Planetary health and digital Agriculture: Rethinking technological innovation*

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Abstract
Currently we are in the middle of an environmental crisis of ever greater severity. This is in large part a consequence of the industrial agricultural methods used, but equally agriculture is one of the areas of human activity suffering the most severe impacts from environmental disruptions. The promise of precision agriculture and smart farming has been significant reductions in the environmental impacts of agriculture. This promise is dependent on a narrow view of the environmental impact of using advanced technologies on the farm. A wider perspective is needed to assess the impact of these technologies such as that provided by the concept of Planetary Health. We present a tripartite approach to evaluating technological innovations inspired by the climate emissions reporting standard and the Planetary Health paradigm. Scope one concerns purely the activities and impact on the farm, scope two concerns the landscape as defined by geographic and social delimiters, and scope three concerns the whole planet. We provide a set of questions at each level to consider the direct and indirect/long distance impacts of any given technological solution.

Keywords
Digital agriculture, planetary health, food system, climate breakdown, biodiversity collapse

1. Introduction

It is widely recognised that we are in the middle of a major environmental crisis. The focus has been on greenhouse gas emissions resulting in the climate breakdown which we have all been witnesses in recent years. However, this only one dimension in a multidimensional crisis including the collapse of biodiversity around the world, and the widespread chemical pollution of our air, water and soil. This has been expressed as the breaching of the planetary boundaries, and 6 of 9 identified planetary environmental boundaries have been exceeded [1]. A major contributor is industrial agriculture as practiced in many advanced economies, as well as more widely the food system [2]. These agricultural practices have been responsible for a large part of the multidimensional crisis. At the same time, agriculture around the world is suffering from repeated periods of floods, droughts, loss of pollinators, and water shortages. The recent weather in Greece is just one example. Thus, agriculture is both a perpetrator and a victim in this crisis.

One widely promoted "solution" has been digital agricultural technologies (DATs) otherwise known as precision agriculture or smart farming.

2. The Agritech Imaginary

The use of information technology and computer systems in agriculture and food production has seen particular growth in the last 15 years. There have been academic papers, policy documents,

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funding strategies and funded projects, and a mushrooming start-up sector which all promote a vision of agricultural digital technologies as saviours for farmers and food production in general. DATs have promised a) a reduction of inputs for the same output e.g. by reducing pesticide and fertiliser usage, b) a reduction of labour costs through automation e.g. robotics, and c) the provision of separate income streams by exploiting the data collected and providing ecosystem services such as carbon sequestration. A key motivation has been a claimed reduction of environmental impact by reducing pesticide and fertiliser use. Given the environmental crisis, and the policies of the European Green Deal and the Farm to Fork strategy, this is a justification for investment and development of DATs. More generally this is part of a techno-utopian imaginary which reflects a deeply held belief that more technology development and adoption is inherently better, and that somehow the problems of the agricultural sector will be resolved by the next technological development. We have seen a series of such silver bullets being touted under labels such as *blockchain, digital twins, AI,* etc.

There have been papers in recent years questioning the possible impact of DATs from the perspective of ethics and potential power imbalances that the adoption of these technologies will result in, and the insufficient consideration to the necessary agricultural transition [3], [4], [5]. Beyond these relatively lone warnings, there has been immense hype about the potential benefits of DATs. If anything, a surprising number of papers have been written of the strange resistance of the agricultural sector in adopting DATs. The history of the introduction of technologies, particularly in the last 200 years does not augur well. Everything from the introduction of fertilisers in the 1830s, hybrid seeds in 1920s, pesticides in the 1920s and 30s, through to the "green revolution" of the 60s and 70s have been to the detriment of both farmers and the environment, and to the advantage of external industries [6]. There is no reason to suppose that the introduction of DATs will be any different.

The real issues are by what criteria are new technologies evaluated and who benefits or *cui bono*. We will only briefly address the first of these aspects in this short paper.

3. Existing Approaches to Evaluation Agricultural Technology Innovation

There are plenty of research papers claiming environmental impact efficiencies being achieved by the use of DATs [7]. Authors such as [7] will point to economic benefits due to reduced input costs. However, the scope of analysis of most studies concerning the benefits of DATs is largely confined to the per hectare unit of production. Thus, environmental benefits are calculated on reduced inputs (fuel, pesticides and fertiliser) translating into reduced GHG emissions and impact on biodiversity. More importantly, it is doubtful whether results (often impressive results) valid for one particular micro-climate, one particular soil and agronomic practices case, can really be generalisable. This was an inherent weakness of the famed Green Revolution – that it essentially ignored all variability due to location, height above sea level and in general the specificities of soil and micro-climate, while farmer developed seeds did just the opposite [6].

