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PROGRAMME

Animal Welfare and Climate Change in Aotearoa

Opportunities to improve animal welfare through climate change action

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

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Executive summary

Sustainability is the hot topic for Aotearoa New Zealand's primary industries. There is increasing regulation for farm businesses to meet especially around improved environmental outcomes. The three pillars model of sustainability include environment, economic and social values. As landowners alter their farm systems to meet legislative requirements and adapt to the already changing climate, all facets of sustainability must be considered. Animal welfare does not have the same regulatory drivers as freshwater, or the global significance of climate change. There is a risk the welfare of pastoral livestock will not be sufficiently prioritised through this period of significant change.

Based on the five freedoms, the Aotearoa Animal Welfare Act 1999 requires owners and persons in charge of animals to provide for their animals' 'physical, health and behavioural needs'. Since the development of the five freedoms, advances in animal welfare over the past three decades have led to the suggestion that instead of focussing on poor welfare and suffering, ideals which would act to ensure good welfare and prevent suffering should also be given consideration. Worldwide, public awareness regarding the treatment and well-being of animals continues to increase. The promotion of good levels of animal welfare is not only a moral obligation towards animals but is also essential in the sustainability of practices and the success of production systems which rely on animals.

Global warming of 1.09°C has already caused widespread impacts globally. This is due to greenhouse gas emissions from human-activities, primarily from burning fossil fuels and clearance of forest for pastoral land but also methane from ruminants and manure in agriculture. Agriculture accounts for 91% of biogenic methane emissions in Aotearoa, and 19% of other 'long-lived' gases specifically nitrous oxide and carbon dioxide (Climate Change Commission, 2021). Finding ways to reduce emissions is crucial for the transition to a low-emissions Aotearoa, and to maintain our reputation as a producer of high-quality food and fibre products. Weather extremes arising from increasing climate change will directly and adversely impact the primary sector, with two significant floods on the West Coast in July 2021 and February 2022. This is coupled with indirect effects such as changes to seasonal growing patterns and the distribution of pests and diseases. As the defining issue of this century, climate change mitigation and adaptation will influence farm system changes for decades. When considering the impact of greenhouse gas mitigation policies on farm animal welfare, the sector must look beyond achieving merely neutral welfare by meeting the basic needs of animals. A 'good life' for animals, where they have opportunities for positive experiences must be the goal.

The aim of this report is to explore whether there are opportunities to improve animal welfare through climate change action. Beginning with a literature review of animal welfare and climate change articles, thematic analysis was then used to code common themes and compare and contrast the information. Using heat stress as an example several areas where greenhouse gas mitigation could improve animal welfare outcomes have been identified. There are more areas where the complex interactions of biological systems could lead to an improvement for animals, but without careful evaluation of the risks and benefits may also negatively impact the welfare of livestock.

As farmers make short-term changes and consider their long-term options in response to climate change and the need to reduce emissions, animal welfare must be explicitly considered as part of the decision making. To help this occur several recommendations have been identified. These recommendations state that:

- Increase the understanding of animal welfare based on the Five Domains Model
- Consider the impacts on animal welfare as part of climate change advice
- Farmers should actively seek information about animal welfare impacts

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It's been a longer than usual experience, with multiple Covid-19 outbreaks between our first Phase in June 2021 and our final Phase in April 2022. Congratulations to the other members of cohort #45 for making it to graduation.

Foreword

I've been in the animal welfare team at the Ministry for Primary Industries for 11 years but for a while I was working part-time and was simultaneously the calf rearer/relief milker/business admin for the Lower Order Sharemilking Business I was a partner in at the time. The 500-cow farm and run-off block where we reared the youngstock and wintered the entire herd are in Southland. Years later, having wintered stock on crop, on heavy clay soil turned out to be the perfect practical experience to be part of the Winter Grazing Action Group, working collaboratively with industry to improve outcomes for animals. While dairy farming was physically challenging, and at times emotionally draining, the practical experience has been hugely beneficial, and the empathy for farmers hugely influential in my day job.

My involvement with winter grazing at MPI has made the interrelationship between animal welfare and the environment very clear to me. The requirement for farmers to find the balance between both aspects of farm management then lead to my interest in the links between climate change mitigation and animal welfare outcomes. This report attempts to look at the links between these two expansive areas in a small way, with a necessarily narrow scope.

Introduction

"Farmers must choose and combine the various inputs and develop the most advantageous production systems dependant on constraints of land, climate and animals, financial and personal circumstances and the threats and promises of markets and society" – Mark Fisher, 2019.

Agriculture is a core part of Aotearoa's economy and culture but is arguably operating beyond the constraints of the land, climate, and animals. Yet these factors are crucial to our country's reputation as a producer of high-quality food and fibre products.

Fit for a Better World (MPI, 2020), the Government's roadmap to accelerating the economic potential of the primary sector, places emphasis on Te Taiao "a deep relationship of respect and reciprocity with the natural world" as the way forward. In his book *Animal Welfare Science, Husbandry and Ethics*, Mark Fisher (2019) takes the reader on a journey of our relationship with animals, from hunter-gatherers where we considered ourselves part of nature, to the rise of Christianity where God gave us domain over animals and they were considered separate to man, merely property.

Now, in the age of modern agriculture people are largely removed from the production of food. We want cheap food, yet conversely require farmers to achieve greater environmental and animal welfare outcomes. A Te Taiao framework for agriculture built on respect for the natural world, aligns with the shift in animal welfare over the last few decades and increasing societal concern for farm animal welfare. Animals are both at the centre of pastoral farming and the centre of animal welfare (see Figure 1).

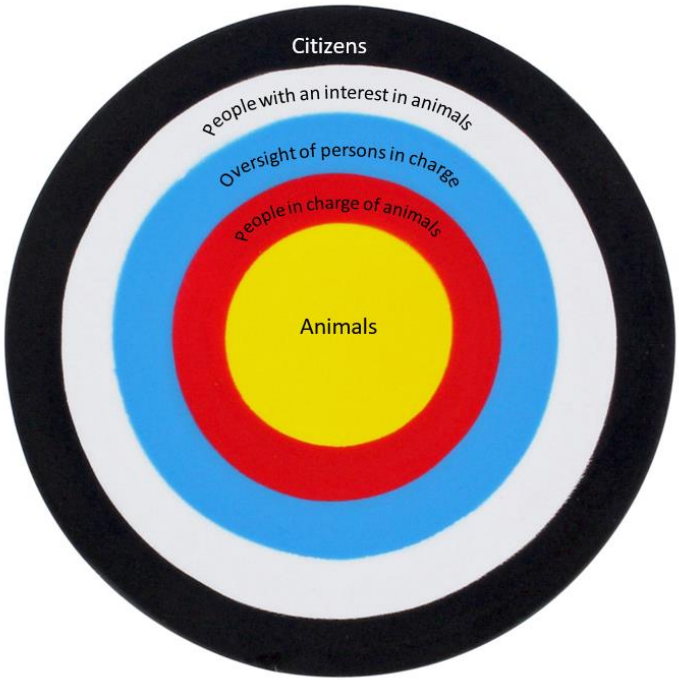

Figure 1: A schematic diagram of the animal welfare system with animals at the centre, moving outwards from those with direct control over animals to the least (adapted from Fisher, 2020).

While the resources livestock have access to (food, water, shelter, health care) are under the direct control of farmers, expectations regarding animal care *"are increasingly influenced and determined by the wider community and societal expectations"* (Fisher, 2020). Consumers are as much a part of the animal welfare system as the farmers who are in charge of the animals, however, consumers are increasingly disconnected from farming due to the shift towards urbanisation and higher wealth in modern industrialised countries

(Sweeney et al., 2022). Animal welfare is important to our reputation as an exporter and farmers' social licence, yet some farming practices are increasingly out of line with societal values.

While important to people and of course the animals themselves, animal welfare does not pose the existential threat that climate change does. Nor does it have the same regulatory push, or investment into research and extension. As conveyed by Barack Obama in 2014 during his address at the United Nations Climate Change Summit, climate change is the defining issue of the 21st century. Our generation is the first to feel the effects of climate change and is considered the last generation that can do something about it.

"There's one issue that will define the contours of this century more dramatically than any other, and that is the urgent and growing threat of a changing climate"- Barack Obama, 2014.

Considering the significance of climate change, and the international and domestic efforts to reduce emissions, the aim of this report is to identify whether there are opportunities to improve animal welfare through on-farm climate change action. The objectives are to:

- examine our understanding of animal welfare and the changing societal expectations for farm animals;
- to understand the impacts of climate change both directly and indirectly on animals; and
- to identify the impacts of reducing farm greenhouse gas emissions on animal welfare, using heat stress as a case study.

Finding ways to reduce emissions is crucial for the transition to a low-emissions Aotearoa, and to maintain our reputation as a producer of high-quality food and fibre products. Weather extremes arising from increasing climate change will directly and adversely impact the primary sector; this is coupled with indirect effects such as changes to seasonal growing patterns and the distribution of pests and diseases.

