How can Animal Health positively impact our Climate Change Targets?

Research project for:

Author: Lance Woods

2022 Nuffield Scholar

Sponsored by:

FBD Trust, IFA, The Irish Farmers' Journal, The Golden Jubilee Trust, Aurivo Co-Op, Glanbia, Bord Iascaigh Mhara, Dairymaster, LIC, MSD Animal Health, Dairygold Co-op & Kerry Agribusiness.

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Scholar Contact Details:

Name: Lance Woods

Phone: +353-87-1085541

LinkedIn: https://www.linkedin.com/in/lancejwoods/

In submitting this report, the Scholar has agreed to Nuffield Ireland publishing this material in its edited form.

Nuffield Ireland Contact Details:

Executive Secretary Nuffield Ireland: Catherine Lascurettes

Phone: +353-87- 2691197

Email: exec@nuffield.ie

2.0. EXECUTIVE SUMMARY

Animal Health plays an integral part in animal food production. Continuous developments in efficient management practices, animal health preventative strategies, animal health agricultural technologies and biopharma solutions have brought a lot of positive benefits to animal food production. However, as the demands for food increase due to an increasing global population, so too do the expectations of animal food production. This puts more stress on the animals that are producing our food, consequently, impacting the environment.

Globally, agriculture is undergoing seismic disruptions arising from the competing challenges of food security, the environment, and societal needs. There is a growing concern over the impact of animal food production on the causes to climate change, most notably methane emissions. Fortunately, the solutions to these challenges are emerging from a parallel revolution in smart and precision agriculture.

The science is indisputable, and the effects of climate change are already clear. Extreme weather events are becoming more frequent with devastating consequences. Climate change is here and is already impacting our world, with risks to global security including food supplies. Ireland is also at risk of more frequent storms and flooding.

The way by which animal health affects emissions intensity is through reduced production efficiency and what is referred to as "unproductive emissions" related to mortality and morbidity. Morbidity causing the reduction in production efficiency, diminishes the growth rate and live weight of animals and leads to lower efficiency in feed utilisation, as well as lower reproductive performance and milk yields (FAO and NZAGRC, 2017a).

Global leaders made landmark agreements in 2021 at COP 26. 103 countries, including 15 major emitters, signed up to the Global Methane Pledge, which aims to limit methane emissions by 30 per cent by 2030, compared to 2020 levels. Methane, one of the most potent greenhouse gases, is responsible for a third of current warming from human activities. In Ireland the Climate Action plan was published to tackle GHG emissions and to comply with our international obligations. The plan focuses on targets of all sectors including agriculture. Whilst Ireland is on track to achieve its 2020 target (20% below 2005 levels) by the purchase of emission credits, the target for 2030 (30% below 2005) will be challenging and will require cuts in carbon emissions from food production. Ireland has committed to a 25% cut in greenhouse gas emissions from agriculture by 2030.

In order to achieve the climate action targets the whole of agriculture will need to respond and diversify. Whilst challenging, it will present opportunities to farmers to increase farm profitability and improve the environmental sustainability of their farms through adopting most efficient practice.

My research project investigates how Animal Health can help us achieve our climate action and sustainability goals. In brief my primary objectives were as follows:

- How do we reduce emissions through Animal Health and how to change behaviour/habits/mindset at farm level- what motivates this change?
- To investigate efficient farming relating to animal health practices, preventative animal health strategies, animal health agricultural technology and prevention at source.

My travels enabled me to discover what agriculture is implementing concerning animal health globally to reduce emissions. I gathered and collated information from academia, researchers, farmers, veterinary practitioners, and leaders in their respective fields. This report has been developed from these interviews, visits, and demonstrations.

I'm positive my findings and recommendations will have a positive impact for Irish, and indeed global agriculture.

Animal Health will play an integral role in successfully achieving our climate change targets.

The objective of this report is to develop a broader understanding of the relationship,

between animal health and emissions.

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4.0. ABBREVIATIONS:

AI	Artificial Insemination
AHI	Animal Health Ireland
AHN	Animal Health and Greenhouse Gas Emissions Intensity Network
BCW	Behaviour Change Wheel
BVD	Bovine Viral Diarrhoea
CIEL	Centre for Innovation Excellence in Livestock
COM-B	Capability, Opportunity, Motivation and Behaviour
COP	Conference of the Parties
DAFM	Department of Agriculture, Food and the Marine
DBI	Dairy Beef Index
DEFRA	Defra - Department for Environment Food and Rural Affairs
EBI	Economic Breeding Index
ECM	Energy Corrected Milk
EFSA	European Food Safety Authority
EPA	Environment Protection Agency
EU	European Union
FAO	Food and Agriculture Organization
GHG	Greenhouse Gases
GHGE	Greenhouse Gas Emissions
GRA	Global Research Alliance
ICBF	Irish Cattle Breeding Federation
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
NZAGRC	New Zealand Agricultural Greenhouse Gas Research Centre
PTAs	Predicted Transmitting Ability Figures
SCC	Somatic Cell Count
SRUC	Scotland's Rural College
TMR	Total Mixed Ration
UN	United Nations
UNFAO	United Nations Food and Agriculture Organisation
WUR	Wageningen University and Research
ZELP	Zero Emissions Livestock Project
3 NOP	3-Nitrooxypropanol

5.0. PERSONAL INTRODUCTION:

I have incredibly fond memories of a childhood immersed in Agriculture where I developed a passion for farming and animals. It laid the foundations for a career in Agriculture. I qualified with an honour's Agricultural Science degree from UCD, specialising in Animal Science, graduating in 2007.

I joined Keenan System (now Alltech) on graduating from UCD and obtained a very positive first full-time professional working experience both in Ireland and New Zealand.

I began working in the Animal Health Industry in 2011, in which I have held various roles. I am currently Ruminant Marketing Manager Ireland and Northern Ireland for MSD Animal Health.

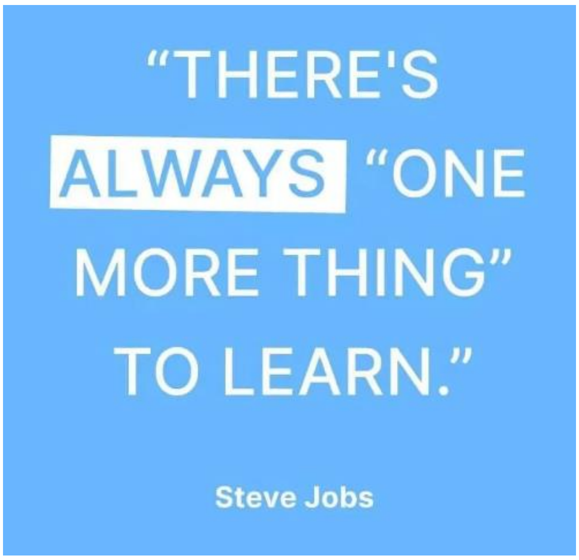
I obtained my NOAH (National Office of Animal Health) Certificate in Animal Health from Harper Adams in the UK in 2015. The NOAH Certificate of Animal health (NCAH) qualification helps ensure that animal medicines representatives can provide accurate and ethical information to prescribers and sellers of animal medicines in compliance with the NOAH Code of Practice for the Promotion of Animal Medicines. I graduated with an Executive Master's in Business Administration (MBA) from DCU in 2018. Whilst completing my MBA was particularly challenging given a young family at home and working full time, I still thoroughly enjoyed the experience.

Throughout my adult life I have had a continuous learning mindset.

"It's not what you know, it's what you understand". Charles Dowding, No dig Gardener.

Completing a Nuffield Scholarship has been one of my most fulfilling experiences to date.

And so, the journey continues…..



6.0. ACKNOWLEDGEMENTS

To my wife, Grace, for her constant encouragement and support throughout not only my Nuffield journey but life in general. My three children, Eli 6, Isaac 5 and Tilly 2 who had no Daddy for long periods throughout the last two years- you have my word, I'll make it up to you. Being away has made me appreciate them so much more. I've also come to appreciate just how important my family is in my life.

To my extended family who understand bedtime with three young kids can be crazy- thank you for all your help in that hectic hour.

To my parents who have constantly pushed me to obtain my full potential- thank you for always being there.

To Nuffield Ireland for this incredible opportunity.

To my employers MSD Animal Health who been incredibly supportive and encouraging throughout.

To the people who have inspired me along the way, there's too many to mention.

I want to express my appreciation to my fellow scholars, Aoife, Pat, and David; it has been a joy getting to know you throughout this experience.

And to the people who have challenged me and encouraged me to understand a different point of view or perspective - thank you.

Last but my no means least, thank you to the scientists, innovators and researchers who are dedicating their life to making our planet a better place by reducing emissions.

7.0. BACKGROUND TO RESEARCH PROJECT

7.1. Climate Change

Climate change refers to significant changes in global temperatures and weather patterns over time. While climate change is a natural phenomenon, recent scientific evidence indicates that human activities, particularly the burning of fossil fuels, deforestation, and industrial processes, are driving an unprecedented acceleration of these changes since the late 19th century.

Key Aspects of Climate Change

Greenhouse Gas Emissions

- Human activities release large amounts of greenhouse gases (GHGs) such as carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) into the atmosphere. These gases trap heat, leading to the greenhouse effect, which warms the Earth's surface. According to the Intergovernmental Panel on Climate Change (IPCC), CO_2 levels have increased from about 280 parts per million (ppm) in pre-industrial times to over 410 ppm as of 2020.

Global Warming

- Global temperatures have risen by approximately 1.2 degrees Celsius since the late 19th century, with significant regional variations. This warming is leading to more frequent and severe heatwaves, droughts, and heavy rainfall.

Impacts on Weather Patterns

- Climate change influences patterns of precipitation, resulting in wetter conditions in some areas and drought in others. The increased frequency of extreme weather events (e.g., hurricanes, floods, wildfires) is closely tied to climate change.

Melting Ice and Sea-Level Rise

- The polar ice caps and glaciers are melting at an increasing rate, contributing to rising sea levels, which threaten coastal communities and ecosystems. According to the IPCC, global sea levels have risen by about 8-9 inches (21-24 cm) since 1880, with projections of continued rise in the coming decades.

Ecological Impact

- Climate change poses a threat to biodiversity and ecosystems. Many species are at risk of extinction as their habitats change or disappear. Coral reefs, for example, are highly vulnerable to rising ocean temperatures and acidification.

Socioeconomic Consequences

- The effects of climate change can exacerbate existing social, economic, and health disparities. Communities reliant on agriculture or natural resources are particularly vulnerable, and climate-related disasters can lead to displacement and migration.

Mitigation and Adaptation

Efforts to address climate change focus on both mitigation (reducing GHG emissions) and adaptation (preparing for the impacts of climate change). Some strategies include:

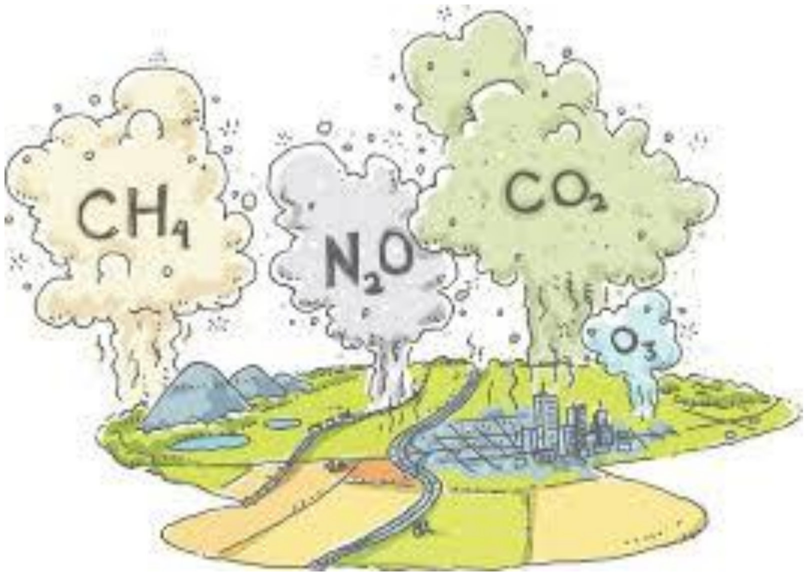
- **Transitioning to Renewable Energy**: Shifting away from fossil fuels to renewable energy sources such as solar, wind, and hydroelectric power.
- **Enhancing Energy Efficiency**: Improving energy efficiency in buildings, transportation, and industries to reduce overall energy consumption.
- **Reforestation and Conservation**: Protecting and restoring forests to enhance carbon sequestration and biodiversity.
- **Policy Frameworks**: Implementing international agreements like the Paris Agreement, which aims to limit global warming to below 2 degrees Celsius compared to pre-industrial levels.

