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Enabling Better Environmental Outcomes in Agriculture

By

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2018 Nuffield Scholar

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Acknowledgement

I am eternally grateful for the opportunity given to me as a Nuffield Scholar, and whilst it sounds like a cliché, it is true, becoming a Nuffield Scholar is life changing, and positively disruptive in so many ways.

Being able to step outside your comfort zone, but to have a wider network of people known as the 'Nuffield Family' there to support you in doing so is something that you cannot place a value on. I believe that I am richer for the experience, and I look forward to being able to give back to both industry and the Nuffield Family in the future so that others may also continue to have the opportunity for personal and professional growth and development.

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Executive Summary

“A pessimist sees the difficulty in every opportunity; an optimist sees the opportunity in every difficulty” – Winston Churchill

The current world of agriculture is uncertain, with challenges of climate change, water quality, animal welfare, the rise of plant-based proteins, and of course feeding an estimated 9.7 billion people by 2050¹. However as global agriculture stands on the cusp of significant change, New Zealand’s ability to adapt quickly will define the degree of opportunity available for us to capture.

New Zealand must sit in the driver’s seat and must come together as a sector and as a nation to achieve effective outcomes for both agriculture and the environment.

Globally New Zealand agriculture is punching well above its weight in terms of both its understanding of the impacts of its activities on the environment, but also in its recognition of the need to change. The key to success will be the development of an array of ‘change inducing tools’ that can be called upon by the sector to enable better environmental outcomes in agriculture.

Whilst it is certain that we have not achieved all that is needed in terms of reducing the impacts of agriculture on the environment, and there remains much which can continue to be done, compared to many other intensive agricultural nations, we have at least started along the path towards finding solutions to reduce the environmental footprint of agriculture.

The purpose of this research is to challenge the status quo, encourage conversation and debate, and spark action for transformational change within the agriculture sector in New Zealand. In this report I have focused on the ways the New Zealand agricultural sector, Local, and Central Government can work to enable better environmental outcomes in agriculture utilising policy and technology tools. My research has identified five key challenges that we need to address to ensure we can successfully reduce the environmental impacts of agriculture. We must build momentum and seek to engage broadly, in order to have any chance of realising success.

The challenges agriculture face are numerous and best described in the context of a “wicked problem”, that is, one which is not easy to define, one which has no easy answer, one which has conflicting and contradictory pieces of the puzzle, and one where the playing field changes frequently.

The **first challenge is goal setting**. My observation is that there is broad consensus on the need to change, however we need clear objectives to guide us on a path to transformational change. Otherwise how do we go about making this change if we don’t know where we are going, or how we will measure our success?

This plan must set out long term, ambitious goals that define what agriculture in New Zealand will look like in the future, what we will value, who our consumers will be, how our communities and our environment will look. We must have a Big Hairy Audacious Goal (BHAG) for New Zealand agriculture. We need to have all of the issues on our agenda when working through what our objectives and goals

¹¹ United Nations, 2015 Revision of World Population Prospects.

will be. The purpose of a goal is to help drive New Zealand towards a more sustainable agriculture framework for the future and to help preserve our position as truly global agricultural leaders. Until we have a vision, any change to our approach remains piecemeal and uncoordinated and unlikely to reduce the footprint of agriculture in a meaningful and measurable way.

The **second challenge is taking a holistic approach**. Our path must encompass holistic management that is outward looking. We can no longer continue to look at the challenges of agriculture as isolated component parts, and we cannot define our goals and objectives without bold leadership at all levels.

We must encompass holistic, community centric, collaborative decision making. The current decision-making tools such as the Resource Management Act 1991 (RMA) are often isolated from the principles of holistic management, despite being an effects-based planning mechanism.

If an RMA framework could be applied to an agreed strategy for agriculture in New Zealand, which had been developed on the principles of holistic management and evidenced based decision making then we may well be in a position to reduce the environmental footprint of agriculture within agreed tolerances relating to the impacts on the economics of farming. It is, however, my belief that an environmentally sustainable business will also be an economically sustainable business. We must recognise agriculture as a critically important New Zealand and global enterprise, but it is about achieving the three pillars of sustainability; Environmental Prosperity, Economic Prosperity and Social Prosperity.

A holistic approach supported by an agreed strategy will ensure balance between environmental, economic and social indicators. However, engaging with all New Zealanders will be critical to solving the challenges that we face. In this case engagement with all of New Zealand is about overcoming the perception that farming is bad for the environment, rather than requiring each and every New Zealander to actually participate. This links to my first recommendation of the need for effective engagement and informed robust conversations, which can and should provide a platform for sharing the good news stories about agriculture and the environment.

The **third challenge is driving evidenced based decision making**. This must play a lead role in shaping our goals and objectives and must inform the debate that we need to have about the future of agriculture and the environment. A good example of citizen led evidence-based decision making comes from an Irish example, known as the "Citizens Assembly".

The assembly strives for "rational and reasoned discussion" and uses a panel of experts drawn from across the political spectrum to guide the deliberations. The discussions aim to build consensus on contentious issues through informed debate.

A process of this nature has the potential to provide a forum to help define the aspirational goals that we set to achieve and enable a consensus to be reached on the direction that we need to take. It will also lead toward a process of identifying what we value and its importance. This challenge is also linked to enabling technology, as data and interpretation of data will become essential for evidence-based decision making.

The **fourth challenge is enabling technology**. We cannot sit back and wait for technology to solve our challenges, as technology will not do this on its own. It is also possible that technology may not eventuate in the way that we need. We must therefore continue to encourage innovation and find new tools that help guide our decision making and enable better environmental outcomes.

Globally there are challenges with policy not readily enabling technology tools to be recognised or implemented.

There are many examples of new developments that fall within the growing global ag-tech space, such as satellite-based crop or pasture monitoring, or the application of in-field sensors and machine learning to make informed on-farm decisions. This space is developing quickly, but currently remains largely focused on precision ag tools that enhance production outcomes, or time/cost savings. There is much less focus on the application of technology to overcome the environmental hurdles that agriculture is facing, compared to the focus on addressing the productivity aspects of precision agriculture.

Sensor technology in an agri-environmental space remains underdeveloped but provides significant future opportunities for reducing the environmental footprint of agriculture. Currently there are challenges in applying technology to solve agri-environmental challenges. Policy and regulation don't always enable technology uptake because they are reactionary in nature and they don't anticipate technological changes as a solution when they are developed.

Take for example the challenge of nutrient losses to waterways, this is a very real problem that New Zealand is having to address. Imagine a world where we can put nutrient sensors into aircraft (or perhaps drones), and that we can map where actual nutrient losses are occurring either at farm scale or catchment scale, in close to real time, and on a regular basis.

In a scenario where we can monitor where actual losses are occurring, we can enable targeted mitigation and remediation. This will not only help improve our natural environment but will mean the cost of remediation and mitigation is applied at the actual source rather than a broad, less specific more generic mitigation approach.

Information and data are the currency that will transform agriculture from reactive to revolutionary, and we must adopt these now at speed and at scale. We will need to enable technology to turn data into opportunities, for example the Internet of Things (IOT) technology will enable us to collect more information, store it and use it to inform decision making.

The **final challenge is driving a shift to outwards looking policy**. The answer lies in redefining our approach to policy. It must be all encompassing and consider that the whole is greater than the sum of the parts.

This requires a shift from a reactive regulatory approach to a proactive regulatory approach, where regulation and policy is the backstop rather than the front door. By working more collaboratively between the agriculture sector and regulators and by putting more emphasis on implementation will also empower farmers to think beyond regulation as well.

We need to move towards monetising our sustainability, to become the world's most sustainable agricultural nation, whilst remaining profitable.

We will be able to meet the demands of our communities and our consumers by setting ourselves high standards and consistently meeting these. To do this we need to address the five challenges;

1. A Clear vision vs. A Vague plan
2. A Holistic approach vs. Working in Silos
3. Evidence based approach vs. Thought based approach
4. Uptake of Technology vs. Maintenance of the Status Quo
5. Enabling Policy Incentives vs. Policy Punishment by Rules.

I encourage you all to get on board with making bold changes for the future of New Zealand, and New Zealand Agriculture, such that changes in policy and technology can create an environment where inspiring goals can be achieved through ground-up collaboration across all stakeholders.



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Approach

In undertaking this research, I have visited individuals, businesses, academics, policy makers, farmers, and both environmental and industry groups. I have visited over 15 countries, and attended countless meetings, presentations and conferences. I have read and reviewed many reports and documents related to agriculture, the environment, policy and technology.

Collecting a wide variety of information has enabled me to undertake a detailed analysis of the challenges that we face in the Agri-Enviro space and has informed my thinking significantly on how we may go about reducing the effects of agriculture on the environment. This has resulted in the documentation of my observations and opinions, and which, where possible, are supported by evidence. My research has explored what I see as significant opportunities for New Zealand to adopt a more holistic approach to agriculture and the environment.



Photograph 1: Inistioge Farm Land, County Kilkenny, Ireland

Where appropriate, I have used examples and case studies to present findings and ideas, some of which were as the result of my own research, and some which arose as examples in the course of my meetings with other people. Due to the confidential nature of many of my one on one conversations, I am unable to attribute some insights to these people, especially where the views of the individual are not necessarily the view of the representative organisation. Overall my assessment is qualitative in nature.

One of the challenges in pulling this report together is that the problems I am trying to explore are incredibly complex, with the complexity spanning many levels. Effecting change when dealing with complex problems is difficult, which is where a clear framework becomes imperative. Whilst there is much science available in terms of understanding the environmental impacts, there appears to be much less science and research which brings together methods or solutions for reducing our impacts or which

focuses on technology transfer in a manner which enables broad uptake of change which will then enable the transition to sustainable agriculture.

I have written this report assuming readers will have baseline knowledge of agriculture and the environment, however I hope it provides interesting reading for a significantly wider audience. Most of all it is written to stimulate questions of our current approach and whether there is a better way to do things. This report is intended to be a starting point to encourage conversation amongst industry leaders, policy makers, and farmers at a deeper level. We must all come together to lead transformational change in agriculture.

