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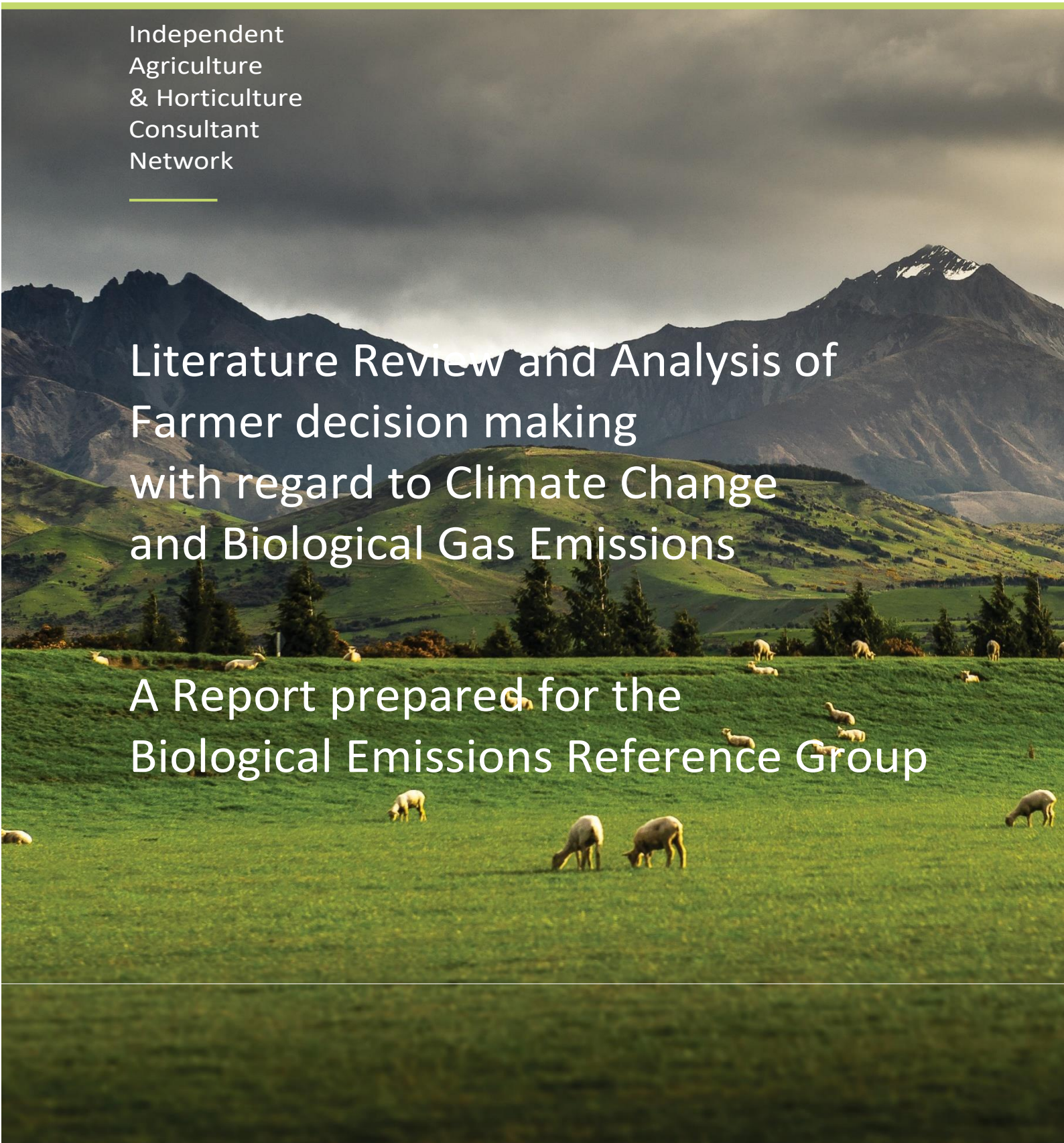

Literature Review and Analysis of Farmer decision making with regard to Climate Change and Biological Gas Emissions

A Report prepared for the Biological Emissions Reference Group

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- The sector experts who participated in the interviews;
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- Peer review by David Fleming (Motu) and Ian Tarbotton (Ballance Agri-Nutrients)

The Biological Emissions Reference Group (BERG) is a partnership between New Zealand's agricultural sector and the Government. BERG has been tasked with collaboratively establishing a robust and agreed evidence base on opportunities available, now and in future, to reduce biological greenhouse gas emissions (methane and nitrous oxide) on-farm. In doing so, it will consider the costs, benefits, and barriers.

This report is one of several commissioned by BERG to build this initial evidence base to inform future policy development. If a policy process were to commence following this analysis, further work would be required. BERG welcomes this report and supports the analysis contained within it. However, it is out-of-scope of the BERG's Terms of Reference to express a preference for any specific options identified or recommended by the author(s).

BERG is comprised of the following voting members: Beef + Lamb New Zealand, Dairy NZ Limited, Deer Industry New Zealand, Federated Farmers of New Zealand, The Fertiliser Association of New Zealand, Fonterra, Horticulture New Zealand, Ministry for Primary Industries, and Ministry for the Environment.

The following organisations are observers of BERG: Climate Change Iwi Leaders Group, Meat Industry Association of New Zealand, Ministry of Business, Innovation and Employment, Ministry of Foreign Affairs & Trade, and The Treasury.

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1.0 EXECUTIVE SUMMARY

The key objective of this study was to investigate and discuss the social and behavioural barriers to adopting practices to mitigate biological greenhouse gas emissions. The three core questions raised were;

(i) What are the social or behavioural barriers to maximising the mitigation potential of biological emissions using existing technologies and practices across a farm system?
(ii) How can social or behavioural barriers to maximising the mitigation potential of biological emissions using existing technologies and practice across a farm system be addressed?
(iii) What policy, practices, tools, or strategies are best able to address potential social or behavioural barriers to maximising the mitigation potential of biological emissions using existing technologies and practice across a farm system?

The study approached this by:

(i) Undertaking a literature review on farmer behaviour and decision making, particularly with respect to climate change and greenhouse gas mitigations;

(ii) Interviewing sector experts on their views on farmer behaviour and decision making, particularly with respect to climate change and greenhouse gas mitigations; and

(iii) Carrying out a survey of farmers as to their awareness of the issue.

Given the limited time availability, the above three activities were carried out concurrently.

The report covers, in sequence:

- A literature review on:
  - A number of human behavioural theories;
  - Adult learning;
  - Farmer behaviour change and adoption of innovations; and
  - Farmer decision making regarding climate change outcomes.
- Sector Expert Interviews
- Farmer Survey
- A Discussion on the above areas
- Recommendations on policy intervention options
- Recommendations for further research

These are summarised below:

1.1 Behavioural Theories

There are a wide range of theories relating to human behaviour, and the means to which behaviours can be adapted or changed. A number of these are outlined in this report (and more so in the appendices). A key aspect to this section is that there is no one behavioural theory that fits everything, with the literature indicating that to achieve behavioural change

across a population, a number of actions, based on a variety of behavioural theories, is required.

1.2 Learning

Learning refers to a change in behaviour that can be observed and managed, and involves the acquisition of knowledge, skills, and attitudes associated with job mastery. Most modern educationalists lean heavily towards the cognitive viewpoint of learning, which is an observable change in behaviour shaped by things or events within the person's environment. This is particularly so as it views people as an active element in their own growth and development, and as individualists who learn differently.
Most adults in most learning projects are motivated by some immediate problem, task, or decision that demands certain knowledge or skill, and learners themselves plan the vast majority of their learning projects. In most projects adults seek assistance from friends, acquaintances, colleagues, members of their family, and neighbours. Professional help makes up only a small part of the resources used.

Groups can also be an important way of learning, and can be very efficient, especially if others in the group want the same knowledge or skill, or that knowledge and skill is contained within the group. A group can also provide positive emotional benefits in terms of enthusiasm, motivation and a sense of achievement.

An adult's efficiency in learning through a group however is rarely as great as it would be if the instructor were used in a one-to-one situation, and the most efficient way to learn is where an instructor interacts with the learner on a one-to-one basis enabling very specific, tailored outcomes for the learner.

1.3 Changing Behaviour/Adoption of Innovations

A key aspect of understanding the drivers of behaviour is how to use these to change behaviour. Particularly (in this instance), where there is a desire to increase farmers' awareness of climate change and achieve uptake of mitigation practices and strategies to reduce biological greenhouse gas emissions.

There are a number of key factors which drive the uptake of innovations, new technologies, and/or new farming systems. These include:

- Awareness of the innovation
- Ease of trialling the innovation on-farm
- Perception that it is worth trialling
- Value of the innovation in achieving the farmers' objectives.

There are also a number of critical aspects of the innovation which interact with the points above:

- Relative advantage – the benefit the innovation provides over current practice. Often expressed in economic terms, but could also include reduced risk or saving in labour/time.

- Compatibility – the degree to which the innovation is compatible with the current farm system. The more compatible the faster the change.
- Complexity – the perceived difficulty to understand or implement the innovation. The greater the complexity the slower the change.
- Trialability – the ease to which the innovation can be trialled on-farm
- Observability – the visibility of the results of the change. The more visible the faster the change.

These factors are important when considering environmental innovations such as improving water quality and mitigation of GHG emissions, in the sense that many are direct barriers to behavioural change:

- Awareness and understanding tends to be low
- Relative advantage of mitigating impacts is often low if not negative; i.e. often there is an economic cost.
- Compatibility and complexity can be variable
- Trialability is often low – often it's an all-or-nothing decision
- Observability is often low – often it is difficult to see an improvement in water quality or a reduction in GHG's, and/or it takes some time for improvements to be apparent.

1.4 Social Factors

There are a wide range of individual and social factors that affect both farmer behaviour and changes in behaviour. The report outlines many of these, with some of the more important ones being:

Individual

- Time availability
- Level of education
- Approach to risk
- Advice sought and from whom they receive it
- Their personal and family circumstances

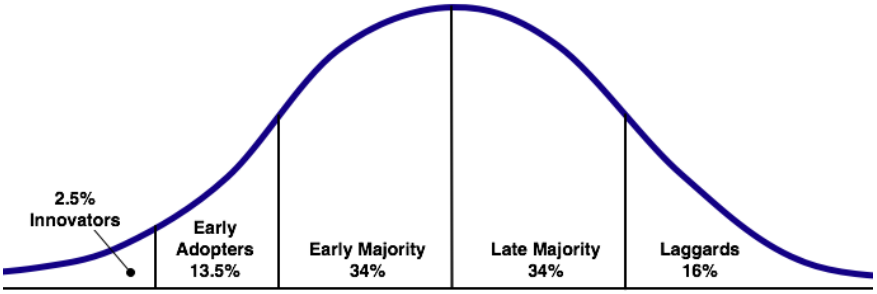
Wider Social

- Farming is a socio-cultural practice – farming is a way of life and a vocation, and sustainability means staying on the farm
- Farmers are not all the same – the farming community is not homogenous
- Farmers don't distinguish environmental issues from other farm management issues
- Women are an integral part of the farm and the farm business
- Farmers often create their own knowledge through experimentation and trial, and often the key source of information is other farmers
- Effective extension requires an understanding of the world view of farmers

- There are many legitimate reasons for non-adoption
- Farmers need to feel valued

1.5 Diffusion of Innovations

The diffusion or adoption of innovations across a population has been illustrated for some time by the Rogers and Shoemaker model, as shown below:



This breaks the population down into various categories, as illustrated above, with the rate of adoption moving from left to right. This categorisation of adopters can vary depending on the characteristics of the innovation or change, and more recent work has indicated a much flatter curve, indicating adoption can occur at a much faster rate across the population.

Nevertheless, the above concept underpins a significant component of marketing and extension. While the "innovators" are important, research indicates that the "early adopters" are more influential on the rest of the population, and therefore should be the target for any initial marketing or extension effort.

A key aspect of the literature research highlights the fact that extension efforts can target a wide range of motivations and drivers to affect the heart of farmers and create an environment for change or improvement

The literature and expert interviews also emphasised the need, within an extension programme, to provide solutions at a whole farm system level. This means that any changes in farm system needs to be explained within the context of the system as a whole. As an example; one potential farm management mitigation is to reduce stock numbers and increase per animal performance (with the same amount of feed eaten). For many farmers this would represent a significant change in their farming system, and they would be looking for information and advice around such matters as; the degree of de-stocking, how this would affect grazing management, other changes in farm management e.g. calving dates, replacement rates, changes in stock types, changes in breeding strategies. Plus, of course, the impact on profitability.

1.6 Sustainability

There are a number of aspects here which influence farmer behaviour and the readiness to change:

- The change in the general "focus" of farming, away from land development and production towards farming systems with a much lower environmental impact.

- The complexity of endeavouring to be "sustainable" given the multiplicity of factors within this, particularly economic and environmental, along with the issue that often it is economic versus environmental. Plus, social aspects, with many hill country farmers noting their main concern around "sustainability" being the demise of local towns as government and commercial services are withdrawn.
- How available information and advice is and how relevant that is to the individual farmer.

Within this is also the issue that in most discussions around sustainability, particularly within the media and by environmental groups, the focus is solely on environmental factors, which are seen to be divorced from economic issues.

1.7 Farmer Attitudes

The (non-statistical/non-randomised) survey carried out as part of this study indicated that the majority of farmers believed that New Zealand agriculture should reduce its greenhouse gas emissions to help combat global climate change, but within this there was a wide range of views from "yes we should do something" through to "it's not an agricultural problem/NZ agriculture should not be penalised".

Relatively few understood the quantum of biological GHG emissions from either their farm or an average farm and hence are unlikely to fully understand the extent of the challenge.

The main mitigation practice indicated was planting of trees, although others such as reducing nitrogen usage and bought-in supplement were also mentioned.

They also felt that a reasonable time frame would be required to achieve a certain level of mitigation, with the average to achieve a 10% reduction being 6-10 years and the average to achieve a 20% reduction requiring 11-15 years. Plus, they felt they need a lot of information to both understand the issue, and the need for change.

1.8 Expert Interviews

Semi-structured interviews were carried out with 11 individuals who had good agricultural sector knowledge, and expertise across extension and/or climate change issues. The key messages from this group were;

- The need for farmer education so that they understand the issues and the need for mitigations.
- The need for mitigation options to be established/researched and the costs/benefits analysed.
- The need for extension to assist farmers to make any changes, particularly as the complexity of any changes increase.
- The relatively long timeframes involved to achieve significant change.
- The need to engage with, and ensure farmers are involved in, mitigation option development and extension programmes.
- Most supported the idea of government assistance to farmers to help incentivise change.

1.9 Timeframes

The timeframes involved in achieving significant behavioural change across a population can vary tremendously, which relates to many of the factors discussed in the report, particularly comparative advantage and compatibility with existing systems.

The timeframes involved in achieving a high level of GHG mitigation was raised by the sector experts and in the farmer survey, with both groups indicating that significant – i.e. 20-30+ years could be involved. Research cited in the report indicated that it took 23 years for 50% of farmers to uptake new agricultural practices over the period of the 1940's – 1960's in New Zealand – a period which saw many major advances in agricultural technologies which enhanced the profitability of farming. Even relatively straightforward mitigations such as fencing off streams on dairy farms has taken around 15 years.

The expectation therefore, is that mitigation of biological greenhouse gases will take some time (i.e. 20-30+ years), and educational/extension programmes designed to assist adoption need to be cognisant of this.

1.10 Policy Intervention Options

Farmer behaviour is driven by a range of factors; intrinsic, personal circumstances, social settings and norms, and economic factors. In short, human behaviour is very complex, and any policy designed to affect behaviour needs to be multi-faceted.

The discussion within the report has led to a number of policy options which could achieve behavioural change and the adoption of GHG mitigation practices. These include:

(i) A policy framework mandating a reduction as well as financial incentives such as imposing a price on biological emissions from agriculture and/or subsidies;

(ii) Polices that will be able to recognise mitigation options that farmers adopt;

(iii) As there are few current options beyond forestry, further options for farmers will need to be developed over time via research and development;

(iv) The development of an educational and extension programme to both help farmers understand the need for change, and assist farmers in making that change. To be successful, the recommendation is that this is an "NZ Inc" approach, involving government, industry bodies and private sector.

1.11 Further Research

Currently there is a research project underway via Motu, investigating "no cost" barriers to adoption of GHG emission mitigation practices by farmers, which will help inform any policy interventions and particularly extension programmes.

The authors feel that, while more research would assist, there is sufficient information on farmer behaviour and adoption to readily implement behavioural change policies.

In noting this though, other potential areas for further research are:

(i) Investigate the link between adaptation and mitigation in a New Zealand farming context. The literature suggests that adaptive practices may also reduce greenhouse gas emissions.

(ii) There is a need to understand farmer decision making and behaviour around "regulated" change, e.g. the demands being made on them with respect to water quality via Regional Council plans (and potentially with GHG emissions).

(iii) With the advent of nitrogen leaching limits in many regions, individual farm nitrogen leaching information is becoming quite important. A survey could be carried out to ascertain farmers' reactions to the information, and the usefulness of it relative to regional rules.

(iv) While some modelling research is currently underway for BERG, more work is required to identify and quantify options for on-farm GHG mitigation relative to impact on farm profitability.

(v) As part of (ii) above, there is a need for more farm system research to understand farm management requirements to ensure any (new) farm systems are profitable.

(i) If an extension programme was to be instigated, then a number of aspects would need to be investigated;

- The policy framework
- The institutional/delivery framework mechanisms
- The holistic nature of the extension programme
- Quantification of the extension capability issue.

1.12 Summary

The report indicates a wide range of factors that drive farmer behaviour, and behaviour change. For environmental issues such as GHG emissions, there are a number of factors which can act as barriers to behavioural change; e.g. relative advantage, compatibility with existing farming systems, complexity of the issue, and the observability of the results of behaviour change. Achieving behavioural change therefore is likely to require a multi-faceted approach, including; pricing biological emissions, provision of mitigation options, recognition of on-farm mitigations, and the provision of information and advice.

2.0 BACKGROUND

New Zealand signed a new post-2020 global climate change agreement in December 2015 at the twenty-first session of the Conference of the Parties to the United Nations Framework Convention on Climate Change, and later ratified this agreement on 5 October 2016. New Zealand is required, as part of the new Paris Agreement, to progressively set more ambitious emission reduction targets over time. The Nationally Determined Contribution, or target, for the 2021-2030 period is to reduce greenhouse gas (GHG) emissions to 30% below 2005 levels (equivalent to 11% below 1990 levels) by 2030. New Zealand's target applies to the whole of the economy, so all sectors will need to explore ways to reduce emissions, which creates significant challenges and opportunities for our primary industries.

As part of their assessments, BERG have commissioned this report, involving three aspects:

(i) A literature review of the relevant material focusing on farmer decision making and participation in regulatory, voluntary, audit, and/or market-driven behaviour change for an 'environmental' purpose. This must have a specific focus on literature investigating the drivers of behaviour change in New Zealand farmers with regard to the reduction of biological greenhouse gas emissions or environmental good practice generally. This may include investigations of New Zealand farmers' understanding of, or belief in, climate change, participation in programmes aiming to reduce other non-point source effects of pastoral agriculture or food production, or drivers, values and identities that impact farmers' willingness to adopt new technologies or actions that reduce biological emissions.

(ii) Production of an annotated bibliography. This will discuss the findings from pertinent bodies of work and their relevance to the core research questions. A diagram highlighting the connections between significant bodies of work, as well as the central articles and studies in these fields, must also be included.

(iii) Carry out an analysis of the potential social and behavioural barriers to on-farm change which reduce biological emissions. This will build upon the literature discussed as well as qualitative interviews with sector experts with experience working directly with farmers on behaviour change and extension uptake. This analysis will provide advice and recommendations on how to design policy options or tools to best influence farmer behaviour change to manage and reduce biological emissions. This will indicate the elasticity of certain behaviours, drivers, beliefs, or values, and highlight potential timeframes for farmer behaviour change. It will also highlight gaps where further research is required, suggest potential future research questions, and provide an outline of what methodologies for future qualitative interviews could be used to conduct interviews/surveys with/of farmers in New Zealand on matters relating to the mitigation of biological emissions.

The core questions from this are:

(iv) What are the social or behavioural barriers to maximising the mitigation potential of biological emissions using existing technologies and practices across a farm system?

(v) How can social or behavioural barriers to maximising the mitigation potential of biological emissions using existing technologies and practice across a farm system be addressed?

(vi) What policy, practices, tools, or strategies are best able to address potential social or behavioural barriers to maximising the mitigation potential of biological emissions using existing technologies and practice across a farm system?

3.0 METHODOLOGY

The methodology behind this report involved:

(i) A review of literature involving three aspects:

(a) A background on behaviour theory, leading into a discussion around adult learning, behavioural components that affect uptake of innovations, characteristics of adopters, characteristics of innovations that influence adoption, social factors, and reaching target groups;

(b) Farmer decision making and extension influencing and driving behaviour change to achieve environmental outcomes in a farm systems context, with a particular focus around achieving nutrient discharge limits; and

(c) Farmer decision making and extension driving behaviour change to achieve reductions in biological greenhouse gas reductions. This component also investigated NZ farmer understanding of/belief in climate change.

The search methodology for the literature review involved searching the following keywords and phrases: behaviour theory, behaviour change, behaviour classification, adult learning, knowledge transfer, technology transfer, extension, uptake, environment, climate change, greenhouse gases, water and biodiversity. These search terms were repeated in combination with the words agriculture, farm, farming, and farmers respectively. Searches were conducted using the Massey University Discovery (EBSCO) search tool and Google Scholar. The search discovered 100 references as used in this report.

(ii) Interviews (by AgFirst) with selected sector experts with expertise and experience across farmer behaviour, agricultural extension, and environmental issues. A total of 11 people were selected, across the dairy, sheep & beef, arable, and deer sectors.

(iii) An email survey carried out on a limited number of farmers to obtain an indication of their thoughts around on-farm GHG mitigations and thoughts on information and support required to make on-farm changes.

[Note: Due to time constraints, (i), (ii), and (iii) were carried out concurrently]

(iv) Feedback from the Biological Emissions Reference Group (BERG) members following development of the #1 draft report. Once these were incorporated, the #2 report then went to peer review to two experts; one from within the agricultural industry, and one more involved in policy development.

(v) A workshop held with BERG members to discuss the analysis and findings, before the report was finalised.

4.0 LITERATURE REVIEW

This literature review is structured into three components:

(i) A background on behavioural theories, leading into a discussion on adult learning, behavioural components that affect uptake of innovations, characteristics of adopters, characteristics of innovations that influence adoption, social factors, and reaching target groups;

(ii) Farmer decision making and extension influencing and driving behaviour change to achieve environmental outcomes in a farm systems context, with a particular focus around achieving nutrient discharge limits; and

(iii) Farmer decision making and extension driving behaviour change to achieve reductions in biological greenhouse gas reductions. This component would also investigate NZ farmer understanding of/belief in climate change.

5.0 BEHAVIOURAL THEORY AND LEARNING

Broadly speaking, human behaviour is the focus of all of the social sciences and, consequently, numerous theories and models have been proposed which seek to define and explain behaviour and/or behaviour change. A number of these are summarised below.

5.1 The Theory of Planned Behaviour & Theory of Reasoned Action

The theory of planned behaviour (TPB) is one of the most widely cited and applied behaviour theories. It is one of a closely inter-related family of theories which adopt a cognitive approach to explaining behaviour which centres on individuals' attitudes and beliefs. The TPB (Ajzen 1985, 1991); evolved from the theory of reasoned action (Fishbein and Ajzen 1975).

This proposed that human behaviour is guided by 3 kinds of considerations:

(i) Behavioural Beliefs; beliefs about the likely consequences of the behaviour

(ii) Normative Beliefs; beliefs about the normative expectations of others

(iii) Control Beliefs; beliefs about the presence of factors that may facilitate or impede performance of the behaviour

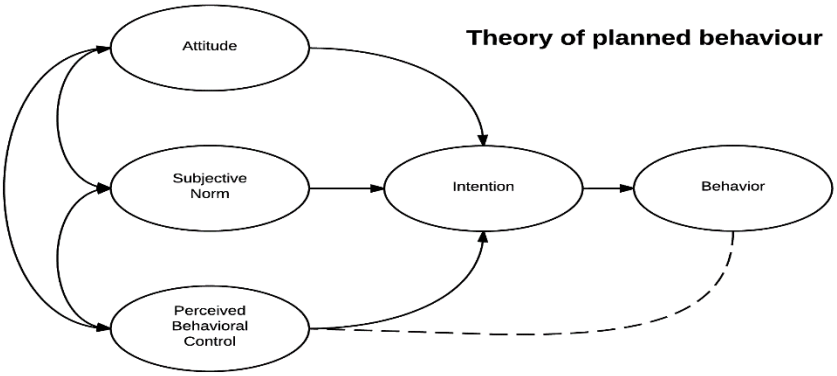


Figure 1: Theory of Planned Behaviour

5.2 Rational Choice Model

The rational choice model assumes people rationally seek to maximise their welfare. People assess the choices before them in terms of costs and benefits and then select the choice that maximises their net benefits. The traditional policy tools follow from this model—sanctions (fines and other penalties), price signals (taxes, financial incentives), regulations and the provision of information (Australian Public Service Commission, 2007).

The traditional policy tools follow from this model—sanctions (fines and other penalties), price signals (taxes, financial incentives), regulations and the provision of information, and are often successful.

The model of rational choice however, tends to ignore the wider environmental influences on human behaviour, such as the power of peer pressure and family expectations, and key motivators other than self-interest. It can also be difficult for individuals to accurately estimate future costs and benefits, particularly if there are relatively high levels of uncertainty around them.

5.3 Health Belief Model

The Health Belief Model (HBM) (Hochbaum, 1958; Rosenstock 1966; Becker, 1974; Sharma and Romas, 2012) is a cognitive model that attempts to explain and predict health behaviours, by focusing on the attitudes and beliefs of individuals to their well-being.

These beliefs are further supplemented by additional stimuli referred to as 'cues to action' which trigger actual adoption of behaviour. Perceived threat is at the core of the HBM as it is linked to a person's 'readiness' to take action. It consists of two sets of beliefs about an individual's perceived susceptibility or vulnerability to a particular threat and the seriousness of the expected consequences that may result from it.

Although designed and developed in the healthcare context, the HBM has been applied to the analysis of other types of behaviour, such as recycling (Lindsay and Strathman 1997), although its predictive capacity of behavioural variance is low, at 10% (Harrison et al 1992).

5.4 Stages of Change (Transtheoretical Model)

The Stages of Change (SoC) model (also referred to as the Transtheoretical Model) (Prochaska 1979; Prochaska and DiClemente 1983; Prochaska et al 1992) is a widely applied cognitive model which subdivides individuals between five categories that represent different milestones, or 'levels of motivational readiness', along a continuum of behaviour change. These stages are:

(i) Precontemplation (Not Ready) – "People are not intending to take action in the foreseeable future, and can be unaware that their behaviour is problematic"

(ii) Contemplation (Getting Ready) – "People are beginning to recognise that their behaviour is problematic, and start to look at the pros and cons of their continued actions"

(iii) Preparation (Ready) – "People are intending to take action in the immediate future, and may begin taking small steps toward behaviour change"

(iv) Action – "People have made specific overt modifications in modifying their problem behaviour or in acquiring new healthy behaviours"

(v) Maintenance – "People have been able to sustain action for at least six months and are working to prevent relapse"

(vi) Termination – "Individuals have zero temptation and they are sure they will not return to their old unhealthy habit as a way of coping

This model shares the problem of other cognitive models in that it is egoistic (centred on the self) and consequently misses the structural economic, environmental and social factors which affect an individual's ability to change behaviour.

SoC also focuses on individual problem behaviours, such as addictions. This has implications for its transferability to behaviours which bring public costs or benefits. The over-use of pesticides, for example, could be a problem behaviour in terms of water pollution but this is not necessarily a problem for the pesticide user directly.

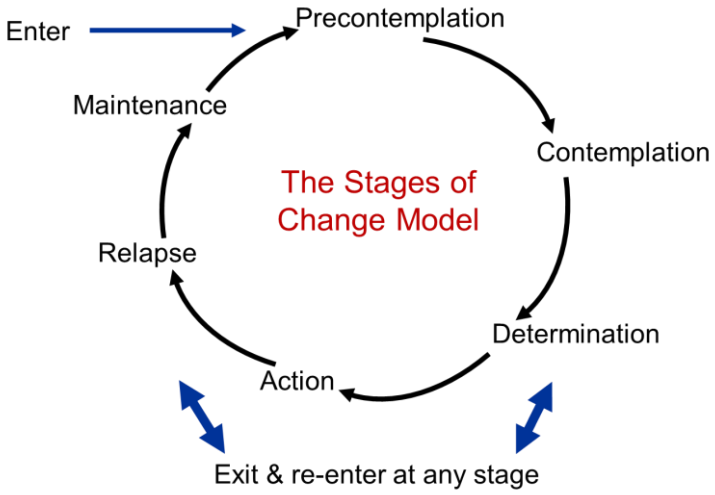


Figure 2: Stage of Change Model

5.5 Social Practice Theory

Social practice theory (SPT) is increasingly being applied to the analysis of human behaviour, particularly in the context of energy use and consumption. Rather than a single theory or 'model', SPT is something of an umbrella approach under which various aspects of theory are pursued. The central insight of SPT is the recognition that human 'practices' (ways of doing, 'routinised behaviour', habits) are themselves arrangements of various inter-connected 'elements', such as physical and mental activities, norms, meanings, technology use, knowledge, which form peoples' actions or 'behaviour' as part of their everyday lives (Reckwitz 2002).

