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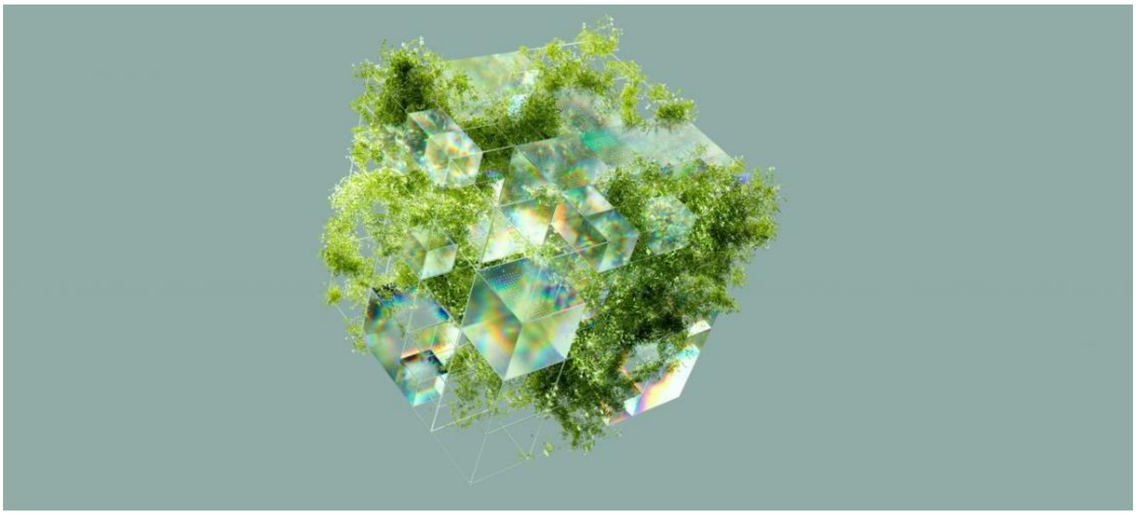

International conference on Digitalization and Artificial Intelligence in Agricultural Management

15-17 November 2023, Stockholm, Sweden

Book of abstracts

Carla Ferreira · Zahra Kalantari · Victor Galaz · Stefan Daume
Editors

Stockholm University
KTH VETENSKAP OCH KONST
Stockholm Resilience Centre | Stockholm University
i2a Polytechnic University of Coimbra

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Editors

Carla Ferreira, Auxiliary Researcher, Polytechnic Institute of Coimbra, Portugal

Zahra Kalantari, Associate Professor, KTH Royal Institute of Technology, Sweden

Victor Galaz, Associate Professor, Stockholm Resilience Centre, Sweden

Stefan Daume, Researcher, Stockholm Resilience Centre, Sweden

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Mission statement

Agriculture plays a vital role and faces tremendous pressure to feed a growing world population from limited available resources. This pressure has been mitigated by intensive management practices, relying, e.g. on the massive use of fertilizers and chemicals and extensive monoculture areas. However, this approach has its own limitations and undesirable effects, making clear the need for sustainable actions while increasing yields. AI-based agricultural management has brought emerging opportunities to improve agricultural sustainability. To find the right, feasible and viable solutions to make the transition towards sustainable agriculture systems that feed an increasing population under the planetary boundaries, it is necessary that scientists from different fields join forces together with industry.

This conference focuses on finding solutions for the agriculture issues of our time. It promotes the exchange of scientific research and solutions from industry for interdisciplinary collaboration and networking. To bring scientists and stakeholders that have the same goal and work on the same societal issue but have different backgrounds. By bringing the people and their knowledge together, we may be able to take the steps towards solutions that can bring our agriculture systems to a more sustainable situation.

This conference is framed around themes connected to our time's big transitions: i) AI in data collection to support monitoring and management of agricultural systems; ii) Climate change and mitigation of environmental impacts using AI; iii) AI in the optimization of agricultural management; and iv) Sustainability science perspective on AI application on agricultural systems.

We want to stress that this conference is not only for scientists but also for those people from outside the scientific world working on transitions to more efficient and sustainable agriculture systems, towards climate mitigation and adaptation, and a circular economy with a focus on the sustainable use and management of the natural resources.

The conference is sponsored by Digital Futures (www.digitalfutures.kth.se) within its Focus Period program.

The Organizing Committee,

Carla Ferreira
Zahra Kalantari
Victor Galaz
Stefan Daume

Keynote speakers

Daniel Jiménez

Scientist, Consultative Group for International Agricultural Research

Daniel Jiménez is a senior scientist at CGIAR Platform for Big Data in Agriculture. He is specialist in digital agriculture with over a decade of experience in the field. His research focuses on topics such as site-specific agriculture, data-driven agronomy, artificial intelligence, Big Data, digital extension, and monitoring of food systems. Currently, he leads the research area on digital transformation of agri-food systems.

His work has received international recognition, including awards from the United Nations in 2014 and 2017, as well as top prizes in the Syngenta Crop Challenge in Analytics 2018 and the INFORMS 2020 Innovative Applications in Analytics Award competition.

Josse De Baerdemaeker

Emeritus Professor, Katholieke Universiteit Leuven

Josse De Baerdemaeker is an Emeritus Professor at KU Leuven, Division of Mechatronics, Biostatistics and Sensors. He is currently chairman of VILT, the Flanders Infocenter for Agriculture. He is recognised as the founding father of the concept of precision agriculture and has been focusing on improving technology in crop cultivation, harvesting and handling to minimize losses and optimize yield and income for farmers.

Matthew Harrison

Associate Professor at the Tasmanian Institute of Agriculture

Matthew Harrison is Associate Professor at the Tasmanian Institute of Agriculture in Launceston, Australia. He is internationally renowned for his work in improving the sustainability of agricultural systems through innovative economic, environmental and social solutions to demand-driven problems. His team uses systems thinking to develop skills, technologies and practices aimed at improving food production, enterprise profitability, social license to operate and long-term agri-food sustainability. The impact of his work on carbon removals, greenhouse gas emissions, the climate crisis and food security will have enduring benefits for decades to come.

He is the Director of the Carbon Storage Partnership, a transdisciplinary initiative that is developing environmentally contextualised pathways aimed at progressing the entire Australia livestock sector to net-zero greenhouse gas emissions by 2030 ('CN30 Initiative').

Tetyana Zelenska

Head of Monitoring, Evaluation and Learning, Digital Green

Tetyana Zelenska is an applied development economist who has been working in international development for over 10 years. She has particular expertise in econometric and statistical evaluation techniques, including both randomized and quasi-experimental approaches, and experience in all technical and managerial aspects of quantitative research projects. Dr. Zelenska also has experience employing qualitative research methods in her research with a special focus on gender issues. Though her research interests span a wide range of agricultural and food system issues, her work is primarily focused on agricultural technology adoption in South Asia. Prior to joining Digital Green, she held various research positions for the international research organizations including Innovations for Poverty Action, Jameel Latif Poverty Action Lab - South Asia as well as in the private sector. In her current role as a Director of MEL with Digital Green, she provides both strategic and technical support for all DG programs that are being implemented globally. She holds a Ph.D. in Economics from the Andrew Young School of Policy Studies, Georgia State University.

Joel Hamrén

Engineer, Agronod

Joel Hamrén is a Swedish engineer specialized in Innovation and Strategic business development.
Having worked in the vehicle manufacturing and retail industries before moving to agriculture, his focus has always been creating value from data, beginning with treating data like it is something of value.

As product owner at the Swedish startup Agronod, he leads the building of a national platform for integrating, processing and sharing agricultural data. The infrastructure enables digitalization in the agricultural sector, mitigating issues such as low degree of innovation, declining profitability and high requirements of security.

Panos Pardalos

Emeritus Professor, University of Florida

Panos Pardalos is a distinguished Emeritus Professor in the Department of Industrial and Systems Engineering at the University of Florida, and an affiliated faculty of Biomedical Engineering and Computer Science & Information & Engineering departments.

He is a world-renowned leader in Global Optimization, Mathematical Modelling, Energy Systems, Financial applications, and Data Sciences. He was awarded the 2013 with the Constantin Caratheodory Prize of the International Society of Global Optimization, and the 2013 EURO Gold Medal prize bestowed by the Association for European Operational Research Societies. This medal is the preeminent European award given to Operations Research (OR) professionals for "scientific contributions that stand the test of time."

Panos Pardalos has been awarded a prestigious Humboldt Research Award (2018-2019), which is granted in recognition of a researcher's entire achievements to date, considering the fundamental discoveries, new theories, and insights that have had significant impact on their discipline.

He is the Founding Editor of Optimization Letters, Energy Systems, and Co-Founder of the International Journal of Global Optimization, Computational Management Science, and Springer Nature Operations Research Forum.

Josh Woodard

Senior Digital Advisor, United States Agency for International Development Bureau

Josh Woodard is a Senior Digital Advisor at the United States Agency for International Development Bureau for Resilience and Food Security. He is the primary designer of studies on inclusive AI and automation in agri-foods systems and farmer-centric data governance. Josh has extensive experience in digital agriculture and resilience, particularly in Asia and Africa. Prior to joining United States Agency for International Development, he ran a technology for development consulting firm, during which he led the development of the digital agriculture strategies for several international donors and organizations.

