THE BOOLEAN
SNAPSHOTS OF DOCTORAL RESEARCH AT UCC

UCC
University College Cork, Ireland
Coláiste na hOllscoile Corcaigh

Decisions Decisions – A Farmer's Mitigation Dilemma

Marion Cantillon[1]

[1] *Cork University Business School, University College Cork, Cork, Ireland*

Abstract

Livestock producers are under rising pressure to nourish a growing population while simultaneously reducing the impact of meat/milk production on the planet's climate. Decision Support Tools (DST) provide a valuable evidence-based decision-making framework in agriculture to improve productivity and environmental outputs. Decision Support Tools are often developed and designed by local stakeholders and tend to represent their national system. While current DSTs may be used to examine the impact of management choices on farm emissions, there are relatively few tools available for Irish farms that take into account both the environmental and financial aspects of decision-making. This research will improve existing farm scale decision support systems designed to cost effectively mitigate Green House Gas emissions from livestock production systems.

Keywords: agriculture, mitigation methods, farm level, decision support tools, agro-economics, climate change.

You cannot make progress without making decisions

— Jim Rohn

Climate Change

Climate change is the buzzword for the 21st century with it being the centre of policy debates, media coverage and world forums. Climate change means a notable change in the measures of climate, such as temperature, rainfall, or wind, lasting for an extended period – decades or longer. Climate change can result from natural processes and factors but more recently due to human activities through our emissions of greenhouse gases. Emissions of greenhouse gases are causing increased air and ocean temperatures, drought, melting ice and snow, rising sea levels, increased rainfall, flooding, and other influences. This will have a disastrous effect on nature, causing permanent changes in many ecosystems and resulting in a loss of biodiversity

and ecosystem functions and services that are essential to human well-being. Higher temperatures and catastrophic weather events will wreak havoc on the global economy and society. One sector that will feel the pressure is Agriculture. As their livelihoods come from the land and their actions greatly affect it. Which gives rise to the farmer's dilemma – How can one continue to produce enough food for a growing population while maintaining a stable financial situation and the environment?

There are many factors to consider in addressing this question. Firstly looking at the greenhouse gas emitted from Ireland and the Agriculture sector. Briefly describing some of the everyday decisions farmers are faced with and their trade-offs. Finally the role of Decision Support Tools in agriculture to assist both Farmers and Advisors in making decision, considering the financial structure of the farm while also satisfying greenhouse gas limitations.

Greenhouse Gas — Ireland

To combat climate change, 197 nations joined the Paris Agreement, which aims to keep global temperature rise below 2 degrees Celsius over pre-industrial levels this century. The EU has also set carbon reduction objectives, with Ireland being assigned a 20% reduction by 2020 and a 30% decrease by 2030 evident in Figure 1[4] Since March 2021, the government has adopted the Climate Action and Low Carbon Development Bill. This legally binding Bill has a target to halve greenhouse gas emissions and achieve net carbon neutrality by 2050. In accordance with the Paris Climate Agreement, the bill also establishes a legal duty to adhere to five-year carbon budgets and sets emission ceilings for all sectors. So far, the most significant reductions in emissions have come from the electricity and industrial sectors, which are already subject to carbon pricing under the EU Emissions Trading System (ETS). Buildings and agriculture, which together contribute three times as much to emissions in Ireland as they do in other EU nations, face unique difficulties.[4]

Ireland's Greenhouse Gases and Agriculture

Numerous factors shape and drive the agricultural sector: Market fluctuations, changes in domestic and international agricultural policies (with subsidies, tariffs, and incentives), land use regulation, and biophysical characteristics are among the primary influences. Being dependent on natural resources means agriculture is also vulnerable to climate change induced uncertainty. Since the 1960s, the significant rise in agriculture production has supported the creation of the present global food system, which is both a key cause of climate change and becoming increasingly sensitive to it. Given the existing food system, the UN Food and Agriculture Organization (FAO) forecasts that a 50% increase in food production is required by 2050 to satisfy the growing population.[4] Assuming a continuation of current production and consumption patterns, this would result in a significant increase in GHG emissions as well as other environmental consequences like biodiversity loss and land degradation due to intensive farming.

