a broader range of crops, horticultural and pastoral systems.

This report seeks to show a range of diversification options, such as alternative dairy milking (sheep and goats) and arable crops (maize and lucerne) that could replace or be conducted on a large part of a farming platform, through to permanent horticulture and trees (kiwifruit, apples, chestnuts and forestry) that may take up a smaller proportion of an existing farm.

The purpose of this analysis is to identify the difference in investment and potential environmental impact. A landowner seeking diversification options not profiled in this assessment (e.g. blueberries, macadamias or hemp) could follow the methodology (**Section 4**) and approach outlined in this report, but to consider specific due diligence to their property and the preferred land use option. Presented in **Figure 1** above is a systematic diagram displaying the diversification scenarios and how additional options could be incorporated into the process.

## 4.3 Approach to Modelling and Analysis

### *4.3.1 Economic*

Quantitative modelling of the financial performance for a range of diversification options has been undertaken. This modelling provides a series of common metrics for economic comparison which are summarised below.

1. **Net Present Value (NPV)**

   The Net Present Value (NPV) is the value in today's dollars of a future cashflow - the difference between gross income less expenditure over a set time period, discounted back using a set interest rate (the discount rate). NPV accounts for the time value of money - it provides a method for evaluating and comparing capital projects or financial products with cash flows spread over time.

   A positive NPV says the project can more than meet its cost of capital (the discount rate). Conversely, a negative NPV says the project fails to meet its cost of capital. Generally, the higher the NPV the more favourable the investment.

   For the purposes of this economic modelling the period of time is 20 years with an assumed interest rate (discount rate) of 6%[3] for all scenarios with the exception of forestry where 8%[4] was used.

2. **Internal Rate of Return (IRR)**

   The Internal Rate of Return (IRR) is the equivalent interest rate return generated by the investment and is used to estimate the profitability of potential investments. It is equivalent to the discount rate at which the NPV equals zero.

   The higher a project's internal rate of return, the more financially desirable it is to undertake. IRR is uniform for investments of varying types and, as such, IRR can be used to rank multiple prospective projects on a relatively even basis, although it is important to consider factors such as total capital costs when using IRR.

3. **Payback period**

   The payback period refers to the amount of time it takes to recover the cost of an investment. Simply put, the payback period is the length of time an investment takes to reach a breakeven point.

   The desirability of an investment is directly related to its payback period. Shorter paybacks mean more attractive investments.

4. **Total Capital**

   Total capital for the purposes of this modelling is the sum of the total capital costs involved for the development of the land use option, plus the operational losses accrued prior to the point where the enterprise first generates a positive revenue (i.e. revenue is greater than operating costs).

[3] Current discount rate used by the NZ Government
[4] Industry norm

5. **Cash farm surplus per ha**
   At peak farm production, cash farm surplus per ha is calculated by subtracting capital purchases and farm working expenses from gross farm income. This metric is a useful and easy to understand metric for comparing farm performance. Although care needs to be taken to consider in conjunction with other economic metrics so the importance of the initial capital outlay is not lost.

### *4.3.2 Risk*

Qualitative assessment of the risk factors including consideration of the non-economic factors that could pose risk to a proposed development or which would need to be considered when entering into the proposed diversification have also been considered. These factors included the following:

1. **Flexibility to further change**
   The ability for the diversification activity to be undone. This flexibility to further change has two components, (a) the amount of the base platform required to create an economic unit; and (b) the degree to which the land resource is changed to facilitate the new production system. Consideration of flexibility is closely linked to total capital requirement and payback periods contained in the economic analysis.

2. **Water Usage**
   In this context consideration around water usage is purely around the business risk associated with gaining access to water which could be additional to rights held by an existing business.

3. **Production Certainty**
   This risk metric relates to a qualitative assessment as to the risks around the new farm enterprise delivering the production levels required to meet the assumptions contained in the modelling, to be economic. A lack of track record for the crops being grown in the Waikato will increase the risk here, as will newness of the industry generally.

4. **Labour**
   Throughout the primary industries, labour is in short supply, and industries with a high labour requirement therefore carry risk.

5. **Upskilling**
   This risk is in effect a metric as to how different the diversified business is from either dairy or sheep and beef farming systems. It is acknowledged that all farms are different. What this risk looks to examine is the difference of first principal skillsets.

### *4.3.3 Environmental*

To establish a reasonable baseline reference for both sheep and beef and dairy farm enterprises, a quantitative modelling assessment has been undertaken.

For the sheep and beef scenario, to practically allow the diversification options to be represented, it was decided that farms with some land capable for finishing or with more intensive grazing blocks should be modelled. This is due to the biophysical constraints of land for conversion and also the location of the farm and access to the market. The typical inputs used for the modelling scenarios are presented in **Appendix A**.

For the dairy farm baseline, a typical farm has been modelled. This is based on the assumption that a large proportion of Waikato dairy farms would have suitable land that could be converted into an alternative diversification options. The typical inputs used for the modelling scenario are presented in **Appendix A**.

To provide an environmental comparison for the diversification options, a similar approach has been taken, whereby average production, yields, stock units and inputs have been assumed. These have been presented in **Appendix B** for each diversification option. Where available, industry specific data has also been used.

The farms were modelled using OverseerFM v6.3.1. The inputs are based on typical values that represent the respective farming system and have not been collected from an operational farm. Default values have been used where appropriate, following the OverseerFM User Guidelines.

Regardless of the inputs used, key drivers for nutrient losses when using Overseer, are soil type and climatic conditions. To maintain a consistent approach, rather than use the S-Map data provided, soil type by soil order and group has been used. However, the control over rainfall is more variable, with approximately 1,200 mm of annual rainfall to the east of Waikato on flat to rolling land, and up to and beyond 1,600 mm to the west. These location specific inputs can influence nitrogen leaching significantly, and while it has been attempted to provide a reasonable baseline, caution must be taken when interpreting the results.

The main GHG emissions from agriculture are methane and nitrous oxide. Methane is produced in the rumen as a by-product of digestion, whereas nitrous oxide is produced from nitrogen in animal urine, and from the use of nitrogen fertilisers. The combination of methane and nitrous oxide are known as 'biological' GHGs, and are the target of reductions under the zero-carbon bill. Within this report, the biological GHGs emitted from each land use option is illustrated, based on analysis of the respective model within Overseer.

## 5.0 BASELINE MODELLING

### 5.1 Representative Waikato Sheep and Beef and Dairy Farms Financial Summary

The following information relating to the financial performance of a representative dairy and sheep and beef farm has been taken from the AgFirst 2019 Financial Survey. The information provided in **Table 7** summarises the modelled 2018/19 performance for a representative central North Island Sheep and Beef Property, whereas **Table 8** models dairy farm performance. Whilst it is acknowledged that a number of Waikato dairy farms will be smaller in area than those presented below, the purpose of this information is more to provide an indication to the types of current financial returns which are representative of dairy and sheep and beef businesses. The baselines will aim to provide the reader with metrics to enable them to consider the financial realism of a number of diversification alternatives which are profiled in **Section 6**.

Table 7: Key parameters, financial results and budget for the Central North Island Hill Country sheep and beef model

| Year ended 30 June | 2018/19 |
|---|---|
| Effective area (ha) | 571 |
| Breeding ewes (head) | 2 355 |
| Replacement ewe hoggets (head) | 670 |
| Other sheep (head) | 35 |
| Breeding cows (head) | 121 |
| Rising 1-year cattle (head) | 157 |
| Other cattle (head) | 113 |
| Debt | $1,659,000 |
| Interest | $84,350 |
| Net cash income ($) | $548,329 |
| Farm working expenses ($) | $313,839 |
| Farm profit before tax ($) | $125,625 |
| Farm surplus for reinvestment ($) | $56,751 |

Table 8: Key parameters, financial results and budget for the Waikato/Bay of Plenty dairy model

| Year ended 30 June | 2018/19 |
|---|---|
| Effective area (ha) | 127 |
| Cows wintered (head) | 373 |
| Replacement heifers (head) | 80 |
| Stocking rate (cows/ha) | 2.9 |
| Total milksolids (kg) | 127,203 |
| Milksolids per ha (kg/ha) | 1,002 |
| Milksolids per cow milked (kg/cow) | 349 |
| Debt | $2,467,588 |
| Interest | $126,429 |
| Net cash income ($) | $895,721 |
| Farm working expenses ($) | $533,841 |
| Farm profit before tax ($) | $186,927 |
| Farm surplus for reinvestment ($) | $109,802 |

## 5.2 Modelled Farms Capacity for development

Whilst every farm business will have a unique financial position and therefore varying ability to take on additional debt for development, the modelled farms above, as demonstrated by 'farm surplus for reinvestment' are businesses which are running on tight margins. 'Farm surplus for reinvestment' is the capital available to both undertake additional capital expenditure and to pay back principal. **Table 9** below indicates a range of principal repayment scenarios. No assumption has been made as to the proportion of farm surplus for reinvestment which could, should, or would be directed to principal repayment and what capital would therefore be available for development or diversification. Regardless of the proportions, based on an assumption of some debt repayment, both the modelled sheep and beef and dairy businesses have limited capacity for development and therefore diversification from cash surpluses may not be possible. Significant capital development such as horticulture would need to be supported by additional borrowing, or the instigation of different capital models such as a joint venture or equity partnerships.

Table 9: Principal repayment scenarios

| | Sheep and Beef Model | Dairy Model |
|---|---|---|
| Model Farm Debt | $ 1,659,000 | $ 2,467,588 |
| Farm Surplus for Investment | $ 56,751 | $ 109,802 |
| **% of Debt** | **Debt repayment ($)** | |
| 1.0% | 16,590 | 24,676 |
| 2.0% | 33,180 | 49,352 |
| 3.0% | 49,770 | 74,028 |
| 4.0% | 66,360 | 98,704 |
| 5.0% | 82,950 | 123,379 |

It is not the place of this report to provide commentary on the affordability for individual developers, or to step through the multitude of diversification options which might exist for an individual property; this report also does not look to provide advice as to how a sheep and beef or dairy business might capitalise on its existing assets, i.e. the cash for wholesale diversification which could be made available from the sale of a dairy herd, the sale of shares and/or the sale of other capital equipment. This notwithstanding, the AgFirst farm monitoring report can provide some insights as to what the order of magnitude might be of cash freed up in a wholesale diversification situation as summarised in **Table 10** below.

Table 10: Assets that could be liquidated to facilitate diversification

| Assets that could be liquidated to facilitate diversification | Sheep and Beef | Dairy |
|---|---|---|
| Plant | $150,000 | $210,000 |
| Stock | $940,000 | $600,000 |
| Dairy Company Shares | | $700,000 |
| Note: This information is taken from the AgFirst Waikato/Bay of Plenty Farm Financial Survey | | |

Caution needs to be exercised when using this information for the following reasons:

1. Every farm will be different, including the size of the property and system type.
2. The proportion of a property that would be converted to the diversified enterprise will differ, i.e. some dairy farms may have small areas suited to horticulture or large scale cut and carry enterprises (Refer to **Section 4.1**) and therefore it is critical to consider the economics of change at the farm scale rather than on a per ha basis.

## 5.3 Environmental Baseline Modelling for Sheep and Beef and Dairy

As detailed in **Section 3.0** the existing key land uses in the Waikato region have been modelled. The following sections detail the environmental footprint for the entire farming operation from the representative sheep and beef and dairy farms on a per hectare basis. These farms and corresponding environmental losses do not intend to represent all systems, and for clarity, the key inputs have been included in **Appendix A** for each enterprise.

### *5.3.1 Sheep and Beef*

For the purposes of considering a broad range of diversification options, the sheep and beef farm modelled for environmental losses is based on a typical Waikato sheep and beef farm that consists of a steep hill country breeding block and a higher stocked finishing block on rolling country. The finishing block has some reasonable contours available for development with a slope class C (8-15 degrees and largely navigable by tractor)[5]. This is assuming that farms with a portion of their land having better land use capability would more likely be developed and converted into alternative agricultural systems detailed in this report. This notwithstanding, the diversification options of both forestry and nut growing are land use opportunities that could be available for properties with higher LUC classification and slopes above 20 degrees, such as a breeding block. The key attributes of the modelled farm are summarised in the assumptions within **Appendix A**. The nutrient and GHG losses based on this analysis are summarised below.

Table 11: Nutrient and greenhouse gas losses for sheep and beef

| Contaminant/Emission Type | Sheep and Beef |
|---|---|
| Nitrogen loss (kg N/ha) | 13.0 |
| Phosphorus loss (kg P/ha) | 0.5 |
| Methane emissions (tonnes $CO^2$ Equivalents/ha) | 3.6 |
| Nitrous Oxide emissions (tonnes $CO^2$ Equivalents/ha) | 1.0 |
| Total GHG emissions (tonnes $CO^2$ Equivalents/ha) | 4.6 |

### *5.3.2 Dairy Farm*

The dairy farm modelled for environmental losses is based on a 'typical' or average farm in the Waikato. The key attributes of the modelled farm are summarised in the assumptions within Appendix A. The nutrient and GHG losses based on this analysis are summarised below.

[5] This is based on Beef + Lamb NZ data showing slope categories for a central North Island farm of: 40% steep (>26°), 53% easy (16-25°), 5% rolling (8-15°), and 2% flat (0-7°).

