Agriculture 4.0
Ethics and responsibility for smart farming

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The ethics of agriculture 4.0

Company responsibility in an era of smart farming

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Agriculture is undergoing a fourth technology revolution. The first so-called revolution saw hunter-gatherers move towards settled agriculture, while new inventions in 17th-19th Century Britain, such as Jethro Tull’s seed drill, marked the second. The third was associated with the Green Revolution, which saw the increased use of technology in the developing world. This fourth technology revolution may equally transform agriculture beyond recognition.

Artificial intelligence, robotics, the Internet of Things, gene editing and big data, amongst other innovations, are already predicted to be the future of modern, smart agriculture. Indeed, the UK Secretary of State responsible for agriculture, Michael Gove, spoke favourably about such technologies in his recent speech to the Oxford Farming Conference. With similar global policy support for the greater use of smart technology in farming, including in Greece, Japan, and parts of the developing world such as India, this fourth agricultural revolution appears to be inevitable.

But, what are the risks associated with this technology revolution? While narratives around smart technology promise increased productivity, better eco-efficiency, and improved profitability, are there social costs that are not being considered? Does new technology like artificial intelligence actually produce unwanted impacts on society? This article explores these questions and considers what innovators within the fertilizer industry might do to ensure that technologies are socially responsible.

The promise of new technology in the fertilizer sector

There is no doubt that new innovations in the fertilizer sector will provide benefits. Precision technology allows fertilizer to be applied in a more targeted, efficient way, saving input costs, whilst limiting problems caused by either over-use or under-use (e.g. environmental damage or yield reduction). Drones can be used to take high-resolution surveys of the land to help plan fertilizer spraying, whilst the use of decision support systems can assist farmers in making informed management decisions about when and where to spray. Autonomous robots, which are becoming increasingly sophisticated as artificial intelligence develops, may apply fertilizer more precisely without the need to pay farm workers and small robots can access parts of the field that are inaccessible to other larger machines. The increased use of technology in agriculture might also attract a younger, more technical workforce to the industry. In some of our previous work, for example, we found that younger farmers were more likely to use decision support technology (see figure 1). The
smart technology revolution might provide more opportunities for this demographic.

The benefits of smart technology are thus seen by some as key to modern, sustainable agriculture and there is plenty of evidence to suggest that yields and income can increase from their application on-farm, as well as fashioning ecologically sound management and reducing waste. Yet, we rarely hear of the potential downsides to this smart farming revolution. The reason for this is clear – most innovations are deliberately sold in a positive way. Would you, for example, be more likely to buy a smart TV that listed (a) only exciting features, such as its picture and sound quality, or (b) these exciting features alongside some of the potential disadvantages, including the potential for it to work intermittently if the wi-fi connection was poor? Most of us would pick the former. When we think about buying a product, we want to know how it is going to improve our lives, and the salespeople are interested in providing an optimistic, positive vision of how it would do this. We become seduced by the benefits and forget to consider the downsides, even though we could probably list several if we thought about it carefully – for example, the potential for a smart TV to compromise our privacy or security (e.g. webcam or voice hacking).

**Technology controversies**

Technology is thus undoubtedly a double-edged sword. While it has the potential to provide benefits to farmers and society, perhaps by increasing yields and eco-efficiency, it also has the power to be destructive. We can all remember controversies caused by agricultural technologies over the past half century or more. From Rachel Carson’s emotive exposé of the impacts of DDT on farmland biodiversity, the current debate over the effects of neonicotinoids on pollinators, to the rural unemployment caused by the post-war mechanization of agriculture. Many technologies designed to improve agriculture have unforeseen, and sometimes unwanted consequences.

We are also all aware of the deep-seated tensions caused by the proposed introduction of genetic modification technologies into many places, such as the European Union. In this case, there was sufficient pressure placed on policy-makers to create the conditions for a ban on implementation, despite the fact that the technology had already been developed.

