Nanotech and AI could hold key to unlocking global food security challenge

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'Precision agriculture' where farmers respond in real time to changes in crop growth using nanotechnology and artificial intelligence (AI) could offer a practical solution to the challenges threatening global food

security, a new study reveals.

Climate change, increasing populations, competing demands on land for production of biofuels and declining soil quality mean it is becoming increasingly difficult to feed the world's populations.

The United Nations (UN) estimates that 840 million people will be affected by hunger by 2030, but researchers have developed a roadmap combining smart and nano-enabled agriculture with AI and machine learning capabilities that could help to reduce this number.

Publishing their findings today in *Nature Plants*, an international team of researchers led by the University of Birmingham sets out the following steps needed to use AI to harness the power of nanomaterials safely, sustainably and responsibly:

- Understand the long-term fate of nanomaterials in agricultural environments—how nanomaterials can interact with roots, leaves and soil;
- Assess the long-term life cycle impact of nanomaterials in the agricultural ecosystem such as how how repeated application of nanomaterials will affect soils;
- Take a systems-level approach to nano-enabled agriculture—use existing data on soil quality, crop yield and nutrient-use efficiency (NUE) to predict how nanomaterials will behave in the environment; and
- Use AI and machine learning to identify key properties that will control the behavior of nanomaterials in agricultural settings.

Study co-author Iseult Lynch, Professor of Environmental Nanosciences at the University of Birmingham, commented: "Current estimates show nearly 690 million people are hungry—almost nine percent of the planet's population. Finding sustainable agricultural solutions to this

problem requires us to take bold new approaches and integrate knowledge from diverse fields, such as materials science and informatics.

"Precision agriculture, using nanotechnology and artificial intelligence, offers exciting opportunities for sustainable food production. We can link existing models for nutrient cycling and crop productivity with nanoinformatics approaches to help both crops and soil perform better—safely, sustainably and responsibly."

The main driver for innovation in agritech is the need to feed the increasing global population with a decreasing agricultural land area, whilst conserving soil health and protecting environmental quality.

Intensification of agriculture has resulted in extremely poor global NUE, which poses a serious threat to environmental quality as large amounts of nutrients are lost to water and air—warming the planet, with nearly 11% of global greenhouse gas emissions coming from agriculture.

Of particular concern is the emission of the 'laughing gas' nitrous oxide as a result of excessive nitrogen fertilization of land, which is 300 times more potent than carbon dioxide in inducing global warming. Some 70% of the anthropogenic source nitrous oxide emissions into air are contributed from the agricultural sector.

Nano fertilizers offers the potential to target crop fertility, enhance NUE and reduce nitrous oxide emission, which can thus help support the net zero greenhouse gas emission by 2050 targets under the UK Climate Change Act.

The research team, which includes experts from the Hellenic Military Academy, in Vari, Greece and Novamechanics Ltd, in Nicosia, Cyprus, note that nanotechnology offers great potential to enhance agriculture in

four key ways:

- Improving production rates and crop yields;
- Boosting soil health and plant resilience;
- Improving the efficiency of resources, such as fertilizer, and reducing pollution; and
- Developing smart sensor plants that can alert farmers to environmental stresses.

Co-author Dr. Peng Zhang, a Marie Sklodowska-Curie Research Fellow at the University of Birmingham, commented: "Computational approaches including AI and machine learning will have a critical role in driving the progress of nano-enabled agriculture. Such approaches are already starting to gain regulatory acceptance for safety assessment of nanomaterials, allowing the development of safe-by-design nanomaterials for consumer products and medicine.

"Integrating AI and nanotechnology into precision agriculture will play a vital role in probing the design parameters of nanomaterials for use in fertilizer and pesticide delivery to ensure minimal impacts on soil health coupled with minimal nanomaterial residues remaining in the edible tissue portions—helping to ensure safe and sustainable agriculture."

More information: Nanotechnology and artificial intelligence to enable sustainable and precision agriculture, *Nature Plants* (2021). DOI: 10.1038/s41477-021-00946-6 , www.nature.com/articles/s41477-021-00946-6

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