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Climate Smart Intensification options for New Zealand Pastoral Farmers

A farmer's guide to intensification options in the Context of Climate Change

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Notwithstanding the acknowledgements above, the contents of this report are the responsibility of the authors.

Key Messages

- A changing climate will bring both threats and opportunities for New Zealand farmers. Small changes in average temperature can lead to large changes in the frequency of extreme events (heavy rainfall, drought or very high temperatures). Spring pasture growth in cooler regions would increase and be beneficial for animal production.
- *Climate–Smart Agriculture (CSA)* is a term that has been developed for farming systems that respond to these issues. It provides an opportunity to increase agricultural productivity and incomes, while adapting and building resilience to climate change. It reduces greenhouse gas (GHG) emissions, adds perceived and real value to export products, while future-proofing efficient food and fibre production.
- Given that climate variability is increasing, vulnerability to climate change will increase unless coupled with adoption of new strategies for CSA intensification.
- Increasing the intensity of farm production may create increased economic risks and exposure to additional impacts from more frequent extreme weather events. Dependence on externally sourced feed supplies may bring exposure to climate change and market pressures outside New Zealand farmers' control. Shifts in land use (especially from sheep and beef to dairy) may reduce flexibility of access to alternative feed and relocation of stock to less drought (or flood) affected areas.
- There are a number of things that farmers can do now to prepare and make their business more resilient to future climate changes. Strategies that provide some flexibility, so farmers can work across a range of future conditions and meet both challenges and capture opportunities are likely to become more important in the future.
- Under CSA there are some intensification strategies that provide a means for New Zealand pastoral farmers to better adapt to climate change, capture further efficiencies and/or secure market access into high value markets. Four promising pathways which could be used in the sheep/beef and dairy sectors to drive climate-smart intensification are:
    1. **Improved risk management strategies** - are needed to cope with greater frequency, intensity and uncertainty of climate changes. These risks include: adverse natural events; financial uncertainty and hardship associated with variable climate, emergence of new plant and animal diseases or pests and the stress on biocontrol systems; and social factors – health, community wellbeing, mental health and cultural impacts.
    2. **More efficient production** - using good management practices and efficient use of resources and technologies that improve both profitability and environmental outcomes.
    3. **Habitat and biodiversity enrichment** - greater diversity of habitat and species increase the potential to benefit from the ecosystems services provided by a healthy environment and agro-biodiversity in particular. Shelter greatly reduces lambing losses from severe spring storms, increases milk production and will become more important as the number of days of extreme heat increases. Trees also provide erosion control, reduce flooding, help water quality and may provide a source of income.
    4. **Adding value rather than just volume to production** - options maybe limited for individual farmers but there may be opportunities for industries or companies. For example, many Chinese and Indian consumers are willing to pay 20–40% extra for New Zealand produce with verified credentials for animal welfare, water care, reduction in GHG emissions and biodiversity care.

About this farmers guide

This farmers' guide is an informal summary of the *Evaluating Intensive Trajectories* project (Contract Agreement ABDG30946) for the Ministry for Primary Industries as part of their Sustainable Land Management and Climate Change (SLMACC) programme. A more detailed description of the results and rationale behind this farmers' guide can be found in two reports found at http://www.argos.org.nz/slmacc-project.html :

- Intensification Trajectories in the Context of Climate Change: Potential Pathways for the New Zealand Pastoral sector literature review
- Evaluating Intensification Trajectories in the Context of Climate Change: Final Report

New Zealand's climate is changing with long term trends toward higher surface, air and sea-surface temperatures, more hot extremes and fewer cold extremes, and changed rainfall patterns. For farmers, this means that they will have to cope with more extremes in climate and more variable seasons.

Given that climate variability is increasing, vulnerability to climate change will increase unless coupled with adoption of new strategies for Climate-Smart Agricultural intensification

There are a number of things that farmers can do now to prepare and make their business more resilient to future climate changes. This report aims to provide you with knowledge to help you to do this and learn from other farmers.

Reading this guide will help you understand:

Projected changes in New Zealand's climate and what it means for farmers in the different regions.

1. Different farmers respond to change, risk and efficiency options depending on what type of farming style they have. Which works for you?
2. There are many strategies and practices that can help reduce risk from a variable climate. What strategies are you already using? What addition strategies could you use on your farm?
3. Four pathways and farmer case studies are provided as examples of how other farmers have responded to the challenges and opportunities of climate change and intensification.
4. Also included in this guide is where to go for more information.

Why climate change and intensification are joined challenges and opportunities?

In New Zealand, agricultural intensification is important for producers facing growing global demands for food, and to achieve greater efficiencies in production. Global climate change, however, poses new risks, constraints and opportunities. The impacts of increasing climatic variation with more frequent drought, heavy rainfall events, and severe winds increase farmers' risk. In addition, inputs commonly used to support intensification (nitrogen fertilisers; petroleum powered mechanization) are considered significant contributors to greenhouse gas (GHG) emissions. In contrast, however, intensification is also credited with realizing environmental and social benefits due to the greater efficiency (relative to land area and carbon emissions) of production achieved through use of high yielding varieties, chemical fertilisers and pesticides.