From this a "three elements model" has been developed to explain this theory (Chatterton, 2011):

Materials: The physical objects that permit or facilitate certain activities to be performed in specific ways

Meanings: Images, interpretations or concepts associated with activities that determine how and when they might be performed

Procedures: Skills, know-how or competencies that permit, or lead to activities being undertaken in certain ways

5.6 Diffusion of Innovation Theory

Instead of focusing entirely on individual decision-makers or social structures, the Diffusion of Innovation theory places its emphasis on innovation as an agent of behaviour change, with innovation defined as *'an idea, practice, or object perceived as new'* (Rogers 2003: 12). Consequently, it is perceived attributes of an innovation that determine its rate of adoption to a greater extent than the characteristics of the adopters. Originally published in 1962, building particularly on rural sociology research into the uptake of agricultural technology in the US, the theory has subsequently been very widely applied to issues including marketing, development and health (Greenhalgh et al. 2004). It is also widely used as an element of extension within agriculture, and is discussed in more detail later in this report.

5.7 Discourse Theory

Discourse theory (analysis) is basically the analysis of "language in context." The words we utter (or write) simultaneously reflect and are shaped/determined by, the context within which we utter them and create (shape, determine) the context.

In general, discourse theory is concerned with human expressions, often in the form of language. It highlights how such expressions are linked to human knowledge. A shared argument is that the things people say or write draw from a pool of generally accepted knowledge in a society, while at the same time feeding back into society to shape or reinforce such knowledge. What a society therefore holds to be true changes over time, depending on the ideas that members of a society exchange, and on the way in which such exchange happens. Another common concern is how specific people, or groups of people, are able to shape these "flows of knowledge".

Certain persons may be in a particularly strong position to define what is true, while others may be excluded from the discussion. For instance, think about the different status that health advice might have when it comes from an experienced, male medical doctor compared to when it comes from your grandmother. Even though you may not know the doctor very well, your view of his social status, of his training, and of his gender all shape how you make sense of his advice. In other words, discourse theory is concerned with questions of power, and often with questions of institutional hierarchies. In discourse theory, such hierarchies lead to domination and resistance, for example when different people try to assert who should speak with authority on issues of health policy.

Besides focusing on the meaning of a given discourse, the distinguishing characteristic of this approach is its stress on power relationships, as expressed through language and behaviour, and the relationship between language and power. In a behavioural change concept, it is also about understanding a person's world view.

5.8 Rational Economic Model

This was proposed by Taylor (1911), who considered that workers were mainly motivated by money - the more money you offer the worker, the more motivated they will be to work. While Taylor was able to achieve increases in productivity by modifying and standardizing work methods, close supervision, and paying bonuses, these methods did not always work.
While money is a strong extrinsic motivating force, it has not been shown to be a good "motivator" of farm behaviour. Gasson (1973) found that farmers had a medium orientation to money, while Greer (1982) found that while farmers were motivated by money, it was more towards an adequate income rather than "maximizing" income. Straus (1964) found that "farm choice" boys preferred to farm even when they had the opportunity to earn considerably more in non-farm occupations.

5.9 Theory X and Theory Y

This theory was developed by McGregor (1960), who proposed a duel theory of motivational behaviour:

Theory X argued that:

- The average human has an inherent dislike of work and will avoid it if possible
- Because of this most people must be coerced, controlled, directed and threatened with punishment to put forth adequate effort to achieve organisational goals
- The average person prefers to be directed, wishes to avoid responsibility, has relatively little ambition, and wants security above all

McGregor reject this theory, and proposed a new theory:

Theory Y argues that:

- The expenditure of physical or mental effort in work is natural as play
- People will exercise self-direction and self-control in the service of the objectives to which they are committed
- Commitment to objectives is a function of the rewards associated with their achievement

Which of these theories is most applicable has been a matter of debate, and there appears to be agreement that a mix of both Theory X "sticks" and Theory Y "carrots" works best.

Schroder (1982) argued that it is difficult to apply McGregor's theory to farmers, in that most are owner/operators, have only themselves to please, and there is no organisational structure to provide either the "sticks' or the "carrots". [But that these can be provided by outside sources].

5.10 Social Capital Theory

Social capital theory relates to forces that influence behavioural change at the broader level of the community, and consists of the networks, norms, relationships, values and informal sanctions that shape the quantity and cooperative quality of a society's social interactions. The core insight is that social networks and cooperative social norms have value—the quality of

these networks can help explain variations in key policy outcomes between communities in areas such as crime, education and health. In general, higher levels of social capital result in communities, and individuals within them, that are better able to act and take responsibility for themselves (Australian Public Service Commission, 2007).

5.11 Knowledge Transfer Theory

Knowledge Transfer (KT) is a term used to encompass a very broad range of activities to support mutually beneficial collaborations between individuals, groups, and organisations.

It can also be defined as:

(i) The act of transferring knowledge from one individual to another by means of collaboration

(ii) Disseminating knowledge and providing inputs to problem solving

At a human behavioural level, KT often incorporates a number of the behavioural theories outlined above, particularly The Theory of Planned Behaviour, Stages of Change, Diffusion of Innovation Theory, and Discourse Theory. Further detail on Knowledge Transfer Theory is outlined in the discussion in the following sections.

The purpose of summarising these behaviour theories is to give an indication of the large number of them; an outline of some further theories (10) is shown in Appendix One. It is difficult to readily categorise farmer behaviour (discussed in the next section) relative to just one behavioural theory, as behaviours can reflect across several.

Traditionally, the Rational Choice model has underpinned a lot of government policy development, but within the theories discussed above, other important models would be: Social Practice Theory, Diffusion of Innovation Theory, Discourse Theory, Rational Economic Model, and Knowledge Transfer Theory. All of which overlap each other.

A lot of the behaviour change/extension approaches discussed in this report are largely based around Knowledge Transfer Theory, particularly given that it incorporates a lot of the theory espoused by the other behavioural theories, and because it also underpins much of the agricultural extension carried out around the world.

Definition of Extension

Within the report the term “extension” (and sometimes “technology transfer”) is used to describe the methodology to achieve behaviour change by farmers. The term “extension” is used in a very broad sense, to encompass the wide range of processes and actions undertaken in programmes to elicit farmer behavioural change, and within this it draws on all of the behavioural theories outlined.

The practice of extension with New Zealand farmers has traditionally been top-down, driven by the translation of science into practical information to farmers delivered by an expert – sometimes the scientists themselves, farm consultants, and industry professionals. In recent years, extension delivery has become much more complex and multi-faceted in nature, as outlined in the literature review. Extension is still often initiated or delivered by an ‘expert’, but farmers have an increasingly important role in driving the outcomes.

In a practical sense, extension can be viewed as one-to-one – where one person holds some knowledge and extends this to another (still the most effective approach), one-to-some – where information is presented in a smaller group with a lot of engagement from the group itself (e.g. land and environment plan workshops, dairy discussion groups), one-to-many – the more traditional larger-scale field day with an expert speaker (or many speakers) presenting to a large group of farmers. Extension can also be delivered through more passive mechanisms such as through rural media, websites, resources, etc. The more complex the ‘change’ needed, and the greater the impact on the farmer, the more of these approaches that are needed. Because farming is biological in nature, and there is such a wide-range of farm systems, farmer drivers/motivators, and capability within farm teams, a wide range of extension approaches are needed for most topics to achieve behaviour-change.

6.0 ADULT LEARNING

The adoption of technology and information has been extensively studied across the world for several decades and within many disciplines. The principles are driven by understanding adult learning and how this can best be applied for a given practice or process.

Learning refers to a change in behaviour that can be observed and managed, and involves the acquisition of knowledge, skills, and attitudes associated with job mastery (Davies, 1981).

Johnson (1979) indicated that there are two major approaches to the psychology of learning: cognitive and behavioural.

On the cognitive side learning is the acquisition, through insight, of cognitive structures. It is an internal process, not necessarily observable, in which information is integrated into the structure of what the person already knows and understands. Humans are life-long explorers of their environment; seeking, organising coding, storing, and retrieving information – building on their cognitive structures to continue learning. People are viewed as active and curious beings, innately social and co-operative, constantly seeking better adaptations to the environment by systemising perceptual and cognitive information into meaningful patterns.

From the behavioural viewpoint, learning is an observable change in behaviour shaped by things or events in the person's environment. People can be induced to learn through "teacher" control of rewards and stimuli. Whether it is a child or an adult, the learning process is assumed to be the same. Teaching consists of pinpointing the behaviour to be learned and reinforcing the person for engaging in that behaviour (Johnson, 1979).

Most modern educationalists lean heavily towards the cognitive viewpoint of learning, especially in its view of people as an active element in their own growth and development. Additionally, people are viewed as individualists who learn differently. Schroder (et al, 1967) noted that "*people process information in different ways under different situational conditions, and different people use different ways of processing information under the same conditions*".

Most adults in most learning projects are motivated by some immediate problem, task, or decision that demands certain knowledge or skill. In relatively few learning projects is a person interested in mastering an entire body of subject knowledge (Tough, 1971).

Tough (1982) noted that research had found that the learner themselves plans the vast majority of their learning projects. The next important "planner" is a group (or its leader), followed by one person in a one-to-one situation, a mixture of the above, and lastly a non-human source such as an instructional book.

In self-planned learning, almost every learner uses at least four or five human resources. In most projects the majority of these helpers are non-professional, friends, acquaintances, colleagues, members of their family, and neighbours. Professional help makes up only a small part of the resources used.

Groups can be an important way of learning, where the group itself, or a leader in the group, plans the learning efforts. Group learning can be very efficient, especially if others in the group

want the same knowledge or skill, or that knowledge and skill is contained within the group. A group can also provide positive emotional benefits in terms of enthusiasm, motivation and sense of achievement, plus a learner may feel better about their learning when they realise that others within the group are at the same learning stage.

However, an adult's efficiency in learning through a group is rarely as great as it would be if the instructor were used in a one-to-one situation, and Tough (1982) found that generally, groups are a minor resource in adult learning activities.

Often the most efficient way to learn is where an instructor interacts with the learner on a one-to-one basis (Tough, 1971). In a one-to-one situation, the learner benefits from having the person's expertise adapted to them as a unique individual and to their particular learning project. The learner can obtain immediate responses to their questions, difficulties, fears, doubts, and concerns. In this situation, the resource person can easily modify the procedure and/or content as appropriate. Tough (1982) found that individuals in a one-to-one situation contributed significantly more than groups in a learning experience (refer Table 1).

Table 1: Extent to which various resources contributed to choosing, planning, and implementing a change (%)

Resource	Choosing	Planning	Implementing
The person themselves	68	69	73
Non Professionals			
Individual one to one interaction	23	19	16
In a group	2	2	1
Professionals			
Individual one to one interaction	3	7	6
In a group	3	1	2
Books and other non-human resources	4	4	2

(from Tough 1982)

Salmon (1980) and Woog (1982) adapted Kelly's (1955, discussed in Journeaux 1985) Personal Construct Theory to adult education in agricultural extension. Kelly's theory suggested that people attempt to predict and control events by asking questions and anticipating answers about them. In this way a person develops a system of ideas or "constructs" which is their view of the world.

Both Salmon and Woog suggested that for continuous learning a farmer will "learn" only those elements given by an adviser which fits the farmer's construct system, and not necessarily all of the information provided. Salmon argued that advisers should encourage an environment that is conducive to, and encourages, personal experimentation by the farmer.

Woog (1982) suggested that the adviser needs to "*construe the farmer's construct system*", which means that the adviser needs to be able to "see" the mental picture the farmer has of themselves, their farm, family, etc. By gaining this commonality of understanding, the adviser will be able to appreciate the farmer's management ability, what their objectives are and where the farmer believes they are in relation to those objectives. With this sort of insight, the adviser is much better placed to help the farmer change his beliefs and attitudes.

Boxelaar *et al* (in Parminter, 2006) echoes a similar view: "*a more receiver orientated approach to communication now prevails in extension, which recognizes that the way the receiver interprets the information is informed by his/her understanding of the issues and his/her particular frame of reference. Consequently, people recognize that communication will only be effective if the sender has a comprehensive understanding of the context in which the receiver interprets the information".*

6.1 Adoption and Diffusion of Innovations

This section directly relates to the Diffusion of Innovation theory touched on in Section 5.6. Katz *et al* (1963) defined the diffusion of innovations as "the acceptance, over time, of some specific item, idea, or practice, by individuals, groups, or other adopting units, linked to specific channels of communication, to a social structure, and to a given system of values or culture". Bandura (2013) *in Manjala (2014),* notes that despite the number of times a person observes behaviour, they will only engage in the behaviour if they believe they can be successful (self-efficacy).

Pannell (2008) noted four conditions necessary for an individual farmer to adopt an innovative farming system: awareness of the innovation, feasibility of trialling the innovation, perception that it is worth trialling, and perception that the innovation promotes the farmer's objectives.

Adoption of innovations and management changes has been described as a bell-shaped curve, initially by Rogers (1962), revised by Rogers and Shoemaker (1971) and again by Rollins in 1993. The bell-shaped curve is widely used amongst extension and technology transfer practitioners to focus activity. Figure 3 shows the bell-shaped curve which describes a population.

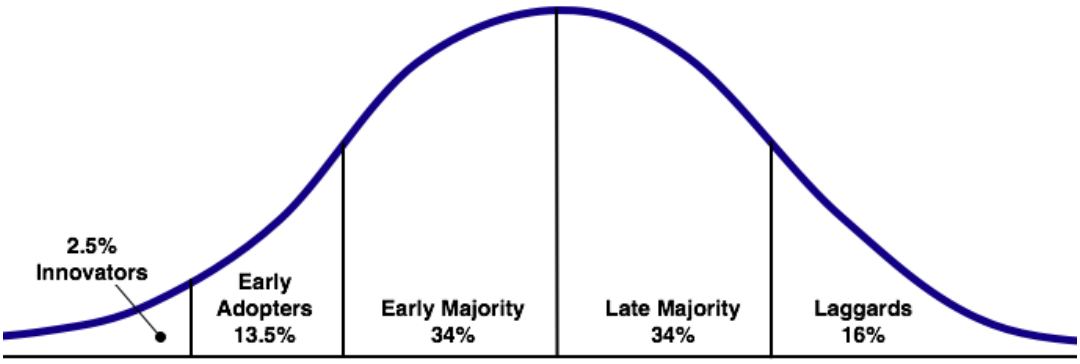


Figure 3: Adoption curve as described by Rogers and Shoemaker (1971)

The first 2.5% of the population are the innovators. Innovators are described as venturesome, eager to try new ideas, have more cosmopolitan social relationships, and often communicate with, and belong to, a group of innovators. They have reasonable financial resources, and strong technical understanding of the relevant component. Early adopters make up 13.5% of the population and are generally more localised than innovators, generally have the greatest degree of opinion leadership and often are looked to by other adopters for advice and information and are therefore key people in achieving positive behaviour change. The early majority are 34% of the population and adopt before the average time. They tend to deliberate for some time before adopting an idea and follow the early adopters willingly, but will seldom lead. The late majority also make up 34% and tend to be sceptical and cautious in

their approach. They do not adopt until most others in their social systems have done so, and social norms need to favour the innovation or practice before they are convinced. The final group are the 16% of laggards. These are traditionalists who have a propensity to be guided by the decisions of the past, are very suspicious and allow a long time to elapse before adopting an innovation or practice.

Using the bell-shaped curve to describe a population and the way people behave (toward adoption of innovations) suggests targeting innovators and early adopters for new practices and innovations, if a rapid uptake of the innovation is desired. It also suggests that any barriers to adoption they may face will be experienced throughout the population and will often be measurably harder to overcome due to the intrinsic characteristics of those further down the bell-shaped curve.

In noting this, a farmers' position on the adoption curve may well change depending on the innovation or type of change required. So a farmer may be a "laggard" for innovation X, but an "early adopter" for innovation Y, depending on the factors which influence the rate of adoption discussed in Section 6.1.1.

Exactly the same framework is used in a marketing approach (McManus and Powe, 2007), who note that any marketing effort should be targeted towards the innovators and early adopters, as these are the people most likely to be attracted to a new product. However, the Rogers model has faced criticisms (Blackstock *et al.* 2010), these include:

(i) That the approach is no longer appropriate for modern multi-functional agriculture;
(ii) That it does not reflect the empirical evidence of how farmers use information;
(iii) It takes no account of other influences upon the uptake of information and advice; and
(iv) It fails to explain or support collective behavioural change.

Note that no other authors appear to have supported these criticisms.

6.1.1 Factors Influencing the Rate of Adoption

There are a range of factors influencing the rate of adoption of innovations or changes to current practices (Rogers & Shoemaker, 1971; Giera *et al,* 2006; McManus & Powe, 2007). The first of these are the characteristics of the new practices:

(i) Relative advantage. This is the degree to which an innovation is perceived as being better than the idea it supersedes. This is often expressed in economic terms, although there are other measures such as saving in time or labour, or reduced risk.

Generally, the greater the relative advantage, the faster the rate of adoption. As part of this, generally the shorter the time it takes for the benefits of the innovation to become obvious, the quicker the uptake of the innovation.

(ii) Compatibility. This is the degree to which an innovation is perceived as consistent with the existing values, past experiences, and needs of the receiver. An idea that is not compatible with the main characteristics of a social system will not be adopted as rapidly as an idea that is compatible. Similarly, if an innovation meets the needs of an individual, it will tend to be more rapidly adopted.

Previous experience can also affect the rate of adoption. A farmer who has been successful with one innovation will approach future innovations more positively than a farmer who has suffered a failure.

(iii) Complexity. This is the degree to which an innovation is perceived as relatively difficult to understand and use. Generally, the more complex an innovation is, the slower the rate of adoption.

(iv) Trialability. This is the degree to which an innovation may be experimented with on a limited basis. If this is the case, adoption will be quicker.

(v) Observability. This is the degree to which the results of an innovation are visible to others. If the results are readily observed, the innovation will be more rapidly adopted.

These factors are reinforced by Giera *et al* (2006), who notes: "*The characteristics of the technology or practice that influence adoption rates are its relative advantage and its ability to be trialled. Relative advantage refers to the perceived net benefits of adoption.*

6.1.2 Segmentation of Farmer Groups

More recent work in Australia describes a framework for understanding farmer behaviour. The Derived Attitudinal Farmer Segments (DAFS) method was developed in conjunction with Dairy Australia who wanted to understand their client base better. The method was identified to better target technology development, extension and communication. The DAFS method has particular strengths in accounting for both individual and situational characteristics of farms and farmers (Waters et al., 2009). The method effectively divides farmers into groups depending on these individual and situational characteristics.

"Farmers are motivated by a diverse range of drivers and constrained (and enabled) by a range of social, cultural, economic and physical factors. Farmers will therefore react in different ways to external drivers of change and will respond differently to encouragement, incentives and legislation aimed at influencing their farming practice." (Thomson, 2008 in Waters *et al.*, 2009).

The attitudinal characteristics that differentiate the segments or groups in the Waters et al 2009 study include: the importance of providing for the next generation, the relative emphasis on self-reliance and knowledge, aversion to risk, level of sustainable improvement, business acumen, tradition and perceived financial pressure. They suggest that attributing a title to a segment can result in value-judgements being made. However, to enable targeted dialogue to begin it can be helpful to name the segments or groups identified in the study.

Waters et al. (2009) identified six groups of dairy farmers.

(i) The 'Family First' group were 5.5% of those in the study and as the name suggests, are driven by their families, are risk averse, lower than average business orientation and lower than average on sustainable improvement and adoption of new practices, they are also difficult to reach, being self-reliant for information.

(ii) The 'Winding Down' group make up 3.6% of the study, are not necessarily motivated towards sustaining or improving their business, are very risk-averse, difficult to motivate,

tend to have a lower level of formal education than average, below average production, very low adoption rates, and prefer others to try new things first.

These two groups could be compared to the laggards identified in the Rogers and Shoemaker (1971) study.

(iii) The 'Established and Stable' group (24.9%) are self-reliant, risk-averse, value tradition, not particularly concerned about intergenerational transfer, under financial pressure, relatively low levels of formal education, lower than average adoption of practice changes, tend to have an aversion to other farmers, consultants and discussion groups as information sources.

These farmers might be compared to the late majority in the Rogers and Shoemaker study.

(iv) In contrast, a total of 17% of the population were in the 'Love Farming' group; these farmers are positive about the future, motivated for the next generation, willing to improve the business, not under financial pressure to the same extent as the majority, are very responsive to research and development, have higher levels of education, tend not to use consultants and advisors, but do attend discussion groups, and prefer information to be very practical rather than academic.

They could be described as the early adopters in the Rogers and Shoemaker study.

The following two groups make up the remainder of the population, and all adopt new technologies and practices, just at different rates depending on their circumstances.

(v) The 'Open to Change' group make up 21.5% of the population. These farmers enjoy running their business, are motivated to develop sustainable and successful businesses, are prepared to take calculated risks, are not particularly bound by tradition and are less likely to be motivated by intergenerational transfer, they are not under financial pressure, are willing to take on new information, ideas and technologies and use consultants. They are generally younger than the average and have higher levels of formal education.

When compared to the Rogers and Shoemaker study this group could be described as a combination of the innovators and early adopters.

(vi) The final group are 'Growing for the Kids' at 27.4%. These farmers are running a sustainable business, keeping up the tradition and looking to the future of the farm. They are risk-aware and moderately financially constrained. They are willing to listen to information and motivated to adopt practices that improve profits, lifestyle and/or ensure intergenerational success. They are older than the average and are more likely to use consultants and advisors. They would be described as the early majority in the Rogers and Shoemaker study.

This study suggests there are a greater percentage of farmers who are more rapid at adopting new technologies and practices than the Rogers and Shoemaker 1971 study suggested. Perhaps this is indicative of a shift in the nature of the farming business in the past 40 years to

be more responsive to change. While this study was focused on Australian Dairy Farms, it is still relevant to New Zealand due to similar systems and cultures. The percentages in each segment may be slightly different for New Zealand, but the relative weighting is likely to be the same.

The Red Meat Profit Partnership (Primary Growth Partnership Project) in New Zealand has also recently completed a segmentation study of New Zealand sheep and beef farmers. The study was conducted by UMR Research (2014a). The study is based on a survey of 789 commercial scale sheep and beef farmers (i.e. farming with more than 700 stock units). Some relevant points from the study are outlined below.

- Three-quarters of farmers said they were willing to make changes to their farm with over half wanting to see strong evidence on other farms showing that the changes would work before they tried themselves. 23% were willing to take a risk. Over 60% also agreed they would like to try innovative ways of farming and keep up with the latest research.
- Despite this, over half of the farmers needed to see strong evidence of success of a particular practice or technology before making changes themselves.
- Informal channels are the most helpful when looking to try something different on-farm (80% of farmers identified other farmers and spouse as the most important). Veterinarians, independent scientists, independent expert advice and small discussion groups led by farmers and supported by independent experts were all identified as helpful (over 60%).
- Barriers to change included stage of life (farming for lifestyle usually due to age), financial constraints, and uncertainty of the outcome of a particular 'change'.
- Planning and measuring performance is important with just under half of farmers having written plans and budgets with annually reviewed goals. Over half of farmers are using financial management tools and performance benchmarking tools. Just under half are using computer planning tools, over a third using a smart phone and slightly less using a tablet.

As pointed out by Waters *et al. (*2009), caution should be given to the use of segments. Rather, the segments should be used to understand the different ways to engage farmers and target information.

These segments are quoted from UMR, (2014a).

(i) The 'Primary Pacesetters' (22%) are performance driven, strategic planners, are most interested in adopting new practices and making changes. They are strongly open to accessing professional and technical advice, have strong husband/wife teams. This segment is skewed towards younger farmers but there are also many older farmers who are pacesetters. These farmers learn from other farmers, spouse and/or other family, and small group sessions led by farmers and technical experts.

(ii) The 'Fast Followers' (23%) will take calculated risks but only on proven practices. They are one of the younger segments, have the energy to keep driving their operation and have a focus on performance. A significant difference between this segment and the Pacesetters

is that they are less comfortable with borrowing money to lift returns. They learn from other farmers, spouse and/or other family and veterinarians.

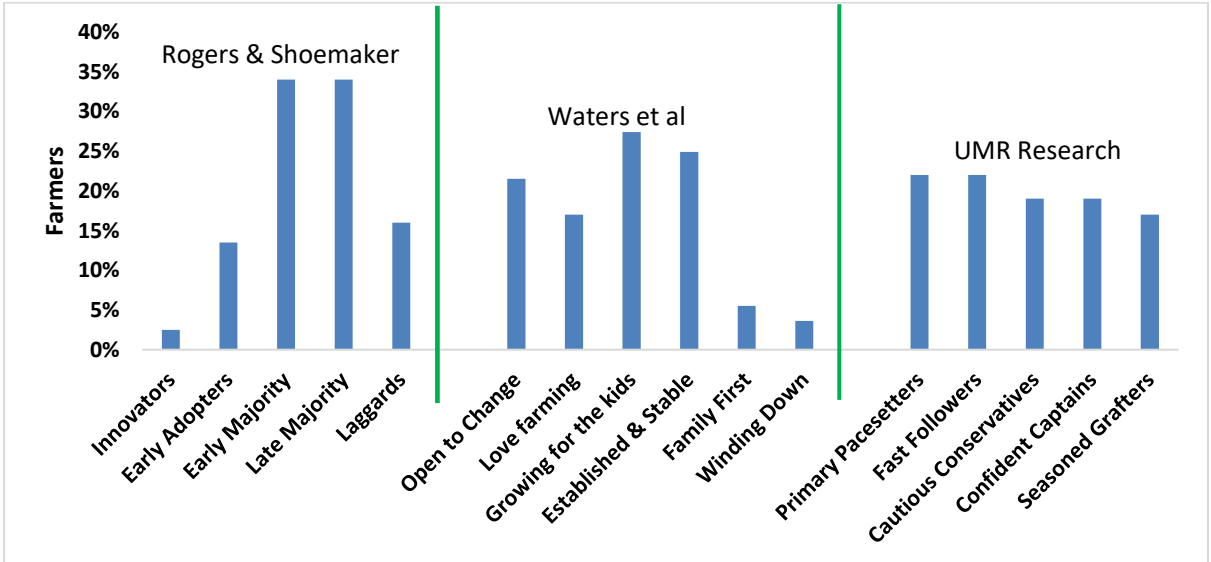
(iii) 'Cautious Conservatives' (19%) are more introverted, less inclined to be involved in industry activities and tend to be more risk adverse. They are less likely to be avid planners and more likely to keep doing what they did last year. They know how to farm to stay in business and would have kept their farms operating through tough times when others would have failed. They learn through other farmers, veterinarians, and independent advice from a technical expert.

(iv) The 'Confident Captains' (19%) are most interested in taking it easier, have a strong focus on lifestyle and have confidence to farm mostly on instinct (or gut feel). They will be solid family farmers that will be reasonably comfortable and will have little need or desire to push harder, unless an on-farm driver such as a son, daughter or motivated manager is prepared to take up the reins. They learn through other farmers, spouse and/or other family and veterinarians.

(v) Finally, the 'Seasoned Grafters' (17%) who are the oldest segment with close to half being over 60 years. They will have worked hard throughout their long farming career and now be quite resistant to change. To be fair, they will not have any need to change; they would have been successful in their own right, evidenced by their ability to survive long-term in a tough industry. They also learn through other farmers, spouse and/or other family and veterinarians.

These segments, are not identical to those identified by Waters *et al* (2009), but do have some similarities and follow a somewhat similar pattern in that the curve is much flatter (Figure 4). There is perhaps less comparison able to be made between this study and the original 'bell-shaped curve' work of Rogers and Shoemaker (1971). Consistently, farmers in the UMR study use farmers, spouse and/or other family members as one of their top three most helpful channels when making a change. Veterinarians also feature highly indicating they are an important target to share information with farmers (mainly, perhaps because virtually all farmers interact with veterinarians over the course of a year).

Figure 4: Different Categories of Adopters



While segmentation is useful as a means of identifying probable responses to extension relative to a group of farmers, one of the key issues is readily identifying which group particular farmers may sit in. This is also compounded by many farmers moving between "segment" depending on the technology/change involved, as well as depending on the stage of their farming career.