He has also served as a primary author of the Food and Agriculture Organization and International Telecommunication Union's National e-Agriculture Strategy guide, which he helped the governments of Sri Lanka and Bhutan to implement. From 2009-2013, he led United States Agency for International Development's FACET project, which focused on promoting the uptake of ICT in agriculture projects across sub-Saharan Africa.

Angelika Hilbeck

Swiss Federal Institute of Technology, Institute for Integrative Biology

Angelika Hilbeck is a senior researcher at ETH Zurich's Institute of Integrative Biology in Switzerland, a sustainability focused organization, where she heads the Environmental Biosafety & Agroecology Research Group. Hilbeck graduated in agricultural biology from the University of Hohenheim. She received her doctorate in entomology from North Carolina State University in 1994.

Hilbeck's teaching and research focuses on environmental risk assessment, ecological biosafety of genetically modified plants and farmer-participatory agroecology research in Eastern and Southern Africa. Through her international work with UN, governmental and non-governmental organisations, she became increasingly involved in broader issues of technology development (GE and digitialization) towards a democratically legitimated, sustainable global future and actively contributes to the debate on biosafety, international agriculture, hunger and poverty alleviation.

Hilbeck Is involved in the negotiations around the implementation of the UN Cartagena Protocol on Biosafety. Because of her experience in international agriculture and in the local situation of small farmers, she was appointed to contribute to the World Agricultural Report (IAASTD 2008). Hilbeck serves on the board of directors of Bread for All. She was a co-founder of the European Network of Scientists for Social and Environmental Responsibility (ENSSER) and Critical Scientists Switzerland (CSS), on whose board she continues to serve. She is a member of the advisory board of the Association of German Scientists.

Guillermo Marcillo

Assistant Professor, West Texas A&M University

Guillermo Marcillo is an Assistant Professor at the Department of Agricultural Sciences at West Texas A&M University. The research and teaching program integrates digital, precision, and statistical methods to help producers thrive in the midst of climate and market instability. To this effect, research activities make use of high-resolution data (remote sensors, field experiments, farm machinery) leveraged by computational methods for advancing the understanding of ecosystem impacts of conservation agriculture and farm technology adoption. Methods used in the lab encompass statistical models, crop simulation models, agricultural experiments, and Artificial Intelligence (AI) algorithms, driven by sound principles of plant, soil, and environmental sciences.

AI in data collection to support monitoring and management of agricultural systems

Keynotes

AI and agricultural management – opportunities and risks

Daniel Jiménez R[1*]

[1] Consultative Group for International Agricultural Research (CGIAR)

* Corresponding author: d.jimenez@cgiar.org

Abstract

Artificial intelligence (AI) has the potential to revolutionize agricultural management by leveraging advanced data analysis and monitoring tools. Farmers and agri-food stakeholders can make informed decisions on crop management, pest and diseases control, and even diet quality, leading to reduced poverty, climate risks, and unhealthy diets.

One of the biggest opportunities of AI is the ability to analyse disaggregated information, providing a better understanding of agricultural systems and the environment. AI can now be used to identify patterns and trends in data, providing actors in the agri-food systems with a more accurate understanding of their agricultural systems and the environment. Additionally, artificial intelligence empowers the creation of early warning systems for pest outbreaks, extreme weather events, and food insecurity.

However, risks include AI bias from non-representative data. This can lead to inaccurate recommendations, especially in agrifood systems in the global South. It is important to refine AI models' generalization capabilities to prevent algorithmic biases and hallucinations. Expert guidance remains crucial for reliable insights. Promoting open access documents and collaboration among academia are key to reduce biases and enhance transparency.

AI's transformative potential in agricultural management is huge. By addressing risks, adopting user-centric approaches, and fostering collaboration, AI can benefit all agri-food stakeholders, promoting sustainability.

Keywords: artificial Intelligence, agricultural management, data analysis, sustainability, collaboration

Quality Challenges for AI adoption in Agri-Food

Josse De Baerdemaeker[1*]

[1] Biosystems Department, KU Leuven, Belgium

* Corresponding author: josse.debaerdemaeker@kuleuven.be

Abstract

Every day on a farm or in a food-processing facility, thousands of data points are collected from robust, reliable sensors with low maintenance and low costs. Artificial intelligence (AI) could be a powerful tool to analyse these data towards managing the complexity of food production from the field to the table.

The data quality should be specified, and efforts made to test the quality of the data considering their potential use. Data from multiple sources can be used by different operators, requiring interoperability and ease of data transfer.

AI algorithms make decision suggestions for farmers or implement certain decisions independently. Model testing is advised before they enter the market using experimental settings (digital sandboxes and testing and experimentation facilities), to ensure that they are effective, safe and secure against accidental failures or unintended consequences.

AI software based on data from production facilities combined with retailer data on consumer behaviour may create a potential for biased recommendations to farmers, to favour the optimisation of supplies being sent to specific food retailers. This may also lead to a small base for decision making, biased decision making or can lead to a reduction in agrobiodiversity.

Keywords: data quality, model testing, interoperability, agrobiodiversity

Presentations

Utilizing Large Language Models in Agriculture: Monitoring & Management Innovations

Lindsey Moore[1]

[1] CEO of DevelopMetrics,

* Corresponding author: lindsey@developmetrics.com

Abstract

Modern agriculture increasingly relies on digital innovations to ensure sustainable food security and environmental balance. This proposed session, led by the CEO of DevelopMetrics, delves into the transformative potential of Large Language Models (LLMs) in agriculture monitoring and management systems. With the capability to analyze vast amounts of unstructured data, LLMs can provide timely insights, optimize resources, and enhance decision-making, all vital for the ever-evolving dynamics of the agricultural domain.

The session will spotlight two compelling case studies: USAID and GIZ's pioneering use of LLMs. Participants will get an in-depth view of how these prestigious institutions harness the power of LLMs to bolster agricultural outcomes, from crop monitoring to supply chain optimization. These real-world examples will demonstrate the tangible benefits, challenges, and best practices of integrating LLMs into agricultural frameworks.

Attendees can anticipate a holistic understanding of LLMs' role in future agriculture, and how such tools can be instrumental in addressing global food challenges. The insights shared will be invaluable for stakeholders looking to innovate their agricultural systems with the latest technological advancements.

Keywords: Large Language Models (LLMs), agriculture monitoring, digital innovations, sustainable food security, decision-making optimization.

Large Language Model for Agriculture

Masahiro Ryo[1*] and Kazunori Suzuki[2]

[1] Leibniz Centre for Agricultural Landscape Research (ZALF), Germany

[2] Brandenburg University of Technology Cottbus-Senftenberg, Germany

* Corresponding author: masahiro.ryo@zalf.de

Abstract

OpenAI's artificial intelligence chatbot ChatGPT is the fastest-growing app in history. ChatGPT or alike, namely Large language models (LLMs), are gaining great attention as an emerging technology that affects our daily life. Here, we show a preliminary result for how to make use of LLMs for agriculture. We address a main challenge where a LLM often provides misinformation to the users (hallucination). We used a Retrieval Augmented Generation (RAG) approach so that it can retrieve facts from an external knowledge base on the most accurate, up-to-date information and to give users insight into LLMs' generative process. We improved the performance of Meta's Llama 2 specialized for the agriculture and relevant environmental sector by inputting several intergovernmental reports including IPCC, IPBES, FAO, and UN SDGs. We compared how the models with and without the RAG-based inputs answer several questions. We also considered the value of data privacy to avoid sending any personal information to the Internet by developing a reasonably small model architecture that can run in an offline workstation. The initial results suggest the promising potential of the approach that can be used by many users. We also highlight the forthcoming challenges and open questions.

Keywords: Large language model, ChatGPT, deep learning, Llama 2

Digital solutions in agriculture management: Databases related to the dairy and beef value-chains

Pia Ulvenblad[1]*, Henrik Barth[1] and Per-Ola Ulvenblad[1]

[1] Halmstad University, Sweden

* Corresponding author: pia.ulvenblad@hh.se

Abstract

This study focuses the possibilities and challenges with digital solutions in the food value-chain. The food value chain can benefit from making it possible to increase the traceability between different parts in the chain. For example, food scandals and product recall might be limited, and safety and quality might be preserved. By the traceability there will also be easier for consumers to make informed choices. The aim with this abstract is to present the first step of co-creating activities to outline challenges with digital solutions in the dairy and beef value chains. We draw on knowledge from an ongoing EU project labelled SustainIT which started in the autumn 2021. There are several challenges regarding ICT solutions. The challenges concern issues such as i) selection of data, ii) spreading of data and iii) commercialization of data. Preliminary conclusions indicate many possibilities with digital solutions in the agri-food sector. However, several challenges need to be addressed which include technical, legal as well as business related aspects.