The success of New Zealand's pastoral agriculture has been built on land use intensification and continual improvements in production efficiency. Climate change and the depletion of natural resources pose likely threats to ongoing intensification by driving increased costs of inputs, especially energy, and by escalating the cost of managing environmental impacts. New Zealand's successful pasture-based agriculture has provided a point of difference in global markets however in the future it may make it increasingly vulnerable to a changing climate. Consumers may also demand reduced GHG emissions.

Climate–Smart Agriculture (CSA) increases agricultural productivity and incomes, while adapting and building resilience to climate change. It reduces greenhouse gas emissions while future-proofing efficient food and fibre production.

Smart intensification strategies provide a means for New Zealand pastoral farmers to better adapt to climate change or to capture further efficiencies to secure market access and competitively priced exports, contributing to the planned doubling in value of primary product exports by 2025.

Increased climate variability and redistribution of rainfall and higher temperatures will stress food production and could disrupt transport and other support services. Ultimately New Zealand can secure and raise the value of agricultural exports by growing production through intensification, or diversify into less intensive land use where profitability rather than production is maximized. It is therefore important and urgent to decide whether intensification should continue and, if so, exactly how it can safely proceed in the face of climate change.

Clarifying terms to get everyone on the same page

Farming intensity and intensification (increasing throughput) could be defined in a variety of ways. Many of the options for climate-smart intensification focus on maximizing productivity rather than production itself. Climate-mart intensification pathways can be segmented into three types of intensification:

1. **Input intensification**: increasing what farmers put in
2. **Output intensification**: increasing what farmers take out
3. **Eco-efficient intensification**, assesses the productive output per unit of environmental and/or social impact e.g. nitrogen use efficiency or milk solid production per unit of GHG emitted.

'Land use intensification' is the most common application of the **input intensification.** In this case a hectare of land is used as the main 'input' to the farming effort. A commonly used measure is product produced per "effective area" on the farm, where the effective area is considered to be the pasture or

cropping area and excludes bush gullies, shelterbelts or riparian strips. Supplementary feed, water or nutrient imports to the farm are additional baselines for farming intensity. Less common (yet potentially important) inputs include the farmer's time, the costs of farm labour or the increasing inputs of knowledge or technology to drive increased production. **Output intensification seeks** to raise production efficiency to get greater returns per unit of input. These may be the result of improved management or skills, technology, or improved plant and animal breeding. Examples of these are kg MS/cow or kg wool/ssu.

Intensification – a Threat or an Opportunity?

Intensification provides both **opportunities**:

- Provides a way to maintain the viability of dairy or meat production.
- Intensification is an important strategy for maintaining market position for New Zealand meat and milk products.
- The majority of farmers use efficiency as a means of controlling costs through the more efficient use of nutrients (feed, fertiliser, effluent), fuel, chemicals, water or labour.

And threats:

- Negative environmental impacts can result from more intensive production methods which include; removal or degradation of natural habitats, increased chemical inputs, mechanisation, and higher stocking rates.
- Loss of resilience associated with increased reliance on external inputs (e.g. supplementary feed) to the production system.

Increasing the intensity of farm production may create increased economic risks and exposure to additional impacts from more frequent extreme weather events. Dependence on externally sourced feed supplies may bring exposure to climate change and market pressures outside farmers' control.

Economic Modelling

Economic modelling was used to more accurately assess the potential effects of climate change for New Zealand agricultural producers under several response pathways. This modelling was performed using the Lincoln Trade and Environment Model (LTEM), an international trade and environment model based at Lincoln University. The LTEM projects global changes in 22 agricultural products in 21 markets around the world.

Economic modelling shows that adaptation strategies to climate change are particularly needed for the dairy sector, partly because of its paramount importance to the prosperity of New Zealand, and partly because in the absence of adaptation, returns from dairying will be eroded by climate change whereas returns from sheep & beef will be increased.

Summary of Projected Changes in New Zealand's Climate

For the past two decades, Intergovernmental Panel on Climate Change (IPCC) Working Group II has developed assessments of climate- change impacts, adaptation, and vulnerability. The IPCC's Fifth Assessment Report WGII AR5 report was released in 2014 and has input from many of New Zealand's leading scientists.

A summary of the projected impacts of climate change for New Zealand from this report is below. (Table 1)

Table 1 Summary of Projected Impacts of Climate Change for New Zealand

The regional climate is changing

Long term trends are towards higher surface air and sea-surface temperatures, more hot extremes and fewer cold extremes, and changed rainfall patterns.

Warming is projected to continue through the 21st century.

Warming is expected to be associated with rising snow lines, more frequent hot extremes, less frequent cold extremes, and increasing extreme rainfall related to flood risk in many locations. Annual average rainfall is expected to decrease in the north-east South Island, northern and eastern North Island, and to increase in other parts of New Zealand. Fire risk is projected to increase in many parts of New Zealand. Regional sea level rise will very likely exceed the historical rate (1971-2010).