Climate change is one of the most significant challenges facing humanity today, with far-reaching implications for the environment, economies, and societies around the world. Addressing this crisis requires a coordinated effort from governments, businesses, and individuals to reduce emissions and adapt to changes that are already underway.

Climate change is challenging for Irish agriculture both in the context of the need to reduce greenhouse gas emissions and the need for adaptation of farming practices to be more resilient to the impacts of climate change.

Animal agriculture is a pillar of the global food system - meat, dairy and eggs provide 18% of the world's calories and 39% of protein, alongside important micronutrients for development. (FAO, Shaping the future of livestock sustainably, responsibly, efficiently, 2018).

7.2. Greenhouse Gases in Irish Agriculture



Greenhouse gas (GHG) emissions from agriculture are a significant concern in Ireland due to the country's strong agricultural sector, especially in livestock production. Agriculture in Ireland contributes a substantial portion of the country's total greenhouse gas emissions, primarily due to methane (CH_4) and nitrous oxide (N_2O) emissions associated with farming practices.

Key Greenhouse Gases in Irish Agriculture

Methane (CH_4): emphasised focus on methane for the purposes of this report as animal health can have the most impact on enteric methane emissions of farm animals:

- Methane is a colourless, odourless gas with the chemical formula CH_4. It is the simplest alkane and consists of one carbon atom bonded to four hydrogen atoms. Methane is a major component of natural gas, which is used as a fuel source for heating, cooking, and electricity generation.

- Methane is produced both naturally and anthropogenically (through human activities). Natural sources include:

  Biological processes: Methane is generated during the decomposition of organic matter in anaerobic (low oxygen) environments, such as wetlands, rice paddies, and the guts of ruminant animals (like cows).

  Geological processes: Methane can be found in underground deposits, often associated with fossil fuels, and is released from these formations during extraction and processing.

- Methane is primarily produced in Irish agriculture through enteric fermentation in ruminant animals, particularly cattle and sheep. During digestion, microbes in the stomach of these animals produce methane, which is then emitted when the animals burp.

- Manure management also contributes to methane emissions, especially when manure is stored in anaerobic conditions (without oxygen).

- Once produced, methane persists in the atmosphere for around 12 years after which it is eventually broken down into carbon dioxide and water. (IEA, Methane and Climate Change, 2022)

- It's important to note; Agricultural methane doesn't only come from animals, though. Paddy rice cultivation – in which flooded fields prevent oxygen from penetrating the soil, creating ideal conditions for methane-emitting bacteria – accounts for another 8 per cent of human-linked emissions. Huge evidence of this from the authors visit to Northern India.

Nitrous Oxide (N_2O):

- Nitrous oxide emissions in Irish agriculture mostly come from the application of nitrogen fertilizers. When nitrogen fertilizers are applied to soils, a portion of that nitrogen is converted to nitrous oxide through microbial processes, especially when the soil is wet.

- Emissions can also occur from manure applications, particularly when manure is spread on fields.

- Nitrous Oxide is a potent greenhouse gas with a 100-year global warming potential 298 times greater than carbon dioxide.

- N_2O is produced in the soil through microbial processes which utilize nitrogen (N) from the above agricultural practices. The rate of N lost from pastures in the form of N_2O is stimulated by environmental conditions which favour microbial activity such as wet soil conditions, rainfall events or high soil temperatures.
- Agriculture produces 90% of N_2O emissions in Ireland.

Carbon Dioxide (CO_2)

- While CO_2 emissions from agriculture are less significant compared to methane and nitrous oxide, they can arise from fossil fuel use in farm operations, land-use changes, and soil degradation.
- Carbon dioxide (CO_2) is the main man-made gas. It accounts for 76% of global emissions. CO_2 does not break down easily and it remains in the atmosphere for several centuries.
- In Ireland, lime and urea application are the main sources of CO_2 from soil.

Overview of Agricultural GHG Emissions in Ireland

According to the **Environmental Protection Agency (EPA)** in Ireland, agriculture accounted for around 37% of total national greenhouse gas emissions in 2021. The sector is the largest contributor to emissions in Ireland, driven largely by the high levels of livestock farming. Key data points include:

- **Livestock Farming**: Ireland has a significant beef and dairy industry, leading to high levels of methane emissions. The country is known for its pasture-based systems, which can potentially mitigate some emissions but also maintain high levels of enteric methane due to herd sizes.
- **Fertilizer Use**: The application of nitrogen fertilizers has increased agricultural productivity, but it has also contributed to rising nitrous oxide emissions.

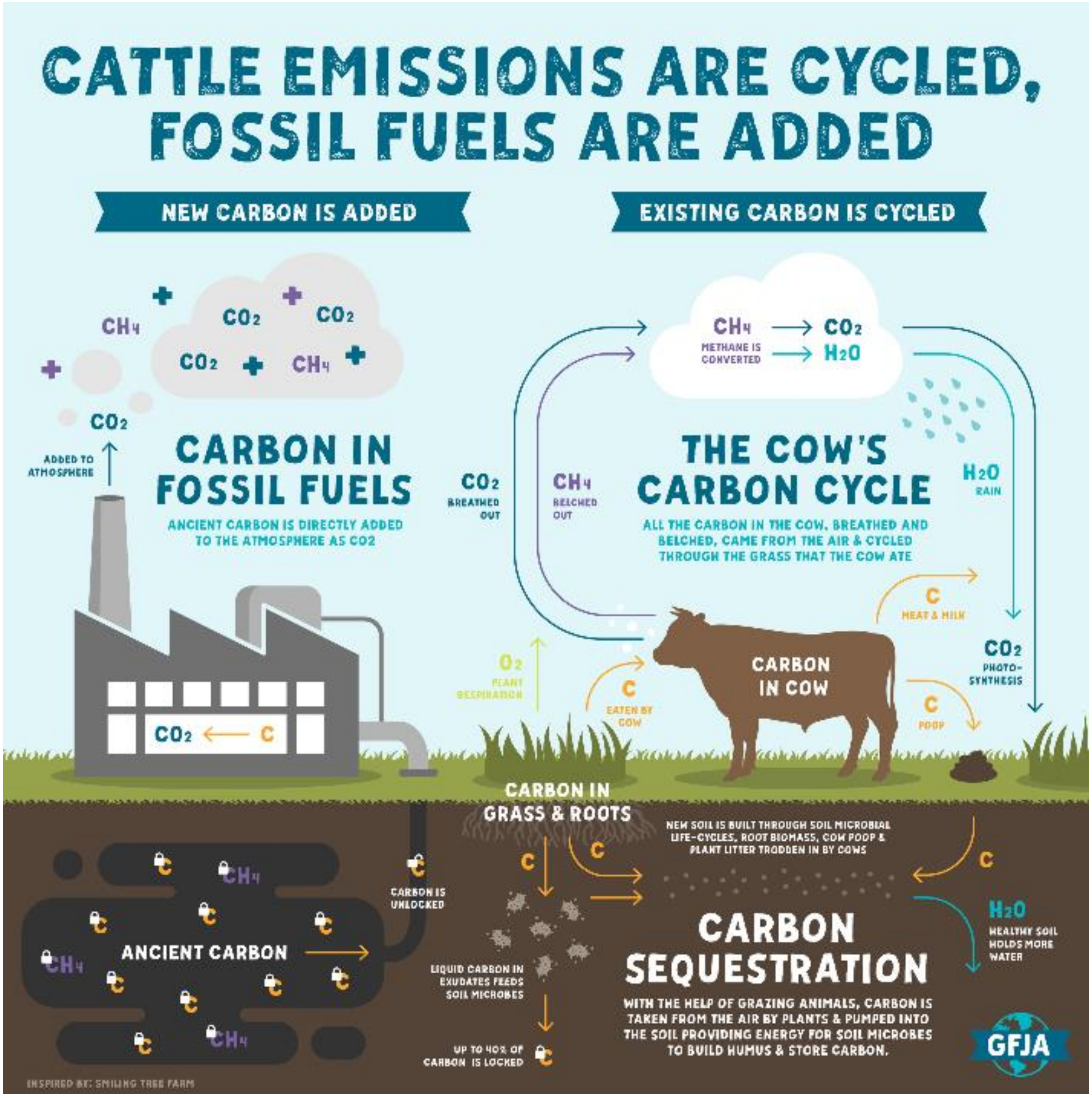
Greenhouse gas emissions from Irish agriculture pose a significant challenge, but there are ongoing efforts to mitigate these emissions through improved farming practices, policy frameworks, and innovative technologies. Addressing these emissions is crucial for Ireland to meet its climate targets and contribute to broader global efforts to combat climate change.

It's important to note; Agricultural methane doesn't only come from animals, though. Paddy rice cultivation – in which flooded fields prevent oxygen from penetrating the soil, creating ideal conditions for methane-emitting bacteria – accounts for another 8 per cent of human-linked emissions. Huge evidence of this from my visit to Northern India.

It is estimated that 90-95% of enteric methane is expelled from the rumen in the breath of the animal (eructation) with the remainder a product of flatulence.

Contrary to common belief, only a small percentage of methane is produced in the cows' large intestine and then expelled. Remember – it's the burps, not the farts!

The diagram below courtesy of Global Food Justice Alliance explains how cattle emissions are cycled whilst fossil fuels are added.



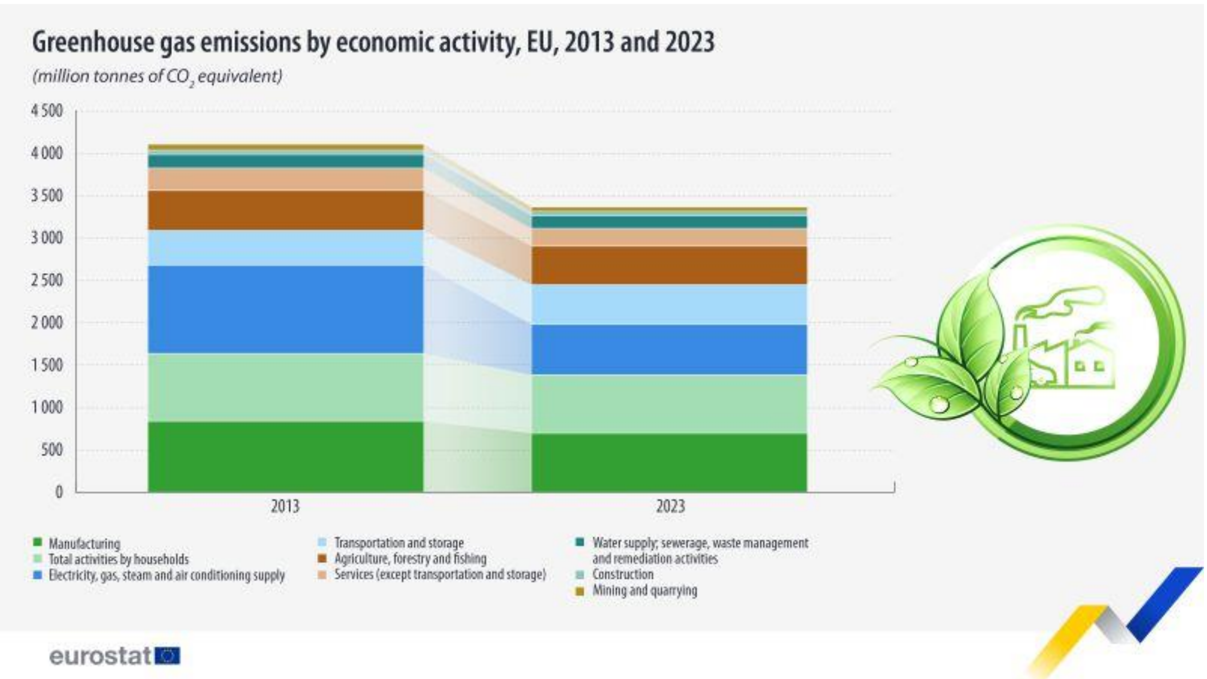
Global Food Justice, 2022.