Table 12: Nutrient and greenhouse gas losses for a dairy farm

| Contaminant/Emission Type | Dairy Farm |
|---|---|
| Nitrogen loss (kg N/ha) | 30.0 |
| Phosphorus loss (kg P/ha) | 0.6 |
| Methane emissions (tonnes $CO^2$ Equivalents/ha) | 7.3 |
| Nitrous Oxide emissions (tonnes $CO^2$ Equivalents/ha) | 2.5 |
| Total GHG emissions (tonnes $CO^2$ Equivalents/ha) | 9.8 |

## 6.0 DIVERSIFICATION OPTIONS

This section includes a number of diversification scenarios. Each section begins with an industry description which includes information both on the industry and its markets but also the biophysical constraints. Economic, environmental and risk assessment follows for each potential industry.

In presenting the economic analysis focus has been on ensuring a reasonable economic unit is presented so that lack of scale does not create an unfavourable bias within the economic modelling.

### 6.1 Dairy Goats

#### *6.1.1 Industry Description*

The New Zealand commercial dairy goat industry began in the 1980s. In the greater Waikato the small but well-established industry comprises the majority of New Zealand's 66,000 dairy goats.

Caprine Innovations NZ (CAPRINZ) is a five-year (2018-2023), $29.5 million Primary Growth Partnership (PGP) programme funded by MPI and DGC. The aim of the programme is to undertake research to underpin a position where goat milk infant formula become a preferred alternative to conventional infant formula and to provide a competitive advantage to the New Zealand goat milk industry that will be difficult to replicate in other parts of the world.

The project aims to increase export revenue in the goat milk industry to $400 million a year by 2023. The industry's current value is estimated to be about $250 million, and to facilitate the goals of this publicly funded research programme, the national goat herd will need to increase to 100,000 by the conclusion of the PGP programme.

A dairy goat business, like a dairy cow business, involves the conversion of forages, crops and grains into milk. The farm system required is however quite different to the majority of dairy and sheep and beef businesses in the Waikato.

This difference is based on the nature of the animal being farmed. Goats, unlike cows and sheep, are browsers rather than grazers, this coupled with the animal's tendency to be severely impacted by parasites means commercial goat milking is generally a cut and carry system with open-sided free stall barns housing the goats, which are fed a range of largely home grown forages. DGC stipulates 75% of the does' diet are forages (based on wet weight).

### *6.1.2 Economic Analysis*

The following analysis is based on the assumptions included in **Appendix B**.

Table 13: Dairy goat economic analysis

| Dairy Goats | NPV | IRR | Payback (years) | Total Capital | Cash farm surplus per ha | Area |
|---|---|---|---|---|---|---|
| | $1,645,697 | 10% | 8.5 | $4,600,000 | $10,410 | 60 ha development |

Given the known limitations on obtaining issued DGC shares, the following sensitivity analysis (Table 10) includes both a consideration of purchasing shares from an existing supplier at a value higher (assumed to be $35.00 per share) than issue price and an option of developing and supplying without shares and therefore certainty that supply will be processed. Un-shared milk is purchased to meet demand as required and is purchased at a reduced rate with existing shareholders given supply preference. For modelling purposes, un-shared goat milk is assumed to be worth $14.00 per kgMS as opposed to $18.00 per kgMS (shared price). This non-shared milk carries significant risk of a producer not having a market to process the product.

Table 14: Dairy goat sensitivity analysis

| Dairy Goats | NPV | IRR | Payback (years) | Total Capital | Area |
|---|---|---|---|---|---|
| **$35 Shares** | $479,296 | 7% | 10.5 | $5,800,000 | 60 ha development |
| **No Shares** | -$434,606 | 3.9% | 13.5 | $2,500,000 | |

### 6.1.3 Risk and uncertainty

The following risk assessment has been prepared as a means to consider the relative risk associated with diversification into Dairy Goats.

| Dairy Goats | Risk 1 (low) to 5 (high) | Description |
|---|---|---|
| Flexibility to Change | 3 | High capital requirement for the development of new housing and milking parlour infrastructure would reduce flexibility. Dairy goat platform has been assumed to require 60 ha of largely mowable contoured land. |
| Water Usage | 2 | Depending on baseline water usage a dairy goat or dairy sheep conversion is likely to require less water that that from a dairy cow operation, but greater than most sheep and beef businesses. Notwithstanding the relativities between an existing enterprise and a diversified option, advice should be sought from Waikato Regional Council around water allocation. |
| Production Certainty | 2 | Dairy goats are a relatively mature industry and therefore a developer should reasonably be able to achieve the production levels modelled in this report. The risk from a production certainty rather relates to availability of DGC shares to enable a premium milk price. |
| Labour | 3 | Dairy goats will have a higher labour demand than dairy cows on a per ha basis, due to the intensity of the housed operations including the cut and carry feed harvesting. Some aspects of the stock work might be less physical than work involving cattle. |
| Upskilling | 3 | New skills will be required in terms of the systems particular to a dairy goat business. The degree of upskilling around managing total mixed rations will depend on the baseline situation for the farm considering diversification. |

### 6.1.4 Environmental Considerations

To maintain a consistent approach, the dairy goat farm modelled for nutrient losses is based on a 'typical' cut and carry operation with Total Mixed Rations (TMR). The TMR feed ratio is based on the requirements set out by DGC which is to ensure that at least 75% of the total feed offered is forage. The key attributes of the modelled farm are summarised in the assumptions within **Appendix B**. The nutrient losses based on this analysis are summarised below. Due to the modelling uncertainties, the GHG modelling results have not been included.

Table 15: Nutrient and greenhouse gas losses for dairy goats

| Contaminant/Emission Type | Dairy Goats |
|---|---|
| Nitrogen loss (kg N/ha) | 19 |
| Phosphorus loss (kg P/ha) | 0.1 |

## 6.2 Dairy Sheep

### *6.2.1 Industry Description*

The dairy sheep industry in New Zealand began following the importation of East Friesian sheep in 1992. In early 2014, there were five dairy sheep operations in New Zealand, which ranged from 70 ewes to the largest, being Blue River Dairy in Southland, with over 20,000 ewes. New Zealand now has more than 30,000 milking sheep, providing quality sheep milk products to overseas markets.

On the back of the commissioning of a new spray dryer at the Waikato Innovation Park, both Spring Sheep Co (a private public partnership involving Pāmu) and Maui Milk (a sheep milking joint venture between Shanghai-based Maui Food Group and Waituhu Kuratau Trust) are actively seeking new suppliers to satisfy increasing demand for their infant formula and other value add products.

The Ministry of Business, Innovation and Employment (MBIE) programme called 'Boosting exports of the emerging NZ dairy sheep industry' is a six-year research programme aimed to grow dairy sheep exports.

### *6.2.2 Economic Analysis*

The following analysis is based on the base assumptions included in **Appendix B**.

Table 16: Dairy sheep economic analysis

| Dairy Sheep | NPV | IRR | Payback (years) | Total Capital | Cash Surplus per ha | Area |
|---|---|---|---|---|---|---|
| | $1,156,722 | 12% | 7.5 | $1,587,500 | $4947 | 60 ha development |

The infancy of the dairy sheep industry in the Waikato at scale poses a number of risks which are discussed in section 6.2.3 below.

### 6.2.3 Risk and uncertainty

The following risk assessment has been prepared as a means to consider the relative risk associated with diversification into Dairy Sheep.

| Dairy Sheep | Risk 1 (low) to 5 (high) | Description |
|---|---|---|
| Flexibility to Change | 2 | The major constraint on changing land use to dairy sheep would be the sunk capital rather than any physical constraint and the industry has invested significantly in developing systems that enable the efficient conversion of existing dairy farms. |
| Water Usage | 2 | Depending on baseline water usage a dairy goat or dairy sheep conversion is likely to require less water that that from a dairy cow operation, but greater than most sheep and beef businesses. Notwithstanding the relativities between an existing enterprise and a diversified option, advice should be sought from Waikato Regional Council around water allocation. |
| Production Certainty | 4 | Lack of fundamental research on production and genetics in a New Zealand context at commercial scale, due to industries infancy so there could be a longer than modelled ramp up to commercially profitable production levels. |
| Labour | 3 | Similar to existing dairy businesses depending on system intensity. Some aspects of the stock work might be less physical than work involving cattle. |
| Upskilling | 3 | New skills required for efficient sheep milking and management, although the principals being developed for the lower intensity systems are closely aligned to the principals of good pasture and animal management. |

### 6.2.4 Environmental Considerations

While sheep milking operations are often compared to a dairy goat system with respect to nutrient losses (due to animal housing systems), for this example, due to the likely conversion from an existing pastoral system, the sheep milking system is based on an outdoor sheep grazing model. While OverseerFM does not have allowance for dairy sheep within the model, a dairy goat has been used to represent a milking sheep. While they are a reasonable match, there are several key variations that need to be considered. Sheep effluent contains less nitrogen, phosphorus and sulphur compared to dairy goats[6], sheep are grazers not browsers, which means less wastage when compared to dairy goats, and while goats are achieving milk solids production of often more than their liveweight, sheep production currently ranges from 50% - 75% of liveweight.

The key attributes of the modelled farm are summarised in the assumptions within Appendix B. The nutrient losses based on this analysis are summarised below. Due to the modelling uncertainties, the GHG modelling results have not been included.

Table 17: Nutrient and greenhouse gas losses for dairy sheep

| Contaminant/Emission Type | Dairy Sheep |
|---|---|
| Nitrogen loss (kg N/ha) | 17 |
| Phosphorus loss (kg P/ha) | 0.2 |

[6] Effluent Management on a Dairy Sheep Farm: Environmental Footprint, AgResearch and Ministry of Business and Employment

## 6.3 Maize

### *6.3.1 Industry Description*

Maize is a high-yielding C4 cereal which is widely grown in New Zealand both for grain and silage. It is a deep rooting plant which can access water and nutrients that have fallen below the root-zone of shallow-rooted pasture species. It has a summer water-use-efficiency three times that of perennial ryegrass pasture.

Waikato maize grain crops produce average yields of 11-13 t/ha of dry (14% moisture) grain. Silage crops grown on repeat cropping ground typically yield 18-22 tDM/ha with higher yields possible under good growing conditions and management.

Maize can be successfully grown across a wide range of soil types, however it does not perform well in waterlogged soils. Maize needs to be grown on land with a slope suitable for large machinery at harvest.

There are two possible end products for maize, either silage or grain. For silage, plant density is higher compared with grain, and is harvested two months earlier (February to April) compared with March to May for grain.

Maize silage is typically sold to dairy farmers on a standing basis with the purchaser paying for harvesting and all subsequent costs. Since there is a high density of dairy farms within the Waikato there is a solid demand for maize silage, with much of the crop being contracted in the spring prior to planting. The demand for uncontracted maize silage in the autumn is more variable and depends on dairy farm feed supply levels and the milk price.

The maize grain market is more unpredictable with grain contract price varying depending on world grain supply and demand dynamics. New Zealand end users can import maize grain, and so the international price and the exchange rate tend to set the price and the demand for locally produced grain.

### 6.3.2 Economic Analysis

The following analysis is based on the base assumptions included in **Appendix B**.

Table 18: Maize economic analysis

| Maize (for silage) | NPV | IRR | Payback (years) | Total Capital | Cash surplus per ha | Area |
|---|---|---|---|---|---|---|
| | $36,337 | 198% | 1 | $2,420 | $3180 | per ha |
| | $2,249,401 | 198% | 1 | $139,200 | - | 60 ha |

Average gross margins are $1,200 - $1,500 per ha for grain which results in a later harvest which often foregoes the option for annual ryegrass or winter forage crops which can either be grazed or as in this modelling harvested for silage

A second alternative to silage and grain would be to lease the land for the purposes of growing maize. Currently lease payments for growing maize are $1,200 - $1,400 per ha, plus the lessee pays the rates, given the lower returns a self-managed silage system has been presented.

### 6.3.3 Risk and uncertainty

The following risk assessment has been prepared as a means to consider the relative risk associated with diversification into Maize for Silage.

| Maize | Risk 1 (low) to 5 (high) | Description |
|---|---|---|
| Flexibility to Change | 1 | Annual cropping cycle with low establishment cost. |
| Water Usage | 1 | No water used above that from precipitation direct to the crop. |
| Production Certainty | 1 | A larger number of cultivars available to manage maturity timeframes, which enables wetter soils where access could be problematic to utilise a shorter growing season. Modelled assumption conservative and likely to be easily achievable. |
| Labour | 1 | Plentiful supply of contractors in the Waikato to undertake all aspects of the crop. |
| Upskilling | 1 | No upskilling likely to be required. Relatively simple crop to grown with significant support available from seed companies. |

### 6.3.4 Environmental considerations

For the maize crop nutrient assessment, an average 20 tonne DM per ha crop yield has been assumed. There will be significant variations between nutrient losses, depending on how recent the land was used as grazed pasture. These have been represented in **Table 19**, with the first scenario indicating nitrogen leaching from a long term maize crop (more than 10 years of cropping) and the second scenario demonstrating the nitrogen loss from a maize crop in its first year out of pasture. This is related to the organic matter that has built up under grazed pasture being mineralised when cultivated. The inputs are based on nutrient requirements for the maize crop, with the key attributes summarised in the assumptions within **Appendix B**. The nutrient and GHG losses based on this analysis are summarised below.