Uncertainty in projected rainfall changes remains large for New Zealand.

Precipitation changes are projected to lead to increased runoff in the west and south of the South Island and reduced runoff in the north-east of the South Island, and the east and north of the North Island. Annual flows of eastward flowing rivers with headwaters in the Southern Alps (Clutha, Waimakariri, Rakaia, and Rangitata) are projected to increase by 5-10 % in response to higher alpine precipitation. Most of the increases occur in winter and spring, as more precipitation falls as rain and snow melts earlier.

Recent extreme climatic events show significant vulnerability of some ecosystems and agriculture to current climate variability

The frequency and/or intensity of such events is projected to increase in many locations. Recent floods caused severe damage to infrastructure, farms and houses. Widespread drought in many parts of New Zealand (2007-2009; 2012-13) resulted in substantial economic losses of NZ$3.6b in direct and off-farm output.

Without adaptation, further changes in climate, atmospheric CO2 and ocean acidity are projected to have substantial impacts on water resources, coastal ecosystems, infrastructure, health, agriculture and biodiversity. Freshwater resources are projected to decline for rivers originating in the north-east of the South Island and east and north of the North Island. Rising sea levels and increasing heavy rainfall are projected to increase erosion, with consequent damages to many low-lying ecosystems, infrastructure and housing; increasing heat waves will increase risks to human health; rainfall changes and rising temperatures will shift agricultural production zones; and many native species will suffer from range contractions and some may face local or even global extinction.

Some sectors in some locations have the potential to benefit from projected changes in climate and increasing atmospheric CO2.

Examples include reduced energy demand for winter heating and forest growth in cooler regions except where soil nutrients or rainfall are limiting. Spring pasture growth in cooler regions would also increase and be beneficial for animal production.

Table 2 Regional climate changes from 1980-1999 to 2039-2049

	Northland	Waikato	Hawkes Bay	Manawatu	Nelson	Canterbury	Southland
Increase in Days over 25 °C	32	22	15	5.1	11.7	11	12
Change in days min temp less than 5 °C	-13	-22	-22	-14.4	-9.4	-39	-42.6
First day of spring* days earlier	0	11	17	6	8	14	8
First day < 0°C days later	1.6	24	8	20	5	25	22
Change in Total annual rain	-52mm	-120mm	-7mm	-22.9mm	36.9mm	22.7mm	94.8mm
Increase in annual pasture production	10%	12%	5%	5%	18%	17%	15%
Increased variability	earlier spring growth	summer & autumn more variable	lower growth Nov-Dec (lower Oct-Nov rainfall)	increase summer	little change except more variable May-June	greater spring peak, variability already high no change	lower variability winter and higher late summer

*First day of spring is when pasture growth is over 20kgDM/ha for 10 consecutive days.

A changing climate will bring both threats and opportunities for New Zealand farmers. Small changes in average temperature can lead to large changes in the frequency of extreme events (heavy rainfall, drought or very high temperatures). Spring pasture growth in cooler regions would also increase and be beneficial for animal production.

In many regions winters will become shorter but there will be increased variability in summer growth. Bog Roy Station uses lucerne and a small area of irrigation to manage variable summer growth.

Farming styles: what pathway and who is going to make the shift to climate-smart intensification?

The ARGOS team in the SLMACC project have identified different pathways which could be used in the sheep/beef and dairy sectors in response to the interaction between the possible intensification of farming practices and climate change. Different farmers respond to change, risk and efficiency options depending on what type of farming style they have. Which group are you in?

Table 3: Where do you fit?

Type	Description
The stable continuous improver	Most efficient, consistent and profitable long term Make incremental changes Fund development out of profit Know what is important in a farming system and focus money effort there In dairying – focus on productivity per cow and quietly push limits Profitable through efficiency, lower labour costs and careful feed storage
The adaptable risk taker	Entrepreneurial High but variable profit, very efficient Dairy – accumulate land, farm as a business rather than 'being a farmer' Cropping/sheep/beef – farming as an agribusiness often finishers not breeders Lower equity Strict soil fertility maintenance
The low input conservers	Self-sufficient, low input May add value on farm- organic, processing grains etc. May have off farm work often associated with farming Profitable through family labour and on-farm stored feed supplies
The extensive farmer	Very large sheep & beef (maybe deer) farms Low production per hectare due to altitude/steepness Fertiliser use in a good year maintains soil reserves
The developer	At the development stage (such as conversions to dairy) Has a project and a plan Development paid for by mortgage (lower equity) Less adaptable – more likely to stick to a plan

Pathways for climate-smart intensification

Four promising pathways that could be used in the sheep/beef and dairy sectors to drive climate-smart intensification are: 1. Improved risk management strategies; 2. More efficient production; 3. Habitat and biodiversity enrichment and 4. Adding value rather than just volume to production.

