Committee: Special Conference on Sustainable Consumption and Production (SPECON)

Topic: Exploring applications of Artificial Intelligence (AI) and analytics in promoting sustainable agricultural practices

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Topic Introduction

Achieving sustainable agriculture has many challenges, including the rise in global population, the increase in food demand[1], the continuation in depleting natural resources, and the productivity of farmers being impacted by climate change.

Fortunately, artificial intelligence (AI) and analytics offer promising solutions to these very challenges, as it has the potential to enhance the efficiency as well as the sustainability of many farming practices. With new AI technologies, such as drones, automated machinery and state-of-the-art weather forecasting systems[2] slowly being integrated into the agricultural systems, crop management could further develop, leading to decreased use of resources and less environmental impacts.

The implementation of AI in agriculture could be pivotal for achieving sustainable farming, as it would minimise waste and enable more efficient use of resources, addressing the current challenges and supporting the long-term goals of food security.

[1] FAO. "Sustainable Food and Agriculture." Food and Agriculture Organization of the United Nations, 2023, www.fao.org/sustainability/en/.

[2] Parvaresh, Nahid, et al. "A Tutorial on AI-Powered 3D Deployment of Drone Base Stations: State of the Art, Applications and Challenges." Vehicular Communications, vol. 36, Aug. 2022, p. 100474, https://doi.org/10.1016/j.vehcom.2022.10047 . Accessed 10 June 2022

Definition of key concepts

Artificial Intelligence (AI)

Artificial intelligence (AI) is the development of a computer system such as software, robots and devices to perform tasks normally requiring human intelligence. Machines like these can be taught to carry out various tasks that would usually be carried out by a human.[3] AI in agriculture refers to using this technology to reduce the need for manual labour and ensure that tasks are carried out to the highest standard possible. The use of AI-enabled systems can be used for weather predictions and assessing farms for disease and pests.

Analytics

Analytics is the scientific process of finding meaningful patterns and correlations in data. This can help draw better insight for decision making.[4] By implementing algorithms farmers can receive insights into crop yield predictions and optimal harvesting times.

Automated Machinery

"The use of automatic machinery and systems, particularly those manufacturing or data-processing systems which require little or no human intervention in their normal operation"[5]. Automated machinery in agriculture is defined as autonomous navigation done by robots without human interference, this will provide precise information to help develop agricultural operations.

Machine learning

Machine learning enables computers to learn from data and then make decisions or predictions without having to be programmed to do so. Machine learning in agriculture "allows farmers to use

[3] Dictionary.com. "Definition of Artificial | Dictionary.com." *Www.dictionary.com*, www.dictionary.com/browse/artificial.

[4] Rouse, Margaret. "What Is Analytics? - Definition from Techopedia." *Techopedia.com*, 2019, www.techopedia.com/definition/30296/analytics.

[5] Oxford Reference. *Www.oxfordreference.com*, 2024.

lavish amounts of data about climate change, crop and soil conditions, and other environmental variables to make informed decisions about plant and animal treatment ."[6]

Sustainability

Sustainability is," a way that allows for continual use of a natural resource without depleting it or causing environmental damage"[7]. In agriculture sustainability can refer to farming in ways that will protect the environment and expand the usage of renewable resources.

Precision Agriculture

"Precision agriculture uses information technology to ensure that crops and soil receive exactly what they need for optimum health and productivity."[8] Precision agriculture is an advanced farming practice that leverages the use of modern technology to create sustainable agricultural practices by reducing waste and environmental impact and ensures that crops are in their optimal conditions.

Background Information

Historical Background

AI and analytics could radically change agriculture, providing new solutions to drive sustainability and productivity in the midst of global challenges. The early AI applications for agriculture date as far back as the middle of the 20th century, when the approach was primarily oriented towards automation and data processing[9]. In the 1980s, early AI systems—termed 'expert systems'—were first developed to support crop management decisions[10]. The 21st century saw the upsurge of rapid developments in the use of machine learning, big data analytics, and sensor technologies. Indeed,

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[6] itransition.com. "Machine Learning in Agriculture: 13 Use Cases & Examples." *Www.itransition.com*, www.itransition.com/machine-learning/agriculture.