Keywords: Digital solutions, agricultural management, dairy and beef value-chain, data bases

Data Driven Artificial Intelligence Applications for Sustainable Agriculture in Kenya

Mercy Kimalat[1]

[1] Association of Startup and SME Enablers of Kenya (ASSEK)

* Corresponding author: mercy.kimalat@assek.ke

Abstract

Kenya is 75% agriculture-based economy that contributes largely to the country's GDP. However, with a growing population and the adverse effects of climate change, the sector has been disrupted and there is need to embrace technology to obtain key insights and trends to transition to precision agriculture and for ecosystem actors engage in evidence-based policy and advocacy. Artificial Intelligence will enable farms access information at the convenient time to make critical management decisions to improve farm productivity and yields. Through the large amounts of data, there is economic opportunity to develop models to combat challenges on seed variety, pests and diseases, automation of routine tasks such as harvesting. At the stakeholder level, there is dis integrated data and research on Agriculture in Kenya due to lack of a collaboration framework amongst the diverse Government and research institutions. AI can play a huge role by having an open platform to collect amounts of data to develop publicly viewed agriculture models. With the collaboration with the ODPC (Office of the Data Protection Commission), ASSEK is able to champion for the integration of automated data collection and analysis in the value chain while safeguarding the rights and interests of the actors involved. Through the consolidated effort, the Association is able to tackle challenges on business, policy and regulation front to champion for an enabling and conducive environment.

Keywords: Agriculture automation, data, models, advocacy

Transforming Agriculture in West Africa: Leveraging Artificial Intelligence for Data-Driven Farm Management and Sustainable Crop Yield

Emmanuel Duah[1]*, Chanik Kwao-Agboado[1] and Anthony Kofi Osei[1]

1 Farmerline Group

* Corresponding author: emmanuel.duah@farmerline.co

Abstract

Food crops are the foundation of our food systems and the primary means to alleviate hunger and poverty. It can be shown that remote agricultural regions in West Africa most especially Ghana, Ivory Coast, Togo, and Benin grapple mostly with the scarcity of reliable agriculture management data. With the untapped potential for sustainable farming, these regions have grappled with the absence of accurate, timely, and accessible agricultural data necessary for complete and reliable decision-making. In order to achieve optimum yield and productivity, systematic collection, analysis, and interpretation of Agriculture data should be automated. This is labour and capital-intensive. Farmerline is building Crop yield monitoring systems that harness satellite imagery and leverage farm polygons to predict farm management supplemented by the integration of weather stations by so doing building a comprehensive repository for agriculture management systems. Farmerline's methodology is to use a Generative AI's LLM that is able to pool these data sources and interact with them to feed into various endpoints for users. The benefits are enormous as this will give real-time insights to various stakeholders in the Agriculture ecosystem. With this unique system, Farmerline is improving the agriculture outcomes for farmers and stakeholders in the sub-region.

Keywords: Crops, farm management, data collection, LLM, yield monitoring

AI-driven data analysis with mobile pictures for enhanced coffee crop management and yield prediction

Juan Camilo Rivera Palacio[1,2,3], Christian Bunn[2] and Masahiro Ryo[1,3]*

[1] Leibniz Centre for Agricultural Landscape Research (ZALF)

[2] Alliance of Bioversity International and CIAT

[3] Brandenburg University of Technology Cottbus-Senftenberg

* Corresponding author: masahiro.ryo@zalf.de

Abstract

The use of earth observation data and unmanned aerial vehicle imagery is a popular method for crop yield prediction. However, the environmental conditions of coffee crops present a barrier to the applications of these methods. This study explored the use of mobile imagery of coffee trees for tree-level yield prediction in agroforestry systems in Colombia and Peru, in the form of citizen science. The deep learning object detection model "You Only Look Once" (YOLO v5) was used for cherry counting and yield estimation together with extensive field monitoring data including information from about 1000 farmers. The model was trained on tree species in Peru. The training data consisted of 35,000 tagged cherries. After model training, we applied the model in Colombia to test if the model can be transferred to other regions with diferent varieties. The yield prediction results showed an R-squared value of 70%. Our study showed that the method can generate yield predictions in seconds without the need for expensive monitoring equipment. In addition, the use of mobile images can be used for coffee traceability and access to financial services.

Keywords: artificial intelligence, deep learning, coffee, object detection, citizen science

A Nextgen Low Power Weather Station for the IoT age

Giuliano Vitali[1]* and Eugenio Magnanini[1]

[1]University of Bologna, Italy

* Corresponding author: giuliano.vitali@unibo.it

Abstract

Internet of Things (IoT) is changing the way of making environmental observations. IoT dramatically reduce the time to develop devices, by easy design and availability of off-the-shelf electronic components and sensors. In the next years we are going to assist to an explosion of difersity of devices and availability of ancillary information. IoT may reduce complexity and price, while increasing accessibility and possible uses. A representative case is given by a new weather station, designed to reduce costs, increase durability, space distribution. Together with the common sensors (Temperature, Relative Humidity, Pressure), it includes Radiation, Wind and Rainfall by non-conventional metering approaches. Rainfall in particular has been implemented with an environmental microphone allowing to characterise the events by the observation of droplets distribution, as usually done in professional disdrometers, and addresing the interest toward extreme events. Radiation is estimated from the same PV cell used to keep charged the working battery, while wind velocity and direction are estimated by two orthogonal load cells. A comparison with a certified weather station used for networks is presented illustrating strengths and weaknesses.

Keywords: IoT, weather station

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Not Everything is Data: Data Practices for AI in Indian Agriculture

Angelina Chamuah[1]

[1] Transitions Research, Senior Research Fellow and Digital Society Program Lead

* Corresponding author: angelina@transitionsresearch.org

Abstract

The belief that data is omnipresent and merely requires collection has been a prevailing assumption in the era of artificial intelligence. Data, characterised as raw and pre-factual information (Gitelman, 2013), is often thought of as adaptive, intangible, and malleable to the requirements of datafied systems. However, a closer examination of the data ecosystem in the Indian agriculture sector and it's utilisation for developing AI solutions, presents a stark contrast to the popular belief that data is everywhere. Based on field interviews with various stakeholders ranging from AI developers, government officials and agricultural extension workers in India, this paper presents a walk through the intricate data webs and practices that inform AI development in the Indian agriculture sector. By dissecting these data journeys, the paper uncovers the numerous bottlenecks and challenges that impede the seamless acquisition of data and disrupt the envisioned data utopia. The paper also challenges the notion of 'data gaps', which is often used to talk about missing data in the Indian agriculture ecosystem and reframes it instead as a 'data mess', pointing to the often messy and difficult process of translating agricultural practices into ready to use forms of datafied representation. Understanding the nuances of data creation and use in specific contexts, like Indian agriculture, is essential for building effective data ecosystems that can truly harness the power of AI for sustainable development and improved livelihoods.

Keywords: India agriculture, data practices, artificial intelligence, data gaps, messy data

AI in the optimization of agricultural management

Keynotes

digital futures

Agronod - a national platform for agricultural data sharing

Joel Hamrén[1*]

[1] Product Owner at Agronod

* Corresponding author: joel.hamren@agronod.com

Abstract

Agronod, established in 2020, is developing a national data-sharing platform to revolutionize Sweden's agricultural sector.

Our mission is clear: to enhance profitability, sustainability, and innovation in Swedish agriculture while ensuring farmers retain control over their data and its use.

Therefore, we are developing the Agronod platform, a technical ecosystem of data collection, data governance, privacy and data sharing infrastructure.

By collecting and structuring data on the Agronod platform we give Swedish farmers insights in and control over their data, while also enabling the development of new applications. One prime example is our climate calculation tool, Agrosfär, which automates a process that used to demand considerable time and effort from farmers.

Agronod recognizes the importance of AI on the way towards a more data driven agricultural sector in Sweden. To achieve this, Swedish agricultural data needs to be collected, structured, and standardized to facilitate AI readiness.

We're a dynamic team, well-versed in data science, design, innovation, and in close collaboration with agriculture experts and researchers. Moreover, we cultivate strong relationships with farmers across Sweden.

Agronod is a partnership between Lantmännen, Växa, LRF, HKScan Sverige, Hushållningssällskapet, and Arla Sverige.

The Agronod-platform, as well as the climate calculation tool Agrosfär, are developed with the support of the European Agricultural Fund for Rural Development.

Keywords: data, platform, sharing, standardization, quality, digitalization

Responsible AI for Agriculture Transformation

Tetyana Zelenska[1]

[1] Director, Monitoring, Evaluation & Learning (MEL), Digital Green

* Corresponding author: tetyana@digitalgreen.org

Abstract

Digital Green has recently launched an AI-powered digital assistant called Farmer.Chat for extension agents (EAs) to provide customized, real-time advice to small-scale farmers. We are currently testing the AI chatbot in India, Ethiopia and Kenya where EAs are actively using it to triage all kinds of questions from farmers, such as seeking information to address plant pests and diseases, assess seed varieties, and help communities adapt to climate change. Initial results from user research conducted in India are promising, demonstrating increased confidence levels among EAs delivering advisory and high degree of trust and satisfaction with the content. We also share DG's principles of responsible AI with concrete examples of how these principles are applied in the context where issues of digital divide, particularly for women farmers and for other marginalized groups, persist.