1. Improved Risk Management Strategies

The risk management pathway addresses the risks from changing climate that are likely to impact on the pastoral sector. Land managers need to adapt their risk management strategies to greater frequency, intensity and uncertainty of climate changes. These risks include:

- Adverse natural events, e.g. increased risk of fire, heat waves, drought, floods, storms, erosion, and sea level rise.
- Financial uncertainty and hardship associated with variable production as a result of climate impacts on farm production, e.g. feed supply, feed quality resulting from changes in pasture species, impacts on animals
- Emergence of new plant diseases, weeds or pests and the stress on bio-control systems or changed distribution of weeds and pests.
- Animal health – disease increases with new vectors, heat stress impacts.
- Social factors – health, community wellbeing, mental health and cultural

Risk management is a process to assess how a farm/business can achieve its objectives given information about the likelihood of the risks above for example, drought or disease. Events such as floods should be examined to see how they affect the business and how often they are likely to occur. Then a plan and changes can be developed to reduce the impact or take advantage of any opportunities that may come out of these events.

Resilience is considered a key element of climate-smart intensification

Another approach is 'learn by doing'; this uses existing knowledge, based on land managers' experience with the variability of climate and production in the past. Drawing lessons from every drought or flood event is a good example, it provides some basis for managing the emerging risks associated with climate change with the adoption of a wide range of farm management strategies (see table 3 for strategies farmers interviewed were using). Strategies that provide some flexibility, so farmers can work across a range of future conditions and meet both challenges and capture opportunities are likely to become more important in the future.

Shifts in land use (especially from sheep and beef to dairy) may reduce flexibility of access to alternative feed and relocation of stock to less drought (or flood) affected areas

There are many strategies and practices that can help reduce risk from a variable climate. From our interviews the following checklist was developed to manage climate risk. Which ones are you already using? Which additional ones would work for your farm?

Table 4: Checklist for managing risk

	Ways of managing risk Which ones are you already using? Which additional ones would work for your farm?	Tick ✓ all the practices you use/could use
Financial flexibility	Reduce debt so can better manage a poor season Have a good financial buffer Undertaking regular (monthly) financial monitoring Have the ability to reduce inputs in drought/poor pay out years	
Good management	Continually plan, measure, monitor and analyse farm results Equip the farm to manage risks - identify, act early and reassess risks regularly Use forward contracts to take out the highs and lows from marketing outputs Use Key Performance Indicators (KPIs) and benchmarking to identify your comparative performance	
Feed	Establish more self-sufficiency with supplementary crops Establish feed pads around the farm to minimise wastage and pugging Plant specialist grasses to suit the climate such as deeper rooting pastures for dry summers Undertake feed monitoring and budgeting	
Stock	Breed stock to suit local conditions and issues e.g. breeding for facial eczema tolerance Be proactive with animal health e.g. fly strike, Barbers pole Change stocking rate and class to better match feed demand and supply Pregnancy test early and cull empties early in drought Maintain flexible stock selling policies Grow young stock faster so they can be sold earlier	
Water access	Ensure there is reliable reticulated stock water Develop Irrigation/ Irrigation efficiency to make water go further	
Efficient use of inputs	Use precision technology including GPS fertilizer placement, GPS guidance & crop sensing, variable rate irrigation Use integrated pest management to reduce chemical use	
Trees	Plant trees for erosion control Plant trees for shade and shelter Prune/remove trees overhanging buildings to reduce wind damage	
Infrastructure	Increase height of stop banks to manage flood risks Increase effluent storage for prolonged wet periods Have a back-up generator or power source	
Farm Systems	Review the farming system – is it appropriate to manage risks i.e. High input systems/Low input systems Is once a day or 16 hourly milking during droughts/floods an option? Maintain flexible stock selling/purchase systems	
Support services	Improve access to long range weather forecasts Use advisors Maintain strong community networks. contacts/rural services	
Diversification	Another farm/run off block in a different climatic zone Diverse crops and products providing income diversity Niche markets, a variety of contracts Off farm investments/Off farm income	

A comprehensive monitoring system helps Hamish and Jane Putt manage a variable climate on their Waikato dairy farm.

Hamish & Jane Putt sharemilk on both organic and conventional dairy farms on the rolling hill country of Waikato, approximately 5 kilometres Southwest of Putararu. This is an area of relatively regular seasonal conditions with a windy spring, dry summer period of approximately 5 weeks and a wet winter with some frosts. At the time of the interview the Putts' were farming 400 cows on the organic farm and 480 on the conventional farm and their business is continually growing. They have strategically diversified into organics. However it is difficult to compare the production with when it was conventional, especially with the seasonal variability they have had.

Hamish uses a comprehensive monitoring system to continually assess the state of the farm's soil temperature, moisture and pasture growth. This means that conditions that could affect production are picked up early and Hamish can stock up on feed before increased demand pushes prices up and also adjust his 10 day grazing plans.