It would be unwise to think that the so-called fourth agricultural revolution will be any different. New smart technologies undoubtedly change society. Take the use of drones, robots, and decision support systems, mentioned above in a positive way – there are possible negative social implications caused by each. The use of drones may create a surveillance-style atmosphere on-farm in which farm workers feel like they are being watched and the local rural population may feel that their privacy is being invaded. The use of robots might replace farm labourers, causing unemployment, and consumers may not wish to eat food produced by an army of automated robots on-farm without a human in sight. The use of decision support systems might make farmers feel that their valuable experiential knowledge is being sidelined. Or, farmers/growers might be happy with their current lifestyles and may consider the introduction of smart technologies to damage that lifestyle. Such farmers could risk being left behind as policy support moves towards investment in technology. Remember, profit and yields are not the only considerations of a farmer! Thus, without incorporating the views of society into the design of smart agricultural technologies, the risk of controversy will be plain, and also the risk of resistance which means promised benefits are not realised (for farmers, nor the environment, nor the technology companies).
**Responsible innovation – what can technology companies do?**

Remembering the analogy of the smart TV, many readers of this article will be the salespeople. The reader might be developing smart fertilizer technologies or advising farmers/growers to use them on-farm and may play on the seductive power of technology by stressing the benefits, rather than potential downsides.

Based on unequivocal evidence that smart agricultural technologies will change life on the farm, champions of innovation are responsible for considering all of the potential impacts of their product. One might argue that it is the responsibility of policy-makers to consider social responsibility, perhaps through the use of regulation, and maybe even that private sector creativity should not be constrained. Yet, we know that the law can rarely keep in step with new emergent technologies, and thus it is partially the responsibility of those companies who are developing a product (and thus who most understand what their product can do). Indeed, one could argue that it is the duty of a socially responsible company to ensure that they consider both the potential winners, but also the losers, generated by the implementation of their product. Where possible, if losers can be anticipated, the company should seek to develop their technology differently so that fewer people lose out. The literature (e.g. work of Jack Stilgoe and others) on responsible innovation suggests four guiding principles (see table 1), which we argue in our paper (source at end) should inform the development of smart agricultural technologies.

1. **The first is anticipation.** Companies should be able to anticipate, and foresee, all of the consequences of their product, both good and bad. If these problems can be foreseen, then the development process may be changed so that these do not occur.

2. **The second is responsiveness.** If a product is launched onto farm, but a controversy occurs, the company should have a system in place to respond to problems quickly, for example shutting down misbehaving robots or recalling faulty products quickly.

3. **The third is inclusion.** As Greta Thunberg so persuasively argued at the World Economic Forum, many businesses prioritise profits over people. Smart technology has implications across agricultural society, including for farmers and farm advisers, and also to members of the public. Companies should embrace user-centred design, putting users at the centre of development so that technologies are relevant and socially responsible. Better methods of public engagement may need to be developed, but listening to public debates on social media and in the press, as well as consulting the public through surveys, consultations, and public forums are a good start.

4. **The fourth, reflexivity, is the most important.** If problems can be anticipated, or if negative impacts actually occur, or if the views of farmers and the public are not supportive of a particular technology, then companies must be reflexive enough to change their trajectory. The implementation of artificial intelligence and robotics on-farm is not inevitable.

Responsive innovation should not be seen as something that is painful for innovators. Of course, public engagement and user-centred design might be seen as slower or dangerous in a sector where there are many commercial sensitivities (designs being kept secret for commercial advantage). But if user-centred, responsible design ultimately creates technologies that farmers want to use on-farm, and helps to produce food that the public wants to eat, then time is saved in the long-run. Bad technologies can be developed quickly without user input, yet they are likely to fail in practice, which means all that time is wasted. As we move forward towards this possible fourth technology revolution, we should all do our bit to ensure that progress is determined collaboratively with user communities and crucially that potential losers are considered alongside the winners.

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**Champions of innovation are responsible for considering all of the potential impacts**

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<tr>
<th>Anticipation</th>
<th>Responsiveness</th>
<th>Inclusion</th>
<th>Reflexivity</th>
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<tr>
<td>Can impacts, both good and bad, of the technology be anticipated?</td>
<td>Can companies respond to problems caused by their technology and limit damage?</td>
<td>How can companies incorporate a variety of diverse user views into the design process?</td>
<td>Are innovators reflective enough to change their design trajectory based on user feedback?</td>
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Source: Based on Jack Stilgoe and others, Developing a framework for responsible innovation. Research Policy, 42 (9), November 2013, 1568. 1580

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This article is based on a paper by Dr David Rose and Dr Jason Chilvers from the University of East Anglia. Their paper, ‘Agriculture 4.0: Broadening Responsible Innovation in an Era of Smart Farming’, can be read online for free at https://www.frontiersin.org/articles/10.3389/fsufs.2018.00087/full. David can be contacted at david.rose@uea.ac.uk and Twitter @d_christianrose.