6.1.3 Social Aspects

The characteristics of an individual such as time availability, level of education, approach to risk, what advice and from whom they receive it and their personal and family circumstances have significant influence on behavioural change and adoption of innovations (Rogers & Shoemaker, 1971: Giera *et al,* 2006). The characteristics of the social system play a role incorporating its norms, beliefs, values, and communication patterns (Journeaux, 2009).

Often forgotten elements of adoption of new practices are the social factors that influence the rate of adoption. This has been described by Vanclay (2004), Ahnström (2008) and others, who suggest for most farmers, farming is not just a vocation, it is a way of life and there is a very strong connection to the land and the environment in which the land is situated. Changes to the farming system are generally carefully considered in the context of an individual farm – what is suitable for one farmer is not necessarily suitable for all farmers. Significant decisions are generally not made by an individual, and women have an integral role to play which is often overlooked by outsiders. There are usually very legitimate reasons for non-adoption of practices that may not be obvious to the average bystander as the reasons can be very farm- or family-specific. Vanclay (2004) observes, that:

> "Agriculture has too long been thought of as a technical issue involving the application of science and the transference of science outputs via a top-down process of technology transfer. It is not. Agriculture is farming, and farming is people."

With respect to social issues affecting farmers, Vanclay (2004) has developed 27 principles, with a number of the key relevant ones outlined below:

- Principle 1. Farming is a socio-cultural practice – farming is a way of life and a vocation. As a socio-cultural practice, it is governed, informed and regulated by social processes.

- Principle 2. Farmers are not all the same – the farming community is not homogenous; farmers and farms are rich and poor; big and small; old and young; ready to adopt new ideas or conservative and traditional. It would be more meaningful for extension agents to group farmers according to farming style rather than adopter/non-adopter, and address these different styles and priorities accordingly.

- Principle 3. Adoption is a socio-cultural process – extension is not just a process of communication between science as the only originator of ideas and farmers as passive adopters. Adoption is a social process – it is not an unthinking response to information provided by extension, but a deliberate decision by a farmer in response to a wide range of issues. Adoption also takes place in a social context with farmers discussing their ideas

with other farmers. Much adoption occurs when the idea or practice has become part of the normative concept of “good farm management”.

- Principle 7. Farmers don’t distinguish environmental issues from other farm management issues. Good farm management is a composite entity; it includes production issues, environmental issues, and social issues. While many extension approaches are differentiated into production issues or conservation issues, this is a meaningless differentiation for farmers. There is only one farm; farming practices have both production and environmental outcomes and extension advice must be integrated.

- Principle 9. Sustainability means staying on the farm. Often sustainability is regarded in a biophysical sense and sometimes in terms of economic issues. For farmers, the social significance of farming means that the social dimension of sustainability is central; sustainability is meaningless unless it involves the ability to stay on the farm.

- Principle 10. Women are an integral part of the farm. A farm is rarely the embodiment of a singular individual male farmer. Farms are often complex partnerships involving many people in financial affairs and in running the farm and farm household. In many cases women play a major role in farm management and even in situations where there is a strong division of labour, the role of women in the private sphere in the household has been essential to the survival of the farm.

- Principle 15. Farmers construct their own knowledge. It is a mistake to believe that only “science” (as a social institution) can create knowledge that is transferred to farmers via extension. Farmers often create their own knowledge through experimentation and trial, and through their own theorising. Farmers use the knowledge created by scientists when it is consistent with their own understanding and even then adapt it to fit their own world view.

- Principle 16. Effective extension requires more than the transfer of technology; it requires an understanding of the world view of farmers. Extension is not uni-directional, from science through to farmers who receive it passively. To be successful extension needs to be relevant to the needs of farmers rather than institutional priorities.

- Principle 17. Farmers have legitimate reasons for non-adoption. There are a range of reasons why farmers do not adopt new techniques, including:

    - Too complex – the more complex the innovation, the greater the resistance to adoption.
    - Not easily divisible into manageable parts. Divisibility allows for partial adoption of an innovation that is consistent with farming objectives. The more divisible into component parts an innovation is the more likely it is to be adopted.
    - Not compatible with farm or personal objectives. The greater the compatibility an innovation has with these objectives, the more likely it is to be adopted.

- Not flexible enough. Many new management practices reduce farmers' flexibility. Farmers' like flexibility as it gives the opportunity to adjust to changes in market or climatic conditions.
- Not profitable. Uncertainty on financial returns is a major reason for non-adoption. Many environmental innovations rarely provide direct economic benefit to individual farmers, but are of benefit to the wider community.
- Too much additional learning is required. This relates to the issue of "complexity" and the intellectual costs to the farmer.
- Risk and uncertainty is too great. While this often relates to commercial risk, it also refers to environmental innovations in that farmers need to be sure that the innovation will provide the environmental outcomes expected.
- There is conflicting information. Often with new ideas and innovations there is debate around its effectiveness and applicability. Which all adds to uncertainty and increases the likelihood of non-adoption.

- Principle 18. Top-down extension is inappropriate. This relates to five major criticisms of traditional top-down extension:
    - Extension has uncritically accepted the products of agro-industrial agri-science and agribusiness, and has seen as its task to simply promote these products.
    - The uncritical acceptance of these products and their adoption by farmers has led to considerable social and ecological impacts.
    - The adoption-diffusion model is premised on commercial innovation in which it is perceived that farmers would benefit. Thus it does not cater for environmental innovations, which may not be of benefit to individual farmers.
    - Farmer's local knowledge has often been marginalised, trivialised or ignored.
    - Extension utilised a psychological model of individual decision-making and ignored the social, political, cultural and historical context of agriculture and adoption behaviour.

- Principle 23. Put degradation into perspective. What is regarded as degradation by scientists and extension agents is not necessarily regarded as such by farmers. Often this discord is perceived by extension as the failure of farmers to develop sufficient "awareness" of the issue. But degradation is a value judgement made about what is an unacceptable rate of change, and often farming practices may alter the speed of naturally occurring changes, and hence the issue is more about the social understanding about the acceptability of the rate of change. (Vanclay also notes that often the greatest form of land degradation is the use of highly productive farmland for urban sprawl).

- Principle 24. The best method of extension is multiple methods. Often the question is raised as to the best method of extension. The answer is that there is no singular best method; multiple methods are required to deliver the message to the diverse range of farmers, and to reinforce the message in different ways.

- Principle 25. Group extension is not a panacea. Group extension is seen as a cost effective way to disseminate extension messages, especially with respect to resource management. But while it has many virtues, it is not a solution to every issue, and individual, one-to-one extension is needed to assist in on-farm issues. An important factor is the credibility of the extension agent, and group facilitators who never provide individual on-farm advice rarely develop credibility and their ideas are easily dismissed.

- Principle 27. Farmers need to feel valued. In terms of natural resource management, farmers are often asked to make a significant personal investment for what is largely a public benefit. Because of the notions of stewardship and the concept of good farm management, most farmers are prepared to make their contribution. But they need to know that this contribution is appreciated and valued by the wider community.

The means of communication are also central to the ability for a farmer to alter their behaviour. Mass media extension, such as printed media, web sites, general advertising, along with group extension, such as field days, monitor farms, are good at raising awareness of innovations, but the greatest level of adoption follows one to one interaction between a farmer and an advisor (Rogers and Shoemaker, 1971). The 'advisor' position is often not one person and can include farm consultants, bank managers, neighbours, friends, family, other farmers, sales reps, industry body representatives and more (Rogers and Shoemaker, 1971). In total, farmers are exposed to a wide range of communication types and levels in all aspects of their farming business, and communication is only effective at creating change if the sender has a comprehensive understanding of the context in which the receiver interprets the information. Thus, farmers are more likely to take advice from those who are closer to their business (i.e. family and friends), rather than someone more detached such as a Government official (Boxelaar et al., in Journeaux, 2009).

This and earlier sections indicate that farmers have a number of networks that influence their decisions and behaviour. In particular, farmers learn from other farmers; they value the experience of other farmers, and they can see for themselves what other farmers are doing and talk about the benefits, pitfalls and technical details (UMR, 2014a). Often, if a farmer is considering a change, they will preferentially talk to a farmer they know well and trust and/or who they know has tried the innovation or change in question. For more specialised advice, they will often seek the advice of recognised specialists (King and Nettle, 2013).

6.1.4 Process for making a change

In developing systems for the transfer of knowledge, consideration should be given to the process that generally occurs when a farmer is looking at a change, particular practice or piece of technology. This process is highlighted in Figure 3 below, adapted from Rollins (1993). Depending on the complexity of the challenge, level of support around it and desire for action, this process can happen quite quickly, or quite slowly. Farmers may drop into different parts of the continuum at different stages of the annual farming cycle and their farming career. It is also possible to skip stages. For example, a farmer may hear about a certain crop and instantly set-up a small-scale trial on-farm to test it, then review it before determining if they will then up-scale it.

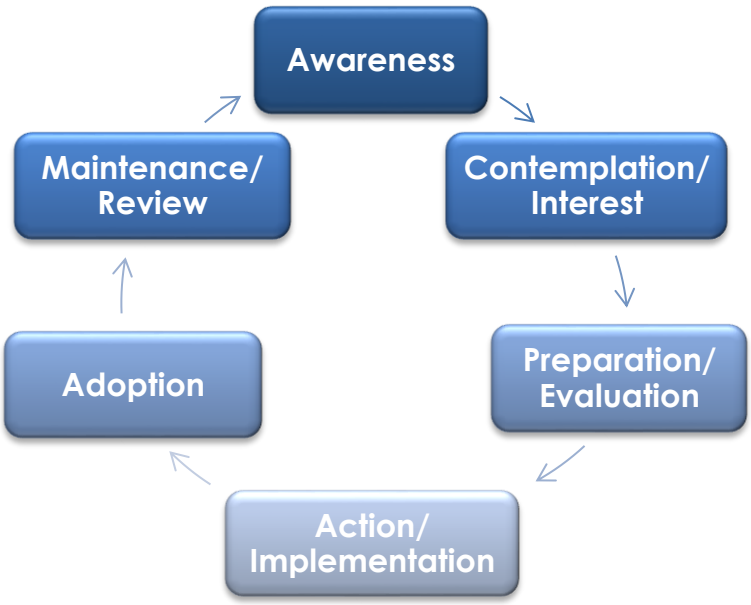


Figure 5: Extension continuum demonstrating steps needed to move from awareness to action (adapted from Rollins, 1993).

Awareness: The farmer is first exposed to an idea, new technology or management practice or need for change, but lacks information about the change and has not pursued the idea any further.

Contemplation/Interest: The farmer is seeking information, talking to others, doing some analysis (not necessarily written).

Preparation/Evaluation: A decision is made to change, or not.

Action/Implementation: Implements the change, may seek more information, may do a trial on-farm.

Adoption: The decision-maker commits to the new practice, technology, or change.

Maintenance/Review: Actively works on maintaining the change and avoiding reversion to former practices. Reviewing and refining the system, may investigate alternative ways of doing things to start the cycle again on a different aspect.

6.1.5 Human elements

Corner-Thomas *et al.* (2015) showed that age and education of farmers had an influence on their use of farm management tools known to improve farm performance. The authors found that fewer farmers with a high school education (and nothing further) used each farm management tool compared with those who had some form of higher education (certificate/diploma/degree/postgraduate degree). They suggested that this was likely to be due to the latter having greater exposure to these tools and their potential uses and advantages. Level of education was linked to age, with more young farmers having higher qualifications, thus the finding above also applied to age and may not be independent of each other.

Along similar lines, Brown & Bewsell (2010), concluded that identifying prior knowledge and learning preferences would be a valuable approach in developing extension delivery options. In their study, New Zealand farmers surveyed to determine their learning needs had a broad range based on their level of prior knowledge, experience, age and gender, suggesting a one-size fits all approach would be highly inadequate. Blackstock *et al.* (2010) supports this, stating the 'heterogeneity of farmers, the importance of acknowledging the social embeddedness of agricultural production, and the role of culture in mediating change' all need to be recognised.

UMR Research (2014b) also conducted a qualitative study focused on Māori farming, involving 10 in-depth interviews with Māori agribusiness leaders with connections to farms and strong knowledge in this area. The key differences identified between Pakeha owned farms, and Māori owned farms were the focus on the long-term (30 to 50+ year plans) and therefore, interest to invest in opportunities that give long-term sustainable returns, and the different management. As well as the governance structures, meaning decisions are often made at a board level, not necessarily at grass-roots level. Three different tiers of Māori farmers were identified:

- Tier 1: Larger Māori farming corporations. These larger operations have developed effective governance structures; they employ good staff; and have the scale to access specialists' advice for improving their on-farm productivity and profitability. Their size also gives them influence in the market and some are forging international relationships to help improve their profits. They make up a small proportion of the Māori red-meat farming sector.

- Tier 2: Estimated to make up a greater proportion of the Māori farming sector. There is thought to be a mixture of performance with some doing well and others struggling to break-even. The operations in this tier have significant potential for increasing productivity, although some are held back by poor governance structures, scalability and on-farm capability.

- Tier 3: Mainly smaller family-owned farms or, in some cases, farms owned by a multitude of people and are estimated to make up the largest proportion of Māori farmers. These farms are mainly either just breaking-even or making a loss – many of them only playing the role of providing employment for the family or being somewhere to holiday.

The study highlighted that the key barrier to overcome for Māori farmers to improve on-farm performance was getting good governance, and there is work underway to try and support this at an industry level. It also identified the chairman of the boards as a critical relationship manager and key point of influence as to how farms will be managed and run. Benchmarking and measurement data were seen as very important so that boards can see how the farm is performing. Consideration needs to be given to how this data is collected and by who to ensure it is robust and valued.

6.1.6 Farm Flexibility

In his study investigating the flexibility of farms, Kaine *et al.* (2010) described two ways that farms can manage critical inputs for the farm system (for example, water). One is by substituting other inputs for the critical input. The other is to change the output mix to reduce

the dependence on the critical input. The ability to do both of these things is limited by the long production cycles in agriculture, the need for capital investment reduces flexibility and there are technical constraints imposed by technology. Farmers utilise tactical flexibility to respond to a change in a critical input. The success or otherwise will depend on the capacity of a tactic to match the variability in an input, and the number of tactics available. Farmers will also use strategy to manage variation. Strategy is the group of objectives for the farm system and how these will be pursued in a given environment. The greater the capacity to alter the mix of outputs on-farm without changing the objectives for the system, the greater the strategic flexibility of the system. When farmers are unable to use tactics to sufficiently substitute for variable inputs then the mix of outputs they use needs to change to reduce the reliance on the inputs.

On the basis of the above, Kaine *et al* (2010) illustrate four classifications of farm flexibility.

(i) 'Rigid farm systems' are characterised by having low tactical flexibility and low strategic flexibility. These farms have limited tactics available and limited capacity to substitute inputs or change output mixes. Examples include specialist crop enterprises or pasture-based dairy systems.

(ii) 'Robust farm systems' have high tactical flexibility and low strategic flexibility. There are several tactics available to cope with variability, therefore, a greater ability to substitute inputs than the rigid type. However, they are limited by low strategic flexibility. A cut-and-carry dairy system is a good example.

(iii) 'Elastic farm systems' have high strategic flexibility but low tactical flexibility. This means they have an ability to alter output mix while maintaining the general farm system. They switch between strategies so tend to not be enterprise specific. Investment is constrained because of the variety of outputs so they have a low level of tactical flexibility. An example is a sheep and/or beef trading system.

(iv) 'Plastic farm systems' are high in tactical and strategic flexibility but due to the biological constraints in farming systems, it is difficult to find an example of this type of system in the primary sector.

Sheep and beef farms could generally be described as 'elastic farm systems'. What this means is that the ability to allocate resources efficiently is key to business success in these systems. Whereas dairy farms are more likely to be 'rigid' or 'robust' farm systems such that they can generally alter inputs easily, but the capital investment constrains their output mix.

> "The more efficient these systems are in choosing which output(s) to produce, given the combination of inputs that are available, the greater their profitability and the greater their capacity as businesses to adapt to variations in input supply." (Kaine *et al.,* 2010)

This highlights that information targeted to dairy farmers and specialist cropping farmers needs to be highly specific and targeted within their business. It should help them increase their strategic flexibility, but also meet their immediate tactical needs.

For sheep and beef farms, there is a broader range of information required to match the diversity of farming systems.

6.1.7 Agency Role

Keeble *et al*. (2012) undertook a case study of co-production to support sustainable irrigation objectives in Victoria, Australia. Co-production describes a functional relationship agencies have with their customer or client (typically the farmer) for interventions (where something is produced by working together). Their study found that farmers place significant value on having interpersonal relationships with agency staff. They suggested that agencies have a 'culture' that supports farmer and community engagement and with the following characteristics (quoted from Keeble *et al.* (2012) are more likely to encourage co-production:

(i) They work together to support this culture across agencies.

(ii) They involve farmer representatives early on and are honest about their level of influence.

(iii) They provide farmer access to frontline staff for local intelligence.

(iv) They establish high-functioning relationships between agency staff.

(v) Frontline staff have flexibility.

(vi) Complementary tools (e.g. planning and incentives) are used to link natural resource objectives (in their case, the Sustainable Irrigation Programme) with productivity outcomes on-farm and over time.

Additionally, they reported that the following is encouraged to avoid a breach of the relationship expectations of farmers:

(i) Clear and consistent farmer influence over the intervention design and implementation.

(ii) Maintenance of frontline staff to maintain interrelationships with farmers.

(iii) If influence is to be reduced by centralisation, or frontline staff numbers reduced, the impact on relational expectations must be considered and managed to avoid breach of the psychological contract.

(iv) Respect farmers' values.

(v) Respect farmers' contributions to co-production: do not politicise committees.

While this work was focused on a specific practice (irrigation) in Australia, it provides a useful comparison to extension principles applied in New Zealand where the private sector, or industry good agencies, and to a certain extent, Regional Government act as the 'frontline' staff, and Central Government, and the head-office of industry good agencies can provide investment and impetus.

Paine (1997, in Parminter, 2006) argues that practice change on farms occurs as a result of farmers working and interacting with different actors, such as service providers, veterinarians or scientists. These different actors work together to make sense of issues and constantly redefine such issues and how they can be implemented on-farm. Marsh *et al*. (2000) showed that concerted extension efforts from the public or private sectors improved adoption start times for a specific practice they researched (the planting of Lupins in Australia).

Eponou (1993) states that several authors have suggested the failure of technology transfer is "as a result of farmer conservatism, inappropriate agricultural policies and weak public institutions". However, he also states that "farmers have proven to be progressive when conditions are right and policy changes are only part of the solution". Eponou (1993) identifies the system perspective as important in the delivery of extension where all research and technology organisations servicing a given set of farmers are part of a single agricultural technology system. Additionally, all of the actors share and adhere to an agreed-upon strategy, which allows them to work towards a shared goal or mission. The six key elements identified were:

(i) Shared strategic goals

(ii) Synergy as the mode of functioning

(iii) Strong leadership for the whole

(iv) Decision-making by consensus

(v) Accountability to clients and policy-makers

(vi) Farmers as partners

Eponou (1993) concluded that to achieve a systems perspective with regards to extension, there are two critical factors. The first is that a single goal must be established for all organisations involved in the system. The second, is that component organisations need to be made accountable, individually and as a group to farmers and policy-makers. The *adoption* of relevant technologies by farmers should be a key deliverable of the system.

Blackstock *et al.* (2010) also stress the importance of trust, and found that 'in general, the higher the source credibility the higher the persuasion factor will be.' They also found that along with trustworthiness, expertise is also important for credibility. They also suggest the use of people from farming backgrounds or trusted networks is likely to enhance message uptake.

6.1.8 Conclusion

The research described above can be summarised by saying that farmers' behaviour, motivations, attitude to change and likely adoption of practices is highly complex with many variables. The identification of different "groups" of farmers through the social science studies provides useful context to those working with these farmers to try and change behaviour or achieve adoption of new technology or systems.

The literature shows when examining how to drive behaviour change on-farm consideration must be given to a number of factors, e.g.:

- That farming is a way of life not just a vocation.

- That innovators and early adopters are more likely to change behaviours first (noting that not all farmers in these categories are so on all issues).
- The perceived net benefit of a new technology/practice change influences rate of adoption, with “net benefit” being much wider than just economic.
- Engagement needs to be customised according to meet the needs of different groups of farmers.
- Social and environmental factors have significant influence on decisions.
- Any regulatory approach needs to be simple and provide certainty.

7.0 FARMER DECISION MAKING REGARDING ENVIRONMENTAL OUTCOMES

7.1 Historical context

To understand current land use and on-farm behaviour, it is important to understand some of the recent New Zealand history with regard to land development. Of particular relevance to this research are the Livestock Incentive Scheme 1976, and the Land Development Encouragement Loans. These schemes are relevant to current farming practices because many of the sheep and beef farmers today, also farmed under these regimes, and were therefore influenced by them.

During the 1960's, as an offset to domestic industry protection, Government became increasingly concerned with sheltering the traditional pastoral industries from the reality of the overseas market place. Instead of allowing the market to drive behaviour, a suite of assistance measures and subsidies were put in place (Rayner, 1990). In 1976 the government introduced the Livestock Incentive Scheme (LIS). It was administered by the Rural Bank and offered a combination of low interest loans, and/or reductions of loan principal and tax rebates if certain livestock expansion targets were met (Tyler & Lattimore, 1990). In 1978 the Land Development Encouragement Loan (LDEL) Scheme was introduced. This scheme was also funded through the Rural Bank and included interest free loans and reductions in principal for farmers if certain land development targets were met. The aim was to increase production, particularly on marginal land (Tyler & Lattimore, 1990).

The schemes were colloquially known as the skinny sheep schemes, and there was a sharp increase in sheep numbers recorded following the introduction of the Livestock Incentive Scheme (Reynolds & SriRmaratnam, 1990). Numbers peaked at 70.3 million in 1982 (Statistics New Zealand, 2011). The numbers have been falling ever since, although production per animal has improved substantially. Total sheep numbers have fallen 51% (from 58 million to 28.3 million) since 1990 with total lamb meat exported only dropping 6% (Beef + Lamb New Zealand, 2016).

The change in land use was also dramatic with the introduction of the schemes causing a similar impact on vegetation clearance as the wool boom during the Korean War in the 1950's (Taylor *et al.* 1997).

> "Agricultural pressures on the land are driven largely by economics and have fluctuated with export prices and past government subsidies. High market prices caused farmers to convert forest to pasture during the 1950's Wool Boom, and government subsidies for pastoral farming had the same effect in the 1970's and early 1980's. Since the incentives ended in the mid-1980's, sheep numbers have declined and several thousand hectares of pasture has been converted to exotic pine forests. An even larger area of marginal pasture on steep erodible slopes has been left to regenerate in scrub and native forest." – State of the Environment Report, 1997

The removal of subsidies in 1985 was one of the defining characteristics of the current farming generation who went from being incentivised to have excessively high stock numbers and a 'slash and burn' mentality to maximise production output on-farm, to a whole new-look

industry where productivity gains were required to meet growing on-farm costs. This highlights the level of influence Government policy has on farmer behaviour and helps explain some of the behaviour seen in farmers today. It is also important to understand this context when developing new policies that are likely to result in land-use change.

A further piece of valuable context relates to cultural differences with landowners. While there is a huge range of cultures within New Zealand land owners, broadly speaking, landowners who own land as individuals or companies with a small number of shareholders are more focused on short-term outcomes, whereas Māori landowners, who often value benefits to future generations are influenced differently by policies which encourage de-intensification of land use (e.g. conversion to forestry or native bush). Māori landowners often face barriers to accessing capital as their land is rarely sold.

7.2 Sustainable Land Management – a multi-faceted issue

A major challenge of the 21st century will be meeting the food needs of an increasing world population, as well as ensuring agriculture implements the principles of sustainable development (Crowder, 1996). Based on FAO projections for food demand and supply, it is clear that much greater investment is required in:

- Research to generate productivity-enhancing technologies without adverse environmental consequences; and
- Extension so that there is widespread dissemination and efficient use of these technologies (Crowder, 1996).

Crowder (1996) notes "*promoting sustainable agricultural development requires that extension agencies shift emphasis from the maximisation of short-term production outputs, which may be attractive in economic terms, to promotion of technologies and practices that are productivity-enhancing without negative environmental consequences. The ultimate purpose should be promotion of environmental concerns as inseparable from the production goals of farmers*".

An OECD report (OECD, 2015) suggests agricultural advisory services, training and extension initiatives play an important role in supporting farmers with green growth strategies in agriculture. The report identified two main roles for providers:

(i) To incentivise farmers by making them aware of the possible benefits of different measures, while retaining or improving the economic performance of the farm (economic role); and

(ii) To encourage and facilitate the adoption of appropriate agri-environmental land management practices and therefore maximise environmental benefits (environmental role).

In 1989 the Australian Government launched its "Decade of Landcare", involving a major programme of work across Australia, with the goal of "*individuals, community organisations and government should work towards sustainable land use by understanding the nature of the*

problem involved; acquiring the necessary information skills and resources to solve such problems; and developing and applying practical solutions on the ground" (DAFF, 1997). By 1994 2,200 Landcare groups had been formed, compared to the goal of 2,000.

An evaluation of this programme carried out in 1997 (DAFF 1997) noted that:

- Awareness of environmental issues had increased significantly;
- Landcare members had a significantly higher level of adoption of best management practices than non-members;
- Research affirmed the desirability of changes in awareness and attitude as prerequisites for change. However, economic factors and technical feasibility are central considerations in the adoption of sustainable land management practices;
- Perceptions among farmers were that profitability and sustainability are different concepts; and
- Land degradation is primarily a social, rather than technical problem. While solutions to land degradation exist, often land managers, for a wide variety of social, economic, cultural, perceptual and situational reasons, do not adopt them.

The report also noted that "*it is essential that land managers have access to cost effective approaches to monitoring the on and off-site effects of implementing sustainable land-management practices over time*", and "*for the future, there is a need for greater focus on economic instruments to encourage sustainable natural resource management, and the development of stronger links on the ground between key agencies*".

It should also be noted that the evaluation recommended that the goals of the programme be revised and that specific performance indicators and milestones be established. Curtis and De Lacy (1998) were relatively critical of the "Decade of Landcare", noting that a survey of landowners failed to establish stewardship differences between Landcare and non-Landcare members, and that there was no relationship between stewardship and adoption for most of the sustainable agricultural practices surveyed.

The importance of attitude and awareness has been endorsed by Battershill & Gilg (1996) who suggest that attitude has more of an influence on farmers' behaviour with respect to the environment than structural aspects such as financial constraints. Further, Durpoix (2010), found that farmers' behaviour towards native fragments of bush on their property could be predicted by their attitudes towards the natural environment, with attitude explaining almost 20% of the behaviour. Pro-environmental attitudes of farmers in this study were primarily explained by direct experience with nature, family influence and knowledge, endorsing the hypothesis that direct contact with nature could induce positive attitudes and behaviours towards the natural environment. Durpoix (2010) in-line with Ahnström *et al* (2008) also suggests that agencies should target farmer attitudes and not just behaviour, as the provision of funding alone has minimal short-term impact on their actions if their attitudes towards conservation are negative. This supports the view demonstrated by farmers in van Reenen's 2012 study, that non-regulatory measures are needed in conjunction with regulations.

In contrast, Cary & Wilkinson (1997) suggests that to achieve pro-environmental behaviour, there needs to be some economic or other benefits associated with the behaviour, and a pro-environmental attitude will not necessarily result in a pro-environmental behaviour. Similar to Durpoix (2010), the Cary & Wilkinson study looked at farmers' planting trees on-farm in Australia. They concluded that immediate financial gain is not realised with many environmental practices and technologies, rather, the gains accrue in the future. If their observed perceptions around the requirement for profitability being a key influence of farmer behaviour is the case, then this has significant implications for the content and approach used by extension practitioners. van Reenen (2012) also found that farmers needed to understand the value of their investment into environmental practices. But also, that their perceived value of their investment improved over-time with farmers talking about the 'reward' of seeing their trees growing, birdlife prevalent, etc.

One of the major issues with the promotion of sustainable land management is the multi-faceted nature of it, and the problem in evaluating the outcomes, especially given the difficulty in determining suitable indicators, and the long, time lags involved.

An indication of the multi-faceted nature of sustainable land management is shown via the desired long term targets promulgated by the Ministry for the Environment (MfE, 2015):

Water

- Freshwater ecosystems are healthy and resilient to pressures
- New Zealand gets best value from freshwater resources; and
- Harmful health impacts from people's contact with fresh water are eliminated;

Land

- Soils and terrestrial ecosystems are healthy and resilient to pressures;
- New Zealand gets best value from land-based resources; and
- Risks from contaminated land, hazardous substances and new organisms are known and managed, proportional to risk

Within these long-term targets there is a multiplicity of intermediate objectives and targets, and given this level of complexity, any extension programme around these objectives/targets would require a significant time-span.