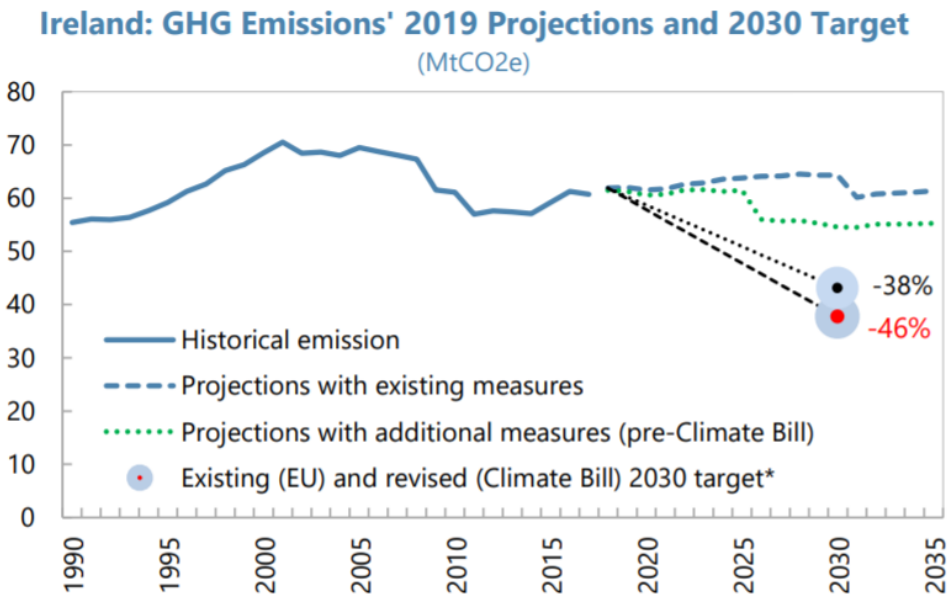

Figure 1: Ireland's GHG emissions and target.[1]

The primary GHG emissions from agriculture are CO_2, CH_4, and N_2O, and their cumulative influence on the climate change impact category may be calculated using the global warming potentials (GWPs in kg CO_2 eq per kilogram of gas emission). The IPCC (International Panel on Climate Change) guidelines is the most widely used methodology for estimating GHG emissions.

Farmers' Decision

Farmers are tasked everyday with making decisions that will impact their business. Farmers make decisions in a dynamic and complex environment that is subject to economic, political, social, and environmental uncertainty. This complexity is exacerbated by volatile market pressures, in which both input and output prices change, as well as variable weather conditions. Farmers invest in inputs and capital to grow and harvest crops, pasture, and animals, but they need to invest in and serve the persons who make the decisions. Defective decision-making may be just as destructive to a farm as faulty and inefficient machinery. The figure below lists just some of the factors farmers may be faced with in deciding farm planning.

Adopting technology for sustainable agricultural systems entails risks and trade-offs. The speed and degree of acceptance vary significantly across farmers and nations.[3] Adopting and implementing technology for sustainable agricultural systems may entail a number of steps (initially investment cost, disruption to production flow and withdrawal costs if system is not suitable). This has significant ramifications for farm structure and the number of farmers who will be able to survive financially into the future.

Farmers will invest in and apply sustainable technology and farming methods if they believe the benefits will exceed the costs, if they have the necessary knowledge and information.[3]