Keywords: Farmer Chat, farm management, agriculture transformation

Presentations

Opportunities and needs of AI for small-scale regenerative agriculture.

Jorge Luis Zapico[1,2]*

[1] LNU DISA, Linnaeus University Center for Data Intensive Science and Applications

[2] Nybrukarna Community Supported Agriculture

* Corresponding author: jorge@zapi.co

Abstract

In the so-called agriculture 4.0 new data from remote sensing and field sensors can be used for monitoring variables while automation is then used for acting upon the created data. Efficiency is increased by a) increasing production per area; b) reducing labour; or c) reducing costs and/or negative impacts (diesel use, fertilizer, pesticides). But, even if decreasing the impacts, most of the current precision agriculture technology is still based on the same principles and values that underspin the current food production systems with high-input/low-labour monocultures.

At the same time there is a growing number of alternative approaches in regenerative agriculture and agroecology where small-medium size producers work with regenerative approaches and a focus on soil health and low-input/higher-labour polycultures. The data and machine learning approaches in these contexts can be similar, but the scale and goals differ to also include regeneration (increasing SOC, biodiversity, social values) and a focus in polycultures and interconnection of flows. Exploring this may not only benefit small scale regenerative farmers, but it can create future opportunities for regenerative farming at bigger scale where data and machine learning help in monitoring and managing a higher complexity of cultures and goals.

Keywords: small-scale, regenerative farming, vision, discussion.

Autonomous Robotic Platform for Orchards Navigation

Adrien Durand-Petiteville[1]* and Viviane Cadenat[2]

[1] Federal University of Pernanmbuco, Recife, Brazil

[2] Université Paul Sabatier Toulouse III & LAAS-CNRS, Toulouse, France

* Corresponding author: adrien.durandpetiteville@ufpe.br

Abstract

In this talk, we present the Autonomous Robotic Platform for Orchards Navigation (ARPON) project. Its main objective consists of designing a GPS-free navigation framework, which is the founding element of any autonomous system aiming at carrying out agricultural tasks such as monitoring, pruning, or weeding. To design such a framework, the project is divided into 4 parts: (i) The design of a reactive vision-based controller allowing the robot to drive through the alleys and perform u-turn at the end of the alleys; (ii) The development of a perception system detecting the key elements: threes, trunks, ground, end of alleys, workers, and animals; (iii) The design of a GPS-free localization and mapping system to provide the current position of the system; (iv) The development of a human/robot interface to ease the adoption by farmers. In this talk, we first present what are the specificities and challenges of each part. Then, we detail how traditional control and perception methods can be coupled with the latest AI tools to achieve these tasks. Finally, we present the results obtained during the different test campaigns conducted in several orchards.

Keywords: orchards, mobile robotic platform, navigation, gps-free, vision

Computer vision models to improve yield estimation in cherry orchards from Chilean central valley

Francisco Altimiras[1,2]*, Mauricio Antonelli[2,3], Osvaldo Yañez[2], Leonardo Pavez[2], Alireza Pourreza[4] and Hector Allende Cid[1]

[1] Department of Computer Science at Pontifica Universidad Catolica de Valparaiso, Valparaiso, Chile

[1] Department of Data Science at Universidad de las Americas, Santiago, Chile

[1] Department of Research and Development at Instacrops Inc, Santiago, Chile

[1] Digital Agriculture Laboratory at University of California Davis, Davis, United States

* Corresponding author: faltimiras@udla.cl

Abstract
Accurate estimation of crop yield plays a crucial role in the agricultural industry, enabling effective planning, resource management, and market forecasting. This study investigates the application of computer vision and machine learning techniques for yield estimation and phenology monitoring in fruit production, focusing on crops from the Chilean central valley. To address this objective, a comprehensive dataset comprising high-resolution images of fruit trees, climate parameters, and corresponding yield records was collected from multiple farms in the respective regions. The dataset was pre-processed to remove noise and ensure consistency across different sources. Computer vision algorithms were employed to extract relevant features from the images, including fruit count, size, and color distribution. Additionally, vegetation indices and climate data were incorporated as contextual information to enhance the predictive capabilities of the models. Various machine learning models, such as convolutional neural networks (CNNs) and random forest regressor (RFR), were trained and evaluated using the dataset. The models were optimized using cross-validation techniques and performance metrics, including mean absolute error (MAE), root mean square error (RMSE), and coefficient of determination (R^2).

The results demonstrate the effectiveness of the proposed approach in accurately estimating fruit yield. The CNN-based models achieved the best performance, outperforming traditional machine learning models. The incorporation of contextual information further improved the accuracy of yield estimation. Practical examples from the Chilean central valley are presented, highlighting the adaptability of the developed methodology to diverse fruit crops, including apples, grapes, and oranges. The study showcases the potential for computer vision and machine learning techniques to revolutionize yield estimation and phenology monitoring in fruit production, providing farmers with valuable insights for optimizing resource allocation and enhancing productivity.

Keywords: Computer vision, machine learning, yield estimation, fruit production, Chilean central valley.

digital futures

Autonomous drones and AI-assisted computer vision for mapping and management of wild stock

Mikhail Popov[1]*, Alex Jonsson[1], Barry Brown[2], Moira Drummond Mcgregor[2], Marco Moletta[3], Matteo Tadiello[3], Sebastian Wallman[3] and Sara Nozkova[3]

[1] RISE – Research Institutes of Sweden

[2] Stockholm University

[3] Flox Robotics AB

* Corresponding author: mikhail.popov@ri.se

Abstract

The damages due to wildlife animals have doubled since 2014. In Sweden, 85 400 tons of grain were destroyed by wild boar in 2020 and wildlife damage occurred on 17% of the cereal area, compared to 8% in 2014 (Swedish Board of Agriculture, 2021). There is an apparent need for proactively preventing damage instead of post-factum restoration. In addition to the farmer needs, identifying and mapping wildlife at scale is essential to wildlife organizations, veterinary institutes, hunting associations, and insurance companies for better inventory purposes, disease tracking, hunting regulations and insurance claims.

By providing reliable data about wildlife gathered by drones on a daily basis will enable insights to these and other stakeholders to make better data-driven decisions, provide for better animal tracking, protection of crops and financial savings. Using AI-assisted computer vision and drones, one can perform precise identification of the animals and map those at scale both in nearly real-time and having those stored for further purposes.

This presentation reports on the latest result from the project working towards an integrated solution for wildlife tracking and management, namely for mapping and, when required, repelling wild animals using autonomous drones with AI-assisted computer vision and ultrasound repellent technology combined with a system for data visualization, analysis and decision making.

Keywords: wild stock mapping, damage prevention, AI, drone, data-driven decision.

Unveiling Transformative Use Cases: AI and IoT in Agriculture at FAO/ITU Focus Group

Raghu Chaliganti[1]*

[1] Fraunhofer- HHI, Germany

* Corresponding author: raghu.chaliganti@hhi.fraunhofer.de

Abstract

The integration of Artificial Intelligence (AI) and the Internet of Things (IoT) is revolutionizing agriculture. In October 2021, the ITU-T SG20, in collaboration with the Food and Agriculture Organization (FAO), launched the Focus Group (FG) on AI and IoT for Digital Agriculture (FGAI4A) to standardize digital agriculture. At the heart of this initiative is the Working Group on Digital Agriculture Use Cases and Solutions (WG-AS), which identifies and analyzes practical applications of AI and IoT technologies. Over seven FG meetings, WG-AS curated 41 use cases, categorized into six domains: Crop Management, Water Management, Livestock Management, Georeferenced Data Management, Regulations, and Agricultural Machinery. This systematic classification offers a comprehensive perspective on how AI and IoT enhance agriculture. Within these domains, selected use cases exemplify AI and IoT's transformative potential. IoT-based farmland surveillance, for instance, mitigates crop losses, enhancing overall productivity.

Similarly, smart irrigation optimizes water usage and soil moisture levels, while compound planting epitomizes precision farming. Furthermore, FG-AI4A places a strong emphasis on critical issues such as data privacy, interoperability, and ethical AI deployment through initiatives like Industrial Data Space Association (IDSA) for Agriculture. This ensures that the integration of these technologies adheres to robust standards like International Telecommunication Union (ITU) & International Organization for Standardization (ISO). In conclusion, these use cases not only highlight AI and IoT's potential to revolutionize agriculture by addressing challenges and enhancing productivity but also underscore their role in promoting sustainability, aligning with the United Nations' SDGs.