8.0. ANIMAL HEALTH AND SUSTAINABILITY

The interrelationship between animal health and sustainability can be summarized in several ways:

- **Productivity and Efficiency:** Healthy animals tend to be more productive, which means less resource use per unit of output. This is crucial for reducing the environmental footprint of animal agriculture.
- **Reduced Dependency on Chemicals:** Maintaining animal health through good management practices can reduce reliance on veterinary drugs and chemicals, contributing to more sustainable farming practices.
- **Public Perception and Consumer Demand:** Increasing public awareness about animal welfare and sustainable practices has led to growing consumer demand for products that are sourced from healthy animals raised in sustainable systems.
- **Climate Change Resilience:** Healthy animals are less susceptible to the stresses of climate change, such as heat and feed shortages, which is important for long-term sustainability in agriculture.

Environmental sustainability in the EU



Greenhouse gas emissions by economic activity, EU, 2013 and 2023.jpg

(Eurostat, 2023. Greenhouse gas emission)

Agriculture is a major contributor to greenhouse gas emissions in the EU.

8.1. Animal Health Diseases

Reducing the prevalence of diseases and parasites would generally reduce emissions intensity as healthier animals are more productive, and thus produce lower emissions per unit of output.

Improving the genetic potential of animals through planned crossbreeding or selection within breeds and achieving this genetic potential through proper nutrition has the potential to lower emissions.

It's fair to suggest animal disease is associated with significant reductions in livestock productivity. It's also fair to suggest reductions in livestock productivity result in increased emissions on farm per unit of production.

Oxford Analytica, a leading research and analysis firm, recently developed a report – Animal Health and Sustainability: A Global Data Analysis, which was commissioned by Health for Animals. The report analyses the relationship between animal health and the three pillars of sustainability, environmental, economic and social.

The report's unique regression model produced findings such as:

- **Economic:** A 60% global vaccination rate for beef cattle is associated with a productivity rise of more than 50%.
- **Environment:** A fall in livestock disease of 10 percentage points is associated with an 800 million tonne decrease in greenhouse gas (GHG) emissions.
- **Social:** Globally, on average, every two cattle vaccinated is correlated with one person avoiding hunger.

The report also offers case studies that show livestock disease represents $358.4 billion in annual production losses, how scaling up existing animal health practices could feed 9+ billion without increasing emissions, and more.

The report also builds upon existing research in the field with case studies that demonstrate how livestock disease control can meet global needs and targets, such as:

Showing through UNFAO data that scaling up existing practices in animal health and husbandry means:

- Livestock could potentially serve more than 9 billion people in 2050 without increasing emissions.
- Calculating that livestock disease losses represent $358.4 billion in lost production per year.

- Estimating that every percentage point reduction in global beef cattle losses due to disease could provide enough additional production to meet the consumption needs of 317 million people.

A case study analysis of UN data found that scaling up existing practices in animal health and husbandry means livestock could serve a world population protein demand of 9 billion in 2050 while holding emissions to current levels.

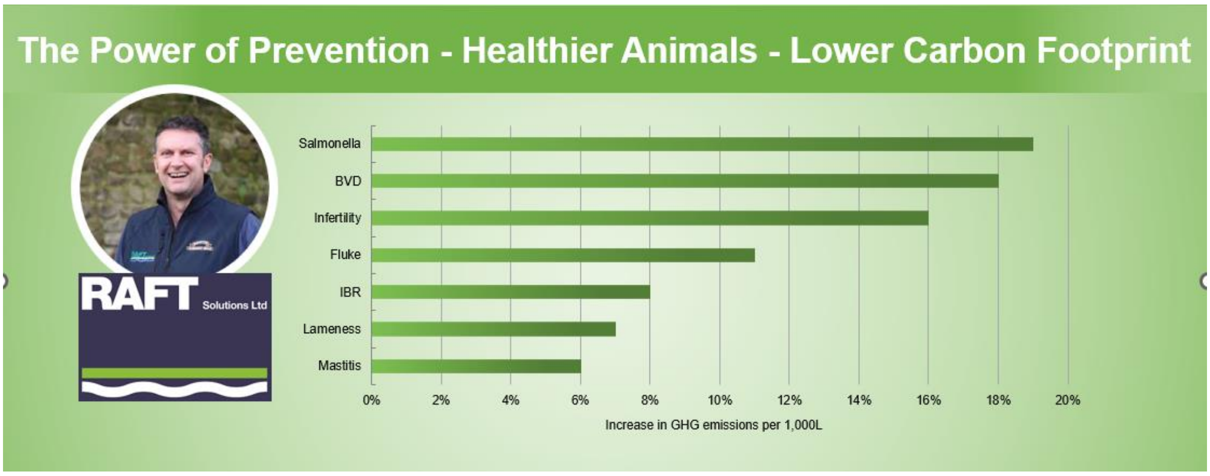
Oxford Analytica's calculations indicated:

- UNFAO estimates that an increased uptake of existing animal health and husbandry technologies and practices can reduce livestock emissions intensity by 18-30%.
- This intensity reduction could allow livestock farmers to increase production by an estimated 46.7 billion kg a year, enough to meet the needs of another 1.6 billion people, while holding overall emissions at current levels.

(Health for Animals Report, 2023)

8.1.1. Diseases

It is widely accepted healthier animals have a lower carbon footprint.



The above graphic illustrates the impact a disease outbreak can have in a herd and the increase in GHG emissions per 1,000 Ltr of milk produced. i.e. a salmonella outbreak can have close to a 20% increase on emissions (Statham, J. et al 2020.)

The way by which animal health affects emissions intensity is through reduced production efficiency and what is referred to as ‘unproductive emissions’ related to mortality and morbidity. Morbidity causing the reduction in production efficiency, diminishes the growth rate and live weight of animals and leads to lower efficiency in feed utilization, as well as lower reproductive performance and milk yields (FAO and NZAGRC, 2017a).

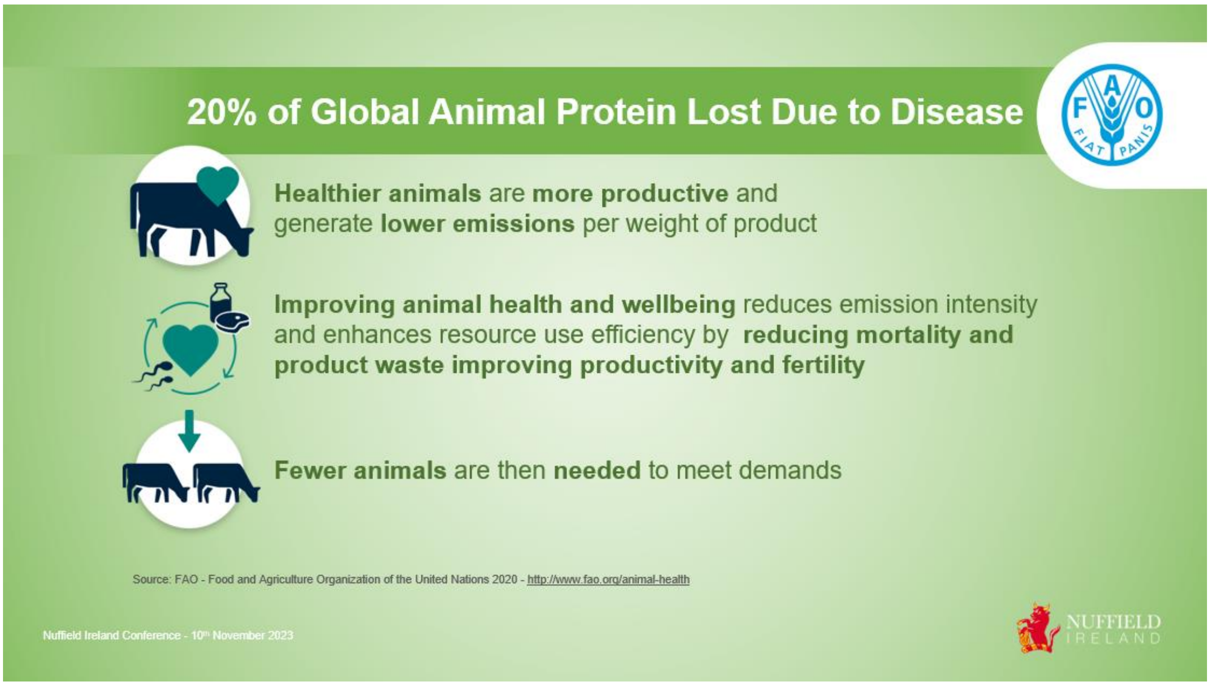
The extent to which animal health conditions interrelate with feeding, breeding, immune response, and the consequential impacts on GHG emissions is an ongoing research arena (Özkan et al., 2016), which is addressed in the Animal Health and Greenhouse Gas Emissions Intensity Network (AHN) of the GRA. Looking specifically at dairy cattle, the increases in GHG emissions from diseases (e.g., clinical or sub-clinical mastitis, foot lesion, foot and mouth disease) can originate from removal of discarded milk, reduced milk production, prolonged calving interval and culling (Mostert et al., 2019, 2018, Özkan Gülzari, Vosough, Ahmadi and Stott, 2018). Though some diseases are more treatable than others (Skuce et al., 2016) and some health issues result in greater GHG emissions than others. One of the immediate impacts of disease in an animal's body is the reduction in voluntary feed intake. In addition, digestion, absorption, and utilization of nutrients can be significantly compromised, especially in the case of gastrointestinal parasitism. Maintenance requirements, especially those of protein, may increase, and the availability of nutrients for maintenance may diminish, which may make the animal more vulnerable to challenges that were otherwise easier to control (Mackenzie and Kyriazakis, 2021).

While some diseases like Johne's disease and Salmonellosis may have greater impact on GHG emissions per animal per year than Bovine Viral Diarrhoea (BVD), the impact of BVD on GHG emissions per 1000 L of milk can be like that of Salmonellosis due to the losses in productive outputs. The main cause of the increase in GHG emissions was the increased mortality in BVD (immunosuppression opening the way for other diseases) and Salmonellosis, and the increased culling rate in Johne's disease. The diseases can cause an increase in both CH_4 and N_2O emissions per kg digestible organic matter intake (ADAS, 2015; Mackenzie and Kyriazakis, 2021).

It is important to note that antibiotic treatment can alter the gut microbiome and increase CH_4 fluxes because methanogens compete with bacteria for hydrogen (Hammer et al., 2016).

Therefore, this illustrates the importance of continuously striving to reduce antibiotics on farm.

A staggering fact - 20% of global animal protein is lost due to disease.



The above graphic explaining that FAO estimate that 20% of global animal protein is lost due to disease when it comes to food production.

(FAO Report, 2022)

8.1.2. Parasite Burden

During an interesting, thought-provoking meeting with Philip Skuce from Moredun Research Institute, the author investigated the impact parasites can have on emissions. Philip's research interests relate to the sustainable control of helminth parasites (worms and fluke) in livestock and his passion for this area is infectious! Philip informs the author that parasites are amongst the most important and prevalent endemic production-limiting diseases of livestock, and represent a significant constraint on efficient livestock production, both in the UK and globally. Philips research involves novel diagnostics, vaccine studies and disease control strategies.

