KELLOGG
RURAL LEADERSHIP
PROGRAMME

Understanding a Future with Genetic Technologies in New Zealand Agriculture

Kellogg Rural Leadership Programme | Course 51 2024

Lisa Lunn

I wish to thank the Kellogg Rural Leadership Programme Investing Partners for their continued support.

Disclaimer

In submitting this report, the Kellogg Scholar has agreed to the publication of this material in its submitted form.

This report is a product of the learning journey taken by participants during the Kellogg Rural Leadership Programme, with the purpose of incorporating and developing tools and skills around research, critical analysis, network generation, synthesis and applying recommendations to a topic of their choice. The report also provides the background for a presentation made to colleagues and industry on the topic in the final phase of the Programme.

Scholars are encouraged to present their report findings in a style and structure that ensures accessibility and uptake by their target audience.

This publication has been produced by the scholar in good faith on the basis of information available at the date of publication. On occasions, data, information, and sources may be hidden or protected to ensure confidentially and that individuals and organisations cannot be identified.

Readers are responsible for assessing the relevance and accuracy of the content of this publication & the Programme or the scholar cannot be liable for any costs incurred or arising by reason of any person using or relying solely on the information in this publication.

This report is copyright, but dissemination of this research is encouraged, providing the Programme and author are clearly acknowledged.

Scholar contact details may be obtained through the New Zealand Rural Leadership Trust for media, speaking and research purposes.

Executive Summary

New Zealand is at a pivotal time as genetic technologies become an increasingly important tool in global agriculture to help address issues such as food security, environmental impact, and changing consumer preferences. The current New Zealand regulatory framework in this space, the Hazardous Substances and New Organisms (HSNO) Act 1996, imposes stringent restrictions, effectively prohibiting the use of these technologies outside of controlled laboratory environments. However, significant advancements in the genetic technology space have outpaced this legislation. The Government is reviewing the framework with new regulations expected by the end of 2025. The proposed reforms aim to create a dedicated biotech regulator, streamline approvals, and align with international standards to enhance economic and environmental benefits.

This report examines the integration of genetic technologies into New Zealand agriculture, focusing on their benefits and risks, the regulatory changes needed, and the support required for adoption by the public and farmers. Prior to the new legislation being implemented, it is important to have a clear understanding of these benefits and risks in relation to New Zealand and our export markets, as well as understanding public perspectives. The research methodology included a comprehensive literature review and semi-structured interviews with 16 key stakeholders. The findings highlight continued public apprehension and emphasise the need for a national dialogue to clarify the technologies' benefits and implications. Identified potential risks include environmental impacts, unintended consequences, and export market, economic and social issues, though the adoption of these technologies is unlikely to harm New Zealand's export reputation. A clear understanding of export market preferences and genetic modification (GM) product definitions is essential.

The findings emphasised the need for a robust, adaptable, trait-based regulatory system to mitigate these risks, and an initial focus on genetic technology tools that address emissions reduction and environmental sustainability in New Zealand agriculture, noting that public acceptance is likely to be higher for environmental applications than for production improvements.

Key Recommendations:

- Engage public and stakeholders early in discussions on genetic technology regulations and use, clearly outlining associated risks and benefits.
- Use unbiased, fact-based communication from trusted sources.
- Focus on technologies that offer environmental, animal welfare, or consumer benefits.
- Understand our export market perceptions and preferences.
- Clearly define and explain the types and implications of genetic technologies for our export markets.
- Develop adaptive regulations centred on product risk rather than process.
- Implement technologies promptly to maintain a competitive edge.
- Rural supplies merchants will have a role to educate and support farmers in the responsible adoption of genetic technologies.

Table of Contents

List of Tables and Figures

Acknowledgments

Firstly, I would like to acknowledge my employer, Farmlands, and show my gratitude and sincere appreciation for this wonderful opportunity. The support and investment for my personal development is extremely appreciated and I am incredibly grateful. Thank you to my fellow Farmlanders for all the encouragement and allowing me the space to grow and develop during this programme.

I would also like to acknowledge Rural Leaders and the Kellogg team for delivering a programme that has been both fulfilling and educational. I have learned skills that I know I will continue to use throughout my career, and the outlook and perspective that the programme has given me will shape my future. Thanks to Dr. Scott Champion, Dr. Patrick Aldwell, Dr. Lyndsey Dance, Lisa Rodgers, and Annie Chant for a well-run, well-supported experience. I am now proud to join the masses who have nothing but praise for the Kellogg course – I couldn't recommend it more.

A special mention to Dr Patrick Aldwell – what a privilege to have been part of the final Kellogg cohort lucky enough to have had your support. Your wisdom, encouragement, prompt replies, and ability to offer clarity whenever confusion took hold of me was instrumental to my project. What an incredible contribution you have made to education and the rural sector – all the best for your next chapter.

To the interview respondents I spoke to about this project – thank you for your time, your openness, your passion, and your input. The generosity you all showed with your time and willingness to be interviewed has been humbling. Your input was exceedingly valuable, and the industry is lucky to have such caring, knowledgeable, and passionate people involved.

To my husband Alex – thank you for your patience, support, and encouragement. You have been a driving force to get me through this project and I couldn't have done it without you.

To my K51 peers – thank you for making this experience an enjoyable, supportive one. I wish you all the best of luck with your future endeavours and look forward to staying in touch.

ChatGPT was used to assist in the thematic analysis process to ensure all key themes and areas of disagreement were captured.

Finally, thank you to my friends and family for your advice and encouragement along the way.

1. Introduction

The use of genetically modified organisms (GMOs) in New Zealand has been subject to stringent restrictions and ongoing debate for decades. Currently, genetic modification (GM) is regulated under the Hazardous Substances and New Organisms (HSNO) Act 1996. While this legislation allows some laboratory research involving GM under strict containment conditions, the use of GMOs outside these parameters is effectively prohibited. Consequently, GMOs are not grown or produced in New Zealand agriculture, in contrast to many other countries where GM crops such as maize and soybeans are widely cultivated.

New Zealand stands at a critical juncture, with the government releasing a policy document (National, n.d.-a) that proposes a review of biotechnology and gene technology legislation. Initial indications suggest that new legislation could be introduced by the end of 2025 to facilitate broader use of genetic technologies in New Zealand (Edlin, n.d.; Hurrell, 2024).

Genetic technologies have evolved significantly over the past three decades (U.S. Food & Drug Administration, 2024). These advancements range from early transgenic techniques to more recent New Breeding Techniques (NBTs), leading to substantial changes in their applications. Recent research highlights the potential of genetic technologies to address global challenges such as food security, environmental degradation, and climate change. Historically, other solutions have been looked at to help address these issues, but as the urgency increases and we run out of solutions, genetic technologies are being seen to have a more critical role to play.

The potential benefits of these technologies include increased production, improved efficiency, enhanced drought and pest tolerance, and adaptation to changing consumer demands. However, there are concerns about the implications of their use in New Zealand, particularly regarding access to export markets and potential domestic risks. Historical opposition to genetic technologies in New Zealand has centred on food safety and corporate control concerns, with significant public protests occurring over the past 25 years. There are apprehensions that public resistance may persist despite the potential advantages of these technologies.

This report aims to evaluate expected public sentiment regarding genetic technologies and propose effective educational strategies to enhance public understanding of modern genetic technologies and potential applications in New Zealand. It will also analyse key agricultural uses for these technologies, taking into account associated risks and regulatory requirements. The insights gained will assist stakeholders in the primary industry by clarifying how these technologies can be integrated, how to support the public and farmers during this transition, and how to address export market demands. Additionally, policymakers will benefit from a clearer perspective on perceived priorities, risk concerns, and regulatory needs, aiding in informed decision-making.

2. Objectives

The objective of this report is to examine the implications of integrating genetic technologies into New Zealand agriculture. This involves evaluating the expected benefits and risks, with a particular focus on export market implications, and understanding regulatory framework requirements. Additionally, the report aims to forecast public perceptions and identify strategies for effective adaptation.

A key focus is to understand the primary environmental, economic, and consumer benefits of these technologies for New Zealand and to assess what this transformation means for New Zealanders. This includes determining how to support both the public and farmers through this transition. For the public, the goal is to gauge sentiment and identify the necessary information to facilitate an adjustment to these changes. For farmers, the report seeks to identify supportive measures through rural service channels to help them with adaptation.

3. Methodology

3.1. Definitions of Genetic Technologies

The term genetic technologies encompasses a broad set of scientific techniques. The World Health Organization (WHO) defines genetically modified organisms as the following:

> *"Genetically modified organisms (GMOs) can be defined as organisms (i.e. plants, animals or microorganisms) in which the genetic material (DNA) has been altered in a way that does not occur naturally by mating and/or natural recombination. The technology is often called "modern biotechnology" or "gene technology", sometimes also "recombinant DNA technology" or "genetic engineering". It allows selected individual genes to be transferred from one organism into another, also between nonrelated species. Foods produced from or using GM organisms are often referred to as GM foods."*

(World Health Organization, 2014)

Under New Zealand legislation in the HSNO Act 1996, a genetically modified organism is defined as the following:

> *"genetically modified organism means, unless expressly provided otherwise by regulations, any organism in which any of the genes or other genetic material —*
>
> *(a) have been modified by in vitro techniques; or*
>
> *(b) are inherited or otherwise derived, through any number of replications, from any genes or other genetic material which has been modified by in vitro techniques."*

(New Zealand Legislation, 1996)

Table 1 shows a range of terminology that is referred to in this report, as well as inter-changeable terms encompassed by this terminology (Te Puna Whakaaronui, 2023). For the purposes of this report, genetic technologies (GT) is an overarching term that captures all terms associated with transgenic modification and New Breeding Techniques.

Table 1: Inter-changeable terms for genetic technologies and selective breeding techniques (Adapted from Te Puna Whakaaronui, 2023)

Terminology	Inter-Changeable Terms
Selective breeding	▪ Conventional breeding ▪ Traditional plant breeding ▪ Traditional breeding ▪ Artificial selection ▪ Random mutagenesis
Transgenic modification	▪ Genetic modification (GM) ▪ Genetically modified (GM) ▪ Genetically modified organism (GMO) ▪ Genetic engineering ▪ Transgenic ▪ Transgenesis
New Breeding Techniques (NBTs)	▪ New genomic techniques ▪ Genome editing ▪ Gene editing (GE) ▪ Precision breeding ▪ New precision breeding techniques ▪ Precision breeding techniques ▪ New plant engineering techniques

One technology that will be referred to in this report is Clustered Regularly Interspaced Short Palindromic Repeats CRISPR-associated protein 9 (CRISPR), which is a gene editing technology. CRISPR can introduce changes to DNA intrinsic to the target species or cultivar, while traditional GM introduces foreign DNA from a different species into the genome of an organism (i.e., transgenic) or from another cultivar of the same species (i.e., cisgenic) (Shew et al., 2018).

The National Party, in its Harnessing Biotech policy document (National, n.d.-a), refers to gene editing as a more precise and targeted technique than GM. The policy document discusses biotechnology and states that this includes technologies such as genetic engineering, gene editing, tissue culture, fermentation, and bioprocessing. This report will focus on genetic engineering, gene editing, and genetic modification.

3.2. Literature Review

A literature review was conducted to gain a comprehensive understanding of genetic technologies. The review covered various types of technology, their use, potential benefits and risks, the history of genetic technology regulation and review in New Zealand, and public perception. The literature included academic research, Government-commissioned reports, polls, and industry stakeholder reviews. It was essential to explore the history of genetic technologies globally and in New Zealand, as well as their current status, and potential future benefits in agriculture. The sources

of literature ranged from peer-reviewed journals and industry reports to news articles and websites of key stakeholders.

3.3. Semi-Structured Interviews

1. Several individuals representing various stakeholder groups were identified as suitable respondents to be interviewed via semi-structured interviews. They were asked 14 questions (Appendix One: Interview Questions) and their viewpoints and answers to the questions were documented. Individuals were not sought out for being experts on genetic technologies, but rather the stakeholder groups they represented. The participants for interviews were identified, via a combination of industry research and recommendations, based on their professional roles, areas of responsibility and experience with genetic technologies.

Table 2: Categorisation of stakeholder groups represented by interview respondents participating in a semi-structured interview qualitative study of the potential fit of genetic technologies in New Zealand agriculture.

Respondent	Scientist	Industry Body	Industry Professional	Farmer	Politician	Environmentalist
1	■	■				
2	■					■
3				■		
4	■					
5					■	
6			■	■		
7	■		■			
8	■	■				
9				■	■	
10	■			■		
11			■			
12	■	■				
13		■				
14				■		
15						■
16				■		

A total of 16 people were interviewed via 16 semi-structured interviews representing a range of different stakeholder groups (Table 2). Respondents have been kept anonymous and are only referred to by their categorisation based on their background as per Table 2. Respondents included representatives from the scientific community, processing companies, industry good organisations, and levy bodies, as well as politicians, plant breeders, farmers, and environmentalists. While many of these groups represented New Zealand agriculture as a whole, there was specific representation across the arable, dairy, red meat, and horticulture sectors. Depending on their backgrounds, respondents were often categorised into more than one stakeholder group. Interviews were conducted via a combination of in-person interviews, Microsoft Teams, Zoom, or phone calls and took approximately 45 – 60 minutes per interview. Respondents were given the background of the study in writing beforehand and were asked 14 questions during the interview. The questions sought to ascertain the respondents' perspectives and opinions on several aspects of the potential use of genetic technologies in New Zealand agriculture.