In trying to understand the role of policy and technology to reduce the environmental impacts of agriculture, I have focused on a number of key questions. These have helped from the point of view of providing both background and context. The purpose of this report is not to directly answer these questions (although I do provide some comments around these questions in Section 7), but to inform the learnings of my research which has been undertaken over the last 12 months. These questions were;

1. Where does New Zealand sit on the spectrum of environmental regulation (affecting agriculture) compared to other agricultural nations throughout the world? i.e. are we highly regulated or not?
2. How is New Zealand performing from an environmental perspective compared to other agricultural nations throughout the world? i.e. are we achieving good, measurable environmental outcomes?
3. What solutions are enabling us to reduce the environmental footprint of agriculture while maintaining financially sustainable farming businesses?
4. What role does technology have in reducing the negative effects of agriculture?
5. What are the practical solutions that would engage farmers to make positive changes for the environment?

Recommendations

“Start with the assumption that the best way to do something is not the way it is being done right now” – Aaron Leure

New Zealand no longer has the luxury of being the lowest cost producer in terms of agriculture. This means we need to shift our focus to higher value food production so that we can command a premium for our products. This positional shift is largely well accepted by our largest food producers, however one aspect of the positional shift that is not being so obviously targeted is the opportunity to monetise our sustainability. There is much talk about ‘sustainability’ in New Zealand agriculture, but we must now also focus on providing the evidence that this is in fact the case and ensure that there is a return on our investment in sustainability.

This will not only value add to our food products, but also provide a significant opportunity in terms of the export of our services and technology to help the rest of the world move towards a more sustainable agricultural model. This however requires us to solve our own agri-environmental challenges, and quickly. This will require transformational change within the agricultural sector. We need to think big to achieve big.

Sustainability is a concept which is often talked about but not always well understood or defined. I consider “sustainable” as being the point of balance between economic prosperity, environmental prosperity, and social prosperity, where these aspects are of equal importance, and decisions are made on the balance of these three factors.

To truly transform agriculture in New Zealand, as opposed to ‘tweaking it’ will require the development and implementation of a clear strategy. But before we can develop a strategy, we need to have robust and difficult conversations and informed debate. My recommendations therefore start with the facilitation of robust conversations and have been ordered on the basis of a clear path to achieve a reduction in the environmental footprint of agriculture.

1. Facilitate Robust Conversation & Engagement

Central Government needs to facilitate a mechanism for informed and robust conversation about what is important to New Zealand. These conversations need to be focused on achieving broad engagement and creating an environment that encourages people to speak up without fear that their views will be ridiculed or dismissed as unimportant. If such an approach is to be agriculture specific, then partnering with the ag sector will be critical.

It is recommended that investigation into the development of a New Zealand version of the ‘citizens assembly’ be undertaken, and if feasible, implemented to facilitate robust conversation and engagement. This option would need to be led by central government, and in my view would only be successful where there is bipartisan government support for such an approach.

2. Set Strategy & Goals

The starting point for transformative change in agriculture in New Zealand is the development of an all-encompassing agri strategy, underpinned by informed conversation and debate. This should be in the form of a National Strategy for Agricultural Sustainability. The purpose of an agri-enviro strategy is to set long term ambitious but realistic goals or BHAG's that will guide the changes within the agriculture sector, as well as setting goals around what will be achieved in terms of our environmental outcomes. This will result in a broad set of agreed principles that can then be applied holistically to science, policy and regulation, health, and other interrelated disciplines. This approach would in my view be best undertaken via a partnership approach between the New Zealand Agricultural Sector (covering representation from all industries) and the Ministry for Primary Industries, much like the Irish Food Wise 2025 example. To be successful however will require engagement with stakeholders, including iwi, science and technology, environmental NGO's and other government agencies.

3. Enable Collaborative Science, Technology & Data

We must start with a comprehensive Gap Analysis of the future science, technology and data needs. This shall be fostered through collaboration and coordination amongst the agricultural, science and technology communities. The establishment of an innovation centre dedicated to holistic sustainable agriculture that fosters collaboration between scientists, business, farmers, and other countries, would be a method for achieving this. It could also be a method for removing the current barriers to collaboration, whilst directing science and technology to where it is required and thus contributing to the outcomes of our strategy. This recommendation would be best led by a joint team representing New Zealand agricultural research institutes, the agricultural sector and the Ministry for Primary Industries, and Ministry for Business, Innovation & Employment. It may also link to the overall science direction work under the document entitled 'Conservation and Environment Science Roadmap'.

4. Re-Design Policy Approach

The final step in undertaking transformative change of the agricultural sector is an overhaul of our approach to agri-enviro policy. Policy needs to be enabling rather than reactionary. This will require us to have greater checks and balances in place to ensure that we are achieving outcomes. Monitoring and data become essential in this process, which is where the continued development of technology will assist us in this space. Policy and regulation are necessary but should be a tool to force late adopters and poor performers to change, rather than limiting the ability of those more able early adopters to innovate and make wholesale changes to their farming systems. This approach will require all of government buy-in, as there is likely to be cross ministry implications, specifically between the Ministry for Primary Industries and the Ministry for the Environment. Changes to a policy approach would be best led at Ministry level but will require wide ranging engagement that focuses on solutions and implementation as a core feature. It is also likely that such an approach will also be applied at a local government level also.

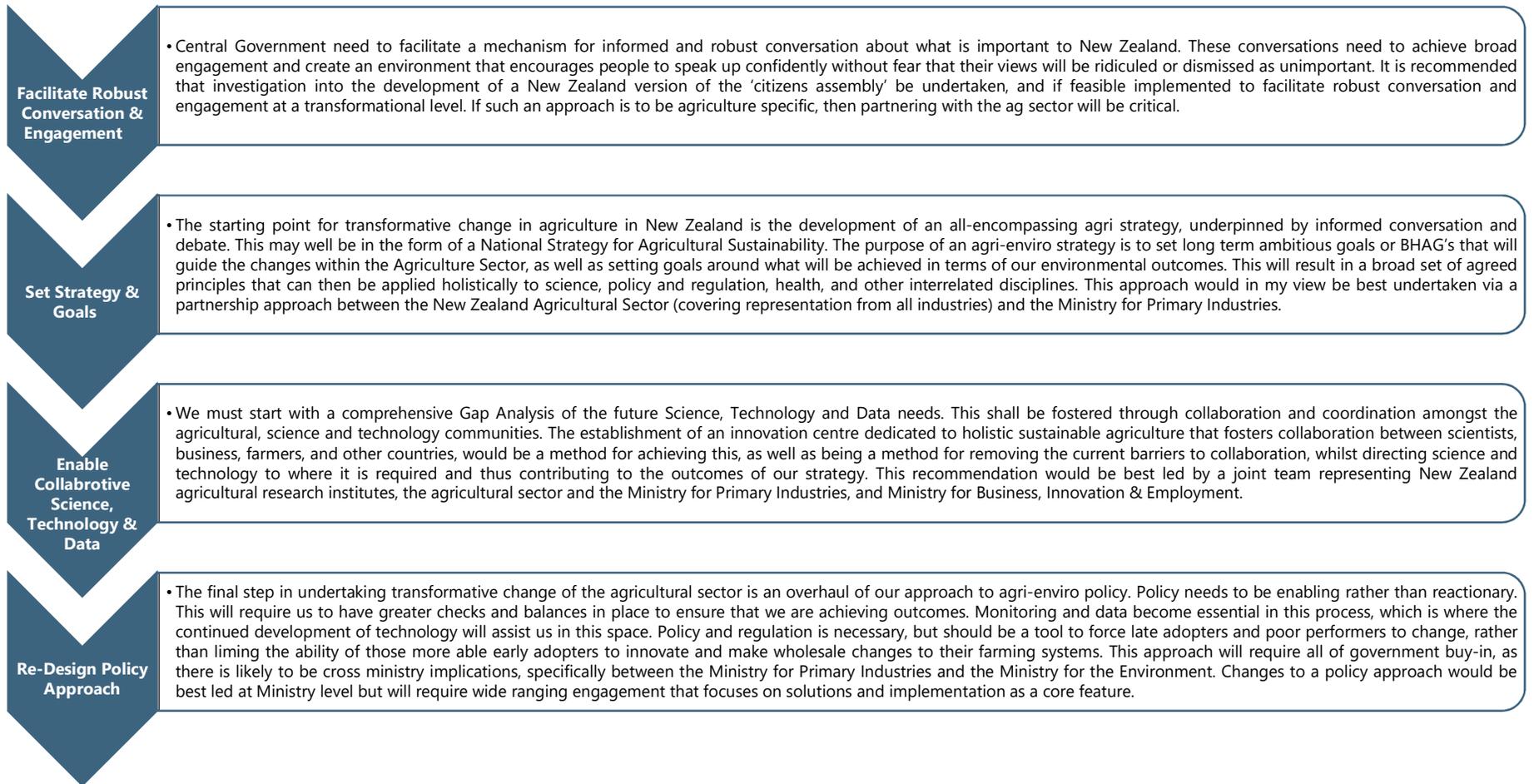
To achieve each of these recommendations we must ensure that we have;

- a. Bold Leadership
- b. A Holistic Approach

c. Evidenced Based Decision Making

Without these enabling factors our ability to foster transformational change within the New Zealand Agricultural Sector will be an unobtainable dream. We must act now to enable better environmental outcomes which support a sustainable future underpinned by economic, environmental and social prosperity.

Figure 1: Recommendations for a path towards Transformative Agricultural Change





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1. Defining our Challenges

1.1 Introduction

This report sets out to explore the challenges that agriculture is facing as a way of setting the scene and providing context to the question of “how do we reduce the environmental footprint of agriculture?”. In doing this I have also set out to understand how changes in policy and technology can enable us to reduce the environmental effects of agriculture.