Keywords: AI & IoT in Agriculture, Sustainability, Standardization

digital futures

Data and machine learning for balancing the agricultural shifts of blue water to green around the world

Georgia Destouni[1,2]*

[1] Department of Physical Geography, Stockholm University, Stockholm, Sweden

[2] Department of Sustainable Development, Environmental Science and Engineering, Sustainability Assessment and Management, KTH Royal Institute of Technology, Stockholm, Sweden

* Corresponding author: georgia.destouni@natgeo.su.se

Abstract

As the main source of freshwater on land, precipitation filters into the soil where some of it is used by plants as a ‘‘green water flux’’ and some flows into rivers as the visible ‘‘blue water flux.’’ The ‘‘green’’ flux sustains crops and societal food security, while the ‘‘blue’’ flux sustains aquatic ecosystems and is critical for societal water security, e.g., for drinking water but also for crop irrigation, which shifts blue water into green. Being able to predict how much water ends up in each flux component is key for planning and management of agricultural systems, as well as for water security and ecosystem health. We use observation data from around the world and develop a global machine learning model to identify patterns in this water flux partitioning. We find that the green flux is mostly greater than the blue around the world. Expansion of crops and irrigation to feed a growing human population shifts more blue water into green, exacerbating the blue water vulnerability to future climate change. These results and the global machine learning modelling for water flux partitioning and its changes are important for guiding land-use planning to optimally balance various freshwater needs on land.

Keywords: water flux partitioning, evapotranspiration, runoff, land-use change, climate change.

Daily Reference Evapotranspiration Forecasting via Novel Hybrid Machine Learning Methods to Conserve Agricultural Water Resources

Jinwook Lee[1], Sayed M. Bateni[1], Changhyun Jun[2]*, Essam Heggy[3,4], Mehdi Jamei[5,6], Dongkyun Kim[7] and Hamid Reza Ghafouri[6]

[1] Department of Civil and Environmental Engineering and Water Resources Research Center, University of Hawaii at Manoa, Honolulu, HI 96822, USA

[2] Department of Civil and Environmental Engineering, College of Engineering, Chung-Ang University, Seoul, South Korea

[3]Viterbi School of Engineering, University of Southern California, Los Angeles, CA 90089, USA

[4] NASA Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, USA

[5] Canadian Centre for Climate Change and Adaptation, University of Prince Edward Island, St Peters, PE, Canada

[6] Department of Civil Engineering, Faculty of Civil Engineering and Architecture, Shahid Chamran University of Ahvaz, Ahvaz, Iran

[7]Department of Civil and Environmental Engineering, Hongik University, Seoul, South Korea

* Corresponding author: jungching.kan@sei.org

Abstract

The accurate forecast of reference evapotranspiration (ETo) has a vital importance in optimal irrigation scheduling, irrigation system design and management, crop yield simulation, and efficient water resources planning and management. Three stand-alone artificial intelligence (AI) models, namely Cascade Forward Neural Network (CFNN), Extreme Learning Machine (ELM), and Bagging Regression Tree (BRT) are used to forecast daily ETo. Thereafter, we combined the K-Best feature selection (KBest) and Multivariate Variational Mode Decomposition (MVMD) algorithms with the stand-alone models and developed three novel hybrid models (namely, MVMD-KBest-CFNN, MVMD-KBest-ELM, and MVMD-KBest-BRT) to predict ETo. All six models are trained and tested at 12 weather stations in California (USA) over 2003-2017 and 2018-2022, respectively. Input variables include solar radiation, air temperature, dew point temperature, vapor pressure, and relative humidity. To assess the performance of AI models, four statistical metrics (i.e., determination coefficient (R2), mean absolute error (MAE), root mean square error (RMSE), and Nash-Sutcliffe efficiency) are used. The hybrid models have significantly a better performance compared to the stand-alone models. The MVMD-KBest-CFNN model has the best results with the 12-site mean R2 of 0.966, 0.960, 0.955, and 0.937 for 1, 3, 7, and 10-day-ahead **ETo** forecasts. Corresponding RMSEs are 0.390, 0.416, 0.450, and 0.517 mm/d.

Keywords: Reference evapotranspiration, Multi-temporal Forecasting, K-Best selection, Cascade neural network, Multivariate variational mode decomposition

Estimation of evaporation and drought stress of pistachio plant using UAV multispectral images and surface energy balance approach

Hamid Reza Ghafarian Malamiri[1] and Hadi Zare[2]*

[1] Department of Geography, Yazd University, Yazd 8915818411, Iran

[2] Faculty of Natural Resources, University of Tehran, Karaj 3158777871, Iran

* Corresponding author: hadi.zarekh@ut.ac.ir

Abstract

Water shortage stress is one of the most important abiotic stress factors for plants in arid and semi-arid regions, which reduces the growth, yield and quality of the product. Estimating evaporation and its changes over growing time is important in drought stress management. The purpose of this research is to calculate evaporation and identify pistachio trees with drought stress in a farm in Yazd province of Iran. For this purpose, the study farm was imaged on July 10, 1401 using a UAV with MicaSense Altum multispectral sensor. Using the SEBAL algorithm, the real evaporation of the field was calculated with high spatial accuracy. The FAO 56 recipe and the relationship between the vegetation coefficient (Kc) and the NDVI index were used to create a map of the basic vegetation coefficient (Kcb) and standard evaporation. In the next step, actual evaporation was compared with standard conditions, and trees with drought stress were identified. Based on the results, the average and maximum daily evaporation in pistachio trees on the date of imaging at the field level were 3.4 and 8 mm per day, respectively. The average real plant coefficient of pistachio, which was obtained from the ratio of instantaneous evaporation to the instantaneous evaporation of the reference plant, was 0.66. The standard plant factor based on FAO guidelines 56 for the target date is 1.17, which was higher than what was observed in reality. This difference is caused by the effect of the stress factor (Ks) in the standard plant factor. Based on the results, there was a significant correlation (P-value < 0.01) between vegetation coefficient (Kc) and NDVI index (R2=0.67). In general, by using the regression model between vegetation coefficient and NDVI index, the vegetation coefficient map can be extracted. The plant coefficient map obtained with the regression model, taking into account the heterogeneity in large farms and gardens, can be effective in improving irrigation management and preventing drought stress.

Keywords: evaporation, Pistachio, AI, UAV, Energy balance

AI in climate change adaptation and mitigation of environmental impacts

Keynotes

AI and Agricultural Management

Panos M. Pardalos[1]*

[1] University of Florida, Gainesville FL 32611, USA

* Corresponding author: pardalos@ufl.edu

Abstract

Artificial Intelligence (AI) is transforming agriculture by enabling precision farming through the integration of data from various sources like satellites, drones, sensors, and weather forecasts. This data empowers farmers with real-time insights into soil health, weather conditions, and crop growth, enabling tailored actions such as adjusting irrigation and fertilization. AI also extends to supply chain optimization, predicting market demands, optimizing transportation, and reducing food waste. Additionally, AI-driven robotics alleviates labor shortages in tasks like planting and harvesting. As the global population grows and the demand for sustainable food production rises, AI in agriculture is pivotal for ensuring food security and sustainability. In the lecture we will discuss a number of applications of AI in agriculture with focus on our research.

Keywords: AI, agriculture, sensors, robotics

Inclusively Advancing Agri-Food Systems Through AI and Automation

Genesis Analytics[1] and Josh Woodard[2]*

[1] Multiple unattributed authors

[2] United States Agency for International Development (USAID)

* Corresponding author: jwoodard@usaid.gov

Abstract

This paper explores the potential of artificial intelligence and automation in agriculture, with a particular focus on small-scale producers in low- and middle-income countries. AI and automation technologies have potential to deliver transformational impact in the agriculture sector, yet that impact will not necessarily be evenly distributed. This paper aims to provide a compass to stakeholders navigating the complexities of these issues, to help them make decisions with inclusion in mind. As the application of these technologies among SSPs is still in the early stages, it is difficult to predict what their net impact will be, and almost impossible to do this quantitatively. This report therefore provides a framework for considering the varied and sometimes contradictory impacts that specific AI and automation use cases may have in different contexts, and the trade-offs that need to be navigated by those working in agricultural and inclusive technology development.

Keywords: inclusion, AI, LMICs, farmers, automation

Presentations

Nurturing Sustainable Futures: AI Enhanced Digital Advisory for Climate adaptation and mitigation

Brenda Gunde[1]

[1] Global Senior Technical Specialist, International Fund for Agriculture Development (IFAD)

* Corresponding author: b.gunde@ifad.org

Abstract

The integration of AI technology in agriculture has the potential to revolutionize how we adapt to climate change and mitigate its impacts. IFAD programs have seen increased demand for rural digital advisory services. However, current digital advisory systems are focused on the broad delivery of extension services based on many farmers. AI can revolutionize extension services by providing individualized advisory based on several data elements, including on-farm data, satellite imagery, remote sensing, and GIS. This can increase the value of extension services to individual farmers. By harnessing the power of AI, we can enhance resource management, optimize crop production, promote sustainable practices, and contribute to a resilient agricultural system. Integrating AI technologies into agricultural practices can develop predictive climate models, optimize resource management, enhance pest and disease control, promote sustainable land practices, facilitate data sharing, and provide decision support systems to empower farmers and stakeholders with real-time insights and actionable recommendations to navigate changing climatic conditions effectively. Early warning systems through AI will support reduced costs for smallholders in pest and disease control, climatic conditions prediction, and effective natural resource management. Collaborative efforts between stakeholders to optimize data are vital to realizing the potential of AI in revolutionizing agriculture's response to climate change and promoting adaptation.