3.4. Analysis

The interview responses were analysed using thematic analysis to help identify common themes and patterns among the data. Thematic analysis is a useful and adaptable method for analysing qualitative data (Braun & Clarke, 2006). ChatGPT (OpenAI, 2024) was used to assist in this process, ensuring comprehensive coverage of key themes and areas of different perspectives. The resulting themes were then visualised in a combination of tables, lists, and mind maps to illustrate the themes among interview responses.

3.5. Findings and Discussion

The context provided by the literature was contrasted against the responses categorised in the semi-structured interviews. Common themes amongst interview respondents and literature were identified, as well as areas where there were divergent views across different groups. The comparison of existing literature and interview responses of these key stakeholders provided a current, New Zealand perspective on genetic technologies in agriculture, highlighting potential future directions, and subsequent recommendations, in this rapidly evolving area.

3.6. Limitations

One of the limitations of this report is that it does not include a survey of farmers or the New Zealand public to understand their perceptions of the current state of genetic technologies and their potential use in New Zealand agriculture. Interview respondents often emphasised the importance of this step, as they believe that there will be a wide range of views and opinions within these groups. Therefore, it would be challenging to make assumptions about the general sentiment in the current climate.

The interview respondents were chosen based on the stakeholder groups they belong to. Many of them clarified that they were not experts, and their input was based on anecdotal evidence, personal experience, or knowledge gained over their careers. Some respondents, however, were well-informed in this area. While this was suitable for the report's scope, it is recognised that the Government should seek expert testimony for the legislative review and potential implementation of these technologies. The respondents were selected based on their roles within their stakeholder groups, but their views may not represent the entire group. Interviewing more representatives from each stakeholder group would provide a more accurate understanding of their perspectives on genetic technologies in New Zealand agriculture. Quotations from respondents have been paraphrased to capture the essence of their responses and they may not be verbatim.

Due to time constraints associated with the prescribed duration of this research project, not all stakeholder groups could be engaged in this research. While publicly available statements on genetic technologies were used, a semi-structured interview may have provided more up to date information. Iwi viewpoints were not included, but it is important to consult with this group on the use and regulation of genetic technologies. Representation was sought from a range of sectors, but a comprehensive understanding of all primary industry sector perspectives is crucial.

Further, the use of genetic technologies is increasingly becoming a significant topic in societal discussions as society becomes more aware of the technology now available and the potential uses. In New Zealand, this is being spurred along by the Government's review and proposed changes in this space. This may lead to a rapid shift in opinions and understanding as people encounter new information sources, shaping the perception of genetic technologies in New Zealand over time. Therefore, a further limitation of this report is temporal changes in perception as this topic garners more attention.

4. Genetic Technologies in New Zealand – Literature Review

4.1. The Past and Present

4.1.1. Regulation and Reviews

Genetic technologies are regulated by the HSNO Act 1996. Under these regulations, the use of genetic technologies in New Zealand outside of laboratory environments is effectively banned. The New Zealand regulator of new organisms, which includes GMOs, is the Environmental Protection Agency (EPA) via the HSNO Act. Applications for field trials or GMO release can be made to the EPA, and they will assess each application via a risk and benefit assessment to determine if the application can be approved (Te Puna Whakaaronui, 2023). To date, only one GMO has been approved for release in the agriculture sector, which was a modified vaccine for equine influenza approved in 2008 (Environmental Protection Agency, 2008).

New Zealand's regulation of genetic technologies involves several key stakeholders: the Ministry for the Environment (MfE) manages GM policy issues and administers the Environmental Protection Authority Act 2011 as well as monitoring the EPA's activity; the Ministry for Primary Industries (MPI) enforces genetic modification requirements at the border, and enforces compliance for containment or conditional release of new organisms; and Food Standards Australia New Zealand (FSANZ) develops and assesses food standards, including those for genetically modified foods, prioritising safety and public consultation (Te Puna Whakaaronui, 2023).

Due to the restrictive nature of this regulation, use of these technologies outside New Zealand laboratories is "all but impossible in this country" according to the National Party's Harnessing Biotech Policy Document (National, n.d.-a). Currently, GM food may be assessed as safe and approved to be sold as food in New Zealand, but that same food may not be grown or produced here. In addition to there being no approvals for GM crops for release or commercial production in New Zealand (Te Puna Whakaaronui, 2023), there is also no genetically modified fresh produce available for sale in the country (National, n.d.-a). There is only one plant GM field trial currently running in New Zealand, and this is a GM *Pinus Radiata* trial being conducted by Scion (Scion, n.d.). The trial was set up in 2010 on a 4ha containment site following EPA approval, and research is expected to continue until 2035.

Like other countries, New Zealand has conducted formal reviews and investigations that examine the management of our regulatory settings and stance on genetic technologies. There have been several reviews – notable ones include The Royal

Commission on Genetic Modification, Report and Recommendations, which was published in 2001 (The Royal Commission on Genetic Modification, 2001). The Commission's mandate from the Government involved exploring strategic options for New Zealand regarding GM, ranging from complete avoidance of GM material and research to full, unrestricted use. To address this, the Commission outlined seven core values, grouped into cultural, ethical, spiritual, environmental, health, economic, and strategic criteria, which were applied to assess various applications of genetic modification, including research, crops, food, and medicine. Additional considerations included intellectual property, the Treaty of Waitangi, and liability issues.

The report discussed how GM had been widely used in New Zealand for research, medical purposes, and food ingredients, and it cited potential benefits in disease control and economic competitiveness in the primary industries. Public consultation indicated support for medical applications but strong opposition to other uses, particularly in food, due to concerns about safety and consumer preferences. Recommendations included keeping our options open, proceeding cautiously to minimise risks, and supporting the coexistence of different agricultural systems. It also proposed establishing a Bioethics Council and a Parliamentary Commissioner on Biotechnology to improve governance and public education in biotechnology. The report emphasised the need for ongoing alignment of regulatory frameworks with evolving technology and societal values. Acting on this recommendation, the Government established a Bioethics Council - Toi te Taiao, for ongoing oversight of biotechnical developments (Te Puna Whakaaronui, 2023), but it was disestablished in 2009.

Subsequent reviews included one undertaken by The Royal Society Te Apārangi in 2019 (Royal Society Te Apārangi, 2019). In its review of the key findings and themes of the various reviews of the New Zealand GMO regulatory regime, the New Zealand food and fibre independent think tank, Te Puna Whakaaronui, summarised the findings (Te Puna Whakaaronui, 2023) of The Royal Society Te Apārangi report as the following:

- **Definitional challenges:** There is inconsistency in defining genetic modification across legislative frameworks, complicating public engagement and debate.
- **Regulatory complexity:** Regulations often do not reflect the nuances of modern genetic technologies, leading to inconsistencies in how organisms are classified and regulated.
- **Treaty of Waitangi considerations:** The report emphasised the importance of incorporating Treaty of Waitangi obligations and Māori perspectives, particularly regarding genetic modification and cultural stewardship.
- **Economic implications:** Concerns were raised about the potential impact of genetic modification on New Zealand's GM-free image and premium market status for agricultural exports.
- **International alignment:** The need to align New Zealand's regulatory framework with international standards and market demands was highlighted to ensure competitiveness and regulatory coherence.
- **Policy recommendations:** The report called for a re-evaluation of current legal and regulatory frameworks to address inconsistencies and better accommodate the complexities of gene editing technologies.

Overall, the report emphasised the necessity of a nuanced, scientifically informed approach to regulation that considers both risks and benefits while aligning with cultural values and international standards.

A report in 2021 by the New Zealand Productivity Commission titled "New Zealand Firms: Reaching for the Frontier" was conducted to seek out policies and interventions that could improve the performance and economic impact of frontier firms in New Zealand, by promoting innovation diffusion and improving performance (New Zealand Productivity Commission, 2021). The Commission, disestablished in 2024, was an independent Crown Entity tasked with advising the Government on ways to improve productivity which will help the overall wellbeing of New Zealanders (Treasury, n.d.). The report findings recommended a comprehensive review of GM regulation by the New Zealand Government. It suggested that the review would consider international regulatory approaches, assess impacts on trade and enforcement, and evaluate consumer attitudes. It also highlighted the importance of Māori perspectives and rights regarding GM and suggested ensuring regulatory consistency across relevant laws.

Furthermore, the findings emphasised the importance of thorough public engagement and education to enhance understanding of modern genetic technologies among the public and industry stakeholders in New Zealand. The report highlighted the necessity of an informed, nationwide dialogue about GM as part of the regulatory review process, a sentiment shared by others, including former Prime Minister's Chief Science Advisor, Sir Peter Gluckman (1 News, 2018). The report acknowledged that this conversation will be challenging but essential. It emphasised the need to gauge public attitudes toward genetic technologies and their current status in order to understand what this means for New Zealand. The report also acknowledged the potential implications for New Zealand companies that wish to maintain a GM-free status, and how this might affect New Zealand's reputation. It recommended that public engagement should provide information and resources on these genetic technology tools.

> *"The science is as settled as it will be… that is that it's safe, there are no significant ecological or health concerns associated with the use of advanced genetic technologies… If we are to remain a biological economy, we will have to have another [national] conversation about it."*
>
> - Former Prime Minister's Chief Science Advisor, Sir Peter Gluckman, (1 News, 2018)

From a food perspective, The Australia New Zealand Food Standards Code underwent a consultation process prompted by the emergence of NBTs in food production (FSANZ, n.d.). The findings of FSANZ, as summarised in the review in the Te Puna Whakaaronui reference document (Te Puna Whakaaronui, 2023), were that existing definitions for 'food produced using gene technology' were inadequate for capturing products derived from NBTs. Stakeholder consultation revealed broad consensus that current definitions lack clarity and need updating to reflect modern genetic technologies. FSANZ proposed amendments in March 2022 aimed at modernising these definitions to ensure they encompass current and future genetic

techniques while appropriately managing associated risks through pre-market safety assessments.

A report from 2023 examined New Zealand's current policy settings for regulating genetic technologies. It found that these policies were not suitable and explored what a more modern approach would entail (Jolly, 2023). The report provided recommendations for updating New Zealand's genetic technology regulations. It emphasised the need for a modern regulatory framework that accommodates technological advancements, focuses on the risk of the outcome rather than the process, incorporates diverse New Zealand values, and ensures clear communication of risks and benefits to the public. The report advocated for a balanced approach that supports innovation while safeguarding environmental, health, and cultural concerns. Key messages highlighted the importance of developing a New Zealand-specific regulatory approach aligned with national values and priorities, including maintaining competitiveness in global markets and respecting Māori values. It noted that effective communication strategies and stakeholder engagement are crucial, and emphasised transparency, inclusivity, and adaptive governance.

Overall, these reviews and reports recommend a modern, inclusive, and scientifically informed approach to genetic technology regulation. They suggest considering societal, economic, and cultural factors while maintaining regulatory coherence and public trust. The reports stress the need for thorough public consultation and education to promote understanding of genetic technologies. They also point out that regulatory complexity is a barrier and call for simplified processes and clearer definitions. They emphasise the importance of incorporating Māori perspectives, inclusive governance, and respect for Treaty obligations. They highlight the importance that New Zealand aligns with international standards for regulatory coherence and trade competitiveness. However, the reports had differing views on how GM regulations may affect New Zealand's agricultural exports and market reputation.

4.1.2. Public Perception

There have been a range of studies conducted to gain an understanding of the perspectives of the New Zealand public on genetic technologies. In 2019, Scion commissioned Colmar Brunton to survey New Zealanders to understand their current opinions and understanding of genetic technology. It was a 10-minute online survey using the Colmar Bruton Fly Buys panel, and it received responses from just over 4,000 people aged between 18 and 69 years.

The study (Scion, 2019) found that, based on those surveyed, most New Zealanders are aware of different types of genetic technologies to varying degrees: genetic modification (68% aware), gene editing (41% aware), genomic selection (35% aware), and marker-aided selection (21% aware). Awareness varied across demographics, with higher levels among males, older individuals, and those with higher education and incomes. However, less than 3 in 10 people felt well-informed about these technologies. While 44% believed genetic technologies are important for New Zealand's future, this sentiment was more prevalent among those who were informed.