Philips's ongoing work focuses on monitoring worm and fluke disease risk in the environment, determining the impact of climate change on livestock disease and understanding the role of improving animal health in reducing greenhouse gas emissions from livestock.

Philip changed my perspective on how parasites can have an impact on emissions. The chances are a parasite outbreak will affect an increased number of animals vs a general disease like salmonella.

8.1.3. Somatic Cell Count

CellCheck is the national mastitis control programme, coordinated and facilitated by Animal Health Ireland. It was developed and delivered in partnership with industry bodies representing farmers, processors, service providers and government.

The objectives of CellCheck are:

- Building awareness.
- Building capacity.
- Evaluating change.
- Establishing best practice.
- Setting goals.

The building blocks of the CellCheck programme include the CellCheck Farm Guidelines for Mastitis Control, the development of service provider training and farmer workshops. CellCheck has achieved great reduction in national SCC. CellCheck is of particular interest when it comes to behaviour change at farm level.

Milking technology can greatly aid a farmer in controlling and managing SCC. The SenseHub Dairy Somatic Cell Count Sensor from MSD Animal Health provides automated somatic cell counts for individual cows at the milking point. It delivers clear, reliable results in under two minutes.

As an indicator of mastitis and milk quality, SCC is linked to GHG emissions via indirect impacts on milk yield; as SCC increases, as do GHG emissions on farm. This was evidenced by Ozkan et al. (2015), who demonstrated that increasing SCC from 50,000 cells/ml to 200,000 cells/ml along with an associated increase in cow culling rate from 32% to 38% increased GHG emissions per kg of ECM by 2%.

Mastitis incidence is linked to SCC. As mastitis incidence increase, so too would GHG emissions.

Statham et al. (2020), attempted to quantify the GHG emissions improvement, the greatest improvements were, not surprisingly, conferred by improving the worst 10% of herds, which could reduce their GHG emissions per kg Energy Corrected Milk by 4.5% for mastitis for the average dairy herd.

8.1.4. Lameness Incidence

Mestert et al 2018 states that foot lesions, i.e. Digital Dermatitis, White Line Disease and Sole Ulcer combined, increased GHG emissions on average by 13.6 (1.5%) kg CO_2e/ t far and protein corrected milk. Culling contributed most to the impact of foot lesions on GHG emissions.

Management that reduces lameness incidence or severity, therefore improving productivity and cow welfare, would be expected to reduce GHG emissions on a dairy farm. No doubt technology thorough camera imagery and artificial intelligence for locomotion scoring will play a part of this management into the future.

Sara Pedersen says the benefits of improved cow mobility extend to helping the environment – more efficient milk production and lower culling rates can help reduce overall carbon emissions by producing more milk from the same number of cows. (Pedersen, 2023)

8.1.5. Longevity

After studying the impacts of cow longevity on GHG emissions from dairy production, von Soosten et al. (2020) concludes that improving health such that cows left the herd after 5-8 lactations would confer a staggering 40% reduction in GHG emissions compared to herds where cattle left after one lactation. This is mainly because of the greater proportion of the lifecycle spent in the productive phase compared to rearing (birth until first calving).

Improving health and fertility to reduce the environmental impact of dairying is also beneficial for cow welfare and farm financial returns. The partnership between farmers and veterinary practitioner can be central to this process.

8.1.6. Milk Production and Milking Efficiencies

For any dairy system, if fewer cows (and replacements) are required to produce target milk output with fewer 'lost' litres of milk, then the environmental impact for every litre of milk sold or every animal on the unit will be reduced. Lost milk here includes discarded milk following treatment or yield reduction following disease or poor reproductive performance. A reduction in GHG/litre of saleable milk, is a positive consequence of improved health and fertility because fewer cows at a given level of production, are required to produce the same quantity of milk.

Milk Yield

Milk yield is often the measurement used to assess CHG emissions in the dairy industry. Common measures I have come across for assessing are energy corrected milk (ECM), CO_2 per kg milk or fat or protein corrected milk. Knapp et al. (2014) suggests that improving productivity efficiencies in the dairy cow can reduce emissions per kg of milk.

O'Brien et al. (2014) reports that top-performing herds had GHG emissions per kg of energy corrected milk 27-32% lower than those of the average herd in the study. This decrease was a result of greater productive efficiencies, i.e., increased milk yield per cow and decreased heifer replacement rate.

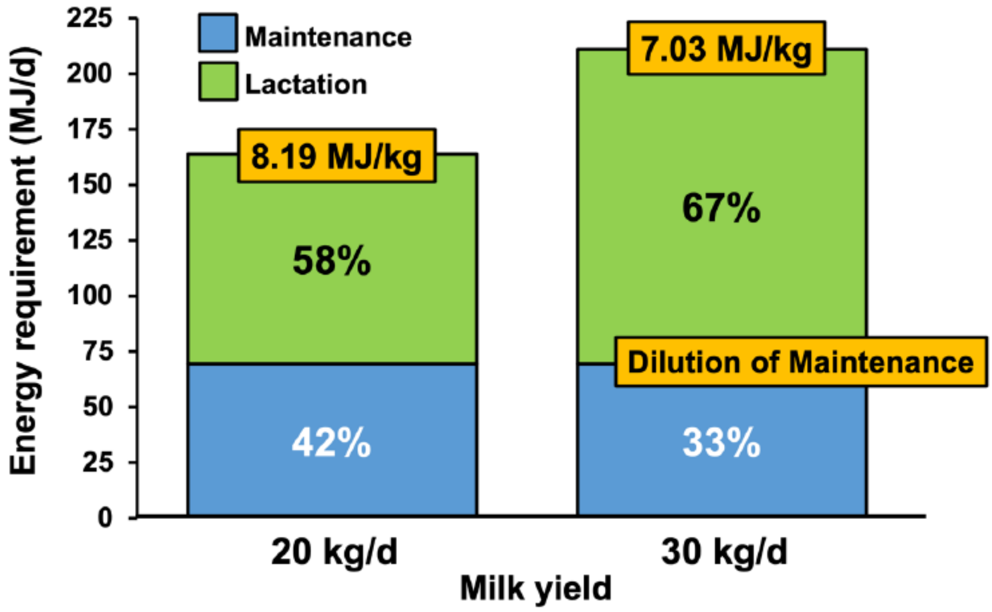


Figure 1. An example of the dilution of maintenance effect in lactating dairy cattle

Milk Composition/Solids

Capper and Cady (2012) report that producing Cheddar cheese from Jersey milk consumes fewer natural resources and has a lower environmental impact compared with that using milk from Holstein cows. Therefore, using Jersey cow milks to produce cheese vs Holstein cow milk decreased emissions per kg cheese produced.

Whilst Holstein cows typically produce larger volumes of milk, Jersey cows produce milk with higher butterfat and protein content, leading to richer milk solids. This difference can significantly influence the choice of breed depending on the intended dairy products.

8.1.7. Reproduction

Management of herd structures to reduce the number of non-productive animals through improved animal and herd fertility and reproduction is an effective approach to reduce emissions per unit of milk and increase dairy profitability.

"Good fertility drives productivity, and therefore supports mitigating those greenhouse gas emissions," Prof Jonathan Statham.

Dry Cow Period Duration

Teagasc suggest an eight-week dry cow period in preparation for the next lactation.

A balance a farmer tries to achieve is optimising productive days over the cow's lifetime and allowing udder tissue to regenerate before calving. A suitable recovery time for a cow is a necessity for overall health of the animal. In more intensive systems, dry cow period duration may be reduced to thirty days, however, numerous studies suggest that this has negative impacts on milk yield production (Kok et al., 2017).

However, despite concurrent negative effects on economic viability, the study published by Kok et al. (2017) also showed that reducing or eliminating the dry period increased GHG emissions by <1%.

Age at First Calving

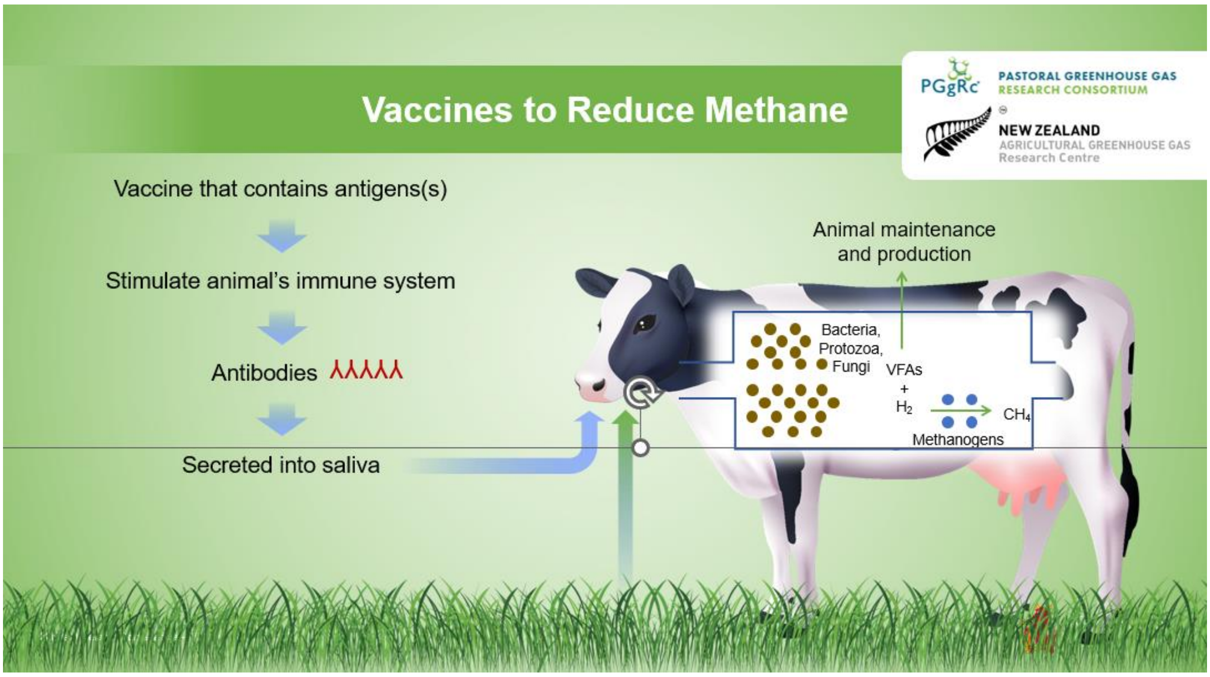
Naturally, there is a correlation between age at first calving and GHG emissions. The longer the animal is on farm before producing milk, the more emissions that animal is responsible for. Knapp et al. (2014) suggests that replacement heifers account for 20-33% of total herd GHG emissions.

Pregnancy Statistics

It is widely accepted that fertility statistics and fertility are a universal key performance indicator the dairy industry global. Terms and descriptions may differ from country to country, but fertility is a key measurement of efficiencies on farm.

Garnsworthy (2004) reports that improving fertility to optimal levels (70 days to first insemination, 70% oestrus detection rate, 65% and 60% conception rates to first and subsequent AI, respectively) would reduce the quantity of enteric CH_4 emissions produced by the herd by 21-24%, primarily because of a reduction in replacement heifers within the herd, with lesser effects of calving interval.

9.0. REDUCTION AT SOURCE



Above graphic illustrates how a vaccine to reduce methane would work.

The agricultural industry in New Zealand is very focused on finding a solution to methane reduction, given the importance of Agriculture in their country. So, they are developing a vaccine that reduces methane emissions from ruminant livestock.

A successful methane vaccine would trigger an animal's immune system to generate antibodies in saliva that suppress the growth and function of methane-producing microbes (methanogens) in the rumen.

A vaccine is a highly desirable tool for reducing enteric methane emissions because it requires no farm system changes, is used infrequently, leaves no residues in products and is applicable to all ruminant farm animals.

Research is now focused on identifying the right antigens that will inhibit the growth and function of methanogens in the rumen.

