Rebound and GHG Effects in AgriTech

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Abstract

In Scotland, GHG emissions arising from agriculture and farming contribute significantly to the overall total. Increasingly, technology is seen as a way to improve efficiency and therefore reduce these emissions. In this work, we explore how this AgriTech forms a complex case study for low carbon computing with a range of opportunities and tensions for both low carbon ICT and its utilisation. We provide the LOCO community with an overview of AgriTech in dairy farming and highlight a number of key areas of future work.

Keywords

AgriTech, Low Carbon Computing, Rebound Effects, GHG Emissions, Digital Twinning

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1 Introduction and Background

Global Green House Gases (GHGs) relating to food and drink production are well documented and modelled. At a global scale they account for 30% of all GHGs [4]. ICT is currently around 2% of GHG and is forecasted to grow to 830 million metric tons of CO2 (MtCO2e) by 2030 [2]. AgriTech is a popular approach for developing and bringing digital technology into farming practices. Low carbon computing is essential to ensure that the GHGs associated with ICT are minimised to ensure the benefits of ICT at scale without significant contributions towards tipping points that cause ecological destruction [12]. Given the scale of farming and growing demand on carbon intensive farming, there is potential that ICTs for optimisation and automation produce a not insignificant GHG or carbon footprint in the context of farming due to scale.

In this paper we are concerned with dairy farming, a subset of agriculture. Our research is based in Scotland and the North West of England. In 2022 GHG emissions from agriculture in Scotland have reduced by 11.9 percent, and are now at their lowest levels (7.7 MtCO2e) since the baseline period in 1990 (8.7 MtCO2e). Yet there is still work to do to meet these targets [10]. Dairy farming operates in very tight financial margins. In the UK the costs of dairy farming are framed in relation to the price of a litre of milk produced. In large part due to the pressure of supermarket price points (which do not reflect the true cost of dairy farming), milk is sold close to, or at cost, in the UK. In recent times, prices have dropped below this, with milk sometimes sold at a loss. This is in tension with attempts to reduce carbon emissions of agriculture, as farmers prioritise reductions in operating costs in order to survive in a harsh market.

Carbon calculators are a tool used to understand and model emissions. However, as with many sectors, those focused specifically on agriculture often do not consider the ICT emissions [18]. That is, existing estimates do not include contributions from the inherent ICT infrastructure that is at the core of AgriTech services, and must be considered as an addition [9]. Indeed, many agricultural GHG calculations only capture emissions 'to the farm gate', and thus do not consider anything outside of this. These are considered *Scope 3*: "indirect emissions, not included in Scope 2 (emissions are the indirect emissions from the generation of purchased energy), that occur in the value chain of the reporting company" [8].

Farming by nature relies on stable environmental and ecological systems for it to be viable and sustainable. Inherently farming and farmers share concerns and values of low carbon computing and ecological sustainability. A key tension is that farming is shaped and limited by tough financial circumstances of the markets, and regulatory pressures and policies that enforce particular behaviours. Currently, there is little consideration of the harmful aspects of AgriTech and high carbon computing due to the invisible nature of ICT infrastructure [7], and that ICT on the farm is primarily a Scope 3 GHG concern as these are often procured services that exist beyond the farm gate. To help richly consider these conflicts in values we turn to rebound effects as a lens from considering the knock on effects of high carbon tech or more generally AgriTech utilisation without the consideration of GHG, environment or ecology.

2 Rebound Effects

Rebound effects occur when an intervention to an existing process (such as the utilisation of AgriTech to improve agricultural efficiency) results in unintended consequences, including those that go directly against the initial intended outcome [6]. For example, using AgriTech to reduce GHGs in a specific scenario, but unintentionally creating a net increase in GHGs by doing so. It is not necessarily limited to the environment either, and could be a societal or economic impact, related to processes beyond the farm gate. For example, could a new technology result in a farmer saving money? This money could then be spent on carbon-intensive activities (such as purchasing brand new equipment for the farm).

There has been recent calls to the wider scientific community to not only identify and analyse rebound effects, but to do so before they occur [11, 16]. This paper looks to provoke this activity within the AgriTech sector. There are very few, possibly no examples, where rebound effects have been considered in the context of the carbon footprint of AgriTech. It is believed that the industry has focused on more tangible aspects of farming practice to change at this stage, using technology as a tool to do so in most cases.