Nimmo-Bell (1999) in their evaluation of the Focus Farm and Orchard Programme in New Zealand also noted the difficulty in setting specific environmental indicators to measure outcomes by, and the need for programmes to operate long enough to ensure measurable outcomes. They also note the need for extended funding of environmental extension programmes; "*experience to date suggests that it takes up to three years to establish a functioning group (talking with respect to monitor farms/sustainable land management groups) and a further three years to achieve tangible environmental outcomes. Thereafter environmental outcomes become apparent over the next 20-30 years, and funding is required over this latter period to monitor the changes and feed this information back into the process*".

A recent study by the OECD (2015) also highlights the challenge in assessing the outcomes from extension, training and advisory services. It suggests challenges are derived from problems such as multiple goals, attribution, lagged effects, spill-over effects, data problems, sample attrition, and difficulties establishing baselines. It also recognised the complexity and often contradictory nature of farming, farmers and their relationship with advisory services. On top of that, it identifies the difficulty of assessing the impact of extension due to the highly contingent nature of farmers' decision-making process.

Nimmo-Bell (1999) also note "*that until farmers are in a secure financial position, they are unlikely to make significant provision for environmental concerns*", and "*that sustainable land management (SLM) initiatives will be limited in their effectiveness unless a clear link between environmental and economic benefits can be made. A stronger focus by SLM groups on the links between environmental and economic sustainability is likely to result in a much greater uptake of environmental improvement measures among land-users*". van Reenen (2012) also supports this finding.

Nevertheless, farmers have made progress on sustainable land management issues. A study by Rhodes *et al* (2000) provides evidence of a substantial commitment by North Island hill farmers to sustainable land management, including the planting of shelterbelts, erosion control measures, establishment of conservation reserves, and a concern for the aesthetic quality of the land. They also found no evidence that sustainable land management was linked to farm size or profitability. Farmer's commitment to sustainability and environmental management was explained in terms of an array of personal and community values which often over-rode financial conditions. They note a number of factors inherent in the information discussed in this literature review:

- The availability of reliable sources of research information sensitively and effectively presented is also fundamental to the shifts in favour of sustainability;
- Progress in favour of sustainability is particularly evident where there is visible evidence of a problem; and
- Farmers felt overwhelmed with the amount of information they receive to help their management – the fundamental information need identified was the form in which the information is provided and its reliability, rather than more information *per se*.

This is supported by Clay (2004) who states that "There is no single 'right' way to practice agriculture. Many farmers have found ways to reduce environmental damage, improve production and increase profitability. How the farmers do this depends tremendously on where they live, what they produce, and where they sell the product.

Rhodes *et al.* (2000) also noted that farmers almost unanimously identified the greatest threat to sustainable agriculture as the overall vulnerability faced by small town rural New Zealand – the need for good roads, communications, health care and schooling, and availability of services for farmers.

In exploring the barriers to uptake of environmental practices on sheep and beef farms in Waikato, Bay of Plenty and King Country, van Reenen (2012) found that farmers were

motivated to invest in environmental practices primarily through the need to protect their capital investment and improve the management of the farm, the environmental outcomes were a side-benefit. Other factors included animal health and welfare, enhancing the value of the property, regulations, the ability to intensify better areas and retire more challenging land, a desire to improve the farm and have pride in it, security of water supply, economics, and wanting to add to the knowledge base for other farmers, the wider community and the next generation. This highlights the fact that extension efforts can target a wide range of motivations and drivers to affect the heart of farmers and create an environment for change or improvement.

Rodriguez *et al.* (2009) identified barriers of economic factors, inadequate management of information, lack of on-farm trials and demonstrations, lack of institutional support, change agent beliefs, influence of the private sector, resistance to change, compatibility with existing practice, complexity, perceived efficiency of the practice, access to finance, land tenure, and personal characteristics such as age and apathy. While this study was completed in the USA, with the exception of 'influence of the private sector', all of these factors were also self-identified by farmers in van Reenen's study when asked what the barriers were to them and to other farmers.

van Reenen (2012) concluded that the industry needs to help farmers increase the uptake of environmental practices by promoting the benefits, including the economic benefits, and providing practical solutions. Evidence-based policy needs to be written in a manner that allows this to occur, targeting the high risk areas first, and progressively covering more over time.

Smith *et al*. (2008) found a degree of paradox in their study of Waikato dairy farmers and their attitude to environmental/GHG mitigations. The study found that;

- The farmers felt responsible for the environment and considered themselves good environmental stewards, but were unwilling to accept that their practices have environmental implications.
- The farmers were sceptical as to the importance of climate change and of their capacity as land users to influence such change, but acknowledged the importance of the management changes they had made to lessen the impact of future droughts.
- They valued the environment more highly for its own value, both aesthetically and as a moral "good", than as a utilitarian concept. However, they explained their decision making solely on the basis of its utilitarian worth.
- They viewed themselves as rational problem-solvers. However, this rationality was narrowly defined in economic terms. They remained unwilling to accept or be influenced by other "expertise" whether in the form of scientific data or regional/national policies.

These paradoxes highlighted the fact that a hierarchical model of environmental concern links values, attitudes and behaviours, these linkages are rarely straightforward. It suggests that while farmers' values and attitudes and behaviours are aligned in response to site-specific, visible and immediate, environmental problems, this is not the case when they are confronted with the long-term impacts of climate change. Smith *et al.* (2008) concluded that "*it is only through greater attention to social and cultural structures, institutional arrangements and*

policy and economic incentives that the necessary value shift and behavioural changes to support the development of a more sustainable agriculture will occur"

7.3 Government role in environmental extension

In 2002 the Ministry of Agriculture and Forestry (now Ministry for Primary Industries) commissioned a report (Allen *et al.*, 2002) on a possible role for government in sustainable development extension.

The report found that:

- Based on Coase (1937) there is a sound rationale for such intervention, which would seek to persuade farmers to act in an environmentally sustainable way by using their own resources, rather than giving farmers direct assistance. Government would provide indirect assistance via providing information and technology transfer, rather than provide direct assistance (e.g. subsidies for planting trees or fencing streams);
- The indirect assistance (i.e. extension) would be specifically required to target environmental off-farm benefits so that benefits are captured by the community, either regionally or nationally. Plus, these benefits would have to be measured using an economic approach and set alongside the costs;
- Policymakers need to take into account the special characteristics of farming that separate it from other activities in the economy, particularly the scale of farming activities, and the externalities associated with scale;
- Policy devised must take into account how the overriding financial and economic farming imperatives interacts with farmer willingness to continue making improvements to the land that are consistent with government environmental policy objectives;
- Policy needs to be flexible to take into account different environmental problems in different regions, and may be delivered differently in different regions depending on the environmental issues, the social and cultural make-up of the region and past history of interventions; and
- Co-ordination between central government and regional/local government is an important ingredient for success of any environmental extension process.

The report also considered the implementation of such a programme, noting; "*that information is key to learning and subsequent behaviour change, but learning will only happen if it is supported by a number of social processes. These include shared understanding, bounded conflict, and a supportive environment. This implies a need to ensure that the different interest groups have adequate capacity to participate in such processes. Therefore, the public good aspect of sustainable development refers to both task (getting sustainable development on-the-ground) and process (creating the conditions for sustainable development) outcomes*". The report suggested there are two key elements which must be improved to achieve this:

(i) Ensuring the development of information and information systems that are responsive to the needs of end-users; and

(ii) Creating a favourable social environment for the use of information to underpin constructive change.

In particular, the report (Allen *et al.,* 2002) noted that the constraints to achieving a more integrated approach to sustainable development extension are:

- Information and knowledge is fragmented; and
- There is a lack of capacity to institute collaborative and learning-based approaches on a scale beyond that of individual groups.

It also noted "*the single most influential piece of legislation affecting the management of rural* land *in New Zealand, the RMA emerged (in 1991) in a climate of changing public perceptions and international trends favouring the concept of "sustainability*", and that "*public attention has turned toward evaluating land-use management not just in terms of production and economics, but also in terms of ecological health*".

Libecap (2014) notes: *Protection of biodiversity, unique habitats, endangered plant and animal species, and reduction in harmful CFC or GHG emissions generate broad global public goods that, by definition, are not excludable.* And; (GHG) *Emission reductions by particular producers and consumers are, therefore, a global public good.*

Journeaux (2009) explored the development of an institutional model for the extension and adoption of environmental best management practices by pastoral farmers in New Zealand. Journeaux concluded that extension is critical to ensure the adoption of research findings and innovation with a range of studies showing high rates of return from individual extension programmes. Journeaux identified many environmental practices are complex, and therefore require a more sophisticated approach than mass-media, and that a one to one approach is more likely to be successful, acknowledging that this is resource-intensive. Other relevant conclusions drawn by Journeaux include:

- Environmental management needs to be seen as an integral part of the overall farm management system which means a significant amount of context is required in the delivery of information to ensure it is relevant to individual farm management systems.
- Incorporating the social factors into environmental extension programmes will be vital to ensure a high rate of adoption, as as adoption is very much a social process. This very much relates to understanding social pressures and norms relating to environmental issues, and incorporating farmer input into the extension design and delivery.
- There is a strong public-good justification for government being involved in environmental extension and in providing leadership and coordination between commercial entities, industry good bodies and regional government.

That environmental management needs to be seen as an integral part of the overall farm management system and the incorporation of social factors into the extension programme was supported by van Reenen (2012). Additionally, van Reenen found that most farmers in her study preferred a voluntary approach to achieving environmental practices on-farm, but they accepted that this would be insufficient to get change from the majority of farmers. van

Reenen recommended that regional authorities are a very useful resource for farmers as they have a broad range of knowledge and the capability to support farmers. Information on enhancing environmental practices on-farm should be constructive, fact-based, and relevant; it also needs to be presented in many different ways to reflect the complexity of farm systems, and variation in learning styles of farmers. Like Journeaux (2009), van Reenen suggests that environmental practices need to be integrated to become part of 'business as usual' on-farm and presented as such. These findings are also supported by Blackstock *et al.* (2010).

A comprehensive UK study by Blackstock *et al.* (2010) explored how to influence behaviour change of farmers to improve water quality. They suggest that to deliver voluntary mechanisms requires an understanding of existing behaviours and how advice can influence this. They also explored what is required to influence group behaviour, important for managing water due to catchment-scale approaches and impacts, and could also apply to climate change.

Similarly, the OECD Report (2015) outlines recommendations for consideration by policy developers:

- Advisory services, training and extension measures should be targeted and have clear objectives regarding their role within the policy objectives.
- The key ingredients for persuading farmers and enabling farmers to adopt green-growth practices are credible, relevant and up-to-date business-acumen advice, training and extension.
- Both public and private funding of initiatives have a role to play and will reflect government policies and resources, the nature of the issues, the type of provider, and the purpose of the measure.
- Agencies that deliver advice, training and extension services to support agri-environmental management will need to be well co-ordinated, effective in reaching different groups of farms and types of farming, and capable of delivering a full range of services.
- There are no general one-size-fits-all evaluation methodologies and approaches. Evaluation of impacts should take into account all factors involved in their provision.

Pannell (2008) explored policy mechanisms to influence change with regards to enhancing the environment or natural resource outcomes. The author suggests that the level of public and private benefit from a proposed land management practice should be considered. Pannell proposes a range of approaches depending on this consideration including the use of:

- Positive incentives where public net benefits are highly positive and private net benefits are close to zero;
- Negative incentives, where public net benefits are highly negative and private net benefits are slightly positive;
- Extension, where public net benefits are highly positive and private net benefits are slightly positive;
- Technology development, where private net costs outweigh, or are similar to, public net benefits; and

- No action, where private net benefits outweigh public net costs, where public and private net benefits are both negative, where private net benefits are sufficiently positive to prompt rapid adoption of environmentally beneficial activities, or where private net costs outweigh public net benefits (provided that technology development is not sufficiently attractive).

A comprehensive survey of extension practitioners across the USA by Rodriguez *et al.* (2009) supports the findings of Brown & Bewsell (2010) and the OECD (2015) that extension efforts need to be focused on specific production systems, not a blanket approach. Rodriguez *et al.* (2009) suggest targeting farmers and change agents who are interested in sustainability, who need the economic assistance, and who can maximise the impact of scarce economic resources should lead to greater impact of programmes.

7.3.1 The value of extension services

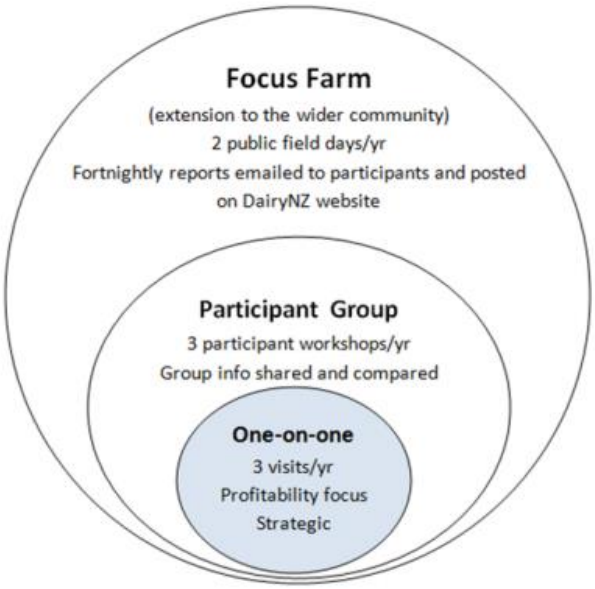
No formal evaluation has been carried out as to the effectiveness of the overall programme of the MAF Advisory Services Division. A number of evaluations of individual programmes have shown internal rates of return ranging from 16% to well over 100% (Squires & Hughes, 1973; Dawson & Smith, 1979; Smith *et al*, 1979; Mace & Peterson, 1979; Armstrong, 1980), Scobie and Eveleens, 1987, cited in Journeaux 2009).

Work in the USA (Fuglie *et al*, 1996) has shown a 35% return on research expenditure, and 20-110% on extension work.

The above extension programmes all relate to projects promoting increased production/profitability, which as outlined in this literature review, have many factors which would enhance their adoption by farmers. Within New Zealand there are no reported evaluations of environmental extension programmes across a wide group of farmers. An outline of the impacts of the Australian Landcare programme is discussed in Section 6.2.

The "Dairy Push" extension programme (Dairy NZ, 2011) indicates a potentially successful methodology combining a focus farm approach along with group meetings along with one on one interactions, as outlined below.

Figure 6: Summary of Dairy Push Programme



The programme was initially run for 3 years, concentrating on productivity and profitability objects, and was then extended for a further 3 years to also incorporate environmental objectives, particularly reducing impacts on water quality.

A formal evaluation of the first 3 years showed that farm profitability had lifted from 43% below the region average to 2% above it, which at an on-farm level was equivalent to an average extra $50,000/year. The second 3 years saw marked improvements in effluent management, and reductions in nitrate leaching.

As such, this methodology represents a prime example of a potential extension programme to address environmental issues.

Perhaps the main point is that if a change in farmer behaviour is required to mitigate GHGs, then an extension programme should be an integral part of the policy mix. There is a public good rationale for government to be involved in this, and similarly there is a "mitigation of a negative externality" rationale for industry to be involved. Which perhaps indicates a partnership approach to the issue.

7.4 Conclusion

The attitude to mitigation of environmental impacts has undergone a significant change over recent decades, from the push to develop land and increase production, to one where environmental impacts are increasingly being recognised and actions implemented to mitigate these impacts.

Part of the issue relating to "actions to mitigate" is the need for farmers to understand the issues, the inter-relationship with farm systems and farm profitability, and how the complexity of all of this fits together. A key factor related to behaviour change was establishing a clear link between environmental and economic benefits, and ensuring practical options were available.

Barriers to behaviour change included a range of factors; economic, inadequate availability of information, lack of on-farm trials and demonstrations, lack of institutional support, change agent beliefs, resistance to change, compatibility with existing practice, complexity, perceived efficiency of the practice, access to finance, land tenure, and personal characteristics such as age and apathy.

Extension in particular was seen as an option to work directly with farmers to support behaviour change, with evaluation of extension efforts indicating significant returns (albeit from programmes concentrating on productivity and profitability) on the extension programme. The "Dairy Push" extension model illustrates a potential methodology for combining economic and environmental extension. Given the multi-facetted nature of sustainable land management (including GHG mitigation) and the barriers noted above, a long-term extension programme is required, and again given the multi-faceted nature of the issues, a range of approaches are required. Within this a combination of public and privately funded initiatives, and positive and negative incentives, have a role to play.

8.0 FARMER DECISION MAKING REGARDING CLIMATE CHANGE OUTCOMES

There is little research on farmers' ability to adapt and make changes with regards to mitigation, with a slightly larger body of work focused on adaptation. The literature reviewed reflects this. Arbuckle *et al.* (2015) suggest that based on their study of farmers in Iowa, farmers are more open to adaptation than mitigation. This was supported by Lobell *et al.* (2013), who found that 'broad-based efforts to adapt agriculture to climate change have mitigation co-benefits'. These studies relate to American farmers who are predominantly crop farmers. Nevertheless, the findings support an emphasis on what will happen with a changing climate.

Jaffe & Stavins (1994) explored the diffusion of conservation technology in the energy sector and concluded that the technology-diffusion process is gradual with reasons for this including, information problems, principal/agent slippage, and unobserved costs (potential market failures), and private information costs, high discount rates, and heterogeneity among potential adopters (non-market failures). While this is not directly related to agriculture, the reasons for the slow uptake of technology and practices to improve energy efficiency could be comparable.

An OECD report (2012) shows that 'the environmental outcome of policy instruments is usually much lower than their potential due to institutional, education, social, and political constraints.' A finding supported by Funk *et al.* (2014). The OECD Report goes on to say, 'policy incentives, education and information, and consistency and compatibility with traditional local practices, all play a determining role in the actual outcome.' The report outlined four recommendations for policy makers (quoted below) in considering climate change in agriculture:

(i) A holistic approach is needed. An agricultural sector that can contribute to GHG mitigation and adaptation to climate change is likely to require a combination of policy instruments and other mechanisms, such as habits, cognition and norms which can influence farmer behaviour.

(ii) Behavioural change should be understood at the local level. In order to deal with spatial heterogeneity, it is important that policy recognises that performance of different policy instruments varies over both landscape and farmers.

(iii) 'Nudging' could be a useful approach to guide policy. 'Nudging' implies a small change in the social context that alters behaviour without forcing anyone to do anything. An example of a nudge approach is 'visualisation' policies such as eco-labelling (carbon footprinting). This approach encourages farmers to establish what they need to do, and allows their efforts to be conveyed to consumers through labelling. Another example would be benchmarking GHG emissions on-farm.

(iv) Forming networks of farmers or working collectively can play an important role. Social capital could influence collective action of farmers. Collective options should be given serious consideration as an alternative to the market or to regulation in addressing many agricultural and natural resource problems.

A Hungarian study (Li *et al.* 2017) found that the link between belief and adaptation behaviour varies between contexts and may not play a role in driving actual adaptation, with their research showing that only awareness of extreme events was a significant cause of adaptation behaviour. This heightened awareness was also linked to a belief in climate change risk. They further concluded that "polices which prioritise ways to reinforce farmers' *general* belief in climate change risks may not be the most effective means of promoting adaptation strategies. Instead, policies that put greater emphasis on the severe consequences of directly observable weather phenomena, rather than being too general and only linked to long-term climate change, may be more successful in promoting farmers engagement in adaptation. Furthermore, without acknowledging the contextual factors of the target, policies focused solely on improving farmers' risk perception may be ineffective and unable to achieve their desired outcomes."

In contrast, Arbuckle *et al*. (2015), suggest that farmers who had stronger climate change beliefs and perceived higher risks of negative impacts of it were more likely to endorse adaptive action (although not necessarily undertake it). The stronger belief and attributing that to human-induced climate change also engendered stronger support for government mitigation policy. They suggested that appealing to farmers' creative responses to the problem of extreme weather may be effective avenues for outreach. Further, Arbuckle *et al.* (2015) found that risk perceptions and attitudes towards action are influenced by trust in the agricultural and environmental actors involved in their decision making. Therefore, those 'actors' should be targeted by climate research and the policy community to engage more with the farming community.

With their profiling work, Li *et al.* (2017) concluded that farmers who have an innovative personality, intend to pass their farm on to the next generation, are actively engaged in networks and extension services, who earn greater farm income, or who have been seeking to gain farm ownership are a potential target for the promotion of adaptation actions. This finding would tend to support the Rogers (1962) model of targeting the innovators and early adopters to influence the remainder of the population. This, and other approaches take time to implement and therefore the associated behaviour change also takes time (Leslie *et al.* 2008; Arbuckle *et al.* 2015). Research solutions need to be proven at farm-scale, the appropriate delivery mechanisms need to be developed, commercialisation of products needs to occur and then be adopted by farmers, and finally, any emissions reductions need to be incorporated into the national emissions inventories (Leslie *et al.* 2008).

In line with Journeaux (2009), Li *et al.* (2017) also suggest that policies promoting adaptation should include information on the projected improvement in profitability and advice on better land use and business management techniques. Communicating through agricultural networks also helps to enhance farmers' beliefs and stimulate actual adaptation to climate change.

8.1 Adapting to a price on carbon

Much of the literature on landowner attitudes to a carbon price is centred around planting or regeneration of forestry as this is a known mitigation which has also been incentivised via the New Zealand Emissions Trading Scheme. However, the principles can be applied to other mitigation practices with some degree of caution.

Funk & Kerr (2009) *in* Funk (2009) examined barriers to decisions about carbon farming (forestry). They suggest that 'creating a market for a new climate abatement commodity (e.g. carbon credits from forestry) produced through land-use change is not sufficient to generate changes in land use.' Due to the fact that the 'carbon market is subject to potential failures due to imperfect information, lack of competition, and poorly defined property rights. Regenerating forestry is also a unique, long-term system, causing challenges for implementation. Funk *et al.* (2014) suggests landowners caution in investing in forestry (already incentivised), is due to a number of reasons including scientific uncertainties in measurements and models, market uncertainties about the price of carbon, and policy uncertainties, which could lead to a collapse of carbon markets or substantial changes in the price of carbon.

Cooper and Rosin (2014) noted that with respect to pricing carbon and market mechanisms; "*that market-based instruments alone are unlikely to dispose pastoral farmers to assume responsibility for GHG emissions and that developing effective agri-environmental governance programmes requires addressing the political-economic and cultural foundations of production practices".* Which would indicate that more than just pricing carbon is required to ensure farmers implement mitigation practices and strategies.

In a similar vein, Cooper *et al.* (2013) stated:

"Measures such as information programmes and agricultural extension activities may be necessary, in addition to a price signal, to achieve large-scale behavioural change".

Plus; ***"justification for including livestock emissions in mitigation regimes needs to be carefully articulated".***

8.2 Policy options from the literature

Funk *et al.* (2014) makes recommendations (around forestry) for policy makers including:

- Encourage more certainty by standardising and simplifying enrolment procedures in multiple sustainability initiatives;
- Establish guidelines for monitoring procedures;
- Establishing durable rules for trading carbon credits in order to improve landowners' ability to make long-term land management commitments; and
- Allow flexibility in commitments for landowners, such as rewarding temporary storage of carbon.

Under the current system for forestry in the NZETS, technical and structural resources are not delivered by the government, thus support for decision-making must come from the market participants themselves or the private sector (Funk & Kerr, *in* Funk, 2009). This could be a case for extension services coordinated by government but delivered by industry and the private sector (i.e. trusted advisors). Funk & Kerr (2009) concluded that a 'combination of contractual options and decision support are effective in helping landowners overcome internal uncertainties and external information barriers.' They went on further to say that most

landowners are unlikely to have all of the technical skills they require and so experts with the appropriate knowledge and skills are required. They also suggest that the source of information delivered to landowners should be the same, or as close as possible to the information used by government to assess, evaluate and operate the market systems.

Ayer (1997) found that there are few incentives for institutions to provide public good services such as good water quality or to curtail the production of pollution due to market externalities. Ayer suggests collective decision-making can be influenced by ensuring the range of incentives and disincentives align with individual and group objectives – either, enabling individuals to capture the benefits, or confronting them to pay the costs of their actions.

8.3 Conclusion

The literature review highlights the complexity of factors that drive farmer behaviour, across the range of socio-economic factors, e.g. personal and family circumstances, goals, support networks, financial security, the personality of the farmer, and their interaction with communication channels.

This review shows that most learning is self-directed, and that other farmers are an important source of information to their fellow farmers. While group learning is important, particularly to give positive reinforcement, the greatest level of learning takes place at a 1:1 level.

From the literature review it is also clear that achieving farmer behaviour-change is a specialist skill that requires expertise in a range of systems, approaches, and practical implications of information, technology or management practices.

The general-held view across a range of literature explored globally looking at influencing farmer behaviour to achieve environmental objectives is that it is complex, that no one-size-fits all (i.e. multiple methods, channels, approaches are required), and that information needs to be evidence or fact-based and presented by a trusted advisor. There are a significant range of approaches and theories which need to be applied in a relevant way to meet the needs of the individual farmers.

9.0 SECTOR EXPERT INTERVIEWS

This exercise involved semi-structured interviews with 11 individuals who had good agricultural sector knowledge, and expertise across extension and/or climate change issues. The interviews were carried out either in person or over the phone, either immediately pre-Christmas/New Year, or immediately afterwards. The interviews started with a major question, followed by a number of subsidiary questions, and general discussion subsequently as led by the respondent. (The names of the interviewees, the questions raised, and the responses are shown in Appendix Two).

Overall, the interviews reinforced a number of the factors outlined in the literature review, particularly:

- The need for farmer education so that they understand the issues and the need for mitigations.
- The need for mitigation options to be established/researched and the costs/benefits analysed.
- The need for extension to assist farmers to make any changes, particularly as the complexity of any changes increase.
- The need to incorporate all environmental issues (e.g. water quality, GHGs) as part of the farm management/mitigation approach, rather than tackle each in isolation.
- The relatively long timeframes involved to achieve significant change.
- The need to engage with, and ensure farmers are involved in, mitigation option development, and extension programmes.
- Finally, most supported the idea of government assistance to farmers to help incentivise change.

10.0 FARMER SURVEY

The opportunity was taken to survey a number of farmers in order to get an indication of their understanding around climate change and biological greenhouse gas emissions. This was NOT a statistical randomised survey as time did not permit this. Rather, it was a brief questionnaire (ref Appendix Three) developed on Survey Monkey (www.surveymonkey.com) and emailed initially to B+LNZ Farmer Council Chairmen and Vice-Chairmen and the farmers on the Waikato/BoP dairy farm monitoring programme. They were also asked to forward it on to other farmers. A total of 68 farmers completed the questionnaire. A full outline of the results is shown in Appendix Three.

A summary of the results is;

Question 1: Do you know the level of greenhouse gas emissions for your farm? 98% No, 2% yes

Do you believe that New Zealand agriculture should reduce its greenhouse gas emissions to help combat global climate change? 64% yes, 36% no

Question 3: Other than planting trees, are you aware of mitigation strategies that would reduce your greenhouse gas emissions? 58% yes, 42% no

Other mitigation strategies mentioned included; use of biofuels, reduced stocking rates, no-tillage for cropping, less cattle.

Question 4: What would you estimate the amount of carbon dioxide equivalent the average farm is emitting? The vast majority (97%) underestimated this, with 82% estimating less than 1,000 tonnes CO_2e[1]/year [The average farm emits circa1,900-2,000 tonnes CO_2e/year]

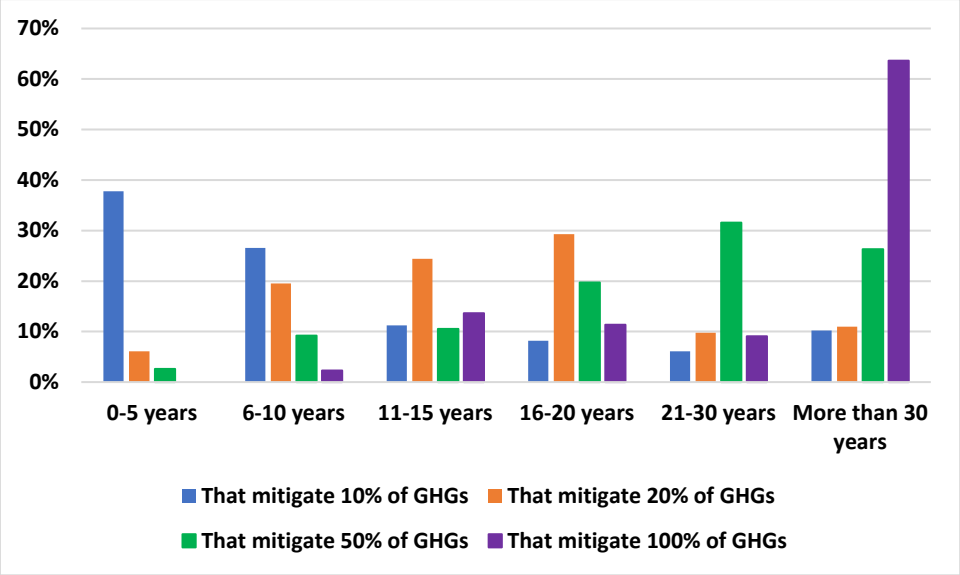
Other than planting trees, are you aware of mitigation strategies that would reduce your greenhouse gas emissions? Mentions were;

- 88% planting trees
- 55% reducing nitrogen
- 38% reduce bought-in supplementary feed
- 28% change stock types
- 25% reduce stocking rate
- 18% make no changes/pay the cost

Question 6: What timeframe do you think would be reasonable to allow farmers to adopt greenhouse gas mitigation practices?