As the defining issue, climate change mitigation and adaptation will influence farm system changes for decades. The aim of this report is to explore whether there are opportunities to improve animal welfare through climate change action. In the context of complex issues like climate change, sustainable agriculture and animal welfare, the scope of this report had to be confined. To that end, this report has a focus on mitigating agricultural greenhouse gas emissions however a short section on adaptation is included for completeness. This report considers pastoral livestock welfare (sheep, cattle and deer), using the impacts of heat stress as an example to examine the links between mitigation options and animal welfare. Due to the lesser availability of heat stress research in beef cattle, sheep and deer, dairy cattle have been considered more than the other species, though heat stress is an issue which clearly affects all pastoral-farmed livestock. Apart from greenhouse gas reductions and heat stress in farm animals, this report sets aside other sustainability considerations such as economics, freshwater and biodiversity, labour and rural communities. Despite the narrow focus, there was still a lot of information to consider.

Methodology

A literature review using thematic analysis to compare evidence that is both complimentary and contrasting was undertaken. As a starting point, the AgResearch library service ran a literature search using the search strings:

- ("animal welfare" AND "climat* change*") AND TITLE (review OR meta-analysis)
- animal welfare AND (climat* adj5 change*) AND (farm* or livestock or pastoral or pastur*) AND limit to (abstracts and year="2015 -Current")

This initially produced a large volume of articles, before the search was restricted to those more recent than 2015, leaving 69 general articles and 14 review articles. Through reading the abstracts a set of literature was

compiled to be read in full. In addition to this structured literature search resources were located by talking to colleagues and accessing government and industry organisation websites.

The method described by Braun and Clarke (2006) in their article *Using thematic analysis in psychology* was applied in reviewing the literature. That is, coding common themes in the literature, assessing the text for complimentary and contrasting views.

Broadly speaking animal welfare literature concerning concepts and frameworks for quality of life is largely in concurrence. However, the ethical element and societal overlay of what *is* an acceptable quality of life provokes contention, as is expected of a values-based discussion.

Similarly, credible science has proven human-induced climate change is caused by greenhouse gas emissions and will have catastrophic impacts if humanity does not respond quickly. The precise methods of reducing emissions and the equitable distribution of costs elicits differing views.

Having explored the evidence of these two key themes, the link between agricultural greenhouse gas mitigations and the potential impact on heat stress in pastoral livestock was examined. I applied my own critical thinking in assessing these two criteria, shown in Table 1.

A limitation of this report is the absence of stakeholder interviews. While many informal conversations took place, the findings are based on publicly available information and any work currently underway but not yet published has not been considered.

A shift towards sustainable agriculture

Sustainability is the hot topic for Aotearoa New Zealand's primary industries. There is increasing regulation for farm businesses to meet, particularly around improved environmental outcomes. To meet climate change obligations, the primary sector must also achieve a legislated reduction in biogenic methane compared to 2017 levels:

- 10% less by 2030; and
- 23-47% less by 2050.

He Waka Eke Noa (HWEN) – a partnership between government, the primary sector, and iwi/Māori to reduce agricultural greenhouse gas emissions – is helping to support farmers meet their obligations for the primary sector under Schedule 5 of the Climate Change Response Act 2002 (amended in 2019) (MPI, 2022a). By 31 December 2022 all farms must hold a documented annual total for greenhouse gas emissions (colloquially referred to as 'Know Your Number'), and by 1 January 2025 a system must be in place to calculate and report emissions at farm level. Failure to meet these targets could see agriculture included in the Emissions Trading Scheme in 2025, without the flexibility to differentiate between short-lived methane and long-lived nitrous oxide emissions (the 'split gas' approach) (HWEN, 2022).

There were also changes to the Resource Management Act in 2020 including the Resource Management (National Environmental Standards for Freshwater) Regulations 2020, which limit intensification of farmland (resulting in the discharge of contaminants to water), with immediate requirements around stock exclusion from waterbodies, and feedlot management. The National Policy Statement for Freshwater Management 2020 requires local government to give effect to *Te Mana o te Wai* and may require further change to farm practice as regional plans are developed and implemented.

Environmental sustainability, whilst a priority, is only one part of the picture. The United States has defined sustainable agriculture in legislation as "an integrated system of plant and animal production practices having a site-specific application that will, over the long-term: satisfy human food and fibre needs, enhance environmental quality and the natural resource base upon which the agricultural economy depends, make the most efficient use of non-renewable resources and on-farm resources and integrate, where appropriate, natural biological cycles and control, sustain the economic viability of farm operations, and enhance the quality of life for farmers and society as a whole" (von Keyserlingk et al., 2013).

The three pillars model of sustainability include environment, economic and social values (Figure 2). As landowners alter their farm systems to meet legislative requirements and adapt to the already changing climate, all facets of sustainability must be considered. Animal welfare does not have the same current regulatory focus as freshwater, or the global significance of climate change. There is a risk the welfare of pastoral livestock will not be sufficiently prioritised through this period of significant change.

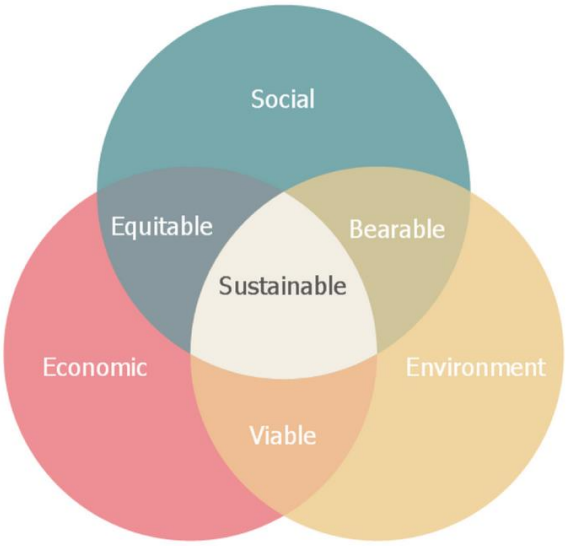

Figure 2: The three pillars of sustainability (diagram adapted from Circular Ecology, 2021).

Similarly, the United Nations Sustainable Development Goals (SDG) (Figure 3) are based on its definition of "meeting the needs of the present without compromising the ability of future generations to meet their own needs" (UN, 2021). Keeling & Stuardo (2021) have led a process mapping the interactions between animal welfare and the Goals, raised later in the report.

Figure 3: United Nations Sustainable Development Goals (UN, 2019).

Animal welfare

Defining animal welfare

Animal welfare is an encompassing term which can refer to the welfare of an animal itself, as well as the societal expectations of what level of welfare is acceptable. These distinctions are demonstrated in the definitions of animal welfare and animal welfare policy made by the OIE, the World Organisation for Animal Health (OIE, 2021a).

- **Animal welfare**: the physical and mental state of an animal in relation to the conditions in which it lives and dies; and
- **Animal welfare policy**: a complex, multifaceted, international and domestic public policy issue with scientific, ethical, economic, legal, religious and cultural dimensions plus important trade policy implications.

There are multiple ways in which animal welfare can be defined (Fisher, 2009), but in its simplest form, an animal which is 'fit and healthy' can generally be considered as being in a state of good welfare. Depending on an animal's ability to cope in its environment, the levels of welfare experienced can range from being very good to very poor (Lowe, 2020). When animals are subjected to difficulties or fail to cope within their environment, poor levels of welfare will be experienced (Broom, 1991). In situations where they are able to successfully cope with the conditions of their environment animals will experience higher levels of welfare (Broom, 1991).

The evolution of animal welfare

As illustrated in Figure 4, animal welfare has evolved significantly over the past five decades.