There are some integrated assessments of DATs, such as that undertaken by the QuantiFarm project (https://quantifarmtoolkit.eu/) building on previous work [8], which is assessing a number of DATs in economic, social and environmental terms. However, here the overall purpose, while seemingly multi-dimensional (assessing environmental, social and economic KPIs), is largely concerned with *comparing* one technological solution with another rather than overall assessing *whether this is a good idea overall.*

4. A Planetary Health Analytical Framework

Planetary health is a relatively old concept revitalized by the Lancet Commission on Planetary Health in 2015 [9]. It recognizes the interdependence between human health and "flourishing natural systems" emphasizing the complex interdependencies. Authors writing from a Planetary Health perspective have noted the "great acceleration" whereby human health outcomes appear to have improved immensely in the last 50 years while at the same time the negative impacts on the environment have accelerated disproportionately. The Planetary Health perspective together with the Planetary Boundaries allows for a more complex, integrative view of digital agriculture than previously. Here we propose an assessment model for whether or not a digital agricultural technology should be adopted inspired in part by the Scope 1,2,3 Green House Gas emissions approach developed by the World Resources Institute and now widely recognized in GHG reporting requirements [10]. We can identify three "scopes" for assessing DATs together with an associated set of questions. We define scopes here in terms of geographic and diachronic space. The on-farm scope concerns not just the physical space of the farm (however defined) in terms of hectares and their location, but also the human and non-human beings involved in that space, both now and over time. The same breadth of vision needs to be applied to the other scopes, Scope 2 – the Landscape and Community, and Scope 3 – the Planet. In each case we have provided only a few possible issues to consider, and the list could be extended considerably.

4.1. Scope 1 – On the Farm

The Farm needs to be defined both as a geographic area, and as involving a human- and non-human community of flora, fauna and fungi. Such a perspective forces us to consider several possible questions with regard to the introduction of any given DAT:

1. Does the DAT help the farmer? Or does the technology lock the farmer into a more complex set of dependencies? Here we have concerns about data governance, data ownership, and data sovereignty.
2. Does the DAT support the non-human inhabitants on the farm?
3. Does the DAT capture the right data on the farm? Here we think of the wide divergence in our capabilities for accurate phosphorus measurement, or the great variety in the processing of EO data. What do we mean by right data? This is taken for granted and depends on your agricultural practices.
4. Does the DAT increase or decrease crop diversity? Or will the use of some form of AI or machine learning lock in use of specific varieties and species? Remember we have already seen this phenomenon with previous agricultural technologies like GMOs.
5. Is the DAT deskilling or reskilling farmers and farm advisors? This occurs frequently in human interaction with computing systems the so called "Computer says no" phenomenon or the automation of processes. There are plenty of major errors in automated processes that should act as warnings to the overdependence on automated decision systems.
6. Is the DAT further distancing farmers (and thus society) from plants, animals and nature as a whole? Some farmers are refusing dairy robots for this reason. We are seeing a widespread "nature deficit disorder" in society, so this may be an exacerbating factor.

4.2. Scope 2 – In the Landscape and the Community

A "landscape" has become an important concept when it comes to having an integrated view of human impacts on the environment. It includes farms, urban areas and protected lands, recognizing that any action in one is bound to affect the wider landscape. Even if we could argue that the adoption of the DAT was positive for the farm and the farmer, some questions need to be asked:

1. Do the automation and other efficiencies on farm mean even fewer jobs in rural areas? This kind of social impact (flight from the land) is of importance for society and recognised by policy makers. There are occasional indications that, on the contrary, DATs are enabling young, qualified individuals to 'return" to the countryside.
2. Within the landscape, do DATs help increase biodiversity? In theory, obviously yes because of the reduction in inputs and consequent environmental damage. On the other hand,

obviously no, because these kinds of technologies are still non-ecologically based approaches to farming.

3. Does the adoption of DATs lead inevitably to greater consolidation of farms across the sector? In a data driven environment, scale is key [11] and consolidation will lead to more monocultures because monocultures are simple to manage.

4.3. Scope 3 – for the planet

There is no question that digital technology is important in understanding planetary forces including climate breakdown, biodiversity loss, ice losses in artic and mountains, land use change. The use of earth observation, mathematical models and data science techniques, sensors and drones have all been useful here. Nonetheless while some uses of technology may be beneficial to society and to the planet, more uses of technology are not necessarily better. Illich’s concept of the “Threshold of Counter-productivity” is relevant to understanding the impact of technologies[12]. So we ask, for example:

1. In what ways do the increased use of sensors, drones, robots, and autonomous vehicles increase overall energy consumption or help achieve Carbon Zero? (NB. not Net Zero). Many of these technologies depend on external sources of data or data processing (on the cloud) creating further environmental challenges.
2. Will the increasing use of technology further increase social inequality, social stratification and disenfranchisement? We should remember majority of farms under 5ha globally.
3. Does greater uptake of DATs increase food security (especially food resilience), or does the dependence on these technologies create new vulnerabilities?

5. Conclusions

This paper has argued for a more systemic, integrative and planetary scale perspective on the growing adoption and continuous promotion of DATs. We have proposed a classificatory scheme with associated questions. This could be extended in future work to quantify the specific potential impacts, possibly with suitable data driven models. However, we would argue that primarily this should be seen as a qualitative tool to be extended further as we become more aware of the complex interdependences around our technologies and their environmental impacts.

Declaration on Generative AI

The author(s) have not employed any Generative AI tools.

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