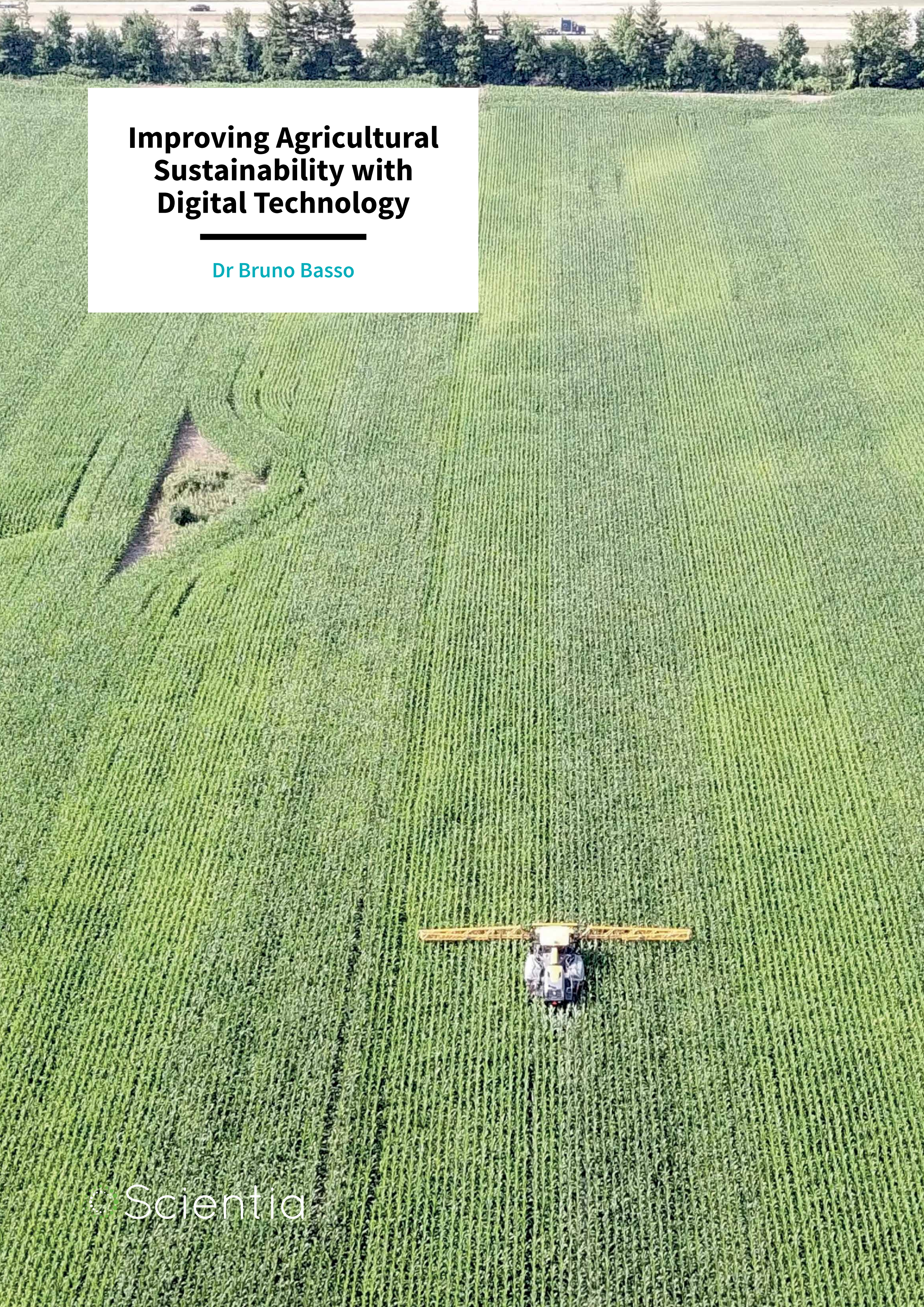


Improving Agricultural Sustainability with Digital Technology

Dr Bruno Basso

Scientia

IMPROVING AGRICULTURAL SUSTAINABILITY WITH DIGITAL TECHNOLOGY

In recent decades, advancements in agricultural practices have made the large-scale production of cheap and nutritious food possible. However, these practices are often damaging to the environment, making them unsustainable in the long term. Technology is now sufficiently developed that many of these environmental impacts can be reduced or mitigated, by using 'big data' to inform farming management decisions. **Dr Bruno Basso** from Michigan State University and his network of researchers have been exploring how digital technologies could usher in a new era of sustainable agriculture that balances competing economic and social interests while minimising trade-offs.