By drawing on the learnings from my travels, and my experience working in the environmental regulation and policy space, I will compare and contrast findings from an overseas perspective which are focused on the potential solutions for reducing the environmental impacts of agriculture. Following which, I will look at opportunities for New Zealand agriculture. This leads to four key recommendations which I believe will only be successful if they are underpinned by three critical factors, being bold leadership, undertaking a holistic approach and ensuring that we have an evidence-based decision-making framework.

In the interests of keeping this report succinct, I have chosen to limit the background aspects to some of the discussions so that I can focus on the broader outcomes which I hope will lead to action. References to further information on the background discussions are provided.

1.2 Challenges for Global Agriculture

Globally, agriculture is under significant and growing pressure in terms of its impact on the environment. This pressure comes from politicians, environmental groups, researchers, consumers and from the general community.

In each country the ranking of these issues will vary. Key factors determining the rank are their agricultural systems, the relationship that the people have with food and agriculture, the population base, wealth and wellbeing, food security, culture, global trade and political stability.

All point to what is a highly complex issue underpinned by many inter-related matters which have a shifting degree of importance depending on the specifics of each situation. For example, the underlying culture of the Netherlands has been defined by the influence of World War II and the impacts of famine on their people that arose in what is known as the ‘Hunger Winter 1944-45’. Following the famine, the Dutch asserted that they never wanted their people to be without access to food again, and since World

War II, they have focused on growing and supporting agriculture to meet this underlying goal of food security.

Historically, food security has been the primary driver for agricultural development not only in places such as the Netherlands, but also in Brazil, Japan, Scandinavia and in the USA. Compare this to New Zealand and Australia, where our drivers for agricultural development have largely been borne out of increasing production for export driven gain. The drivers are quite different, but the resulting intensification of agriculture is the same.

Over the past 5 to 10 years, the environment has become a more important focus for many of these countries, but it is fair to say that the pace of change in terms of reducing the environmental footprint of agriculture is much slower.

Obtaining a balance between the need for agriculture to provide for global food demand yet ensuring the impacts of agriculture on the environment are minimised is difficult, and one that has not yet been solved.

The challenges that agriculture faces can be identified as either being caused by agriculture, or as having an effect on agriculture. In some instances, the challenges will be both a cause and an effect.

Figure 2 provides an overview of the predominant issues facing global agriculture and it attempts to quantify the relationship between cause and effect. It is noted for completeness that agriculture is not the only creator and contributor to these challenges but is one of many contributing sectors.

Figure 2: Overview of Global Challenges Facing Agriculture



Figure 2 highlights three key issues which stand out for having both a cause and an effect on agriculture, these are;

- Climate Change
- Decreasing Water Quality/Quantity
- Increasing Public Scrutiny (Social Licence)

For many agricultural nations the impacts of climate change are real and are seen as continuing to have a significant effect on agriculture in the future. The OECD recognises climate change as the leading issue facing OECD countries.



Photograph 2: CIMMYT International Maize and Wheat Improvement Centre, Mexico

1.3 Challenges for New Zealand Agriculture

From a New Zealand perspective, agriculture faces the same issues. Although the issue of decreasing water quality/quantity is the most prominent at present, social licence and climate change are growing. *“Water quality for example has been consistently singled out as the most important issue of concern for New Zealanders. Also, in the 2008 survey, for the first time farming superseded stormwater and waste as the perceived top cause of damage to freshwater”* (Hughey, Kerr, & Cullen, Public Perceptions of NZ's Environment, 2011-2012).

I have observed a significant shift in the understanding of New Zealand farmers in respect to the impacts of agriculture on water quality/quantity in particular. There is also greater understanding of the role that nutrient losses play in impacting the environment. This was not so evident a few years ago but has changed in the last 2 to 3 years. There now appears to be a greater willingness to accept the fact that our agricultural activities have an impact, and that we must change our practices if we are to become more sustainable. Effecting change however still remains a challenge because of a number of barriers,

including, in my opinion, technological and regulatory barriers. These issues are explored in more detail in Section 4 and Section 5.

The complexities of issues such as water quantity/quality are also confounded by the increasing public scrutiny of farming activities, especially where understanding of farming and environmental effects are not often well understood. This is defined by the issue of social licence. This issue of social licence appears to be more heightened in New Zealand compared with other countries.

In a report by Penny Clark Hall titled 'Social Licence to Operate', Clark Hall notes;

The topic of social licence has become more mainstream in New Zealand in the past five years as our primary sector has grappled with what appears to be a public discontent with its environmental, health and safety, animal welfare and employment performance. The public discontent appears as if it is driving a wedge between the primary sector and urban communities (rural urban divide), however a recent report by the Ministry for Primary Industries on New Zealander's views of the sector shows declining views of the sector from both urban and rural communities. (Clark Hall, 2018)

In regards to climate change, in a 2016 report prepared for the Biological Emissions Reference Group (BERG), a survey of New Zealand farmers noted that "*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*". (AgFirst, 2016)

My observations within New Zealand would be consistent with the findings of this survey, compared with Europe in particular where the issues of climate change are much more prevalent than other environmental impacts of agriculture such as water quality. This is perhaps prefaced by the significant industrial and manufacturing history that Europe has compared to New Zealand, and as such Air Quality is the number one issue facing OECD Countries (OECD, 2017) compared with matters such as water quality.

2. Setting Goals & Objectives

In the 1960's researcher Edwin Locke developed what is known as 'goal-setting theory'. Locke found that those who set specific, difficult goals performed better than those who set general, easy goals. Locke also identified that for goal setting to be effective the following mechanisms were necessary;

- Goal acceptance/commitment
The individual must find the goal important and must believe they can achieve it
- Goal specificity
The goal must be specific and measurable
- Goal difficulty
The goal must be set high enough to encourage high performance
- Feedback on progress toward the goal
Feedback is necessary in order for goals to remain effective and retain commitment

Since the 1960's Locke's theory has been refined and has resulted in other similar concepts such as SMART Goals (Kenneth Blanchard). SMART Goals are defined as being Specific, Measurable, Assignable, Realistic and Time-bound.

Another similar concept is that of BHAG's or *Big Hairy Audacious Goal* which was developed by Jim Collins in the book "Built to Last: Successful Habits of Visionary Companies". BHAG's are intended to be long term goals which are bigger, and bolder than regular goals, and are expected to be a 10 to 30-year commitment.

"The best BHAG's require both building for the long term AND exuding a relentless sense of urgency. What do we need to do today, with monomaniacal focus, and tomorrow, and the next day, to defy the probabilities and ultimately achieve our BHAG?" (Collins, 2019)

It follows therefore that if we are to reduce the environmental footprint of agriculture in New Zealand, that we must start with a BHAG. This goal should be big, and it should be bold.

Whilst many industries within the agricultural sector have industry or company specific goals, there is no overarching BHAG for the agricultural sector in New Zealand, and until such time as we have goals that relate to the three pillars of sustainability, being economic, environmental and social prosperity, then we will not be able to capitalise on our sustainability.

Whilst an argument could be made that the overall goals in terms of water quality for example are set out in the National Policy Statement for Freshwater 2014 (NPS), there remains questions as to the specificity of the NPS, and whether the adoption of specific targets by Regional Councils (whose role it

is to implement the NPS) is in fact leading to the setting of clear, long term goals that have achieved a high level of buy in from the agricultural sector.

The agricultural sector, like all individuals, companies and interest groups has the opportunity to participate in regional planning processes, but the success of these processes from an engagement and understanding perspective are questionable. If engagement and understanding is not high, then the chance of successfully achieving water quality outcomes is likely to be lower.

The complexity and drawn out nature of regional planning processes is also a barrier to participation and because it is a regulatory process it is often considered to unfairly impinge upon the rights of property owners.

This leads to a question of whether regulation can achieve specific, difficult goals if it is imposed from the top-down, due to the lack of engagement and commitment to the end goal.

If the reverse situation were to be applied, and an industry wide initiative that has all sectors agreeing to specific, difficult goals is developed, it is likely to have greater engagement and buy-in, and therefore will more likely achieve measurable outcomes than a more traditional top-down regulation approach.

The challenge of the bottom-up approach is ensuring that industry apply high enough standards to themselves, but again in the context of the NPS, if industry were tasked with setting out the methods and limits that they would impose to meet the objectives of the NPS, then we may be able to achieve greater commitment to the goals, and in time achieve better environmental outcomes, particularly where such outcomes are linked to a National Strategy for Sustainable Agriculture.

When it comes to finding solutions to reducing the environmental footprint of agriculture, there appears to be limited focus on the importance of setting clear goals and objectives, right from a farm level to an industry level. We need to identify the balance which is the right fit for New Zealand as there is no such thing as the environment OR agriculture. We need to find a way to enable environment AND agriculture.

In terms of examples of long-term strategic planning in agriculture there appears to be a lack of overarching guidance documents prepared at a country level. My research has identified that there are many isolated instances of such plans being prepared at a specific state or industry level, but that for the most part there seems to be a lack of country wide specific long-term agricultural planning, with the exception being Ireland, as outlined in Section 2.2 below. In any event, very few of these plans take a focus on 'farming for the environment', and nor are many of these taking a holistic approach to land use management, so as to enable the value of our sustainability to be captured.

This must change as the future of agriculture in New Zealand depends upon us reducing impact on the environment.

2.1 Holistic Approach

There are many definitions for what holistic management is, but what these definitions have in common is that they focus on looking at the "whole". The Collins English Dictionary defines holistic as being;

“Concerned with, or dealing with wholes or integrated systems, rather than with their parts”

In terms of holistic management in agriculture this is often associated with the ‘regenerative agriculture’ movement, but as defined by Holistic Management International;

“Holistic Management is a whole farm planning system that helps farmers, ranchers and land stewards better manage agricultural resources in order to reap sustainable environmental, economic, and social benefits. This “triple bottom line” of benefits can be achieved by maximizing the management of current resources.” (Holistic Management International, 2019)

Whilst the concept of holistic management is being applied in some instances at a farm scale, as a concept it is often overlooked in terms of our approach to agricultural and environmental policy and regulation, i.e. we do not look at regulation on the basis of the three pillars of sustainability; environmental, economic and social.