[7] "Definition of Sustainably | Dictionary.com." *Www.dictionary.com*, www.dictionary.com/browse/sustainably.

[8] Wigmore, Ivy. "What Is Precision Agriculture? - Definition from WhatIs.com." *WhatIs.com*, Oct. 2022, www.techtarget.com/whatis/definition/precision-agriculture-precision-farming.

[9] Trendov, Nikola M, et al. *DIGITAL TECHNOLOGIES in AGRICULTURE and RURAL AREAS*. 2019.

[10] "Agriculture's Connected Future: How Technology Can Yield New Growth." *Mckinsey & Company*, 9 Oct. 2020, www.mckinsey.com/industries/agriculture/our-insights/agricultures-connected-future-how-technology-can-yield-new-growth.

these changes have propelled the development in precision agriculture and robotics in farming[11], among others.

Potential of Artificial Intelligence

AI has huge potential to drive sustainable agriculture. It employs precision farming, crop monitoring by drones and satellites, predictive analytics, smart irrigation systems, and robotics. Precision farming ensures that resources are used optimally, since the input is only used where necessary and in line with real-time data, hence minimising the impact on the environment while at the same time maximising output. AI-driven crop monitoring drones and predictive analytics detect diseases by using cameras and sensors this can help assist in detecting pests, and weather patterns early, hence putting farmers in a better position to act proactively.[12]

Links for further research:

Precision farming:
https://www.gao.gov/products/gao-24-105962
Crop monitoring:
https://www.controlunion.com/service/inspections/collateral-management/crop-monitoring/
Predictive analytics:
https://dig8italx.com/agri-predictive-analytics/
Smart irrigation systems:
https://www.scip.org/news/660666/Smart-Irrigation-Systems-A-Sustainable-Approach-to-Agriculture-.htm
Robotics:
https://www.mdpi.com/2073-4395/11/9/1818

Challenges to adopting AI in agriculture

[11] "DSpace." *Openknowledge.fao.org*, www.fao.org/documents/card/en/c/ca4887en.
[12] US Department of Agriculture. "Precision Agriculture | AgLab." *Aglab.ars.usda.gov*, 2023, aglab.ars.usda.gov/fuel-your-curiosity/sustainability/precision-agriculture.

Challenges to full-scale AI adoption in agriculture remain. Key constraints include high upfront costs[13], inaccessible technology in most rural areas, issues of data privacy, and the need for specialised training. Noteworthy are also ethical concerns regarding the distribution of benefits from AI between different stakeholders and the consequences this may have for local farming practices and associated livelihoods.

Links for further research:
https://intellias.com/artificial-intelligence-in-agriculture/
https://supublication.com/index.php/ijmts/article/view/1275

Case Study - John Deree

John Deere is an agricultural machinery giant that has embraced precision farming through AI-driven technologies. John Deere machinery, optimising crop management from sowing to harvest. These new and intelligent systems would be able to consider a lot of variables like soil quality, moisture levels, weather conditions, and other real-time adjustments during planting. For instance, the AI provides the optimum depth and spacing of seeds, allowing each plant to develop in perfect conditions.

These new innovations are used at harvest as they analyse crop maturity and health to execute the optimum time of harvest so that a maximum number of crops can be reaped with minimum loss. The company has achieved appreciable results with these technologies, which include dramatic increases in crop yields, improvement in resource efficiency, and reduction in input costs such as seeds, water, and fertilisers.