Table 19: Nutrient and greenhouse gas losses for maize

| Contaminant/Emission Type | Maize |
|---|---|
| Nitrogen loss (kg N/ha) for continual maize crop | 6 |
| Nitrogen loss (kg N/ha) for maize crop in first year out of pasture | 99 |
| Phosphorus loss (kg P/ha) | 0.3 |
| Methane emissions (tonnes $CO^2$ Equivalents/ha) | - |
| Nitrous Oxide emissions (tonnes $CO^2$ Equivalents/ha) | 0.8 |
| Total GHG emissions (tonnes $CO^2$ Equivalents/ha) | 0.8 |

## 6.4 Lucerne

### *6.4.1 Industry Description*

Lucerne is a deep-rooted, temperate, perennial legume which is grown in the Waikato, albeit not at a large scale. Lucerne prefers free draining soils with an optimum soil pH of 6.3 (above the Waikato average). Waterlogging and/or damage to the crown of the plant increases the risk of fungal disease reducing both yield potential and stand life. The latter is an important economic consideration as stands are relatively expensive to establish. Established Lucerne stands produce an autotoxin that inhibits the germination and growth of Lucerne seeds. This means Lucerne cannot be re-established in the same paddock without growing a break crop for at least a year.

Lucerne has a long tap root which can access water at depth. It grows well over the warmer period of the year. Most of the varieties available in New Zealand are dormant or semi-dormant, which produce less than 10% of their total growth over the winter period. Winter active varieties (which produce up to 20% of their growth in the winter) are less common and not practical to manage in the Waikato, where relatively wet winters make it is almost impossible to avoid crown damage.

Lucerne hay is well sought after, particularly by horse farmers and lifestyle farmers. In the Waikato It is difficult to consistently make Lucerne hay due to the four days of wilting to reach target harvest moisture.

Silage or baleage is a more feasible option and there is good demand from dairy farmers (both cow, sheep and goat) who require high quality brought in feed. While goat and sheep farmers are prepared to pay a premium for lucerne silage, cow farmers are more likely to compare it to the price of good quality pasture silage.

### 6.4.2 Economic Analysis

The following analysis is based on the base assumptions included in **Appendix B**.

Table 20: Lucerne economic analysis

| | NPV | IRR | Payback (years) | Total Capital | Area |
|---|---|---|---|---|---|
| Lucerne | $26,378 | 127% | 1 | $2,050 | per ha |
| | $1,582,659 | 127% | 1 | $123,000 | 60 ha |

The above economic analysis are based on a situation where the farmer manages the Lucerne stand themselves with the big bales of silage produced marketed by the grower. Less profitable options could be to sell the Lucerne as standing feed, leasing the stand to a contractor or focusing on hay production where it is likely that in the Waikato weather will affect the quality of hay given the long period of drying required to create a premium and highly sought after product.

### 6.4.3 Risk and uncertainty

The following risk assessment has been prepared as a means to consider the relative risk associated with diversification into Lucerne for Silage.

| Lucerne | Risk<br>1 (low) to 5 (high) | Description |
|---|---|---|
| Flexibility to Change | 1 | One year payback period and a crop which can be removed as easily as it is established. |
| Water Usage | 1 | No irrigation required. Crop will grow with rain water only. Lucerne is a crop which has performed very well in dry environments. |
| Production Certainty | 3 | Moderate, as a crop which is not grown a lot in the Waikato at scale, and a crop which is known to not like 'Wet Feet' which could restrict the number of locations in which the crop could be grown. |
| Labour | 1 | No Labour requirement with all tasks able to be undertaken by agricultural contractors with standard equipment. |
| Upskilling | 1 | Little to none. Understanding of when to cut the crop and how to manage pests, weeds and the crop drying process, although most pastoral farmers will already hold these skills. |

### 6.4.4 Environmental Considerations

For the Lucerne crop nutrient assessment, an average annual stand life yield of 12 tDM/ha has been assumed. As Lucerne naturally fixes nitrogen, there is no proven benefit of applying synthetic nitrogen. It has been found that adding nitrogen can stimulate weed growth, potentially limiting the life of the crop. The key attributes of the modelled farm are summarised in the assumptions within **Appendix B**. The nutrient and GHG losses based on this analysis are summarised below.

Table 21: Nutrient and greenhouse gas losses for lucerne

| Contaminant/Emission Type | Lucerne |
|---|---|
| Nitrogen loss (kg N/ha) | 8 |
| Phosphorus loss (kg P/ha) | 0.1 |
| Methane emissions (tonnes $CO^2$ Equivalents/ha) | - |
| Nitrous Oxide emissions (tonnes $CO^2$ Equivalents/ha) | < 0.1 |
| Total GHG emissions (tonnes $CO^2$ Equivalents/ha) | < 0.1 |

## 6.5 Alternative Broadacre Crops

A number of other broadacre crops could be grown including hemp, peas, soya, canola and sunflowers. As mentioned elsewhere in the report, the Waikato's humidity poses challenges for grain or seed drying. This challenge is added to by the current lack of post farm gate manufacturing capability of seed/alternative grain extraction and oil pressing. Consideration of diversifying into these types of crops comes at increased cost and at presently it is more difficult to assess the per ha or farm scenario returns. Another consideration for these crops is the global supply. Therefore, to be grown economically in New Zealand there needs to be a local market identified (due to population not likely to be large) or significant post gate value added through either marketing/brand development, health claims and further processing etc.

In terms of other broadacre crops which are known to grow well in the Waikato, none provide the same cash opportunity as maize or lucerne. Oats, triticale, plantain and chicory for example are usually grown directly as a feed crop grazed in situ, either as a supplement during a feed shortage, and/or as part of a regrassing programme. All of the above crops would not yield the same dry matter tonnage per ha as either lucerne or maize and are not likely to have the same number of markets. Other possibilities would be vegetable crops, e.g. potatoes or onions, as there are a number of key areas already profiled around the Waikato including Pukekohe and areas around Matamata.

Photo 1: Hemp production

The level of nutrients required to support these types of crops are significant, and are foreseen by WRC as intensification of land use, which under the PWRPC1 is a non-complying activity.

Photo 2: Sunflowers

The Waikato currently produces around 20% and 30% of the nation's potato and onion crops respectively. There is room for expansion of these vegetable crops, however there are significant environmental considerations. Both crops require a high volume of heavy machinery for seed bed preparation, planting, spraying and harvesting. To optimise yields and financial return high, fertiliser inputs are necessary and these are in conflict with the desire to reduce nutrient losses to water within the region. For farmers in the Waikato and Waipa River catchments, changing from any land use to commercial vegetable production requires a resource consent.

## 6.6 Kiwifruit

### *6.6.1 Industry Description*

The New Zealand kiwifruit industry was founded in the 1970's and has been based on the Hayward (green) variety. Following the 2010 PSA outbreak the SunGold variety has expanded with typical orchard gate returns for mature orchards double that of its green predecessor, with the added benefit of greater resistance to PSA.

Today, there are approx. 2,600 kiwifruit growers and 2,900 registered orchards in New Zealand covering approximately 12,185 ha of kiwifruit. 81% of New Zealand-grown kiwifruit comes from the Bay of Plenty, which provide by virtue of proximity offers the Waikato an opportunity to be an area of expansion.

Currently, the kiwifruit industry makes up 29% of New Zealand's horticulture export revenue. Zespri wishes to the see the industry grow from a 2018 base of 58 million tray equivalents to 250 million tray equivalents in 2025. This ambitious goal is benchmarked to historical performance prior to the impact of PSA. Exports have increased from 82.3 million trays in 2005/06 to 117 million trays in 2015/16 with a value of $1.9 billion.

Kiwifruit prefer free draining soils and have a high summer water demand (average water requirement of 3,000 $m^3$/ha/year rising up to 5,500 $m^3$/ha/year in drought conditions). To enable this an irrigation rate in the order of 50 $m^3$/ha/day would be required. Any development would need to obtain this water allocation, which could be challenging when water is a limited resource.

### *6.6.2 Single Point of Entry – Zespri*

The Single Point of Entry (SPE) structure is the use of one exporter over multiple exporters. Zespri is the SPE for the NZ kiwifruit industry and is the world's largest marketer of kiwifruit, selling into more than 53 countries and managing 30 percent of the global volume, and is the most recognised fruit brand in China's largest cities.

This marketing structure helps producers deliver scale in the market place and enables Zespri to choose a few motivated distributors to serve each market, making kiwifruit a significant priority and an essential part of their business.

Additional benefits include investment, branded premium product, commercialisation of new varieties, consistent quality, customer service, sustainability and competitive returns.

### 6.6.3 Economic Analysis

The following analysis is based on the base assumptions included in **Appendix B**.

Table 22: Kiwifruit economic analysis

| | NPV | IRR | Payback (years) | Total Capital | Cash surplus per ha | Area |
|---|---|---|---|---|---|---|
| Kiwifruit SunGold | $469,149. | 8% | 10.5 | $2,763,846 | $76,000 | 5 ha |
| Kiwifruit Hayward | -$122,264. | 5% | 13.5 | $1,262,310 | $28,000 | 5 ha |

The economic analysis for kiwifruit has been simplistically based on two scenarios where Hayward or SunGold are grown as the whole 5 ha orchard. This approach was taken as a means to clearly show differentiate the economic performance between the two varieties from a profitability perspective.

In reality a developer might choose to develop a mix of SunGold and Hayward. This diversified strategy would reduce price risk and upfront capital requirements associated with SunGold licence. Such a strategy would retain flexibility as should it be desired the Hayward kiwifruit could be removed and the root stock utilised for the re-grafting of a new variety into an orchard with developed infrastructure.

### 6.6.4 Risk and Uncertainty

The following risk assessment has been prepared as a means to consider the relative risk associated with diversification into Kiwifruit.

| Kiwifruit | Risk 1 (low) to 5 (high) | Description |
|---|---|---|
| Flexibility to Change | 4 | Capital cost for kiwifruit, particularly SunGold is significant. Given the nature of the infrastructure associated with the development, making the decision to enter kiwifruit is likely to be permanent for any land developed. This considered, a kiwifruit development is likely to be developed on only a portion of a dairy or sheep and beef platform and therefore flexibility on the balance of the property would be maintained or enhanced by managing risk and creating a diverse income stream. |
| Water Usage | 4 | As indicated earlier in this report, horticultural crops require summer irrigation to ensure a reliable crop production. Obtaining additional water within the Waikato river catchment to facilitate development will come with risk and costs. Notwithstanding, there are potentially opportunities to learn from other regions, with increased water-take volumes during high flows and storage of water for when required. |
| Production Certainty | 2 | Well established industry with significant research behind it, and support available through pack houses in the Bay of Plenty who have grower liaison reps who provide significant support to the orchard development and operations. Risk relates to new growing areas for kiwifruit, i.e. there is a risk between actual production and desktop assessed production which may be affected by microclimatic factors. |
| Labour | 4 | Horticultural crops have a very high labour requirement per ha. Attracting reliable and suitably skilled staff for key activities such as picking, pruning and thinning nationally is difficult and this would be no different in the Waikato. |
| Upskilling | 4 | There would be a significant requirement for upskilling to manage a commercial sized orchard. This upskilling would be across all facets of the production process, from pest and weed management, crop management to harvesting. |

### 6.6.5 Environmental considerations

As with other orchard varieties, there is limited nutrient modelling available for a Waikato kiwifruit orchard. For this comparison, a typical Bay of Plenty orchard has been used. To ensure that the nutrient losses would be representative of the Waikato region, soils have been defaulted to artificial drainage, and local climate and rainfall data has been used. When modelled in Overseer, the nitrogen losses from different scenarios were variable, particularly depending on the age of the tree and the production that is estimated. In comparison, orchards in the Bay of Plenty region have been modelled with losses between 15 to 20 kg N/ha/yr[7]. The key attributes of the modelled orchard are summarised in the assumptions within **Appendix B**. The nutrient and GHG losses based on this analysis are summarised below.

Table 23: Nutrient and greenhouse gas losses for kiwifruit

| Contaminant/Emission Type | Kiwifruit |
|---|---|
| Nitrogen loss (kg N/ha) | 18 |
| Phosphorus loss (kg P/ha) | 0.3 |
| Methane emissions (tonnes $CO^2$ Equivalents/ha) | - |
| Nitrous Oxide emissions (tonnes $CO^2$ Equivalents/ha) | 0.4 |
| Total GHG emissions (tonnes $CO^2$ Equivalents/ha) | 0.4 |

## 6.7 Apples

### 6.7.1 Industry Description

Behind kiwifruit and wine, apples are New Zealand's third largest horticultural export. The industry has had a recent renaissance on the back of strong intellectual property positions, with new varieties differentiated by strong brands into Asia rather than the 1970's focus of Royal Gala, Braeburn and Fuji being sold to the EU and US. Apple growing has in part, due to low returns from 2004 - 2012 relative to traditional Waikato land uses (dairy), retrenched in growing distribution nationally to concentrate in Nelson and (especially) the Hawke's Bay.

Apple production is expected to continue with growth in 2019 on the back of increased areas in production in Hawke's Bay, with a diversified export market dominated by Asia. The Asian market has underpinned strong performance by new cultivars including ENVY™, B Dazzle®, Pacific Queen™ and Rockit™.