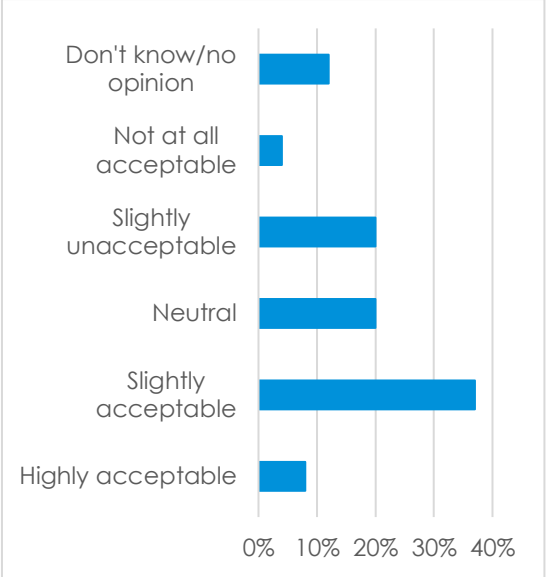

Figure 1: How accepting would other New Zealanders be of gene editing technology? (Adapted from Scion, 2019)

Acceptance of genetic technologies varied with higher acceptance among younger age groups and higher income earners. The most acceptable use was deemed to be for the conservation purpose of saving the Kauri tree. Respondents were asked how accepting they thought other New Zealanders would be of gene editing technology, and 45% felt they would be highly or slightly accepting (Figure 1). Answers related to acceptance were significantly higher among 55–69-year-olds, those living in rural areas, those with university education, and those accepting of genetic technologies. Enhancing public perception and bridging the awareness gap through education, especially in conservation contexts, was highlighted by the report as crucial for shaping future attitudes.

The study had a large sample size, but it focused more on issues related to trees, such as wilding pines and the conservation of various tree species with a genetic technology angle. This was because Scion is a Crown research institute specialising in research, science, and technology development for forestry, wood products, wood-derived materials, and other biomaterial sectors. The survey had a wide audience and represented the New Zealand public well. However, the audience was drawn from the Colmar Brunton Fly Buys panel, where participants take surveys in exchange for Fly Buys points (Flybuys, n.d.). As a result, the panel may have consisted of individuals who are financially motivated and active shoppers. The study may have been affected by response bias, overrepresentation of specific demographics, incentive-driven responses, and limited generalisability.

New Zealand has a history of opposition to genetic technologies, particularly led by the environmental activism group Greenpeace. Since 1992, Greenpeace has actively opposed GMOs and genetic engineering in New Zealand through protests and advocacy. They have organised demonstrations and campaigns to prevent the introduction and cultivation of GMOs in New Zealand agriculture. Greenpeace advocates for strict regulations and labelling of GMO products, citing environmental and health concerns (Greenpeace, n.d.).

In the early 2000s, there were several protests across the country in opposition to GMO use in New Zealand. There were protests in response to the Government's proposed lifting of the moratorium on the commercial release of genetically engineered organisms (NZ Herald & NZPA, 2003). In 2003, 9,000 protestors were reported to have marched in Auckland, with other protests occurring in other locations around the country. News articles reported that some individuals felt so passionately about this issue that they were compelled to protest, despite never having protested before.

> *"I feel so strongly about this I had to join others who feel the same way. I just can't believe the government's going to do this when the majority of the country really want it to be GE [genetic engineering] free."*
>
> - Protestor at anti-genetic engineering protest in Auckland in 2003 (NZ Herald & NZPA, 2003)

Established anti-genetic engineering groups such Mothers Against Genetic Engineering, the Auckland GE-Free Coalition, and Greenpeace attended the Auckland protest, along with several members of the public. Pro-genetic engineering groups also attended, but they faced confrontation from the anti-genetic engineering groups.

Further public protests were held again in 2013 with marches occurring in protest against genetic engineering and seed company, Monsanto. One such march was in New Plymouth, with nearly 300 people attending, with signs saying, "Don't mess with our food" and chanting "Say no to GMO". Other protests were held across New Zealand and globally (McMurray & AP, 2013). Newspaper reports stated that the protest in New Plymouth drew a larger crowd than expected, indicating strong local sentiment.

> *"I think it shows the grass roots feelings around these issues."*
>
> - Protestor at anti-GMO protest in New Plymouth in 2013 (McMurray & AP, 2013)

Protestors also expressed concerns about the impact of GM cotton seed purchases on farmers, citing purported instances where farmers in India faced financial difficulties after purchasing seeds that did not perform as expected. The debate surrounding genetically modified seeds included discussions on mandatory labelling, driven by concerns about contamination of traditional crops and potential health risks.

In 2022, a survey conducted by Research First examined responses to gene editing and advanced breeding solutions in New Zealand food production (Research First, 2022). The sample group was reported to be statistically robust and nationally representative of the New Zealand public. It showed 32% were for, 47% neutral, and 21% against the use of GE in New Zealand food production. There were also 36% in support of growing GM crops in New Zealand (34% neutral and 30% opposed). Those in support stated reasons including GM offering benefits such as increased yields to meet growing demand, resilience to climate change and pests leading to reduced pesticide and water use, production of nutritionally enhanced foods, job creation,

lower costs for consumers, longer shelf life, belief in the scientific process, or they generally lacked compelling reasons for opposition.

The group in opposition to GE in New Zealand food production gave reasons such as their perception that the techniques and food products are not natural or necessary and that there is a lack of information about the long-term effects on human health and the environment. This group also cited they felt the technologies are at odds with New Zealand's "clean, green" image. Further, 43% of respondents stated they would be concerned about buying GE fruit and vegetables, and 47% had concerns about buying products from animals fed GE feed. This shows a mixture of responses, and with 35% not aware of NBTs, such as CRISPR and only 8% stating they had a decent level of knowledge, it shows public education is required. Further, the study showed the level of acceptance of gene editing was highest (62%) for protecting taonga species, followed by 52% for both improving pasture quality on farm and for gene editing trees to control invasive species and support biodiversity. The lowest acceptance was for improving the commercial traits of fruit, at 36%.

More recently, during the National Fieldays at Mystery Creek in June 2024, AgResearch conducted an informal poll at their stand. Visitors were asked two questions about genetically modified (GM) plants and products. "Q1: Would you grow a genetically modified plant on your farm (once approved)?" and "Q2: Would you eat produce that has been grown on a farm using genetically modified pasture products?".

Visitors were provided a sticker to indicate their response on a yes-no continuum. As shown in Figure 2, most respondents indicated they were open to cultivating GM plants on their farms or consuming products from farms that have grown GM pasture products. The engagement at the stand was reported to be positive (AgResearch, 2024), with even anti-GMO groups having constructive conversations. However, it's important to note that the event is primarily attended by farmers, so the poll results should be interpreted in that specific context. Another limitation is the informal nature of the poll.

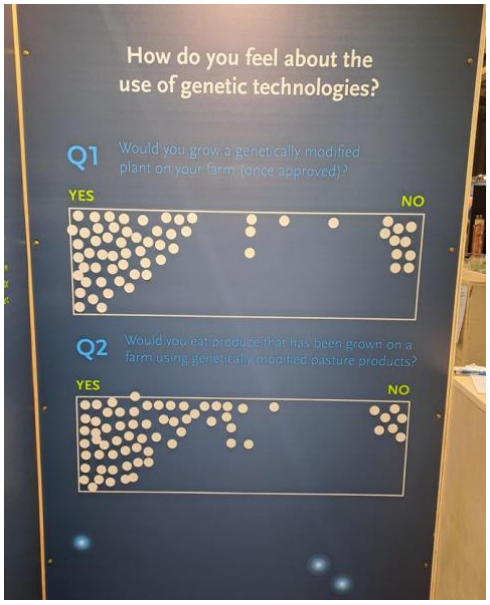

Figure 2: Results from an informal poll conducted by AgResearch at the National Fieldays, 2024, regarding feelings about the use of genetic technologies.

4.2. The Future

4.2.1. The Benefits

One of the essential aspects of understanding the future of genetic technologies in New Zealand agriculture is to examine the potential benefits they could bring to the country. These benefits will depend on factors such as the form of the technology (GMO vs CRISPR), the type of trait, the intended usage, the sector(s) they may be used in, and the applications that are important to New Zealand.

There are 2 main areas where genetic technologies can be used in agricultural production systems. They can influence the input traits (first generation) or the output traits (second generation). Output traits include enhanced nutritional composition, while input traits include attributes such as herbicide tolerance and insect resistance traits (Stein & Rodríguez-Cerezo, 2010), with the latter making up the majority of GM traits in GM crops. The use of output traits has been less prevalent and is less advanced than input traits (Napier et al., 2019).

In terms of benefits to agriculture, GM has been widely used in crops internationally for 25 years, but there has been limited commercial adoption in grazed forages. A review by Grasslanz in 2023 on the benefits and risks for New Zealand grassland production systems concluded that GM plants will not solve all challenges in managed grasslands, but they could potentially alleviate some environmental issues (Caradus, 2023a). The review also recognised that if new GM cultivars of grazed forages were introduced, there would be a need to address consumer concerns about food safety, environmental risks, and genetic impacts in New Zealand.

A literature review by Sendhil et al of literature published between 1981 and 2021 concluded that public support for the use of GM technologies is higher when the potential benefits are clear, there is trust in regulation, and trust in science via positive media campaigns (Sendhil et al., 2021). Another New Zealand study of several international experts found that advances in genomics, including gene

editing technologies like CRISPR, could be transformative for New Zealand's agriculture. Some interviewees highlighted that New Zealand's cautious approach to gene editing, despite our "clean and green" reputation, might be contradictory if gene editing could potentially reduce environmental impacts (Davies et al., 2018).

Currently, AgResearch is researching how improvements in pasture species, using genetic technologies, could improve production and livestock health and reduce environmental impacts. There is work underway with overseas trials looking at technologies such as GM high metabolisable energy ryegrass and GM white clover with high condensed tannins which show promise in reducing methane emissions from livestock and preventing bloat, respectively. They are also trialling gene-edited endophytes for use in plants, with the intent to improve plant protection from pests and reduce potential toxicity to livestock (AgResearch, n.d.). AgResearch is actively pursuing these innovations to provide farmers with tools that can enhance climate resilience, address environmental challenges in agriculture (The Country, 2024), and provide animal health improvements.

4.2.2. The Risks

Equally, it is essential to understand the potential risk factors associated with the commercial use of these technologies in New Zealand. It is important to anticipate possible challenges in New Zealand, recognise public concerns, and understand what regulatory measures would be needed to mitigate any risks.

In 2013, a study was undertaken to ascertain what the potential damage of GM crops could be to the image of the producing country (Knight et al., 2013). This study was predicated on the fact that arguments were often heard in New Zealand to suggest that introducing GMOs could harm the country's "clean green" image and impact food exports and tourism. However, based on face-to-face interviews with food distribution gatekeepers in Europe, China, and India, and surveys of first-time tourist visitors at Auckland International Airport, the study found there was little evidence to suggest that GMO introduction would significantly damage perceptions of New Zealand's food exports or its appeal as a tourist destination.

The study asked the tourist visitors how they felt about the acceptability of another controversial technology, nuclear power, as well as their acceptance of GM for food production or environmental protection, as shown in Figures 3 and 4. The results showed that 55.1% of respondents definitely, somewhat, or slightly agreed that nuclear power is an acceptable form of electricity generation, while 49.2% definitely, somewhat, or slightly agreed that GM is an acceptable form of technology for food/environmental uses.

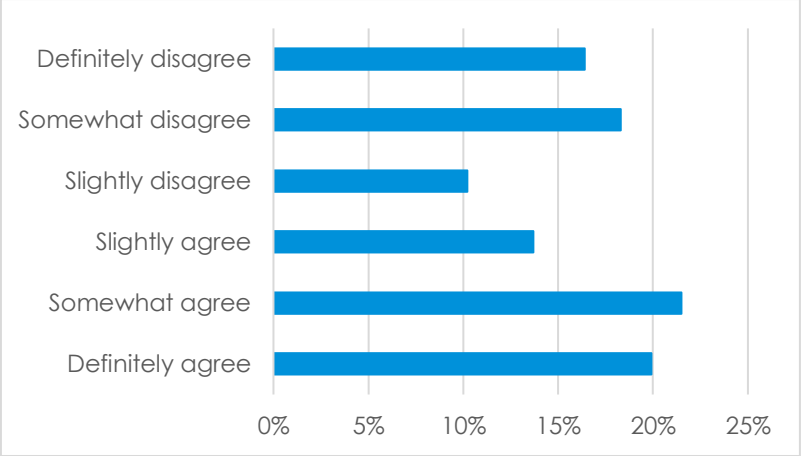

Figure 3: Survey results of in-bound New Zealand tourists asked if nuclear power is an acceptable form of electricity generation (Adapted from Knight et al., 2013)

A series of other questions were asked of the 2 controversial technologies, and it was found to scarcely affect tourist destination choice. This is also seen globally with high tourist numbers in France where nuclear power is the major source of electricity generation, and New Zealanders travelling to Australia where GM crops are grown.