The development of a National Strategy for Sustainable Agriculture would provide a vehicle for applying a holistic approach to agriculture that goes beyond the farm, and which would also provide guidance for policy and regulation.

To put the concept of holistic management into context, imagine a tree, its large sturdy trunk represents agriculture, the land from which it grows is New Zealand. This tree has many branches, which represent all the aspects of agriculture, including its impacts and its benefits. Such as social, economic, environmental, technological, policy and regulations. The fruit this tree bears is entirely dependent upon the relationship between all of these things, if we have too much of one branch then our tree becomes unbalanced and will break or bear less fruit. To make this tree grow strong we need to take care of the land from the land up not from the top of the tree down, this is the role of our people, and we must work collaboratively to ensure the longevity of our tree.

Figure 3: Holistic Management - A New Zealand Agricultural Concept



We need to encompass holistic, community centric, collaborative decision making if we are to reduce the environmental footprint of agriculture without compromising the economic viability of the primary industries. All of the branches of the tree are interrelated and co-dependent upon the other.

“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”. (AgFirst, 2016)

2.2 Case Study – Irish Food Strategy

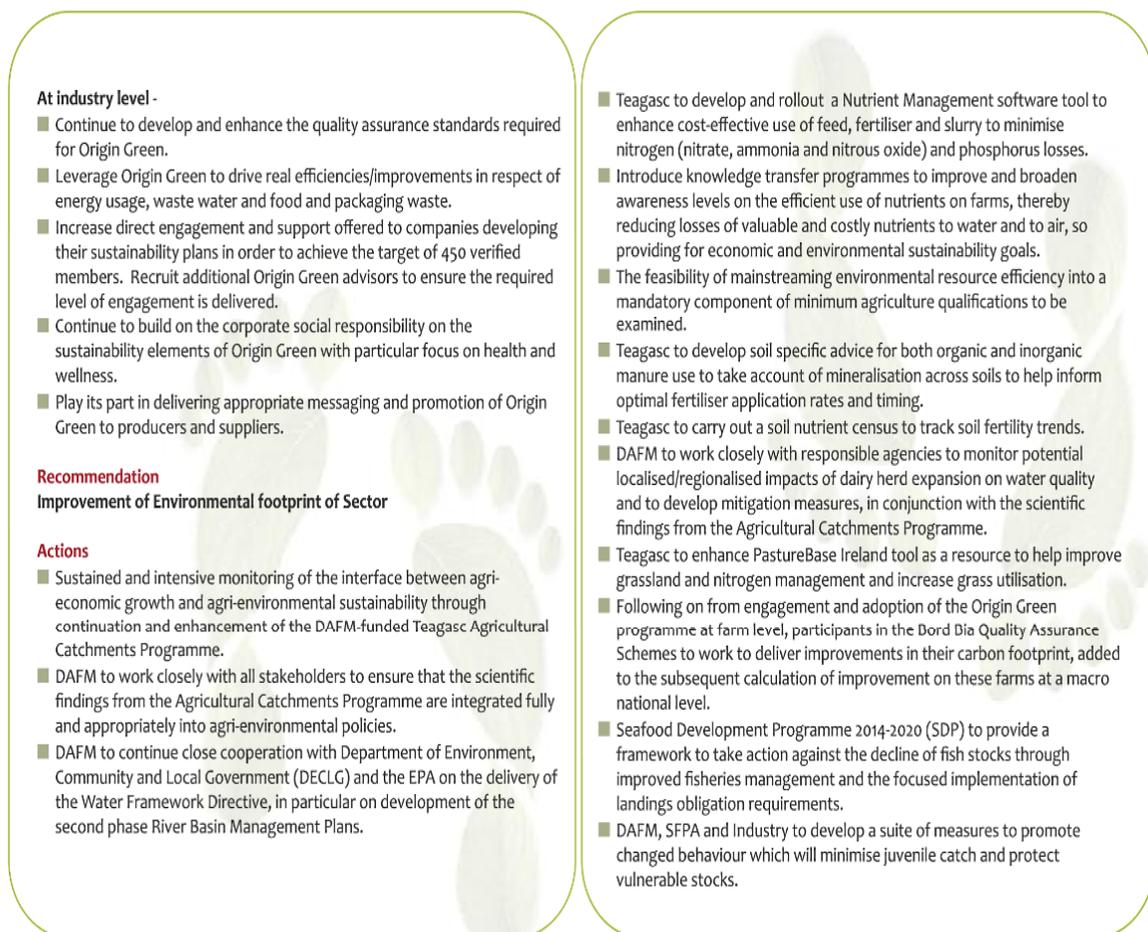
In 2010, on the back of the Global Financial Crisis (GFC), and a depressed economy, the Irish Government set about finding a way to stimulate the Irish Economy, which resulted in the development of *Food Harvest 2020 (FH2020)* which was a strategy document that detailed the forward direction of agri-food, forestry and fisheries for the 10-year period 2010 – 2020. Since its first development, the plan has now been extended under a revised document called *Food Wise 2025 Strategy*. The Food Wise strategy is also an example of an industry led, bottom-up approach. The Food Wise strategy was developed by a committee broadly representative of the agriculture industry but also included both environmental and health sector representation. Following a path of informed decision making the committee developed the strategy which was subsequently adopted by the Department of Agriculture as its own strategy.²

² Pers Coms, Allan Matthews, March 2019.

The Food Wise Strategy envisages expansion within the Irish dairy sector as well as significant expansion of the arable, pig, poultry and forestry sectors. A guiding principle that Food Wise 2025 will seek to embed at all levels of the agri-food industry is that environmental protection and economic competitiveness are equal and complementary: one will not be achieved at the expense of the other. Food Wise 2025 also recognises that the three pillars of sustainability - social, economic and environmental - are equally important and carry commensurate weight. As the sector continues to develop and grow, the view that development must be undertaken within a framework of sustainability must become further embedded in the industry (Department of Agriculture, 2015).

Foodwise 2025 also goes on to set out a number of recommendations, one of which is *the improvement of environmental footprint of sector*. The actions for this goal are shown in Figure 4 below. These are largely high-level targets which would result in further science/data capture to help measure and understand on-farm system processes which may help reduce the overall footprint of agriculture.

Figure 4: Example Recommendation from Foodwise 2025



One of the actions relates to the Agricultural Catchments Programme Which is run by Teagasc Johnstown Castle. In July 2018, I had the opportunity to visit the Johnstown Castle Campus to look at a number of agri-environmental research initiatives.



Photograph 3: Johnstown Castle Campus, Nitrogen Trial Plots

Johnstown Castle is the Teagasc Research Centre for Soils and the Rural Environment, and is located in County Wexford, Ireland. The research centre, which is responsible for research on nutrient efficiency, gaseous emissions, agroecology, soils and water quality. *"The aim of the Crops, Environment and Land Use Program is to develop and transfer cost-effective sustainable agricultural production systems along with evidence based knowledge to support and underpin the development of a profitable, competitive and environmentally sustainable agri-food sector"* (Teagasc, 2017).

The Agricultural Catchments Programme (ACP), is predominantly focused on measuring the effectiveness of Good Agricultural Practice (GAP) measures which are implemented under the Nitrates Directive, at a catchment scale. The program has been running since 2008 and is looking at whether it is possible to achieve what is known as "sustainable intensification" as is set out in Foodwise 2025. One of the key strengths of the ACP is the strong focus on socio-economic elements alongside biophysical elements, looking at a deeper level at changes in the agri-environment due to policy drivers.

3. Evidence Based Decision Making

The basic idea of evidence-based decision making (EBDM) is that good-quality decisions should be based on a combination of critical thinking and the best available evidence. And whilst decisions are typically made on evidence, the quality of the evidence is not always well established. EBDM is enhanced where there is good data available.

In an evidence-based decision-making framework, a decision maker should routinely assess four different types of evidence;

- Scientific literature
- Organisation data, i.e. the data, and statistics that are kept.
- Professional experience of practitioners
- Stakeholders values and concerns

Evidenced based decision making must play a lead role in shaping our future, and in identifying ways to look after our “tree” by being the cornerstone of a national approach to sustainable agriculture. This is already being considered in a broader New Zealand context through the MBIE Vision for Science System 2025 which sets out a long term outcome that *“New Zealand has a highly dynamic science system that enriches New Zealand, making a more visible, measurable contribution to our productivity and wellbeing through excellent science”*. (Ministry for Business, 2015)

An example of community centric, evidence-based decision-making processes is the Irish Citizens Assembly. The assembly is described as being “an exercise in deliberative democracy, placing the citizens at the heart of important legal and policy issues facing Irish society today.” The assembly strives for “rational and reasoned discussion” during its meetings and uses a panel of experts drawn from across the political spectrum to guide the deliberations. Importantly the assembly does not include politicians. The discussions aim to build consensus on contentious issues through informed debate. (The Citizens Assembly, 2018)

The assembly does not replace democratic parliamentary processes but helps to provide a framework to discuss contentious issues free from political influence. The Citizens Assembly was established by resolution of the Parliament. The assembly engages the public by live streaming its sessions and inviting submissions from the broader public. After a thorough conversation, issues are tabled for voting. Through the principle of majority vote, resolutions are passed by the assembly in the forms of reports and recommendations that are submitted to parliament for further debate. Once the recommendations of the assembly are provided to the Parliament, a committee of the Parliament will examine the recommendations, but are not bound to adopt them. The value of the assembly process and subsequent review of the recommendations is that it creates the opportunity for bipartisan support of new legislation. Another important aspect is that if a committee of the government does not choose to implement the recommendations of the assembly, it must publicly state its reasons before Parliament providing an avenue for greater transparency at a decision-making level.

The assembly is operated on the basis of six key principles, as outlined below and as depicted in Figure 5.