Plans are afoot to mitigate climate risk for their business include moving to lower stocking rate (2.5 cows/ha) and increase per cow production so that they are doing the same or better total production. This would build flexibility into the system so they would not be as susceptible to feed shortages in dry summers or poor winters and provide more efficient use of pastures and supplementary feed. Additionally they are consciously focusing more on young stock to ensure their potential is obtained. One of the key focuses is to react quickly when stock start to get pinched in a dry period. The farm's pastures are made up of a diverse range of pastures so that it performs better in poor growing conditions. The plan is to grow more pasture by having specialist grasses to suit their climate

These specialty pastures would be deeper rooting and water efficient in dry summers. These strategies would lead to more suitable pastures and fewer cows, which would have less of an impact on the environment and reduce risk from a variable climate.

Where can I seek further information?

MPI Climate Change Adaptation Tool box and case studies http://www.mpi.govt.nz/environment-natural-resources/climate-change/resources-and-tools

Beef + Lamb New Zealand Land and Environment Plan http://www.beeflambnz.com

Towards Resilient Farm Business in Northland, funded by MPI Sustainable Farming Fund, Northland Regional Council and NZ Landcare Trust http://www.landcare.org.nz/files/file/333/farm-resilience-sheep~and~beef.pdf

2. More efficient production

The objective of the production efficiencies pathway is to increase the amount of production (e.g., kilograms of milk solids or meat) relative to the level of inputs (e.g., chemical fertilisers) or the level of externalities (e.g., GHGs, nutrient loss). The efficiency goal applies to all farm inputs, not just the area of land deployed for food and fibre production. If achieved, an equivalent level of consumption will be responsible for a smaller environmental footprint. Shifting emphasis from maximising production to maximising profit provides immediate financial buffers that provide the economic resilience for learning how best to adjust to climate-smart farming and provides funds to invest in climate change adaptation.

A more targeted variation of production efficiency is referred to as eco-efficiency. The emphasis here shifts to include environmental impacts within the efficiency calculation, or to adaptation to climate change by reduced use of inputs that may be exposed to climate change impacts.

The implications of this pathway for intensification include:

- the need for technological innovation
- maintaining or increasing current intensity
- the reduction of inputs (reduced input intensity)

For example, using precision applications of fertiliser may reduce the tonnage of fertiliser used (reduced input intensity) without reducing production (an efficiency gain or increased output per unit of fertiliser input). Cost minimisation is a common strategy within this pathway because of a law of diminishing returns (pushing for the last 10% growth in production may cost a lot more than the increased farm gate revenue from added production).

Having the right breeds with the right genetics on the right country, and feeding the right feed is the key to South Canterbury's Lisa and David Anderson's success.

Bog Roy Station owned by Lisa and David (Grundy) Anderson, is a 2860 ha sheep and beef farm in South Canterbury and has 1/3 steep hill, 1/3 rolling hill and 1/3 flats including about 1000 ha in unimproved native grasses. The altitude ranges from 350 to 1000m, combined with the 420mm annual rainfall means there is very little pasture growth in Jan- Feb and July-August. The stock include 3900 ewes, 140 beef cattle and 1600 lambs wintered. Of the remaining lambs 200 are sold to the works and the others sold store mid-January. The farm manages the summer dry by having 153 ha of irrigation growing Lucerne and mixed pasture as well as 40 ha in Ryecorn mostly grazed by ewes and lambs.

The focus of the Andersons' is to increase the "Velocity dollar – Have the right breeds with the right genetics on the right country, and feed the right feed to hit target weights quicker so young stock are on the farm for less time." By doing so they are more profitable and more resilient to dry summers. To do this they measure and monitor ewe liveweight and condition score four times a year, measure pasture growth rates and the soil and air temperatures. This coupled with the Lucerne grazing creates a very efficient system with lambs growing at about 250gms per day from birth to weaning at 100 days. By taking dry matter cuts using cages, on different paddocks, they can determine the economics of different pastures and Lucerne. This identifies the areas with the most potential for development on property and "works out the best bang for buck". The consultant for the benchmarking group has worked out converting from native grasses to Lucerne on this property had a 27% internal rate of return.

Table 5: Checklist of Efficiency measures to improve productivity and reduce environmental impacts