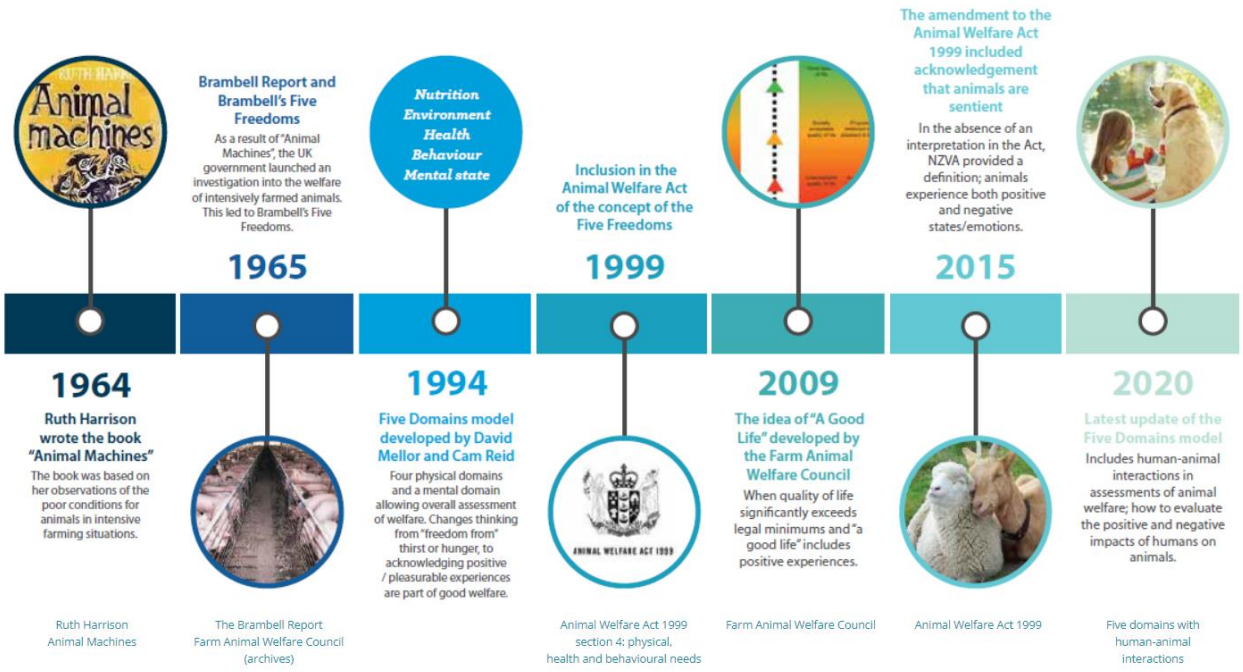

Figure 4: Evolution of animal welfare (NZVA, 2019).

The publication of Ruth Harrison's book Animal Machines in 1964 which depicted the horrors of intensive farming practices was a key part in the evolution of animal welfare. In response to public concern stemming from the publication of Animal Machines, the British government commissioned a technical committee to investigate farm animal welfare. Chaired by Professor Roger Brambell, in 1965 the committee produced the

Report of the Technical Committee to Inquire into the Welfare of Animals Kept under Intensive Livestock Husbandry Systems which would become known as Brambell's freedoms concluded that:

"An animal should have at least sufficient freedom of movement to be able without difficulty, to turn round, groom itself, get up, lie down and stretch its limbs" – Roger Brambell, 1965.

Brambell's freedoms were expanded on in 1979 by the Farm Animal Welfare Council (FAWC) who developed and formalised them into the concept of the Five Freedoms as we know them today (Elischer, 2019) (Figure 4). The concept of the Five Freedoms was developed to reflect the ideals of animal welfare (FAWC, 2013). Each of the five freedoms is comprised of two parts, i) the freedom and ii) the provision, with four of the five freedoms (freedoms 1-3, and freedom 5) denoting a freedom "from" and freedom 4 denoting a freedom "to" (Lowe, 2020). Freedoms denoting a freedom from, relate to the animal not being in the state or condition outlined in the freedom, with the freedom to, referring to the animal having the ability to express normal behaviour (McCulloch, 2013). The Five Freedoms highlight nine conditions, to enforce ideals whereby an animal should be free from, hunger, thirst, discomfort, pain, injury, disease, fear and stress and should be capable of expressing normal behaviours (McCulloch, 2013).

Figure 5. The Five Freedoms concept of animal welfare developed in 1979 (diagram adapted from the Five Freedoms as outlined by FAWC, 2009).

Today, the concept of the Five Freedoms is still widely recognised and acts as a framework which contributes towards the development of animal welfare legislation and codes of welfare. The OIE for example, bases its welfare standards in the Terrestrial codes on the Five Freedoms (OIE, 2021b). Many developed countries have also based their animal welfare legislation on the Five Freedoms, including Aotearoa's Animal Welfare Act

1999 (AWA). The AWA was a significant change from the previous legislation, the Animal Protection Act 1960 which prevented cruelty to animals but did not encourage a duty of care. Based on the Five Freedoms, the AWA requires owners and persons in charge of animals to provide for their animals' 'physical, health and behavioural needs' as defined in section 4 (Figure 6).

4 Definition of physical, health, and behavioural needs

In this Act, unless the context otherwise requires, the term **physical, health, and behavioural needs**, in relation to an animal, includes—

(a) proper and sufficient food:

(ab) proper and sufficient water:

(b) adequate shelter:

(c) opportunity to display normal patterns of behaviour:

(d) physical handling in a manner which minimises the likelihood of unreasonable or unnecessary pain or distress:

(e) protection from, and rapid diagnosis of, any significant injury or disease,—

being a need which, in each case, is appropriate to the species, environment, and circumstances of the animal.

Compare: 1960 No 30 s 3(b)

Section 4(a): replaced, on 10 May 2015, by section 7 of the Animal Welfare Amendment Act (No 2) 2015 (2015 No 49).

Section 4(ab): inserted, on 10 May 2015, by section 7 of the Animal Welfare Amendment Act (No 2) 2015 (2015 No 49).

Figure 6: Definition of physical, health and behavioural needs as outlined in the Animal Welfare Act 1999.

Since the development of the Five Freedoms, advances in animal welfare over the past three decades have led to the suggestion that instead of focussing on poor welfare and suffering, ideals which would act to ensure good welfare and prevent suffering should also be given consideration. To refine the Five Freedoms, the Five Domains Model was developed in 1994 to provide a structured and comprehensive framework for assessing an animal's quality of life (Mellor and Reid, 1994).

The purpose of the Five Domains Model is to provide a comprehensive and systematic means to assess both negative and positive welfare impacts. The first four domains (nutrition, environment, physical health and behaviour) collectively termed the physical/functional domains, consider positive and negative inputs provided to the animals, and the last domain (affective experience) considers positive and negative outcomes the animal might experience (Webster, 2016). Within the model, factors considered in the first four domains cause affective states which are assessed in the fifth domain (the affective experience domain) which relate to the animal's mental state (Webster, 2016) (Figure 7). The model is designed to support a structured and comprehensive approach to assessing animal welfare, focussing not only on factors which can compromise welfare, but additionally those which can ultimately improve welfare and enable animals to experience a good life.

Based on the Five Domains, an animal's level of welfare may be considered good when their nutritional, environmental, health, behavioural and mental needs are met; these needs can be met when animals are managed in such a manner as to enable the avoidance of negative mental states, whilst allowing and encouraging the promotion of positive mental states (Green and Mellor, 2011). The Five Domains Model is widely accepted and has been used extensively in order to assess the impacts of both current and proposed practices for managing and interacting with animals (Mellor, 2017).

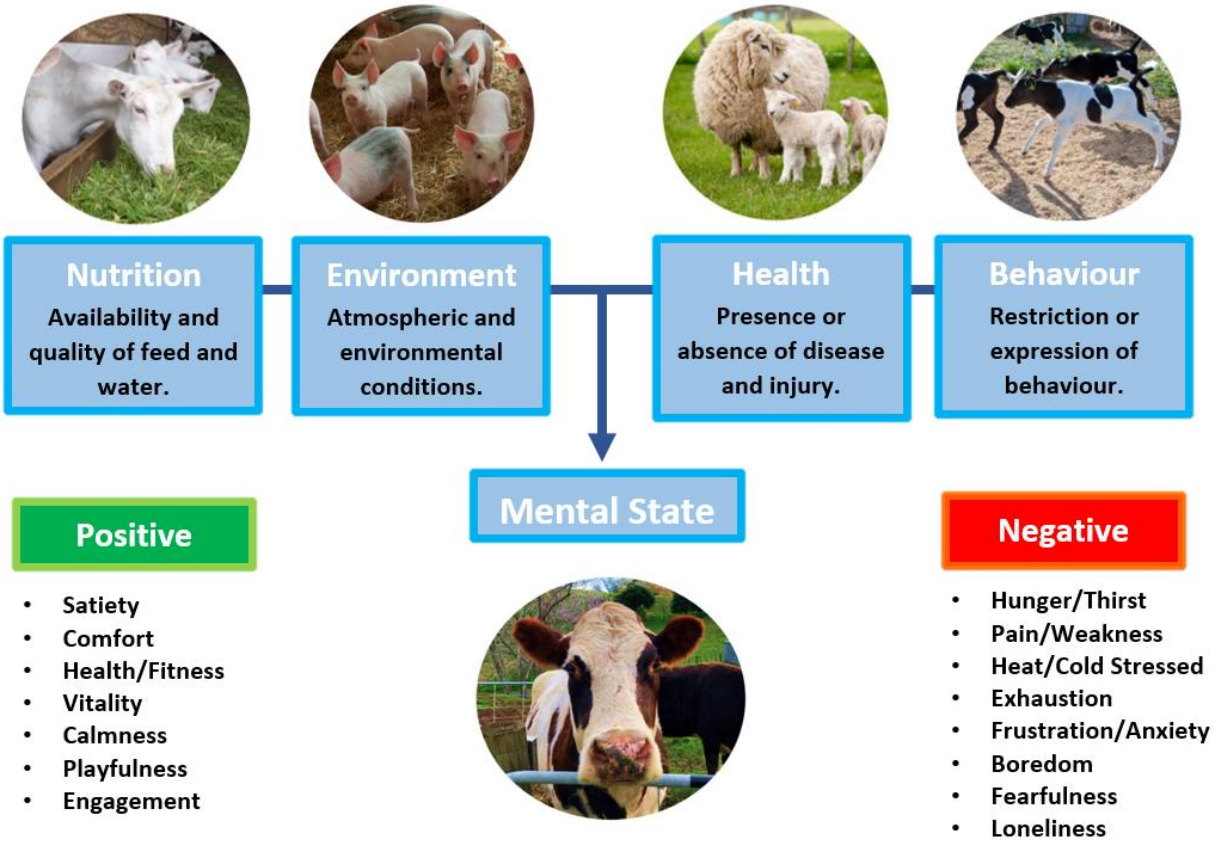

Figure 7. Five domains model of animal welfare (diagram adapted from Mellor, 2017).