Figure 5: Key Principles of the Citizens Assembly



Openness: The Citizens' Assembly operates with complete transparency with all plenary meetings being broadcast live at www.citizensassembly.ie and all documentation freely available. The Assembly is open to hearing from all sections of society on any issue, including young people under 18 years of age, who are not directly represented in the Assembly membership;

Fairness: It is important that the full spectrum of views is allowed to be heard on every issue and that briefing material for Assembly members is of the highest quality;

Equality of voice: Amongst all Assembly members. Each member will be given an opportunity to voice their opinions, should they so wish;

Efficiency: The Assembly will make best use of the limited time together and ensure that all documentation is circulated in advance so members can properly prepare for meetings;

Respect: It is important that members can freely and confidently make contributions and express their views without fear of personal attacks or criticism; and

Collegiality: We will work together in a spirit of friendship as together we embark on this task.

The assembly was established in 2016 to enable informed debate on five key issues of significance to Ireland and its future. The topics for discussion included;

- Abortion
- Fixed term parliaments
- Referendums

- Population ageing; and
- Climate change

In respect to the discussions on Climate Change, the assembly was asked to consider the topic of *“How the State can make Ireland a leader in tackling Climate Change”*.

After two weekends of deliberations, and over 1185 submissions being received from the public, the assembly passed a total of 13 recommendations. Some of the recommendations included;

- 97% of the Members recommended that to ensure climate change is at the centre of policy-making in Ireland, as a matter of urgency a new or existing independent body should be resourced appropriately, operate in an open and transparent manner, and be given a broad range of new functions and powers in legislation to urgently address climate change.
- 100% of the Members recommended that the State should take a leadership role in addressing climate change through mitigation measures, including, for example, retrofitting public buildings, having low carbon public vehicles, renewable generation on public buildings and through adaptation measures including, for example, increasing the resilience of public land and infrastructure.
- 89% of the Members recommended that there should be a tax on greenhouse gas (GHG) emissions from agriculture. There should be rewards for the farmer for land management that sequesters carbon. Any resulting revenue should be reinvested to support climate friendly agricultural practices.
- 99 % of the Members recommended that the State should review, and revise supports for land use diversification with attention to supports for planting forests and encouraging organic farming. (The Citizens Assembly, 2018)

The clear benefits of this process are that through informed engagement and debate, a clear mandate that is representative of society is achieved, which is then used to guide Parliament on regulatory and policy outcomes.

A process similar in nature to the Citizens Assembly would provide a forum to help define the aspirational goals that we set to achieve, which are comparatively free of political whims, and which would then guide us across all facets of decision making into the future. An approach of this nature could be adopted to help develop a National Strategy for Sustainable Agriculture.

4. Technology, Agriculture & the Environment

"The development of environment related technologies grew remarkably between 2000 and 2010 this was particularly apparent with applications to climate change mitigation in buildings, transport and energy generation." (OECD, 2017)

It is however interesting that this growth in inventive activity appears to have had little focus on agriculture, which may be underpinned by the challenges of global food security, and how we can reach a balance between food demand and the protection of the natural environment, especially given the overall contribution of agricultural emissions to climate change.

"A large majority (90%) of green inventions originate in OECD countries, especially in the United States, Japan, Germany, Korea and France. However, the contributions from China and India are increasing rapidly." (OECD, 2017)

In the US, there is a strong start-up sector focused on Ag Tech, albeit many of these start-ups are operating in the precision ag, and crop insurance space or are focused on vertical food production, for example 'Descartes Lab' and 'Plenty'.

When people consider technology and technology solutions, they tend to think in the 'high technology', space, yet there is a significant amount of work going into the development of more 'low tech' solutions to help reduce the environmental footprint of agriculture. For example, the declining cost of sensor development will continue to make technology more affordable and will make the continued collection of data easier. It follows that the more data that we have, then the more we enable evidence-based decision making. In my view data will become the new currency for agricultural businesses.

Expanded access to and more sophisticated use of information will play an increasingly important role in agriculture. There is exciting potential to use more granular data (for example, data for every ten-meter-by-ten-meter square of a field) and analytical capability to integrate various sources of information (such as weather, soil, and market prices) with the goal of increasing crop yield and optimizing resource usage, thus lowering cost. (McKinsey & Co, 2015)

In looking at technology and its application to reducing the environmental footprint of agriculture, my observation is that few technology developments are focused wholly on creating solutions to reduce the environmental footprint of agriculture.

It is true that some technology has a clear environmental benefit, but the environmental benefit is not typically the main reason for its creation, it more often than not happens to be a secondary outcome. For example, precision application or variable rate application of fertiliser. The development and the uptake of variable rate application technologies is predominantly driven by the financial gains that can be achieved by applying less fertiliser, the choice to utilise this technology is therefore primarily an economic decision. The fact that the application of the right amount of fertiliser to the right place at the right time also has an environmental benefit in terms of reducing the potential for nutrient run-off or accumulation is secondary. Only the very astute will see the primary value as being the environmental gain, and the secondary gain as being financial.

One area where technology is focusing on reducing environmental effects is in the genetics space. A New Zealand example of this approach is the work being undertaken by Dairy NZ to breed cows with a lower nitrogen footprint. The seven-year program is called *Livestock Genetics and Management to Reduce Farm Environmental Impacts*. The program is designed to help farmers meet environmental targets in three key ways;

1. Developing genetically low N-footprint animals.
2. Offering breeding and management strategies to reduce N Leaching.
3. Reducing sector-wide N leaching by 20 percent. (Dairy NZ, 2019)

An overarching constraint in terms of technology uptake (aside from the cost) is the way in which technology links to policy and regulation. Policy and regulation operate on a very different timescale to technology. Policy and regulatory change is slow, whereas technological change is fast. However, because a range of tools both regulatory and technological will be required to reduce the environmental footprint of agriculture, we need to find a way for policy and regulation to help enable technology.

Providing continuous incentives for innovation towards environmental objectives remains a challenge. OECD work suggests that stringent, predictable and flexible environmental policies are more likely to provide long term signals to innovators. (OECD, 2011).

There is also a case that could be made that *"Subsidies have a role to play in incentivising start-ups and in helping to overcome barriers to adoption in the early stages of a technology. The difficulty with relying only on subsidies to achieve our emission reduction targets in agriculture is that they have to be paid by somebody"* (Matthews, 2017).

Technology and innovation uptake will be essential if New Zealand agriculture is to reduce its environmental footprint. Innovation and technology can not only drive productivity and economic growth but can also help achieve environmental objectives. *"It is widely acknowledged that far-reaching innovation will be needed to address climate change and other environmental challenges, and to accelerate the transition to green growth"* (OECD, 2017).

New Zealand is already on the path towards supporting technology innovation, particularly within the Ag-Tech space, however we remain well behind nations such as Israel where Ag-Tech Innovation is well engrained, with some reports of as many as 460 individual Ag-Tech start-ups operating in Israel alone (Evoke Ag, 2019).

New Zealand needs to find ways to enhance the uptake of technology, because we will require technology tools to help manage land use change and reduce the environmental effects of agricultural, especially in terms of reducing the impacts of climate change.

Agritech New Zealand, was launched in 2018 with the vision;

"Agritech New Zealand's vision is for New Zealand to become a global leader in science, technology and innovation, delivering commercial outcomes for the global primary sector. Agritech New Zealand is a purpose driven, inclusive, membership funded organisation that brings together a broad range of active members who have a shared passion for the opportunities that agritech can bring. Agritech New Zealand takes a practical, but information and evidence-based approach, focussing on harnessing the opportunities

and addressing the issues. It draws on the active contributions of all members. This approach is intended to balance the dual aims of (1) clearly identifying the real issues to be addressed so actions have maximum effect, and (2) moving to action rapidly. We act as an industry thought-leader, supporting NZ agritech innovators at home and abroad.” (Agritech New Zealand, 2019)

Organisations such as Agritech New Zealand, are a starting point for bringing together the wider agricultural sector in New Zealand and for providing a forum that enhances the uptake of technology. It is important that we foster cross-sector collaboration and focus rather than continuing to operate in our various sector silos.

4.1 Case Study – VITO Belgium

In July 2018, I had the opportunity to meet with a number of research scientists from VITO, in Antwerp, Belgium. VITO is the equivalent of a Crown Research Institute (CRI) that is owned by the Flemish Government. VITO is focused predominantly on cleantech and sustainable development, although started out as Nuclear Research Facility in the early 1990's.

In the agricultural space much of the research undertaken by VITO is focused on remote sensing, analysis and data management. Many of the projects undertaken by VITO to date have focused on agricultural production gains, for example the development of their Crop Monitoring program called MAPEO, but in the last few years they have also started to focus on ways to measure environmental effects of agricultural and land use change.

An example given was the analysis of 3D aethomosaic photos of off-shore wind turbines, and through the analysis of the data they were able to assess turbine lag in the water and through the application of marine science they were able to assist in determining potential effects on marine sea life from off-shore wind turbines. Another area of their research of interest was a large-scale water quality monitoring project they were leading. While the project was not focused on agricultural land use, it was focusing on the impacts of sedimentation in waterways. The project involved the use of drones to undertake site specific water quality monitoring via RGB cameras. In this case suspended solids and turbidity were the measures which were being used as a guide to overall water quality. An interesting observation was that as a technology focused research institution, they often encounter challenges in policy enabling the uptake and use of technology in a regulatory role. www.vito.be

5. Enabling Policy Incentives

Policy is one of the most applied tools for delivering change. It sets out the high-level guiding principles that are fundamental to giving effect to the desired change. For example, the NPS sets out a series of objectives for water quantity and water quality. Interestingly, in the document titled *"A Decade of Public Perceptions of the New Zealand Environment: A Focus on Water and its Management"* by Hughey et al, the survey results found that Economic and Regulatory approaches were the most favoured by respondents in terms of achieving desired outcomes.

Regulations on the other hand are focused on implementing policy and are often created as laws or rules to give effect to the policy. i.e. regional plans have to make rules to implement the NPS. Often rules and regulation are seen as being highly prescriptive, especially where the purpose is to drive changes or outcomes which are slow to change of their own accord.