On reduction at source, it is also worth mentioning Ruminant Bio Tech's CALM Bolus, they plan to have this bolus commercially available by 2025 and are claiming it will reduce methane emissions by 70%.

10.0. NUTRITION

Red Seaweed (Asparagopsis Taxiformis)

Methane Tamer™ Beef Feedlot is a natural supplement with Asparagopsis seaweed that is proven to reduce methane emissions by up to 90%. Just a tiny amount in the daily ration takes immediate effect to prevent formation of methane in the rumen. However, the author feels more research is required here.

The compound present in seaweed that reduces methane production, is volatile, potentially carcinogenic to animals and humans, and, also known to negatively affect the ozone layer. (Sturges et al., 2000.)

3- NOP

The use of ruminal modifiers like 3-nitrooxypropanol (3-NOP) within dairy cow diets also appears to show promise for reducing enteric CH_4 emissions through modification of the rumen microbiome, although these are not yet widely available on-farm. Bovaer is an example of a 3-NOP additive. The author would also suggest that further research is required as to how ruminal modifiers would fit into a typical extensive grass grazing system in Ireland agriculture.

The Humble Daffodil

SRUC scientists' research into reducing cattle methane emissions using a chemical from daffodils is part of a project awarded £2.8 million by the UK's Department for Environmental Food and Rural Affairs (DEFRA).

The scientists have successfully extracted a chemical called haemanthamine from the plants.

In the laboratory, using an artificial cow's stomach, they showed it could reduce emissions by 30 per cent when added to feed.

In partnership with Innovate UK, The Dancing with Daffodils project, which is being run by a consortium including SRUC, will look at transforming the efficiency and sustainability of ruminant farming.

The partnership organisations also include Rumenco, Agroceutical Products Ltd, Analox Group, Beneve Ltd, Bioextraction Ltd, Bangor University, CIEL (Centre for Innovation Excellence in Livestock), Grampian Growers Ltd and Wynnstay.

Professor Jamie Newbold from SRUC said: “New innovations are required to address the need to maintain ruminant production while decreasing the environmental consequences. We are delighted to be involved in such an innovative project with a wide range of partners.”

SRUC will be involved in the evaluation of the newly developed feed additive and will also be responsible for assessing the dose of feed additive with the greatest potential to reduce methane emissions and improve feed digestion efficiency at farm level.

Annie Williams, Business Development Manager at CIEL, said: “The project will focus on the development of an innovative feed additive to reduce methane emissions and enhance protein utilisation in ruminants. Secondly, the cultivation of a new cash crop, daffodils, for farm diversification purposes, and then finally the creation of a precision on-farm gas analyser to monitor methane emissions.

“Currently, livestock farming faces scrutiny in terms of its environmental impact and resource utilisation, particularly when it comes to methane contributions.”

“Through the project, we can work to address these challenges head-on and find a practical solution for making livestock farming more sustainable.”

The consortium will work closely with farmers, industry stakeholders, and policymakers throughout the project's lifecycle to ensure alignment with the sector's needs and priorities.

By fostering collaboration and knowledge exchange, the consortium aims to bring tangible benefits to the farming community while contributing to national and global sustainability goals.

(SRUC, 2023)

Feed Efficiency

Fregulia et al. (2021), discusses differences in enteric CH_4 emissions between individual cattle have been attributed to three different hypotheses:

- Efficient animals emit less CH_4 because they lose less energy during methanogenesis.
- Efficient animals consume less feed and therefore have a proportional decrease in methane production.
- The composition of methanogenic archaea differs between animals, leading to variation in the quantity of CH4 emitted.

11.0. Animal Behaviour and Welfare

Cow Lying Behaviour

Deviations or differences from typical dairy cattle behaviours, e.g. changes in the duration, position or location of lying behaviours, are often associated with a less-than-ideal health, welfare or nutritional status (Lovarelli et al., 2020) and therefore may have indirect negative impacts on greenhouse gas emissions.

Rumination Behaviour

Time spent ruminating is an important parameter relating to enteric CH4 emissions, as it increases rumen buffering, acetic acid production and methanogenesis, but also reduces feed particle size and the potential for feed to be rapidly fermented (Beauchemin, 2018).

12.0. THE AUTHORS STUDY TOUR

12.1. Israel

Israel's agriculture is unique amongst developed countries in that land and water resources are nearly all state-owned and that agricultural production is dominated by co-operative communities or Kibbutz. Since the late 1980s, agriculture in Israel has benefited from: a stable macroeconomic climate; policy reforms; high levels of investment in R&D; a developed education system; high-performing extension services; and accumulated farm management expertise.

Israel is a world leader in agricultural technology, particularly in farming in arid conditions. Israeli agriculture thus relies on an 'induced', rather than 'natural', comparative advantage, one built on knowledge and technological progress.

Israeli dairy farmers, who use the most up-to-date technology available, are very proud of their industry and have some of the best producing cows in the world. Over 90% of dairy cows in Israel wear monitoring technology.

The country is home to around 115,000 cows producing around 1.6 billion litres of milk per year. There are two farming systems in Israel, including 164 kibbutz farms built around the communities, and another 573 larger private farms called moshav farms.

The author on a Kibbutz in Israel - May 2022

12.2. Netherlands

The Netherlands is a very densely populated country, where rural areas have urban centres in which most of the people live. The author believes of the because few people live in rural Netherlands, the divide between rural and urban dwellers is evident. The Dutch agricultural sector is characterised as highly productive, modern, innovative, and export-oriented and it employs about 2% of the Dutch working population. Ornamental horticulture products, dairy and eggs, meat, vegetables, and fruit are the most important sectors in terms of production value. I visited the Netherlands a few times during my Nuffield Scholarship and every time, Dutch farmers continually impressed me with their pure innovation, drive and entrepreneurship.

Intensive farming has left the small nation with higher nitrogen oxide levels than EU regulations allow.

There is tension in the Dutch Agricultural community at present.

The author with Pieter Winters, farmer in Giethoorn, Netherlands- Oct 2022

Peter is an impressive Dutch farmer, mainly a potato grower who processes his own raw product into branded frozen fries, but when there he didn't talk about growing potatoes – he talked about no waste philosophy, circular farming and generating electricity.

12.3. Greece

Agriculture in Greece has a rich history based on its Mediterranean climate. The Greek Agricultural industry consists of a wide array of crops, including olives, grapes, citrus fruits, cereals, and vegetables. It's fair to the Greeks are particularly renowned for their olive oil production.

Farming is tough in Greece - more than 70% of the Greek agricultural area faces natural or other specific constraints (for example: extreme slopes, low temperatures, dryness of soil, unfavourable soil texture, borderline areas, island regions) which significantly affect farming.

13.0. GLOBAL FOCUS PROGRAMME- INSIGHTS

13.1. Singapore

As a highly urbanized country with little local agricultural production, Singapore is almost entirely dependent upon imports for its food requirements. Singapore's food laws are therefore focused on ensuring consistent foreign supply of safe food and agricultural products.

In 2019, Singapore launched its '30 by 30' initiative: the objective to locally produce thirty percent of its nutritional needs by the year 2030. For a crowded city with over five million inhabitants that imports almost 90 percent of its food, this plan is clearly very ambitious.

So how will they achieve this ambitious plan? Perhaps by embracing technology and innovation when it comes to food production.

With limited space available on the ground, Singaporeans must be creative in where to farm. Government and farmers have embraced technology and innovation to improve product quality and efficiency. At rooftop farms such as Citiponics and ComCrop, fresh greens are grown using less land, less water and less electricity, minimizing resources and maximizing produce. And at indoor farms, everything from harvest to temperature to airflow can be controlled digitally.

The author with fellow Irish Nuffield Scholars at the commencement of the GFP in Singapore - May 2023

13.2. India

Indian Agriculture proved a fascinating exploration. India is one of the major players in the agriculture sector worldwide and it is the primary source of livelihood for around 55% of India's population. India has the world's largest cattle herd (buffaloes), the largest area planted for wheat, rice, and cotton, and is the largest producer of milk, pulses, and spices in the world. It is the second-largest producer of fruit, vegetables, tea, farmed fish, cotton, sugarcane, wheat, rice, cotton, and sugar. India has the second-largest agricultural land in the world.

India was a tale of two halves. South India is still underdeveloped and very rural, with small tea, coffee, cardamon and banana growers. There's an endearing innocence regarding South Indian Agriculture. North India's agriculture is much more developed. Huge efforts are being made to reduce methane emissions from burning scrub after growing rice which is a huge mindset change for Indian farmers. When it comes to dairy, it's interesting to note India is number one in the world for the number of cows, however average herd size is single digit. There are some very positive developments in the dairy industry with the rise of the Co-Op model.

The author on a farm in India - June 2023

13.3. Qatar

The Qatari government has attempted to encourage agriculture and fishing to provide a degree of self-sufficiency in food. Farming in the desert is quite a challenge.

A highlight in Qatar included a visit to Baladna Dairy Farm. Baladna is a 100% Qatari company and is the largest dairy farm the author has ever visited! The farm has a capacity to house up to 24,000 cows in a comfortable and well-conditioned environment, allowing them to reach their optimum production capacity comfortably. Cows are milked daily using a rotary milking system to provide a wide selection of dairy products. Furthermore, the farm is open to the public and features the region's most advanced rotary milking parlour, as well as a restaurant, a carefully manicured garden, a children's play area, and a petting zoo. A proud moment for the author, being an MSD Animal Health employee, was that the cows all wore SenseHub Dairy Monitoring Technology.

The author discovered Irish produce in a supermarket in Doha, Qatar - June 2023

13.4. Germany

Agriculture in Germany plays a significant role in the country's economy and is characterized by its high level of mechanization, productivity, and emphasis on sustainability.

German Agriculture still bears the mark of stark differences in East and West is stark. We visited farms from East to West, visiting innovative farms with an entrepreneurial spirit.

Germany is one of the leading dairy producers in Europe, producing approximately 33 million tons of milk annually (as of recent figures around 2021-2022). This positions Germany as the largest producer of milk in the European Union. The dairy herd consists of around 4 million cows, with most of the milk coming from Holstein and Jersey breeds, known for their high milk yields and quality. Dairy farming is concentrated in specific regions, with Bavaria and Lower Saxony being the largest milk-producing states. Other notable regions include Baden-Württemberg and North Rhine-Westphalia.

A highlight included visiting the German Bundestag in Berlin to understand the powerhouse that is German politics.

The author with GFP Group on a farm visit in Germany - June 23

13.5. USA

U.S. agriculture is quite a powerhouse. The scale and statistics are mind boggling, the USA Farm Bill is worth $1 trillion, they spent $29 billion in subsidies as result of the trade dispute with China. The USDA suggest the Farm Bill is a matter of national security. The U.S. is one of the largest agricultural producers in the world, providing a wide array of products for domestic consumption and international trade.

We visited an array of farms throughout Pennsylvania. In the U.S.A., farmers are respected and appreciated for the food they produce for their nation. There is a strong farming culture, and many farms are tourist attractions for urban families. The key insight is that US farmers are being supported and encouraged to make changes with assistance, rather than forced to do so with regulation as is the case in Europe.

The author left the U.S. reflecting; do the U.S. have a better model than Europe to affect change at farm level?

The author at The Washington Monument in Washington DC enroute to meeting USDA - June 2023

14.0. CASE STUDIES

14.1. Case Study One

ZELP (Zero Emissions Livestock Project) was founded in 2017 to help the world get to net zero emissions through the technological transformation of the livestock industry.

The cow gets a new harness. The device fits comfortably around the cow's head - there's no change to feeding, rumination, or interaction within the herd. The gas is captured and oxidized.

As the cattle exhales, methane travels through a catalyst where it's oxidized, then released into the air as CO2 and water vapour. The cow and the planet get healthier. The technology precisely tracks methane reduction and key data for farmers.