In May 2015, the Animal Welfare Act 1999 was amended to allow for stronger standards, to improve transparency, and to broaden enforcement powers (MPI, 2022b). The 2015 amendment also saw animal sentience recognised explicitly in the AWA for the first time. The National Animal Welfare Advisory Committee (NAWAC) understands animal sentience to mean that "animals have emotions, feelings, perceptions, and experiences that matter to them. These experiences can be both negative (such as pain or boredom) and positive (such as pleasure or comfort)" (NAWAC, 2022).

An animal's level of welfare can be affected by two types of experiences: those which are critical to their survival, and those related to how they perceive their environment. Experiences which are critical for survival such as thirst, hunger, and pain motivate the animal to engage in particular behaviours, such as drinking and feeding, to correct imbalances in its internal state. Experiences which are critical to survival are generally negative because they signal to the animal that something is going wrong or soon will go wrong, and that actions such as drinking or feeding are required. A cold, hungry animal for example, will seek shelter and food, and having those needs met will reach a state of neutral welfare. The UK Farm Animal Welfare Council have classified quality of life for farm animals from a life not worth living, to a good life (FAWC, 2009) (Figure 8). By going beyond just minimising negative experiences and instead enabling animals to have positive experiences throughout their lives we can help to ensure that they experience a good quality of life.

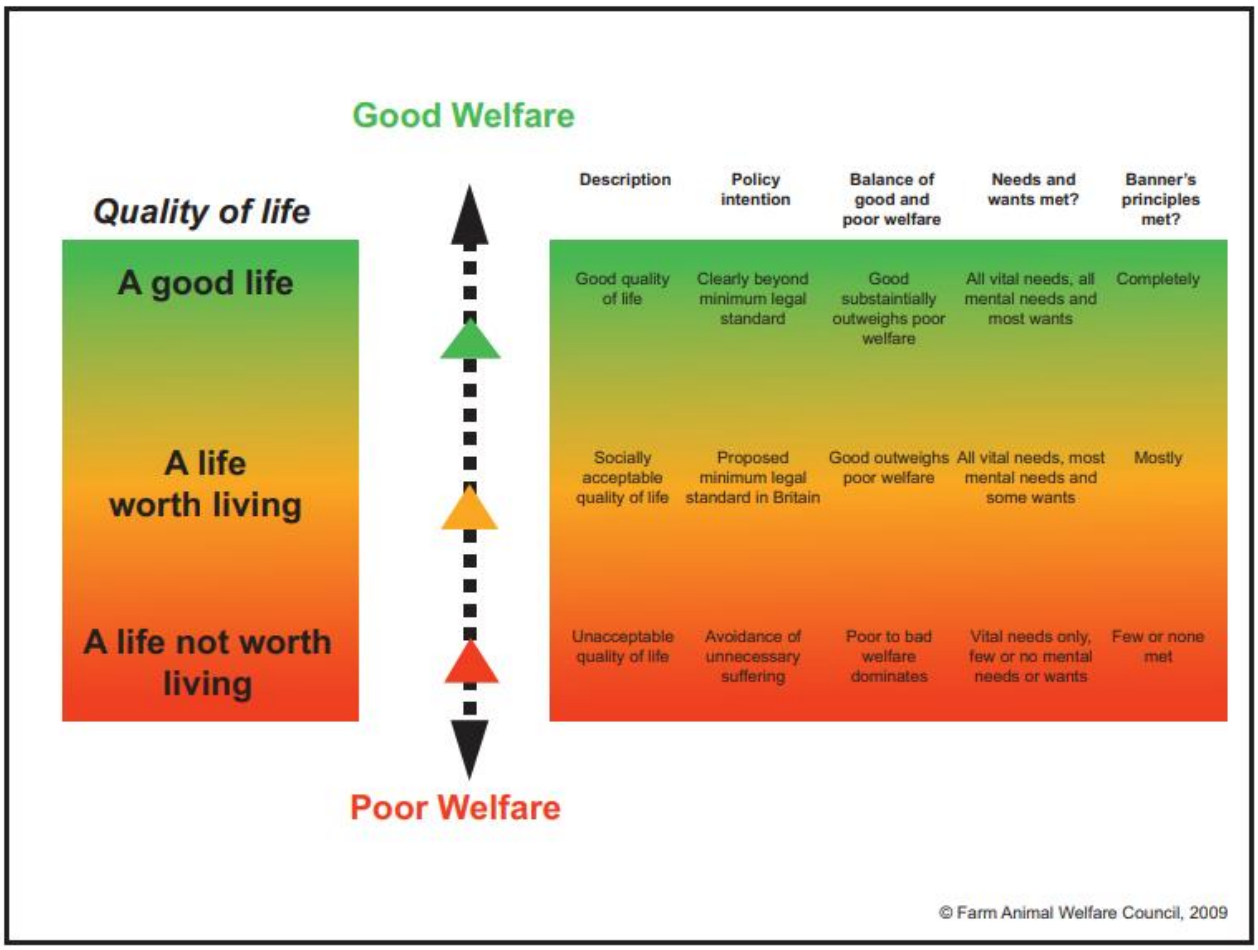

Figure 8: The concept of quality of a life for a farm animal (FAWC, 2009).

As our understanding of animal welfare and approaches to measure it have evolved, so too have ethical concerns for the treatment of animals (Bennett and Blaney, 2003; McEachern et al., 2007; Gremmen, 2020). Fraser et al (1997) offers three ethical paradigms by which the treatment of animals is considered (Figure 9). There has previously been a strong focus on the physical state of the animal, with the idea that "a healthy animal is a productive animal" (Rice et al., 2019). However, a practice that provides for the health of the animal, without providing for a positive mental state or allowing the animal to engage in natural behaviours, may still be deemed unacceptable by society.

As an example, layer hens kept in conventional ("battery") cages have high levels of egg production. They are kept at the appropriate temperature and receive sufficient food and water; however, they are unable to engage in highly motivated behaviours such as nesting, perching, scratching, ground pecking, and dustbathing (Layer Hens Code of Welfare 2018). Conventional cages are set to be phased out by 1 January 2023 in New Zealand, and in response to consumer demand major retailers have committed to selling only barn-raised and free-range eggs by 2027 (Nichol, 2017). To identify practices which will provide farm animals with acceptable levels of welfare, it is critical that all three paradigms are considered.

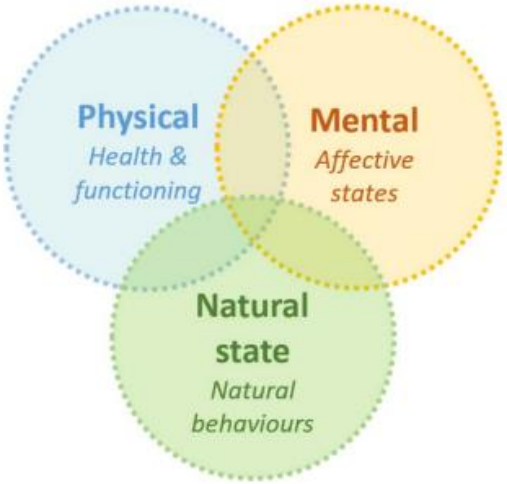

Figure 9: Three paradigms of animal welfare (adapted from Fraser, 2008).

Worldwide, public awareness regarding the treatment and wellbeing of animals continues to increase. The promotion of good levels of animal welfare is not only a moral obligation towards animals but is also essential in the sustainability of practices and the success of production systems which rely on animals (Broom, 2010; 2011). In relation to production animals, public awareness and perceptions around the ways in which animals are farmed are increasingly driving a demand for high quality products (Napolitano et al., 2010). This is partly due to the understanding that high quality products are acquired when high levels of animal welfare have been achieved (Lowe, 2020).