	Efficiency measures to improve productivity and reduce environmental impacts	**Tick ✓all the practices you use/could use**
Nutrient use efficiency	Use variable rate fertiliser using soil mapping and testing within a paddock. Utilise GPS guided fertiliser placement. Deeper rooting pasture species that can take up more nutrients and water. Lower rates, more strategic use of nitrogen fertilisers. Nitrogen (including effluent) only applied when the 10 centimetre soil temperature at 9am is above 5°C in spring and 8°C in autumn. All spreader equipment is calibrated and well maintained. Dairy effluent is applied efficiently including storage, deferred irrigation, and uniform application at the correct application depth for the soil type.	
Animal and feed efficiency	Attention to Animal genetics and selection. Utilising lucerne and high quality pastures to achieve high lamb growth rates so lambs sold earlier. Once a day or 16 hourly milking to reduce cow walking time. Low empty rates in cows and therefore lower replacement rates. Condition scoring, weighing and monitoring to control animal condition loss and gain throughout the year. Flexible stock buying and selling policy to utilise grass and reduce supplement requirements. Change stocking rate and type to better match feed demand to supply. Small feed pads next to feed crop paddocks to improve feed efficiency especially in winter and wet springs. In-shed feeding and supplement use for dairy cows to get high production per cow and reduce animal maintenance costs.	
Water use efficiency	Use of deep rooting species (Lucerne, chicory, fescues). Grazing and crop management that helps build up the organic matter, improving the water holding capacity of the soil. Soil and fertiliser management to improve soil structure (aggregates) to improve water holding capacity. Volume of dairy shed water is minimised by scraping, recycling grey water Irrigation water will be applied at rates equal to or lower than 50 percent of soil moisture holding capacity of the soil. Irrigation application rate and depth adjusted according to ET, rainfall and soil moisture status to ensure that drainage and runoff is minimised. Utilising Electromagnetic (EM) mapping shows the relative conductivity of soils in a field. An EM Map of a field being irrigated, shows the variability of the field as a starting point for a Variable Rate Irrigation (VRI) plan. Soil moisture monitoring and weather forecasting.	
Fuel and energy	Teaching staff more efficient tractor driving skills. Direct drilling, minimum tillage and minimising number of tractor passes. Bring stock closer to stored feed in winter to reduce fuel use with feeding	

Effective use of technology ensures Craige and Roz Mackenzie achieve eco-efficiency and profit

Methven farmers Craige and Roz Mackenzie of Greenvale Pastures Ltd run an intensive arable operation that utilises technology to maximise production in a sustainable manner. Greenvale grows mainly specialist crops, with this season's rotation including radish, chicory, wheat, ryegrass, fescue, barley and faba beans. Along with 200ha at Greenvale, the Mackenzie's' also hold a 50 percent equity share in a neighbouring 330ha dairy unit.

Effective utilisation of soil test and plant requirement information to plan and monitor improves nutrient use efficiency. For both farms they have taken technology to the next step "using every available tool to improve their production and cost efficiency". Electromagnetic soil mapping, for example, is used to give a clear picture of water holding and productive capacity within specific zones. Fertiliser is spread using a variable rate spreader equipped with technology that allows targeted nutrient application to meet specific crop and pasture requirements. The introduction of variable rate irrigation on both the arable and dairy farms in 2013 has increased productivity and saved up to 50 percent of water use. Variable rate irrigation, soil moisture monitoring and weather forecasting ensures crops and pasture are never over or under watered, maximising plant growth and minimising the loss of nutrients below the root zone. The strategic use of irrigation to ensure maximum seed germination enhances the activity of applied chemicals and increases nitrogen use efficiency. Craige has developed a system of nitrogen application, which they have patented internationally, calling it Smart-N. This can ensure N application is targeted exactly where it is wanted allowing a 30 percent cost saving and greatly reducing N leaching.

Variable rate irrigation, soil moisture monitoring and weather forecasting ensures crops and pasture are never over or under watered, maximising plant growth and minimising the loss of nutrients below the root zone on the McKenzies' farm.

Where can I seek further information?
EECA's Dairy Farm Energy Efficiency tool to calculate energy use www.eecabusiness.govt.nz › Tools & calculator

Booklets on Nutrient use efficiency http://www.fertiliser.org.nz/Site/resource_center/Booklets.aspx

Irrigation efficiency http://irrigationefficiency.co.nz

3. Habitat and biodiversity enrichment

The use of tussocks reduces lambing losses

This pathway addresses the potential to increase a farm's resilience to climate change pressures or shocks through practices that enhance both habitat and biodiversity.

The impact of agricultural intensification, including replacement of native vegetation and intensified management of land already cleared for agriculture, has had a harmful effect on biodiversity in rural landscapes. Greater diversity of habitat and species increase the potential to benefit from the ecosystems services provided by a healthy environment and agri-biodiversity in particular.

Shelter greatly reduces lambing losses from severe spring storms. A recent study in the Waikato showed a 3% increase in milk production because cattle graze for longer when they have access to shelter and shade in the summer. Preliminary research has shown that some New Zealand native plants kill intestinal parasites of deer (Johnson 2012), so indirect and tangible benefits of planting the right trees in the right places on farms could assist animal husbandry and reduce the reliance on expensive chemicals used to control intestinal parasites.

Unless a farm is irrigated, intensive agriculture generally dries out land and landscapes. Removing trees opens the land to direct sunlight and allows the wind to reach ground level. Unless farmers use "minimum tillage" strategies, a hot dry summer wind can desiccate the topsoil, or facilitate wind erosion. Additionally many wetlands, even small seepage areas in gullies, are drained and replaced by pasture. Tile and mole drains are often inserted into heavier soils to maximise pasture production by aerating and warming the soils faster in spring.

As we experience more extreme weather, trees for shade, shelter and erosion control will become increasingly important.