[1] CO_2e = carbon dioxide equivalents

Figure 7:



Question 7: What information, support or systems do you need to help you manage a future cost on greenhouse gases?

Many of the comments here were around the need to understand GHG emissions, the options for reduction, the costs/benefits involved, and the need for good scientific information.

10.1 Discussion

The survey highlights the complexity of this issue. While the majority of farmers responding indicated an agreement that NZ agriculture should address the issue of climate change/GHG emissions, they also indicate limited knowledge around emissions from their farms or the average farm, which is a prerequisite to understanding the size of the issue and any implications from a carbon charge. [The total biological GHG emissions from the average farm is in the order of 1,900-2,000 tonnes CO_2e per year; Average dairy farm = 147 ha @ circa 13 T/ha = 1,911 tonnes, average sheep & beef farm = 640 ha @ circa 3 T/ha = 1,920 tonnes, but with significant variation around these levels].

The estimate of a reasonable timeframe is somewhat predictable, with the higher the level of mitigation required the longer the time period required to achieve this. Even for a 10% reduction the majority of respondents indicated a time period greater than five years.

The favoured means of mitigation is forestry, followed by reduced nitrogen fertiliser usage, accepting that the list of mitigations presented was relatively limited. The comments provided under this section indicate a much wider understanding of a number of mitigations, including (especially) the idea of carbon sequestration via soil carbon – in itself indicating that farmers are aware of the possibility, but perhaps not aware that it is not included within the "officially accepted" mitigations.

While a number hinted at farm systems change (i.e. more sheep/less cattle, reduced stocking rate), none explicitly expanded on this as a mitigation option.

Within the comments around further information or support there were varying responses:

- Some rejected the idea of anthropogenic causes of climate change and hence the need for any action
- Some accepted the need for NZ agriculture to be involved, but not to the extent of limiting biological emissions
- Some accepted the need for agriculture to be involved, but had limited knowledge as to what would be needed.

A particular theme coming through was around the need for education on the issue and credible information on mitigation options, including cost benefit analyses. The need for more/better science around mitigation options, along with better means to measure farm-level GHG emissions, was also stressed.

11.0 DISCUSSION

There are a large number of behavioural theories, all with their particular view, but also incorporating aspects of other theories. The literature directly notes that for most behavioural change exercises, no one theory fits all; aspects across a range of behavioural theories need to be incorporated into any programme.

As outlined in the literature review, there are a wide range of inter-acting factors which drive farmer behaviour, which then in turn inter-relates with the characteristics of the innovation or change required, which all affects the rate of uptake or adoption of the innovation or practice. The following discussion is the authors' thoughts, based on the literature review, interviews, and survey.

The issue with environmental/natural resource issues is that the characteristic of the change required conveys little or no comparative advantage (or any comparative advantage is not readily apparent), often requires a significant change in the farming system, is difficult to trial, and its observability is often a matter of faith. All of which hinders the ready adoption of the change. These represent a key barrier to behavioural change.

This of course varies depending on the complexity of the practice change, as outlined in the expert interview section. Straight-forward practices, such as requiring farmers to fence off waterbodies to prevent stock access is relatively simple; farmers understand fencing – the issue is mainly one of cost and practicality in difficult terrain. Similarly, with planting trees as a carbon sink – the concept is generally understood, and the process relatively simple – the issue is one of availability of land to plant, and cost.

On the other hand, the idea of reducing stocking rate and increasing per animal production, within the same amount of dry matter fed, as a means of reducing both nitrogen leaching and biological greenhouse gas emissions, while maintaining profitability, is a complex farm management issue which will take some effort to get farmers to adopt.

This complexity and difficulty in readily observing outcomes is compounded by the general lack of explanation as to how they fit within a farming system. As noted in the literature review and inferred in the expert interviews, if farmers have a more holistic understanding of how a new technology or innovation impacts on the system as a whole – how it either fits into the current system, or how the current system can be altered to accommodate it, this then enhances its probability of adoption. It is a common fault in many extension programmes whereby the new innovation/management change is explained in isolation to the rest of the farming system, which directly detracts from the probability of its adoption.

This whole farm approach is perhaps one of the key factors in the adoption of environmental management factors. Their complexity and difficulty in readily observing outcomes is not likely to be readily overcome, which reinforces the desirability of having a whole farm systems approach such that farmers can see how they fit within their farming systems.

As the survey has indicated, farmer understanding around climate change and greenhouse gas emissions is varied. There is not necessarily a good understanding of the science, the need to act, and the options available. As noted in the expert interview section, farmers are currently

very focused on water quality issues given the regulations being promulgated by Regional Councils, and while greenhouse gases and climate change are "on the horizon", they are currently regarded as yet another compliance cost, that hopefully will still take some time before it is imposed.

This raises one of the significant factors around adoption of environmental practices which relates to the costs and benefits of it – part of the "relative advantage" of an innovation as discussed in the literature review. The issue that arises is that (negative externalities not withstanding) often the cost of environmental action is borne on-farm, while much of the benefit accrues off-farm. In this respect therefore, often the affordability of implementation of environmental practices on-farm need to be judged against the current income of the farm – as the benefits are often hard to gauge, most environmental work is judged as a cost.

Many decisions around adopting environmental practices therefore are subject to this economic/environmental trade-off. It is interesting to note that nutrient budgeting, the first step toward nutrient management, has become popular because it has shown farmers that they can save money by reducing fertiliser inputs, and still maintain production – the economic benefits are obvious and often significant.

Overall therefore there are a range of inter-linked factors which would conspire to reduce adoption of GHG mitigation practices.

This then raises the issue of extension, and the means of providing information to farmers, working with them, and achieving change. The main current means of communicating with farmers around environmental issues very largely falls within the "mass media" approach. This includes a range of approaches, including: television, printed material, field days, workshops, and monitor farm programmes. These channels are quite effective in raising awareness of issues, and in imparting some knowledge about the issue in question. They can be quite effective in triggering "innovators" (aka the innovation diffusion model) to investigate the issue further and, having worked through the pros and cons, take the decision to adopt. However, they are much less effective in persuading later groups in the innovation diffusion model to take the innovation any further, unless the innovation is relatively simple and easy to incorporate into farm systems. In this respect therefore, an extension system that relies solely on a mass media approach will almost inevitably result in a slow rate of adoption.

As outlined in the literature review and the sector expert interviews, the greatest level of adoption has consistently been shown to occur when advisors work on a one-to-one basis with farmers. Under this approach, the advisors can tailor advice around the innovation to suit the farmer, including discussion around pros and cons/costs and benefits, and as part of this, provide advice as to how the innovation can be worked into the current farming system, or how the farming system can be altered to incorporate the innovation – i.e. take more of a whole-farm approach.

Possibly a half-way house between these two approaches would be the traditional discussion group – where a local group of farmers meet regularly with an advisor to look at individual farms and discuss farming systems and associated issues, including environmental issues. Often this approach can be quite effective in advancing adoption rates, particularly by raising

awareness around an innovation to a greater degree than generally is the case with a mass media approach, and often by motivating farmers to then seek individual advice on the issue. But discussion group type activities can be quite effective in increasing adoption rates amongst innovators and early adopters.

The next aspect is social factors and how they influence adoption. The initial consideration is the social process of adoption, and the fact that farming, as outlined in the literature review, is a socio-cultural practice - a way of life - rather than just a technical activity. This has direct implications for extension in that the traditional linear approach of a top-down process of extending science outcomes to farmers via an extension agent is very limited in its effectiveness. This is more so with the extension of natural resource management issues given the limited, direct benefit to farmers.

To be effective, extension needs to take into account a wide range of factors; extension agents need to understand the world view of farmers and to understand the reasons why farmers do not readily adopt alternative technology and management practices, and look to adapt their extension approaches and messages accordingly. The literature review and interview also indicate the value of direct farmer participation in extension programmes and the value of a social marketing approach in order to gain insights into farmer beliefs and attitudes, to segment the potential audience, and consequently allow for a more targeted approach to each segment.

[Note. Farmer participation means exactly that – they are actively involved in the design and delivery of an extension programme. It does not mean they do it all themselves – the involvement of scientists, extension agents and others is still vital].

A further consideration around social factors, is the combination of societal acceptance and social pressure for change. While not directly canvassed as part of the interviews or survey, the main driving force for farming to reduce its environmental footprint is via social pressure. Over recent decades this has resulted in a degree of urban/rural split, with the perception by the farming community that they are often portrayed as environmental vandals by an urban society that has consistently refused to accept that they also need to change. Such misconceptions, on both sides, means that more time is spent on arguing the point rather than devoting energies to develop better approaches for adoption of environmental mitigation practices. This is possibly a simplified explanation of a complex and nuanced situation, but the net effect is a factor in slowing the readiness of farmers to adopt environmental mitigation practices.

Which leads onto a crucial aspect highlighted in the interviews and survey; the need for good science so that farmers understand the issues, can readily measure their greenhouse gas emissions, and understand the mitigation options, including the costs and benefits around these.

11.1 Timeframe for uptake of new practices

Little empirical work has been done on the uptake of innovations or new practices across a whole population of farmers. In the authors' experience this uptake can vary considerably, from a few months through to decades, with a direct correlation between the complexity of

the issue and uptake – the more complex an issue (such as factors affecting the whole farm management system), the longer the lag period of diffusion across the whole population. New Zealand research (cited in Journeaux 2009) calculated an average lag period of 23 years for the impact of research, i.e. it took 23 years for the impact of a particular research and extension programme to reach a peak. While this relates to the effect of the R&D on productivity – the effect starts slowly, builds and then fades away as the knowledge or technology becomes obsolete, it is roughly equivalent to being adopted by 50% of farms.

The above uptake period of 23 years was achieved during a period of major expansion of the agricultural sector, and the systems being promoted were directly linked to increasing the profitability of the farm business. As such there were very direct incentives for farmers to adopt the practises in question.

The issues around adoption of environmental mitigation practices has been commented on in the literature review (e.g. limited comparative advantage), and the timeframes for adoption are also commented on in the interview and survey sections. In essence, the timeframes are likely to be long; 10 - 30 years plus. It is interesting to note that fencing off streams on dairy farms – not exactly technically complex, has taken around 20 years to achieve. Similarly, dairy shed effluent management – somewhat more technically challenging, has taken 25 years and there are still issues on a number of farms.

A key component of this study discusses the need to support farmer learning and decision making, i.e. extension programmes.

Within this is an issue which is somewhat outside the terms of reference for the project, but bears directly on the probability of extension programmes succeeding, namely the lack of capability in the extension area in New Zealand, particularly with respect to;

- Understanding and providing farm systems advice
- Provision of advice on on-farm nutrient and greenhouse gas mitigations
- Design and implementation of an extension programme, including iterative learning

This issue needs to be addressed, which the integrated system discussed in the policy options would go some way towards this.

12.0 POLICY INTERVENTION OPTIONS

This paper has outlined a number of behavioural theories, background on farmer behaviour, farmer involvement in environmental issues including climate change, and ways this may be influenced. Policy development and implementation is required across a range of fronts within an integrated, longer-term strategy for maximum behavioural change.

The following are the authors' thoughts on a range of policy intervention options based on the review discussed in the report. They are not necessarily in any order of importance.

12.1 Incentive to act/Economic Instruments

A key aspect is the initial impetus or incentive, or motivation, to trigger behavioural change. As noted in this report there are a wide range of "behavioural change options". For the New Zealand government looking to incentivise farmers to act on GHG mitigations, a key approach to provide such an incentive would be via a legal requirement, i.e. a mandated reduction and/or via a financial incentive such as imposing a financial cost on carbon (aka Rational Choice/Rational Economic Theory).

This then imposes two kinds of incentive on farmers:

(i) Being law-abiding citizens they would want to comply with the law, even if they didn't like it much; and

(ii) A carbon cost would impose an economic cost which they are likely look to mitigate

While this is essentially a "stick" approach, the relative opposite of moral persuasion is also an option, and within this, education is a key component (discussed later).

12.1.1 Financial Incentives

Financial incentives are also an economic means of incentivising behaviour change, and there is a case to be made for them to be included in the support mix to achieve faster take-up of mitigation practices.

Several Regional Councils have provided financial incentives to farmers in the form of part funding for fencing off streams and areas of native forest, provision of poplar poles for erosion control planting, and plants for riparian protection planting. Generally, this has been an effective incentive for farmers to take action, and significant areas have been fenced and/or planted.

Currently central government provides a financial incentive to plant trees (Afforestation Grant Scheme), which has been effective in incentivising farmers to plant trees for GHG mitigation, as evidenced by the rapid uptake of the original scheme, resulting in it being extended.

As an example, many farmers (particularly hill country) are likely to undertake planting or retirement of land as part of their response to a price on carbon. A potential financial incentive mechanism could be to provide rates relief for these areas, subject to certain conditions.

12.2 Point of Application

This issue relates to the application of an incentive to change behaviour; whether applied directly or via a third party, with the latter potentially diluting the impetus to change behaviour.

As such, any policy needs to ensure that it can (a) incentivise, and (b)capture and recognise any change in behaviour, at a farm level where the environmental outcomes are realised and/or influenced directly.

12.3 Research

This aspect relates to the understanding of the issue, and provision of options to mitigate – the more options available, the more likely there will be a change in behaviour.

Currently the government is funding a range of research projects, via a range of organisations. In many respects, research is the only option for providing a long-term solution to GHG emissions; forestry, the *mitigation du jour*, will only provide a 20 - 30-year solution, and therefore a continuation of, if not an increase in, expenditure on research is required.

The explicit funding of research from funds collected via a carbon tax, as noted in the interviews, would also be a means of helping to "sell" the idea of a carbon tax to farmers.

12.4 Forestry as a Carbon Sink

Currently forestry is promoted as the main/easiest way to offset GHG emissions. While many farmers are likely to plant marginal areas of their farms if necessary, whether they plant further areas is dependent on a number of factors. The key aspect here is provision of information/clarification; without this, behaviour change is likely to be slower than desired.

Key aspects here would be;

- Improved information provision on forestry economics, and
- If planting was made more profitable through favourable changes to current forestry rules in the NZ ETS and inventory, it is likely to further incentivise planting.

12.5 Extension and Education

The main component of this report is around the literature review on farmer behaviour, uptake of innovations, and education/extension as a means of improving uptake of mitigations practices.

The first policy option outlined above is essentially a "stick" approach; a mandated requirement to act. While this is an option, it does not necessarily achieve either acceptance or compliance. What is also required is also a "hearts and minds" exercise which (a) educates people as to the need for action, and (b) provides them with options and advice as to how to mitigate GHG emissions. This is what an education/extension programme is all about. Either approach is unlikely to succeed in isolation, but combined they can be quite effective.

At an educational level, as the interviews and survey have indicated, there is a need to inform farmers (as well as the general public) as to the cause and effects of GHG emissions, and the value proposition in mitigating biological emissions. Given the polarised views around climate change this may well be fraught, but needs to happen. The main objective is to ensure an understanding of why action is required.

Part of this is ensuring an understanding that while biological emissions from agriculture is a significant part of the New Zealand GHG profile, the efficiency of our production (i.e. kg of CO_2e per kg of product) is very good relative to the rest of the world.

The major component though is the need for an extension programme to assist farmers in developing and implementing mitigation practices. As outlined in this report, many environmental mitigations requiring farming system change are relatively complex, and infer relatively minimal comparative advantage to the farmer; usually the cost is private and the benefit is public. Hence the incentive to act is limited.

While this report is centred around climate change and GHG emission mitigations, there is a wider issue of reducing agriculture's environmental impact, of which GHG emissions are but part. The need for coordinated extension therefore is across the wider scope of environmental mitigations rather than just biological GHG emissions per se. This is particularly so given direct co-benefits across aspects such as improving water quality and reducing GHG emissions.

As discussed in the report, extension is a critical component in assisting farmers to adopt research findings and innovations, with very positive returns shown from extension programmes.

As the literature review shows, most learning is self-directed, but as the complexity of the issue increases, the value of interacting with other "experts" increases; the greatest degree of change occurs with 1 to 1 interactions. The need for increased extension would depend on the size of the GHG reduction sought by government. But while a 5% reduction seems small, and potentially could be addressed via "mass media" extension (e.g. field days, workshops, discussion groups) such a reduction other than via planting forestry, would require some significant systems change on-farm, and hence the need for an increasing extension effort. The cost of any extension effort is more likely to increase exponentially rather than linearly, with an increasing level of emission reduction.

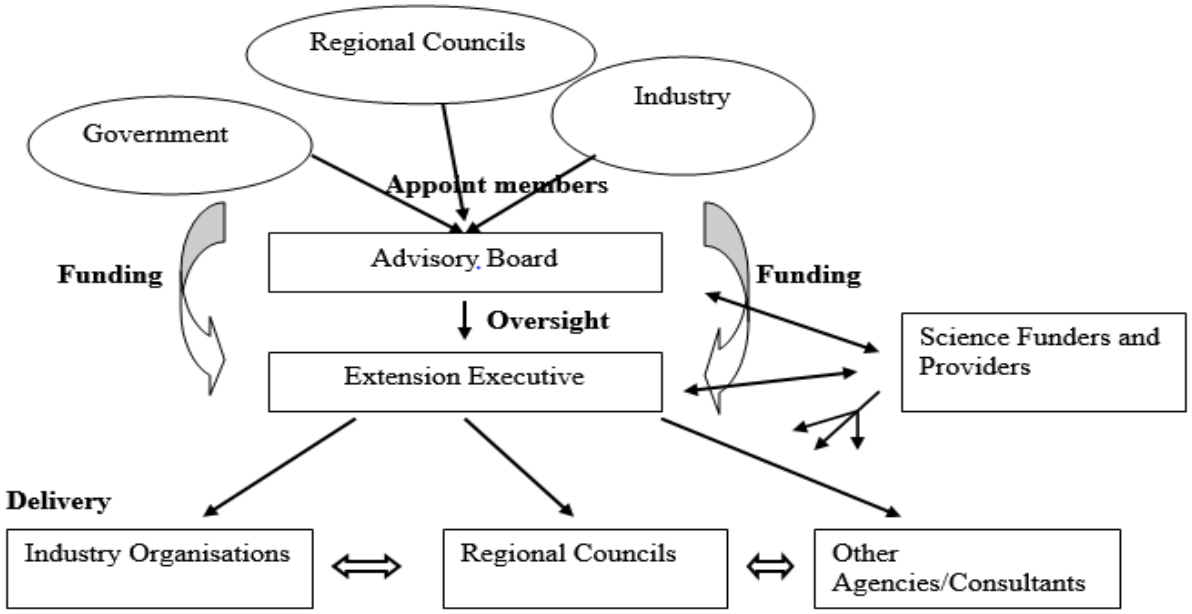
Currently within New Zealand there are a range of organisations involved in environmental extension, particularly the Industry Good Bodies and Regional Councils. Input from Government is relatively limited, for example funding for individual projects via the Sustainable Farming Fund (SFF). Overall though, each effort is relatively limited due to resource and capability constraints.

As outlined in the literature review section, there is a rationale for Government to be involved in environmental extension, given the large public-good aspect of mitigation practices. In addition to this is the rationale for industry (as an agent of farmers) to address the negative externality involved in GHG emissions. Any extension programme could therefore be a

partnership between government and industry (and regional councils assuming water quality was also involved)

One proposition around a combined partnership approach to extension was outlined in Journeaux (2009), as illustrated below.

Figure 8: Possible Institutional Extension Model



As outlined in this report, farmer input and involvement into extension programmes is vital; their input would be part of the "industry" component above, as well as into the various projects that were part of the delivery aspect.

Perhaps the main aspect is that there needs to be a considerable step-up in environmental extension if progress in reducing agricultural environmental impacts are to be achieved.

12.6 Other

While the following are not policy options per se, they pertain to the discussions above.

12.6.1 Mix of influences

Each of the above recommendations would have different influences with different farmers. To be successful all of them are required as a policy mix to achieve a significant change.

12.6.2 Universal Farm Environment Plans

One of the key requirements following Regional Councils introducing regulations around water quality, is the need for farmers to develop Farm Environment Plans (FEPs) which outline the issues at the farm level, and how these will be addressed. Including assessment of GHG emissions in existing FEPs would be more efficient and consistent with managing farm systems holistically compared with separate documentation of GHG emissions and water quality

management. This reinforces the need to encompass all environment extension and mitigations as a whole rather than approaching them separately.

13.0 FURTHER RESEARCH

Currently there is a research project underway (Motu/AgResearch) investigating "Barriers to Adoption for no-cost mitigations" with respect to uptake of GHG mitigations. This will help design any education/extension programmes.

The authors feel that, while more research would assist, there is sufficient information on farmer behaviour and adoption to readily implement behavioural change policies.

In noting this though, other potential areas for further research are:

(ii) Investigate the link between adaptation and mitigation. The literature suggests that farmers are more likely to act towards more adaptive practices, and that many of these also reduce greenhouse gas emissions. It would be beneficial to explore this in a New Zealand farming context.

(iii) There is a need to understand farmer decision making and behaviour around "regulated" change, e.g. the demands being made on them with respect to water quality via Regional Council plans (and potentially with GHG emissions).

(iv) With the advent of nitrogen leaching limits in many regions, this information is becoming quite important. A survey could be carried out to ascertain farmers' reactions to the information, and the usefulness of it relative to regional rules.

(v) While some modelling research is currently underway for BERG, more work is required to identify and quantify the benefits and costs of on-farm GHG mitigation options and their relative impact on farm profitability.

(vi) As part of (iii) above, there is a need for more farm system research to understand farm management requirements to ensure any (new) farm systems are profitable.

(vii) If an extension programme was to be instigated, then a number of aspects would need to be investigated;

- The policy framework within which the extension effort would operate
- The institutional/delivery framework mechanisms
- The holistic nature of the extension programme, incorporating all of the environmental issues of concern, e.g. water quality, GHG emission, soil erosion
- Quantification of the extension capability issue; what capability currently exists, what would be required, and policies/processes/mechanisms to rectify any gap.

14.0 ANNOTATED BIBLIOGRAPHY

Ahnström, J., Höckert, J., Bergeå, H.L., Francis, C., Skelton, P., & Hallgren, L. (2008). Farmers and nature conservation: What is known about attitudes, context factors and actions affecting conservation? *Renewable Agriculture and Food Systems*: 24(1), 38-47.

A literature review outlining what is known in regards to farms and nature conservation. The review includes studies from across the globe, including Europe, North America, Australia and New Zealand. Emphasis is placed upon the importance of stewardship, meaning farmers have a strong connection with the land, and consequently, feel a moral obligation to look after it. Suggests farmers' attitudes towards conservation will strongly impact their behaviour to adopt changes. Hence, agencies should target farmer attitudes as well as behaviour, to ensure provisions of funding results in successful adoption of new practices. Develops a useful model to demonstrate the interactions between farmer attitudes, the farming context and agricultural environmental schemes. Concludes that much of the reviewed literature contains conflicting information and suggests more research needs to be done to overcome this. Literature also highlighted the diversity of farmer attitudes and the way in which they continually change within individuals. The review only used peer-reviewed articles, to ensure information was reliable. However, it solely examined literature published in scientific journals, meaning other potentially useful literature was not considered. Literature published beyond 2005 was also not reviewed. Targeted towards conservation biologists, developers of agricultural environmental schemes, extension officers and those training them, researchers and nature conservationists.

Allen, W.J., Kilvington, M.J., Nixon, C., Yeabsley, J. (2002). *Sustainable development extension*. MAF Technical Paper 02/03. ISSN 1171-4662. ISBN 0 478 07663 0

A report commissioned by the Ministry of Agriculture and Forestry, which investigated the potential roles for government in sustainable development extension. Found there is strong reasoning for government intervention to encourage farmers to practice sustainable agriculture through indirect assistance, such as providing information as opposed to direct assistance such as funding. The report recognises that policymakers must consider the unique characteristics of farming that differentiate it from other economic activities, as well as the need for polices to be flexible between regions. Highlights the need for co-ordination between central, regional and local government. When implementing policy information social processes are key to learning. Defines the two key constraints to achieving an integrated approach to sustainable agriculture. Allen *et al.* suggests the introduction of the Resource Management Act (1991) has been the most influential piece of legislation affecting management of rural land in New Zealand.

Arbuckle, G., Wright Morton, L., & Hobbs, J. (2015). Understanding farmer perspectives on climate change adaptation and mitigation: the roles of trust in sources of climate information, climate change beliefs, and perceived risk. *Environment and Behavior:* 47(2), 205-234.

A study of farmers from Iowa that investigates farmers' perspectives on climate change, in regards to adapting to a changing climate and mitigation of greenhouse gas production.
Arbuckle *et al.* found that farmers are more open to adaptation than mitigation. The research was based predominantly on American crop farmers, who have more mitigation options available to them than pastoral-based animal agriculture in New Zealand, which limits the usefulness of this article. However, the findings are still valuable in illustrating the implications climate change.

Australian Public Services Commission, (2007). *Changing Behaviour; A Public Policy Perspective.* ISBN 978-0-9803978-5-7
A report that summaries a number of behaviour theories and discusses these in relation to their use in government policy formulation and delivery. It notes the growing number of policy problems where influencing human behaviour is very complex and the effectiveness of traditional approaches may be limited without some additional tools and understanding of how to engage citizens in cooperative behavioural change.

Ayer, H.W. (1997). Grass roots collective action: agricultural opportunities. *Journal of Agricultural and Resource Economics:* 22(1), 1-11.
Ayer, a professor in agricultural and resource economics, reviews the use of grass roots collective action as a viable alternative to governmental collective actions such as applying taxes, regulation or subsidising developing agricultural environmental policies. Proposes grass roots collective action has shared economic benefits and may solve many agro-environmental problems. Found there were few incentives for institutions to provide public goods services or to reduce pollution. Ayers asserts farmer-initiated, collective decision-making can improve rural welfare and allows remunerative opportunities to be captured. Useful for providing an alternate perspective on possibilities for government policy against climate change.

Ajzen, I. (1985). From intentions to actions: A theory of planned behaviour. In Kuhl, J.& Beckman, J. (Eds.) *Action-control: From Cognition to Behaviour.* Springer, Heidelberg, Germany.
Aizen applies the theory of planned behaviour, which has evolved from the theory of reasoned action, developed by Fishbein and Ajzen (1975). The theory can be used as a predictor of behaviour, which could be applied to an agricultural context. Looks at a number of factors affecting behaviour.

Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes,* 50, 179-211.
Ajzen reviews the theory of planned behaviour and discusses some unresolved issues. Illustrates how intentions to perform different behaviours can be accurately predicted from attitudes toward the behaviour. Identifies that behaviour can only be partly justified by the model which has limitations in its reliability.

Battershill, M.R.J., & Gilg, A.W. (1996). New approaches to creative conservation on farms in South-West England. *Journal of Environmental Management:* 48(4), 321-340.
A paper which reports findings from a study examining the characteristics and behaviour of farmers engaged in environmentally-friendly, farming initiatives. Battershill and Gilg suggest that farmer attitude has a greater influence on farmer behaviour in terms of the environment, compared with structural aspects such as financial constraints. Highlights the important role attitude and awareness play in adoption of environmentally-friendly practices. Farmers in the study again expressed how they would never deliberately damage the environment. The article has been peer-reviewed. The study was conducted in South-West England, so findings may not necessarily relate to New Zealand farmers. However, many principles relating to farmer attitudes can still be applied to New Zealand.

Becker, M.H. (1974). *The health belief model and personal health behavior*. Charles B. Slack, Thorofare, NJ.
Becker looks at the use of the health belief model (HBM) in the health sector. The HBM is a cognitive model developed in the 1950's which uses attitudes and beliefs of individuals to predict and explain health behaviors. The HBM was one of the first attempts to describe individual disease prevention and health maintain behaviour. The HBM has since been applied to many other fields, so could potentially be useful for predicting farmer behaviour relating to environmental management in New Zealand.

Beef + Lamb New Zealand. (2016). *New season outlook 2016-17.* Beef + Lamb New Zealand Economic Service, Wellington.
An annual report which overviews the latest economic and production trends for meat and wool. Useful information on global economic conditions and international production for sheep and beef production. Also includes a brief commentary on regional production. Provides statistics on current production figures. This publication is updated annually, along with mid-season updates. Hence, older editions are available to review recent and historic trends.