Consumer perceptions around animal products are based not only on the nature and safety of the end product, but also the welfare of the animals from which those products have been produced (Blokhuis et al., 2003). In addition, the occurrence of practices which are deemed detrimental to an animal's welfare can affect a producer's ability to operate (Hampton and Teh-White, 2019). Society continues to demand higher standards of animal welfare, and assurances that those standards are being met and these expectations span not only to production animals, but further to include those which we rely on for companionship, education, research and entertainment.

Animal welfare in Aotearoa

Animal welfare is vitally important to New Zealand for several reasons:

- It is important for the quality of life that animals experience;
- New Zealanders care about how animals are treated;
- Animals play an important role in many New Zealanders' lives: they offer food and fibre, income and companionship, education, research, and entertainment;
- The New Zealand economy is dependent on animals;
- International trade of animal products is a key part of our economy; and
- Animal welfare is a priority for many of New Zealand's trading partners, therefore New Zealand's reputation for high levels of animal welfare has helped achieve international market success.

Aotearoa is recognised as having high standards of animal welfare (World Animal Protection, 2014) based on the requirements set out in the AWA, regulations and codes of welfare. Measuring actual performance with these standards is more difficult with little published data on livestock welfare in Aotearoa. Interestingly, Williams et al. (2015) found that while farmers considered themselves as being knowledgeable of the animal welfare standards, and had a high level of self-reported compliance, many were unable to identify the physical, health and behavioural needs of the Act. However, when provided with the information, most felt they could achieve them. However, our understanding of welfare science has shifted from minimising negative experiences, to providing opportunities for animals to have positive experiences, taking into account sentience and affective state. Another report into animal welfare performance found enforcement of the AWA to be underfunded and called for extra resourcing to enable the Ministry for Primary Industries and RNZSPCA to carry out their compliance functions (Ferrere et al., 2019).

A large proportion of society is largely unaware of farming practices and instead simply trusts farmers to care for their livestock (Bolton, 2018). Farm practices that do not align with individual citizen's values – which are shaped by ethical, social, cultural, economic and religious values (Green and Mellor, 2011) – despite meeting the requirements of the Animal Welfare Act 1999, may not be acceptable in the future and may impact a producer's social licence to operate (Hampton and Teh-White, 2019).

Educating citizens to overcome the knowledge gap is unlikely to be successful (Weary & Von Keyserlingk, 2017). One Canadian study found that people whose values aligned with the natural state paradigm, had a more negative view of the sector after visiting a dairy farm and learning about cow-calf separation and zero-grazing practices. However, they were reassured about practices which fall under the physical domain such as sufficient food and water (Ventura et al., 2016).

When considering the impact of climate change and Green House Gas (GHG) mitigation policies on farm animal welfare, the sector must look beyond achieving merely neutral welfare by meeting the basic needs of animals. Instead, we must be aiming to offer opportunities for positive experiences and to provide farm animals with a good life.

Climate change

Agricultural greenhouse gas emissions

Global warming of 1.09°C has already caused widespread impacts globally (IPCC, 2022). This is due to greenhouse gas emissions from human activities, primarily from burning fossil fuels, but also methane and nitrous oxide from agriculture. Aotearoa New Zealand's total greenhouse gas emissions were equivalent to 82.3 million tonnes of carbon dioxide in 2019 (MFE, 2021). With biogenic methane and nitrous oxide converted into the equivalent of carbon dioxide, agriculture contributed to 48% of the gross emissions from NZ.

Taking a split-gas approach and separating short-lived gases like methane, agriculture accounts for 91% of biogenic methane emissions in Aotearoa, and 19% of other 'long-lived' gases like carbon dioxide and nitrous oxide, as shown in Figure 10. The split-gas approach takes into account methane's different properties i.e., it breaks down relatively quickly unlike carbon dioxide which remains for centuries unless actively removed. Methane emissions cannot be reduced completely to zero as they are closely linked to food production (Climate Change Commission, 2021), but must be decreased to meet the internationally agreed global warming target of below 2°C compared to pre-industrial levels (UNFCC, 2022).

Figure 10: The sources of gross long-lived greenhouse gases and biogenic methane in Aotearoa 2019 broken down by sector. For all agricultural biogenic methane emissions, 50% are attributed to the dairy industry, 48% to the sheep and beef industry and 2% to other industries (Climate Change Commission, 2021).

Farm planning guidance from He Waka Eke Noa (2021) focuses on three greenhouse gases:

- **Biogenic methane** (CH_4) – generated by ruminant livestock during digestion. A small amount also comes from effluent systems.
- **Nitrous oxide** (N_2O) – released from dung and urine patches, and nitrogen fertilisers.
- **Carbon dioxide** (CO_2) – can be sequestered by woody vegetation on-farm or released back into the atmosphere when vegetation is cleared. Soil may also sequester/emit carbon but currently this cannot be adequately modelled to count towards emission obligations.

Farm machinery with an internal combustion engine will also emit CO_2 however this is already captured by the Emissions Trading Scheme via fuel supply companies and is not a focus.

Measures to mitigate greenhouse gases on farm

The Farm Planning Guidance (He Waka Eke Noa, 2021) document outlines the various mitigation practices pastoral farmers can implement to reduce their GHG emissions, shown in Figure 11. One of the main drivers of enteric methane is total feed eaten which can be reduced through changes in stocking policy, improving animal health, improving pasture management, and converting low producing land to trees or high-value horticulture. Actions to limit methane emissions then revolve around improved farm management practices, more so than significant infrastructure investments.

Harrison et al. (2021) outlines additional GHG mitigations such as renewable and alternate energy sources and access to more accurate long-range and seasonal climate forecasts. Some of the mitigations discussed by Harrison et al. (2021) are relevant to developing countries and would be less applicable to Aotearoa's pastoral farming systems. However, the bulk of the mitigations analysed by Harrison et al. (2021) reflect the He Waka Eke Noa (2021) Farm Planning Guidance.

The agriculture industry will enter the Emissions Trading Scheme (ETS) in 2025 if the sector cannot design an alternative approach to price and reduce 2024 emissions, to be in place by 1 January 2025. Any pricing option chosen should be effective in reducing emissions, practical, scientifically robust, integrated with other sector activities, and equitable so that early adopters are recognised. He Waka Eke Noa consulted on a pricing option between January – March 2022 with farm-level and processor-level levy options proposed (He Waka Eke Noa, 2022). Regardless of the final structure of the pricing mechanism and the mitigation options included in the individual payment calculation, this will become a driver of on-farm change, and another factor which farmers will need to consider when making decisions about breeding, stocking policies and feed management. The decision-making processes around these, should include animal welfare as a consideration so that welfare outcomes are at least maintained, and preferably improved.

Opportunity	Greenhouse Gas	Potential Reduction
Improve the efficiency of pasture and crop production		
Minimise N-Surplus through reduced N-fertiliser use	N_2O	Med
Reduce N-Surplus through reduced use of supplementary feed	N_2O	Med
Use inhibitor coated N-fertilisers	N_2O	Med – Low
Improve crop husbandry	N_2O	Low
Optimise soil pH levels	N_2O	Low
Reduce total feed eaten		
Convert less productive land to indigenous or exotic trees	CH_4 N_2O	Med
Cull less productive stock early	CH_4, N_2O	Med – Low
Adjust stocking policy	CH_4, N_2O	Med – Low
Reduce stock losses and optimise replacement rates	CH_4, N_2O	Low
Increase animal performance through genetic selection	CH_4, N_2O	Low
Convert more productive land to high value crops	CH_4, N_2O	Low
Match feed demand with pasture growth and utilisation		
Reduce bought-in supplementary feed	CH_4, N_2O	Med
Use of lower protein forages	N_2O	Med – Low
Optimise pasture quality and production	CH_4	Low
Improve the management of livestock effluent		
Use captured effluent as a fertiliser	N_2O	Low
Capture and store carbon in vegetation		
Plant indigenous or exotic trees	CO_2	Med
Minimise periods of bare land	CO_2	Med

Figure 11: An overview of the currently available farm greenhouse gas reduction opportunities and potential reduction in emissions (He Waka Eke Noa, 2021).

In addition to the mitigation options presented in Figure 11 new technologies are in various stages of being explored, tested and commercialised (HWEN, 2021). Some of these are:

- **Breeding low-methane emitting livestock –** AgResearch has been working to identify low-methane emitting rams for the last decade. They have shown that after three generations the lowest-emitting sheep produce close to 13 per cent less methane than the highest emitters, per kilogram of feed consumed (AgResearch, 2021). The two major dairy breeding companies in NZ, LIC and CRV, have begun measuring the methane emissions from their yearling bulls. If successful, this work will lead to the development of a breeding value for methane emissions which could then be used for genetic selection and potentially incorporated into the Breeding Worth or other selection indexes (McNaughton, 2021). The benefits of using genetics to lower emissions is that it is permanent and cumulative.