Tree roots hold the soil together, especially on the steeper sites, and their litter stores water before releasing it more slowly back into the air or into the streams and rivers. In most cases with little sediment suspended in it. If the right trees are planted in the right places temporary streams will flow more steadily and for more of the year; a paddock will stay greener for longer as a drought sets in and bounce back faster when it breaks; the stream will run clearer where it leaves a property than where it entered upstream from a neighbour that has not planted trees. Planting trees therefore is a potentially useful strategy to mitigate the effects of drying and increased wetting of regions because of climate change, and it contributes to biodiversity as well.

Reducing the impact of major rainfall and flood events is going to be very important in the future. Farmers can adjust their management practices and planting to minimise the risk of local sources of flooding.

Forestry or income from tree crops may be an option. Carbon sequestration payments are available, including the Permanent Forest Sink Initiative (PFSI). The PFSI is an opportunity for landowners and investors to earn units for the increase in carbon stored in eligible forest land established from 1 January 1990. Carbon prices are currently low but may change. Work is underway to investigate other eco-services payment options.

A fundamental reason for conserving biodiversity and functioning ecosystems is the maintenance of adaptive capacity and varied species may keep essential ecosystem processes going in an increasingly variable climate. A big part of sustainability is about "resilience" – making sure that New Zealand's farms, forests, rural communities and markets can take the knocks and adjust to changing environmental conditions. Species that appear redundant now may turn out to be the key providers of "ecosystem services" like pollination and pest control in future.

This 'win-win' aspect can partially off-set the impacts of intensity by:

- increasing efficiency and resilience of production through enhanced ecosystem services
- reducing reliance on externally derived nutrient, water and pesticide inputs
- enabling reduced intensity (at whole farm level) for same profit by reducing operating costs
- contributing to climate change mitigation by increasing carbon sequestration
- Substantiating/proving the 'licence to farm' and attracting price premiums in export markets

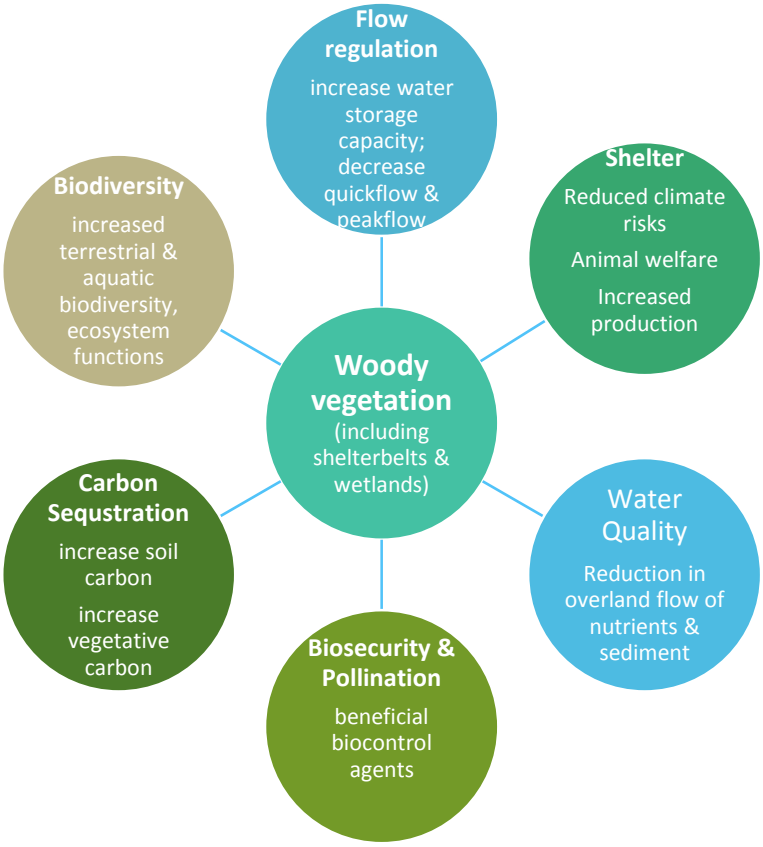

Figure 1 Importance of Woody Vegetation

(Blackwell et at 2008, Moller 2008)

Table 6: Checklist for increasing woody vegetation

Benefits	Why	Tick ✓ Already on my farm	Worth considering	Not applicable
Trees for erosion control	An increase in extreme rainfall could increase the number of slips on erosion prone land			
Wind erosion	In some regions extreme wind events may increase. A 5 metre high shelter belt protects about 50 m of ground. About 50% permeability and continuous planting is best. Some species are less prone to wind damage than others. Strip planting is another option for cropping.			
Water Quality	Riparian and gully planting helps reduce nutrient and sediment runoff and improve water quality. Planting suitable species can help reduce local flooding by reducing quickflow and peakflow during heavy rain.			
Shade for animal productivity & welfare	With an increase in very hot days trees for shade will become increasingly important for animal productivity and welfare.			
Pollination & biocontrol	'Trees for bees' and plants that host biocontrol agents can increase production and decrease chemical costs			
Biodiversity	By fencing off gullies, wetlands and other areas of significance to encourage regeneration you can help the local plants, birds and reptiles.			
Income diversification	Forestry or income from tree crops may be an option. Carbon sequestration payments are available, carbon prices are currently low but may change. Work is underway to investigate eco-services payment options.			