The authors first encounter with Francisco Norris was at the Animal Health Ag Tech Innovation Summit in Amsterdam in October 2022. Having fond memories of growing up in Agriculture, Francisco grew up on a sustainable grazing Aberdeen Angus farm in Argentina. He is probably the most knowledgeable person on emissions and methane the author encountered throughout my research. Francisco was generous with his time and was eager to support in any way he could. It was a privilege to have had such access to such an innovative leader in his field, a privilege entirely due to the Nuffield network.

The following is taken for the ZELP (2023) website:

"ZELP is committed to eliminating emissions while taking care of our animals, our farmers, and each other. They believe neutralizing methane emissions is the single fastest way to stop climate change. They harness the most advanced mitigation and data processing technologies to reduce livestock emissions and improve animal welfare. ZELP's scientists, engineers, and veterinarians are dedicated to studying and reducing the environmental impact of methane gas through the development of cutting-edge technology. ZELP began at London's Royal College of Art – the world's top postgraduate university for product design. The start-up was incubated by Innovation Royal College of Art, the College's centre for innovation and business support, while working in close collaboration with the chemical engineering department at Imperial College, and the veterinary team at the Royal Veterinary

College. As ZELP grew in technological readiness, key partners joined the company's mission to drastically reduce methane emissions. This includes many of the largest food companies striving to feed the world while meeting robust environmental targets. The future of ZELP is focused on achieving global scale with our ground-breaking technology. With corporate, government, and livestock partners, it's not only possible to achieve net zero emissions – it's the only future we're dedicated to working towards."

ZELP- ANIMAL WELFARE

In conversation with Francisco Norris -

Q. What impact does ZELP technology have on animal welfare?

A. The ZELP technology has been developed with animal welfare at its core and independent studies conducted with leading academic institutions in the UK and Argentina have demonstrated that animals wearing the device show no change in their behaviour or cortisol levels, and no impact on their feeding, yields or rumination patterns – which are the most sensitive indicators of stress by the animal.

On the other hand, our technology's data and methane sensing capabilities make us unique. Through this monitoring, we can help farmers identify diseases early and minimise the spread and onset of harmful conditions and tap into a brand-new layer of analyses in the fields of digestion, feed optimisation, and disease management. The ability of ZELP to monitor animals for health in addition to methane conversion places farmers and their animals at the forefront of the technology.

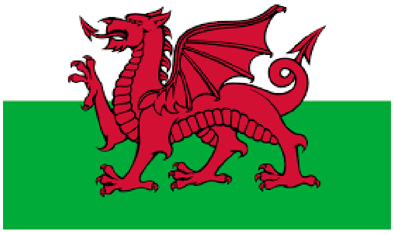
Q. What are the key benefits of the technology for the animals?

A. Our device is fine-tuned into the needs of every individual animal, ensuring through 24/7 monitoring they are maintained at the best of welfare standards. The device monitors subtle behavioural changes ensuring welfare conditions can be identified and prevented early. We know exactly how the animals are feeling through the data we collect allowing us to act quickly if anything changes.

Q. Has the technology been tested on live animals?

A. We have conducted multiple trials of our technology in the UK, Ireland, Argentina and the Netherlands, with both small and large groups of animals. We carry out these trials to continue improving the design and functionality of our device, to demonstrate the mitigation potential of our technology and the accuracy of our cattle tracking application, and to ensure our technology has no impact on the animal's wellbeing, behaviour, or performance.

14.2. Case Study Two



The Farm of Marc and Lucy Allison

A Welsh family dairy has almost halved its carbon footprint from 1,447g to 809g of carbon dioxide equivalent per kilogram of fat - and protein-corrected milk. Marc and Lucy Allison milk 300 autumn-calving cows at Sychpant Farm, near Cardigan. They say the improvement has been made by making small, incremental gains across the business in the past three years. Their carbon footprint, which stands at 1,173g of carbon dioxide equivalent (CO_2e) per kilogram of fat- and protein-corrected milk. “We have done lots of little things and every year we tweak things in areas we think we can do better,” explains Marc.

Farm Facts: Sychpant Farm, Cardigan

Farming 210ha (519 acres).

Growing 24ha maize, 2ha fodder beet, 8ha winter barley, 24ha winter wheat and the remainder grass.

Milking 300 Holstein cows yielding 10,103 litres at 4.34% butterfat and 3.37% protein.

One of the areas is feed efficiency. Feed rate has fallen from 0.33kg/litre to 0.27kg. This has been achieved by focusing on growing more home-grown, good-quality feed, with 68% of the diet now made up of forage. This has helped lift milk from forage from 3,711 litres to 5,093 litres.

This improvement has been helped by buying more land, enabling them to double the farm size, as well as paying attention to detail, such as pushing up food regularly to ensure the cows always have access to food. Previously, maize was bought in from a grower in Shropshire, but now, 24ha (59 acres) of the crop is grown on-farm.

It is established under film to create a microclimate and offset the challenges brought about by farming at 152m above sea level on predominantly north-facing land.

This has helped negate transport emissions and allows the crop to be harvested early in September, which avoids soil damage in a wet autumn. It helps improve starch content, with last year's crop averaging 37% starch.

Grass is under sown in first-year maize to protect the soil over winter and provide an early bite of spring grass for in-calf heifers. The Allisons operate a multicut silaging system, aiming to cut leys of ryegrass and red clover four times annually. Better use of slurry has helped lower nitrogen use from 184kg/ha to 126kg/ha. Slurry is applied to crops using a trailing shoe at 45cu m/ha, with the grazing platform receiving dirty water during any dry periods of weather.

Last year, 4ha (10 acres) of fodder beet was grown to counteract rising feed prices and has replaced beet pulp. This yielded 400t and was chopped and mixed into the milkers' total mixed ration.

Roofing the main silage clamp has improved daily ration consistency, too. "It is an exposed farm and driving rain comes in off the sea. The clamp was catching so much water and it was hard to feed accurately day-to-day. [Some days,] the ration was like soup," he says.

Milkers are fed grass silage, maize, wheat and barley and brewers' grains or blend, which is regularly reformatted to match forage supply (see Milkers' ration box below).

Soya has been replaced in the total mixed ration (TMR) this year by a blend of protected rape expellers, methionine and rape.

The TMR is fed alongside a 16% concentrate, which is fed to yield in the parlour up to a maximum of 4kg a head.

Transition of Calving Pattern

Switching from all-year round to autumn calving four years ago has helped the Allisons reduce the age at first calving from 30 months to 24 months, which has also helped lower their carbon footprint.

All replacements are born in the first eight weeks of the 16-week block. Lucy says: "When it comes to getting the heifers in-calf, it is a lot simpler".

"We start serving on the third week in October and we put heat detection collars on the heifers."

Calves will be expected to hit 100kg ready for weaning at 10 weeks. "I want calves to grow into the winter; for us to hit two-year calving, it's an important growth stage," adds Marc.

Cows graze from March. Heifers calve outdoors while cows graze standing hay for four weeks before being brought inside and transitioned to a dry cow diet four weeks pre-calving.

Cows are milked three times a day from September until April. This helps shorten each milking time to 2.5 hours while cows are in peak milk, benefiting cow health by reducing standing times and improving udder health, says Marc.

Heifers are genomic tested with the highest-ranking animals based on predicted transmitting ability for constituents and health traits.

They are then served to sexed semen, alongside the best cows that come back bulling in the first eight weeks of the block.

The remainder of the cows are served to Limousin, Charolais and British Blue, while heifers are mated to Angus for easy calving.

Herd Health

Good preventative herd health is underpinning good fertility, milk production and low antibiotics use at Sychpant. All these are key drivers for lowering carbon emissions.

The herd is vaccinated for leptospirosis, bovine viral diarrhoea, infectious bovine rhinotracheitis and rotacorona, with all cows receiving a calcium bolus after calving.

Cows are housed in sand-bedded cubicles in a well-ventilated, spacious, bird-proof shed. Last season, mastitis rates averaged only six cases in 300 cows and there were just half a dozen cases of milk fever.

“If the cows are happy and comfortable, that makes our job a lot easier because we are dealing with low levels of disease. We haven’t had a displaced abomasum for three years,” he says.

(Farmer’s Weekly, 2023)

14.3. Case Study Three

Animal Breeding/Genetics

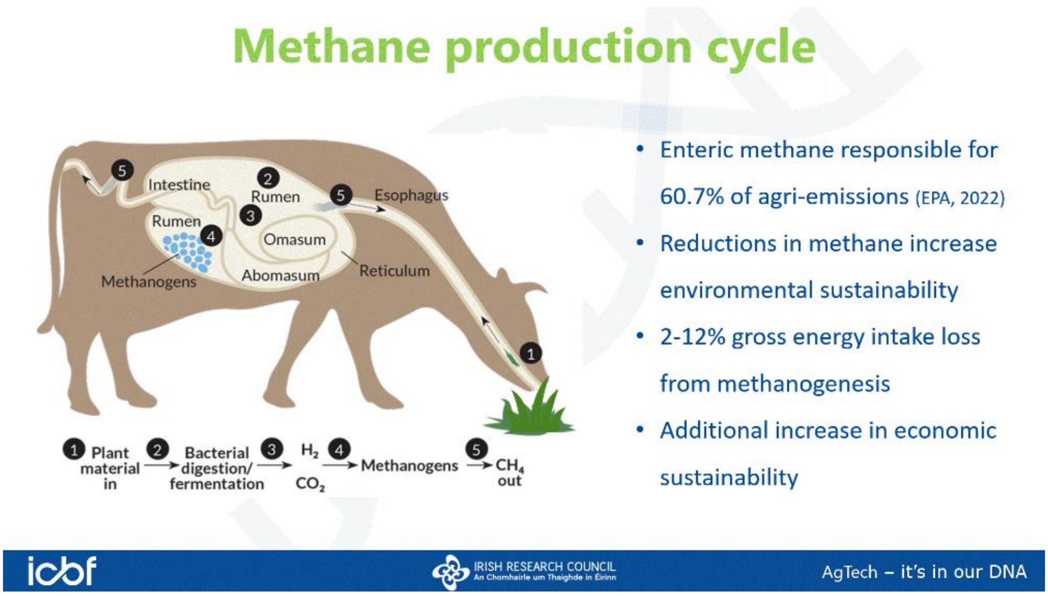
Historically, dairy cattle breeding goals targeted improvement of milk production and functional traits like health, fertility, and longevity. The industry is now evaluating selection strategies on traits that reduce emissions. Until now, selection strategies have ignored the effects of changing the traits that may reduce emissions.

Improving the genetic potential of animals through planned crossbreeding or selection within breeds and achieving this genetic potential through proper nutrition gives an opportunity to reduce emissions.

In April 2023 the Irish Cattle Breeding Federation (ICBF) announced that Methane Evaluations were live.

Once again, the Irish agricultural industry is leading the way by publishing the first enteric methane evaluations across breed on AI sires with phenotyped commercial progeny destined for slaughter. Enteric methane is a by-product of the natural digestive process which occurs in cattle. The generation of Methane Evaluations comes as a direct result of the collaborative effort between ICBF, DAFM and Teagasc through innovative projects such as GREENBREED, RumenPredict and MASTER with funding from the Irish Research Council.

This collaboration of industry and scientists coupled with the cutting-edge beef research facility in Tully Co. Kildare will continue to allow for the provision of genetic solutions to challenging traits which are long-lasting and cumulative.



Graphic above illustrates Methane Production Cycle

How is the Data Recorded?

Large-scale recording programmes are required to facilitate genetic selection for reduced emissions. In Ireland, ICBF, through the Tully Progeny Performance Test Centre, has started the large-scale recording programme, using GreenFeed Emission monitoring systems.

GreenFeed monitors the metabolic gas composition of animals in a non-intrusive way. Its design and measurement capabilities have been initially tailored to the measurement of metabolic gases emitted from ruminants. The system is optimised to quantitatively capture cattle's breath and analyse the emitted gases for trace constituents, including methane (CH_4) and carbon dioxide (CO_2).