- **Feed additives to reduce methane production –** 3-Nitrooxypropanol, marketed under the name Bovear, is a feed additive which suppresses the enzyme that triggers methane production (DSM, 2022). It has been registered for use in Brazil, Chile and very recently the European Union, where it can be added daily to a total mixed ration diet but is not yet approved for use in Aotearoa. Cattle eating a pasture-based diet without daily supplements will require a different method for Bovear to be administered.

- **Vaccination to inhibit methane production –** If it can be developed, a successful methane vaccine would trigger an animal's immune system to generate antibodies in saliva that reduce the function of methane-producing microbes in the rumen (NZAGRC, 2022).

- **Genetically modified plants –** Genetically modified high lipid ryegrass cultivars could reduce methane production and nitrous oxide (HWEN, 2021).

Impacts of climate change on animal welfare

While the focus of my report is around greenhouse gas mitigation and the intersection with animal welfare, the changing climate presents a risk to welfare. Impacts of climate change include extreme weather, heavy and more frequent rainfall and flooding, droughts, fire, changing seasons, and sea-level rise (IPCC, 2022). As well as threats, climate change will present opportunities in some regions, for example, previously colder regions may have increased dry matter production in spring (Vallee et al., 2021) which may benefit animal welfare.

The changing climate will impact animal welfare directly through extreme weather and indirectly through pests, diseases and feed availability. Effects of climate change on animal welfare include:

- Increasing **adverse weather events** will impact farm animal welfare both during the event and in the following recovery period: e.g., if pasture and supplementary feed are destroyed livestock will experience hunger.

- Increased **heat and cold stress** from hotter summers and colder winters, with regional variation.

- The changing climate will alter the **risk of disease** which affects animals. Vallee et al. (2021) have outlined several mechanisms of how this will occur such as:

    - Improved survival conditions for infectious agents outside the host e.g. Leptospirosis will survive in the soil longer;

    - Modified life cycle and a change in distribution of disease vectors: e.g., climate modelling shows the suitable habitat for ticks, which act as a vector for *Theileria,* will continue to spread south; and

    - Change in distribution of intermediate hosts: e.g., the risk of liver fluke infection is predicted to increase by 29-186% by 2090 (depending on region) based on a change in lymnaeid snail distribution linked with wet environments and a change in grazing habits of livestock in drier environments.

Vallee et al. (2021) undertook an analysis of farm animal disease, and through multiple criteria decision analysis, ranked the diseases most important for climate change preparedness. The top five are: facial eczema, mastitis, Haemonchosis (internal parasite disease), leptospirosis, and salmonellosis.

Adaptation to the direct and indirect impacts of climate change must be integrated with the mitigation options in Figure 11 to optimise animal welfare outcomes. The actions to adapt and mitigate sit within the broader context of sustainability, meaning they must be economically, environmentally, and socially acceptable also. Due to the regional variation of weather impacts and animal disease modelling, adverse event planning and resilience will need to be considered at an individual farm level, dependant on the stock classes and farming operation.

Interactions between agricultural GHG mitigation and animal welfare

At a broad level, the on-farm changes required to reduce greenhouse gases (and adapt to climate change) will have direct and indirect impacts on the care and management of livestock, and the welfare outcomes achieved. This can be as simple as reducing the number of livestock and therefore the number of animals which may experience illness, injury, or distress. However, there are likely to be more indirect, or unintended consequences: i.e., increased spending on effluent management to reduce methane may result in a small reduction in animal health spend to remain profitable. Because of the complexity one animal welfare impact - heat stress - was chosen to assess the potential for negative and positive outcomes due to greenhouse gas mitigation strategies.

The impact of heat stress on animal welfare

Aotearoa's pastoral farming system is largely beneficial for animals' welfare, as they can perform normal behaviours like grazing and social grooming, with a lower disease prevalence than indoor systems which are more prominent overseas. The downside of keeping animals' outdoors is when the weather is too cold, too hot or too wet it can negatively impact their welfare. The Animal Welfare Act 1999 requires farmers to care for their livestock's physical, health and behavioural needs, including the provision of adequate shelter. More detail is contained in the three pastoral species Codes of Welfare – Dairy cattle, Sheep and Beef Cattle, and Deer – which set out minimum standards of care under the Act (see www.mpi.govt.nz/welfarecodes).

Heat stress occurs when the environmental temperature surpasses the upper limit of an animal's thermoneutral zone. The occurrence of thermal stress in an individual animal depends on a multitude of environmental factors including temperature, humidity, wind speed, solar radiation, precipitation, ground surface conditions, as well as animal factors (species, breed, sex, age, metabolic state, coat or fleece cover, acclimatisation, nutrition and hydration, disease, and individual variability) (Fisher, 2007). Physiological responses to dissipate heat and reduce heat production then occur, to maintain the body temperature within the thermoneutral zone (Sailo and Das, 2016; Fisher, 2020). Behavioural responses to reduce heat load include seeking shade, panting and decreased dry matter intake.

The impacts of heat stress on dairy cattle are well studied, with heat stress recognised as one of the main challenges affecting cattle in pasture-based systems because of the environmental variability to which they are exposed (Deniz et al., 2021) and high metabolic load from milk production. From searching through the literature, it is apparent that compared to dairy cattle there is less information about the impacts of heat stress on beef cattle, sheep and deer, particularly in a pasture-based context. A lot of the information below applies to dairy cattle, however the common physiology between ruminants indicates some of the same impacts will apply, to a greater or lesser extent across species.

Animals experiencing heat stress will have an increased respiration rate and heart rate, and reduced dry matter intake (Herbut et al., 2019). They will drink more water if given free access to troughs. Dairy cattle are highly motivated to seek shade and will increase the time spent under shade as environmental temperatures increase (Tucker et al., 2008). Dairy cattle may have a compromised affective state, as heat stress potentially induces feelings of hunger, thirst, frustration, aggression and malaise (Polsky and von Keyserlingk, 2017). The

key impacts of heat stress on biological functioning and health, natural living and affective state are shown in Figure 12 (Polsky and von Keyserlingk, 2017).

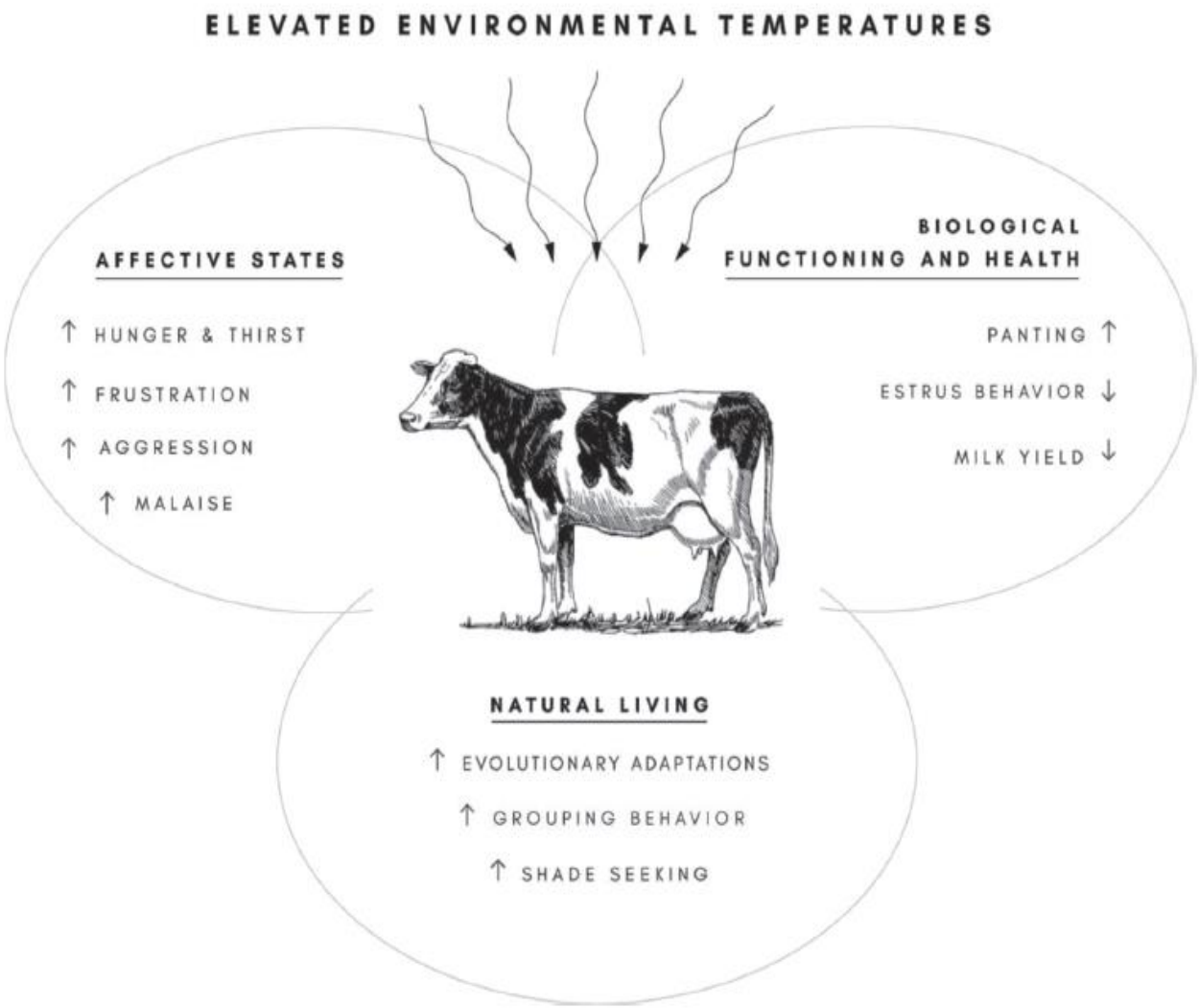

Figure 12: The relationship between the immediate effects of heat stress and the three key constructs of animal welfare: physical health and function, affective state and natural behaviours (Polsky and von Keyserlingk, 2017).