Apples are grown in the Waikato[8], and although the more humid summer and autumns relative to traditional growing areas pose challenges for disease control, the challenges are not insurmountable.

[7] Freshwater quality and eco-verification of kiwifruit orchard practices, Benge, J. (The AgriBusiness Group), Clothier, B. (The New Zealand Institute for Plant & Food Research Limited) May 2016

[8] There are 140 ha of apples grown in the Waikato, 1.6% of the national area.

Apples prefer free draining soils and have a high summer water demand (water requirements for irrigation could be in the order of 3,000 $m^3$/ha/year rising up to 5,500 $m^3$/ha/year in drought conditions).. Any development would need to obtain this water allocation, which could be difficult when water is a limited resource.

### 6.7.2 *Economic Analysis*

The following analysis is based on the base assumptions included in **Appendix B**.

Table 24: Apple economic analysis

| Apples | NPV | IRR | Payback (years) | Total Capital | Cash surplus per ha | Area |
|---|---|---|---|---|---|---|
| | $1,488,737 | 14% | 7.5 | $ 511,274 | $24,115 | 5 ha |

Economic modelling for apples has been based on industry average values. The apple market is one which sees significant variation between varieties and the quality of the produced product in terms of profitability. In general terms, well managed new PVR protected varieties are profitable (although there is uncertainty around production in the Waikato), whereas older varieties and orchards subject to average management are only marginal business proposition. To manage this uncertainty the modelling has assumed industry averages.

### 6.7.3 *Risk and Uncertainty*

The following risk assessment has been prepared as a means to consider the relative risk associated with diversification into an apple orchard.

| Apples | Risk 1 (low) to 5 (high) | Description |
|---|---|---|
| Flexibility to Change | 4 | Capital cost for apples is a significant, and with the infrastructure associated with the development, making the decision to enter into apples is likely to be permanent. This considered, an apple development is likely to be developed on only a portion of a dairy or sheep and beef platform, and therefore flexibility on the balance of the property would be maintained. |
| Water Usage | 4 | As indicated earlier in this report, horticultural crops require summer irrigation to ensure a reliable crop production. Obtaining additional water within the Waikato river catchment to facilitate development will come with risk and costs. Notwithstanding, there are potentially opportunities to learn from other regions, with increased water-take volumes during high flows and storage of water for when required. |

| Apples | Risk<br>1 (low) to 5 (high) | Description |
|---|---|---|
| Production Certainty | 4 | Apples can be grown in the Waikato, however there are risks in managing disease control and the ability for the modern varietals to generate a large quantity of high quality high value fruit. |
| Labour | 4 | Horticultural crops have a very high labour requirement per ha. Attracting reliable and suitably skilled staff for key activities such as picking, pruning and thinning nationally is difficult, and this would be no different in the Waikato. |
| Upskilling | 4 | There would be a significant requirement for upskilling to manage a commercial sized orchard. This upskilling would be across all facets of the production process, from pest and weed management, crop management to harvesting. |

#### 6.7.4 *Environmental considerations*

There is limited nutrient modelling available for a Waikato apple orchard. For this comparison, a typical Hawke's Bay apple orchard has been used. To ensure that the nutrient losses would be representative of the Waikato region, soils have been defaulted with artificial drainage, and local climate and rainfall data has been used. The irrigation scheduling has been based on micro-irrigation and soil moisture sensors. The nutrient leaching is higher than in the Hawke's Bay base scenario, likely due to the increased rainfall and artificial drainage. The key attributes of the modelled orchard are summarised in the assumptions within **Appendix B**. The nutrient and GHG losses based on this analysis are summarised below.

Table 25: Nutrient and greenhouse gas losses for Apples

| Contaminant/Emission Type | Apples |
|---|---|
| Nitrogen loss (kg N/ha) | 23 |
| Phosphorus loss (kg P/ha) | 0.1 |
| Methane emissions (tonnes $CO^2$ Equivalents/ha) | - |
| Nitrous Oxide emissions (tonnes $CO^2$ Equivalents/ha) | 0.3 |
| Total GHG emissions (tonnes $CO^2$ Equivalents/ha) | 0.3 |

### 6.8 Chestnuts

#### 6.8.1 *Industry Description*

Chestnuts were first introduced to New Zealand by some of the earliest European settlers. Currently, importing overseas cultivars is extremely difficult, due to the risk of overseas pests and diseases being introduced.

As of 2016, fresh nut production was around 300 - 400 tonne per annum, with only a small amount (i.e. <1 tonne) exported.

Globally, chestnut production has constantly been rising, growing from almost 650,000 tonnes in 1993 to over 2 million tonne in 2013[9].

[9] FAOSTAT

Overseas processed products include peeled frozen free flow chestnuts, canned whole peeled chestnuts, vacuum-packed whole peeled chestnuts, ice cream yogurts, flour etc. Many products are sold on the health market for premium prices.

By developing a range of processed products from chestnuts, the New Zealand chestnut industry hopes to firstly, avoid becoming over supplied, thus crashing growers' returns, but secondly and more importantly, to develop added-value products to build the industry in New Zealand.

### *6.8.2 Economic Analysis*

Chestnuts may not have been an obvious diversification scenario given no established supply chain. One of the main reasons for modelling chestnuts was due to their ability to produce a crop in lower fertility and colder climates typical of some of the southern parts of the Waikato. The following analysis is based on the base assumptions included in **Appendix B**.

Table 26: Chestnut economic analysis

| | NPV | IRR | Payback (years) | Total Capital | Cash farm surplus per ha | Area |
|---|---|---|---|---|---|---|
| Chestnuts | $155,126 | 9% | 12.5 | $352,000 | $9,850 | 10 ha development |

As mentioned earlier in the report, chestnuts are the only diversification scenario selected where there is not a clear supply chain for the product produced. Therefore, caution needs to be made with respect to the above given there is a real risk a market might not exist for the Chestnuts produced thereby eroding all value.

Compared to many horticultural crops, a chestnut orchard is cheap to establish and maintain, and has a low input requirement (except at harvest). This allows most orchard owners to follow additional vocations as well. There may also be the potential with the use of tree surrounds, to still maintain some form of productive pasture grazing.

Growers gross returns (at gate) can range from $2.00/kg for local market to $3.00/kg for fresh export or processing, depending on the size or grade of the nuts, with larger or earlier season nuts usually fetching a premium.

Harvesting costs range from 50 cents to $1.00/kg depending on tree age. Given reasonable conditions, most orchards can achieve around 4 tonne/ha once the trees reach maturity by year 10. Average growth returns at maturity (calculated at $2.50/kg average) would translate to $10,000 per ha.

### *6.8.3 Risk and Uncertainty*

The following risk assessment has been prepared as a means to consider the relative risk associated with diversification into a stand of chestnut trees.

| Nuts | Risk 1 (low) to 5 (high) | Description |
|---|---|---|
| Flexibility to Change | 2 | Slow maturing tree which once planted are committed to otherwise significant opportunity cost in making a change. Not a tree which is likely to be developed across the entirety of a property and therefore whilst there is low flexibility for the area planted it does not restrict land use across the entire property. |
| Water Usage | 1 | No irrigation or animal consumption. Would be a system which would utilise natural rainfall. |
| Production Certainty | 2 | Whilst untested on a commercial scale in the Waikato, it is assumed that the trees would grow well. Risk and uncertainty is in relation to the ability to sell the product given the value chains are not well established. |
| Labour | 2 | Low labour requirement (except at harvest, and generally these types of developments are family type operations). Nuts are a relatively resilient crop and compared to some delicate fruit crops require less labour or technology to deliver the crop to market in a form suitable for consumption. |
| Upskilling | 2 | Some new skills to learn to achieve optimum production, although generally a simple system without the level of pest management activities of the other horticultural activities. |

### *6.8.4 Environmental considerations*

There is limited environmental data available for chestnut orchards, with limitations beginning within Overseer, as the closest tree for comparison was an avocado. There are uncertainties with this approach, as the yield for avocado trees are significantly higher than chestnuts. Therefore, the model is potentially overestimating the nutrient losses based on the tree being very inefficient. Previous modelling commissioned by New Zealand Agricultural Greenhouse Gas Research Centre (NZAGRC) has estimated the nitrogen leaching from chestnuts as being 12 kg N/ha/yr. Further to this, consideration needs to be made as to how to manage the pasture around the orchard (sheep or pigs etc.). The key attributes of this modelling are summarised in the assumptions within **Appendix B**. The nutrient and GHG losses based on this analysis are summarised below.

Table 27: Nutrient and greenhouse gas losses for chestnuts

| Contaminant/Emission Type | Chestnuts |
|---|---|
| Nitrogen loss (kg N/ha) | 12 |
| Phosphorus loss (kg P/ha) | 0.1 |
| Methane emissions (tonnes $CO^2$ Equivalents/ha) | - |
| Nitrous Oxide emissions (tonnes $CO^2$ Equivalents/ha) | 0.1 |
| Total GHG emissions (tonnes $CO^2$ Equivalents/ha) | 0.1 |

## 6.9 Forestry

### *6.9.1 Industry Description*

The interest in forestry on NZ farms has varied significantly over the years with changes in government subsidies, timber prices and wider farm conditions. Through the 1970's major government subsidies were provided for forestry. This created a significant increase in planting on farms and other locations during this period. In the early 1990's the price for timber increased dramatically for a 2-3 year period. The area annually planted on NZ farms rapidly increased to a peak of 100,000 ha per year in 1996. Various forest investment projects were launched allowing an urban investor to own part of a commercially managed forest.

Since the 1990's, timber prices have reduced to a lower level. Prices have fluctuated, often on approximately 2-3 year cycles over this period, in relation to short term demand and supply. Sometimes poor planning of the location and subsequent poor management of forest blocks on farms has resulted in poor returns at harvest. When this has combined with a period of lower prices, this has created poor results, providing negative stories and reducing interest in farm forestry.

Recently media has been highlighting the potential for significant land use change from pasture to forestry, potentially as a result of recent rises in the price of carbon or following the 1 Billion Tree programme announcements. Establishment of forestry has been identified as part of the pathway for NZ to a target of zero carbon by 2050. At a regional level, plan changes in the Waikato Region will see increased pressure on landowners to reduce erosion and N leaching risks to waterways. One of the tools for managing and mitigating these risks is land use change in key areas to forestry.

Integration of forestry into a farming business has long been an opportunity for farmers. Some of the hurdles to involvement in forestry have been capital investment, new skills required and potential loss of pasture and livestock production.

The establishment of forest at a farm scale could occur in a number of ways. These range from a variety of approaches involving careful integration of areas of forest on the less stable and poorer performing pastoral areas, to establishing forest across a whole farm, often with involvement of external investors. These two options have been modelled in this report and summarised below.

### Scenario 1: Farm Forestry of Poorer Performing Land

The first scenario, presented in **Table 28**, assumes around 12% of the farm will be planted in forest, which is established on poorly performing pastoral farming LUC Class 6 and 7 land. An assumption has been made to establish an area of 40 ha for a farming enterprise. The establishment of the forest is assumed to be staggered, with 8 ha of forest being established every five years, which means at the stage the last 8 ha is established, the first planted area will be 20 years old, and harvest could begin five years after this if necessary.

### Scenario 2: Fence to Fence Forestry Development

The second scenario, presented in **Table 29**, assumes that the whole property is established in forest over one year. This would represent, for example, the situation of a major forestry investor buying the farm and planting it all in forest. In most cases this approach will result in the farm landowner moving on from the property or perhaps subdividing the property.

### *6.9.2 Economic Analysis*

Assumptions are used to generate a cash flow for the different options, which include timber and carbon yields and revenue estimates. Where options involve forestry with timber income, the situation with and without carbon income have been modelled. The following economic indicators are set out for each option: Establishment cost, Silviculture year 5-10, Net harvest return, NPV (8%), IRR, Equivalent annuity, average cashflow, and average carbon income (15 years). Average carbon income is based on the assumed carbon price, for the first 15 years of growth. This equates to the point at which maximum amount of carbon can be claimed under averaging rules for the forest that is being harvested. If the forest is to be replanted, this can be claimed once it is harvested, but it can only be claimed once. Carbon income can be generated in cash in the year following its sequestration, from sales of New Zealand Units (equivalent to a tonne of $CO_2$ and represented as NZU).