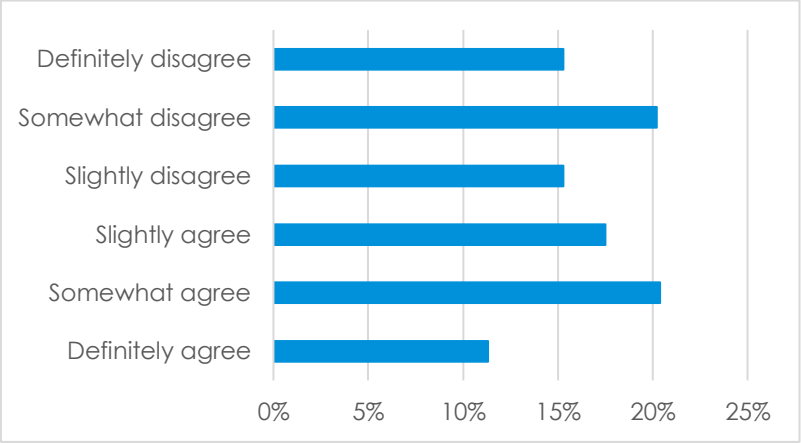

Figure 4: Survey results of in-bound New Zealand tourists asked if genetic modification is an acceptable form of technology for food production/environmental protection (Adapted from Knight et al., 2013)

The study also presented data from Statistics NZ that indicated food imported into New Zealand did not slow after countries like the USA and Australia started growing GM crops (Figure 5). The growth appears to have accelerated more rapidly after the introduction of GMO crops; however, this may have been due to exchange rate fluctuations or population growth increasing food demand. Either way, the concerns raised by New Zealand protestors on GMO food does not seem to have markedly impacted consumption of food from countries growing GMO crops, with 26 permissions for GMO food granted for import into New Zealand under FSANZ Scheule 26 (Australian Government, n.d.).

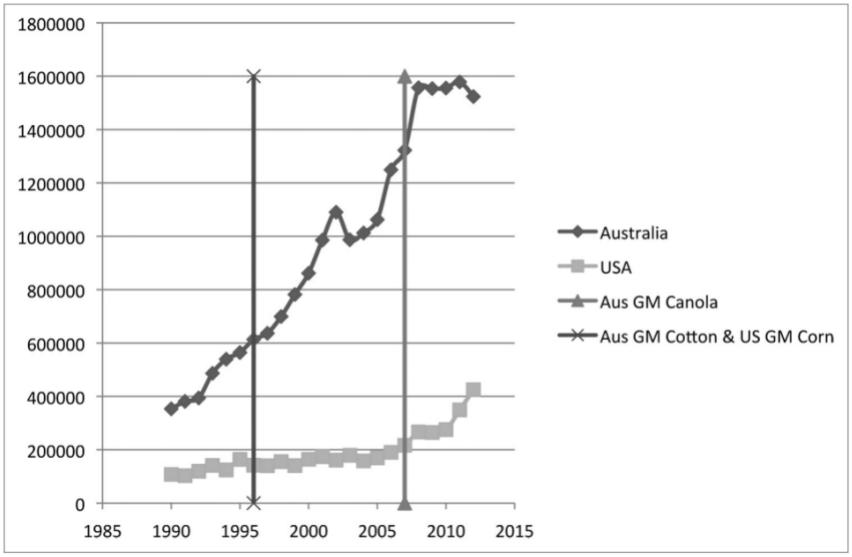

Figure 5: New Zealand food imports from Australia and the USA ($NZ 000s) in relation to the introduction of GM crops in those countries (From Knight et al., 2013)

A review article by John Caradus (2023b) assessed the 25-year global impact of GM crops, highlighting benefits like increased yields, reduced pesticide use, lower carbon emissions, improved soil quality, enhanced crop nutrition, and lower production costs. Concerns include potential food safety issues related to toxicity and allergenicity, environmental risks such as gene flow and impacts on non-target organisms, and the possibility of unintended genetic changes leading to new diseases or antibiotic resistance. Overall, the review found that GM crops offer substantial economic and environmental advantages, but effective regulatory frameworks must balance these benefits with risks. Other public concerns about GM foods include safety, environmental impact, labelling, ethics, and intellectual property. The review found that, despite opposition, GM foods are unlikely to harm New Zealand's food exports. Addressing these issues requires clear impact analysis, political will, and dialogue with trading partners. The review showed that consumer acceptance of gene edited plants is rising, driven by perceived health and environmental benefits (Beghin & Gustafson, 2021). Scientific evidence supports GM food safety, with no major documented harm. The review stated that public support will grow with informed communication and trusted regulation, and stipulated that labelling is crucial for consumer choice. The review made it clear that criticism of GM technology often overlooks its potential benefits, and New Zealand's regulatory approach is seen as restrictive, potentially missing economic opportunities. It recommended that future regulations should focus on assessing risks and benefits of GM end-products, not just processes.

A common concern raised in discussions about the adoption of genetic technologies in New Zealand's agriculture systems is the potential impact on our reputation as a food producer and, consequently, our access to certain export markets. There is some consumer demand for food free of GMO and New Zealand food exporters have taken advantage of this market niche. Companies such as Fonterra and have introduced the Non-GMO Project label into certain products sold in North America (Carapiet, 2023), with Fonterra having 42 products verified under the Non-GMO Project for sale in the United States (Fonterra, n.d.) due to their sought-after nature (Shoup, 2017). Lewis Road Creamery has also stated they would like

New Zealand to stay GMO-free and claim this as a product benefit for their dairy products (Lewis Road Creamery, n.d.). New Zealand's GMO-free status has allowed produce from many sectors, including dairy, red meat and kiwifruit, to capitalise on consumer demand for non-GMO food.

In contrast, there was a 2021 review (Beghin & Gustafson, 2021) of literature surrounding consumer attitudes, willingness, and conditioning factors to pay for food produced by New Plant Engineering Techniques (NPETs, including genome/gene editing, cisgenesis, intragenesis, and RNA interference). This review indicated that, in general, a significant portion of consumers were willing to pay for foods from gene-edited plants, especially those believed to improve human and animal health and the environment. However, the study suggested that emerging literature on NPETs indicated that foods from genetic technologies tended to be priced lower than similar products produced via conventional breeding, with GMO-derived foods facing slightly larger discounts. Consumers perceived foods from newer genetic technologies as more natural, despite having limited knowledge and familiarity with them.

A review by Grasslanz of published literature concluded that using GM plants in New Zealand food production would not result in any deleterious effects in overseas markets (Caradus, 2023b). The review referenced interviews with key food distribution channel gatekeepers in Europe, China and India which showed that the use of specific GM technologies in New Zealand will not have harmful effects on perceptions of New Zealand as a country that produces high-quality food and beverage products for export (Knight et al., 2008).

4.2.3. The Plan

The National Party has long talked about a review of New Zealand's biotechnology laws, even before the appointment of the Sixth National Government (National, n.d.-b) and promised to review the laws and the effective ban if elected (RNZ, 2023). Under the new coalition Government, the Minister for Science, Innovation and Technology, Hon Judith Collins, has confirmed there could be new legislation by the end of 2025 to enable wider use of gene technologies while establishing robust protections for human health and the environment (Edlin, n.d.; Hurrell, 2024).

National's Harnessing Biotech Policy Document (National, n.d.-a) discusses how New Zealand's biotechnology and gene technology rules are out of date, emphasising the fact that the HSNO Act 1996 has not been amended since 2003 despite significant advancements in genetic technology, such as the development of CRISPR. The document states that these technologies are safe and beneficial, and they effectively address health, environmental, and agricultural challenges. This outlook is backed by scientific consensus, including the Prime Minister's Chief Science Advisor, Professor Dame Juliet Gerrard.

> *"[O]ur current legal and regulatory frameworks are not fit for purpose… Hypothetically, if CRISPR-Cas [gene editing] were used to cure your grandmother's cancer, a case could be made that she was a new*

organism and therefore if she lived, she could not leave containment. These anomalies need addressing."

- Professor Dame Juliet Gerrard, Prime Minister's Chief Science Advisor (National, n.d.-a)

The policy document reinforces the fact that current laws effectively ban field trials and commercial use of GE and GM organisms outside of laboratories, hindering scientific progress and economic opportunities. It discusses how other countries have embraced biotechnologies to enhance agricultural productivity and address climate change while New Zealand lags due to outdated regulations.

National's Harnessing Biotech Plan:

1. **End the effective ban on GE and GM in New Zealand.**
2. **Create a dedicated regulator to ensure safe and ethical use of biotechnology.**
3. **Streamline approvals for trials and use of non-GE/GM biotech.**

Table 3: National's Harnessing Biotech Plan Objectives (From National Party, n.d.)

The document also references statements from senior scientists, public research institutions, and industry leaders on their concerns about New Zealand's outdated and restrictive rules. The consensus among these stakeholders is clear: current regulations on genetic technologies are outdated and restrictive, hindering scientific progress and economic potential. There is widespread support for updating these regulations to embrace advancements like gene editing safely, promoting innovation and competitiveness, and addressing pressing global challenges.

"They want to talk about New Zealand's use of GM tech, but we need action, or we will be left far behind. Future generations will not be interested in staying in Aotearoa if we don't use cutting edge technologies. We will see more brain drain, and New Zealand will miss out on the fourth industrial revolution… If New Zealand wants to reach its goals to reduce net greenhouse gas emissions… we must do something different."

- Dr Zahra Champion, Executive Director, BiotechNZ (F+B Tech, 2022)

National proposes reforms to enable responsible use of GE and GM technologies, including establishing a dedicated biotech regulator, streamlining approvals (Table 3), and aligning with international norms to unlock economic and environmental benefits. These changes aim to position New Zealand as a leader in biotechnology, leveraging innovation to address global challenges while ensuring safety and ethical considerations are prioritised.

4.3. Rural Servicing Companies – Current and Future Role

Companies like Farmlands, PGG Wrightson, and Farmsource offer goods and services for customers in agriculture and horticulture. These include product supply, services, and technical expertise. The products provided are agricultural inputs such as fertilisers, agrichemicals, seeds, and animal health products, as well as general farm supplies including irrigation equipment and fencing materials. These companies provide important agronomic and technical advice to farmers (Farmlands, n.d.) to help maximise productivity and profitability while promoting sustainable farming practices.

The rural servicing companies also collaborate with agriculture industry stakeholders to drive innovation and sustainability. This involves working with key agronomy input providers such as seed breeding companies, agrichemical suppliers, and fertiliser companies. Many of these input suppliers invest heavily in research and development to ensure that new, innovative, and improved products are available to New Zealand farmers. The servicing companies ensure that their staff providing agronomic advice are suitably qualified and regularly trained to stay up to date with current farming practices and the latest product developments. The rural servicing companies also engage with the agricultural community, participate in industry events, and contribute to initiatives that enhance the primary sector (PGG Wrightson, n.d.).

These companies will have a crucial role to play in a future with genetic technologies in New Zealand agriculture. What this role would entail will depend on the form these technologies take, but as trusted advisors to the agriculture sector, these companies must stay updated on the changes and potential uses of genetic technologies to ensure they can continue to support New Zealand farmers and the food and fibre sector.

5. Analysis and Results of Semi-Structured Interviews

5.1. Current Stance

Interview respondents were asked what their current stance was on the Government's proposal to review and potentially revise the effective ban on the use of GM and GE in New Zealand, per the Harnessing Biotech policy document (National, n.d.-a). There were a mixture of responses including supportive (25%), supportive but cautious (38%), and neutral or unclear (37%) as shown in Figure 6. None of the respondents stated that they were outright opposed to a change to the effective ban. In general, there were a mixture of responses across all stakeholder groups, but they have been categorised into 3 distinct groups.

5.1.1. Supportive of a Change

A quarter of respondents could be categorised as being supportive of the proposed change (Figure 6), citing strategic competitive advantages for New Zealand exports through genetic technologies. They highlighted the need for New Zealand to enhance its global market position, and, as noted by one respondent, a need for New Zealand to "punch above our weight competitively". emphasising pragmatism amidst geopolitical challenges. They highlighted benefits to the agriculture industry, including animal welfare, and societal issues such as food security and public health. Respondents stressed the importance of public education to foster acceptance of

genetic technologies while advocating for a balanced evaluation that considers potential risks and unintended consequences.

Some argued that opposition to these technologies often overlooks alternative risks, such as the impact on food production and public health. For instance, one respondent noted the opposition to Golden Rice, a genetically engineered rice that provides essential vitamin A to impoverished regions (Tang et al., 2009). This respondent argued that people may oppose these technologies due to the fact they are genetically engineered, yet the alternative would be more people going blind because of a lack of vitamin A, illustrating that rejecting genetic technologies could result in greater harm than acceptance. They emphasised the necessity of carefully weighing benefits against risks.

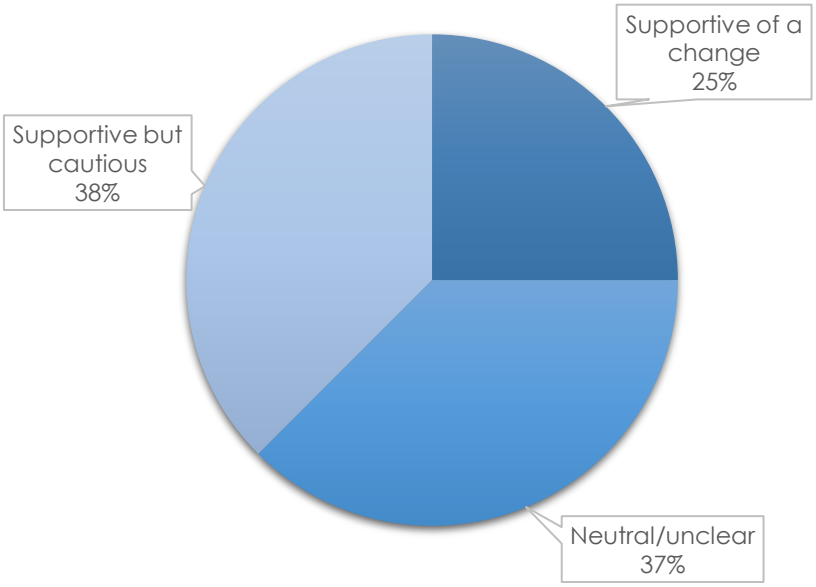

Figure 6: Current stance of interview respondents on the Government's proposed change to the effective ban on genetic technologies based on semi-structured interview responses of key stakeholders.