These physiological and behavioural responses result in decreased milk production in lactating cattle, a negative impact on reproduction as hormonal responses are altered, and animals may be more susceptible to health issues due to nutritional and metabolic changes (Sailo and Das, 2016).

An animal's genotype is a major factor which influences their susceptibility or tolerance to heat stress. (Hoffman, 2010). However, selection for heat tolerance may impact negatively on production (Rhoads et al., 2013; Moore and Ghahramani, 2013). As well as breeding for heat tolerance, other mitigation options include environmental modifications such as shade, sprinklers and fans, modifying feed quality and quantity, and off-paddock solutions.

Greenhouse gas mitigations and correlation with heat stress

To identify whether the options to reduce greenhouse gas emissions on-farm will have a negative or positive impact on welfare issues caused by heat stress, this table was constructed showing each mitigation option and the expected impact. At a high-level, a reduction in greenhouse gases will help slow the rate of the warming climate and indirectly reduce the heat load on animals.

Table 1: Mitigation options to reduce GHG emissions on-farm and the potential impact on welfare issues caused by heat stress

Greenhouse gas mitigations Adapted from HWEN (2021) and Harrison et al (2021)	**GHG**	**Impact on heat stress** • **Yes** • **Potentially** • **No**	**Potential <u>negative</u> impact on welfare issues caused by heat stress**	**Potential <u>positive</u> impact on welfare issues caused by heat stress**
Current options				
Improved pasture and crop production / efficiency				
Minimise nitrogen surplus through reduced use of N fertiliser and/or supplementary feed	N_2O	Potentially, through impact on feed quality and quantity.	Feed quality and quantity impacts heat stress. Poorer quality, fibrous feed will generate more heat in the rumen.	Feed quality and quantity impacts heat stress – less, high-quality feed will generate less heat in the rumen.
Manage pasture and crop husbandry to optimise production	N_2O	Potentially, through impact on feed quality and quantity.		Feed quality and quantity impacts heat stress – less, high-quality feed will generate less heat in the rumen.
Optimise the use of lime	N_2O CO_2	No.		
Reduce total feed eaten on farm				
Identify and cull less productive stock early	CH_4 N_2O	Potentially, dependant on the environmental temperature when culling.	Animals culled during hot weather may suffer heat stress during transport (Stewart et al.,2010).	Unproductive animals culled early in the season (spring/early summer) will not be exposed to environmental conditions that cause heat stress on farm.
Reduce livestock wastage rates	CH_4 N_2O	Potential.		Better pregnancy rates and fewer deaths could allow for faster inclusion of heat tolerant genetics in the herd (i.e. heat shock proteins, 'slick' gene).
Adjust livestock class / ratio within the farm system to reduce feed eaten	CH_4 N_2O	Potential.		Compared to NZ Jersey cattle, NZ Holstein Friesian are more sensitive to impacts of heat (Bryant et al., 2007). A change in breed-type can increase heat tolerance.
Genetic selection to increase animal performance and	CH_4 N_2O	Yes.	One study found the genetic correlation between milk production and heat tolerance was -0.3 in dairy cattle. This implies a decrease in heat	

decrease livestock maintenance			tolerance will result if genetic selection is weighted to production (Gauly et al., 2013).	
Manage animal health	CH_4 N_2O	Yes.		Healthy animals cope better with environmental challenges.
Retire less productive land from grazing	CH_4 N_2O	Potentially	Less shade available for livestock if the land that is retired previously provided access to trees.	
High value land use change / fewer livestock	CH_4 N_2O	Potentially	Less shade available for livestock if the land that is converted previously provided access to trees.	If regional climate has more days above acceptable THI, reducing livestock will be positive. Fewer livestock can access more shade.
Milking cows less frequently (assuming corresponding decrease in dry matter eaten)	CH_4	Yes.		Fewer walks to the shed will generate less metabolic heat.
Match feed demand with pasture growth and utilisation				
Optimise pasture quality and production to better meet feed demand	CH_4 N_2O	Yes.		Feed quality and quantity impacts heat stress – less, high-quality feed will generate less heat in the rumen.
Optimise supplementary feed inputs to better meet feed demand	CH_4 N_2O	Potentially, dependant on supplements.	Feed quality and quantity impacts heat stress. Poorer quality, fibrous feed will generate more heat in the rumen.	Feed quality and quantity impacts heat stress – less, high-quality feed will generate less heat in the rumen.
Use of alternative forages to reduce protein in the diet	N_2O CH_4	Potential. Impacts of different feed types and rate of inclusion in diet may affect heat load.	The quality and quantity of protein in the diet needs to be considered when feeding heat stressed cows. Overfeeding of protein should be avoided (Sailo and Das, 2016).	High fat supplements (e.g. soybeans) may reduce heat stress and maintain milk production in hot weather (Sailo and Das, 2016).
Capture and store carbon in vegetation				
Converting less productive land into indigenous vegetation	CO_2	Potentially, depending on plant selection and stock access.		If livestock have more shade available to access this will reduce heat load and improve affective state.
Converting less productive land into exotic forest	CO_2	Potentially, depending on plant selection and stock access.		If livestock have more shade available to access this will reduce heat load and improve affective state.
Establishing wetland forests	CO_2	No. Assuming this area is fenced off.		
Planting riparian setbacks	CO_2	No. Assuming this area is fenced off.		
Planting erosion control trees	CO_2	Potentially, depending on plant selection and stock access.		If livestock have more shade available to access this will reduce heat load and improve affective state.

Planting trees for animal welfare and pasture protection	CO_2	Yes.		Increased access to shade will allow livestock to reduce heat load. Access to insufficient shade may increase aggressive interactions between animals.
Fencing and pest control for indigenous forest	CO_2	No.		
Capture and store carbon in soils				
Increase the different types of plant species in pasture swards	CO_2	Potential. Quality and nutritional profile of feeds may impact metabolism and therefore heat load.		Feeding regimen could be altered to enhance animal's ability to cope with metabolic and climatic heat load during summer (Sailo and Das, 2016).
Future options				
Breeding low-methane emitting livestock	CH_4	Potentially negative.	Genetic correlation between methane emissions and heat tolerance unclear. Selecting low-methane emitting livestock will slow genetic selection for heat tolerance.	
Feed additives to reduce methane production	CH_4	Not known at this stage.		
Vaccination to inhibit methane production	CH_4	Cannot be quantified as the vaccine does not yet exist, but welfare impacts should be considered as it is developed.		
Genetically modified plants - Lipids - Tannins	CH_4 N_2O		Feeding excessive tannins impacts on animal performance and induces metabolic disorders (Jerónimo et al., 2016).	

While this report has attempted to show the impact of GHG mitigation on heat stress, there are possibly interactions that go the other way. As an example, increased milk production per animal lowers emission intensity per kg milk solid. However, heat stress tolerance and milk production are genetically negatively correlated. Selecting for a more heat tolerant breed could reduce emission efficiency as production increase, though the impact of heat stress which reduces production also needs to be factored in. These are complex interactions, which are incomplete without also fully considering adaptation, economics, or the other social values (i.e., community, labour).

Greenhouse gas mitigation and animal welfare impacts across the supply chain

Animal welfare risks and opportunities that span across the supply chain and/or across the different sectors, become even more difficult to analyse in relation to climate change. Briefly, approximately 5 million dairy calves are born in Aotearoa every year, of which roughly 25% will be raised as replacement heifers for the dairy herd. The non-replacement calves may be reared for beef, breeding or home kill, sent for slaughter, or die due to calving difficulties/ illness. The fate of non-replacement calves fluctuates yearly based on several factors including weather events, relative dairy and beef prices, and whether the relevant industry is experiencing growth or contraction (MPI, 2017).