In this section I provide a high-level overview of the agri-enviro policy in Europe and the United States of America, followed by an overview and comparison to regulation in a New Zealand context.

The purpose of this analysis is to identify if there are any comparative or innovative approaches to policy which make policy more enabling.

"Policy may change the opportunity costs of production and consumption. If that happens, they have the potential to induce innovative responses by firms and consumers. Some responses could be to adopt environmentally friendly alternatives, develop new technological solutions or shift towards new management methods" (OECD, 2017).

5.1 A European Perspective

Agri-environmental payments have been an integral part of international agricultural policies for many years. In the 1990s, these were often scarcely related to the environmental results and the effects could only be evaluated with difficulty. In the meantime, major changes have been made to the content of agricultural policies with regard to environmental aspects (Sterly, et al., 2018).

European Union (EU) countries are governed by the Common Agricultural Policy (CAP). Since 2000, the CAP has had a focus on meeting rural development needs, such as public goods, farm modernisation, innovation and diversification alongside income support (direct payments). This has resulted in the 'decoupling' of production-based payments in the EU and focuses on payment for the maintenance of good agricultural practice and ecological conditions.

In the EU, environmental regulation is often under-pinned by non-financial policy incentives focused on environmental improvements in agriculture. The EU is well known for trying to incentivise agri-environmental benefits, but this is typically done through additional payments or subsidies

From around 2013, the CAP placed a stronger focus on the provision of environmental public goods/services to society and a 'greening' component of direct payments was introduced.

All farms in receipt of the single farm payment are expected to maintain Good Agricultural Environmental Conditions. This includes:

- Establishment of buffer strips along watercourses.
- Protection of ground water against pollution.
- Minimum plant cover to protect soils as bare soil can be eroded and lose soil carbon.
- Minimum land management reflecting site specific conditions to limit erosion.
- Maintenance of soil organic matter through appropriate practices.
- Retention of landscape features

In November 2017, the European Commission published the communication *The Future of Food and Farming* (European Commission 2017), which outlined ideas on the European Commission on the future of the CAP.

The general objectives of the future CAP according to the European Commission are:

1. to foster a smart, resilient and diversified agricultural sector ensuring food security;
2. to bolster environmental care and climate action and to contribute to the environmental and climate objectives of the EU; and
3. to strengthen the socio-economic fabric of rural areas.

In considering the link between agriculture and the environment, the interaction between the two continues to present some challenges. *"[In Europe] there has been a slight trend towards the use of results-oriented instruments. More attention is paid to measures that promote the expected environmental effect rather than payments for certain goods and means of production. Although these approaches have received increased support, they continue to account for only a minimal proportion of the funds used.*

Conservation or improved use of water, soil and air resources is clearly the main focus of the environmental instruments used. Not forgetting that the aspects of animal health and welfare, renewable energies and also organic farming play similarly important roles in agricultural policies and are often supported with their own measures and programmes. It should also be noted here that the importance and interpretation of agri-environmental policies within the agricultural policies of the countries differ greatly. Although efforts are generally made at national level to reduce greenhouse gas emissions and thus also the carbon footprint of the agricultural sector, there are hardly any specific targets. Various initiatives are therefore taking place at the multinational and bilateral level." (Sterly, et al., 2018)

In a European context in particular, emphasis has been on ways to design agri-environmental incentive payments, environmental standards or at a national level taxes (the EU itself is unable to use taxes as a policy instrument).³ The voluntary incentive payment scheme as an example, is vastly different to a New Zealand context where there is no subsidisation of agriculture or environmental outcomes.

The EU's CAP reforms show a shift from price support policy measures to direct payments, where the latter are increasingly linked to specific targets. This movement reflects the increasing market orientation and the increasing emphasis on environmental and sustainability objectives. The newly

³ Pers Coms Allan Matthews, March 2019.

proposed CAP 2021-2027 is another step in this direction with a proposed revised green architecture, including an extended baseline and additional options to reward farmers for public goods (more emphasis on climate action). (Sterly, et al., 2018).

5.2 A US Perspective

In the United States, farm policy is mainly formed and funded by the Federal Government in the form of the 'Farm Bill'. The US Congress is the main focus for farm policy debates, while the United States Department of Agriculture (USDA) is tasked with implementing policies through a physical presence in most states and counties in the country.

While each farm bill updates US agricultural policy to address both current policy concerns and new underlying conditions, the main way this is done is by amending various individual pieces of legislation that each focus on a specific issue. Importantly, each Farm Bill has a relatively short life of 4 to 6 years and its provisions expire at the end of this period. Should a Farm Bill expire without a replacement, the so-called permanent legislation of the Agricultural Adjustment Act of 1938 and the Agricultural Act of 1949 would replace current legislation. The expected effects of this are seen as so negative for farmers, consumers and the government that it creates a strong incentive to complete a new Farm Bill or extend the existing one.



Photograph 4: Sunmaid Sultana Grapes, California, USA

The main objective of US farm policy remains support for farm income and stabilisation of farm commodity markets, although the main form of support has recently shifted from direct payments to insurance type products.

Another unique aspect of US agricultural policy is the Supplement Nutrition Assistance Program (SNAP) or food stamps program.

In terms of agri-environmental policy, this is largely administered by the various state governments, rather than the Federal Government, with the exception of the Conservation Reserve Program which was implemented in the 1985 Farm Bill. The purpose of the Conservation Reserve Program was to reduce the environmental damage on environmentally sensitive land by taking it out of production for an extended period. Payments are provided to participating farmers to compensate them for lost income. A secondary motivation in 1985 was to reduce farm output to stabilise prices and incomes.

Because of the state government approach to environmental regulation, there is significant variation in policy and regulation depending on which state you are in. For example, in California environmental regulation in an agricultural context is much more stringent than the Mid-West of America.

5.3 A New Zealand Perspective

Readers will be acutely aware of the mounting pressure that agriculture faces domestically, here in New Zealand with recent opinion polls indicating that as many as 82% of New Zealanders are concerned about water quality as a result of the impacts of agriculture.

These 'opinions' are a strong driver for continued regulatory interventions as a mechanism to address the challenges of agriculture and the environment. *"New Zealand's developed economy, and unique constitutional arrangements result in central government playing a dominant role in public administration, and remaining relatively agile, yet with a bias towards regulatory responses, in meeting emerging challenges and opportunities"*. (McFetridge & Morrison, 2017)

In a regulatory context, New Zealand adopts an extensive, non-prescriptive, risk-management based approach to regulation which:

- *Places responsibility on regulated businesses to demonstrate compliance, while facilitating innovation.*
- *Is at risk of atrophy as the libraries of legislation and regulation increase, imposing greater regulatory review and maintenance burdens on government ministries and affected industry sectors.*
- *Is dependent on the maintenance and development of a talented workforce to govern, administer and maintain the regulatory system across the various contributing institutions.* (McFetridge & Morrison, 2017)

The New Zealand government does not provide direct economic support to the nation's primary sector but works to support and enhance the nation's primary industries in order to remain innovative, efficient, and globally competitive.

Whilst not likely to gain traction in a New Zealand context, is it worth asking the question of whether financial incentives are in fact an appropriate tool to help drive a reduction in the environmental footprint of agriculture? An opportunity to have an informed debate about such an approach would be beneficial. Based on the work of Hughey et al, as many as 43% of survey respondents indicated that they were willing to pay a targeted rate in relation to enhance or improving lowland streams. (Hughey, Kerr, & Cullen, A Decade of Public Perception of New Zealand Environment: Focus on Water and its Management, 2011).

There are many examples of countries that consider efforts by farmers to improve the natural environment as a public good, for example, The United Kingdom, or Denmark, and as such farmers efforts to improve outcomes are financially rewarded. In my view we need a broad range of tools to help reduce the impacts of agriculture on the environment. Because of the complexity of the issues, one single approach is unlikely to be effective.

Environmental regulation in New Zealand is underpinned by the Resource Management Act, 1991 (RMA), which sets out how natural resources such as land, water and air in New Zealand shall be managed. The RMA focuses on the sustainable use of natural resources, and seeks to control the effects of activities, including the effects of agriculture. Both the benefit and the detraction of the RMA framework is that there can be significant regional variation in how it is implemented as each region develops its own rules to give effect to Central Governments laws and policies.

Further, in 2014 the implementation of the National Policy Statement for Freshwater Management was introduced to provide direction on how local authorities should carry out their responsibilities under the RMA for managing fresh water. From this point onwards, agriculture and the environment have begun to truly intersect.

New Zealand's land use policy, as far as it seeks to regulate diffuse pollution to manage water quality, has been built around the assumption that 'rule by numbers would remove ambiguity and provide clarity and certainty for both governments and resource users. It has been shown that the opposite is unfolding and is likely to continue. As foreshadowed by Porter (1996, p.49), making numbers work in practice is never straightforward and can compromise "those key virtues" for adopting a quantitative approach in the first place. (Duncan, 2014)

This work by Duncan broadly supports the need for a variety of tools to solve the environmental challenges of agriculture, rather than just regulatory tools, especially given the socio-political drivers that underpin environmental policy development.

"An argument can also be made that policy development for regulating diffuse pollution is not just a scientific and technical endeavour – it is also very much a social-political one. Research suggests that the workability and enforceability of policy regimes that seek to institute resource limits can be undermined by these broader social-political aspects. The research highlights the epistemological, institutional and practical challenges of tightly linking numbers derived from predictive models to compliance and enforcement mechanisms." (Duncan, 2014)

The challenge of the current New Zealand approach is the perceived and actual layers of bureaucracy. There are also increasing instances of poor policy and regulation disincentivising good environmental outcomes. An example of this might be where regional plans create unintentional barriers through policies and rules which make doing the right thing environmentally difficult because of the consenting process, i.e. someone who wants to change land use or reduce stocking rate has to go through a consenting process to achieve this outcome.

As a broad generalisation I would consider that the general lack of knowledge about farm systems and the importance of implementation by policy makers is creating additional challenges for us all to achieve

the well-intentioned, but often impractical outcomes and environmental gains that everyone agrees are important. This is an area which represents significant opportunity for improvement. These views were also highlighted by Ag First who noted;

"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." (AgFirst, 2016).