5.1.2. Supportive but Cautious

The respondents in the supportive but cautious group (38%, Figure 6) called for a review of the current legislative framework, expressing concerns about its complexity and the potential risks of rushing changes. They stressed the importance of robust public consultation to mitigate potential backlash. Like the supportive group, they recognised potential benefits such as competitive export advantages and environmental sustainability goals.

They emphasised the need for stringent testing and risk assessment protocols, akin to those employed in Australia. Differentiating between genetic modification and gene editing, they highlighted concerns about associated risks and public perceptions. They stressed the critical role of public acceptance and trust, advocating for clear communication of both benefits and risks to prevent opposition, particularly within the agricultural sector. Environmental impacts, including threats to biodiversity and unintended consequences, were identified as significant risks needing careful consideration.

There was consensus on the need to review and potentially update legislation to accommodate advances in genetic technologies. They called for a flexible regulatory framework capable of adapting to rapid technological changes while ensuring safety and maintaining public confidence.

5.1.3. Neutral/Unclear

The neutral/unclear group of respondents did not take a definitive stance for or against genetic technologies, citing a lack of specific information needed to understand the implications of proposed changes. They stressed the importance of clarity on the types of technologies involved, potential sector impacts, and regulatory details.

Evidence-based assessments of safety and necessity were highlighted as essential by these respondents. Some noted personal or anecdotal research suggesting genetic technologies might not pose inherent risks, questioning ongoing bans or restrictions. Concerns were raised about potential environmental impacts, especially in organic and regenerative farming. Economic fears included worries about corporate control over agricultural resources and markets.

Calls were made for inclusive discussions involving farmers, industry experts, and the public, emphasising transparent decision-making processes to ensure comprehensive understanding and debate of all relevant details. Ethical considerations regarding genetic technologies in agriculture and broader societal impacts, including potential monopolisation by large corporations, were also mentioned.

7.2. Public Perspectives

5.2.1. Public Opinion

Respondents shared mixed expectations regarding public opinion in New Zealand if genetic technologies, like gene editing, were permitted in farming systems. As shown in Figure 7, 19% (3 respondents) anticipated immediate public acceptance, while another 19% believed acceptance could grow over time with education and engagement efforts. Conversely, 19% foresaw public resistance. A significant portion (31%) expected varied responses based on the specific trait or application of genetic technology, influenced by perceived benefits, impacts on consumer choice, and agricultural practices.

The "other" group highlighted that public acceptance of genetic technologies would vary based on the type – transgenesis versus cisgenesis – and emphasised the need for a comprehensive risk-based regulation system. They noted significant differences in public perception and regulatory attitudes between countries, with Australia experiencing less protests compared to New Zealand's more polarised views. The group stressed the importance of addressing public concerns regarding choice and risk management. They highlighted that consumers value their ability to choose GT products, particularly in food, and that perceived risks differ based on the product's application – therefore, it would be hard to gauge what public response would be. They called for transparent communication of benefits and risks to maintain consumer trust and ensure informed choices.

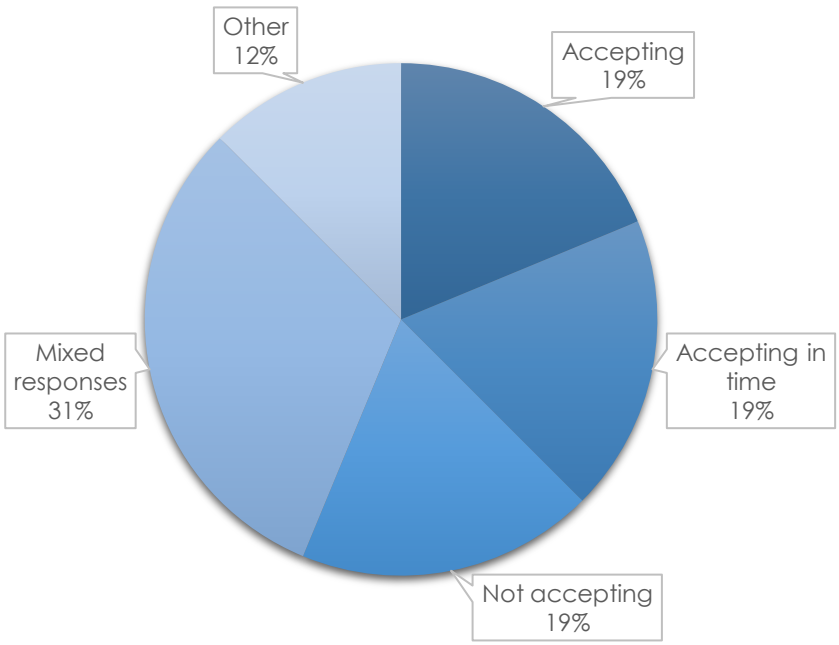

Figure 7: Answers of interview respondents on public acceptance of genetic technologies in New Zealand farming systems based on semi-structured interview responses of key stakeholders.

Across all respondents, it was emphasised that public perception of genetic technologies is heavily influenced by widespread misinformation. They recommended extensive educational campaigns to clarify what genetic technology entails and its potential benefits. Safety concerns were raised, highlighting the need for thorough risk assessment and transparent communication to build public trust. They stated that public acceptance hinges on demonstrating clear societal benefits and addressing issues such as climate change and agricultural productivity. Themes of balanced regulation, effective communication strategies, and combatting misinformation emerged consistently. The consensus among respondents was that there would be greater receptivity by the public to applications aimed at climate or environmental benefits compared to those focused on agricultural production improvements.

Respondents attributed the effective ban to concerns over GMO safety, amplified by public fear and misconceptions, which spurred a strong anti-GMO social movement rooted in economic and safety concerns. This has been compounded by stringent regulatory frameworks and historical legislative challenges. Perceived lack of consumer benefits and apprehensions about corporate control over food systems have also played a role. New Zealand's commitment to preserving its clean, green image, coupled with concerns about potential market responses, has further deterred GMO adoption. Respondents also noted delays in embracing new technologies, insufficient public education on GMO advantages, and a cautious approach to technological risks as additional contributors to the current ban.

5.2.2. Public Understanding

Respondents were asked what the public would need to better understand the current status of genetic technologies and whether New Zealand could benefit from their use. The answers were categorised into groups as shown in Table 4.

Table 4: Recommendations on ways to help the public better understand genetic technologies (GT) and their benefits to New Zealand identified in semi-structured interview responses of key stakeholders.

Recommendations	Key Points
Promote public understanding	▪ Prioritise human-centred design and collaborative partnerships to shift public perception ▪ Showcase tangible benefits to New Zealand, citing examples such as medical uses ▪ Deploy a robust communications strategy (like COVID-19 strategy) to effectively communicate these benefits ▪ Tell the story well – let them see where it could lead
Address public concerns and ethical considerations	▪ Provide evidence of the social and environmental benefits of GT ▪ Communicate data on safety and risks transparently. ▪ Proactively counter misinformation through targeted communication ▪ Tailor messages to align with different societal values and viewpoints ▪ Ensure communication is delivered by unbiased, credible organisations and individuals
Engaging relatable messengers	▪ Use trusted public figures who have connections to farming and are relatable to the public ▪ Avoid using politicians to deliver the message. Instead, choose individuals who can effectively bridge the gap between government, farmers, science, and the public
Demonstrating beneficial impacts and trust	▪ Explain clearly how GT can solve specific problems, such as sterilising wilding pines, with straightforward, legislatively supported solutions ▪ Build communication strategies based on trust, delivered by trusted figures such as scientists, Federated Farmers, universities, and consumer associations ▪ Focus on consumer benefits and ensure alignment with scientific findings to build public trust
Educational outreach and communication channels	▪ Use social media and TV series for education ▪ Tailor communication to different audiences ▪ Avoid technical language and be clear about the benefits
Ethical and evidence-based discussions	▪ Promote evidence-based discussions nationally and engage in open dialogue ▪ Address ethical concerns around GT and provide clear explanations on containment and safety measures ▪ Use real-world case studies from countries like Canada to illustrate positive outcomes of adopting GT
Contextualising benefits for New Zealand	▪ Place GT in the context of practical changes it could bring, such as reducing methane emissions or improving environmental sustainability ▪ Provide examples of how GT can enhance agricultural productivity and address public concerns over issues like animal welfare and environmental impact
Balanced approach to communication	▪ Balance discussions by giving proportional time to both proponents and critics of GT ▪ Engage with adversarial groups constructively and align communication efforts with their environmental goals ▪ Acknowledge risks openly while emphasising the benefits of GT in a balanced manner

5.3. Risk and Regulation

5.3.1. Risk Factors

Regarding the risks associated with the commercial use of genetic technologies in New Zealand, there were varying perspectives relating to the level of perceived risks, with some respondents expressing minimal concern compared to others who emphasised significant potential risks across environmental, health, economic, and social dimensions. The risk areas stipulated by respondents were broken down into 7 main areas, as shown in Figure 8Figure 8: Key themes in potential areas of risk associated with the use of genetic technologies in New Zealand agriculture based on semi-structured interview responses of key stakeholders.. Many respondents acknowledged that the risk profile would be dependent on the type of technology and what is allowed, how it is used, and what the regulatory/legislative framework would be. There were numerous mentions of the unintended consequences of using these technologies. For example, there were references to products such as DDT (a pesticide) and thalidomide (a medicine), as these products were initially widely used because they were seen as safe solutions to certain problems, however, they ended up having disastrous unintended consequences that were only discovered after extensive use.

Other concerns over unforeseen impacts were related to human health, such as allergenicity, and the environment, with concerns about disruptions to biodiversity and the emergence of super weeds that are difficult to control. Respondents also stated there are risks associated with market perception and trade, including potential impacts on New Zealand's export image, labelling complications, and challenges in maintaining markets that prefer non-GMO or organic products. Respondents stressed the need for strong regulatory frameworks to mitigate these risks.

There was also concern raised about social and political issues which may present as protests, polarisation of viewpoints in the New Zealand public, trust issues, and a negative perception of these technologies. They emphasised the importance of transparent communication and education about genetic technologies to address potential consumer backlash.

While some believe genetic technologies can be managed with proper regulation and monitoring, others emphasise the need for caution and thorough risk assessment to avoid unforeseen consequences.

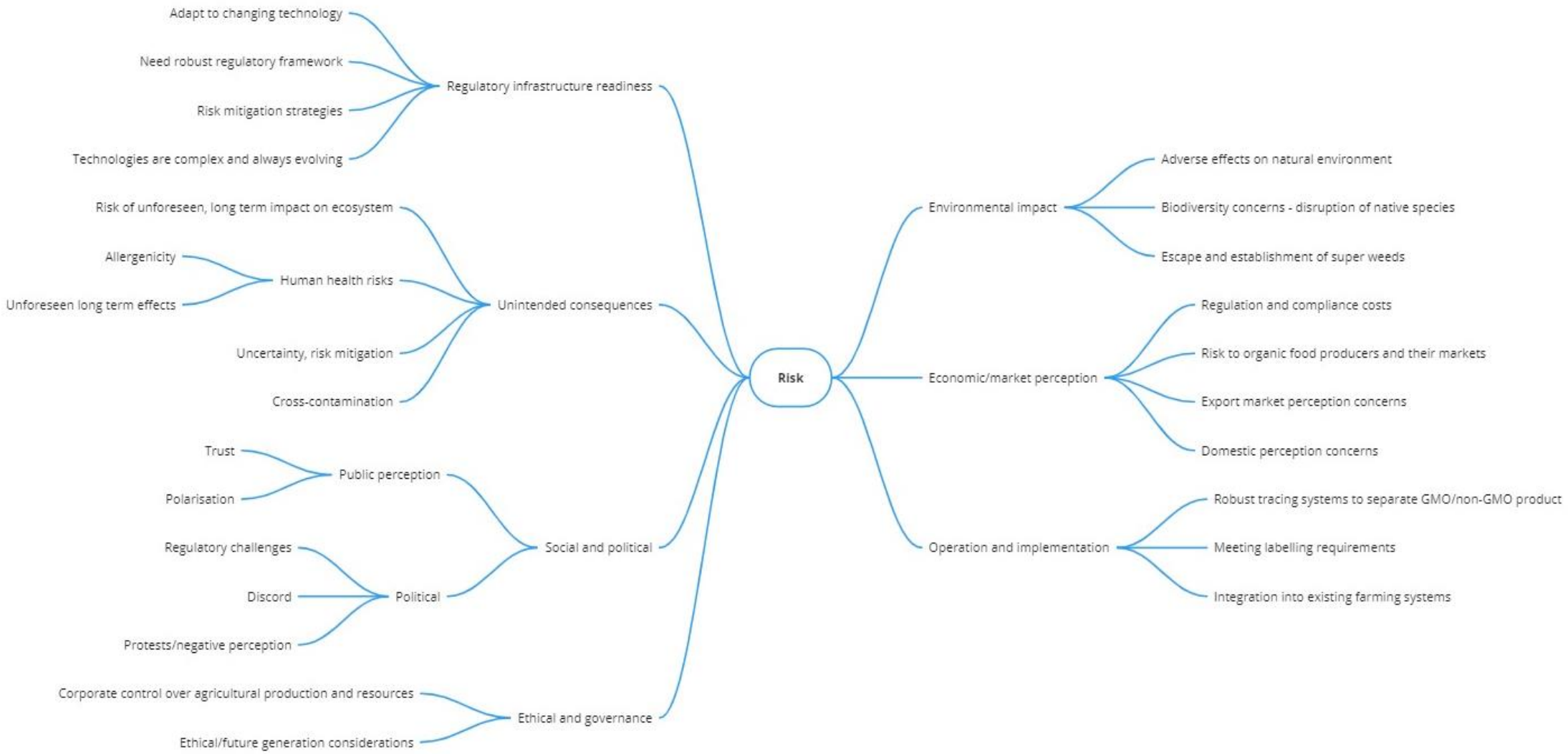

Figure 8: Key themes in potential areas of risk associated with the use of genetic technologies in New Zealand agriculture based on semi-structured interview responses of key stakeholders.