Keywords: *Climate, digital advisory, AI, IFAD, Partnerships*

Impact of AI in the agriculture sector to maintain climate change resilience and environmental sustainability

Sumanta Bhattacharya[1] and Bhavneet Kaur Sachdev[2]*

[1] MAKAUT and NALSAR

[1] University of Calcutta and IGNOU

* Corresponding author: sumanta.21394@gmail.com

Abstract

Climate change concerns food, water, and crop output. AI offers new approaches to reduce environmental consequences while improving economic growth, food security, and sustainable development. Satellite images and machine learning can help farmers improve their operations. Farmers can reduce resource waste and CO2 emissions by improving irrigation, fertiliser, and pest control. AI-powered models can foresee bad weather and adjust farming practises to protect crop productivity. Farmers keep profitable and reduce environmental effect. AI can improve food security by streamlining supply lines. AI can track and predict climate-related food supply chain disruptions. AI could enhance food distribution and cut food waste, now a third of worldwide food output. AI improves supply networks and climate-resilient agriculture to feed a growing population.

Timely data and accurate estimates from AI help farmers respond to climate change. Weather, soil, and agricultural yield data can predict planting, variety, and watering periods for machine learning algorithms. Farmers can adapt to weather, reduce calamities, and maintain agricultural yield. AI optimises precision agricultural water, fertiliser, and pesticide use. Properly applying these inputs decreases farmer waste and runoff. This resource-saving method decreases pollutants and improves soil and water quality. AI-powered sensors and image recognition monitor crops 24/7. These sensors identify pests, diseases, and nutritional deficits early. AI reduces pesticide use and food production by preventing farm harm. Different Climates Need Better Crops. AI promotes drought- and heat-resistant plant growth. AI technologies scan massive genetic data sets for heat-, cold-, drought-, and other-tolerant agricultural characteristics. Increasing crop variety weather resilience saves agriculture. Governments and farmers make smart decisions with AI. AI can analyse massive agricultural data to improve land use planning, crop diversity, and sustainable farming, greening agricultural systems. Climate-resilient agriculture needs AI. The data-driven insights and cutting-edge technology of AI enhance resource utilisation, waste reduction, and farmer and stakeholder resilience. It lowers agricultural pollution and promotes climate change adaption.

Keywords: AI, agricultural pollution, climate change, crops, fertilisers, food security

Advancing Carbon Sequestration Estimation in West African Agricultural Systems through AI-Driven Biomass Modelling

Emmanuel Duah[1]*, Anthony Kofi Osei[1] and Chanik Kwao-Agboado[1]

[1] Farmerline Group

* Corresponding author: emmanuel.duah@farmerline.co

Abstract

As global concerns about climate change intensify, understanding the role of agricultural systems in carbon sequestration becomes paramount. Farmerline is currently working on the development of an advanced AI-driven model to estimate above-ground biomass (AGB) and carbon stock in cash crop farmlands across West Africa. This model employs a multi-faceted methodology that extracts and combines vegetation indices as raster files, leveraging satellite imagery. The AGB values are plotted on images and mean vegetation indices within predefined zones are computed, forming a comprehensive dataset. Harnessing machine learning algorithms including Random Forest Regression, we establish relationships between AGB and spectral indices. The model empowers sustainable land management, aiding informed decisions on crop cultivation and carbon mitigation. Importantly, it facilitates farmer engagement in carbon markets, fostering economic gains and incentivizing eco-conscious practices. Collaborating with domain experts and harnessing cutting-edge technology, our research bridges agriculture and sustainability. Our innovative methodology, coupled with powerful algorithms, offers a robust framework for climate adaptation and mitigation. By uniting data-driven insights with practical applications, we forge a resilient and harmonious future for our planet.

Keywords: Climate Change, Agricultural Systems, Carbon Sequestration, AI-driven Model, Above-Ground Biomass & Carbon Stock

Agricultural drought under climate change: a national scale prediction

Jung-Ching Kan[1,5]*, Carla Ferreira[2,3], Georgia Destouni[2], Haozhi Pan[4], Marlon Vieira Passos[5], Karina Barquet[5] and Zahra Kalantari[1,2]

[1]Department of Sustainable Development, Environmental Science and Engineering, Sustainability Assessment and Management, KTH Royal Institute of Technology, SE-100 44, Stockholm, Sweden

[2]Department of Physical Geography and Bolin Centre for Climate Research, Stockholm University, SE-106 91 Stockholm, Sweden

[3]Research Centre for Natural Resources, Environment and Society (CERNAS), Polytechnic Institute of Coimbra, Coimbra Agrarian Technical School, Bencanta, 3045 Coimbra, Portugal

[4]School of Public and International Affairs, Shanghai Jiao Tong University, 800 Dongchuan Rd., Shanghai 200240, China

[5] Stockholm Environment Institute (SEI), Stockholm, Sweden

* Corresponding author: jungching.kan@sei.org

Abstract

Agricultural drought has adverse effects such as crop yield reduction, thus affecting food security and economy. Climate change has a major impact on agricultural droughts. This study predicted agricultural drought in Sweden, using machine learning (ML) models to forecast Palmer drought severity index (PDSI) and soil moisture. Seven ML models (random forest (RF), decision tree, multivariate linear regression, support vector regression, autoregressive integrated moving average (AMIRA), artificial neural network, and convolutional neural network) were built with three different data arrangement methods (multi-features, temporal, spatial). Seven variates, obtained from Google Earth Engine, were used as features and analyzed with recursive feature elimination (RFE) to find the optimal feature set. The results showed that the temporal ARIMA model was most suitable for local scale prediction with MAE=9.1, R2=0.79 in soil moisture prediction. The multi-features RF model was most ideal for national scale prediction (MAE=11.95, R2=0.59 for soil moisture prediction). Models had a higher accuracy in predicting soil moisture compared to PDSI. Soil moisture was identified as the most important variate and with four other variates (PDSI, precipitation, evapotranspiration, elevation) made up the optimal feature set. The drought indicators prediction is essential as an early warning system and support crisis preparedness in Sweden.

Keywords: Drought, Soil moisture, Palmer drought severity index, Climate, Machine learning

Climate smart advisory for smallholder farmers through ML-enhanced weather predictions

Andreas Vallgren[1]*, Lorenzo Bottarelli[1]

[1] Ignitia AB

* Corresponding author: andreas.vallgren@ignitia.se

Abstract

Accurately predicting rainfall is a meteorological challenge with implications for billions of people in the Tropics, including SubSaharan Africa, where agriculture is mostly rainfed and hence dependent on both actual rainfall as well as accurate predictions thereof.

Global forecast models fall short in predicting rainfall to such a degree that climatology itself provides the same level of performance as daily global forecast model predictions in places like West Africa, despite being a poor predictor in a region with large day to day and year to year variability.

Addressing this, Ignitia has developed a high-resolution numerical ensemble prediction system enhanced by machine learning techniques for tropical weather predictions. Ignitia reliably predicts the rainfall distribution allowing for improved agricultural performance and livelihoods. Ignitia's approach has been extended to several spatiotemporal scales, improving underlying forecasts which allows for reliable mobile alerts/advisories in support of climate smart agriculture, to date having reached 2.7m smallholder farmers. For example, extended range predictions of rainfall probability & amount/anomaly can help identify optimal seed varieties, when to prepare the soil, plant & provide inputs throughout the crop calendar year. Enabling better-informed decisions reduces crop-losses while increasing yields, as has been validated by third party evaluations.

Keywords: Tropics, rainfall, forecasting, machine learning, smallholders

Optimizing advice for nature-based solutions at the farm level: a case study in the Netherlands

Gerard H Ros[1,2], Tessa van der Voort[2]*, Sven Verweij[2], Kees van den Dool[2], Brent Riechelman[2] and Yuki Fuijta[2]

[1] Wageningen University, Environmental System Analysis

[1] Nutrient management Institute, Wageningen

* Corresponding author: tessa.vandervoort@nmi-agro.nl

Abstract

Reducing adverse environmental impacts of agriculture whilst safeguarding agricultural production is crucial in a world undergoing major environmental changes compounded by climate change and a growing population. A key challenge is that whilst the impact of farming is felt on regional and ecosystem level, the main drivers as well the opportunities to change heavily rely on activities done at farm and field level. Environmental policies however often lead to one-size-fits all solutions which can lead to a one-size-fits-nonenvironmental result. In this contribution, we present a data driven framework where farm-level advice is underpinned that reduces adverse environmental impacts on soil, water and climate for farmers: the Farm Oriented Water and Soil Plan. This approach leverages private and public databases of field-level soil properties, cropping systems and regional environmental targets, and combines it this with state-of-the-art agronomic insights and open-source algorithms to translate it to effective-farm level advice. The framework integrates this knowledge in a user-friendly web-application using integrative Key performance Indicators to assess the sustainability of farming systems (KPIs). The tool has been evaluated with various stakeholders (farmers, policy makers, scientists) and has high potential to boost the environmental performance of farming systems. The Water and Soil Plan includes field specific advice for carbon sequestration, reduction of nutrient leaching to surface water and groundwater and increase water retention. This contribution leverages AI in agriculture to facilitate sustainable decisions by providing effective and tailor-made advice. Currently it is in the scale-up phase with several hundred farmers in the Netherlands using it in combination with a farm advisor.