5.4 Analysis of Policy Instruments

Major changes have been made to the content of agricultural policies with regard to environmental aspects, especially in the case of regulations and requirement for land management. In a New Zealand context, the Resource Management Act 1991 (RMA) has oversight for environmental outcomes, including agricultural discharges and agricultural land use which have come into greater focus by regional councils as they work towards meeting the objectives of the NPS by 2025.

Whilst in the EU there is a clear focus on the importance of rural development, which is aimed at improving the quality of life and economic wellbeing of people living in rural areas, there is little government specific support for similar approaches in a New Zealand context, albeit there has been a recent move to support regional development, although this is not agricultural sector specific in terms of its target.

"Increasingly, ecological sustainability is being addressed, especially with regard to expected climate change, where agriculture is likely in the future to have to contribute in order to allow countries to achieve their climate action commitments set out under the Paris Agreement."

"The variations in rural development approaches and instruments across the world is also reflected in the fact that there are no comparable statistical indicators on financial support estimates for rural development available at a global level." (Sterly, et al., 2018)

The same challenge occurs when trying to compare environmental indicators as each country reports on different measures.

"New Zealand's approach to nutrient management is similar to the Total Maximum Daily Load (TMDL) regime in the United States (US) where predictive modelling is used to set numeric limits by predicting the assimilative capacity of water bodies and their potential nutrient enrichment from predictions of current and/or future land use and pollutant sources (Copeland, 2012; EPA, 2013; Norton and Kelly, 2010; Sims and Volk, 2013). Like Europe, New Zealand's approach differs from the US in terms of coverage where limit setting, and remedial action are triggered by impaired water status. In New Zealand, all water bodies and/or their catchments are subject to enforceable limits and regulations under the NPS. Here the policy

aim is prevention rather than cure where thresholds have not been exceeded (PCE, 2012, 2013)." (Duncan, 2014)

In regard to policy mechanisms to address the environmental impacts of agriculture, underlying guidance from the OECD in respect to 'Green Growth' initiatives indicate that sustainability of agri-food systems is at the centre of green growth considerations. *"There are three main concerns related to sustainability; food security, run-off of nutrients such as Nitrogen (N) and Phosphorous (P) from commercial fertiliser use and intensive livestock farming, and pesticides residues that may leach into surface water and groundwater and enter the food chain. Farming also contributes to climate change and can lead to deterioration in soil, water and air quality and to loss of natural habitats and biodiversity. These environmental changes can, in turn have implications for agricultural production and limit the sustainability of agriculture. But farming can provide sinks for GHG's, help conserve biodiversity and landscapes, and help prevent floods and landslides"* (OECD, 2017)

The challenge remains of finding ways to reduce negative impacts of agriculture and increase positive impacts of agriculture. An approach which enables agriculture to reduce its effects on the environment will ultimately also enable ecosystem functions to be maintained and food security to be enhanced.

The OECD asserts that achieving changes which result in a reduction in the negative effects of agriculture will require two types of interventions. *"First the productivity and sustainability of agri-food systems must be improved through better land management practices. In addition, pollution discharges from agriculture can be reduced through better management of nutrients. Second, agriculture support measures linked to production that encourage intensive production and exacerbate the rate of biodiversity loss must be addressed."* (OECD, 2017)

Improving the environmental performance of agriculture is a high priority for OECD countries. But measuring and evaluating the impact of agri-environmental policies on the environment can be challenging, as it requires linking economic and biophysical models in country-specific contexts. (OECD, 2010).

6. Opportunities for NZ Agriculture

For change to be effective, a ground up approach will be more effective than top down led change, because it creates an opportunity for greater buy-in. This is why it is important for New Zealand to act swiftly so that we can build on the changing momentum amongst our farmers and agribusinesses, who are more supportive than ever of the need for wholesale change.

Opportunities lie in the ability for New Zealand to capitalise on its innovative nature (No.8 Wire Mentality) and to find ways to export environmental related products alongside high-quality food products. Is there an opportunity for us to substitute some of our agricultural growth with knowledge (technology and expertise) which the rest of the world is prepared to purchase?

We need to re-think the methods we deploy in trying to control the impacts of agriculture which have typically focused on policy and regulation, which have arguably had little success in achieving real environmental gains not just in New Zealand, but elsewhere in the world.

We need to ask, “what are the tools that can help reduce the environmental footprint of agriculture?” We also need to focus on the right drivers as all too often our regulatory approach fails to recognise the practicalities of its application at a ground level and can ultimately disincentivise and drive the wrong behaviour. Implementation is where our policy and regulatory approach routinely fails to achieve the desired outcomes, and a focus on implementation is a significant opportunity for improvement.

OECD work suggests that stringent, predictable and flexible environmental policies are more likely to provide effective long-term signals to innovators (OECD, 2011).

For us to move successfully into a new future of agriculture we must set aside our differences and focus on solutions. We need to ask ourselves hard questions, and we need to be confronting, so that we can balance the need for safe, good quality food production practices alongside world leading environmental practices which reduce the impacts of agriculture on the environment.

Globally, I believe that New Zealand is in a strong position to lead change, and that due to our relatively ‘short’ history of intensive farming that it is possible over time and with an appropriate focus to reverse the impacts of our effects on the environment. However, to achieve this we need to all be singing from the same song sheet. The opportunities lie in transformational change and include;

- Fostering & enabling technology development and uptake
- Moving towards a truly sustainable economy that embraces the three pillars (Environment, Economic & Social). The world leader in sustainable agriculture.
- Monetisation of Sustainability.
- Re-designing policy approach to integrate technology and develop a new way of engaging and measuring outcomes.
- Utilising data and information as the currency of choice for agriculture.
- Export our knowledge and technology to the rest of the world.

Almost every industrialised nation began its economic ascent with an agricultural transformation. Recent examples include Brazil, China, and Vietnam, each of which at least doubled the value of its agriculture sector within 20 years of starting its transformation (McKinsey & Company, 2017).

Is it time therefore that a country such as New Zealand moves towards transformation of its agriculture sector? Could 'Environmental Agriculture' be Agriculture Version 4.0 for New Zealand?

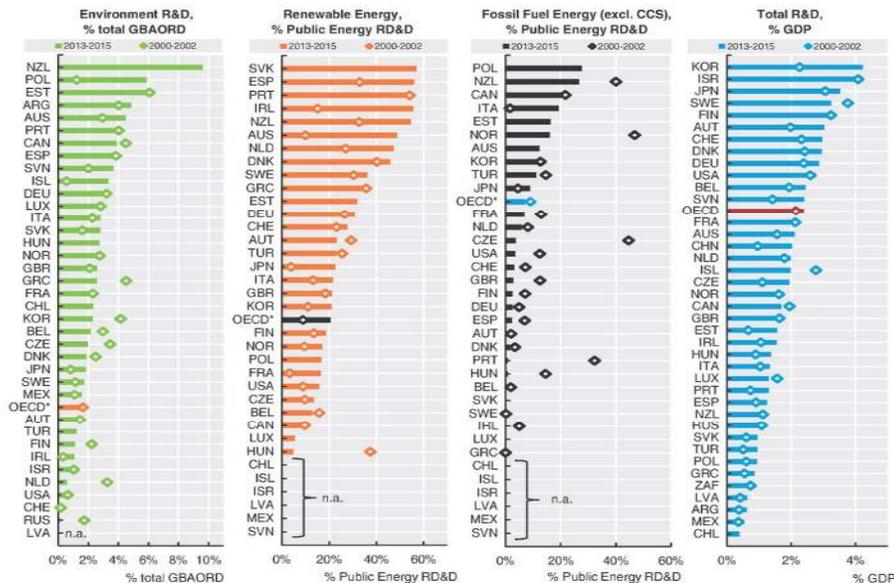
"Effective policy making for agricultural transformation needs to become more evidence based over time." (McKinsey & Company, 2017)

A green growth strategy is centred on mutually reinforcing aspects of economic and environmental policy. *"It takes into account the full value of natural capital as a factor of production and its role in growth. It focuses on cost effective ways of attenuating environmental pressures to affect a transition towards new patterns of growth that will avoid crossing critical local, regional and global environmental thresholds."* (OECD, 2011)

Progress has been mixed on the innovation front. Government research and development funding is rising, however the share dedicated to environment and energy objectives remains stagnant. Green growth is not a replacement for sustainable development, but rather should be considered a subset of it. It is narrower in scope, entailing an operational policy agenda that can help achieve concrete, measurable progress at the interface between the economy and the environment (OECD, 2011).

In a country such as New Zealand, whose primary focus is the primary sector, then it reasons that a move towards green growth in agriculture is essential to a sustainable future, one where both the environment and the economy are seen as equal measures of success.

Figure 6: R & D Spend OECD Countries



While New Zealand's comparative spend on Environmental R & D is high, overall as a total percentage of GDP New Zealand's expenditure on R & D is relatively low as shown in Figure 5 above. (OECD, 2017).

7. Conclusions

Agriculture globally is at a crossroad as it faces increasing pressure from diminishing natural resources, climate change, increasing population, and changing consumer trends. Overcoming these challenges will be essential for ongoing global sustainability. The complexity of these issues is immense with many conflicting drivers influencing the decisions that countries make in terms of trying to reduce the environmental footprint of agriculture. My travels have highlighted the acuteness of the challenge we face in reducing the impacts of agriculture on the environment not only for the reasons outlined above, but because of the geo-politics of food and agriculture. Nations are driven by the desire to achieve a position of food security for their people, which in turn requires a need to establish and rely on agriculture. When this ability to produce food comes under pressure, from the likes of climate change there is likely to be resistance to change.