Table 28: Analysis summary, integrated farm forestry (12% of farm)

| Indicator | Radiata Pine farming | | | | Radiata Pine plant and leave | |
|---|---|---|---|---|---|---|
| | Per ha | | Total | | Per ha | Total |
| | Carb | No Carb | Carb | No Carb | Carb | Carb |
| Establishment cost | $1,300 | $1,300 | $10,400 | $10,400 | $1,200 | $9,600 |
| Silviculture Yr 9 | $700 | $700 | $5,600 | $5,600 | $0 | $0 |
| Net harvest return (28 yrs) | $29,879 | $29,879 | $239,033 | $239,033 | $0 | $0 |
| NPV (8%) | $5,745 | $849 | $45,692 | $6,793 | $4,529 | $36,234 |
| IRR | 23.6% | 9.3% | 23.6% | 9.3% | 26.3% | 26.3% |
| Equivalent annuity (8%) | $520 | $77 | $4,159 | $615 | $410 | $3,279 |
| Average annual cashflow | $1,224 | $881 | $9,696 | $7,051 | $542 | $4,332 |
| Average annual carbon income (15 yrs) | $602 | $0 | $4,813 | $0 | $602 | $4,813 |
| Carbon price is $25 per NZU (tonne CO2 equivalents).<br>Modelling is for one 8 ha area. As multiple areas are established total annual carbon returns for the property will at times be three to four times that stated. | | | | | | |

Table 29: Whole farm conversion to forestry

| Indicator | Radiata Pine farming | | | | Radiata Pine plant and leave | |
|---|---|---|---|---|---|---|
| | Per ha | | Total | | Per ha | Total |
| | Carb | No Carb | Carb | No Carb | Carb | Carb |
| Establishment cost | $1,300 | $1,300 | $435,500 | $435,500 | $1,200 | $402,000 |
| Silviculture Yr 9 | $700 | $700 | $234,500 | $234,500 | $0 | $0 |
| Net harvest return (28) | $34,637 | $34,637 | $11,603,240 | $11,603,240 | $0 | $0 |
| NPV (8%) | $6,297 | $1,401 | $2,109,376 | $469,197 | $4,529 | $1,517,319 |
| IRR | 23.7% | 10% | 23.7% | 10% | 26.3% | 26.3% |
| Equivalent annuity (8%) | $570 | $127 | $190,875 | $42,457 | $409 | $137,301 |
| Average annual cashflow | $1,389 | $1,045 | $465,148 | $350,208 | $542 | $181,420 |
| Average annual carbon income (15 yrs) | $602* | $0 | $201,558 | $0 | $602 | $201,558 |
| * Carbon price is $25 per NZU (tonne CO2 equivalents).<br>Note: A no carbon income option is not provided for the plant and leave regime, as there is no planned timber harvest from this forest regime. | | | | | | |

Land for Waikato sheep and beef farms may range in value from $6,000 to $18,000 per ha. The average land value based on average capital values across Northland and Waikato sheep and beef farms is around $13,000 per ha.

Two examples of land use change to incorporate carbon forestry have been examined in this modelling. In one, smaller forest woodlots are integrated into a farming operation; in the other, forestry replaces the entire farming operation. The way forestry land use change occurs is potentially very important. Integration of forestry into existing farms could improve farm resilience and viability. This potentially retains and stabilises existing rural communities.

In the alternative scenario of whole farm conversion to forestry, a farm business is replaced by a forestry one. Evaluating the costs and benefits of these two situations to local communities and economies is complex and needs further investigation, however it seems likely that whole farm conversion will cause significantly more impact.

### *6.9.3 Risk and uncertainty*

The following risk assessment has been prepared as a means to consider the relative risk associated with diversification into Forestry (Pinus Radiata).

| Forestry | Risk<br>1 (low) to 5 (high) | Description |
|---|---|---|
| Flexibility to Change | 5 | Once trees are planted there is a 28 year wait on average for harvest and therefore a degree of permanence.<br>The first scenario has less risk involved than scenario two, as only 12% of the farm is developed into forestry, so there is more flexibility. A viable sheep and beef operation are maintained, which decreases risk. It financially strengthens the farm by having access to long term cash flow every five years from forest harvest, as well as initial income from carbon. It also allows the current farm owner to stay on the farm if they wish to.<br><br>The second scenario allows for less flexibility as the entire property is established in forest, which will lower the land value, and it means difficulty to change land back into another farming operation if the conversion is unsuccessful. |
| Water Usage | 1 | No water applied other than natural precipitation. |
| Production Certainty | 2 | Low risk, well researched method for producing quality product. Some risk exists around social licence to operate as it relates to sediment loss from current harvest methods. |
| Labour | 1 | Low risk as limited labour other than thinning activity and harvest |
| Upskilling | 1 | Low input activity in terms of the growth of the trees. A degree of upskilling would be required around management of the asset from a carbon perspective. This can be carried out by a consultant under contract. |

### *6.9.4 Environmental considerations*

When planting a forestry block on pastoral land, the organic matter within the soil will mineralise over time, which will result in nitrogen losses higher than that of a mature forest. However, the losses would reduce as the plantation matures. Once mature, overseer reports insignificant nutrient losses from a forestry block which is similar to native bush. However, there are still significant environmental risks to consider during the harvesting and ground preparation, particularly sediment losses. For the modelling undertaken for this assessment, OverseerFM® was utilised, and sediment is not a contaminant that it can model. Therefore, the values presented in **Table 30** are not inclusive of all the environmental risks associated with forestry.

The key attributes of the modelling are summarised in the assumptions within **Appendix B**. The nutrient and GHG losses based on this analysis are summarised below.

Table 30: Nutrient and greenhouse gas losses for forestry

| Contaminant/Emission Type | Forestry |
|---|---|
| Nitrogen loss (kg N/ha) | 2.5 |
| Phosphorus loss (kg P/ha) | 0.1 |
| Methane emissions (tonnes $CO^2$ Equivalents/ha) | - |
| Nitrous Oxide emissions (tonnes $CO^2$ Equivalents/ha) | - |
| Total GHG emissions (tonnes $CO^2$ Equivalents/ha) | - |

## 6.10 Other Diversification Options

AgFirst acknowledges that there are a multitude of additional agricultural land use options that could be considered in the Waikato due to favourable biophysical conditions (**Section 3.0**). However, the purpose of this report is not to exhaustively list and assess every option but to profile alternative land use options with established/known supply/value chains to enable a landholder to compare a range of options from an economic and environmental perspective. **Figure 6** demonstrates alternative enterprises that could be substituted, i.e. macadamia nuts with Chestnuts or Manuka for Honey with Plantation Forestry, with a similar risk framework needing to be applied.

The rationale for selecting industries with established value chains was to enable like for like comparison economically rather than making assumptions around the costs associated with establishing a supply/value chain which would be difficult to do at a strategic non-farm specific level and would be overly influenced by a series of assumptions. There are a range of potential land use options, especially in the horticultural area. But most of these have no current viable value chain, and whether this can be developed is largely dependent on the individual.

## 7.0 DIVERSIFICATION ANALYSIS SUMMARY

### 7.1 Economic Performance

Table 31: Analysis of economic performance

| Enterprise | NPV | IRR | Payback (years) | Total Capital | Cash farm surplus per ha | Area |
|---|---|---|---|---|---|---|
| Sheep and Beef | | | | | $388 | 127 |
| Dairy Farm | | | | | $2,444 | 571 |
| Dairy Goats | $1,645,697 | 10% | 8.5 | $4,637,250 | $10,410 | 60 ha development |
| Dairy Sheep | $1,156,721 | 12% | 7.5 | $1,587,500 | $4,947 | 60 ha development |
| Maize | $36,337 | 198% | 1 | $2,420 | $3,180 | per ha |
| | $2,249,401 | | 1 | $139,200 | - | 60 ha |
| Lucerne | $26,267 | 127% | 1 | $2,050 | $2,976 | per ha |
| | $1,576,014 | | 1 | $123,000 | - | 60 ha |
| Kiwifruit SunGold | $ 469,149 | 8% | 10.5 | $2,763,846 | $76,000 | 5 ha |
| Kiwifruit Hayward | -$122,264 | 5% | 13.5 | $1,262,310 | $28,000 | |
| Apples | $1,488,737 | 14% | 7.5 | $511,274 | $24,115 | 5 ha |
| Chestnuts | $155,125 | 9% | 12.5 | $352,000 | $9,850 | 10 ha development |
| Forestry (12%) farm Forestry | $29,879 | 24% | Income at year 28 (harvest) | $2,000 | - | Per ha |

* Sheep and Beef/Dairy is taken from the AgFirst modelled farms. Please note given diversification analysis has not factored the purchase or lease of land it is not possible to carry out investment analysis (NPV, IRR, Payback and Total Capital) for these baseline industries.

### 7.2 Risk Matrix

The following risk matrix brings together the risk assessments carried out for each of the proposed diversification scenarios. These risk assessments were prepared based on AgFirst's professional experience and can be considered as subjective. It is worth noting that the higher the score the riskier the diversification activity. Please note that a lower risk score does not indicate no risk and conversely a higher score does not indicate that the development is not feasible.

Table 32: Analysis of Risk performance

| Enterprise | Flexibility to Change | Water Usage | Production Certainty | Labour | Upskilling | Total Risk Score[10] |
|---|---|---|---|---|---|---|
| Dairy Goats | 3 | 2 | 2 | 3 | 3 | **13** |
| Dairy Sheep | 2 | 2 | 4 | 3 | 3 | **14** |
| Maize | 1 | 1 | 1 | 1 | 1 | **5** |
| Lucerne | 1 | 1 | 3 | 1 | 1 | **7** |
| Kiwifruit | 4 | 4 | 2 | 4 | 4 | **18** |
| Apples | 4 | 4 | 4 | 4 | 4 | **20** |
| Chestnuts | 2 | 1 | 2 | 2 | 2 | **9** |
| Forestry | 5 | 1 | 2 | 1 | 1 | **10** |

[10] Note a lower score denotes a lower assessed risk.

## 7.3 Environmental Performance

Modelling has been undertaken to broadly represent the various enterprises. As specified in **Section 2.1**, any change in land use will need to be that of a lower environmentally impacting operation. The modelling results have been summarised in **Table 33** and indicate for the most, by changing from the existing dairy or sheep and beef enterprises to the proposed diversification options meet this criteria. As discussed previously, the results presented are losses based on the entire enterprise, and detailed assessment will need to be undertaken for block specific conversions.

Table 33: Summary of nutrient and greenhouse gas losses

| Enterprise | Nitrogen (kg N/ha/yr) | Phosphorus (kg P/ha/yr) | Methane ($CO^2$ Eq/ha/yr) | Nitrous Oxide ($CO^2$ Eq/ha/yr) | Total GHG ($CO^2$ Eq/ha/yr) |
|---|---|---|---|---|---|
| Dairy Farm | 30.0 | 0.6 | 7.3 | 2.5 | 9.8 |
| Sheep and Beef | 13.0 | 0.5 | 3.6 | 1.0 | 4.6 |
| Dairy Goats | 19.0 | 0.1 | Not reported | | |
| Dairy Sheep | 17.0 | 0.2 | Not reported | | |
| Maize | 6 \ 99 * | 0.1 | - | 0.8 | 0.8 |
| Lucerne | 8 | 0.1 | - | < 0.1 | < 0.1 |
| Kiwifruit (Gold) | 18 | 0.3 | - | 0.4 | 0.4 |
| Apples | 23 | 0.3 | - | 0.3 | 0.3 |
| Chestnuts | 12 | 0.1 | - | 0.1 | 0.1 |
| Forestry | 2.5 | 0.1 | - | - | - |

* Maize was modelled as two scenarios, immediately out of pasture and as a permanent crop

# 8.0 INTEGRATED FARM ANALYSIS

In **Section 8.1** an example at the strategic level is provided demonstrating the economics of a change in land use from a dairy farm to a combined maize cropping and kiwifruit orchard. In **Section 8.2** a range of integrated farm scenarios are worked through to highlight the potential risk that combined development might have from a water use perspective.

Note: integrated analysis has not been completed for nutrient losses as loss rates referred to in the report are presented on a per hectare basis and therefore it is reasonable for the reader to deduce an integrated situation for themselves.

## 8.1 Dairy to Maize and Kiwifruit

The following is a worked example based on the AgFirst modelled dairy farming selling the cows, shares and plant and changing land use into Maize and Kiwifruit.

Under this scenario it has been assumed that 80% of the 127 ha dairy platform or 102 ha will be utilised for growing maize and 5 ha will be utilised for growing SunGold kiwifruit. The balance will be left to the discretion of the landowner and is not modelled for this illustrative purpose.

In **Table 34** below we have presented the modelled debt and EBIT positions. Also shown is the debt servicing cost. As shown during the development period of the kiwifruit orchard prior to mature crop yields there would be a requirement for the enterprise to obtain income from another source if the business was to be supporting drawings, debt servicing, taxation or other likely outgoings.