The Agricultural Revolution is Digital

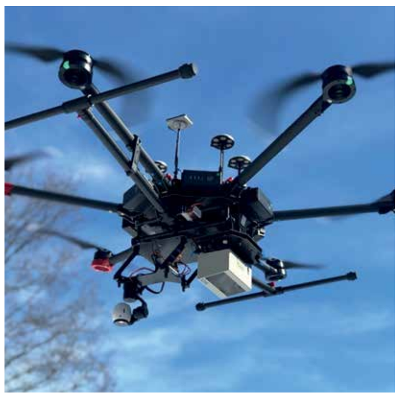
Consumers today have more choices and easier access to nutritious and inexpensive foods than ever before, thanks to the developments in agricultural technologies that have now become common practices. Machinery, fertilisers, pesticides and irrigation have allowed farmers to grow larger crops with much higher yields, to meet the demands of the growing population.

However, these conventional agricultural practices have damaging consequences for the environment. For example, excess fertiliser that is not used by the crop plants often finds its way into local waterways, disrupting the delicate aquatic ecosystems and causing large algal blooms that suffocate plants and animals. Pesticide usage and loss of suitable habitats have had dire consequences for beneficial insects such as pollinators. Greenhouse gas emissions from agriculture contribute to global climate change, having impacts far beyond the farms' localities.

It is becoming increasingly apparent to farmers, consumers, scientists and policy-makers alike that agricultural practices must become more environmentally sustainable, to ensure our future food security.

Fortunately, much of the technology required to support an agricultural revolution already exists. By combining sensor technologies, satellites, drones and GPS facilitates, collecting detailed information about the health of plants and soil is now possible. Using these tools, crop health can be monitored closely across large fields and at different stages of crop development or between seasons with relative ease.

New powerful analytical tools, such as Artificial Intelligence systems and computational modelling, allow researchers and farmers to incorporate all of this information – or 'big data' – into precise agricultural management plans, which reduce resource wastage and improve environmental sustainability.



‘Filling in the gaps with big data to create the next agricultural revolution will benefit not only the economics of agriculture, but the environment as well. We are only leasing the Earth’s land, so we must leave it in better condition than that in which it was given to us.’

Dr Bruno Basso of the Department of Earth and Environmental Sciences at Michigan State University has been exploring how advanced monitoring, analysing and predictive tools – together called ‘Digital Agriculture’ – can help farmers to balance the complex needs of a growing human population.

‘The best hope for meeting the challenge of sustainable agricultural development lies in the ongoing process of innovation now taking place using modern genetic and information technologies to increase agricultural productivity while balancing economic, environmental and social outcomes associated with agriculture and the food system,’ he says.

Through their extensive research, Dr Basso and his team have demonstrated how digital healthcare for plants and soil, in the form of better management of fertiliser and irrigation, can maintain better crop health throughout its growth cycle and improve environmental sustainability.

Precision Plant Health

Rarely are the fields used to grow crops a uniform, flat area. Even a single field can show significant variations in soil quality, microclimate, elevation and water cycling. These factors impact plant development and can lead to dramatic differences in the health and yield of the crop across the field.

Despite this, conventional agricultural practices usually treat these fields as a homogenous area, for example, by applying nitrogen fertiliser uniformly across the field. Consequently, some plants may not be getting adequate fertiliser to support their growth, while others whose growth is limited by other factors cannot use all the supplied fertiliser, which then finds its way into the surrounding ecosystem.

Dr Basso and his collaborators have been exploring how detailed crop management plans can be produced by combining Digital Agriculture with ‘precision agriculture’ – systems that allow variable inputs of fertilisers and irrigation according to the spatial variability of crop growth.

‘Thus far, algorithm developers for precision management have lacked the data and computational tools needed to convert complex spatial information on soil and plant status into appropriate crop management actions,’ explains Dr Basso. ‘Misinterpretation and misuse of data appears to be a consequence.’ For example, many farmers use precision technologies to increase nitrogen fertiliser application on low-yielding areas of fields in an effort to increase yields, rather than reducing application in these areas to avoid the excess leaching into the surrounding environment.

Dr Basso and his team developed new methods of analysing the spatial and temporal data from satellites and the yield sensors on farming machinery to produce informative yield stability maps. ‘Yield stability maps depict areas within a field characterised by consistently high productivity over time, other areas with consistently low productivity, and other areas where yields are unstable – high one year, low the next,’ Dr Basso explains.