The long-term results from John Deree in terms of productivity and cost savings to farmers, are only a measurable testament to the successful AI integration by John Deere. Other than assisting in maximising output, the company has also helped farm more sustainably with reduced waste and less impact on the environment. Farmers who used John Deere's AI-driven machinery have reported

[13] Piddubna, Alina. "AI in Agriculture — the Future of Farming." *Intellias*, Intellias, 10 Feb. 2022, intellias.com/artificial-intelligence-in-agriculture/.

higher profits and claimed to have an easier time managing their operations, thus marking this technology as one of the successful innovations in precision agriculture.[14]

Problems Solved and Created by AI and Analytics

Among many other things, AI and analytics solve some of the most pressing concerns in agriculture, such as crop yield prediction, better control over pests and diseases, resource use efficiency with regard to water and fertiliser, mitigation of the environmental impact of farming, and access to better markets and greater efficiency in the supply chain. This could be vital in order to sustainably produce sufficient food to feed the world and make a lesser impact on the environment.

However, establishing AI and analytics also poses problems.[15] Among these are the high costs of adopting technologies that are unaffordable for small-scale farmers, thus creating a division between the developed and developing nations. The collection and primary utilisation of data by AI systems related to farmers crop out the ethical issue of data privacy. More than that, dependence on technology and loss of jobs in farming practice gets created due to automation.

Links for further research:

Data concerns:
https://www.bankbarn.io/blog/concerns-and-benefits-of-sharing-farm-data

High costs:
https://intellias.com/artificial-intelligence-in-agriculture.

Problems solved:
https://www.mckinsey.com/industries/agriculture/our-insights/from-bytes-to-bushels-how-gen-ai-can-shape-the-future-of-agriculture

https://www.sciencedirect.com/science/article/pii/S258972172030012X

[14] "The Future of Farming Technology | John Deere." *Www.deere.co.uk*, 2022, www.deere.co.uk/en/agriculture/future-of-farming/.
[15] Sahota, Neil. "The Dawn of AI in Agriculture Is Harvesting the Future." *Forbes*, 23 July 2024, www.forbes.com/sites/neilsahota/2024/07/23/the-dawn-of-ai-in-agriculture-is-harvesting-the-future/.

Date	Description of the event
1965	Introduction of computers in agriculture, marking the start of digital technology use in farming.
1977	First use of GPS in farming equipment, enabling precise field mapping and Variable Rate Technology (VRT).
2000	USDA launches the National Precision Agriculture Awareness and Adoption Campaign, promoting data analytics in farming.
6 January 2004	John Deere launches the GreenStar System, a significant commercial application of precision farming.
2008	First use of drones in agriculture for crop monitoring, enhancing data collection for AI systems.
2014	IBM launches Watson for Agriculture, integrating AI-driven insights into mainstream farming practices.
25 October 2016	India passes the National Agricultural Technology Policy, supporting AI and analytics in agriculture.
25 April 2018	The European Union announces its AI strategy, highlighting agriculture as a key sector for AI innovation.
23 September 2021	United Nations Food Systems Summit emphasises the role of AI and digital innovation in global food systems.

Fig 1: Drones being used for farming[16]

Major countries/ organisations and alliances

United States of America (USA)

The USA is proactive in advancing its agricultural practices with AI and analytics while promoting sustainability. The United States Agriculture Department (USDA) believes that the implementation of technologies will greatly improve America's food systems.[17] This stance supports the USA's implementation of precision farming and overall efforts to improve sustainability. These motions have led to the agricultural community successfully integrating AI technology, such as drones, automated machinery, etc into their farms.

China

[16] Meola, Andrew. "Agricultural Drones: Precision Agriculture, Mapping & Spraying - Business Insider." *Business Insider*, Business Insider, 8 Jan. 2020, www.businessinsider.com/agricultural-drones-precision-mapping-spraying.

[17] Elliott, Scott. "Artificial Intelligence Improves America's Food System." *Www.usda.gov*, 10 Dec. 2020, www.usda.gov/media/blog/2020/12/10/artificial-intelligence-improves-americas-food-system.