Beukes, P.C., Gregorini, P., Levy, G., & Waghorn, G.C. (2010). Improving production efficiency as a strategy to mitigate greenhouse gas emissions on pastoral dairy farms in New Zealand. *Agriculture, Ecosystems and Environment:* 136, 358-365.
New Zealand research which uses modelling to prove profitability can be maintained or improved whilst reducing greenhouse gas emissions. Study looked at the impacts dairy management decisions can have on achieving environmental outcomes. This paper looks more specifically at the ability of on-farm practices to reduce greenhouse gas emissions at a farm scale, rather than how policy or extension can assist in achieving these reductions.

Blackstock, K.L, Ingram, J., Burton, R., Brown, K.M. & Slee, B. (2010). Understanding and influencing behaviour change by farmers to improve water quality. *Science of the Total Environment:* 408, 6513-5638.
Comprehensive UK study which explores how behaviour change of farmers can be influenced in order to improve water quality. Reviews literature relating to provision of information and advice mechanisms to farmers, to encourage mitigation of pollution. Highlights a number of gaps in research relating to farmer behaviour. Explored what is also required to influence group behaviour at a catchment-scale. Could be applied to climate change in New Zealand, which may need to be delivered at this scale, making this aspect of the study very relevant.

Brown, M., & Bewsell, D. (2010). Using a market segment approach to better target agricultural extension programs – aligning learner needs with learning programs. *Journal of Extension:* 48(5), 1-9.
Study which analyses the merits of using market segmentation to enhance extension programmes through better meeting learner needs. Notes that traditional extension has been based on the assumption that farmers have similar learning styles. Suggests that identifying previous education, prior knowledge and learning preferences would be beneficial when developing extension delivery options. A survey of New Zealand farmers was conducted as part of the study to determine their specific learning needs. The results demonstrated the diversity of ages, gender, experience and prior knowledge, suggesting the traditional one-size-fits-all delivery method is unsuitable, and instead must be tailored to each segmentation. These

findings are relevant in helping make informed decisions regarding the best methods of delivery for extension programmes relating to greenhouse gas emissions.

Cary, J.W., & Wilkinson, R.L. (1997). Perceived profitability and farmers' conservation behaviour. *Journal of Agricultural Economics:* 48(1), 13-21.
Study investigating the influence prior perceptions have on conservation practices and the subsequent behaviour of farmers. This included looking at farmers planting of trees on farms in Australia. Suggests that attitude alone will not result in pro-environmental behaviour, and there must be other benefits, such as economic. Perceived profitability was determined as the factor which had the greatest influence on adoption of conservation practices. Cary & Wilkinson's study found that financial benefits are often not gained immediately by implementing environmental practices and technology, but instead accrue over time. This is of relevance in relation to adoption of mitigation practices, as if a farmer's behaviour is strongly motivated by financial gain, then extension practitioners must adapt their content and approaches in order to achieve the desired outcomes.

Clay, J. (2004). *World Agriculture and the Environment.* Island Press, Washington D.C.
Comprehensive book which considers how production must be balanced with concern for the environment. Discusses environmental sustainability of the food system, whilst incorporating social factors such as over-consumption. Asserts the idea that there is no single, correct way to practice agriculture. Uptake of environmental practices will depend on factors such as production type and location. Clay presents the idea that the most environmental damage is caused by low-input agricultural methods. Also provides statistics on commodities in terms of their respective production, economics and environmental impacts. Clay is a conservationist specialising in sustainable food production, with experience in farming, teaching and government service. He has written over 300 articles and 15 books. A number of highly credible references are used throughout the book. It is targeted at both people wanting to gain an overview of global agriculture, as well as those interested in working to reduce its environmental impacts. Provides an extensive list of recommendations for global agriculture, however, many are of little relevance to New Zealand. Not a strong focus on greenhouse gas emissions or agricultural extension.

Chatterton, T. (2011). *An introduction to thinking about 'Energy Behaviour': A multi model approach.* Department for Energy and Climate Change, London
Chatterton uses the three elements model to explain the social practice theory. The elements are: materials, meanings and procedures. The social practice theory has been applied to aid the understanding of sustainable behaviors in the energy, transport and waste fields. Chatterton builds on this by using the theory for policy analysis in the energy sector. However, the model in this study was not used in its original form so is not a precise representation of the model.

Coase, R.H. (1937) The Nature of the Firm. *Economica:* 4(16), 386-405.
An article by Coase, a highly-distinguished economist, which explains in economic terms, why people look to form partnerships, companies and other business entities. Considers the conditions under which it is appropriate to employ staff and form a firm. Used to provide rationale for the possible role of government in sustainable development extension, through providing indirect assistance, such as information and technology transfer. The majority of the

article comprises of discussion on the characteristics of firms and is of little relevant to the topic of environmental best practice or extension.

Cooper, M.H., Boston, J., Bright, J. (2013) *Policy challenges for livestock emissions abatement: lessons from New Zealand, Climate Policy*, 13:1, 110-133, DOI: 10.1080/14693062.2012.699786

A paper which evaluates key challenges to the inclusion of livestock-based farming within a market-based mitigation policy. These challenges were; design of a policy framework that appropriately aligns the measurement of emissions, abatement options, and the incentives facing livestock producers; and means to address the risk of leakage (of production to other countries) and economic impacts that arise from unilateral domestic policy action.

Cooper, M.H., Rosin, C. (2014) *Absolving the sins of emission: The politics of regulating agricultural greenhouse gas emissions in New Zealand.* Journal of Rural Studies 36 (2014) 391-400

A paper outlining the results of discussions with New Zealand farmers as to their views on climate change policy and GHG mitigations. It outlines the challenges the farmers posed on the policy along with the implications and issues they faced on-farm, and indicates the need for "agricultural and environmental governance" to assist in change rather than rely solely on market-based instruments.

Corner-Thomas, R.A., Kenyon, P.R., Morris, S.T., Ridler, A.L., Hickson, R.E., Greer, A.W., Logan, C.M., & Blair, H.T. (2015). Influence of demographic factors on the use of farm management tools by New Zealand farmers. *New Zealand Journal of Agricultural Research:* 58(4), 412-422.

Involved a survey of all New Zealand sheep farmers asking them to indicate farm management tools which had been used in the previous three years. 962 responses were obtained, representing 7.8% of New Zealand sheep farmers. The results found that only a small proportion of farmers had utilised a number of management tools. Of greater relevance though, was the finding that demographic factors could be correlated to the use of management tools, such as farmer age, farm size and level of education. Farmers with a higher level of education were more likely to use management tools. These findings are useful since they show that the delivery of technology transfer should be tailored towards farmers of different demographics. The article has been peer-reviewed. The survey was only sent to sheep farmers, so results may not necessarily represent New Zealand farmers as a whole.

Crowder, L.V. (1996). *Ag extension for sustainable development*. FAO Research, Extension and Training Division. http://www.fao.org/sd/exdirect/exan0004.htm

Crowder notes that meeting food demand for a growing population and implementing sustainable agricultural practices, will be a major challenge of the 21st century. Crowder believes greater investment in extension will be necessary to ensure there is extensive and efficient adoption of new technologies. Suggests extension agencies need to transition their focus from maximising short-term production outputs to promoting practices which enhance efficiency, whilst minimising environmental impacts.

Curtis, A., & De Lacy, T. (1998). Landcare Stewardship and Sustainable Agriculture in Australia. *Environmental Values*: 7, 59-78
Reviews the "Decade of Landcare", criticising some of the techniques used. Suggests too greater emphasis was being place on attitudinal change, and the survey was inadequate.

Davies, I.K. (1981). *Instructional Technique.* McGraw-Hill Publishers, London, England.
Book aimed at people interested in providing effective instruction. Provides a clear and concise definition of learning. Davies is a professor at the School of Education for Indiana University, specialising in cognitive science and human performance technology. He has published fifteen books and an extensive number of journal articles and reports. Could be useful for making recommendations on best practices for instruction.

Department of Agriculture, Fisheries and Forestry (Australia). (1997*). Evaluation report on the decade of landcare plan – National overview*. ISBN 0 642 23445 0
An evaluation report prepared as part of the Australian Government's "Decade of Landcare". Describes the impacts the programme had on environmental awareness and adoption of best management practices. Key findings from the report included determining that farmers perceived profitability and sustainability as different concepts. Of note, a desire for change in awareness and attitude is needed as pre-requisites for change, and that land degradation is primarily a social problem, rather than technical. DAFF is a credible source, though the report is not peer-reviewed. While this report is based on an Australian situation, many of the principles learnt can be applied to a New Zealand context.

Durpoix, D. (2010). *Farmers' attitudes and behaviour towards the natural environment: a New Zealand case study.* Doctoral Thesis. Massey University, Palmerston North, New Zealand.
Thesis which investigates farmers' attitudes and behaviour towards the environment in New Zealand. Found that farmers' attitudes towards the natural environment could be used to predict their behaviour towards native bush on their property. This suggests the need to target farmer attitudes as well as behaviour through non-regulatory measures to achieve long term impacts. While the concept of native bush was not directly related to the scope of this project, findings regarding the relationship between attitude and behaviour of farmers are applicable. Contains a considerable amount of statistical data and analysis which was of little relevance to policy recommendations or extension regarding greenhouse gas emissions.

Eponou, Thomas. (1993). Integrating agricultural research and technology transfer. *Public Administration and Development:* 13, 307-318.
Paper which examines the linkages between research and technology transfer components in adopting new agricultural technology systems. Eponou argues that the key constraint is a lack of a true system perspective in the delivery of extension. Identifies six key elements required for successful agricultural technology systems. Concludes the two critical factors to achieving this are establishing a single goal shared by all organisations, and that component organisations must be made accountable. Eponou was leader of the International Service for National Agricultural Research (ISNAR) project on research-technology transfer linkages, and has also published the article Partners in Agricultural Technology. The paper has been peer-reviewed, however, it is not of New Zealand origin. Useful for understanding the importance of systems and synergies between components.

Funk, J.M. (2009). *Carbon farming in New Zealand: an interdisciplinary assessment of indigenous reforestation as a land use system.* Doctoral dissertation. Stanford University, Palo Alto, CA. https://searchworks.stanford.edu/view/8389213
As the basis of his thesis, Funk looks at barriers to decisions about carbon farming in New Zealand. Highlights the challenges faced by carbon farming. Suggests that changes in land use will not be achieved through creating a market for a new climate abatement commodity such as carbon credits. Identifies reasons for potential failures in the carbon market. Useful to compare with the potential implications for pastoral agriculture in New Zealand if new policy was introduced.

Fishbein, M. & Ajzen, I. (1975). *Belief, attitude, intention and behaviour: An introduction to theory and research.* Addison-Wesley, Reading, MA.
Fishbein and Ajzen formulated the theory of reasoned action, which was derived from attitude research from the Expectancy Value model. The publication is useful for illustrating how models can be effectively applied to understand and predict behaviour, and provides another example of a cognitive model, though it does not link directly to New Zealand or agriculture. This model also informed the development of the TPB model by Ajzen, (1985, 1991).

Fuglie, F., Bellinger, N., Day, K., Klotz, C., Ollinger, M., Reilly, J., Vasavada, U., Yee, J. (1996). *Agricultural Research & Development, Public and Private Investments under Alternative Markets and Institutions*. USDA Agricultural Economic Report 735.
An analysis on the investment return on publicly funded agricultural research and extension in the USA. It notes that while stronger ownership rights for intellectual property have increased incentives for private investment in agricultural research, key elements still require direct public support. As a result the USDA is developing new mechanisms to build a more effective public-private partnership in agricultural research.

Funk, J. M., Field, C.B, Kerr, S. & Daigneault, A. (2014). Modelling the impact of carbon farming on land use in a New Zealand landscape. *Environmental Science & Policy:* 37, 1-10.
A study which uses modelling to assess the impact of carbon farming on land use in New Zealand. Suggests that farmers who are cautious to invest in forestry is due to factors such as uncertainties regarding scientific measurements, carbon prices and policy. Asserts that the environmental outcome of policy instruments is generally much lower than its potential. Has relevance to policy design for greenhouse gases as provides several recommendations for policy makers.

Greenhalgh, T., Robert, G., Macfarlane, F., Bate, P. & Kyriakidou, O. (2004). Diffusion of innovations in service organisations: Systematic review and recommendations. *The Milbank Quarterly*, 82, 581-629.
In this paper, the diffusion of innovation theory is reviewed and critiqued. The theory was originally designed to model the uptake of agricultural technology in the US, while this study applies it to other fields. Recognises there are a number of limitations to the model. Provides useful recommendations about how use of the model can be optimised.

Giera, N., Meister, A., & Buchan, D. (2006). *Bridging the gap between environmental knowledge and research, and desired environmental outcomes to achieve sustainable land management.* Report to MAF Policy. www.maf.govt.nz
A three-phase, research project commissioned by MAF Policy, which looked to identify successful and sustainable approaches for integrating environmental knowledge, research and actual land management practices. The report analyses why these transfer practices are successful. Suggests the characteristics of technology, practices and individuals which can influence the rate of adoption. Also notes that as profit is a key driver of decisions, the lower the perceived profitability of an innovation, the stronger the goals of a farmer for conservation must be in order for adoption to occur. Giera, a financial and economic consultant, is highly involved in environmental sustainability for the primary sector. Meister specialises in science policy and adoption, while Buchan has extensive experience with theories and models in behaviour change and adoption.

Harrison, J.A., Mullen, P.D. & Green, L.W. (1992). A meta-analysis of studies of the Health Belief Model with adults. *Health Education Research,* 7.
The HBM model used by Hochbaum, (1958) Rosenstock (1966), Becker (1974) and Sharma and Romas, (2012) has been reviewed by Harrison, Mullen and Green. The paper generally criticises the model, suggesting it has weak predictive power and can only predict around 10% of behavioral variance. Findings from this paper can be used to consider whether models such as the HBM are appropriate for predicting behaviour change.

Hochbaum, G. (1958). *Public participation in medical screening programs: a socio- psychological study*. (Public Health Service Publication No. 572). Government Printing Office, Washington, D.C.
Hochbaum uses the HBM as part of his socio- psychological study as part of his study into medical screening programs.

Jaffe, A.B., & Stavins, R.N. (1994). The energy paradox and the diffusion of conservation technology. *Resource and Energy Economics:* 16, 91-122
Jaffe & Stavins develop a framework for the gradual diffusion of cost-effective energy conservation technologies. The results of the study found a number of reasons why the process of technology uptake is gradual, such as information problems and unobserved costs. Indicates how alternative policy instruments such as economic incentives, can increase the speed of uptake. The study was not based on agriculture or greenhouse gas emissions. However, the reason for gradual technology-diffusion when improving energy efficiency can be compared to an agricultural context.

Johnson, D.W. (1979). *Educational Psychology.* Prentice Hall Inc., Englewood Cliffs, NJ.
Book which explores different types of psychological learning. Johnson asserts that cognitive and behavioural approaches are the two major types of psychology learning. Cognitive learning is described by Johnson as the acquisition of cognitive structure through insight, and is not necessarily observable. Information is integrated into knowledge a person understands. Using a behavioural approach, learning is an observable change in a person's behaviour shaped by their environment. Of relevance for understanding how to maximise the effectiveness of knowledge transfer through extension.

Journeaux, P.R. (1985). *Increasing the Rate of Adoption*. Unpublished Masterate essay

A discussion around the psychology of learning, and how beliefs, attitudes and values influence farmer behaviour. It discusses farmer motivation, and how innovations are adopted by farmers, and makes recommendations on the implications of this for extension strategies.

Journeaux, P.R., Stephens, P. (1997). *The Development of Agricultural Advisory Services in New Zealand*. MAF Policy Technical Paper 97/8. ISSN 1171-4662. ISBN 0 478 07453 0.
A paper in two parts; the first discusses the history of government-funded advisory services through to the late 1960's, while the second part updates this through to the cessation of the service in the early 1990's, discusses the impact of this, and the rationale behind public versus private provision of such a service.

Journeaux, P. (2009). *Developing an institutional model for the extension and adoption of environmental best management practices by pastoral farmers in New Zealand.* Master's Thesis. University of Waikato, Hamilton, New Zealand.
Journeaux explores the issues faced in the practice of extension of environmental Best Management Practices in New Zealand and proposes strategies for moving forward. Asserts there has been little co-ordination between organisations involved. Includes a literature review on adult learning, extension theory and extension practice in New Zealand, as well as findings from an individual and focus group survey. Includes list of survey and interview questions in the appendix. Provides five key factors which must be fulfilled in order to improve on-farm adoption. Being New Zealand focused, it is a highly relevant resource.

Keeble, B., Wright, V., & Kaine, G. (2012). *A case study of co-production to support sustainable irrigation objectives in Victoria.* Goulburn Broken Catchment Management Authority, Victoria, Australia.
A case-study which examines co-production, a functional relationship agencies have with their client for interventions. Describes the importance farmers place on having interpersonal relationships with agency staff. Suggests characteristics of agencies which are likely to encourage co-production and key actions encouraged to maintain relationships with farmers. Keeble and Associate Professor Wright are both from University of New England, while Kain is a specialist in market segmentation research in Australia and New Zealand. Report is based on Australian farmers; however, it is useful for comparing to extension principles applied in New Zealand. Identification of different groups of farmers potentially useful for those working with behaviour change of farmers or achieve adoption of new technology.

Kaine, G., Cowan, L., & Wright, V. (2010). *Assessing the tactical and strategic flexibility of farms.* Practice Change Research Working Paper 02/10. Victorian Government Department of Primary Industries, Tautara, Australia.
Study which analyses the flexibility of farming systems. Describes ways in which farms can manage critical inputs – one by substituting other inputs, the other is change the output mixture or dependence on the critical input. This will help maximise profitability and ability to adapt to fluctuations in input availability. Demonstrates four classifications of farm flexibility. Suggests that for sheep and beef farms, the ability to allocate resources efficiently is key to business success, whereas dairy farms are able to alter inputs more easily but their output mix is constrained by capital investment. Kaine is a specialist in market segmentation research, Cowan a senior researcher in agricultural policy, and Wright an Associate Professor at the University of New England. This study provides a helpful information for improving farm flexibility which may be beneficial for evaluating mitigation strategies.

Katz, E., Levin, M.L., & Hamilton, H. (1963). Traditions of research in the diffusion of innovations. *American Sociological Review:* 28, 237-252.
A paper which defines the process of diffusion of new ideas or practice using an "accounting scheme" of elements. Gives a clear definition for the diffusion of innovations. Several diffusion studies from an array of fields are reviewed. Focusses on reviewing historic studies of diffusion and concludes with suggestions for future research. While not directly related to agriculture, many principles can still be applied though much of the discussion is of little relevance knowledge transfer or extension in agriculture.

Keeble, B., Wright, V., & Kaine, G. (2012). *A case study of co-production to support sustainable irrigation objectives in Victoria.* Goulburn Broken Catchment Management Authority, Victoria, Australia.
A paper which defines the process of diffusion of new ideas or practice using an "accounting scheme" of elements. Gives a clear definition for the diffusion of innovations. Several diffusion studies from an array of fields are reviewed. Focuses on reviewing historic studies of diffusion and concludes with suggestions for future research. While not directly related to agriculture, many principles can still be applied. However, much of the discussion is of little relevance to knowledge transfer or extension in agriculture.

Kelly, G.A. (1955). *The Psychology of Personal Constructs*. Norton and Company Inc, New York.
Kelly postulates that a person's processes are psychologically channelized by the ways in which he anticipates events; that the person is a whole and integrated individual who may be viewed as a process or form of motion as opposed to an object temporarily pushed or pulled into motion. He notes that a person anticipates events by construing (placing an interpretation upon) their replications (placing an interpretation upon). He also notes that persons differ from each other in their construction of events.

King, B., Nettle, R. (2013) *Private-public advisory networks: A case study of Australian dairy pasture seed* Extension Farming System Journal Vol 9 No. 1
A paper that explores dairy farmer networks in Australia with respect to seeking advice about seed selection for sowing pastures. The paper shows that both formal and informal relationships are important for sharing between researchers, advisors, seed companies, and farmers who comprise the dairy pasture seed network. Farm system advisors, both public and private, tend to refer farmers to seed specialists for advice about specific varieties, highlighting how specialised pasture seed knowledge has become

Leslie, M., Aspin, M. & Clark, H. (2008). Greenhouse gas emissions from New Zealand agriculture: issues, perspectives and industry response. *Australian Journal of Experimental Agriculture:* 48, 1-5.
Provides an overview of research conducted in New Zealand and research from 2007 and onwards in regards to greenhouse gas emissions. Includes an overview of the Pastoral Greenhouse Gas Research Consortium, including its achievements and future challenge. Leslie *et al.* recognises it will take time to achieve emissions reductions at a farm scale. Suggests solutions needed to be proven at a farm scale and delivered using appropriate mechanisms. Leslie is a researcher at the Pastoral Greenhouse Gas Consortium, while Aspin and Clark are researchers for AgResearch. Features a large number of current statistics relating to greenhouse gas emissions, referenced from reliable sources such as the Ministry for the

Environment. Useful for obtaining an overview of research that has already been conducted and how this can influence future policy.

Li, S., Juhász-Horváth, L., Harrison, P.A., Pintér, L. & Rounsevell, M.D.A. (2017). Relating farmer's perceptions of climate change risk to adaption behaviour in Hungary. *Journal of Environmental Management:* 185, 21-30.
A study which explores the relationship between farmer's perceptions of climate change risks to their adaption behaviour in Hungary. Suggests that the relationship between belief and adaptation behaviour may not be a driver of actual adaptation. Findings from the study support the theory of targeting innovators and early adaptors to achieve effective diffusion of new practices. Li *et al.* asserts the need to provide information on profitability and business advice when promoting adaptation, which is something that should be considered when developing policy in New Zealand.

Libecap, G. D., 2014. Addressing Global Environmental Externalities: Transaction Costs Considerations. *Journal of Economic Literature 2014, 52*(*2*)*, 424–479.* https://www.aeaweb.org/articles?id=10.1257/jel.52.2.424
Libecap discusses understanding why some global environmental externalities are addressed effectively, whereas others are not, and the analysis of transaction costs as a framework to defining the property rights to mitigation benefits and costs.
This approach views international cooperation as a contractual process among country leaders to assign those property rights. Leaders cooperate when it serves domestic interests to do so. The demand for property rights comes from those who value and stand to gain from multilateral action. Property rights are supplied by international agreements that specify resource access and use, assign costs and benefits including outlining the size and duration of compensating transfer payments, and determining who will pay and who will receive them. Four factors raise the transaction costs of assigning property rights: (i) scientific uncertainty regarding mitigation benefits and costs; (ii) varying preferences and perceptions across heterogeneous populations; (iii) asymmetric information; and (iv) the extent of compliance and new entry.

Lindsay, J.J. & Strathman, A. (1997). Predictors of recycling behaviour: an application of a modified health belief model. *Journal of Applied Social Psychology,* 27, 1799-1823.
Lindsay and Stratman examine the recycling behaviour of Missouri residents by applying the heath belief model (HBM) as part of their investigations into environmentally related behaviour. While the model was designed for the healthcare context, the paper showed that the HBM can be used for of other types of behavioural analysis, with results suggesting the HBM was a useful predictor of recycling behaviour. Perceived barriers, perceived likelihood of negative outcomes, self-efficacy and consideration of future consequences were all found to be useful predictors. As with several of the papers which use the HBM, there is no direct relation to New Zealand agriculture or emissions of biological gases. Again the outcomes from the research can be used to inform decisions made when developing policy regarding biological gases in New Zealand, especially given the findings from the use of the HBM are consistent with those from other papers.

Lobell, D., Baldos, U.L.C., & Hertel, T.W. (2013). Climate adaption as mitigation: the case of agricultural investments. *Environmental Research Letters:* 8, 1-12.

A study of USA farmers which investigates potential co-benefits of adaptation from land use change. Uses a model called SIMPLE to model a scenario of global adaptation. Suggests that investing globally the least developed areas of the world will have little effect, and efforts should instead be targeted at highly productive, land scare regions. Found that mitigation co-benefits can be achieved through broad-based efforts to adapt agriculture to climate change.

Manjala, T. (2014). *Good to great extension. Influencing on farm change at pace and scale.* Report completed for Nuffield Programme. Nuffield New Zealand.
Report prepared as part of The Nuffield Scholarship. It is aimed at professionals whose role is to influence and encourage practice change, especially in agriculture and those who wish to increase the value they offer. Manjala looks at ways farm changes can be achieved through innovative extension practices at pace and scale. The most useful part of this research is Manjala's interview with Bandura, a professor at Stanford University who develops and tests change principles. Bandura suggests to change people you must change their behaviour, which requires changing the way people think and the need for self-efficacy in order for people to engage in new behaviours. Features four brief case-studies. Provides recommendations to extension professionals, extension managers and extension funders along with a checklist for change practice.

Marsh, S.P., Pannell, D.J., & Linder, R.K. (2000). The impact of agricultural extension on adoption and diffusion of lupins as a new crop in Western Australia. *Australian Journal of Experimental Agriculture:* 40, 571-583.
Paper which investigates the influence agricultural extension has on adoption and diffusion, using planting of lupins in Australia as a case study example. Illustrated that extension efforts from the public and private sectors increased the rate of adoption. Despite the study only focusing on one specific practice, the findings can be applied to extension and adoption in general.

McManus, G., Powe, M. (2007). *The Entrepreneurial Process.* Marcus Powe, Melbourne, Australia.
McManus and Powe look at the essentials of starting, growing and managing businesses or organisations. Discusses marketing approaches and the importance of targeting innovators and early adopters, based on the bell-shaped curve for rates of adoption. The publication is not specifically based on agriculture, but the same business opportunities and principles can be applied to this context.

Ministry for the Environment (MfE). (2015). *A Generation from now – Our Long-Term Goals*. Ministry for the Environment, Wellington, New Zealand.
Report which outlines the long-term outcomes and targets, along with intermediate outcomes and targets, for air, atmosphere and climate, fresh water, land, marine, urban, and environmental management system, for New Zealand.
Useful for showing the multi-faceted nature of land management, illustrated by the desired outcomes of the strategy which are described in the report.

Nimmo-Bell. (1999). *Evaluation of the Focus Farm and Orchard Programme*. MAF Policy Technical paper 99/6. ISSN 1171-4662, ISBN 0 478 07517 0

http://www.maf.govt.nz/mafnet/rural-nz/profitability-and-economics/performance/focus-farm-evaluation/

A paper evaluating the Focus Farm and Orchard Programme in New Zealand. Highlights the complexity in setting environmental indicators to measure outcomes such as those in MfE (1996), and the extensive length of time programmes must operate for to ensure these outcomes are achieved. Based on this, Nimo-Bell suggest extended funding is required to finance these extension programmes, since environmental outcomes may not be achieved for 20-30 years. Also recognises the need for farmers to be financially secure before they will make significant provision for environmental concerns. Sustainable land management initiatives must also clearly link environmental and economic sustainability to improve uptake of environmental practices. While the entire paper is not relevant to this project, the findings can be used when considering the development of effective, extension programmes for biological gases.

OECD (2012). *Farmer behaviour, agricultural management and climate change.* OECD Publishing, Paris.

Comprehensive report by OECD (Organisation for Economic Co-operation and Development) which reviews the relationships between farmer behaviour, agricultural management and climate change. The report illustrates that the actual environmental outcomes of policy instruments tend to be less than their potential. Provides four useful recommendations for policy makers in regards to climate change in agriculture.

OECD. (2015). *Fostering Green Growth in Agriculture: The Role of Training, Advisory Services and Extension Initiatives.* OECD Green Growth Studies, OECD Publishing, Paris.

This report looks at the role advisory services, training and extension initiatives play in supporting agricultural growth while minimising environmental impacts and adopting environmentally sustainable farming practices. Provides guidelines and recommendations for optimising successful extension measures that enhance adoption of sustainable practices. Also investigates OECD countries such as New Zealand, which have supported environmentally friendly practice in agriculture. Identifies the main roles for advisors being to incentive farms through raising awareness of the benefits of different measures, and secondly to encourage and facilitate adoption of appropriate agri-environmental land management practices. Suggests extension programmes must be specific to each system, rather than a blanket approach. Similar to Nimmo-Bell (1999), the report notes the complexity of measuring outcomes from extension initiatives. This resource is relevant to developing extension strategies appropriate for achieving reductions in greenhouse gas emissions in agriculture.

Pannell, D.J. (2008). Public benefits, private benefits, and policy mechanism choice for land-use change for environmental benefits. *Land Economics,* 84(2), 225-240.

A paper which examines the fundamental challenge of getting farmers to adopt and maintain new farming systems. Identifies conditions necessary for farmers to adapt an innovative farming system and discusses challenges in fulfilling these. Pannell focuses on farming systems based on the mimicry of natural resources. Professor Pannell is Head of School of Agriculture and Resource, director at The University of Western Australia, and director at the Centre for Environmental Economics and Policy. He has authored 200 journal articles and book chapters, and received the Eureka Prize for Interdisciplinary Research. Useful for identifying requirements to successfully achieve adoption of new systems by farmers.