The individualised crop management plans arising from this analysis allow farmers to incorporate not only the productivity of different areas of their fields, but also variations in other factors that affect plant development, such as rainfall, and adjust their crop treatments accordingly. Many previous attempts at prescriptive maps for precision agricultural inputs have been based solely on soil maps, neglecting the interactions between soil, weather, and other farming practices that may significantly impact crop yields in different years.

Dr Basso's evidence-based predictive approach helps to take the guesswork out of crop production and could help to reduce environmental impact. His team demonstrated that if fertiliser application was based on plant demand rather than relying on a uniform application, nitrogen fertiliser use in the Midwest of the USA could be reduced by as much as 36%. Aside from reducing waterway pollution, decreasing fertiliser use also reduces greenhouse gas emissions and energy usage.

Additionally, yield stability maps can also help farmers to re-design fields or areas within fields. Dr Basso suggests that parts of fields that are unprofitable or environmentally unsustainable can be identified and allocated to other purposes, such as wildflower patches to support pollinators and increase biodiversity, thus further increasing the environmental benefits of this approach. In high-yielding areas of the field, farmers can sustainably intensify crop production by increasing fertiliser inputs, knowing that the plants will respond positively.

'Digital Agriculture can truly lead to higher resource use efficiency by reducing losses to the environment and at the same time, increase profitability by removing low areas from production with a precision conservation approach, which should reward farmers for these environmental benefits and ecosystems services,' says Dr Basso.

Barriers and Solutions for Implementation

The agricultural sector currently faces enormous challenges. With the human population expanding, producing enough food to feed everyone is becoming increasingly difficult. Balancing this need with protection of the environment, which we all rely on, often leads to tough trade-offs.

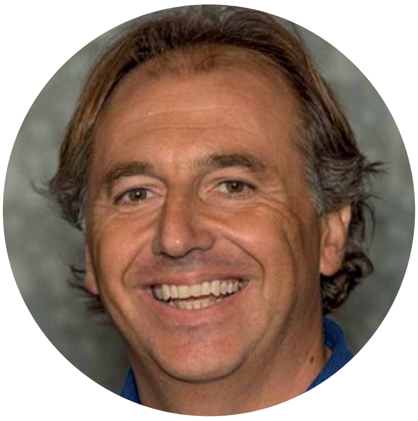
'The current agricultural system needs to adapt and become more efficient on less farmland, and under climate change threats, in order to feed a growing population,' says Dr Basso. 'Farmers must consider their personal ability, financial stake, and a myriad of environmental considerations before leaping into a new practice or adopting innovative technology.'

Farmers are generally very aware of the negative impacts agricultural practices have on the environment, but it is important to recognise that policymakers and consumer demands also play a large role in shaping agricultural systems. While Digital Agriculture is still developing, through the work of researchers including Dr Basso, precision agriculture has been possible for around three decades. However, it has thus far failed to produce the expected improvements in environmental performance of farms. Dr Basso suggests that this may be, at least in part, due to the lack of effective policies to incentivise the use of precision agriculture technologies.

To ensure Digital Agriculture does not suffer similar failures, appropriate policies, subsidies and investments will be necessary to encourage behavioural changes in both consumers and producers. Thus, at its core, the mission of the Digital Agricultural revolution is to balance complex economic and social needs by incorporating agriculture, science, technology, policy and education.

Additionally, to ensure the success of sustainable technologies across the globe, they need to be economically viable for the large-scale systems of commercial agriculture, as well as the smaller-scale systems common in developing countries. Public policies and investments could also help to support the development of sustainable technologies that achieve this goal. Dr Basso notes that until investments are made towards this, progress is likely to remain limited.

Fortunately, tools such as Digital Agriculture are advancing rapidly. 'Filling in the gaps with big data to create the next agricultural revolution will benefit not only the economics of agriculture, but the environment as well,' concludes Dr Basso. 'We are only leasing the Earth's land, so we must leave it in better condition than that in which it was given to us.'



Meet the researcher

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Dr Bruno Basso earned his PhD in Crop and Soil Sciences from Michigan State University, before continuing onto an assistant professorship in the Department of Crop Systems at the University of Basilicata, Italy. He currently holds the position of University Foundation Professor in the Department of Earth and Environmental Sciences at Michigan State University. His research interests focus on how to improve the sustainability and yields in agricultural systems, in particular, by using digital technologies and computational modelling. Dr Basso has received numerous academic awards and fellowships for his research, has been invited to present his work at meetings across the world, and has published nearly 200 articles in peer-reviewed journals. Additionally, Dr Basso is the co-founder and chief scientist of CiBO Technologies, an innovative land intelligence system that utilises geospatial technology to identify the value and environmental sustainability of a piece of land.

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