Respondents were asked what they felt were the main risk factors specific to New Zealand's export markets if genetic technologies were introduced in agricultural production.

- **Consumer perception and market preferences**: Concerns that consumers in key export markets, particularly those valuing non-GM/non-GE products (e.g., North America), might prefer non-GM/non-GE options, potentially leading to market loss or reduced premiums.
- **Regulatory and trade barriers**: Challenges related to differing international GMO definitions and regulations, which could hinder market access or require specific labelling and compliance measures.
- **Competitive positioning**: Risk of losing the "GMO-free" market advantage currently held by New Zealand, impacting competitive positioning and market share in certain segments.
- **Industry and consumer education**: The need for effective communication and education about the benefits and safety of genetic technologies to gain consumer acceptance and maintain market access.
- **Reputational risk**: Potential damage to New Zealand's "clean, green" image if genetic technology adoption is perceived negatively by global consumers, affecting overall market perception and export opportunities.
- **Market segmentation**: Variation in consumer preferences across different export markets, requiring tailored strategies to accommodate both GM/GE and non-GM/non-GE market demands.

5.3.2. Risk Sectors

Respondents were further queried about which sectors they believed would be most vulnerable to having their export markets affected if New Zealand were to adopt genetic technologies in agriculture. Sectors identified included:

1. Dairy industry
2. Meat industry
3. Horticulture (especially products consumed directly)
4. Wood industry
5. Organic growers
6. High-value products (e.g., high-end meat products)
7. Exported primary products in general

The dairy, meat, and horticulture sectors came up most frequently, with horticulture thought to be more likely to be at risk in areas where products were directly consumed, e.g., apples and kiwifruit. These sectors were highlighted due to concerns about market perceptions, potential loss of premium markets, and consumer preferences in various export markets, particularly in regions like Europe where GMO regulations and consumer sentiment are more restrictive.

5.3.3. Regulation

Respondents outlined essential regulatory needs for genetic technologies in New Zealand agriculture, as shown in Figure 9.

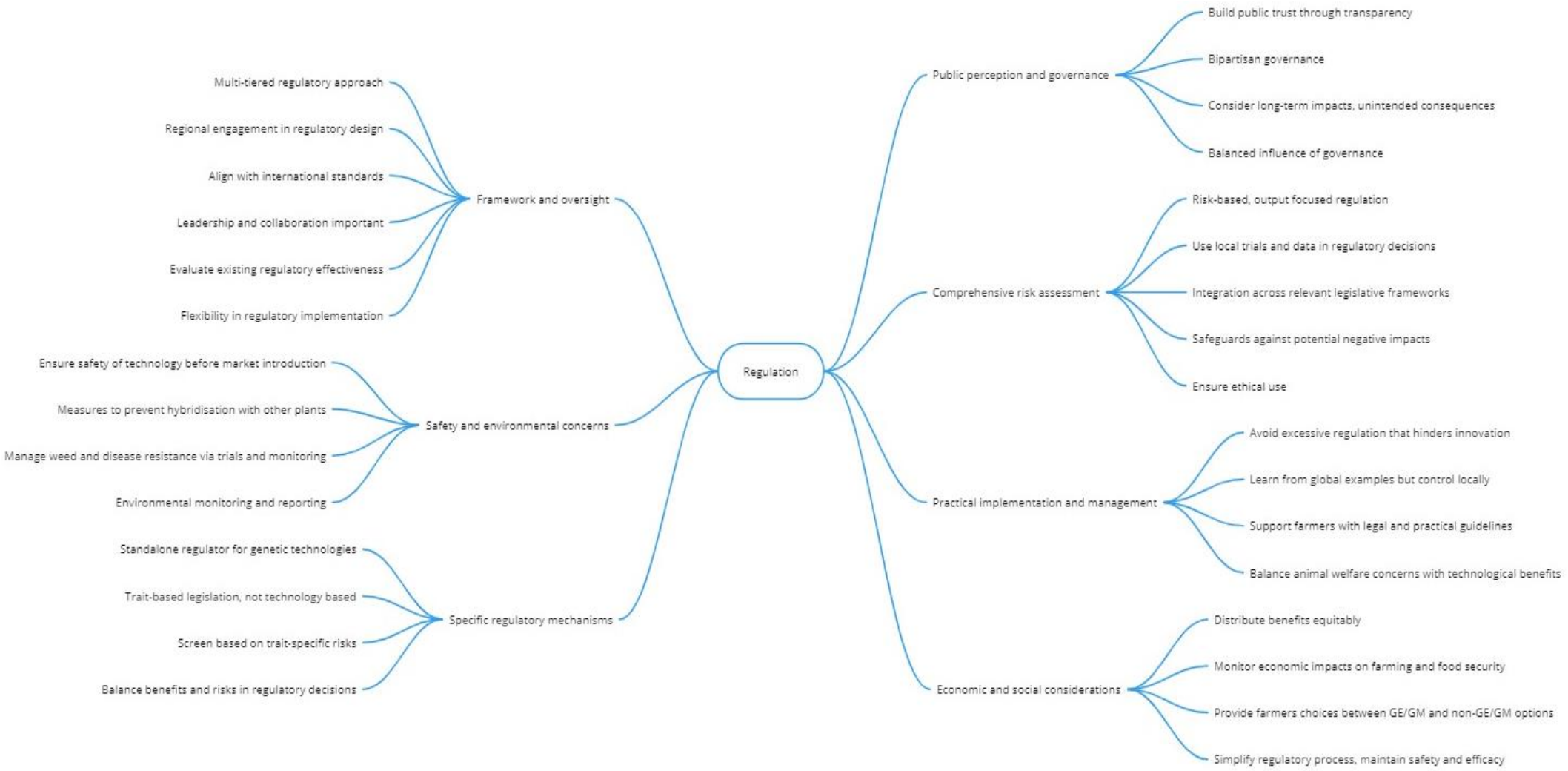

Figure 9: Key themes in responses associated with regulatory requirements if genetic technologies were to be used in New Zealand agriculture based on semi-structured interview responses of key stakeholders.

Respondents emphasised the need for a robust and adaptable regulatory framework that balances safety, risk management, and technological advancement. They advocated for a multi-tiered approach with regionally engaged, flexible regulations and recommended a shift from technology-based to trait-based legislation. Ensuring the safety of genetic technologies through comprehensive testing and monitoring was considered crucial to assess risks to human health, the environment, and agricultural systems.

A phased approach to trials, with independent reporting, was widely supported by the respondents to identify and mitigate potential risks. The need for independent regulatory bodies or a standalone genetic regulator was also highlighted, with some suggesting an independent commission to provide unbiased evaluation and effective management. While strong regulation is essential, respondents cautioned against excessive constraints that could stifle innovation, advocating for a balance between regulation and flexibility to support progress while managing risks. A bipartisan approach, akin to the bipartisan climate laws introduced by former Climate Minister James Shaw, was recommended by some respondents.

Addressing the coexistence of GMO and non-GMO agriculture in New Zealand was deemed important, with considerations for market perceptions, protection of non-GMO producers, and management of cross-contamination risks. Aligning with international standards and practices to ensure trade and regulatory consistency was also emphasised, including understanding what their definitions of GMO are. Learning from global experiences and adapting them to New Zealand's context was viewed as beneficial.

Respondents stressed the importance of public and stakeholder engagement to build trust in the regulatory process. Effective communication should be unbiased, fact-based, involve trusted sources, and occur early in the process. The regulatory approach should account for the economic impact and social implications of genetic technologies, ensuring equitable distribution of benefits and addressing concerns about corporate control and market concentration.

Overall, respondents advocated for a regulatory system that ensures safety and effectiveness while remaining flexible and responsive to technological advancements and market needs.

7.4. The Future State

7.4.1. Potential Uses

Respondents held diverse opinions regarding the most important potential applications of genetic technologies in New Zealand agriculture, yet there were consistent themes identified across the identified uses (Table 5).

Table 5: Most important potential uses for genetic technologies in New Zealand agriculture identified in semi-structured interview responses of key stakeholders.

Potential Use Categories	Examples
Environmental emissions reduction and sustainability	▪ Lowering methane emissions from livestock ▪ Reducing nitrogen loss to the environment and improving water quality ▪ Developing climate-resilient crops and pastures
Improved productivity and efficiency	▪ Enhancing crop yields and nutritional content ▪ Increasing milk production efficiency in dairy cows ▪ Developing heat-tolerant and drought-resistant crops ▪ Improving water use efficiency in plants ▪ Reducing nitrogen use in crops
Pest and disease management	▪ Creating crops resistant to diseases and pests, improved weed control ▪ Enhancing animal health through disease resistance
Animal welfare and management	▪ Improving animal health and welfare e.g., polled cows, heat-tolerant livestock ▪ Improving disease resistance in livestock
Market and consumer demand	▪ Improving product characteristics such as shelf life and taste ▪ Meeting consumer preferences for sustainable and environmentally friendly products
Long-term climate change mitigation	▪ Addressing long-term environmental impacts like reducing greenhouse gas emissions, especially methane
Innovation and adaptation	▪ Driving innovation in agriculture through new genetic technologies ▪ Adapting to climate change by developing resilient farming practices and products

Respondents were also asked to identify the single most important potential use out of the possible use categories that they suggested. The responses could be categorised into the following 3 areas:

- Emissions reduction and environmental sustainability
- Plant and animal pest and disease management
- Animal welfare and efficiency

Some participants gave different responses based on the industry they represented. For example, a stakeholder in the horticulture industry ranked the capability to keep up with global plant breeding and develop new products as the most important potential use. Others mentioned that several of the uses outlined in Table 5 are equally important and should be balanced in discussions about future use, specifically balancing out uses for the environment, production, and consumers. However, the most consistent response regarding the most important use was emissions reduction and environmental sustainability, with 50% of respondents emphasising that this was the most critical and urgent use. Some even explained that this should be the primary focus, with other uses such as animal welfare being considered next.

7.4.2. A Future Without Genetic Technologies

Respondents were asked about the potential impact of not using genetic technologies in New Zealand agriculture. The responses were categorised into 4 main areas of concern: economic impact and competitiveness, environment and sustainability, technology and innovation, and consumer perception and markets, as shown in Figure 10.

There were concerns that agriculture would face more challenges without genetic technologies, making it difficult for New Zealand to stay competitive. Respondents mentioned potential issues such as struggling to meet evolving consumer demands for healthier and more nutritious products, difficulties in reducing environmental and animal health impacts, and slower progress in production and efficiency improvements. They believed that this could result in a loss of market share, constraints on farming locations due to climate change, increased reliance on agricultural chemicals and fertilisers, and a risk of falling behind as competitor countries use genetic technologies to improve their efficiency and market position.

Some respondents stated that New Zealand, as an innovative farming nation, would continue to produce high-quality food for discerning consumers and find other solutions to address the challenges we face. There was also speculation that remaining GMO-free could attract a premium in some markets based on perceived health, environmental, and ethical benefits. However, some respondents believed that genetic technology could be a tool – in and of itself – to deliver those benefits. There were concerns about the environmental impacts of pasture-based farming systems, and that if our mitigation methods are not effective at helping us reduce our emissions and meet targets, some respondents had concerns that our consumer base may prefer more efficiently produced alternatives. Generally, there was a consensus amongst respondents that if New Zealand is going to move down this pathway, changes need to be implemented now – if we wait a few more years, we risk being left behind by competitor producers.

During the interview process, many respondents mentioned that genetic technologies were not a "silver bullet" or "quick fix" for issues such as the environmental impact of agriculture and stressed the importance of these technologies not being seen as a final resolution, but rather as another "tool in our toolkit" that must be used with other solutions. Some respondents believed that remaining GMO-free may encourage the adoption of sustainable farming practices that reduce reliance on synthetic inputs like fertilisers and pesticides. By focusing on organic and regenerative farming methods, some respondents highlighted benefits such as improved soil health, biodiversity conservation, and reduced environmental impact.