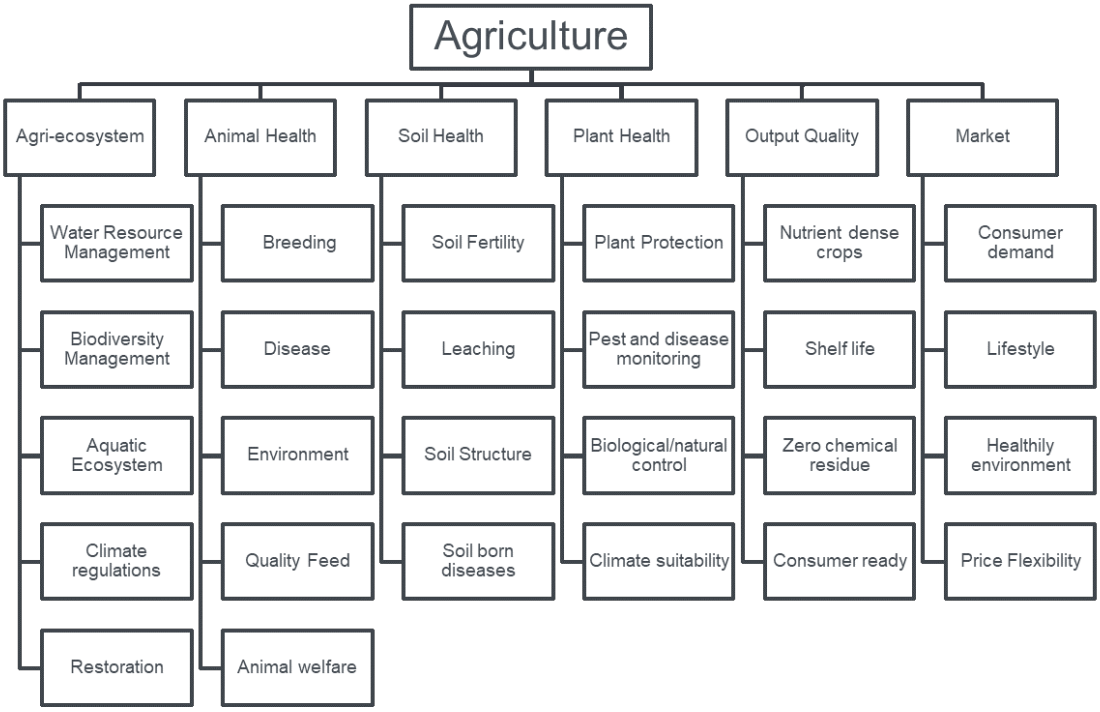

Figure 2: Decision categories.

Given the complexity of the issues farmers face and the vast array of mitigation and production decisions, decision support tools could prove a useful aid in the battle against climate change.

Decision Support Tools (DST)

Feeding the world's growing population while minimising the impact of livestock production on the environment is one of the greatest challenges facing modern society. Farmers need to adopt a range of mitigation strategies to reduce the contribution of livestock to climate change. Many of the choices farmers face in this regard are complex and Decision Support Tools (DST) may be useful for farmers in selecting appropriate mitigation strategies. DST provide farmers with a valuable evidence-based decision-making framework to improve productivity and environmental outputs. Decision Support Tools are often developed and designed by local stakeholders and tend to represent their national system. Decision support tools are software-based systems that incorporate models and databases that are used in decision-making. Currently there is a vast array of decision support tools available. There are five classification types of decision support models: Simulations, Optimisations, Heuristic, Predictive/forecasting and Statistical models. Each model has their own strengths and weaknesses and are applicable for farm decision-making and carbon footprint estimations.

Mitigation strategies is one of the key decisions farmers must make. Mitigation as defined by the Intergovernmental Panel on Climate Change, is described as "An anthropogenic intervention to reduce the sources or enhance the sinks of greenhouse gases"[2] in other words it is

Grass based Systems	Crop Systems	Livestock systems
Improving Pastures	Establish cover crops in autumn	Early finishing of beef heifers and steers
Grass legume swards	Early harvesting and establishment of crops in autumn	Improve total genetic merit of dairy cow
Incorporating straw in the soil	Cultivate land for crops in spring rather than autumn	Feeding nitrate
Ditch management on grassland	Buffer zones	Nutrient management planning
Using high sugar grasses	Use clover in place of fertiliser nitrogen	Increasing weight gain
Cultivate compacted tillage soils	Cover crops in rotation	Increasing calving rate
Reduce field stocking rate when soils are wet	Under sown spring cereals	Cover solid manure stores with sheeting

Figure 3: Mitigation strategies in DST.

an action taken to lessen the sources of greenhouse gases or improve their sinks. Mitigation options and strategies in agriculture include cropland management, livestock management, organic soil management (peatlands and wetlands), land use modification, and improving energy efficiency /renewable energy usage. There are numerous techniques to assist with reducing GHG emissions in agriculture:

- emissions can be decreased;
- emissions may be avoided or transferred;
- sinks can be developed to remove emissions.

Figure 3 depicts just some of the mitigating methods linked with decision support systems. However, it is worth mentioning that of the seventeen decision support tools reviewed during the course of this research, only five provided mitigating methods. A combined total of 116 mitigation methods were collected from these decision support tools. These mitigation techniques were divided into three systems: Grass based Systems, Crop Systems and Livestock systems.