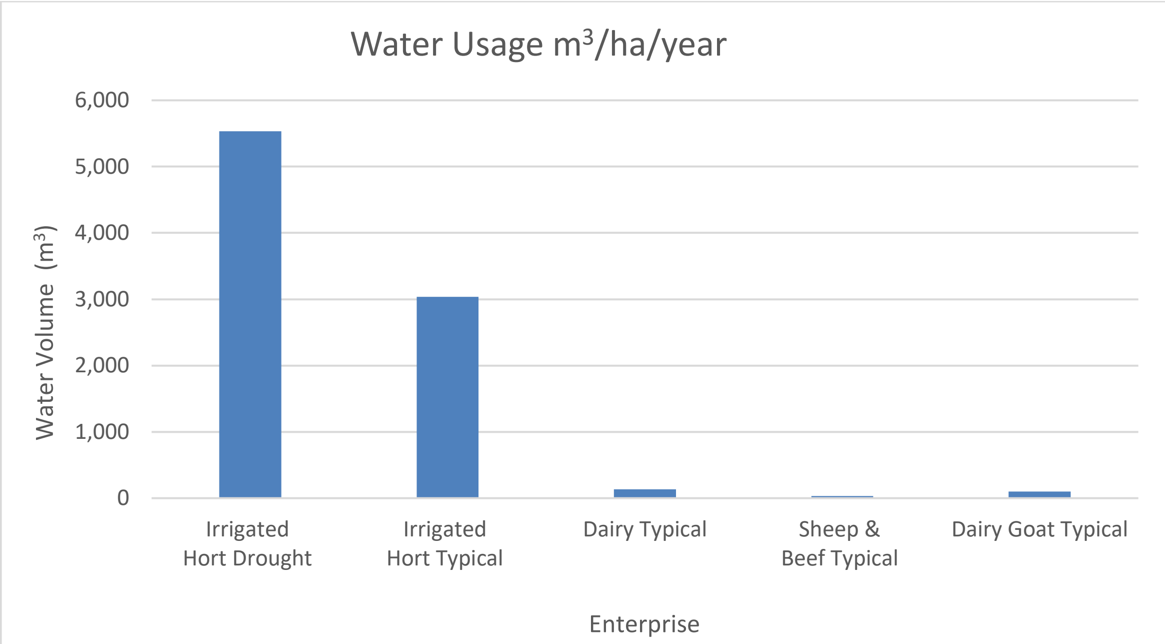
Table 34: Modelled Dairy Farm converting to Maize for Silage and Kiwifruit

| | Dairy Farm | Maize | Maize + Kiwifruit under development | Maize + mature Kiwifruit orchard |
|---|---|---|---|---|
| EBIT | $361,880 | $204,000 | $204,000 | $584,000 |
| Debt | $2,467,588 | $957,588 | $3,721,434 | $3,721,434 |
| Debt servicing @ 5% | $123,379 | $47,879 | $186,072 | $186,072 |

## 8.2 Diversification and Water

**Figure 8** below indicates that the per hectare water usage for a range of enterprises. Note: all diversification options have not been modelled. Forestry, chestnuts, Lucerne and maize will have no water demand as all water to sustain growth will come from precipitation. The analysis below for the pastoral sector involves the water required for animal health but also the water required as relevant for the dairy shed. The horticultural water usage figures allow for a reasonable level of spray use to maintain the crop and for irrigation.

Figure 7: Water usage per hectare

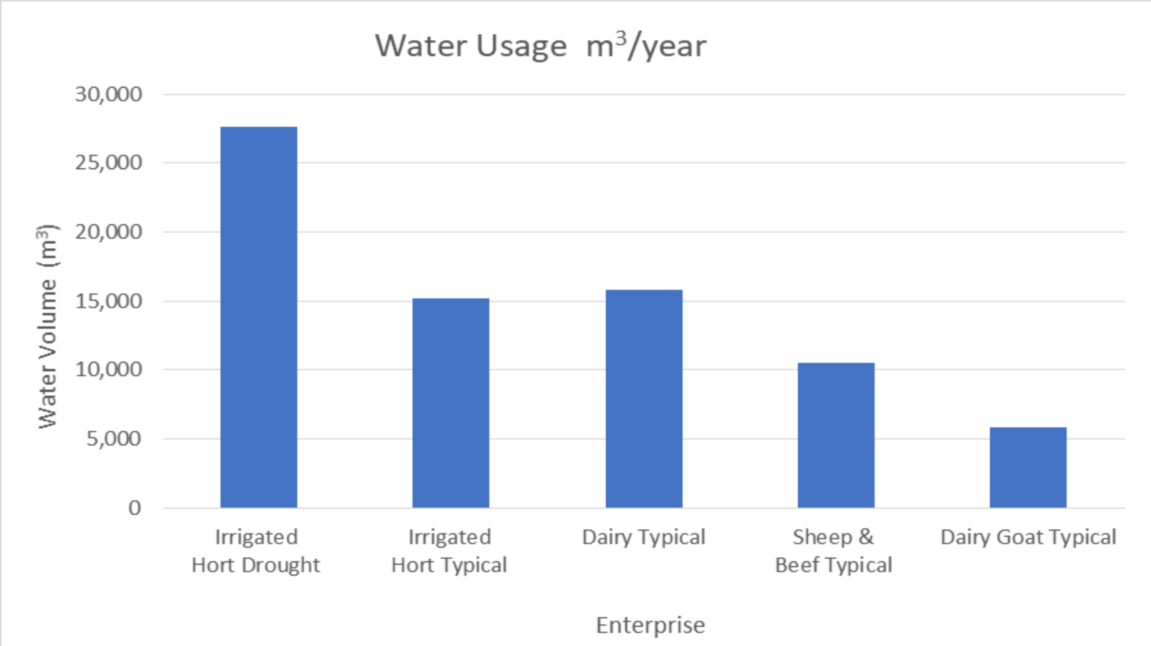



Source: Pers Comms Kiwifruit Industry, Horizons Regional Council.

### *8.2.1 Water usage per enterprise*

To understand the impact of water take on the environment there is a need to not just consider the intensity of water use per ha, but the water use for a reasonable enterprise. A set of reasonable enterprises and their water usage is summarised in **Figure 9**. This water usage has been obtained with assumptions made around a typical enterprise from a water foot printing perspective.

Figure 8: Water usage per year



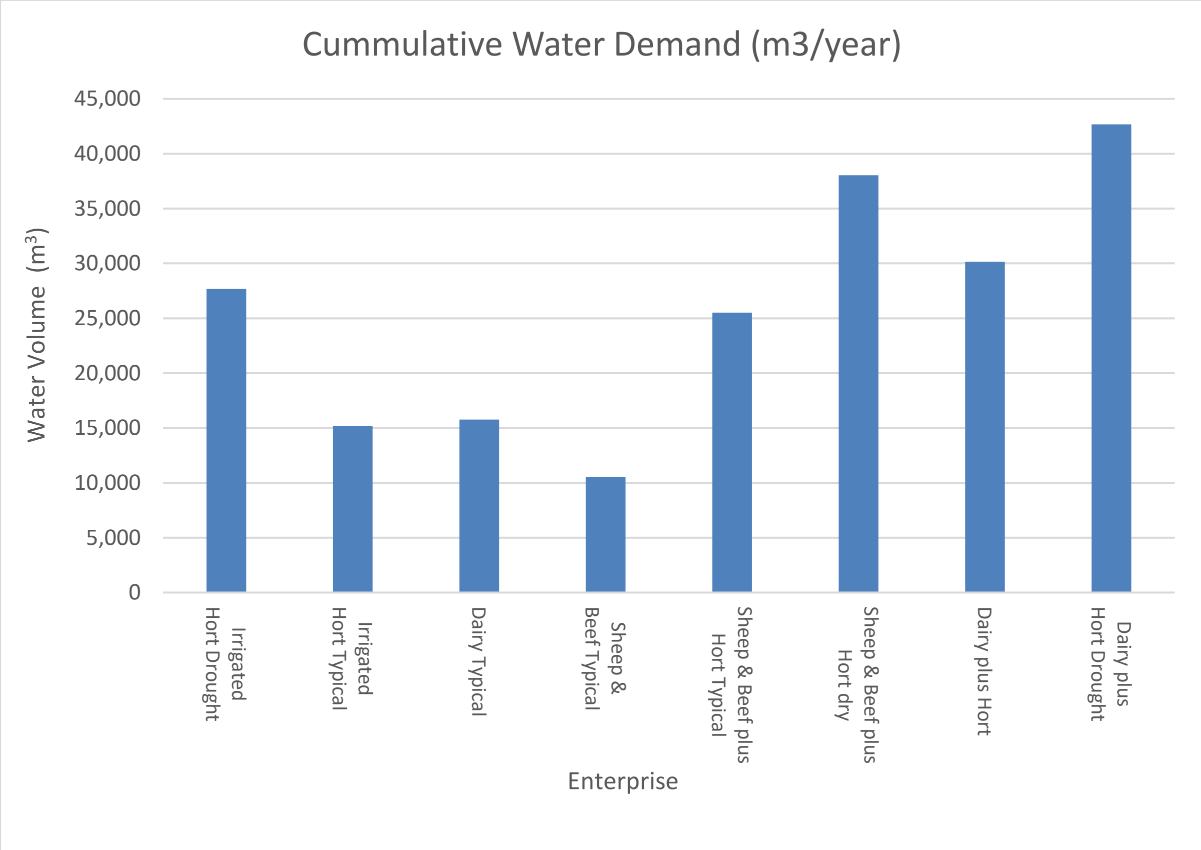

Source: Pers Comms Kiwifruit Industry, Horizons Regional Council.

### *8.2.2 Water usage for a diversified enterprise.*

Land use diversification by its nature will produce a wide range of different water usage intensities. In this report, **Figure 10** has been included to demonstrate that from a water usage perspective it will not always be the case of swapping out one enterprise type for another, as it might be for converting from a sheep and beef or dairy enterprises to a dairy goat or sheep enterprise. Even in this situation, the change is unlikely to be absolute with a portion of the diversified platform either being retained in the original land use or converted to a land use that is more complimentary to the new enterprise, i.e. a dairy farm converting to a dairy goat business may well look to graze a number of beef cattle as a means to consume the feed either not able to be mowed or rejected by the goats as a part of the cut and carry enterprise.

In the case of the development of horticulture, given the intensity of operations per ha, only a part of an existing pastoral farm will be required for horticultural conversion. Therefore, the impact from a water usage perspective will be cumulative.

Figure 9: Cumulative water demand




Source: Pers Comms Kiwifruit Industry, Horizons Regional Council.

## 9.0 PROCESS TO CONSIDER DIVERSIFICATION

As noted throughout, this report seeks to provide a range of different diversification examples for a landholder to consider.

Presented below is a practical guide to support a farmer in making a decision around diversification that can be applied regardless of the existing or proposed enterprise. In the left hand column a series of higher level questions are suggested with the right hand column providing prompts to assist a landowners diversification thinking at a strategic level. It is noteworthy that in the Waikato the line of enquiry for would be diversifier is more centred around economic and human centred strategic considerations than biophysical or environmental. This is consistent with the body of literature around land use and farmer behaviour change.

### Is the principal Diversification Driver Financial or other?

Albeit somewhat simplistic, in our experience it is important to tease out if the driver for change is from a financial or business perspective or prompted by something more intrinsic. Regardless, the following questions and prompts will be appropriate to exploring the options however the focus will change as the intrinsic motivation differs.

### Why is your business considering diversification?

Consider this with a mind to the driver for diversification mentioned within this report, I.e. Financial, wanting a new challenge, environmental, provide for next generation etc.

a) Don't neglect system optimisation (reduction in costs, increases in production, reduction in labour) or simplification (change is system to reduce the complexity or the labour requirement. An example would be once-a-day milking or the implementation of an efficient beef system) prior to or as opposed to land use change. Optimisation and simplification will be cheaper and there is always value in sticking to one's knitting to manage risk.

b) Has the farm been benchmarked recently? This is a powerful tool to understand position relative to others and the potential for within system growth.

### What financial capacity does the farming business have to make a land use change or to diversify?

In general terms diversification into alternative land uses comes with capital costs. These can be in the form of new plant, equipment or crops.

In addition to the requirement for capital up front, most diversification options require a ramping up period where either the new crop is established (up to five years for horticulture) or where the genetics of the new dairy, sheep for instance, are improved to make the activity economic. This ramping up period comes at the time of capital outlay so the farmer, being realistic about the position of their balance sheet, along with risk appetite for further debt, or more complicated commercial operating models, i.e. JV's or equity partnerships are required.

### What are you into and why?

- What are the activities of farming that you like most, what do you like least and why?

Different to above in that with the reasons for change identified, it will be important to gain a deeper understanding of why a particular diversification scenario is being considered and whether it will be the best one for the farming business.

Basic questions to consider would be:

(i) Is there a like for livestock or is the passion for machines?

(ii) Is there a desire to be growing a product which is not an animal protein?

(iii) Is there desire to be carbon neutral, organic or just to be doing something no one else is doing?

Again the nature of diversification could vary. A dairy farmer who is looking to retire from milking cows, yet takes enjoyment from other farm activities could look to diversify in a number of ways. He/she could look to intensify the dairy to involve the growing and feeding of more crops, develop a contracting business and undertake activities to simplify the dairy farm (to make the time available for the contracting), or they could reduce stock numbers and focus on growing crops, such as growing Lucerne hay or a number of broad acre vegetable crops. Or they could consider moving to a dairy goat or sheep enterprise.

Another driver could be more recreational time in which the change required would be simplification rather than creating greater complexity through diversification.

### Who are the stakeholders in any diversification decision?

- Who are all the stakeholders in the diversification decision? Have they all be involved in the consideration?

It will often be an intergenerational decision to diversify.

### What are the skill sets of all those involved?

Often diversification at the scale of land use change will involve similar conversations to that of farm succession and it could be the case that one of the main drivers to diversification is a desire by the farming principal to provide for the next generation. By way of an example it could be the case that a 120 ha dairy farm could look at reducing its dairy platform by 5 to 10 ha to allow the development of a kiwifruit orchard with the orchard and the dairy farm to be operated by a different member of the family. Diversification occurring within the context of a farm succession situation can often change the financial considerations. Through the experience in farm succession planning the key to success in this area is to commence the conversation early, and for all parties to be involved in the process. There is a significant amount of information available around farm succession planning with the key message being that like a consideration around farm diversification it is a **process and not an action** and therefore there needs to be time taken to work it through.

### Where do you see your involvement in the value chain starting or stopping?

Put simply, in making a change is there a desire to remain focused within the farm gate in production or to be involved in post farm gate activities. With the exception of chestnuts, this work has focused on activities i.e. that have existing value chains.