The evaluations for methane emissions are powered by individual animal methane records from over 1,500 growing animals representing 19 different breeds. Research signified large differences in daily methane emissions between animals fed the same diet and 11% of these differences could be traced to genetic differences. This implies that breeding programmes to reduce daily methane emissions will be fruitful especially when undertaken in tandem with the national genomic evaluations for age at slaughter released last year.

Tully Progeny Test Centre slaughters 650 animals (steers, bulls and heifers) annually, 55% suckler bred, 45% from dairy dams. These animals have a wealth of phenotypic data available, including liveweights, ultrasound muscle measurements, feed intake, carcass weight, conformation, fat and the added benefit of being genotyped and sire verified.

Interpretation and Delivery

Genetics will play an essential role in reducing methane emissions. Selective breeding and genetic modification approaches offer promising solutions for producing cows that are less methane-intensive and more environmentally friendly.

Methane PTAs (Predicted Transmitting Ability figures) will be initially available for AI sires that have had progeny with methane data recorded in the Tully Progeny Performance Test Centre. The Methane Evaluations section of the website shows the methane PTAs currently available.

As the aim is to reduce methane emissions permanently and cumulatively, more negative values in PTA's are desirable. The trait is measured in grams per day.

Future Developments

Work is now focusing on collaboration with other research entities to scale up the recording of this trait and to cover more systems of production such as grass-based diets and lactating cows. With the further accumulation of records, Methane PTA's will become available for genotyped animals. Methods on how best to include a methane trait in the dairy (EBI), dairy-beef (DBI) and beef (Terminal and Replacement indices) are currently being developed.

This global first genomic evaluation for individual animal methane emissions in a multi-breed population of growing animals complements the other breeding strategies developed in the Carbon sub-index launched, strengthening the arsenal of tools available to farmers seeking to reduce their environmental footprint.

Greenfeed system in operation- ICBF Website.

Methane evaluations will become an essential part of the broader effort to improve the sustainability of Irish farming. By providing farmers with methane data, they will be able to identify opportunities to reduce emissions and improve the sustainability on their farm.

14.4. Case Study Four

HANSKAMP
Innovation for dairy farming

Hanskamp is a technical innovation company based in Doetinchem, The Netherlands. They develop and sell practical solutions for dairy farmers throughout the EU and beyond. Amongst these solutions is the CowToilet, a toilet for cows. The CowToilet is an automatic urinal that cows use voluntarily and is designed to collect urine before it hits the floor.

The CowToilet is placed against the cow's suspensory ligament and moves in unison with the cow. The technique locates the nerve. Once located, the nerve, which triggers the urinary reflex, is stimulated and the cow starts urinating. With the CowToilet, Hanskamp has managed to automate this long-known technique to make a cow urinate. The urine is collected in the CowToilet container and extracted through a suction line into a separate storage tank.

By ensuring that the urine stays separated from the manure there is considerably less ammonia emission, so the CowToilet deals with the ammonia problem at source.

Cows go to their CowToilet voluntarily as each visit to the toilet is combined with receiving their daily portion of feed.

Economic Advantages and Benefits for Animal Welfare

Because most of the urine is collected an enormous reduction in ammonia emissions is achieved. This is good for both the environment and animal welfare, a healthier air in the shed, for example. The CowToilet also offers economic advantages as it saves on manure storage costs and may even be an alternative to ammonia emission reducing floors.

This system also offers great opportunities for new revenues. Pure urine can be used as a high-quality raw material in, for example, precision fertilisation. There are also ongoing developments in which urine is used to generate 'yellow' power or as a source of hydrogen.

European agreements stipulate a reduction of ammonia emissions. Following this, national limits aimed to reduce emissions have been implemented. Approximately 90% of ammonia emissions come from agriculture, according to Wageningen University & Research (WUR).

When manure and urine mix, ammonia is formed. If this is released into the air, it can precipitate in nature, causing large amounts of nitrogen to end up on the ground. Plants can only process up to a certain amount of nitrogen. The remaining amount acidifies the soil and affects the groundwater. High concentrations of ammonia are harmful to humans and animals.

To limit ammonia emissions from the agricultural sector, dairy farmers must pay high fees to meet manure disposal requirements. Therefore, ammonia reduction is a high priority for many dairy farmers.

The Hanskamp CowToilet.

14.5. Case Study Five

A methane vaccine for cows is an emerging area of research aimed at reducing methane emissions from cattle. The following is an overview of the concepts surrounding the development of a methane vaccine, its potential benefits, challenges, and current research status.

Understanding Methane Emissions from Cattle

Enteric Fermentation: Cows produce methane during digestion through a process called enteric fermentation. Microbes in the stomach (particularly in the rumen) break down feed, producing methane as a byproduct, which is expelled by belching.

The Concept of a Methane Vaccine

Mechanism: The proposed methane vaccine would aim to alter the microbial population in the rumen or modulate the metabolic pathways to reduce methane production. This might involve stimulating the immune system to target specific microbes responsible for methane production or introducing other microbes that can outcompete methane-producing bacteria.

Research Focus: Scientists are investigating various approaches, including the use of specific proteins or compounds that can be administered to cattle to trigger an immune response against methane-producing microbes.

Potential Benefits

Reduction in Methane Emissions: If successful, a methane vaccine could significantly reduce methane emissions from cattle, contributing to climate change mitigation efforts.

Economic Viability: Reducing emissions can also lead to more efficient feed use, potentially lowering costs for farmers. Healthier animals may also result from reduced methane emissions and improved digestive efficiency.

Animal Health: A vaccine approach could potentially enhance overall animal health by promoting a balanced microbial population within the rumen.

Current Research and Developments

Ongoing Studies: Several research institutions and universities are actively studying methane vaccines. For example, researchers from institutions such as the University of Alberta and various agricultural research organizations are exploring microbial interventions and vaccine approaches.

Field Trials: Some studies are moving towards field trials to assess the vaccine's effectiveness in real-world settings and to evaluate its impact on overall farm operations.

Challenges and Considerations

Scientific and Technical Hurdles: Developing a safe and effective vaccine requires extensive research to understand the complex microbiomes of cattle and the specific interactions that lead to methane production.

Regulatory Approval: Any vaccine would need to undergo rigorous testing and regulatory approval processes to ensure it is safe for animals and does not negatively impact food safety or human health.

Adoption by Farmers: For a methane vaccine to be effective in reducing emissions at scale, it must be accepted and used by farmers. This requires education about the benefits, ease of administration, and economic implications.

Broader Context in Climate Change Mitigation

Holistic Approaches: While a methane vaccine could be a valuable tool, it is essential to consider it as part of a broader strategy for sustainable livestock management, which may include better feed practices, improved genetics, grazing management, and other technologies, like feed additives that reduce methane emissions.

Global Initiatives: The development of methane vaccines aligns with international climate goals and initiatives aimed at reducing agricultural emissions as part of broader climate change mitigation strategies.

John Roche, an Irish born scientist who serves as chief science adviser at New Zealand’s Ministry for Primary Industry and is a climate science expert to the New Zealand Government is a researcher known for his work in the field of livestock emissions, particularly focusing on developing strategies to reduce methane emissions from cattle. He has been involved in research on novel approaches to mitigating the environmental impact of livestock farming, including the development of a methane vaccine.

Overview of John Roche's Methane Vaccine Research

Research Focus: Roche's work centres around understanding the microbiome of ruminants, specifically how the microbial population in the stomachs of cattle contributes to methane production. By targeting certain microbial communities, the goal is to reduce the amount of methane produced during digestion.

Vaccine Development: The methane vaccine being developed under Roche's guidance aims to stimulate the cow's immune system to reduce methane emissions. This involves using an immunological approach to alter the population of microbes responsible for methane production in the rumen.

Potential Impact: If successful, this vaccine could significantly decrease methane emissions from cattle, addressing one of the main contributors to greenhouse gas emissions in agriculture. This would have implications not just for climate change mitigation but also for improving the overall sustainability of livestock production.

Research Advancements: Roche and his team are conducting various studies, including trials to assess the effectiveness of the vaccine in live animals. There have been promising results indicating that the vaccine may indeed reduce methane emissions, but further research and validation are required before it can be widely implemented.

Collaboration and Funding: The research often involves collaboration with universities, agricultural institutions, and funding from governmental and private sectors interested in sustainable agriculture and climate solutions.

15.0. COMBAT THE ARGUMENT

Communication is key, knowing the facts and the counter arguments for the debate is a necessity. The public discourse on climate change in Ireland increasingly focuses on agriculture, especially livestock production, as partly to blame. However, we need to combat the argument and discuss it more. Agriculture has a role to play to ameliorate and mitigate climate change.

Dublin Airport largest Irish polluter last year - COP27 data

Updated / Wednesday, 9 Nov 2022 18:36

Dublin Airport was the specific source for just over one million tonnes of Ireland's greenhouse gas emissions in 2021

By George Lee
Environment Correspondent

Debunking the Myth: How Cows Are Not Ruining the Planet

In recent times, there has been a growing concern about the environmental impact of cattle farming, with many blaming cows for significantly contributing to climate change. However, upon closer examination and research, it becomes evident that the vilification of cows is unjust and oversimplified. While it’s true that cattle farming has its challenges, it’s essential to separate fact from fiction and recognise the valuable role that cows play in sustainable agriculture.

First and foremost, it’s essential to acknowledge that cattle farming has been a part of human civilization for thousands of years. Cows have provided us with not only meat but also milk, leather, manure to fertilise crops and other essential products. Moreover, cattle have played a crucial role in shaping landscapes and ecosystems through grazing, which, when managed properly, can promote biodiversity and healthy soil.

A common argument against cattle farming is its contribution to greenhouse gas emissions, particularly methane. It is true that cows produce methane as part of their digestive process, but it’s essential to consider the full picture. The majority of methane emissions from cows come from enteric fermentation, a natural process in which microbes in the cow’s digestive system break down fibrous plant material. Science has shown that methane emissions from cattle are part of a natural carbon cycle and are not comparable to emissions from fossil fuel combustion, which introduce additional carbon into the atmosphere.

Well-managed grazing systems can sequester carbon in the soil, helping to mitigate climate change. When cows graze on grasslands, their hooves break up compacted soil, allowing water and air to penetrate, which promotes plant growth and carbon sequestration. Additionally, the organic matter from cow dung enriches the soil, further enhancing its ability to store carbon.

Cows can play a vital role in sustainable agricultural systems by converting low-quality forage, such as grasses and crop residues, into high-quality protein for human consumption. In many parts of the world, cattle are raised on land unsuitable for crop production, making efficient use of resources that would otherwise go to waste.

In conclusion, cows are not the environmental villains they are often made out to be. When managed responsibly, cattle farming can be part of a sustainable agricultural system that promotes biodiversity, sequesters carbon, and provides essential resources for human consumption. Rather than blaming cows for the planet’s problems, let’s work together to find solutions that allow us to coexist with these valuable animals while protecting the environment for future generations.

Many experts suggest ruminants can be part of the climate change solution - an empowering statement.

16.0. STOP THE WASTE

If we eliminated food waste in the morning we wouldn't have a problem with combating climate change.

This statement is thought provoking, we need to stop the waste when it comes to fertility on farm, feed waste on farm, disease waste, the list goes on.

More than 1/3 of all food is wasted. That's 1.3 billion tonnes every year according to The UN Food and Agriculture Organisation (FAO). If food waste were a country, it would be the 3rd largest emitter of greenhouse gases after the US and China causing 3.3 billion tonnes of CO_2 emissions a year.

It's not just the food itself that goes to waste, it's all the resources that went into making it, from water to land and labour. Food waste is a massive problem affecting people, planet and profit: almost 870 million people in the world go hungry every day, food waste contributes 8% of the world Green House Gas Emissions and the estimated global cost is €1.2 trillion of lost profit every year. (Colgan, 2019)

According to the Stop Food Waste website we generate at least 1 million tonnes of food waste each year here in Ireland. Most of us are unaware of where the food we waste, ends up, so we don't fully understand the direct and indirect consequence. The worst case is that food waste is collected and then either disposed of in landfill or incinerated. Less than half is recycled into biogas and compost or used for animal feed within the EU. (Colgan, 2019)

Tackling Food Loss and Waste Along the Value Chain

As the world faces the challenge of feeding a global population projected to reach 9.7 billion by 2050, demand for animal protein continues to rise.