To reduce the number of non-replacement calves sent for slaughter ("bobby calves") many would instead be reared for beef, displacing other livestock, notably the traditional beef breeding herd. Reducing beef cows and rearing dairy beef calves in their place will reduce methane emissions calculated behind the farm gate due to the reduction in beef dams. But when carbon emissions across the supply chain are included it becomes less obvious. Calf rearers use milk powder which has already required energy, to harvest, transport, process and distribute back to farms (von Keyserlingk et al., 2013) (Figure 13). There is also a welfare equation that could be considered. Beef cows which rear their calf for six months can engage in maternal behaviours. Replacing these with non-replacement calves from the dairy sector which are removed from their dams at an early age, reduces the total number of animals able to express and enjoy maternal behaviours.

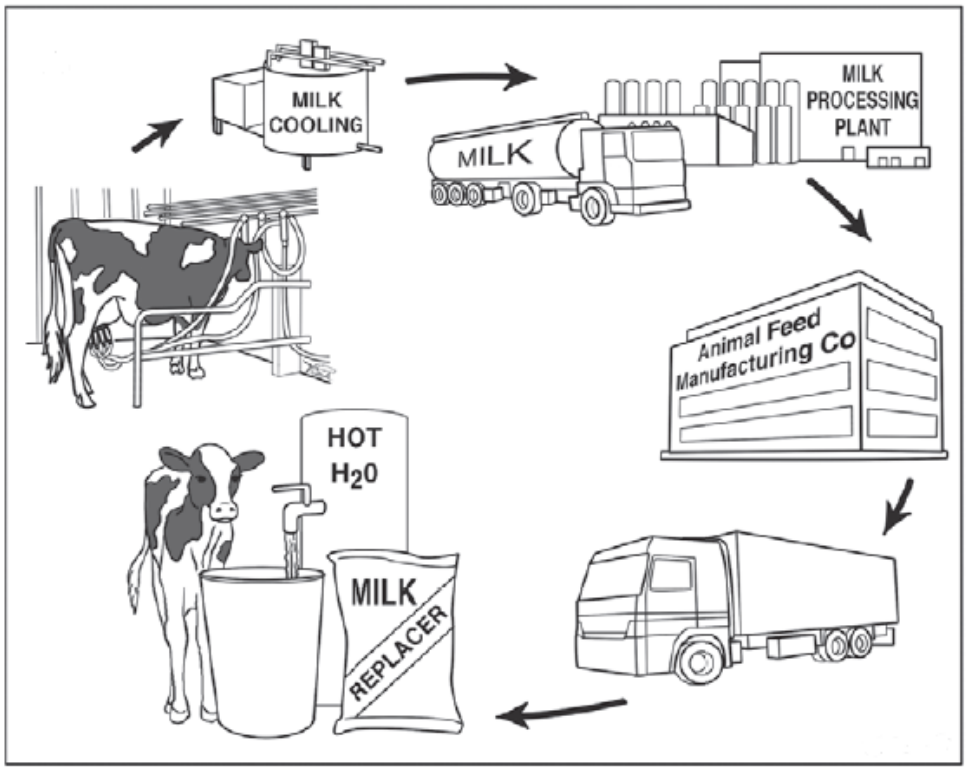

Figure 13: An illustration of the energy costs associated with using milk powder to rear calves (von Keyserlingk et al., 2013).

Discussion

How we think about animal welfare is changing as new research helps us better understand animal needs and wants, as are societal expectations as we become more removed from agriculture. For most of the population living in urban centres, animal interactions are limited to companion animals with which we have a very different relationship in comparison to farmer relationships with farm animals. Farmers looking to make changes to their operations should consider opportunities to improve animal welfare through all three paradigms of physical health, affective state, and natural behaviours. Meeting the basic survival needs of livestock to reach a level of neutral welfare may not meet societal expectations.

To maintain our reputation as a producer of high-quality products and succeed in international markets, Aotearoa's livestock sectors must reduce greenhouse gas emissions. The Primary Sector Climate Action Partnership, He Waka Eke Noa, is supporting farmers to calculate and reduce their emissions. When landowners must begin paying for a portion of their emissions from 2025, either through the Emissions Trading Scheme (ETS) or one of the alternative sector-designed models proposed by He Waka Eke Noa, this is expected to help to increase the speed of on-farm changes to reduce GHG.

Work by OIE members highlighted the complex interactions between animal welfare and the Sustainable Development Goals and found that improving sustainability can improve animal welfare outcomes for certain Goals. However, the linkages between welfare and the SDGs are moderated through human choices and behaviours, and there is still potential for negative impacts on animal welfare depending on the decisions made. They concluded that there is a need to consider animal welfare in the context of policy and planning under each SDG (Keeling and Stuardo, 2021).

Narrowing the scope of this report to the mitigation of agricultural GHG and the potential for positive and negative impacts on animal welfare in relation to heat stress echoed the OIE's finding. My analysis found that there are few straightforward impacts, with many potential links dependants on the stock class, farm system, regional climatic impacts and how the mitigations are implemented on-farm.

Some of these links include:

- The planting of trees for carbon sequestration will allow animals to mitigate the impacts of heat stress, if they are able to access the shade without undue competition
- Achieving good animal health gives efficiency and productivity gains, and therefore a reduction in enteric methane emitted, with animal health being a key component of good welfare
- The use of different pasture species and better utilisation of feed could affect heat stress negatively or positively. The effect of nutrition on heat stress is complex, and varies due to feed quality, quantity and the levels of macronutrients.

Moving from two variables (GHG vs. heat stress) to cross-sector, multivariable issues which span across the supply-chain from farm to processor to consumer, makes the impacts on animal welfare through greenhouse gas policies even more complex.

Conclusion

Like many other businesses, farming is undergoing significant change in response to a dynamic and complex world. High standards of animal welfare are one of several key requirements farmers will have to meet as Aotearoa New Zealand and the world continue to develop more sustainable food systems. While farmers will continue to consider animal welfare into the future, they must do so while balancing myriad other interests and demands.

The aim of this report was to explore whether there are opportunities to improve animal welfare through climate change action. Using heat stress as an example several areas where greenhouse gas mitigation could improve animal welfare outcomes have been identified. There were more areas where the complex interactions of biological systems, could lead to an improvement for animals, but without careful evaluation of the risks and benefits it may also negatively impact the welfare of livestock. In the short term (this decade), achieving best practice on-farm and making changes within the existing system, will contribute to climate adaptation and greenhouse gas mitigation, through incremental improvement (Cradock-Henry et al., 2019). In the longer term, more significant changes may be required as environmental conditions no longer support some farm systems to operate profitability.

As farmers make short-term changes and consider their long-term options in response to climate change and the need to reduce emissions, animal welfare must be explicitly considered as part of the decision making. The current sector advice to support farmers does not make these linkages obvious. Ultimately animal welfare impacts will need to be evaluated at an individual farm level, dependant on the farm, livestock, regional climate, business goals and the values of the decision maker.

Recommendations

1. **Increase the understanding of animal welfare based on the Five Domains Model** – the Animal Welfare Act 1999 is based on the Five Freedoms and the requirement to meet animals physical, health and behavioural needs to achieve a state of 'neutral' welfare. While this is our legal framework and outlines what animal owners and persons in charge must do, changes to farming practice, especially significant ones which must be sustainable in the long-term to be profitable, should aim to give livestock a 'good life'. To achieve a shared understanding of animal welfare, the industry good organisations and Ministry for Primary Industries (which "leads and facilitates the management of animal welfare policy and practice in New Zealand") should develop information for livestock owners and other parties in the supply chain, i.e., transporters, stock agents. This should be incorporated into environmental resources when changes on-farm may impact animal welfare.

2. **Consider the impacts on animal welfare as part of climate change advice** – the industry good organisations and He Waka Eke Noa are working to support farmers through a time of significant change, particularly regarding environmental regulations. As animals are at the centre of our livestock industry, the impacts on animal welfare should be explicitly considered. While the intersection of climate change and animal welfare is complex and not all outcomes can be foreseen, it should be a key criterion when assessing the viability of an emission reduction option. This approach should be incorporated into advice and resources from He Waka Eke Noa, industry good organisations and government.

3. **Farmers should actively seek information about animal welfare impacts** – No two farms are the same and animal welfare impacts from climate change mitigation (and adaptation) will need to be evaluated at an individual farm level. This will require the farmer / decision maker to actively seek advice from other farmers who have made similar changes, farm consultants, veterinarians, and other rural professionals. The understanding of animal welfare amongst these professionals was outside of the scope of my report, and it may be primary industry advisory services will also need advice to support their clients make environmental improvements and maintain or improve animal welfare.

Animals are both at the centre of pastoral farming and the centre of animal welfare. It is essential that farm animal welfare be explicitly considered not only alongside climate change, but across all aspects of farming systems.

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