### Through refection do the stakeholders in the business possess the skills to make the business work, or if not held is there a strong desire to learn them?

Diversification will involve change, and in a number of situations a change to land use requiring a new set of skills. Those involved need to identify existing skills and those that will be required to make the new business work i.e. is there an understanding of sales or marketing or integrated pest management which could be required. If not known, how successful have they been in previously with learning new skills and increasing capability?

### What is the farming businesses appetite for complexity? Is there a desire to grow the business with more moving parts and staff?

Labour is often cited as a primary industry constraint, therefore in making a decision around diversification there needs to be consideration of the labour requirements. If farmers are looking to change on this basis then careful consideration would be needed before changing to activities such as horticulture with an appreciably higher labour requirement than sheep and beef or dairy operations.

## APPENDIX A: ENVIRONMENTAL BASELINE MODELLING ASSUMPTIONS

### Sheep and Beef

The inputs that have been used to generate the nutrient and GHG results from Overseer are presented in the table below. As discussed in the body of the report, these inputs have been included to provide reference to a 'typical' system that may be considered for diversification rather than inputs that have been collected based on a specific farming system. Individual modelling of land management units has not been reported, however, depending on the system type, the blocks can generate varied outputs which will have implications on diversification options.

| Total Farm Size | 350 ha | Breeding (250 ha) | Finishing (100 ha) |
|---|---|---|---|
| Soil Types | Volcanic (80%) | Sedimentary (20%) | |
| Stock RSU | 13 RSU/ha | Sheep 7.4 RSU/ha | Beef 5.6 RSU/ha |
| Fertiliser | 20% Potash Super | 150 kg/ha | Breeding: Oct |
| | | 250 kg/ha | Finishing: Oct |
| | Urea | 55 kg/ha | Finishing: Oct, Apr |
| | Lime | 1,000 kg/ha | Finishing: Oct |
| | | 500 kg/ha | Breeding: Oct |
| Supplements | Baleage | 200 t DM/ha | Distributed: Pasture |
| | Grass silage harvested | 40 t DM - Finishing | Distributed: Pasture |

## Dairy Farm

The inputs that have been used to generate the nutrient and GHG results from Overseer are presented in the table below. As discussed in the body of the report, these inputs have been included to provide reference to a 'typical' Waikato dairy farming system rather than inputs that have been collected based on a specific farming system.

| Farm Size | 120 ha | Effluent (40 ha) | Non-effluent (80 ha) |
|---|---|---|---|
| Soil Types | Volcanic (100%) | | |
| Peak Cows | 350 (2.9 cows/ha) | Friesian X Jersey | 23% Replacements |
| Wintered off | 0 | Replacements | Off farm from weaning |
| Production | 122,500 kg MS | 350 MS/cow | |
| Fertiliser (Total N applied: 145 kg N/ha | Superten | 300 kg/ha | Effluent: Oct |
| | Superten 10K | 300 kg/ha | Non-Effluent: Oct |
| | N-rich Urea | 65 kg/ha | All Farm: Sep - Nov |
| | PhaSed N | 100 kg/ha | All Farm: Apr |
| | SustaiN Ammo 36N | 50 kg/ha | Non-Effluent: Jul – Aug<br>Effluent: July |
| | Superten 25K | 300 kg/ha | Rotating Maize: Oct |
| | N-Rich Urea | 200 kg/ha | Rotating Maize: Dec |
| | DAP | 250 kg/ha<br>100 kg/ha | Rotating Maize: Oct<br>New Grass: Apr |
| | Lime | 1 t/ha | Rotating Maize: Sep |
| Supplements | Maize grown on farm | 22 t DM/ha (6 ha) | Distributed: Feed pad |
| | PKE | 200 t DM | Distributed: Feed pad |
| | Grass silage harvested | 45 t DM | Distributed: Paddocks |

## APPENDIX B: DIVERSIFICATION MODELLING ASSUMPTIONS

### Dairy Goats

- 60 ha goat platform.
- Housed system of 900 goats.
- 180 replacement kids reared.
- Goats purchased for $400.00 per head
- Milksolids per goat of 108 kg/hd?
- Housing system will cost $1100/goat to develop.
- $18 per KG MS for milk produced.
- Dairy goat cooperative shares are available and will cost $23.00/share with business to be 'fully shared up'. Given supply and demand for shares, obtaining the number of shares for 900 goats would not be probable.
- Other costs of $300/goat to allow for the purchase of vehicles that would not be present on a typical dairy or sheep and beef farm.
- Costs of $720/head for implement sheds, kid raising shed and other initial development requirements.
- Farm operating expenses of $1250/goat.
- No allowance has been made for utilisation of existing shed facilities, i.e. all built infrastructure for the dairy goat business will be new.
- No allowance has been made for income generated from dairy heifers, beef cattle or the sale of rejected food to a neighbouring enterprise. It is understood that dairy goat businesses have significant wastage associated with foodstuffs rejected by the milking goats.

The inputs that have been used to generate the nutrient and GHG results from Overseer are presented in the table below. As discussed in the body of the report, these inputs have been included to provide reference to a 'typical' system rather than inputs that have been collected based on a specific farming system.

| Total Farm Size | 70 ha | Goat Platform (60 ha) | Beef Block (10 ha) |
|---|---|---|---|
| Soil Types | Volcanic (100%) | | |
| Liquid Effluent | 5 ha | Barn Shavings (55 ha) | |
| Peak Does | 900 (15 goats/ha) | Saanen | 20% Replacements |
| Production | 97,200 kg MS | | |
| Fertiliser | Sustain | 55 kg/ha | Non-Eff: Aug-Nov |
| | | | Effluent: Oct-Nov |
| | PhaSed N | 100 kg/ha | Non-Eff: Apr |
| | Sulphur Gain | 200 kg/ha | Goat platform: Apr |
| | 20 Potash Sulphur Super | 150 kg/ha | Goat Platform: Oct |
| Supplements | Forage Imported | 100 t DM | Distributed: Housing |
| | Pasture Harvested/Fed | 500 t DM | Distributed: Housing |
| | Non-Forage Imported | 225 t DM | Distributed: Housing |
| | | 125 t DM | Distributed: In-shed |

## Milking Sheep

- Outdoor farming system with no barn infrastructure.
- 650 ewes. Model is based on the Tauwhare Spring Sheep Dairy conversion example.
- New milking parlour and plant is required at a cost of $850,000.
- A new lamb shed is required at a cost of $30,000.
- The tractor and other ATV type vehicles will be retained. This assumption differs to the dairy goat assumption on the basis that the dairy sheep scenario does not require a cut and carry system, i.e. all feed stuffs will be consumed via grazing. An allowance has been made for the replacement of this plant in year 10.
- No allowance has been made for parts of the farm which may not be suitable for the sheep enterprise. On the basis that Sheep are grazers rather than foragers the expected wastage is not anticipated to be as high as it is for a dairy goat enterprise.
- Assumes effluent upgrades are required at a cost of $65,000. This is made on the basis of an assumption that the business converting is a dairy farm. Should it be a sheep and beef farm, then the cost would be significantly higher.
- Assumes additional fencing is required, i.e. to convert the cattle fencing, which may be two or three wire, into fences which are sheep-proof. It is also assumed that additional subdivision will be required to create smaller areas for a grazing sheep business. It is assumed this fencing will cost $60,000.00 and will be a one-off capital cost.
- Assumes an allowance of $75,000 for re-grassing and cropping to develop the types of forages that would suit a sheep milk business.
- Assumes $550/ewe purchase price.
- Assumes milk production of 250 litres/ewe in year one, increasing to 295 litres in year, 340 litres in year three, 385 litres in year four and 415 litres in year five onwards. This increase is associated with genetic improvement of the national milking sheep flock.
- Assumes MS 17.5% per litre of production
- Assumes $14.30 per KG MS

The inputs that have been used to generate the nutrient and GHG results from Overseer are presented in the table below. As discussed in the body of the report, these inputs have been included to provide reference to a 'typical' system rather than inputs that have been collected based on a specific farming system.

| **Total Farm Size** | **50 ha** | | |
|---|---|---|---|
| Soil Types | Volcanic (100%) | | |
| Liquid Effluent | 5 ha | Non-Effluent 45 ha | |
| Peak Sheep | 650 (13 sheep/ha) | Saanen (No sheep breeds in Overseer) | 30% Replacements |
| Production | 40,000 kg MS | | |
| Fertiliser | N-rich Urea | 65 kg/ha | All farm: Aug-Nov |
| | PhaSed N | 100 kg/ha | All Farm: Apr |
| | Superten 10k | 300 kg/ha | All Farm: Oct |
| Supplements | Maize grain | 100 t DM | Distributed: In-Shed |

## Maize

- The farmer will be responsible for the growing of the crop, i.e. it will not be leased out to a contractor to grow.
- Maize is sold into the maize silage market.
- The maize crop yield is 20 T/ha. This is to accommodate for a 10 year growing cycle where the same block will be continuously cropped and to account for seasonal variation.
- A sale price of $0.25 kgDM.
- An annual rye grass crop is planted over the winter period, with 4 tonnes of pasture produced which is sold as standing silage for $0.28 kgDM.
- Maize growing costs of $2,320.00 per ha.
- Annual rye grass growing costs of $400.00 per ha.

The inputs that have been used to generate the nutrient and GHG results from Overseer are presented in the table below. As discussed in the body of the report, these inputs have been included to provide reference to a 'typical' system rather than inputs that have been collected based on a specific farming system.

| **Total Maize Block Size** | **20 ha** | | |
|---|---|---|---|
| Scenario 1 – Long term crop (10 years) | | Scenario 2 – grazed pasture to crop | |
| Soil Types | Volcanic (100%) | | |
| Crop Yield | 20 tonnes DM/ha | Conventional cultivation | Planted – Oct<br>Harvested – Mar |
| Alternating Winter Crop | Annual Ryegrass | Minimum tillage | Yield 4 t DM/ha |
| Fertiliser | Superten 25K | 300 kg/ha | Oct |
| | DAP | 250 kg/ha | Oct & Apr |
| | N-rich Urea | 200 kg/ha | Dec |
| | Lime | 2 t/ha | Sep |

## Lucerne

- Stand life of 6 years.
- No growth activity in winter.
- Stand production of 9 tonne per ha year 1 increasing to 15 tonnes in years 3 and 4 with decline in years 5 and 6.
- All Lucerne is baled into round silage bales and sold for $105.00 per bale.
- Baling cost of $42 per bale.
- Silage bales have a weight of 220 kgDM.
- Growing costs in conjunction with Pioneer guidance, i.e. $1300.00 per ha per annum and an establishment cost of $2,050.00 per ha.
- A one-year break is required between crops (i.e. every 6 years). During this period a maize and annual ryegrass rotation would take place.
- Maize yield in accordance with assumptions for Maize silage modelling.
- Fertiliser requirements are based on the crop demands for a 12 t DM yield
- The inputs that have been used generate the nutrient and GHG results from Overseer are presented in the table below. As discussed in the body of the report, these inputs have been included to provide reference to a "typical" system rather than inputs that have been collected based on a specific farming system.

| Total Lucerne Block Size | 20 ha | | |
|---|---|---|---|
| Soil Types | Volcanic (100%) | | |
| Crop Yield | 12 tonnes DM/ha | Conventional cultivation | Planted – Oct<br>Harvested – Mar |
| Alternating Winter Crop | Annual Ryegrass | Minimum tillage | Yield 4 t DM/ha |
| Fertiliser | Superten 25K | 500 kg/ha | Oct |
| | Muriate of Potash | 300 kg/ha | Mar |
| | Superten | 200 kg/ha | Mar |
| | Lime | 2 t/ha | Sep |

## Kiwifruit

- 5 ha developed.
- SunGold licence price of $300,000/ha.
- Development costs assumed to be costs in year one of $263,000/ha. These additional development costs will include the establishment of irrigation and infrastructure, fast track shelter, wires and poles to support training of the vines, permanent shelter or wind break planting, base fertiliser and the development of the orchard structures.
- Kiwifruit will yield two years after planting for SunGold.
- Hayward will yield 3 years after planting
- An assumption for orchard working expenses has been made at $215,000 p.a.
- Waikato yields for SunGold kiwifruit have been assumed to be 4,000 trays two years after planting, 10,000 trays three years after planting, and 14,000 trays four years after planting. Following the fourth year from planting the orchard is considered to be mature and will yield at 14,000 trays per ha.
- Waikato Hayward yields have been assumed to be 4,000 trays 3 years after planting, 10,000 trays 4 years after planting and 12,000 trays for a mature orchard.
- For long-term economic analysis it has been assumed that the tray price for SunGold kiwifruit will be $8.50/tray equivalent.
- For long-term economic analysis it has been assumed that the tray price for Hayward kiwifruit will be $5.00/tray equivalent.