China is actively advancing in its agriculture and food systems. It has also implemented precision farming technologies in agriculture, utilising AI to monitor soil conditions, and using analytics to forecast weather patterns, which helped it optimise the usage of resources. Programs that support this are their 'Smart Agriculture' initiative as well as their 2017 National AI Development Plan However, China has a barrier when it comes to applying AI in agriculture on a bigger scale due to the lack of technological literacy among it's farmers[18]. Additionally, the use of AI in China's agriculture also threatens and displaces countless farmers from their jobs.

India

India is making significant efforts to utilise AI and analytics in their agriculture with the overall goal of increasing productivity and promoting sustainability. The Indian government strongly supports farmers to collaborate with the private sector as well as tech companies, believing that it is pivotal to the transformation of the industry.[19] India's Cropin platform and application that was founded in 2010. This is an agritech company based in India that leverages technology, particularly AI, big data, and cloud computing, to provide solutions for sustainable and efficient farming. This has proved to be very successful as it has helped farmers improve their farm management and is used as an AI tool for farmers, assisting them in efficient ways to maintain crop health and data driven decisions.

Brazil

Brazil does leverage AI to a certain extent to improve farming practices and sustainability. However, Brazil still remains sceptical about further adapting AI into farming due to data concerns and the impact on small farmers. ManyBrazilian farmers fear that AI will only benefit large members in the agricultural industry. This highlights the careful consideration that needs to be made by the Brazilian government moving forward.

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[18] "China AI in Agriculture by Market Share, Size & Forecast 2029 | TechSci Research." *Www.techsciresearch.com*, www.techsciresearch.com/report/china-ai-in-agriculture-market/1887.html.

[19] Ministry of Agriculture & Farmers Welfare. "Ministry of Agriculture & Farmers Welfare Is Leveraging Cutting-Edge Artificial Intelligence (AI) Technologies for the Benefit of Farmers and to Increase Overall Productivity." *Pib.gov.in*, 2024, pib.gov.in/PressReleaseIframePage.aspx?PRID=1997066.

Netherlands

The Dutch government stimulates AI in agriculture with policies aimed at ethical, legal, and societal issues, ensuring that AI is trustworthy and respects human rights. Yet, the lack of standardised guidelines casts uncertainty over data privacy and AI compatibility for farmers. It is expected however, that the Netherlands will be a global leader in the implementation of AI in precision farming with efficient irrigation, pest control, crop monitoring, and livestock management. Its collaborative environment of seed companies, growers, and tech providers helps with innovation. Through its involvement in global partnerships, the country stands squarely as a nation committed to advanced and sustainable farming practices.[20]

Food and Agriculture Organization (FAO)

FAO has a keen interest in the promotion of AI and analytics use in bettering sustainable agricultural practices. They emphasise the use of AI technologies in advancing data-driven decision-making, climate resilience, and precision agriculture. According to FAO, AI can offer the right tools that will help improve resource use efficiency, productivity in agriculture, and reduce the impacts of climate change. This therefore calls for proper utilisation of such technologies towards the realisation of sustainable development in agriculture.[21]

International Fund for Agricultural Development (IFAD)

The IFAD is a United Nations agency that provides financial and technical support to rural communities to improve agricultural productivity and promote sustainable development. The IFAD views Artificial Intelligence and analytics as important levers in advancing sustainable agricultural practices. It supports the integration of AI and data analytics to achieve productivity, enhance resilience to climate change, and optimise resource use in agriculture.[22]

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[20] "Netherlands AI in Agriculture Market Growth, Analysis, Share, Size & Forecast 2029 | TechSci Research." *Www.techsciresearch.com*, www.techsciresearch.com/report/netherlands-ai-in-agriculture-market/1899.html.
[21] Food and Agriculture Organization of the United Nations. "Home | AgroInformatics | Food and Agriculture Organization of the United Nations." *AgroInformatics*, www.fao.org/agroinformatics/en.
[22] BOUSIOS, THOMAS, et al. "4 Ways IFAD Is Using AI to Transform Rural Development." *Ifad.org*, www.ifad.org/en/web/latest/-/4-ways-ifad-is-using-ai-to-transform-rural-development.