Regenerating native bush provides better water quality, shelter and shade on Richard and Jill Simpson's beef and dairy support farm.

Richard and Jill Simpson have transformed a gorse invested property purchased 16 years ago into a productive beef and dairy support unit with 100 Ha of regenerating native bush in two coastal valleys. The Simpsons have three covenants that protect lower reaches of the stream and bush remnants in the steep gullies. Higher up the valley, Richard and a neighbour have also protected part of the watershed with a conservation covenant of a bush remnant. This covenant not only protects the top of the catchment but provides a corridor for birds, lizards and insects to move from the summit of Banks Peninsula to the coast. Stock access across the farm is maintained by double fencing tracks. The limitation to increase woody vegetation was the cost, to fence 70 ha it was $70,000 to $80,000 and now would cost $150,000. There is also an on-going cost to maintain and manage plantings and pest control. The benefits to the farm are better water quality in the streams, which is then piped to the stock water troughs, better shade for stock and shelter from the cold coastal winds and lower stock losses. By concentrating stock on the better parts of the farm Richard has improved production through fencing, fertiliser and pasture management. To manage dry summers there is now a more flexible stocking policy with lower beef cow numbers and usually all calves are finished, but they can sell some early as stores if needed.

Regenerating native bush provides better water quality, shelter and shade

Where can I seek further information?

- Your local regional council website or staff
- New Zealand Farm Forestry Association http://www.nzffa.org.nz/
- Landcare Research Nature Services plant selection guide http://natureservices.landcareresearch.co.nz
- Tress for bees - http://www.treesforbeesnz.org/home

4. Adding value rather than just volume to production

One way of maximising profit and building economic resilience is to capture price premiums for ethically grown food and fibre. Market accreditation systems lock in these economic benefits by incorporating eco-verification of food quality and associated intangible values (food safety, sustainability, animal welfare, biodiversity support, labour welfare, local rural community resilience etc.). By creating an opportunity for price premiums for New Zealand products, farmers can earn a greater profit from their goods and use the additional funds received to increase their resilience against the impacts of climate change. Although the market signals are variable and relatively weak at the moment, 7-8 years ago, for example there were strong market signals for carbon labelling and reporting.

Recent work by Lincoln University's Agribusiness and Economic Research Unit has estimated that many Chinese and Indian consumers are willing to pay 20–40% extra for New Zealand produce with verified credentials for animal welfare, water care, reduction in GHG emissions and biodiversity care.

This pathway envisages a shift in focus from the quantity to the value of agricultural products. It also realises efficiencies, in this case involving greater economic return per unit of production and per unit of input. This shift can increase a farm's resilience by enabling access to a greater diversity of markets – including those which distinguish and reward environmentally and socially responsible land management.

- Retain profit while reducing emphasis on production
- Fit intensity to environmental and social wellbeing
- Build market resilience
- Some market initiatives are achieving a premium for products from climate-smart farms such as Lake Taupō Beef and organic certification.

Value added options may be limited for individual farmers but there may be opportunities for industries or companies.

It was also identified that by investing in eco-certification and monitoring tools for accreditation now, one can also become well prepared for the future impacts of climate change and ensure market access in increasingly climate sensitive markets. The group identified tools such as Farm IQ and the Dairybase database/benchmarking that could be useful to enable farmers to compare themselves with others to identify best practices and opportunities for improvement.

We recommend that industry monitor international market trends and consumer attitudes to climate change and intensification responsiveness, especially where these could develop into potential market access barriers.

A certification programme recognises and financially rewards Michael and Sarah's farm best practice.

Michael (Woody) and Sarah contract milk on a farm that milks 1050 cows near Dunsandel, and also have a manager on Robindale Dairies at Te Pirita (20km away), with 2000 cows at 3.5 cows/ha. They own 520 cows that are leased to Synlait, a corporate farm owner and dairy processing company. Lower performing cows are mated to Wagyu beef to get better returns than bobby calves.

Both farms have high production per cow utilising the high quality irrigated pastures. Robindale has in-shed feeding for the shoulders of season (system 3 - 4) to help manage the large herd and cooler climate. The farms are part of Synlait's 'Lead With Pride' programme that recognises and financially rewards suppliers who achieve dairy farming best practice. 'Lead With Pride' has four pillars – environment, animal health & welfare, milk quality and social responsibility. Woody and his farm staff go through a certification process to demonstrate that the farm is maintaining standards in all four areas that are additional to those that all Synlait Farms have to meet. This includes a demanding documentation and auditing process, and once certified they get a premium per kg milksolids. One thing that really stood out on Woody's farms was the excellent team of staff achieved through a systems approach to recruitment, management, training and health & safety. The staff were encouraged to be innovative, efficient and take responsibility to improve the overall farm performance. Woody encourages staff to have pride in the farm and develop innovative ways to increase efficiency and reduce the time to do things. This culture of innovation and efficiency will help the farm be flexible in a changing climate and also reduce the carbon footprint.