Cost Analysis	DST
Not Apparent	8/17
Basic Economic Assessment	6/17
Estimated Mitigation Method Costs	3/17

Figure 4: Cost Assessment in DST.

The diversity and variation of mitigation strategies show how challenging it can be for the farmers to choose between them. As they vary in approaches from soil management to animal husbandry, the risk and requirements for each strategy is different. The specific mix of appropriate and cost-effective mitigation options will vary according to the type of farming system and the agro-ecological properties of the farm. With the abundance of information available (e.g. environmental, crop-related, and economic data), stakeholders and farmers may struggle to make appropriate agricultural management decisions since it is challenging for them to translate this information into practical knowledge. As a result, platforms such as decision support tools are required to aid them in making evidence-based and accurate judgements.[5]

While the degree of cost analysis varies significantly across all seventeen-decision support systems, it ranges from not apparent to basic cost functions (revenue, expenditures, and profit) to a more complete cost breakdown of mitigation strategy and economic impact on farm (Figure 4). Determining financial performance is a key element when evaluating mitigation strategies. Using DST at farm level, the effects of mitigation strategies on emissions and costs should be assessed more systematically and precisely as the agricultural sector operates in tight margins.

Having an adequate and rapid economic section in these DSTs is vital in being able to assess the trade-off between profit and carbon foot print (as implementing any mitigation option will come at an expense to the farmer). DST use a vast array of input variables that generate a report sheet as an output. This usually consists of a GHG emission report, general farm data, biodiversity assessment and energy consumptions but little on financial implications. The example below is a before and after representation of an Irish farmer who reduced his application of fertiliser by 10% which showed a corresponding drop of 3% in his GHG emissions (Figures 5 & 6) However, there is no indication of the financial impact this will have on farms gross output (i.e. Milk and Beef). This missing component is critical for a farmer to make a financially sound decision.

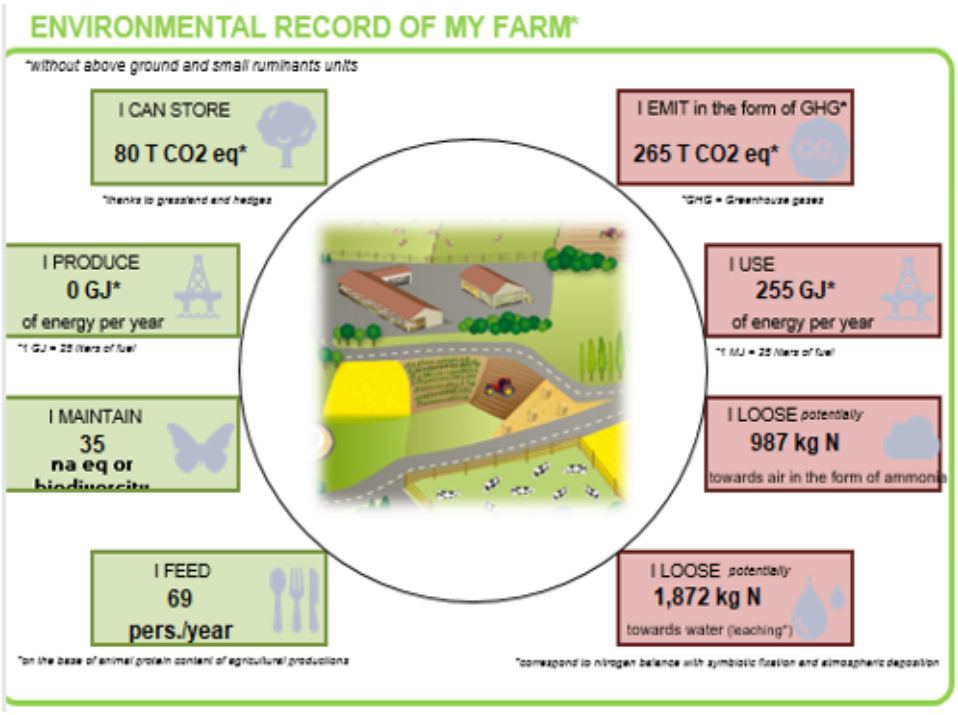

Figure 5: Model results before.