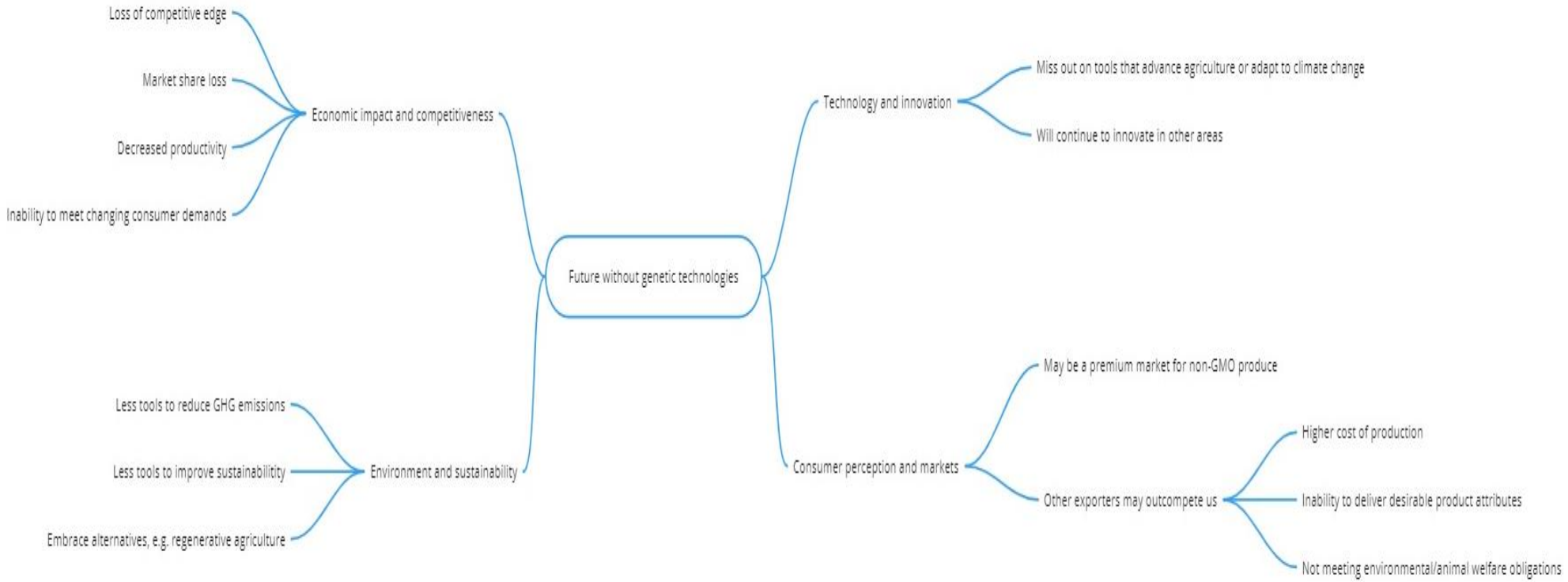

Figure 10: Key themes in responses associated with the consideration of a future without the use of genetic technologies in New Zealand agriculture based on semi-structured interview responses of key stakeholders.

5.4.3. Supporting Farmers in a New Future

Respondents were asked how the role of New Zealand rural servicing companies might need to change to meet the needs of farmers who may ultimately end up utilising genetic technologies.

Their responses were categorised into the following 4 areas:

Education and training:

- Rural servicing companies need to focus on education and training. This includes organising field days, workshops, and small group sessions where farmers can learn about genetic technologies in agriculture.
- There should be an emphasis on practical, on-farm demonstrations and trials to showcase the benefits and outcomes of GT.
- Staff need to be upskilled to provide evidence-based discussions on the value of GM/GE plants and animals, addressing both farmer concerns and societal benefits.

Communication and engagement:

- Companies should play a role in facilitating discussions and being a trusted source of information on GT. This involves transparently discussing risks, benefits, and the proper use of GT products.
- Engaging with farmers through various channels (field days, workshops, direct communication) to ensure they understand the technology and its implications.
- Building enduring relationships with farmers and communities and acting as a bridge between regional needs and national policies or initiatives.

Market differentiation and support:

- Companies need to differentiate between GT and non-GT products, ensuring transparency in labelling and supply chain assurances, especially for their organic/non-GT farmer customers.
- Providing clear guidelines and support for farmers transitioning to GT products, including ongoing agronomic advice and support for compliance with regulations.
- Considering market dynamics and farmer preferences, some of whom may be hesitant or opposed to GT, and ensuring options are available to cater to different preferences.

Strategic collaboration and advocacy:

- Collaborating strategically with government bodies, research institutions, and industry stakeholders to advocate for supportive policies for farmers using GT.
- Advocating for changes in regulations or frameworks that may impact the adoption or market acceptance of GT in agriculture.
- Playing a proactive role in influencing policy discussions at both regional and national levels, ensuring farmer voices are heard and needs are met effectively.

8. Findings and Discussion

Based on the literature review and the stakeholder interviews, it is clear that the use of genetic technologies in New Zealand is an emotive, historically important issue that many New Zealanders feel passionately about. Often likened to our staunch anti-nuclear stance, the use of genetic modification and gene editing technologies in New Zealand has faced strong opposition, as seen in the protests over the past 30 years. This was evidenced by the stakeholder interviews as only 19% felt the public would be outright accepting.

These strong views seem to have had some influence, as our laws continue to effectively ban their use outside of contained laboratory environments. This was reinforced by the stakeholder group interviewed, who attributed the continued effective ban to public fear of GMO safety and economic concerns, coupled with concerns about market reaction, damage to our image, and corporate control. However, the current legislation has been surpassed by advances in genetic technologies, such as NBTs. The HSNO Act 1996, the primary governing document in this area, has not undergone a review in over 20 years. It is widely acknowledged that a review is overdue, a sentiment echoed by numerous prominent scientists, research institutes, industry leaders, and the Government. Therefore, with the current Government's impending plans to review the legislation and end the effective ban on genetic technologies, it is timely to have a national conversation about this issue.

Findings from the interview group were that this conversation would require a multifaceted approach that includes clear communication, trusted messengers, comprehensive education, and respectful engagement with diverse perspectives. This was further supported by previous interviews from other notable stakeholders, such as Sir Peter Gluckman, who stated that we need to have another conversation as a country about it now that the science has settled. It is acknowledged that this conversation will be difficult given that previous polls indicate a slight majority of the population would not be accepting. Interview respondents cited that there is widespread misinformation on this issue, and there seems to be a misinterpretation of how this technology would impact us – public opinion often states concern over the loss of our "clean, green" reputation, yet the literature reviewed indicated this would likely not be the case. Both the literature and interview responses highlighted the importance of this public engagement and education, as well as stakeholder involvement, as part of the regulatory process.

The interview respondents recommended that a national conversation would need to demonstrate clear social and environmental benefits, taking learnings from the communications strategy from the COVID-19 pandemic. It would need to provide the public with data on safety, risks, and ethical considerations associated with genetic technologies, and address misinformation early to build public trust. The respondents recommended using relatable messengers and unbiased organisations like universities to deliver balanced information and engage diverse viewpoints effectively. This is supported by findings in other reviews on science communication in the primary sector, which recommends developing a comprehensive national strategy integrating agricultural science into mainstream media and public discourse, fostering collaboration among scientists, media, industry, and Government (Morris, 2021). Multiple respondents highlighted the importance of telling a story and contextualising it to show how it will benefit New Zealanders. Respondents also stated we need to showcase where this technology could take us

using issues important to New Zealanders, e.g., "imagine if we had cows that didn't get heat stress", and then introducing the concept of genetic technologies from there.

There are clear patterns that New Zealanders seem to have a more favourable outlook on the acceptance of genetic technologies when they are proposed to be used for conservation, environmental, climate change, or animal welfare benefits. Previous polls have shown this, and there was overwhelming consensus within the stakeholder group interviewed that the public would be more accepting of technologies for climate/environmental benefits than production improvements. This was further reinforced when respondents were asked what they believed the most important potential uses were. Respondents identified pest and disease management, adapting to consumer demand, production efficiency improvements, environmental benefits, and climate change mitigation as significant potential uses. However, reducing emissions and enhancing environmental sustainability emerged as the most critical and pressing use, which is highlighted by the work underway overseas by AgResearch to help quantify the benefits to New Zealand agriculture of using GM and GE pasture species to help build climate resilience and improve animal health (The Country, 2024). Respondents did emphasise that genetic technologies in the context of environmental sustainability or emissions reductions should not be seen as a "silver bullet" and should be used in conjunction with other mitigation measures.

The literature highlighted concerns about risks including potential food safety issues, environmental risks, and unintended genetic changes. This was reiterated by the interview responses, where human health effects, unintended consequences, negative environmental impacts, and export market perception concerns were pointed out as being potential risk areas. There was variation in perceived risk depending on the type of technology used, the end product, and the sector involved. These factors highlight the complexities and considerations involved in adopting genetic technologies in New Zealand's agricultural sector. It emphasises the importance of understanding our markets and consumer preferences, as well as ensuring we have robust regulatory and governance frameworks. Some of the respondent group discussed the fact that our consumers are looking to more sustainably produced alternatives, as environmental impact becomes an increasingly important purchasing habit. It was speculated that the potential benefits offered by genetic technologies, including reduced greenhouse gas emissions, nutrient or water use efficiency, and production enhancements, could help New Zealand meet some of our targets and consumer preferences. This was supported by studies that showed that consumers were accepting of products from gene-edited plants, especially those believed to improve human and animal health and the environment (Beghin & Gustafson, 2021).

Respondents highlighted the need for a regulatory framework that is both flexible and comprehensive, effectively balancing safety, risk management, and technological advancement. They advocated for a multi-tiered approach with regionally tailored regulations and a shift from technology-based to trait-based legislation, similar to those successfully implemented in Australia and Canada, which focuses on the end product rather than the process. Rigorous testing and assessment were deemed essential to evaluate the safety of genetic technologies,

addressing potential risks to human health, the environment, and agriculture. A phased trial process with independent reporting was supported to identify and mitigate risks, alongside the establishment of an independent regulatory body or commission to ensure unbiased evaluation. However, respondents cautioned against overly restrictive regulations that could suppress innovation. They also suggested a bipartisan approach akin to previous climate laws. They emphasised the importance of managing the coexistence of GM/GE and non-GM/GE agriculture in New Zealand, as well as aligning with international standards and incorporating learnings from global genetic technology regulatory frameworks and implementation. Effective public and stakeholder engagement through transparent and factual communication regarding the regulatory process was also highlighted as important. The respondents and previous legislative reviews noted inconsistencies in genetic modification definitions across different countries, stressing the need for clarification to improve public understanding and ensure compliance with international definitions, as some end products altered via NBTs may not be classified as GMOs (Jolly, 2023).

Respondents were asked what they felt a future without genetic technologies would look like for New Zealand agriculture, and they expressed concerns that the sector would face more challenges, making it difficult for New Zealand to stay competitive. They raised potential issues around meeting changing consumer preferences for healthier products, reducing negative environmental and animal health impacts, and slower gains in productivity and efficiency if we do not adopt these technologies. Conversely, some felt we would innovate in other ways and could continue to seek access to certain markets by producing non-GMO food. Many competing producers have already adopted genetic technologies and are using them to improve their efficiency and market relevance, therefore there was a strong emphasis by many of the respondents that if New Zealand is going to use these technologies, changes need to be implemented now or we risk being left behind by competitor nations.

Adapting to this future was also examined from the perspective of rural servicing companies and how they could continue to support farmers. These companies currently play an important role as trusted advisors and providers of agronomic support. The interview responses showed that there is a need for these companies to not focus on being product suppliers, but to become educators, facilitators, and advocates for farmers in the realm of genetic technologies in agriculture. They must navigate challenges such as public perception, regulatory compliance, and market dynamics while ensuring farmers are equipped with the knowledge and support they need to adopt genetic technologies responsibly and effectively.

9. Conclusions

New Zealand is at a pivotal time as legislation is being reviewed to keep pace with advances in genetic technology. There have been several recommendations made to the Government that the legislative framework needs to be scientifically

informed, balancing risks and benefits while aligning with cultural values and international standards. It is clear to see the importance of taking learnings from regulatory frameworks overseas that have been adaptable and output trait-based.

Public attitudes toward these technologies are likely to remain hesitant. Therefore, initiating a national dialogue is crucial, emphasising clear communication, trusted messengers, comprehensive education, and respectful engagement with diverse perspectives. Educating the public on modern genetic technologies, including their benefits to New Zealand's environment and economy, will be key. Given the public and our end consumer's preference for conservation and sustainability uses, focusing initially on environmental and climate applications may be the most effective approach, as well as considering animal welfare uses.

Concerns about food safety, environmental impacts, and unintended consequences accentuate the need for robust regulatory frameworks; and market access concerns highlight the need to understand and align with our export markets. Conversely, it is recognised that environmental concerns and the need to maintain consumer acceptance may be addressed by using genetic technologies to meet these expectations. Rural servicing companies are also urged to not assume the role of genetic technology product suppliers, but to educating and supporting responsible adoption of these technologies among farmers. With rapid advancements and active use of these technologies by competitor nations, prompt action is essential to avoid falling behind.