Keywords: Agriculture, Nutrient management, carbon, Decision Support Tool.

digital futures

Analysis of the use of Artificial Intelligence (AI) in three levels of climate change mitigation- Using a three-level model approach focused on mitigation and resilience

Saeed Givehchi[1]

[1] Faculty of Environment, University of Tehran, Tehran, Iran

* Corresponding author: givehchi12@gmail.com

Abstract

Artificial Intelligence (AI) could be a valuable tool for mitigation the climate disasters through three dimensions of measurement, reduction, and removal of existing greenhouse gases from the atmosphere. The artificial Intelligence (AI) has a great potential to assess, predict, and mitigate the risk of climate change effects using big data, applying learning algorithms, and sensing devices. AI performs precise calculations and predictions for critical decisions how to decrease the impact and climate disasters impacts. In recent years, with the increasing availability of large databases and artificial intelligence (AI) models continue to be used to process and interpret data at a more reliable rate. However, its application in natural disaster management (NDM) has become increasingly widespread. To reduce the consequences of natural disasters effectively, AI models have been gradually applied in different bases of DM due to its ease of using, high speed operation and acceptable accuracy.

AI is a comprehensive subject that integrates computer science, mathematics, philosophy, neuroscience, psychology, cybernetics, linguistics, and other professional fields. Despite this subject that AI has received considerable attention from the government and practitioners, there is no widely acknowledged definition.

In this research, it is intended to consider the analytical applications of artificial intelligence (AI) in large-scale measurements of the consequences of climate change. The focus of this research will be specifically on the three main components of Mitigation of the consequences of natural disasters. In general, Mitigation of natural disasters effects is done in three steps, and in this article three parts, Measurement, Reduction, and Removal are considered. The method of doing this article is a review study on the dimensions of the use of artificial intelligence in some published articles.

The results of this research indicate that the most important applications of this tool are in the stage of large-scale measurements of estimating remote carbon natural stock. In the area of reduction, the most important application is reducing GHG emissions intensity. But the most important function of mitigation the effect in agricultural management is related to Removal. In this research, the main focus is on this issue.

The results of this research indicate that artificial intelligence has wide applications in the Hazard Removal phase in the Mitigation process against climate change, which broadly includes land use monitoring, which has been reviewed and analysed in this article.

Keywords: Artificial Intelligence (AI), climate change, natural disaster management (NDM), Agricultural Management

Explainable AI in Predicting Anthropogenic Forest Fire Risk in Austria: A Multi-Criteria Approach

Elisabeth Wimmer[1]*, Kevin Mallinger[1,2], Caroline Lawitschka[2], Sebastian Raubitzek[1], Thomas Neubauer[1] and Sebastian Schrittwieser[2]

[1] SBA Research, Vienna, Austria

[2] University of Vienna, Austria

* Corresponding author: ewimmer@sba-research.org

Abstract

Forest fires are becoming more frequent due to climate change and its effects, with increasingly devastating consequences for nature and society. Therefore, predictive modelling of forest fire ignition risk is a crucial step for forest management toward implementing mitigation measures.

Our work introduces a high-resolution modelling approach for predicting anthropogenic forest fire ignition risk in Austria, enabling a precise risk estimation for each specific geographical coordinate. We analysed a decade of fire data from Austria (2012-2021) and generated an equivalent amount of no-fire data points to create a balanced data set and validate the results. For the first time, human movement patterns, as well as features such as slope, FFMC mean, vegetation, and socio-economic indicators (e.g., the amount and type of infrastructure in proximity) have been combined with state-of-the-art machine learning models to increase prediction accuracy. A cross-validated accuracy of 78% was achieved by a random forest classifier, followed closely by CatBoost with an accuracy of 77%. By deploying interpretable models, a feature importance analysis was conducted to investigate relevant drivers of fire risk. The predictive probabilities obtained from the model will be presented within a forest fire susceptibility map at the municipality level (LAU 2) to pinpoint high-risk areas.

Keywords: Climate Change, Forest Fire Prediction, Explainable AI, Susceptibility Map, Human Movement Patterns

Sustainability science perspective on AI application on agricultural systems

Keynotes

Supporting ecological transformation of agro-food systems with digital tools

Angelika Hilbeck[1]*

[1] Swiss Federal Institute of Technology Zurich, Switzerland

* Corresponding author: angelika.hilbeck@env.ethz.ch

Abstract

Digitalisation, including machine learning, in its current mainstream forms, does not yet deliver the necessary solutions for deep sustainable transformation of agriculture. In the European D4S project, the researchers therefore called for a ‘Digital Reset: a fundamental redirection of the purpose of digital technologies towards a deep sustainability transformation’ also for agriculture. In currently dominating industrialized agro-food systems, manual labor is replaced by mechanized and, today, increasingly digitalized, factory-based mass production that heavily relies on synthetic fertilizers and pesticides and promotes patented seeds. These forms of production ignore the ecological laws and planetary boundaries of our Earth. It is therefore unsurprising that industrial farming is a recognized driver behind climate change, biodiversity loss, chemical pollution of terrestrial and aquatic ecosystems and soil erosion. However, digital tools could assist in the ecological transformation process of agro-food systems if they followed several principles: technologies should be built according to regenerative designs and pursue system innovations that advance circularity and sufficiency, improve economic resilience, and foster digital sovereignty, diversity and social equity. In agriculture, digital technologies should support a transformation towards locally adapted and ecological farming practices rather than optimising high-impact industrial monocultures.

Keywords: Agroecology, ICT, transformation

Artificial Intelligence and Digital Agricultural Technologies: Their value on Applied Agroecosystem Research

Guillermo Marcillo[1], Colton Atkins[1], Craig Bednarz[1,2], Brent Auvermann[2] and Carolina Brandani[2]

[1] West Texas A&M University, Department of Agricultural Sciences, Canyon, Texas

[2] Texas A&M AgriLife Research, Amarillo, Texas

* Corresponding author: gmarcillo@wtamu.edu

Abstract

Agriculture is a major field for the application of innovative data-driven technologies. In a world increasingly dominated by data footprints from human activity, agricultural stakeholders (growers, researchers, policymakers, etc.) can now use streams of data from diverse digital sources, ranging from proximal sensors to satellites, and pair them to field-level measurements on soil and crop production to tackle problems what were seemingly impossible years ago. In this context, research that integrates computational methods (statistical models, process-based simulations, Artificial Intelligence (AI) algorithms) driven by sound principles of plant, soil, and environmental science are key elements to assist in the process of making more informed and better decisions. In this presentation, past and current research, as well as collaborative efforts with US State agencies and co-operators, will be reviewed to illustrate successful applications of Machine Learning (ML) and Crop Simulation Models (CSM) on integrative agroecosystems driven research involving varied cropping systems and production regions in the United States. Also, opportunities will be discussed for harnessing computational resources for the advancement of fundamental knowledge derived from agricultural experimentation, and for scaling applications leading to restore soil health and conserve water for agricultural use in water-limited regions.

Keywords: Sustainable Agriculture, Digital Agriculture, Machine Learning, Crop Models

Presentations

Artificial Intelligence (AI) in Agriculture: Transforming Farming for a Sustainable Future

Amandeep Singh[1]*, Balvinder Singh[2], Siby Samuel[1], Aida Z. Kebede[3], Manjit Singh[4] and K.N Dewangan[5]

[1] Department of System Design Engineering, University of Waterloo, PO Box N2L 3G1, Waterloo, Canada

[2] Department of Computer Science and Engineering, Guru Gobind Singh Indraprastha University, New Delhi, PO Box 110078, India

[3] Agriculture and Agri-Food Canada, Ottawa, Canada

[4] Department of Farm Machinery and Power Engineering, College of Agricultural Engineering and Technology, Punjab Agriculture University Ludhiana, India

[5] Department of Agricultural Engineering, North Eastern Regional Institute of Science and Technology, Nirjuli 791109, India

* Corresponding author: a82singh@uwaterloo.ca; amandeep.singh@polymtl.ca

Abstract
Agricultural sector is transitioning from traditional practices to advanced technological solutions. AI driven by digital technology plays a pivotal role in ensuring the sustainability of global agriculture. AI optimizes irrigation, detects anomalies, monitors crop and soil, identifies diseases and pests, ensures livestock health, applies pesticides intelligently, predicts yields, automates weeding and harvesting, sorts produce, and enhances surveillance. AI's potential in agriculture is amplified when integrated with digital technologies such as big data informs decisions, IoT sensors capture real-time data, and intelligent automation through robotics minimizes manual labor. AI adoption faces challenges such as farmer unfamiliarity and upfront costs hinder progress. Overcoming resistance and ensuring practical experience in emerging technologies, a lengthy adoption process, addressing technological limitations, and security concerns are key. As agriculture embraces AI, the adoption of smart tools, automation, and AI-driven products promises to enhance efficiency, optimize resource allocation, and enable real-time monitoring. This transformative shift will empower farmers to become efficient stewards of advanced agricultural systems, underscoring the vital role of innovation and sustainability in modern farming. The future of AI in agriculture offers a pathway to promote sustainable and highly efficient farm practices through the judicious application of cutting-edge technology.