As discussed in the body of the report, the nitrogen losses from different scenarios were variable, particularly depending on the age of the tree and the production that is estimated. Orchards in the Bay of Plenty region have been modelled with losses between 15 to 20 kg N/ha/yr[11]. Therefore, we have used typical inputs based on plant requirements to determine the GHG and phosphorus losses, but have based the nitrogen losses on industry modelling.

| Total Orchard Size | 5 ha | | |
|---|---|---|---|
| Soil Types | Volcanic (100%) | 100% artificially drained | |
| Product Yield | 8,000 trays sold per ha | Reject rate – 5% | Pruning - mulched |
| Fertiliser | Calcium Ammonium Nitrate | 185 kg/ha | Sep-Nov |
| Micro-Irrigation | Soil moisture sensors | Trigger point | Nov-Apr |

[11] Freshwater quality and eco-verification of kiwifruit orchard practices, Benge, J. (The AgriBusiness Group), Clothier, B. (The New Zealand Institute for Plant & Food Research Limited) May 2016

## Apples

- 5 ha developed.
- No assumption has been made regarding variety. There is significant variation in revenue received across apple varieties. Given the diversity and some uncertainty as to which apple would be grown in which part of the region average values have been applied to this modelling exercise.
- Per ha development cost of $84,000 per ha.
- Yield of 70 tonne per ha.
- Carton return of $28,000.00 per ha.
- There is limited nutrient modelling available for a Waikato apple orchard. For this comparison, a typical Hawkes Bay apple orchard has been applied. Presented below are the default settings and typical inputs that were entered into OverseerFM. To ensure that the nutrient losses would be representative of the soil and climatic conditions within the Waikato region, soils have been defaulted to allophanic with artificial drainage and local climate and rainfall data has been used. The irrigation scheduling has been based on micro-irrigation and soil moisture sensors. The nutrient leaching is higher than in the Hawkes bay base scenario, potentially due to the increased rainfall and different soil with artificial drainage.

The inputs that have been used to generate the nutrient and GHG results from Overseer are presented in the table below. As discussed in the body of the report, these inputs have been included to provide reference to a 'typical' system rather than inputs that have been collected based on a specific orchard.

| Total Orchard Size | 5 ha | | |
|---|---|---|---|
| Soil Types | Volcanic (100%) | 100% artificially drained | |
| Product Yield | 80 tonnes picked per ha | Reject rate – 10% | Pruning - mulched |
| Fertiliser | Calcium Ammonium Nitrate | 150 kg/ha | May |
| Micro-Irrigation | Soil moisture sensors | Trigger point | Dec-Mar |

## Chestnuts

- 10 ha planted with a total of 2,041 trees.
- Mature production of 7,500 kg/ha on the basis of 50 kg/tree and a 25% reject rate.
- An assumed per kg price of $2.50 on the basis of an assumption of $50/tree and a 25% rejection rate.
- No assumption made for grazing stock, including pigs, beneath the treed canopy area.
- Mature operating costs assumed to be $89,000 for the 10 ha chestnut development.
- Mature production occurs at year 10.
- Year six production at 15% increasing to 30% in year seven, 60% in year nine and 100% for the mature orchard in year 10.
- A shed will be required to pack the nuts, along with the associated machinery to sort them.
- Assumes the need for a new harvester.
- Development costs will be split with a number of orchard development costs up front, however the timing on purchasing infrastructure associated with the first harvest, i.e. a shed to pack the nuts and the associated harvesting equipment can be deferred, in the model that has been carried out, in year two, although given year three and year four production is only 1% and 2% of mature production respectively, a decision could be made to defer this investment until year five or even year six.
- The inputs that have been used to generate the nutrient and GHG results from Overseer are presented in the table below. As discussed in the body of the report, these inputs have been included to provide reference to a 'typical' system rather than inputs that have been collected based on a specific orchard.

| Total Orchard Size | 10 ha | | |
|---|---|---|---|
| Soil Types | Volcanic (100%) | | |
| Tree type | Avocado (Overseer does not model chestnuts) | | |
| Product Yield | 7.5 t/ha | Reject rate – 25% | Pruning - mulched |
| Fertiliser | Calcium Ammonium Nitrate | 75 kg/ha | May |

## APPENDIX C: WATER UTILISATION

### Dairy Cows

Assumptions consistent with the above. The following additional assumption are made for water foot printing.

- Milking season to be 10 months of the year where the daily demand for each cow will be 70 litres (l) per cow per day.
- Dry Cows consume 45 l per cow per day.
- During lactation it is assumed that the dairy cows will require 70 litres per cow for shed use.

Whilst at present there is no regulation in the Waikato on water for the purposes of stock water this may change in the future with potentially greater restrictions on water use.

### Sheep and Beef

Assumptions consistent with the above. The following additional assumption are made for water foot printing.

- Yearling bulls to consume 25 litres per day
- Ewes consume 9 l per day. These numbers do not depict seasonal demand and therefore the potential strain placed on the water resource with the proportion of water consumed from a trough as opposed to from dew on pasture or natural sources changing significantly from season to season.

Whilst at present there is no regulation in the Waikato on water for the purposes of stock water this may change in the future with potentially greater restrictions on water use.

### Dairy Goats and Sheep

#### *Goats*

Water usage for dairy goats has been estimated (Horizons Regional Council 2007) for stock drinking at 5 litres per goat per day (average) and 10 litres per goat per day (peak) based on a 60 kg doe. Estimates of shed water usage (plant wash, hosing down etc.) is also between 5 - 10 litres per goat per day. Therefore, if the land use is converting from dairy cows to dairy goats, the water use is likely to be similar or less on a per ha basis.
However, if the conversion was from a sheep and beef farm, the water use would be much higher. This is due to lactating animals drinking more water than dry stock animals, and also the daily water use required for the milking shed, yards and cleaning the plant. This changes the risk depending on the current land use.

#### *Sheep*

There is limited information available for water requirements of dairy sheep. Therefore, due to the similarities between the industries, it has been assumed that a dairy sheep would require a similar volume of water as a dairy goat. Water usage for dairy goats has been estimated (Horizons Regional Council 2007) for stock drinking at 5 litres per goat per day (average) and 10 litres per goat per day (peak) based on a 60 kg doe. Estimates of shed water usage (plant wash, hosing down etc.) is also between 5 - 10 litres per goat per day. Therefore, if the land use is converting from dairy cows to dairy sheep, the water use is likely to be similar or less on a per hectare basis. However, if the conversion was from a sheep and beef farm, the water use would be much higher. This is due to milking animals drinking more water than dry stock animals and also the daily water use required for the milking shed, yards and cleaning the plant. This does change the risk depending on the current land use.

### Horticulture

Assumptions consistent with the above. The following additional assumptions are made for water foot printing.

- During summer periods it has been assumed that a kiwifruit orchard in the Waikato would require two months of irrigation at a daily rate of 5 mm per day or 50 $m^3$ per ha.
- 5 ha development would require 3,000 $m^3$ per hectare of water per annum for irrigation.
- This amount could reasonably increase to 5,500 $m^3$ per hectare per annum in a dry year.
- It is estimated that spray usage would be in the order of 35 $m^3$ per ha for a 5 ha development.

## APPENDIX D: BIBLIOGRAPHY

The majority of the information for this report has been sources from industry sources and was provided in commercial confidence. Information has been obtained via personal communication and industry prospectus

AgFirst Financial Survey 2019: Central North Island Hill Country Sheep and Beef. https://www.agfirst.co.nz/wp-content/uploads/2019/08/Central-NI-Hill-Country-Report2019.pdf

AgFirst Financial Survey 2019: Waikato & BOP Dairy https://www.agfirst.co.nz/wp-content/uploads/2019/09/WaikatoBoPDairyReport2019.pdf

Barr, N., & Cary, J. 2000. Influencing Improved Natural Resource Management on Farms. A guide to Understanding Factors Influencing the Adoption of Sustainable Resource Practices. Bureau of Rural Sciences

Beef + Lamb NZ Economic Service. 2019. Sheep & beef farm survey, Class 9 New Zealand all classes.

Beef + Lamb New Zealand. 2018. New season outlook 2018-19. Beef + Lamb New Zealand Economic Service, Wellington

Britton, R., & Fenton, T. 2007. Identification and Analysis of Drivers of Significant Land Use Change. Environment Waikato Technical Report 2007/40. Environment Waikato. Hamilton

Clothier, B. and Benge J. 2016. Freshwater quality and eco-verification of kiwifruit orchard practices.

Clothier, B., Müller, K., Hall A., Thomas, S., van den Dijssel, C., Beare, M., Mason, K., Green, S., & George, S. 2017. Futures for New Zealand's arable and horticultural industries in relation to their land area, productivity, profitability, Greenhouse gas emissions and mitigations. A Plant & Food Research report prepared for: New Zealand Agricultural Greenhouse Gas Research Centre. Milestone No. 71808. Contract No. 33960. Job code: P/423079/01. SPTS No. 14440

Dairy NZ, 2018. DairyNZ Economic Survey 2017-18. https://www.dairynz.co.nz/publications/dairy-industry/dairynz-economic-survey-2017-18/ [accessed 1 October, 2019]

Handford, P and Praat, JP (Groundtruth). 2019 Landuse Diversification in the Waikato. Forestry Scenarios. A report prepared for AgFirst Waikato. Not Published.

Journeaux, P., Kingi. T., 2019. Farm Systems Modelling for GHG Reduction on Multiple Enterprise Māori Farms. NZAGRC. To be published

Journeaux, P; Van Reenan, E; Manjala, T; Pike, S; Hanmore, I;Miller, S; [2017] Analysis of Drivers and Barriers to Landuse Change. A report prepared for the Ministry for Primary Industries.

Ministry for Primary Industries. 2019. Situation and Outlook for the Primary Industry. www.mpi.govt.nz [accessed 1 October 2019]

Statistics New Zealand. (2016). Agricultural Production Statistics: June 201*6* (final). http://archive.stats.govt.nz/browse_for_stats/industry_sectors/agriculture-horticulture-forestry/AgriculturalProduction_final_HOTPJun16final.aspx

Stewart, G and Rout, R. 2007. Reasonable Stock Water requirements for resource consent applications technical report prepared for Horizons Regional Council. http://www.horizons.govt.nz/HRC/media/Media/One%20Plan%20Documents/Reasonable-Stock-Water-Requirements-Guidelines-for-Resource-Consent-Applications.pdf?ext=.pdf

Thorrold, B.S. 2010. The future landscape of New Zealand Agriculture. Proceedings of the New Zealand Grassland Association. 72: LXIII-LXVI.

**Land Cover by LUC Classification**
Based on analysis of:
LUCAS NZ Land Use Map 1990 2008 2012 (v016)
https://data.mfe.govt.nz/layer/2375-lucasnz-land use-map-1990-2008-2012-v016/

NZLRI Land Use Capabilityhttps://lris.scinfo.org.nz/layer/48076-nzlri-land use-capability/

Stats NZ regional boundaries
http://www3.stats.govt.nz/digitalboundaries/annual/ESRI_Shapefile_2017_Digital_Boundaries_High_Def_Clipped.zip

## Useful and referred to Websites (All sites accessed October 2019)

**Sheep and Beef**
Beef and Lamb New Zealand https://beeflambnz.com/

AgFirst Financial Survey 2019: Central North Island Hill Country Sheep and Beef.
https://www.agfirst.co.nz/wp-content/uploads/2019/08/Central-NI-Hill-Country-Report2019.pdf

**Dairy Cows**
DairyNZ Dairy Base https://www.dairynz.co.nz/business/dairybase/benchmarking/latest-dairybase-benchmarks/

DairyNZ https://www.dairynz.co.nz/

AgFirst Financial Survey 2019: Waikato & BOP Dairy
https://www.agfirst.co.nz/wp-content/uploads/2019/09/WaikatoBoPDairyReport2019.pdf

***Maize***
Pioneer Maize for Silage Growing Harvesting Costs Calculator
https://www.pioneer.co.nz/maize-silage/tools/growing-and-harvesting-costs-calculator/

Corson Maize https://www.corsonmaize.co.nz/Planting-and-Establishment

***Lucerne***
Pioneer Lucerne Calculator https://www.pioneer.co.nz/lucerne/tools/lucerne-calculator/

***Chestnuts***
New Zealand Chestnut Council http://www.nzcc.org.nz/factsheet.html

***Apples***
New Zealand Apples and Pears https://www.applesandpears.nz/

***Dairy Goats***
Dairy Goat Cooperative https://www.dgc.co.nz/

***Dairy Sheep***
Spring Sheep Dairy https://springsheepnz.com/

Maui Milk https://mauimilk.co.nz/

***Kiwifruit***
Zespri https://www.zespri.com/

Kiwifruit New Zealand https://www.knz.co.nz/

Eastpack https://www.eastpack.co.nz/orchard-management

ANZ Kiwifruit Industry Insights Update 2019 https://comms.anz.co.nz/tp/download/691383/e979b12bd5aadaa8f1420822dbf518c3/anz20702-Kiwifruit-white-paper-2019-11.pdf

MyFarm - Kiwifruit Orchard Investment https://www.myfarm.co.nz/kiwifruit-orchard-investment

***Forestry***
Ministry for Primary Industries Forestry Data https://www.teururakau.govt.nz/news-and-resources/open-data-and-forecasting/forestry/new-zealands-forests/

New Zealand Farm Forestry https://www.nzffa.org.nz/

***Pan-Sector***
Situation and outlook for primary Industries (SOPI) https://www.mpi.govt.nz/news-and-resources/economic-intelligence-unit/situation-and-outlook-for-primary-industries/sopi-reports/

AgFirst Waikato (2016) Ltd
26D Liverpool Street
PO Box 9078, Hamilton 3240, New Zealand
07 839 2683
waikato@agfirst.co.nz
www.agfirst.co.nz