New Zealand, like most countries, is grappling with how we also reduce the impacts of our activities and move towards a future of sustainable agriculture. I believe we are making good progress in terms of the understanding that our farmers and agri-businesses have around the actual impacts of our activities on the environment, particularly when I compare this to some of the farmers and agri-businesses, I had the opportunity to meet with during my travels. I also believe that there is an increased awareness amongst New Zealand agri-businesses and farmers of the fact that we need to change the way we undertake our agricultural activities so that the impacts on the environment are minimised. We now need to focus on finding solutions and truly transforming our agricultural system from one which is wholly production and development focused to one which is value focused, and where decisions are based on the balance of social, environmental and economic outcomes, rather than focusing on just economic outcomes. A change in approach will enable us to move towards monetising our sustainability, and ensuring our long-term position as high quality, sustainable food producers.

We cannot however afford complacency if we are to take advantage of our position in the global food market. New Zealand will never be in a position to 'feed the world', therefore we must continue to focus on extracting more value from our agri-food products. Alongside this however, there remains significant opportunity for New Zealand to capitalise on the export of technology and knowledge, especially in the agri-enviro space.

We must capitalise on our sustainability, but for this to have any traction we need to be able to demonstrate that our agricultural sector embodies the three pillars of sustainability (environmental, economic and social). This will require us to challenge the status quo and operate within a holistic environment. We also need to have a framework which supports and promotes transparency.

I believe one of the significant advantages we have is that we are innovative by nature, and that with an agreed National Strategy for Sustainable Agriculture, and a focus on adopting a ground up approach we will be able to be the global leaders in sustainable agriculture.

Finally, in drawing to a close, I have attempted to provide some commentary to the five questions that I developed for guidance at the outset of this project.

1. Where does New Zealand sit on the spectrum of environmental regulation (affecting agriculture) compared to other agricultural nations throughout the world? i.e. are we highly regulated or not?

In my view, New Zealand is highly regulated in terms of managing the environmental effects of activities, including agriculture. Especially compared to the likes of Australia. Our RMA is often considered by detractors to be ineffective in managing the impacts of activities on the environment. But based on other approaches to environmental management and agriculture that I have observed, its effects-based framework sets it apart and continues to be an appropriate approach to manage the effects of activities on the environment. The benefit of this approach is that it enables a site-specific assessment of what effects will occur and where, while focusing on how they will be mitigated.

The 'how' remains the biggest challenge for us to overcome, but with evidence-based decision making will become more achievable.

2. How is New Zealand performing from an environmental perspective compared to other agricultural nations throughout the world? i.e. are we achieving good, measurable environmental outcomes?

This question has been more difficult to answer because there are few genuinely comparative standards of environmental performance. However, based on my observations of the last 12 months, New Zealand is performing at or above the level of most countries in terms of achieving good environmental outcomes. I would emphasise however that we are not achieving at a level that is good enough for us to have absolute confidence that our activities do not have an impact on the environment, or to be certain that we are truly sustainable. In terms of the measurability of environmental outcomes, my general observation is that the tracking of policy and regulatory outcomes could be improved, and the opportunity lies in harnessing technology to assist with improved measurement of methods that will reduce the environmental footprint of agriculture.

I also believe that the answer to this question is linked to the state of the environment of any given country. For example, in a European scenario, the baseline for comparing impacts on the environment is significantly lower given they have had many 100's of years of degradation of their natural environment, compared to a country like New Zealand which only has 100 or so years of degradation. So, while our overall water quality as an example remains high compared to other countries, in the context of what it was like in our living memory it has reduced significantly, therefore the perception is that we are performing much worse than we actually are.

3. What are the solutions for enabling us to reduce the environmental footprint of agriculture while maintaining sustainable farming businesses?

There are many solutions such as advances in sensor technology, or genetic modification of animals to reduce methane emissions which will in time contribute to the overall reduction of impacts on the environment but there is no 'silver bullet'. We must start with engagement and move towards the development of a National Strategy for Sustainable Agriculture which enables us to call upon many tools to reduce our impacts We must also focus on technology and science,

and on what we need to do to reduce the impacts of agriculture. Finally, we must re-define our policy approach.

These solutions will only be effective when applied with Bold Leadership, Holistic Management and Evidence Based Decision Making.

4. What role does technology have in reducing the effects of agriculture?

Technology will be one of many solutions, and not the only solution. Technology such as advances in remote sensing, and data analytics i.e. measuring where our nutrient losses are occurring, and therefore where they need to be managed will support a transformative change in agriculture and will provide a significant opportunity to help reduce the environmental impacts of agriculture. We need to ensure that environmental solutions become a key driver of Ag Tech development. We also need an approach to policy and regulation that enables technological advance and widespread implementation.

5. What are the practical solutions that would engage farmers to make positive changes for the environment?

A holistic, ground up approach that seeks meaningful two-way engagement between regulators, stakeholders and the agriculture sector would go some way to engaging farmers to make positive changes for the environment. We need to focus on celebrating the good work that has been done and use this as a positive way to engage people to continue to strive for agricultural sustainability. Our current approach is often one of 'pointing the finger' at who is to blame for the challenges we face, yet we should be focusing on how we can incentivise and enable solutions. In the context of initiatives from other countries, the question of financial incentives should also be explored. Whilst this is not a tool that is likely to find favour within our current culture. there may be an opportunity to provide financial incentives via other approaches such as contestable funds or research and development partnerships which may enable technology to be taken up at lower cost.

I am confident that changes in policy and technology can create an environment where inspiring goals can be achieved through ground-up collaboration across all stakeholders.

8. Recommendations

1. Facilitate Robust Conversation & Engagement

Central Government needs to facilitate a mechanism for informed and robust conversation about what is important to New Zealand. These conversations need to be focused on achieving broad engagement and creating an environment that encourages people to speak up without fear that their views will be ridiculed or dismissed as unimportant. If such an approach is to be agriculture specific, then partnering with the ag sector will be critical.

It is recommended that investigation into the development of a New Zealand version of the 'citizens assembly' be undertaken, and if feasible, implemented to facilitate robust conversation and engagement at a transformational level. This option would need to be led by central government, and in my view would only be successful where there is bipartisan government support for such an approach.

2. Set Strategy & Goals

The starting point for transformative change in agriculture in New Zealand is the development of an all-encompassing agri strategy, underpinned by informed conversation and debate. This should be in the form of a National Strategy for Agricultural Sustainability. The purpose of an agri-enviro strategy is to set long term ambitious but realistic goals or BHAG's that will guide the changes within the agriculture sector, as well as setting goals around what will be achieved in terms of our environmental outcomes. This will result in a broad set of agreed principles that can then be applied holistically to science, policy and regulation, health, and other interrelated disciplines. This approach would in my view be best undertaken via a partnership approach between the New Zealand Agricultural Sector (covering representation from all industries) and the Ministry for Primary Industries, much like the Irish Food Wise 2025 example. To be successful however will require engagement with stakeholders, including iwi, science and technology, environmental NGO's and other government agencies. In my view such an undertaking will require bold leadership that is focused on outcomes, and in setting a new direction for agriculture in New Zealand.

3. Enable Collaborative Science, Technology & Data

We must start with a comprehensive Gap Analysis of the future science, technology and data needs. This shall be fostered through collaboration and coordination amongst the agricultural, science and technology communities. The establishment of an innovation centre dedicated to holistic sustainable agriculture that fosters collaboration between scientists, business, farmers, and other countries, would be a method for achieving this. It could also be a method for removing the current barriers to collaboration, whilst directing science and technology to where it is required and thus contributing to the outcomes of our strategy. This recommendation would be best led by a joint team representing New Zealand agricultural research institutes, the agricultural sector and the Ministry for Primary Industries, and Ministry for Business, Innovation & Employment. It may also link to the overall science direction work under the document entitled 'Conservation and Environment Science Roadmap'.

4. Re-Design Policy Approach

The final step in undertaking transformative change of the agricultural sector is an overhaul of our approach to agri-enviro policy. Policy needs to be enabling rather than reactionary. This will require us to have greater checks and balances in place to ensure that we are achieving outcomes. Monitoring and data become essential in this process, which is where the continued development of technology will assist us in this space. Policy and regulation are necessary but should be a tool to force late adopters and poor performers to change, rather than limiting the ability of those more able early adopters to innovate and make wholesale changes to their farming systems. This approach will require all of government buy-in, as there is likely to be cross ministry implications, specifically between the Ministry for Primary Industries and the Ministry for the Environment. Changes to a policy approach would be best led at Ministry level but will require wide ranging engagement that focuses on solutions and implementation as a core feature. It is also likely that such an approach will also be applied at a local government level also.

To achieve each of these recommendations we must ensure that we have;

- a) Bold Leadership
- b) A Holistic Approach
- c) Evidenced Based Decision Making

Without these enabling factors our ability to foster transformational change within the New Zealand Agricultural Sector will be an unobtainable dream. We must act now to enable better environmental outcomes which support a sustainable future underpinned by economic, environmental and social prosperity.

9. Scholar Bio



Growing up in rural Taranaki typically means that you will have some link to agriculture. My early life began in the cowshed and fields of South Taranaki, trying to keep up with my Grandfather and Father, both of whom were and are passionate innovators within the primary sector.

As a school leaver, agriculture was not something that stood out as a career opportunity, but through my interest in the environment, I attended Victoria University, where I obtained a degree in Geography and Political Science. Following this I embarked on a career as a consultant in the resource management space, and since this time have continued to link my interest in agriculture and the environment.

A shift to the South Island in the mid 2000's provided an opportunity for me to get into hands on farming, alongside my husband, and subsequently led to the establishment of my own consultancy business, Landpro.

Landpro started as a small Central Otago based planning and surveying consultancy, mainly servicing the primary industries, but has since grown to a team of around 45 people, with offices throughout New Zealand. These day's Landpro provides a broad range of environmental science, geospatial and aerial mapping services in addition to the traditional planning and surveying offering.

As the agri-enviro space has continued to grow, I have found myself working in a dynamic and complex space, which is both challenging and rewarding, and which provides many opportunities to shape the future of agriculture in New Zealand.

I am passionate about the rural sector, and the opportunities for agriculture in New Zealand, and want to thank you for taking the time to read my report.

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