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2.1 Opportunities for Digitalisation and AgriTech

There is pressure on dairy farmers to seek out optimisations in their systems and processes in order to reduce costs and lower emissions. In this context the potential for digtialisation is immensely appealing to dairy farmers with four key opportunities:

- Digital technology and autonomous systems can automate a range of repetitive and laborious tasks on a farm, reducing person hours and manual labour required [5].
- Remote sensing allows for farmers to understand the performance of their farms through ICT (e.g., interactive dashboards) [13].
- Optimising costly processes and reducing waste through data driven and remote sensing enabled services in complex systems [15].
- ICT enables Precision farming, which is a digital and data rich approach to AgriTech, enabling advanced optimisations, forecasting, and closes the automation loop by enabling dynamic and responsive data-driven farming [14].

However, these opportunities have limited or no consideration of the carbon intensity of the digtal services or infrastructures, and are primarily concerned with reducing the costs of farming and increasing the opportunities for profit making in a challenging market. This prioritisation of cost reduction is entirely sensible and logical given the financial pressures of dairy farming and the lack of regulatory pressure to account for the carbon footprint of digital services and infrastructures in AgriTech.

2.2 Risks and Rebounds

Whilst there are a range of opportunities, there are also a number of risks that may lead to high carbon AgriTech and other unsustainable outcomes. We have used rebound effects as a lens for analysing and problematising low carbon computing in the context of AgriTech and Dairy Farming. The risks in this section include a brief discussion of the potential for rebound effects. In our work we have identified a range of risks and rebound effects relating to the carbon intensity and broader sustainability of AgriTech:

2.2.1 Farmers being oversold technology. Due to the potential optimisation and financial savings, farming is at risk of drowning in a deluge of tech and data. Whilst there is valid pressure from savings and optimisations, there is a large risk that wasteful data collection and tech infrastructure being deployed in search of evergreen techno-optimisations. It is here that there is a risk of farmers being sold technology that is carbon intensive (e.g., AI, digital twins). There is an opportunity for AgriTech suppliers to be more transparent about the carbon intensity of their data collection and storage practices, alongside greater transparency about the carbon footprint of their business models. This information being made more available and transparent enables more informed procurement by farmers, and may help farmers consider the carbon footprint of AgriTech in ways that are currently difficult.

2.2.2 Spending less time with the farm, and more time with digital twins. Digital twins promise to help close the loop and automate systems change grounded in real world data. Contextualising the data and signals from a service or interface relies upon a user's knowledge of the broader system in which the service is being used. In this case it would be an AgriTech service, such as a digital twin, being deployed in a dairy farming system. If farming is seen only through the lens of data and digital reporting, there is a risk that farmers may lose common knowledge and experiences of farming, compounded by data decontextualisation (where data is detached from the context and meaning of the system) which will likely impact the farmers relationship with livestock, ecology and could impact the care that goes into farming. Whilst it might be tempting to spend increasing amounts of time optimising a digital twin, there is something experiential about being with the cows, land and nature, that is abstracted away from when just considering the farm through the lens of the dashboard and data.

2.2.3 Increasing path dependency and lock-in with carbon intensive services and solutions. Digital technology such as digital twins, AI, etc is carbon intensive. Digital Twins are an emerging solution for visualising the farm and considering interventions in the farming system [3]. Once a farmer utilises these technologies in their work, these high carbon technologies may get locked into practice and default service offerings as they are powerful and have a lot of potential utility for optimisation. There is a risk that, like with other areas of technology use, that a cornucopian paradigm becomes the norm, where ever growing usage and reliance on digital technology and data becomes the norm (cf. [17]). These are data and technology rich solutions that rely on cloud computing and vast infrastructure. This has implications for Low Carbon technology in the future, as it means that low carbon tech will have to alter this relationship with the carbon intensive solutions, which may be a serious barrier for the uptake of low carbon technology in farming. The constraints of dairy farming (e.g., low profit margins, high labour demands) alongside the barrier of the farm gate means that there is limited scope for farmers to currently engage with carbon intensity of AgriTech. AgriTech should be responsible for accounting for it's own carbon intensity and better communicating this with the agricultural sector.

2.2.4 The carbon footprint of AgriTech is a low priority? Another risk is that the carbon footprint of AgriTech is a low priority beyond concerns of optimisation and the economic models of farming. Whilst the focus is on other larger areas of GHG emissions (e.g., fuel, fertiliser and feed [1]) there is a risk that the GHG associated with an increased reliance on AgriTech remains deprioritised meaning that the carbon footprint of AgriTech may grow in its proportion of GHG relating to farming.

2.3 Conclusion

We look forward to engaging further with the LOCO community to understand emerging areas of research, using this to steer our own work on understanding and developing low carbon computing approaches in the context of AgriTech.

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