Approximately one-third of food derived from animal protein production is currently lost or wasted. Action at every stage of the food supply chain is required to tackle this issue.

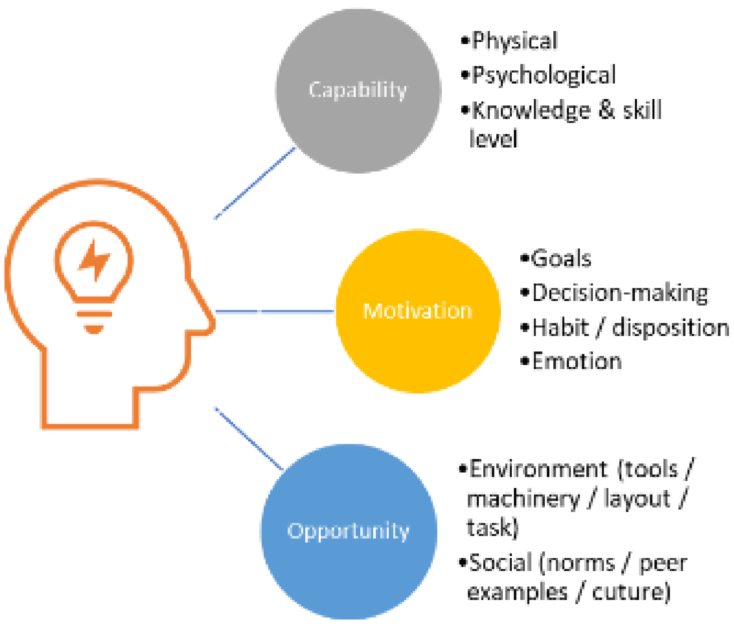
Animal protein is a key part of healthy, balanced nutrition and is also essential for the provision of key micronutrients. We must avoid losing or wasting such a precious resource. One approach is through specific nutritional intervention during the animal production period. (DSM- Firmenich, 2023)

17.0. BEHAVIOURAL CHANGE

The author felt that it was imperative as part of this project given the outcomes to research behaviour change in society. To reach our climate goals, reduce emissions on farm and reduce food waste requires behaviour change at an individual level.

Behaviour change at societal level is complex and multifaceted, involving various stakeholders and influences. Successful behaviour change initiatives require understanding the social, cultural, and structural factors that contribute to behaviours. By leveraging theories, models, and effective strategies, the farming community can foster positive behaviour changes that lead to improved farming efficiencies and environmental sustainability.

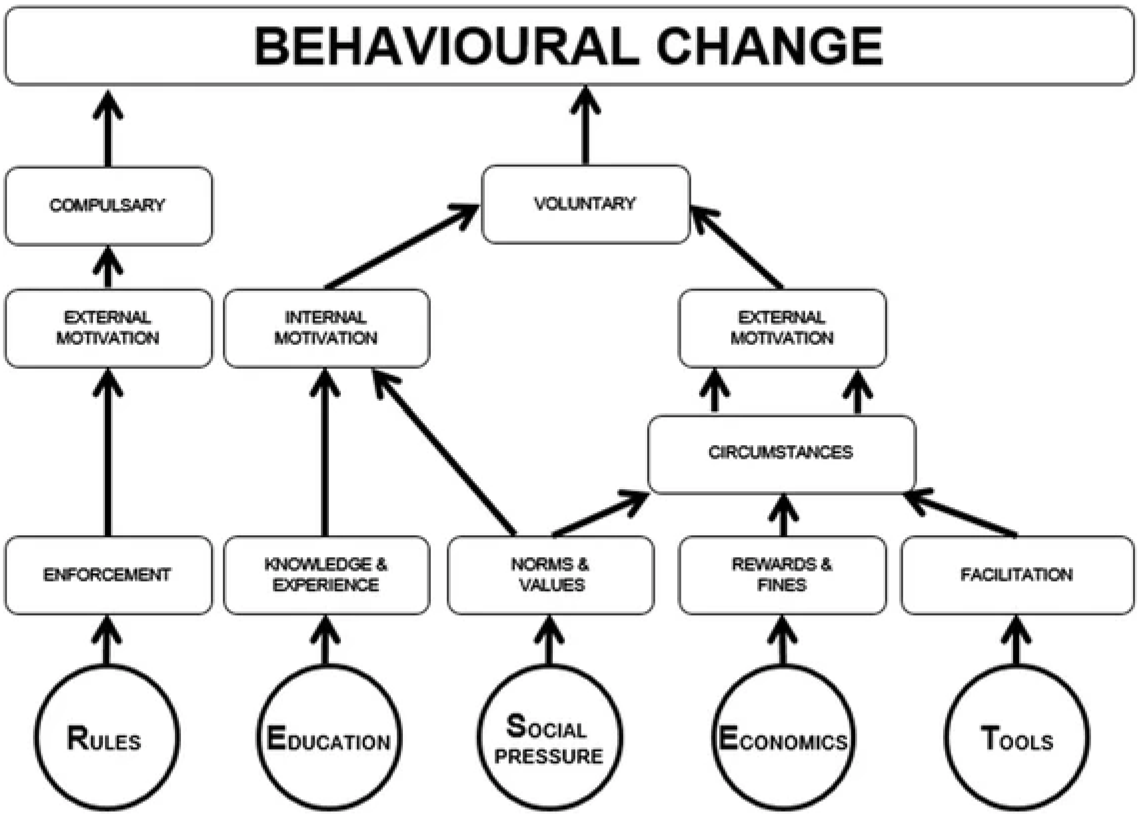
The Behaviour Change Wheel (BCW) is a comprehensive framework developed by Susan Michie and her colleagues, designed to provide a systematic approach for planning behaviour change interventions. It was introduced in their 2011 paper titled 'The Behaviour Change Wheel: A new method for characterizing and designing behaviour change interventions' (Michie et al., 2011). The BCW integrates various behaviour change theories into a practical tool for researchers and practitioners looking to implement effective behavioural interventions.



A popular model for guiding the development of interventions is the COM-B model (Michie et al., 2011) which requires the assessment of Capability, Motivation and Opportunity in order to understand Behaviour.

This model was utilised when decreasing antibiotic usage in dairy cattle in the Netherlands.

The Behaviour Change Wheel provides a structured approach for understanding behaviour and designing interventions. Its comprehensive nature enables practitioners to consider multiple aspects of behaviour change, making it a valuable tool for developing effective strategies to influence behaviour across various contexts.



The RESET Mindset Model, adapted from Woerkum et al.

Behavioural change simplified for the author; is it the carrot or stick approach. Initially, the author believes we need to fully understand farmer beliefs and motivations.

An example of a successful campaign in an Irish agricultural context would be the BVD Eradication Scheme lead by Animal Health Ireland. This is a good example of change at farm level and involved both the carrot and the stick.

18.0. CONCLUSIONS

This research project investigated how Animal Health can positively impact our climate change targets. The Nuffield scholarship presented the author with an incredible opportunity to travel and explore the world, to challenge his opinions and perspectives, to put him out of his comfort zone and give the licence to be curious about all thing's agriculture. It has given the author an increased understanding in a global and Irish context the challenges faced concerning emissions.

Climate is the average weather in a place over many years. Climate change is a shift in those average conditions. It is driven predominately by an increase in global temperatures caused by emission of greenhouse gases (GHGs) from human activities. There are three main GHGs relevant to Agriculture: carbon dioxide (CO_2); methane (CH_4); and nitrous oxide (N_2O). While CO_2 is released mostly from burning fossil fuels, for agriculture, the main GHGs are methane (65%) and nitrous oxide (30%). In Ireland, agriculture currently contributes 37% of the total GHGs emitted. GHG emissions on Irish farms come primarily from methane belched by cattle and sheep, fertiliser use, animal excrement and diesel. (Teagasc, 2021)

The European Food Safety Authority defines the concept of one health of covering animal diseases, as well as the interplay between animal welfare, human health, environment protection and food safety. (EFSA)

The FAO inform us that healthy animals can help reduce effects of disasters and climate change. (FAO)

Improving animal health can help to:

- Reduce the impact of climate change: disease surveillance and control help to protect animals from impacts on their health, caused by climate events, changes in disease patterns or other disruptions.
- Mitigate climate change: healthier animals are more productive and generate lower emissions per weight of product produced.
- Adapt to climate change: healthy animals are more resilient than crops to adapt to marginal conditions and withstand climate shocks.

The following are the main conclusions from this research project:

- Improving animal health on farm through efficient management practices and animal health preventative strategies will play an integral part in decreasing emissions.
- Animal health agricultural technology will play a role in achieving our climate change targets.

- We need to challenge the 'status quo' and understand behavioural change to achieve desired outcomes.

  "We've got to put a lot of money into changing behaviour." -Bill Gates
- Effective collaborations between industry, policy makers and academic researchers will be required to guarantee that real science is translated to pragmatic, realistic advice and recommendations.
- Reducing emissions is a complex issue as measuring emissions is complex.

The dairy sector is already part of the solution to address climate change. However, it needs to accelerate its current efforts by continuing to improve production efficiency and continue to reduce emission intensity of milk. To achieve this, the sector needs to adopt more rapidly the technologies and best practices which will potentials for GHG emission.

There is no silver bullet or simple solution here. Based on extensive research conducted during their travels, the author concludes that any product designed to reduce emissions must also enhance productivity or profitability, presenting a significant challenge.

Global experts suggest Managing livestock methane can be part of the climate change solution.

In conclusion:

- The concept of 'The Power of Prevention' refers to the importance of having a robust prevention and vaccination or herd health plan in place.
- Animal health agricultural technology can significantly improve efficiencies on the farm, therefore reducing emissions.
- Additionally, there is research on a novel concept focused on reduction at the source of emissions in the rumen.

19.0. RECOMMENDATIONS

- Improve general herd health status by embracing animal preventative strategies and efficient animal health practices.
- Improve awareness and communication on how to reduce emissions with animal health through education and data. Communicate ways that key stakeholders can support or add to these sustainability initiatives. Incorporate opportunities for feedback on sustainability aspects in its procedures.
- Ireland should have a taskforce across all stakeholders to reach our environmental goals.
- Promotion of further research and investment in solutions to reduce methane emissions. E.g. vaccine and bolus research applicable to Ireland.
- Farmers need to be incentivised to seek and adopt solutions to reduce emissions.
- Successful reduction in emissions requires a comprehensive approach.
- Farms should have a bespoke climate action plan to reduce emissions related to farm operations.
- Communication and cross collaboration - tackle the issue head on. There needs to be increased dialogue with the stakeholders involved.

We need to continue to embrace existing tools, the temptation is to be always looking for something new and shiny. The author's research travels suggested that Ireland's farmers have made significantly more efforts to reduce emissions than farmers in other parts of the world. However, there is still a lot of work to do on Irish farms.

The FAO estimates that an increased uptake of existing animal health and husbandry technologies and practices can reduce livestock emissions intensity by 18-30%.

Knowledge Transfer - Further education and awareness is required at farm level as to how animal health can dramatically reduce emissions. We hear a lot of talk reseeding our grassland with multi-species swards and increased use of dribble bars, in terms of slurry spreading but there are more solutions out there.

We should explore the factors that explain the current rates of adoption of agricultural technology and vaccines. Finally, further research is required to reduce emissions at source in an Irish context.

Capper 2023 suggests; As livestock producers become more aware of the importance of improving health and reducing GHGe, this knowledge gap will urgently need to be filled. Ideally, this would be achieved through implementation of an accurate and continuous global disease surveillance monitoring and reporting system, coupled with improved on-farm GHG assessment tools and metrics.

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