Parminter, T.G. (2006). T*heoretical Frameworks for Policy: A description of world views underlying alternative decision making frameworks and how these can influence the formulation of policy for biodiversity.* Unpublished AgResearch science report. http://www.agresearch.co.nz/socialresearch/pdf/document-15.pdf

Reports alternative decision making frameworks and how these can influence the formulation of policy for biodiversity which cites two useful resources. Boxelaar *et al.* explains that knowledge transfer will only be effective if the sender has a comprehensive understanding of the context that the receiver will interpret information. Understanding this concept should influence how extension programmes for greenhouse gas mitigation are developed. Paine (1997) suggests change occurs are a result of the interactions between farmers and different actors such as service providers or scientists. This illustrates the importance of actors working together to overcome issues, such as helping farmers to reduce biological gas emissions.

Prochaska, J.O. (1979). *Systems of psychotherapy: A transtheoretical analysis.* Dorsey Pres, Homewood, IL.

Prochaska use the Status of Change model as a method to predict and explain behaviour change. The Stages of Change model is a cognitive model which categories individuals into five categories that represent different milestones of change along a continuum of behaviour change. The book is not directly applicable to agriculture but the resource does provide evidence that the Status of Change model can be applied as an effective model for evaluating behaviour change.

Prochaska, J. & Diclemente, C. (1983). Stages and processes of self-change of smoking: Toward an integrative model of change. *Journal of Consulting and Clinical Psychology*, 51, 390-395.

Study which uses the Status of Change model to understand behaviour change in relation to smoking. Study looked at 872 people changing their smoking habits on their own. Identified smokers went through five stages of change, which fit the Status of Change model. Less applicable to extension and agriculture than other papers, but provides another example of the use of the Status of Change model to understand behaviour change.

Prochaska, J.O., Diclemente, C.C. & Norcross, J.C. (1992). In search of how people change - applications to addictive behaviors. *American Psychologist*, 47, 1102-1114.

Reviews the use of the Stages of Change model. Recognises the limitations of the model, including that the model is egoistic, and does not consider economic, environmental or social factors. These limitations should be considered when using or developing models for predicting environmental behaviour change in New Zealand.

Rayner, T. (1990). The Seeds of Change. In Sandry, Ron., & Reynolds, Russell (Eds), *Farming without subsidies: New Zealand's recent experience* (pp14-24). MAF, Upper Hutt.

Explains why agricultural subsidies were put in place for New Zealand farmers by the government in the 1960's. Author Tony Rayner was a highly-regarded professor of economics at Lincoln University, who had held positions at M.I.T., Oxford and the University of Tokyo. Paper is of limited usefulness in regards to knowledge transfer or greenhouse gas emissions, but provides historic information to briefly set the scene in regards to the impact government policy can have on farmer behaviour and the environment.

Reynolds, Russell., & SriRamaratnam, S. (1990). Assistance to Agriculture. In Sandry, Ron., & Reynolds, Russell (Eds), *Farming without subsidies: New Zealand's recent experience* (pp157-182). MAF, Upper Hutt.

Brief piece in a paper which outlines the history of farming subsidies in New Zealand, and the impact this had on livestock numbers. Useful for obtaining background information but little relevance to knowledge transfer, extension or environmental practices.

Rhodes, T., Willis, B., & Smith, W. (2000) *The Impediments to Optimising the Economic and Environmental Performance of Agriculture – A study of Issues Affecting North Island Hill Country Farmers.* MAF Policy Technical paper 2000/17. http://www.maf.govt.nz/mafnet/rural-nz/profitability-and-economics/performance/impediments-to-optimum-performance/

A technical paper by MAF Policy on optimising economic and environmental performance of agriculture. The study involved an analysis of Meat and Wool Economic Service data for North Island hill country farms, an in-depth survey of 35 farm households, six focus group meetings with farmers, and a literature review on impediments to optimising agricultural economic and environmental performance. Farmers identified that the greatest threat to sustainable agriculture is the vulnerability faced by small rural towns. Concluded that sustainable land management was not linked to farm size or profitability, but rather explained by an array of personal and community values, which often over-rode financial conditions. Provides evidence of significant commitments by North Island hill country farmers to sustainable land management. Limitation of the paper is that it only considered North Island hill country farmers, rather than across different farm systems.

Rodriguez, J.M., Molnar, J.J., Fazio, R.A., Sydnor, E., & Lowe, M.J. (2009). Barriers to adoption of sustainable agricultural practices: Change agent perspectives. *Renewable Agriculture and Food Systems,* 24(1), 60-71.

The study involved a comprehensive survey of extension practitioners across the USA which recognised the importance of focusing extension efforts on specific production systems. These findings agree with both Brown & Bewsell (2010) and the OECD (2015). Makes suggestions on what types of farmers' environmental extension programmes should be targeted at to maximise impact. Also identifies several barriers to uptake of environmental practices. Despite primarily being a USA study, the same barriers were again identified by New Zealand farmers in van Reenen's (2012) farmer survey. This makes it a very relevant resource for identifying what barriers must be overcome in order to achieve adoption of new practices to mitigate greenhouse gas emissions.

Rogers, E.M. (1962, 1983). Diffusion of Innovations. Free Press, New York.

Rogers was a professor and chair of the Department of Communication and Journalism at the University of New Mexico. The book is renowned for its discussion on diffusion of innovations and explains how new ideas spread via communication channels over time. Explores historical research, rates of adoption and innovation in organisations. Features a number of case studies, Agricultural Extension inclusive. Rogers uses the bell-shaped curve to explain adaption of innovations and management changes, which is now widely used amongst extension and technology transfer practitioners.

Rogers, E.M. & Shoemaker, F.F. (1971). *Communication of innovations; a cross-cultural approach.* Free Press, New York.
Book which explores the diffusion of new ideas and innovations through addressing how social systems are swayed by the influence of new ideas. Suggests that only a very small proportion of innovations are actually adopted. Rogers and Shoemaker revised the initial bell-shaped adoption curve developed by Rogers. An illustration of this curve is included in the book which helps to clearly demonstrate its use. This book is highly valuable for understanding the adoption of innovations and new practices for sustainable agriculture.

Rollins, T. (1993). Using the Innovation Adoption Diffusion Model to target Educational Programming. *Journal of Agricultural Education:* 34(4), 46-54.
Rollins agrees with the generalisations regarding innovativeness made by Rogers & Shoemaker (1971), including the use of a 5-step approach to adoption similar to that of Rogers & Shoemaker. Also confirms their findings that frequency of the numbers of adoption of an innovation follow a bell-shape curve, and comprise of five characteristics. By providing further evidence on the theory of adoption, this resource aids in developing appropriate mechanisms to help mitigate greenhouse production in New Zealand agriculture.

Rosenstock, I.M. (1966). Why people use health services. *Milbank Memorial Fund Quarterly,* 44, 94-124.
This paper was written with the aim of increasing professional workers knowledge in the health sector of research findings and help them to understand behaviour. Examines the health belief model (HBM). By understanding and predicting behaviour through the model, changes in behaviour can be better achieved. Findings of the cause of behaviour change could be applied to an agricultural context.

Salmon, P.W. (1980). *A Personal Construct Theory Approach to Agricultural Extension.* School of Agriculture and Forestry, University of Melbourne.
Salon adopts Kelly's (1955) Personal Construct Theory to adult education in agricultural extension. Each person develops their own unique system of ideas, which is their view of the world. Suggests farmers will only learn elements provided by an advisor that fit within the farmer's construct system, not necessarily all information provided. Argues that advisors should create environments which encourage farmers to undertake personal experimentation.

Schroder, H.M., Driver, M.J., & Steufort, S. (1967). *Human Information Processing*. Holt Rinehart and Wintson Inc., New York.
Illustrates that people should be seen as individuals who each learn and process information differently. Schroder was professor of psychology at Princeton University. The 'Schroder framework' is an objective measure of leadership behaviour critical for managing complexity and change, used by many leadership consultants. Not highly relevant to the topic of agricultural extension and greenhouse gases, but useful to confirm the findings of other studies such as Brown & Bewsell (2010).

Sharma, M. & Romas, J.A. (2012). *Theoretical foundations of health education and health promotion*. Jones and Bartlett Learning, London.
Similar to Hochbaum, 1958; Rosenstock 1966; and Becker, 1974, Sharma uses the Health Belief Model to predict and explain health behaviours. This resource is limited in its application to

this topic as it is not New Zealand based or related to agriculture and greenhouse gases. However, the principles learnt from this book can be applied

Smith, W., Kelly, S., Rhodes, T. (2008) *Information, Decision and Action - The Factors that Determine Farmers Environmental Decision-making.* Contract report to MPI.
This report examines the psychological, social and other factors that determine farmers' different responses to environmental change. In particular, it explains why some farmers implement environmental strategies but others remain intransigent and resistant to change.

The report identifies four paradoxes in farmers' values, attitudes and behaviours and explains these within a simple model framework. This is then used to support the need for a new research agenda which gives greater priority to social and cultural structures, institutional arrangements and policy and economic incentives. It is argued that it is only through greater attention to these contextual factors that the necessary value shift and behavioural changes to support the development of a more sustainable agriculture will occur.

Statistics New Zealand. (2011). *Agricultural Production Statistics: June 2011 (final).*
http://www.stats.govt.nz/browse_for_stats/industry_sectors/agriculture-horticulture-forestry/AgriculturalProduction_final_HOTPJun11final.aspx

Annual report providing statistics and brief commentary on national and regional production trends for agriculture. Data available in excel format. Useful for investigating both historic trends and obtaining current data. Limited usefulness given this resource was produced in 2011, as many statistics may have changed since then, though updated versions are available (latest being 2015/16). Commentary is limited to focusing on the numbers, with brief details on what had caused changes in production.

Taylor, R., Cochrane, P., Stephenson, B., & Gibbs, N. (1997). *The State of New Zealand's Environment 1997*. Ministry for the Environment, Wellington
Describes the impact historic, economic factors such as government subsidies have had on the land and environment in New Zealand. Notes how the introduction of subsidies for pastoral farming resulted in significant vegetation clearance, while the removal of subsidies caused a reversion to exotic forest, and marginal pastures on erodible slopes were allowed to revert to scrub and native forest. Useful for illustrating the effect Government policies can have on farmer decision-making and behaviour, and the associated environmental impacts. Highlights the importance of recognising possible consequences when developing new policies which could result in land use change.

Tough, A. (1971). *The Adult's Learning Projects.* Research in Education Series 1. Ontario Institute for Studies in Education.
A book which provides a comprehensive picture of adult learning, based on eleven major research studies. Tough, a researcher specialising in adult learning, suggests most adults in learning projects are motivated by some immediate problem or skill, and few are interested in mastering an entire body of subject knowledge. Different learning methods from self-planned learning to attending conferences are also covered. Benefits of one-on-one learning are also highlighted.

Tough, A. (1982). *Intentional Changes.* Follett Publishing Co., Chicago

Book focuses on understanding the natural process of intentional change and how professionals can provide effective help in this process. Tough suggests learners themselves plan the majority of learning projects, followed by a group or leader. Emphasises learning efficiency is almost always greater if instructors are used in one-on-one situations than in groups. Seven potential strategies for improving professional practice and policy are suggested by Tough. Not focused on agriculture but does relate some aspects to rural sociology. Much of the book's emphasis is on numbers rather than discussion of concepts. Useful table comparing individual's contributions in a one-on-one learning situation with those in groups. Helpful chapter on optimal amounts of professional control.

Tyler, L., & Lattimore, R. (1990). Assistance to Agriculture. In Sandry, Ron., & Reynolds, Russell (Eds), *Farming without subsidies: New Zealand's recent experience* (pp60-79). MAF, Upper Hutt.
Provides historical context on the agricultural subsidies introduced by the New Zealand government in the 1960s. Used to detail information on the Livestock Incentive Scheme and Land Development Encouragement Loan (LDEL) Scheme, established in 1976 and 1978 respectively. This resource is not directly related to agricultural extension or environmental practices. However, it can be used to demonstrate the influence government interventions can have on farmer decision-making.

UMR Research. (2014a). *Red Meat Profit Partnership: Sheep and beef farmer segmentation.*
Study conducted by UMR Research as part of the Red Meat Profit Partnership in which 789 New Zealand sheep and beef farmers were surveyed. Identifies five different farmer segments, describes each of their characteristics and willingness to change. The segments identified by UMR are similar but not identical to those of Waters et al (2009). Also examines barriers to change and possible mitigations for these. Asserts the key message that farmers are willing to change but need to let them make up their own minds. UMR Research are a market research and evaluation company specialising in rural research. This information is useful as it indicates to policy-makers that farmers will be more receptive to change and adopting sustainable practices if it is their own choice, not dictated by regulation. Thus, involve them in the decision process and give them time to process new ideas.

UMR Research. (2014b). *Red Meat Profit Partnership: Māori farming qualitative report.*
Study also conducted by UMR Research focusing on Māori farming, based on the understanding that Māori have a unique way of viewing and sharing ownership of their land (whenua). Involved in-depth interviews with ten Māori agribusiness leaders who had connections to farms and a strong knowledge of the area. Report is largely comprised of direct responses to interview questions provided by Māori industry leaders and farmers. Main differences identified between Māori and Pakeha owned farms were a greater focus on the long term, different management and governance structures. Also identifies three segments of Māori farmers and the effectiveness of information transfer to these groups. Research is useful in improving communication and cultural awareness when developing policy and extension programmes.

van Reenen, E. (2012). *Increasing uptake of environmental practices on sheep and beef farms*. Kellogg Report. Lincoln University, Canterbury, New Zealand.
As part of a Kellogg Rural Leadership Programme report, van Reenan investigates the barriers of uptake of environmental practices. Study involved obtaining perspectives of farmers from Waikato, Bay of Plenty and King Country through a number of interviews, along with a number

of environmentalists. Concluded that to help increase farmer uptake of environmental best practices, industry must promote the benefits and provide practical solutions. van Reenan, a New Zealand agricultural and environmental consultant, has extensive experience in development and delivery of extension programmes, and development of climate change policy. Demonstrates that environmental policies must be deemed by farmers to be workable and beneficial. Have to be realistic in terms of everyday, farm management. A limitation of the study is that it looks at sheep and beef farmers from a limited region of New Zealand.

Vanclay, F. (2004). *Social principles for agricultural extension to assist in the promotion for natural resource management*. *Australian Journal of Experimental Agriculture:* 44, 213-222.
Paper which focuses on the 'people' aspect of farming, in relation to agricultural extension. Vanclay, a Professor of Rural Sociology, argues that agriculture has been too focused on the application of science, with social issues often being overlooked. Asserts the importance of recognising social factors when encouraging adoption of new practices. Vanclay concludes farming is a way of life, and therefore has strong connections with the land and environment. Presents twenty-seven principles, including recognising social diversity of farmers and awareness of farming as a social activity. Helps to better understand the depth and intricacy of agricultural farming from a sociological viewpoint. Gives a broader, more holistic perspective.

Waters, W., Thomson, D., & Nettle, R. (2009). Derived attitudinal farmer segments: A method for understanding and working with the diversity of Australian dairy farmers. *Extension Farming Systems Journal*: 5(2), 47-57.
Paper which examines different farmer groups and their associated characteristics. Identified six manageable segments of the farming population to better target technology development, extension and communication using the Derived Attitudinal Farmer Segments method. Study involved interviews and focus groups with farmers. Segmentations are defined and implications for research, development and extension are explored. Identifies that it is difficult to segment farmers without defining their characteristics as being good or bad management practices. Found prediction of practice change was not accurate based on segments alone. However, stronger relationships could be found when segments were combined with a region and enterprise scale. Relevant to people who practice extension, those involved in developing extension programmes, researchers and investors. Asserts there is a complex interaction of individual characteristics and their situational context, which requires extension resources to be efficiently and effectively allocated. Identifies farmer group segmentations similar to that of UMR (2014). Research is Australian based but concepts are again relatable to New Zealand agriculture and extension.

Woog, R.A. (1982). *Agricultural Extension As I Have Experienced It*. Paper to ADS Extension Workshop.
Like Salmon (1980), Woog adapts Kelly's (1955) Personal Construct Theory to adult education in agricultural extension. Asserts that a farmer will only learn elements which fit their system of ideas, and not necessarily all information provided, which agrees with Salon (1980). Also suggests that in order to be better positioned to change the attitude of a farmer, advisors must be able to see the mental picture a farmer has of themselves and their farm.

Wright, V. 2011. *Rates of Adoption: The Diffusion of Agricultural Innovations.* Service Design Research Working Paper 06-11. Victorian Government Department of Primary Industries.

Estimating the extent and rate of adoption is essential to assessing the benefits to be had from research into agricultural innovations and evaluating the success of marketing and extension programs. While advances have been made in regard to methods for predicting the likely extent of adoption of agricultural innovations, the same cannot be said in regard to methods for predicting the rate of adoption of agricultural innovations.
In this paper, the economic literature on consumer adoption and organisational adoption are reviewed to identify how decisions by farmers about the adoption of agricultural innovations might best be described and modelled. The results provide a foundation for developing better methods for predicting the rate of adoption of agricultural innovations.

Yeo, B.L., Anastasiadis, S., Kerr, S., Springborn, M., & Brown, O. (2014). *Synergies between policy instruments for regulating interdependent pollutants: a numerical analysis of emissions trading schemes in New Zealand*. Draft paper prepared for the NZARES conference, Motu Economic and Public Policy Research, Wellington.
Paper targeted at policy makers and those who advise them, which builds on the findings of Smeaton *et al.* (2011) by investigating the potential benefits of holistic policy approaches for pollutants. Suggests one type of pollution may interact with efforts to reduce other types of pollution, such as nutrient loss or and greenhouse gases. On this basis, Yeo *et al.* advocates the use of a holistic policy approach which deals with multiple independent pollutants. Found that there is good cause for policy-makers to consider a broader approach than solely carbon pricing. Study examines two, tradable pollution schemes, one for Nitrogen and another for Greenhouse Gases, similar to the Nitrogen Trading system operating in the Lake Taupo Catchment. Lake Rotorua Catchment is also used as a case study, where local government are considering implementing a nutrient trading scheme. However, it does not consider how this can be applied to extension or farmer learning.

15.0 REFERENCES

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16.0 APPENDIX ONE: OVERVIEW OF THEORIES OF HUMAN BEHAVIOUR & THE SOCIAL ENVIRONMENT

(from Forest Research: Forestry, sustainable behaviours and behaviour change – setting the scene. http://www.forestry.gov.uk/pdf/behaviour_review_summary.pdf/$FILE/behaviour_review_summary.pdf)

THEORY OF HUMAN BEHAVIOUR	FOCUS OF THEORY	MAIN CONCEPTS RE: HUMAN BEHAVIOUR	SOME THEORISTS	SOME PRACTICE APPLICATIONS	SOME PRACTICE INTERVENTIONS
SYSTEMS THEORY **Includes:** **Ecological Systems** *[Systems Perspective]*	How persons interact with their environment	*Persons are in continual transaction with their environment *Systems are interrelated parts or subsystems constituting an ordered whole *Each subsystem impacts all other parts and whole system *Systems can have closed or open boundaries *Systems tend toward equilibrium	Parsons Merton Germain Gitterman	*Useful for developing holistic view of persons- in-environment *Enhances understanding of interactions between micro-meso-macro levels of organization *Enriches contextual understanding of behaviour	*Strengthen one part of the system or subsystem to impact the whole system *Ecomaps & genograms for understanding system dynamics *Networking & referrals to facilitate change
Includes: **Family Systems** *[Systems Perspective]*	How the family system affects the individual and family functioning across the life-span	*Individual functioning shapes family functioning and family systems can create pathology within the individual *Boundaries, roles, communication, family structure influence family functioning	Bowen Satir Minuchin Carter & McGoldrick	*Useful for understanding family systems and life cycles over multiple generations	*Assessment of family development and life- cycle transitions *Use of multi-generational genograms *Use of family and parent coaching
BEHAVIOURISM & SOCIAL LEARNING THEORY **Includes: Cognitive theory, Behavioural theory,** **Social Learning theory** *[Social Behavioural Perspective]*	How individuals develop cognitive functioning and learn through acting on their environment	*Imitation & reaction to stimulation shape behavioural learning *Knowledge is constructed through children physically and mentally acting on objects *Intelligence is an evolutionary, biological adaptation to environment *Cognitive structures enable adaptation & organization	Pavlov Skinner Watson Piaget Bandura Beck	*Useful for enabling behavioural & symptomatic change *Useful for assessing individual cognitive functioning, group & family interactions	*Behavioural interventions such as classical or operant conditioning, positive or negative reinforcement *Time-limited, problem-focused interventions *Cognitive reframing of automatic thoughts about presenting problems to facilitate change

THEORY OF HUMAN BEHAVIOUR	FOCUS OF THEORY	MAIN CONCEPTS RE: HUMAN BEHAVIOUR	SOME THEORISTS	SOME PRACTICE APPLICATIONS	SOME PRACTICE INTERVENTIONS
PSYCHODYNAMIC THEORY **Includes: Classical psycho- dynamic theory, Ego-psychology, Object-relations theory, Self-psychology** *[Psychodynamic Perspective]*	How inner energies and external forces interact to impact emotional development	*Unconscious and conscious mental activity motivate human behaviour *Ego functions mediate between individual and environment *Ego defence mechanisms protect individuals from becoming overwhelmed by unacceptable impulses and threats *Internalized experiences shape personality development and functioning *Healing occurs through attention to transferences and the treatment relationship	S. Freud Adler Jung Horney A. Freud Kernberg Kohut Klein Mahler Bowlby	*Useful for understanding inner meanings & intrapsychic processes *Useful for understanding motivation, adaptation, & interpersonal relationships *Useful for assessing strengths & ego functioning	Ego supportive treatment: *Clarification, education, & support of adaptive functioning *Empathy & attention to affects and emotions *Understanding of ego defence mechanisms & underscoring of ego strengths *Establishing, building, & using the treatment relationship to facilitate change
PSYCHOSOCIAL DEVELOPMENTAL THEORY *[Developmental Perspective]*	How internal & external forces shape life development, generally by life stages	*Human development occurs in defined & qualitatively different stages that are sequential & may be universal *Individual stages of development include specific tasks to be completed & crises to be managed *Time & social context shape & individualize the meaning of life stages	Erikson	*Useful for understanding individual growth & development across life cycle *Beneficial for assessing individual strengths & deficits	*General assessment of developmental functioning that can be compared with chronological age of the client

THEORY OF HUMAN BEHAVIOUR	FOCUS OF THEORY	MAIN CONCEPTS RE: HUMAN BEHAVIOUR	SOME THEORISTS	SOME PRACTICE APPLICATIONS	SOME PRACTICE INTERVENTIONS
TRANSPERSONAL THEORY *[Developmental Perspective; built upon Humanistic Perspective]*	How the spiritual and religious aspects of human existence can be understood How spiritual development builds upon and goes beyond biopsychosocial development	*Focuses on meaning, connection, and purpose *Some people achieve developmental level beyond the *personal* (ego-based) level into *transpersonal* (beyond self or ego) levels of consciousness and functioning. *There is an inherent tendency to express innate potentials for love, creativity, and spirituality *There is a difference between psychopathological phenomena and spiritual growth experiences	Maslow Jung Fowler Wilber Washburn	*Provides nonsectarian frame for understanding spiritual aspects of human experience *Describes developmental process beyond self actualisation *Provides guidelines for clinical discussions of spiritual or transcendent experiences *Stresses the importance of spiritual and religious support systems for life meaning and well-being	*Assess and understand client's spiritual & faith development *Ethically and appropriately utilize spiritually-derived interventions *Understand and support clients' spiritual and religious beliefs, practices, and support systems
SOCIAL EXCHANGE THEORY *[Rational Choice Perspective]*	How persons minimize costs and maximize rewards through social exchange	*Antecedents, consequences, personal expectations, and interpretation shape and maintain behaviour in the present *Self-interest determines social exchange *Unequal resources determine power inequities and reciprocity is essential *Six propositions: --Success proposition --Stimulus proposition --Value proposition --Deprivation-satiation --proposition --Aggression-approval proposition --Rationality proposition	Homan Thibault Kelley Blau	*Useful for assessing and understanding power inequities and distributed justice *Basis for cost-benefit analysis	*Assess resources and power inequities at the meso-macro level *Facilitate group and community interaction *Maximize costs, minimize rewards in the macro environment

THEORY OF HUMAN BEHAVIOUR	FOCUS OF THEORY	MAIN CONCEPTS RE: HUMAN BEHAVIOUR	SOME THEORISTS	SOME PRACTICE APPLICATIONS	SOME PRACTICE INTERVENTIONS
SOCIAL CONSTRUCTIONISM *[Social Constructionist Perspective]*	How sociocultural and historical contexts shape individuals and the creation of knowledge How individuals create themselves	*All experience is subjective and human beings recreate themselves through an on-going, never static process *Knowledge is created through an interplay of multiple social and historical forces *Social interaction is grounded in language, customs, cultural and historical contexts *All phenomenon, including the sciences, must be approached with doubt in order to understand how people construct reality *Humans are self-interpreting beings	Foucault Berger Luckmann Gergen	*Enhances understanding of individual and cultural connection *Useful for understanding non-dominant and oppressed groups in a non- marginalized manner	*Listen for cultured narratives *Approach practice with a stance of "not knowing" *View practice as "mutual interchange" because relationships have "mutual influence" *Recognize how individuals and groups construct their identities through an ongoing, fluid process
SYMBOLIC INTERACTIONISM *[Social Constructionist Perspective]*	How the "self" is influenced and shaped by social processes and the capacity to symbolize	*Human action is caused by complex interaction between and within individuals *Dynamic social activities take place among persons and we act according to how we define our situation *We act in the present, not the past *Individuals are actors on the stage and take on roles, interacting with the environment	Charon Mead Goffman	*Enhances understanding of the relationship between the individual and society and the "self" as a social process *Provides framework for individual, group, and societal assessment *Provides alternative view of deviance and psychopathology	*Formulate assessment and intervene through understanding roles assumed by individuals and groups through individual and society interaction *Focus on diminishment of the sense of stigma for individuals, families, groups, and communities

THEORY OF HUMAN BEHAVIOUR	FOCUS OF THEORY	MAIN CONCEPTS RE: HUMAN BEHAVIOUR	SOME THEORISTS	SOME PRACTICE APPLICATIONS	SOME PRACTICE INTERVENTIONS
CONFLICT THEORY *[Conflict Perspective]*	How power structures & power disparities impact people's lives	*All societies perpetuate some forms of oppression & injustice and structural inequity *Power is unequally divided & some groups dominate others *Social order is based on manipulation and control by dominant groups *Social change is driven by conflict, with periods of change interrupting periods of stability *Life is characterized by conflict not consensus	Marx Marcuse Haberrmas Feminist theorists and GLBT theorists	*Informs policy and may guide macro-level practice *Useful in formulating assessments involving oppression and client vulnerability *Enhances understanding of conflict between persons, ideas, groups, classes, & larger social structures	*Listen for evidence of oppression within individuals, groups, and communities *Pay attention to the role of conflict leading to client vulnerability *Organize to alter power relationships *Recognize that dominant and subordinate groups compete for resources
CONTINGENCY THEORY *[Systems Perspective]*	How individuals & groups gain power, access to resources, & control over their lives, often through collective action	*Groups are open, dynamic systems with both change and conflict present *Groups are stratified, with different and unequal levels of power and control *High discrimination and low privilege equals low opportunity *Oppression occurs when upward mobility is systematically denied *The social context must be critiqued and deconstructed *Assumptions for analysing organizations: --there is no best way to manage organizations --there must be a match between the environment and internal resources --the design of the organization must fit with the environment	Weber Scott Lawrence Lorsch March	*Useful in macro practice through providing framework for community work on behalf of the powerless and stigmatized *Provides assessment for identifying power blocks contributing to powerlessness *Provides understanding of the objective & subjective dimensions of empowerment *Useful in administering programs by requiring a review of the organizational-environmental fit	*Explain & map the direction & role of collective action *Assess power blocks *Build individual & community strengths *Support upward mobility of oppressed groups *Empower oppressed & vulnerable populations through collective action *Assess internal and external resources to make structural and process decisions within a organization

17.0 APPENDIX TWO: SECTOR EXPERT INTERVIEWS

The individuals interviewed for this section were:

Tony Pearse – National Production Manager, DeerNZ

Diana Mathers – National Research Manager Farm Systems (Foundation for Arable Research)

Janet Gregory – South Island Team Leader, NZ Landcare Trust

Raewyn Densley - Agricultural sales and marketing consultant

Sarah Payne - Consulting Officer DairyNZ

Simon Sankey - DairyNZ Regional Teams Coach

Mark Paine - Strategy and Investment Leader DairyNZ

Dick Lancaster – Private Consultant (Sheep & Beef)

Geoff Kaine – Geoff Kaine Research

Cecile deKleen – Scientist, AgResearch

Mark Aspin – Manager, Pastoral Greenhouse Gas Research Centre

Questions raised were:

(i) Explain how you would develop and implement an extension programme to ensure farmers would adopt greenhouse gas mitigation practices?