10. Recommendations and Next Steps

- Early engagement by the Government, including the EPA, MfE, and MPI, with the public and key agriculture industry stakeholders on proposed changes to regulation and the use of genetic technologies – clear explanation of the risks, benefits, and what it means for them.
- Public communication strategies from the Government, including the EPA, MfE, MPI, the proposed biotech regulator, and relevant agriculture industry stakeholders need to be unbiased, fact-based, and delivered by trusted messengers.
- The proposed biotech regulator and the agriculture industry should focus on genetic technologies that benefit the environment, animal welfare, or the consumer first.
- Primary industry processors, exporters, and marketers must have a good understanding of their export markets and the perceptions and preferences of those export markets.
- The Government, including the proposed biotech regulator, need to clearly define the different types of genetic technologies and what they mean in the context of our export markets.
- The Government needs to ensure our new regulations are robust and adaptive, while also minimising any risks. They should be output-based and measure product risk, rather than being process-based.
- If New Zealand is going to use these technologies, we must start implementing them as soon as possible to maintain our competitive position.
- Rural supplies merchants should assume the role of educating and supporting farmers in the responsible adoption of genetic technologies.

9. References

1 News. (2018, July 1). *'It is safe'—Sir Peter Gluckman says GMO usage has no significant ecological or health concerns.* https://www.1news.co.nz/2018/07/01/it-is-safe-sir-peter-gluckman-says-gmo-usage-has-no-significant-ecological-or-health-concerns/

AgResearch. (n.d.). *Gene edited endophytes*. Retrieved 13 June 2024, from https://www.agresearch.co.nz/our-research/gene-edited-endophytes/

AgResearch. (2024). *Discussion at the National Fieldays*.

Australian Government. (n.d.). *Federal Register of Legislation*. Retrieved 29 April 2024, from https://www.legislation.gov.au/F2015L00450/latest/versions

Beghin, J. C., & Gustafson, C. R. (2021). Consumer valuation of and attitudes towards novel foods produced with new plant engineering techniques: A review. *Sustainability (Switzerland)*, *13*(20). https://doi.org/10.3390/su132011348

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*(2), 77–101. https://doi.org/10.1191/1478088706qp063oa

Caradus, J. R. (2023a). Genetic modification – benefits and risks for New Zealand grassland production systems. *Journal of New Zealand Grasslands*, *85*, 39–49. https://doi.org/10.33584/jnzg.2023.85.3654

Caradus, J. R. (2023b). Impacts of growing and utilising genetically modified crops and forages–a New Zealand perspective. *New Zealand Journal of Agricultural Research*, *66*(5), 389–418. https://doi.org/10.1080/00288233.2022.2077380

Caradus, J. R. (2023c). Intended and unintended consequences of genetically modified crops–myth, fact and/or manageable outcomes? In *New Zealand Journal of Agricultural Research* (Vol. 66, Issue 6, pp. 519–619). Taylor and Francis Ltd. https://doi.org/10.1080/00288233.2022.2141273

Carapiet, J. (2023, June 9). *'Strict regulation of gene editing benefits farmers, exporters'*. Farmers Weekly. https://www.farmersweekly.co.nz/opinion/strict-regulation-of-gene-editing-benefits-farmers-exporters/

Davies, P., Moore, D., & Yarrall, D. (2018). *Report to the Ministry for Business, Innovation and Employment Current land based farming systems research and future challenges*.

Edlin, B. (n.d.). Judith Collins promises gene-editing law changes – but they are not on the urgent list. *AgScience*. Retrieved 30 April 2024, from https://agscience.org.nz/judith-collins-promises-gene-editing-law-changes-but-they-are-not-on-the-urgent-list/

Environmental Protection Agency. (2008). *HSNO Application Register: GMR07001*. https://www.epa.govt.nz/database-search/hsno-application-register/view/GMR07001

F+B Tech. (2022, April). *New Zealand needs genetic modification*. https://www.fbtech.co.nz/2022/04/26/new-zealand-needs-genetic-modification/

Farmlands. (n.d.). *Agronomy*. Retrieved 28 April 2024, from https://www.farmlands.co.nz/Productsandservices/Agronomy/

Flybuys. (n.d.). *Have your say and earn Flybuys for free with Kantar New Zealand*. Retrieved 8 June 2024, from https://www.flybuys.co.nz/extras/free-flybuys

Fonterra. (n.d.). *Cared for cows*. Retrieved 18 May 2024, from https://www.fonterra.com/lk/en/about-us/the-way-we-farm/animal-wellbeing/cared-for-cows.html

FSANZ. (n.d.). *Proposal P1055 - Definitions for gene technology and new breeding techniques*. Retrieved 29 March 2024, from https://www.foodstandards.gov.au/food-standards-code/proposals/p1055-definitions-for-gene-technology-and-new-breeding-techniques#:~:text=new%20breeding%20techniques-,Proposal%20P1055%20%2D%20Definitions%20for%20gene%20technology%20and%20new%20breeding%20techniques,Standards%20Code%20(the%20Code).

Greenpeace. (n.d.). *Genetic engineering campaign*. Retrieved 19 April 2024, from https://history.greenpeace.org/aotearoa/genetic-engineering/

Hurrell, G. (2024, March 11). New genetic engineering law expected by end of next year: Judith Collins. *Business Desk*. https://businessdesk.co.nz/article/editors-picks/new-genetic-engineering-law-expected-by-end-of-next-year-judith-collins

Jolly, N. (2023). *Genetic technologies -The next steps for modernising New Zealand's policy framework Kellogg Rural Leadership Programme Course 50 2023*.

Knight, J. G., Clark, A., & Mather, D. W. (2013). Potential damage of GM crops to the country image of the producing country. *GM Crops & Food*, *4*(3), 151–157. https://doi.org/10.4161/gmcr.26321

Knight, J. G., Holdsworth, D., & Mather, D. (2008). GM food and neophobia: connecting with the gatekeepers of consumer choice. *Journal of the Science of Food and Agriculture*, *88*, 739–744.

Lewis Road Creamery. (n.d.). *Our White Milk*. Retrieved 18 May 2024, from https://lewisroadcreamery.co.nz/pages/better-for-the-planet-better-for-you

McMurray, K., & AP. (2013, May 27). *Protesters join global call against Monsanto*. https://www.stuff.co.nz/taranaki-daily-news/8719648/Protesters-join-global-call-against-Monsanto

Morris, N. (2021). *Science communication-Responsibility and integrity in New Zealand's primary sector Kellogg Rural Leadership Programme Course 42 2021*.

Napier, J. A., Haslam, R. P., Tsalavouta, M., & Sayanova, O. (2019). The challenges of delivering genetically modified crops with nutritional enhancement traits. In *Nature Plants* (Vol. 5, Issue 6, pp. 563–567). Nature Research. https://doi.org/10.1038/s41477-019-0430-z

National. (n.d.-a). *Harnessing biotech*. Retrieved 18 May 2024, from https://www.national.org.nz/harnessingbiotech

National. (n.d.-b). *National welcomes Labour's U-turn on gene technology*. Retrieved 30 March 2024, from National welcomes Labour's U-turn on gene technology

New Zealand Legislation. (1996). *Hazardous Substances and New Organisms Act 1996*. https://legislation.govt.nz/act/public/1996/0030/latest/DLM381228.html?search=sw_096be8ed81e069f2_vitro_25_se&p=1&sr=0

New Zealand Productivity Commission. (2021). *New Zealand firms: Reaching for the frontier*.

NZ Herald, & NZPA. (2003, October 12). *Thousands unite to send anti-GE message to Government*. https://www.nzherald.co.nz/nz/thousands-unite-to-send-anti-ge-message-to-government/JL7MP72HIJKELO754ZMNTKZ5AM/

OpenAI. (2024). *ChatGPT Version 3.5 [Chat interaction]*. https://openai.com/chatgpt

PGG Wrightson. (n.d.). *Technical Expertise*. Retrieved 19 April 2024, from Technical Expertise

Research First. (2022). *Public sentiment toward gene editing/ advanced breeding solutions*. chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://researchfirst.co.nz/wp-content/uploads/Gene-Editing-July-2022_v1.1-twopager.pdf

RNZ. (2023, June 11). *National would end genetic modification 'ban' if elected*. https://www.rnz.co.nz/news/political/491773/national-would-end-genetic-modification-ban-if-elected

Royal Society Te Apārangi. (2019). *Gene Editing Legal And Regulatory Implications*.

Scion. (n.d.). *Genetic engineering*. Retrieved 9 June 2024, from https://www.scionresearch.com/science/genetic-engineering#:~:text=Genetic%20modification%20at%20Scion&text=Our%20current%20GM%20research%20involves,radiata%20pine%20and%20other%20conifers.

Scion. (2019). *A look at New Zealanders' current opinions and understanding of genetic technologies*.

Sendhil, R., Yadav, S., Prashat, P., & Ragupathy, R. (2021). Consumer perception and preference towards genetically modified (GM) foods: bibliometric evidence and policy imperatives. *AgriRxiv. Wallingford*, 42. https://doi.org/https://doi.org/10.31220/agriRxiv.2021.0006

Shew, A. M., Nalley, L. L., Snell, H. A., Nayga, R. M., & Dixon, B. L. (2018). CRISPR versus GMOs: Public acceptance and valuation. *Global Food Security*, *19*, 71–80. https://doi.org/10.1016/j.gfs.2018.10.005

Shoup, M. E. (2017, April 14). Fonterra's NZMP non-GMO ingredients part of plan to make 'dairy nutrition accessible to the world'. *Dairy Reporter*.

Stein, A. J., & Rodríguez-Cerezo, E. (2010). International trade and the global pipeline of new GM crops. *Nature Biotechnology*, *28*, 23–25.

Tang, G., Jian, Q., Dolnikowski, G. G., Russell, R. M., & Grusak, M. A. (2009). Golden rice is an effective source of vitamin A. *American Journal of Clinical Nutrition*, *89*(6), 1776–1783. https://doi.org/10.3945/ajcn.2008.27119

Te Puna Whakaaronui. (2023). *WELL_NZ : modern genetic technology - what it is and how it is regulated : a reference document from Te Puna Whakaaronui: New Zealand's independent food and fibre sector think tank.*

The Country. (2024, May 15). *Genetic technologies: AgResearch to showcase opportunities at Fieldays*. New Zealand Herald. https://www.nzherald.co.nz/the-country/news/genetic-technologies-agresearch-to-showcase-opportunities-at-fieldays/NL3QKQD5AVG3TNKH6S6LA4BJ5U/

The Royal Commission on Genetic Modification. (2001). *Report of the Royal Commission on Genetic Modification*.

Treasury. (n.d.). *Productivity Commission (2011 - 2024)*. Retrieved 29 May 2024, from https://www.treasury.govt.nz/information-and-services/nz-economy/productivity/productivity-commission-2011-2024

U.S. Food & Drug Administration. (2024, May 3). *Science and History of GMOs and Other Food Modification Processes*. https://www.fda.gov/food/agricultural-biotechnology/science-and-history-gmos-and-other-food-modification-processes#:~:text=1994%3A%20The%20first%20GMO%20produce,safe%20as%20traditionally%20bred%20tomatoes.

World Health Organization. (2014, May 1). *Food, genetically modified*. https://www.who.int/news-room/questions-and-answers/item/food-genetically-modified

10. Appendix

12.1. Appendix One: Interview Questions

Background Questions

1. Please outline what your current role is and what background knowledge, if any, you have regarding genetic technologies.
2. What is your current stance on the Government's proposed change to the effective ban on genetic technologies?
3. In your view, what factors do you think have contributed to genetic technologies/GMO being effectively banned for use in food and fibre farming systems in New Zealand?

Export Market Considerations

4. Companies such as Fonterra use non-GMO as a marketing strategy for dairy products in some export markets, such as North America. In your view, what are the possible risk factors to our export markets if we were to start using genetic technologies in our agricultural production systems?
5. Which sectors do you think will be most at risk to having export markets affected?

Public Sentiment

6. If genetic technologies, such as gene editing, were to be allowed in New Zealand farming systems, what do you think public opinion might be within New Zealand?
7. What do you think the response would be to the use of genetic technologies for climate/environmental benefits versus production improvement?
8. In your opinion, what information would the public need in order to gain a better understanding of the current status of genetic technologies and whether New Zealand could benefit from their use?

Potential Uses and Fit

9. What do you feel are the most important potential uses of genetic technologies in New Zealand agriculture, if any?
10. In your view, what do you see as the most important potential use?
11. In your opinion, what might a future without the commercial use of genetic technologies in New Zealand agriculture look like?

Regulation and Risk

12. If genetic technologies were to be allowed in New Zealand agriculture, in your view, what would be needed from a regulatory perspective?
13. In your view, what risks, if any, do you perceive may be associated with the commercial use of genetic technologies in New Zealand and why?

Rural Servicing Merchant Support

14. How might the role of New Zealand rural servicing companies, such as Farmlands and PGG Wrightson, need to change to meet the needs of farmers utilising genetic technologies?