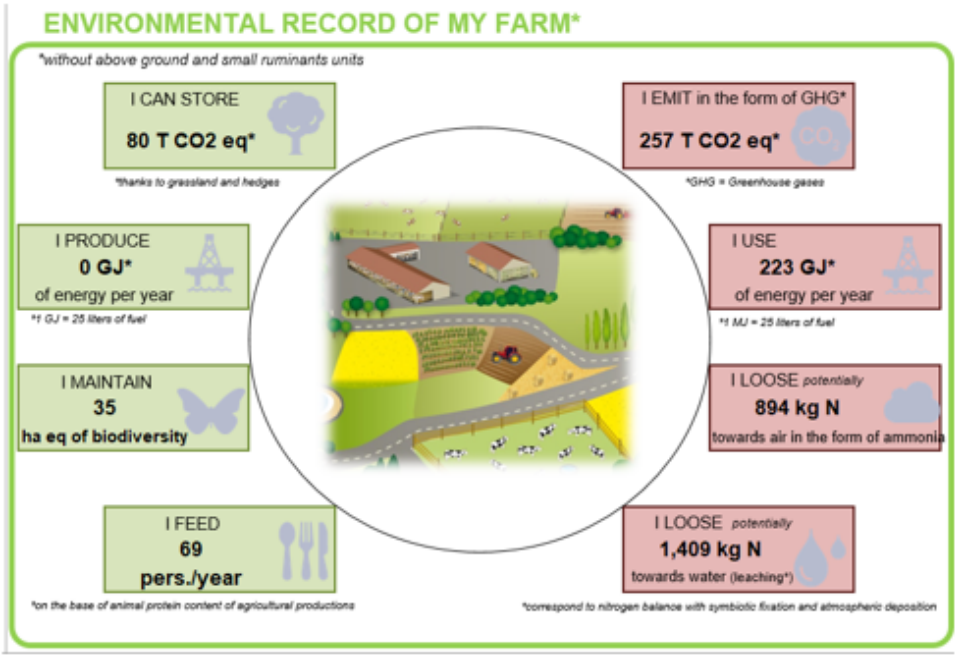

Figure 6: Model results with mitigation strategy.

Summary

While existing DSTs can be used to assess the impact of management decisions on the emissions generated by the farm, relatively few tools exist for Irish farms that consider both environmental and financial implications of decision-making. This is the gap that this research aims

to address. This will be done by developing a cost evaluation report on each mitigation strategy along with the amount of emissions reduced/stored by the strategy and linking it to a cost per unit of product produced by farm.

This set of new financial reports will provide the farmer with five main segments: Farm profitability segment for short term planning, Farm sustainability module for medium term planning , Farm Management Plan- Plan for the next season, Farm goals segment for long term planning/investing and finally a Solution trade-off Manager which will manage the Carbon footprint and Profit trade-off.

Acknowledgements

I would like to thank my supervisors Professor Thia Hennessy, Professor Armagan Tarim, Dr Donal O'Brien and Dr Saoirse Cummins for their encouragement and support. I would also like to gratefully acknowledge funding provided by the Teagasc Walsh Scholarship. All ethical guidelines relating to the research and publication process were adhered to throughout this study.

References

[1] International Monetary Fund. European Dept. Ireland: Selected issues. *IMF Staff Country Reports*, 2021(124):A001, 2021.

[2] John Theodore Houghton, YDJG Ding, David J Griggs, Maria Noguer, Paul J van der Linden, Xiaosu Dai, Kathy Maskell, and CA Johnson. *Climate change 2001: the scientific basis: contribution of Working Group I to the third assessment report of the Intergovernmental Panel on Climate Change (IPCC)*. Cambridge university press, 2001.

[3] OECD. Adoption of technologies for sustainable farming systems. In *Wageningen Workshop Proceedings*, 2019.

[4] Expert Meeting on How to Feed the World in 2050, Food, and Agriculture Organization of the United Nations. *Proceedings of the Expert Meeting on How to Feed the World in 2050 [electronic resource] : 24-26 June 2009, FAO Headquarters, Rome*. Food and Agriculture Organization [Rome], 2009.

[5] Zhaoyu Zhai, José Fernán Martínez, Victoria Beltran, and Néstor Lucas Martínez. Decision support systems for agriculture 4.0: Survey and challenges. *Computers and Electronics in Agriculture*, 170:105256, 2020.