Previous attempts to solve the issue

Global Partnership on AI (GPAI) - 2020

The Global Partnership on AI was formally launched in 2020. It will work to promote the responsible development and use of artificial intelligence to meet global challenges, notably those related to sustainability, while ensuring that AI works for humanity through respecting human rights and the promotion of social good.[23] At the moment, the GPAI isn't seen as a failure as it has brought together governments and private institutions and has gained participation from a broad range of countries and organisations. [24]However, the GPAI has faced criticism regarding its coordination and implementation. The challenges to GPAI lie in coordination and organising efforts with a large number of stakeholders and effectively implementing agreed-upon good practice.[25]

Consultative Group on International Agricultural Research (CGIAR) program- 1971 (year founded in)

The CGIAR Digital Agriculture Program is an initiative of the Consultative Group on International Agricultural Research, CGIAR. [26] Over the past years, CGIAR has been integrating digital technologies into its agricultural research and development activities. Institutionalisation and scaling up of these activities are currently underway. Within the broader context of CGIAR's efforts towards the adoption of digital tools and technologies in agricultural research, this began to gain momentum in the mid-2010s when CGIAR saw that it was transformative in enhancing agricultural productivity and sustainability. While much of this has been fairly easy to adopt for many farmers and key stakeholders, there are, nonetheless, certain barriers to its adoption, such as the lack of hardware, poor digital literacy, and poor infrastructure. A number of concerns have also been raised with regard to the use of personal data from digital technologies. The program has not addressed these issues yet, delaying its progress.[27]

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[23]"Global Partnership on Artificial Intelligence." *OECD*, www.oecd.org/en/about/programmes/global-partnership-on-artificial-intelligence.html.
[24] oecd.ai. "The Global Partnership on AI (GPAI) - OECD.AI." *Oecd.ai*, 2022, oecd.ai/en/gpai.
[25] www.oecd.org. "Digital." *OECD*, www.oecd.org/en/topics/digital.html.
[26] "Strategy." *CGIAR*, 2024, www.cgiar.org/how-we-work/strategy/.
[27] "Digital Innovation." *CGIAR*, 2024, www.cgiar.org/initiative/digital-innovation/.

Possible solutions

Enhancing farmers' education in AI by creating new applications and platforms

However, farmers require whole-of-spectrum education and training in the practical applications of AI technologies. The United Nations and a host of nongovernmental organisations can offer a range of training necessary for the farmers. Such programs will empower farmers with the necessary knowledge and skills to become familiar with AI applications, get practical experience, and develop actual practical skills in using AI tools for agriculture. By developing and providing innovative applications and platforms for the farmers' needs, these efforts are taking an immense potential of empowering them to harness AI for enhancing their agricultural practices and outcomes.

Developing infrastructure in Rural areas

Develop rural infrastructures. This is not limited to the creation of reliable internet connections, but also the establishment of energy infrastructures and transport networks in the rural areas. Improved infrastructure supports the emplacement of AI technologies, such as automated machinery and remote sensing for real-time data collection. Advantages of this could be operational efficiency, as well as the increase in connectivity. However, high initialisation costs could lead to higher need for logistical efforts.

Creation of programs to foster the exploration of AI and analytics in agriculture

One such solution could be to develop national or international programs under which AI and analytics would innovatively and sustainably be used in agriculture. Such a program would prioritise funding for the research and development of AI-driven technologies that reduce water consumption, limit the amount of pesticides applied, and improve soil health. Financial incentives, grants to farmers, and tech developers would encourage the adoption of these technologies. Moreover, the structure provided for public-private partnerships or partnerships with the United Nations or various NGOs, will bring to the fore scalability in such innovation while ensuring personal data protection and security. This will enhance the adoption of sustainable farming practices, improve agricultural productivity, and encourage environmental conversation.

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