(ii) How would this differ if the mitigation goal was 10/20/50/100% of emissions?

(iii) What timeframe do you think would be realistic to achieve adoption by >75% of farmers?

(iv) How much of a motivation factor (to adopt mitigation practices) would you think a carbon tax would be? How high would it need to be?

(v) What difference would it make if the point of obligation was at an industry level (i.e. the industry paid the tax and then passed it on to farmers in the form of a lower payout/schedule)?

(vi) If you were to isolate three critical steps/risks to achieve success, what would these be?

The bullet points below represent direct quotes back from the interviewees.

Question: Explain how you would develop and implement an extension programme to ensure farmers would adopt greenhouse gas mitigation practices?

Respondents broke this down into a Focus on Research and Development, then Extension.

Research and Development

- Clearly define the GHG emissions that can be decreased by management strategies.

- Identify the information that outlines the main causes, then develop and test 'reasonable' farm management strategies that will decrease emissions. Reasonable is defined as 'achievable (including financially)'.

  Generally, farmers don't understand GHGs and how management of them will impact on their farming systems.

- Ensure mitigation practices are co-developed with farmers.
- Ensure mitigation options are science-based.
- Clarify the impact of mitigation practices on production and profit.

  Many mitigation factors show significant production decreases because the work hasn't been done to refine the mitigation techniques to maintain yield or profitability.

- Define the baseline GHG emissions.
- Establish measurement and monitoring protocols to ensure accuracy and develop a tool for farmers to assess their emissions.

  Need accuracy on how emissions will be measured and monitored (need to avoid the controversy of OVERSEER, around the accuracy of calculating nutrient discharge figures).

- Incorporation of pastoral GHG research findings into the measurement tool.

  OVERSEER is the current default measurement tool but was not designed for that, hence the need for a better tool.

- Develop tools/resources for extension. Keep messages simple such as a one-page checklist on things you need to do on-farm to reduce GHGs.
- Ensure mitigations are not treated in isolation.

  An example is water quality improvements which require a farm plan. The same plan should also include GHGs so there is no risk of improvements in one area negatively impacting another area. Everything documented in the one place.

- Demonstrate benefits of investment in GHG mitigation to farmers as part of the development process.

  Base a demonstration programme on small groups of farmers across different regions, land use and different development stages to test mitigations replicability before targets are set.

- Develop case studies to tell the story of the journey of farmers who are successfully integrating mitigation strategies into their farm systems, and are achieving positive results for their farm business.

Extension

- Any extension programme is going to be determined by the scale of the changes required, the complexity of the technologies and whether there are benefits to the farmers or if they will be driven by hard-rules.

The role of extension changes with increasing complexity of the solutions. There are 4 tiers to complexity[2].

(i) Incremental example: Reduce nitrogen fertiliser use from 100 kg N/ha/year to 50 kg N/ha/year. This is a modification of an existing practice.

(ii) Modular example: Shifting from flood irrigation to centre pivots. In this example, farmers are familiar with the basic practice, but a technology change also requires some new knowledge and skills.

(iii) Architectural example: Moving calving from spring to autumn. This requires a change of relationships between multiple components of the business.

(iv) Radical example: Going from pasture based to housed total mixed ration system.

As the technology solutions progress down this continuum then the role of extension changes towards more one-on-one farm-specific solutions. The more complex the technology, the greater the role of the delivery of extension has in reducing the effort in the learning process

When there is a benefit to the farmer e.g. a productivity gain from a mitigation practice, then extension can accelerate change through the promotion of the benefits. Where there is no gain or a disadvantage from a mitigation then there is a need to offset the loss incurred or rules that force change.

- To get any form of change on-farm, the approach should be bottom-up (ideas to come from farmers from all sectors). Get farmers involved to get buy-in.
- Have solid science-based options. Explore productivity gains and emphasise these. Think about it in terms of "What's in it for me?" from the farmer perspective. Support farmers in finding out what their emissions really are.
- Use language that the public understand.
- Highlight where value for the farmers can be achieved.
- Use simple, repetitive messages highlighting the costs and benefits.
- It is better to use the carrot to persuade farmers to change at the start and once you achieve >75% adoption then utilise the stick (carbon tax and penalties) to motivate the 'laggards'. Using the stick at the start will just create animosity and resistance.
- Need to have farmer champions – Identify farmer groups (e.g. farmer groups developed in the deer industry Primary Growth Partnership Project (P2P)) or individuals who have the trust and confidence of their peers to promote the messages more broadly.
- Introduce GHGs as part of business-as-usual delivery at discussion groups or field days and involve science speakers who can connect with farmers.
- Support farmers in finding out/measuring what their emissions on their farm are.
- Ultimately, the best extension will involve working one-on-one with farmers to review economically viable options which will be unique to each farming operation

[2] From Wright, 2011

- Need cross-industry communication so industries can work together to deliver consistent messages to farmers.

Communication; which is part of extension but separated for emphasis

- Listening to farmer views and insights to ascertain their drivers, challenges and potential solutions.
- Understand farmer information needs and preferences.
- Understand the planning cycle for farmers, so that information can be targeted to match implementation decisions within the farming calendar.

Subsidiary Questions

How would this differ if the mitigation goal was 10/20/50/100% of emissions?

- It will depend on the complexity of the mitigations and how many farmers need to make the change. Suggested that to get beyond 10% reduction will require rules and money spent on intensive extension.

- The higher the goal the more the government may need to consider putting in incentives and support for farmers to adopt practices.

  If the target is too high, it won't work. There is a need to encourage a stepped approach. Need to start small – 10%, get some people involved, and use them to demonstrate to others. Also, need to focus on the financial gains as well as the other on-farm benefits.

  As part of this process it is paramount to explain what the targets mean in a practical sense at a global-, national-, and farm-level.

- The communication needs to be transparent and honest.

- Goals more likely to be achieved if they are incremental, starting at 10%.

- As a concept the goal could be categorised by the availability of practical replicable mitigations:

  - 10% - modify current practices to good farm management practices, eliminate error, reduce wastage, increase efficiency.

  - 20% - whole-farm system shift, goals of the business and passion to change.

  - 50% - can't be achieved unless there are new technologies.

  - 100% - not many would be farming (impossible).

- The programme would remain similar across a range of emission goals. What would change is the effort and expense of implementation to farmers and to Government.

What timeframe do you think would be realistic to achieve adoption by >75% of farmers?

- Respondents identified a 10 – 25+ year timeframe with comments that:
  - It is very dependent on the complexity of the technologies. If the target is >75%, then clear regulation and rules will likely be required with defined timeframes. Minimum of 5 -6 years with technologies of moderate complexity.
  - Need realistic timeframes. Best tool to answer this is running the mitigation options through the ADOPT[3] model.
  - One expert mentioned a rule of thumb, 'it takes eight years before you reach 25% of farmers achieving change' unless a market-driven approach is working well. As an example, with a market-driven approach, the dairy industry significantly reduced somatic cell count in the 1990's by 100,000 on 80% of farms in a two-year period.

How much of a motivation factor (to adopt mitigation practices) would you think a carbon tax would be? How high would it need to be?

Done well, a carbon tax will be essential to provide an economic signal:

- It will generally increase uptake as there will be no choice.
- Depends on where the tax will be going to. If it goes to help further research that benefits farmers, then the tax may be more accepted.
- Very reluctant to introduce a carbon tax as farmers are being bombarded with a host of compliance issues currently and this is just another one that is not adding to their bottom line. It will be a significant demotivator.
- It is more important to focus on productivity gains that accompany GHG reductions.
- Start low and step tax up each year so the impact on farm profitability is gradual.
- Any tax will be a motivation factor if options are practical, for example, use of a bolus might be a good practice. However, if farmers have to use a bolus five times per year this maybe a de-motivator.
- Tax needs to be higher than the cost of not doing anything. Tax needs to be seen as a penalty for inaction, not as a legitimate option, i.e. pay the tax and do nothing.
- There needs to be greater rewards for those who make bigger reductions hence less tax. Carbon tax will only be motivating if mitigation goals/strategies are realistic. Anything more than $1,000 will get farmer's attention.

[3] ADOPT (Adoption and Diffusion Outcome Prediction Tool) is an MS Excel-based tool that evaluates and predicts the likely level of adoption and diffusion of specific agricultural technologies and practices, with a particular target population in mind. https://research.csiro.au/software/adopt/

What difference would it make if the point of obligation was at an industry level (i.e. the industry paid the tax and then passed it on to farmers in the form of a lower pay-out/schedule)?

- No difference, doesn't matter how the money is taken it will still be perceived by the farmer as a paying a tax and not promoting better practice.
- If simply passed on as lower product prices, then it will probably be ineffective. Would need to show up as a line-item in farmer expenses to create tension for change. Could it be linked to the uptake of mitigation technologies in the form of rebates.
- More sensible to have applied at farm level but cost of collection becomes an issue. Need to have incentives for choices. I.e. farmers might choose to have a herd vaccinated. Other tools such as genetics would probably be accounted for at a national level.
- Some farmers do not send stock to a meat processor (e.g. grazers or store farmers) so would not necessarily face a liability.
- NZ farmers compete on a global market and any tax reduces competitiveness with other countries not signed up to a GHG accord.
- What needs to happen for any tax system to be minor to the cost of taking action is that other parts of the market need to signal the importance and value of it to the market, e.g. red meat sector brand and market advantage that goes back to the farmer with low emissions. Three things required to make this market-driven approach work:

  (i) Education and adoption – learning programme

  (ii) Regulation system – tax system

  (iii) Market signal – value-chain benefit

  All three working together in a self-reinforcing way will result in adoption, appreciating that the three factors will interact in a complex manner.

If you were to isolate three critical steps/risks to achieve success, what would these be?

- Be clear on what percentage of farmers need to adopt the technologies to reach the required change.
- Being clear if rules are going to be required to reach the change or are there sufficient gains for the farmer from the voluntary adoption of the technologies.
- Understand that the extension practices and methodologies are going to change significantly, as is the cost of those extension activities, as the complexity of the solutions escalates.
- Farmers need to understand where emissions come from and what the options are for mitigation.
- Lack of practical options for farmers to adopt is a risk.
- Evidence-based technologies that are practical and give results over a range of environments is required.

- The on-farm impacts of required changes would ideally be cost-neutral at a minimum.
- A successfully implemented co-development model will help ensure a well-designed approach.
- Keep the message simple, focus on what drives positive outcomes.
- Need to develop nationally recognised experts and an extension team that is trusted.

What Policies do you think that the government should be looking at implementing to ensure farmer adoption of CC mitigations?

- Using small steps to achieve final target. Gradual step-up of tax to reduce impact on profitability.
- Introduce an emissions tax.
- Provide financial incentives, e.g. rebate on tax if certain activities are implemented on-farm.
- You must have the 'carrot' first, i.e. inspire and motivate the change-makers to move to the new framework of GHG reduction farming, and once 50% have moved there, then bring the others along with 'stick' to motivate them.

17.1 Other comments

- Make sure GHG mitigation is not dealt with in isolation, e.g. water quality improvements require farm plans. This plan should also include GHG plans so there is no risk of improvements in one area negatively impacting another area. Everything should be documented in the one place.
- Farmers feel that they are adsorbing all the costs associated with nutrient management losses, and now GHG, and yet output values aren't increasing in line with the additional charges they now face for compliance.
- We need to merge conversations and approaches regarding GHGs with those that are currently occurring focused on water quality. Farmers can gradually be exposed to get used to the concept before it is regulated.
- Farmers will innovate if given the opportunity, but they will need to have the finances to try new ideas. The timing will be critical to include this with all of the other things needing to be done.
- Need to provide positive encouragement at the start/lead-in period. The NAIT scheme had a three-year lead in and within that time 80% of farmers could see the value, so, aim for 80% encourage and 20% adopt through enforcement.

18.0 APPENDIX THREE: FARMER SURVEY QUESTIONS

1. Do you know the level of greenhouse gas emissions for your farm? Yes/No

2. Do you believe that New Zealand agriculture should reduce its greenhouse gas emissions to help combat global climate change? Yes/No

3. Other than planting trees, are you aware of mitigation strategies that would reduce your greenhouse gas emissions? Yes/No

If yes – any comment? (Optional)

4. What would you estimate the amount of carbon dioxide equivalent the average farm is emitting?

	Please tick one
50 T/yr	
100 T/yr	
500 T/yr	
1000 T/yr	
1500 T/yr	
2000 T/yr	

5. If a carbon charge of some sort was introduced, what mitigation strategies would you look to implement on your farm?

	Tick as many as applicable
Plant trees (including Manuka)	
Reduce stocking rate	
Reduce nitrogen fertiliser usage	
Reduce bought in supplements	
Change stock types	
Make no changes	

6. What timeframe do you think would be reasonable to allow farmers to adopt greenhouse gas mitigation practices? (tick one in each column)

	That mitigate 10% of GHGs	That mitigate 20% of GHGs	That mitigate 50% of GHGs	That mitigate 100% of GHGs
0 - 5 years				
6 - 10 years				
11 - 15 years				
16 - 20 years				
21 - 30 years				
More than 30 years				

7. What information, support or systems do you need to help you manage a future cost on greenhouse gases?

8. Any other comments?

The results discussed below are based on the raw data, and are qualitative rather than quantitative.

18.1 Results

Figure 9: Question 1: Do you know the level of greenhouse gas emissions for your farm?

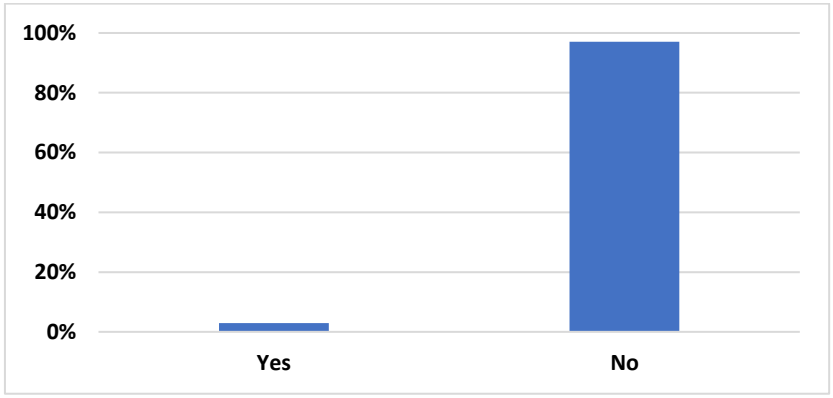


Figure 10: Question 2: Do you believe that New Zealand agriculture should reduce its greenhouse gas emissions to help combat global climate change?

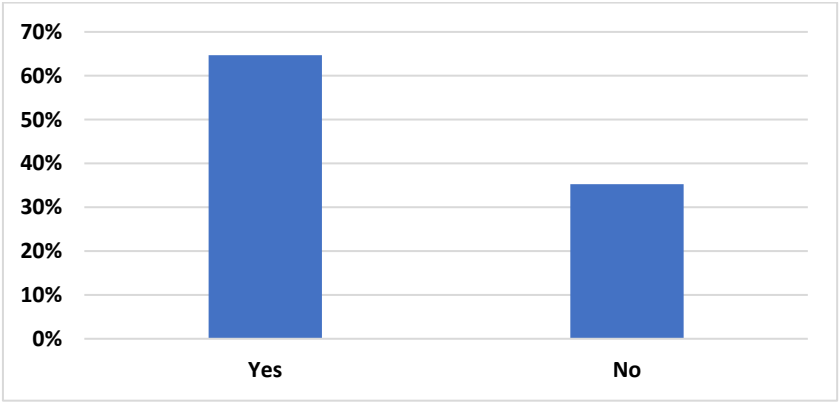
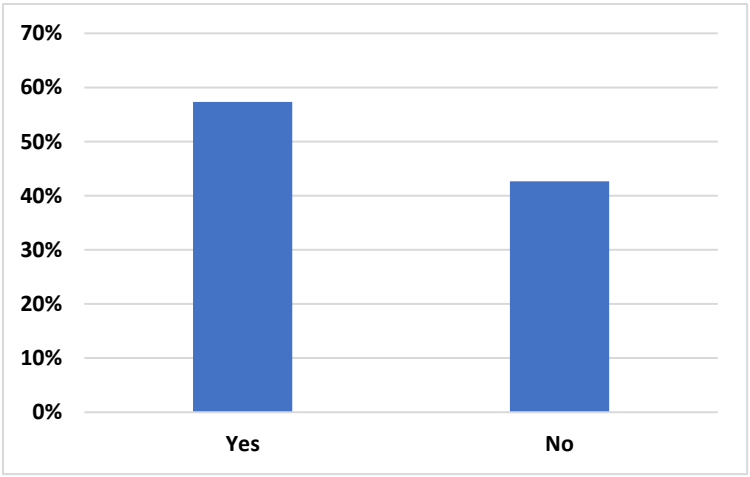


Figure 11: Question 3: Other than planting trees, are you aware of mitigation strategies that would reduce your greenhouse gas emissions?



Mitigation strategies that were mentioned included:

- Use biofuels instead of fossil fuels. Alter rumen bacteria to reduce CH_4 output by vaccines. Improve carbon storage.
- Reduced stocking rate. Feed ration changes.
- Zero tillage, continuous cover in cropping systems.
- Different stock feeds, different fertilisers.
- Lower methane emitting animals (genetics). Forages that produce less emissions.
- No tillage, better root systems building soil carbon, faster growth in animals.
- Less cattle, more sheep.
- Regenerative agricultural techniques like holistic grazing that sequester carbon into soil and planting perennial polyculture food systems with integrated animal systems.
- Precision agriculture – fertiliser application, cropping systems.
- There are indications that breeding for lower emitting animals may be possible. Use less fuel, reduce N applications, reduce stock numbers.
- Changing stock classes, animal and plant genetics, effluent management, fertiliser management, pasture species, grazing management, soil biology management (methanogens), irrigation management, cultivation practises. Most of these affect soil carbon flows which can also be increased by additions of biochar, compost.

Figure 12: Question 4: What would you estimate the amount of carbon dioxide equivalent the average farm is emitting?

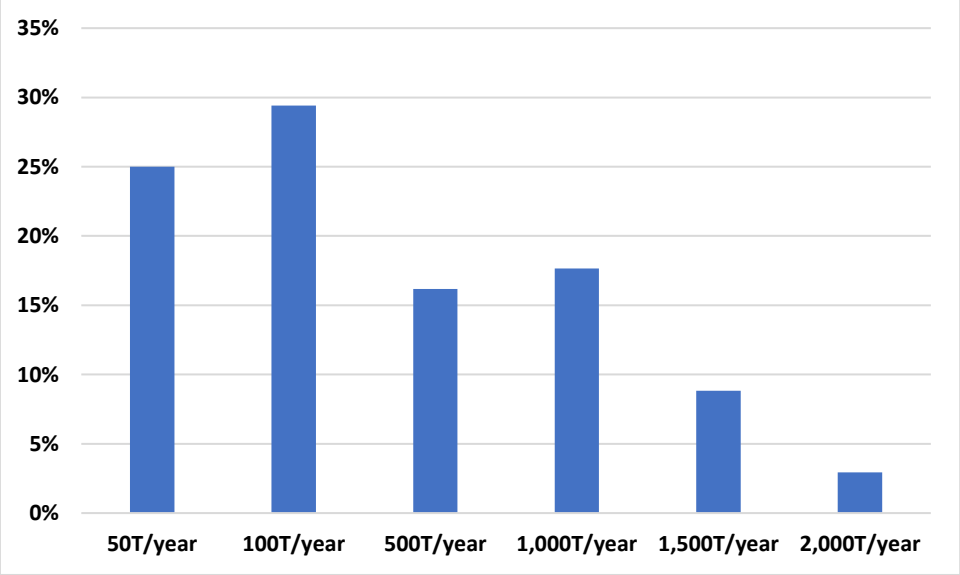


Figure 13: Question 5: If a carbon charge of some sort was introduced, what mitigation strategies would you look to implement on your farm?

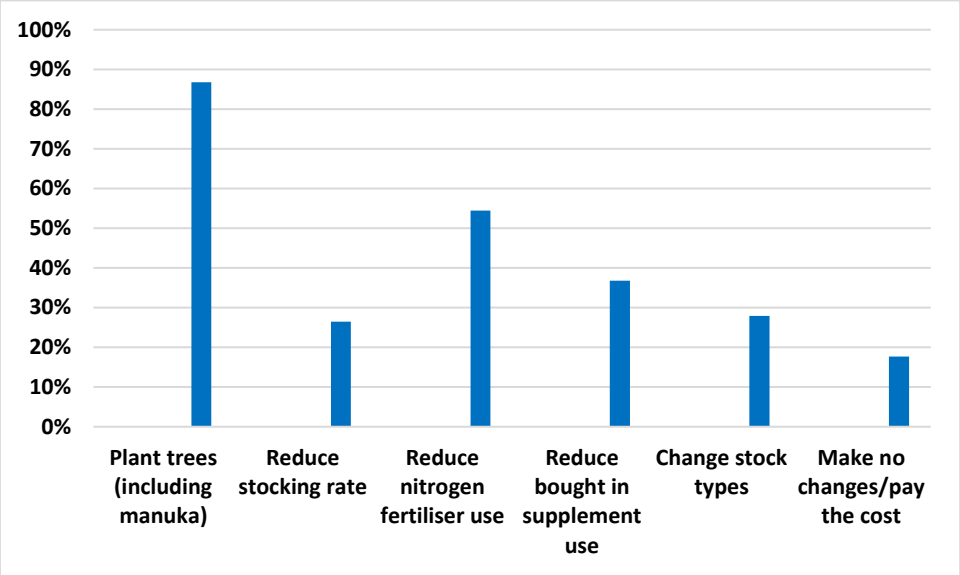
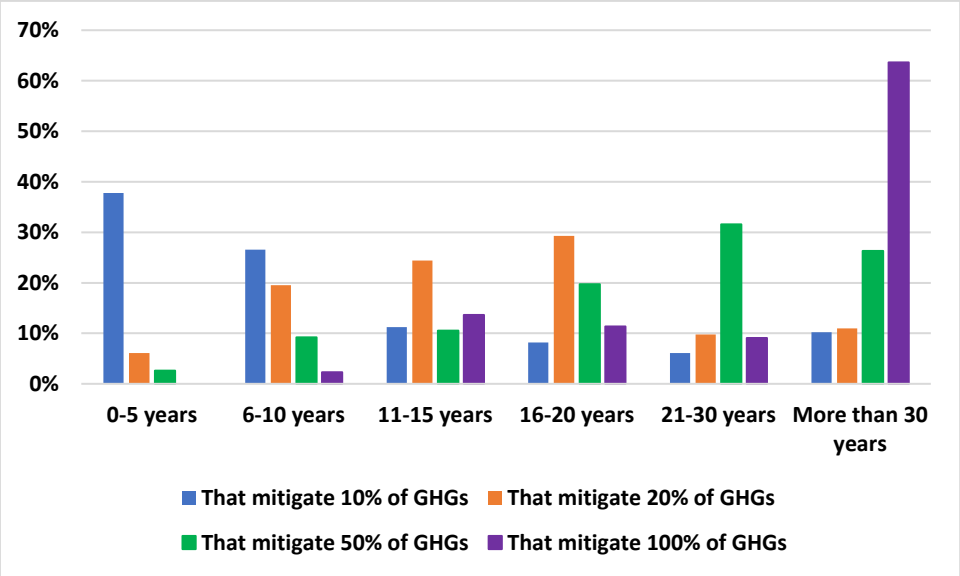


Figure 14: Question 6: What timeframe do you think would be reasonable to allow farmers to adopt greenhouse gas mitigation practices?



Question 7: What information, support or systems do you need to help you manage a future cost on greenhouse gases?

Comments on this were:

- We would need a lot of help, education, science and technology to reduce or offset GHGs. There is no point in introducing carbon charges of any type until we have options available to farmers, the options mentioned earlier in this survey are not enough. Planting trees, reducing stock numbers or changing stock type are not suitable options, we need science and technology options.

- Funding for it. It shouldn't have to come out of farmers' pockets. Financially it is really tight for farmers anyway without having another cost. (Several mentions)
- Information about what we emit now on farm, support around how we can mitigate this, and information around the benefits of doing this. (Several mentions)
- Need to see peer reviewed literature around the accuracy of OVERSEER (or what model is used) in predicting GHGs. (Several mentions)
- Higher food prices or tax on food .
- Proof it needs to happen/will actually help.
- Information on the future price of carbon.
- Models that correctly predict outputs in a NZ system, rather than global averages. Costs of emissions to be determined in a predictable manner. (Several mentions)
- Accurate science and cost/benefit analysis first before any regulation.
- There needs to be an advisory group set up to inform lawmakers & the general public of the TRUE cost of a carbon tax and the futility of a tax as a punishment for being among the top 10% of farmers who are the most efficient and environmentally friendly food producers in the world.
- On farm visits from experts to give advice - would have to be funded by government.
- Higher product prices.
- What farm systems can be used to mitigate farm greenhouse gas emissions? What trees can be claimed and grown to receive carbon credits? What is the cost/value of greenhouse gas emissions?
- People in the industry that have or are farming that can see both sides of the fence. Better income for our products so we can afford to make some of these changes. Proof that the changes being asked for actually work. The time-frame you are asking for above depends on the level of farmer knowledge, type of farming i.e. dairying/organic/conventional sheep and beef. Lots of education.
- Scientific verification of the current systems that work. Opportunities to mitigate soil sequestration on hill country - information and a system to allow this to work.
- There is not enough accurate information to enable individual farmers to devise strategies without incurring significant costs with no foreseeable benefit to the business.
- Better understanding of the system and its implications.
- Factual, scientific information so we are working on knowns and not unknowns.
- Factual education to farmers i.e. statistics, free advice, economic support from government.
- Recognition for soil carbon.
- Better whole farm understanding and planning. We already have a greater area in QE2 than our effective farmed area. This QE2 has been disregarded, to date, as making a valid contribution to carbon sequestration
- An easy to use online calculator and auditing/compliance porthole.

- What are the expectations, are the options affordable, what are the options, there is a need for information sessions. Advertise handy websites where one can find information to over time implement environmentally friendlier options.
- We need information on how soil biology management, soil structure and chemistry, cultivation techniques and technologies, pasture species genetics and relationships between different species, stock types classes and genetics, feed supplements, grazing management, tree-pasture integrations and various types of integrated or sole forest establishment all affect greenhouse gases, both in isolation and integrated within our farm system. We need certainty that investments/decisions that we make aren't going to be unexpectedly undercut by political whims. We need certainty that prices on greenhouses gases emissions or sequestration are comparatively predictable compared to recent years. We need access to decent independent advice from people who understand the practicalities of our farm system. We need policy that accurately recognises our efforts and provides incentives to act - this means emissions accounting must be behind the farm gate and we must have access to measured/monitored emissions so that we can respond. We might need short-medium term financial support for up-front investments that are capital intensive. We can't afford to have regulations that are based on proxies or inaccurate measures that don't reflect the practicalities of farming and therefore restrict our ability to adapt/innovate to achieve emissions reductions. We want to work alongside researchers, land managers and policy makers to solve problems and develop ideas together, rather than continuing the current disconnect.

Other comments included:

- NZs contribution is so small we could produce zero GHG's and it would have zero effect on climate change. It could, however, be a selling point to get a premium for our produce, which would be the way to go to convince farmers to think about being more sustainable.
- It is very hard to reduce farm greenhouse gas emissions when the only present understandable means of doing so, is to reduce the production farm animals that we depend on to derive farm income.
- I'm not a believer in anthropogenic global warming so don't see changing farming practices will fix climate change.
- Emissions depend on so many things. Isn't our grass farming a carbon sink, which is not taken into account? What about the other businesses and their emissions? How are carbon charges going to be determined?
- Farmers need to be informed and consulted with. The government officials and "Planners" of the carbon charges need themselves to gain a thorough understanding of the current costs and risks associated with farming in NZ. Carbon charges need to be realistic in view of the other farm costs and changes we don't know about yet!
- New science is needed to mitigate ruminant emissions. More needs to be done to reduce much bigger discharges from major industry internationally.
- Hurry up and find how to reduce methane from rumen digestion.
- I'm sure the numbers aren't exact but it would be good to get more info out there via DairyNZ and B+LNZ because I think there's a bunch of things that farmers would do

voluntarily if they had the information. At least it would give farmers a 'heads up' on what's coming anyway even if they don't want to change anything now.

- In regards to time-frame, it has to be 20 plus years due to the lack of understanding around this issue and if trees are 1 way of lowering levels then need adequate time for trees to get established to adequately balance emissions. Any other ways of lowering levels will make farming even more uneconomical than it already is.
- I don't have a problem with paying for GHGs but would want to be sure that it is a level playing field with our competitors overseas and we are all paying at the same rate.

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