Keywords: Digital Agriculture, Artificial Intelligence, Automation, Internet of Things (IoT), Sustainable Farming

Redesigning horticultural food systems with digital twins

A. John Mawson[1], Paul Johnstone[1*] and Richard D. Newcomb[1]

[1] The New Zealand Institute for Plant and Food Research Limited

* Corresponding author: Paul.Johnstone@plantandfood.co.nz

Abstract

Perennial horticulture is facing many challenges as consumers and societies reconsider what is expected of future food systems in the face of increasing shocks. Digital technologies offer many opportunities for increasing the precision of production systems and supply chains in response to these challenges. However, many current agritech products and services address only single needs and do not explicitly draw on the richness of our knowledge in plant and ecological sciences. These limitations can be addressed through digital twins, which are increasingly being adopted across diverse fields to monitor, analyse, simulate, and control complex systems. Here we describe the approach and progress The New Zealand Institute for Plant and Food Research Limited (Plant & Food Research) is making to develop a digital twin to leverage the opportunities offered through the integration of biology and digital technologies. Our goal is to dynamically couple physical components of apple production and supply chain systems with their virtual analogues. The digital twin will direct sensors and external interfaces to obtain input data from the real world, and prescribe optimal interventions based on models that robustly simulate the impact of selected biotic and abiotic stresses on key physiological, ecological, and quality modifying processes.

digital futures

Smart Waste Management Hub for Sustainable Agriculture

Balvinder Singh[1]*, Amandeep Singh[2] and Siby Samuel[2]

[1] Department of System Design Engineering, University of Waterloo, PO Box N2L 3G1, Waterloo, Canada

[2] Department of Computer Science and Engineering, Guru Gobind Singh Indraprastha University, New Delhi, PO Box 110078, India

* Corresponding author: balvinder.loothra@gmail.com

Abstract
In today's evolving agricultural landscape, there is a critical need for intelligent waste solutions that enhance efficiency and sustainability. Our approach revolves around a centralized hub that utilizes cutting-edge X-ray technology and Artificial Intelligence (AI) for precise waste sorting. AI continuously refines segregation, reducing errors, thereby streamlining waste management processes. We introduce circular agriculture, transforming organic waste into valuable resources such as bioenergy and biodegradable materials, offering an eco-friendly and resource-efficient approach. Internet of things (IoT) sensors offer real-time waste monitoring, providing vital data for optimizing resource allocation and waste reduction strategies. Integration of blockchain ensures transparency and traceability in the supply chain. This approach not only ensures high-quality organic waste management and valuable by-product creation but also significantly reduces the environmental impact of agricultural waste, contributing to a more sustainable ecosystem. Authorities and agricultural organizations can play a pivotal role in promoting the adoption of this advanced approach. They can provide comprehensive training to farmers, offer financial incentives, and establish supportive regulatory frameworks. Embracing this approach allows agriculture to evolve into a sustainable, efficient system, paving the way for a greener future while addressing the pressing challenges of waste management in agriculture.

Keywords: Intelligent Waste Solution, Blockchain, Transparency, Traceability, Sustainability

Optimization of Agricultural Management Using Deep Reinforcement Learning and Large-Scale Simulations

Carla S. S. Ferreira[1,2]*, Ran Tao[3], Pan Zhao[3], Jing Wu[3], Matthew T. Harrison[4], Nicolas Martin[3], Guillermo Marcillo[5], Naira Hovakimyan[3], Zahra Kalantari[6]

[1] Polytechnic Institute of Coimbra, Applied Research Institute, Coimbra, Portugal

[2] Research Centre for Natural Resources Environment and Society (CERNAS), Polytechnic Institute of Coimbra, Coimbra, Portugal

[3] University of Illinois at Urbana-Champaign, Champaign, USA

[4] University of Tasmania, Australia

[5] University of Texas, USA

[6] KTH Royal Institute of Technology Stockholm, Sweden

* Corresponding author: carla.ferreira@ipc.pt

Abstract

Improving agricultural management, namely fertilization and irrigation, has tremendous potential to support the achievement of sustainable agriculture; however, it is challenging to develop the optimal management practices for mitigating the environmental impacts of intensive cropping as well as the crop yield. This paper presents an intelligent crop management system that optimizes nitrogen fertilization and irrigation simultaneously via reinforcement learning (RL), imitation learning (IL), and crop simulations using the widely used DSSAT crop model. Deep RL is used to train management policies that require a large number of state variables from the simulator as observations. Then, IL is used to train management policies that only need a limited number of variables that are measurable in the real world, by mimicking the actions of the RL-trained policies. Simulated experiments using maize in Florida, USA, and Zaragoza, Spain, demonstrate that the trained policies under both RL and IL achieve better outcomes than a baseline policy (i.e. technical guidelines for maize farmers in Florida, and the real practices used by farmers in Zaragoza). The IL-trained management policies are directly deployable in the real world as they use readily available information. This study demonstrates the potential of deep RL in optimizing crop management for more sustainable and resilient agriculture.

Keywords: Reinforcement Learning; Imitation Learning; Intelligent Crop Management; Sustainable Agriculture

digital futures

Machine Learning and Process Based Water Quality Modelling: Synergies and Opportunities

Martyn Futter[1]*, Emma Lannergård[1] and Paul Whitehead[2,3]

[1] Swedish University of Agricultural Sciences

[2] University of Oxford

[3] Aquascope Solutions

* Corresponding author: martyn.futter@slu.se

Abstract

The ever-expanding literature on application of machine learning (ML) techniques to hydrological and water quality prediction has focused on how it can be used as an alternative to process based modelling, with limited exploration of how ML could improve the usability of process based environmental models. ML predictions are criticized for being "black boxes" lacking the necessary physical realism for making robust predictions. On the other hand, process-based models are criticized for perceived difficulties in parameterization and long run times. Parameter space exploration is a topic ideally suited to machine learning (ML). Parameter sets and their associated performance statistics generate data sets ideally suited to "off the shelf" ML analysis using decision forest and deep learning techniques. Here, we evaluate an "off the shelf" ML pipelines (e.g., Google CoLabs, Keras and TensorFlow) to streamline parameterization of process-based models. We hypothesize that an appropriately tuned ML model will be able to identify ensembles of plausible parameter sets and that these pre-screened parameter sets can then be used to identify promising starting points for a simulated annealing ("hill climbing") framework for model calibration. Preliminary results are encouraging, however, further work is needed to improve ML predictions of plausible parameter sets.

Keywords: parameterization, process-based models, water quality

Advances and opportunities presented by the 4.0 revolution to manage the green (ecosystems and agriculture)

António J.D. Ferreira[1]*, J.P.N.M. Amaro[2], Jorge Bernardino[2], Arlindo Ribeiro[3], Carla S.S. Ferreira[1,4] and A-K Boulet[1]

[1] Research Centre for Natural Resources Environment and Society (CERNAS), Polytechnic Institute of Coimbra, Coimbra, Portugal

2 Higher Institute of Engineering of Coimbra, Coimbra, Portugal

3 AXIANS

[4] Polytechnic Institute of Coimbra, Applied Research Institute, Coimbra, Portugal

* Corresponding author: aferreira@esac.pt

Abstract

The introduction of new technologies to monitor and govern ecosystems, either natural or managed ecosystems (agriculture) presents avenues of new possibilities that can be used to identify risks and overall improve crop management and a more judicious use of assets, and to provide a much higher resolution in terms of properties and processes.

The new IT tools, such as IoT, AI, Machine learning, drones, bear the potential to revolutionize ecosystem governance, albeit with some difficulties. First of all, agriculture and natural ecosystems are often located in remote rural areas or in the middle of the wilderness, where communication can be a problem and the implementation of IT equipment and structures difficult and costly, with an increased risk of vandalism.

Yet, the potential for innovation is enormous, in particular if we can mingle together technology with biological processes at different scales.

For instance, this joint venture allows for a more sustainable and competitive form of agriculture, due to a timely and judicious use of production factors, may result in an increase in biodiversity and better products, with less effort and the highest potential added value of the products.

Innovation can extend to the management of biological processes, namely the management of insects, either pollinators, auxiliaries, pests or vectors of diseases, on the activity of soil fauna and on the development of root systems.

The potential to develop specific sensors is immense, allowing the monitoring of environmental parameters, crop development and plagues and diseases for intercropping, using for this purpose the development of specific algorithms through artificial intelligence. The development of specific sensors, and the sensors and detection dimension, which encompasses the development of specific sensors to monitor environmental and biological parameters. The set of sensors embodies an IoT logic, which through a local communication network is transferred to a temporary storage location

(edge), being the object of a first quality treatment (cleaning, filtering, etc.), instant viewing, etc.), to reduce the need for communication with the cloud, and thus mitigate any problems arising from connectivity issues. The data is then sent to the cloud, where through Artificial Intelligence methodologies it will be subject to advanced and predictive analyzes that will carry out a wide range of predictions and decisions.

Data treatment can also be further improved. The use of platform that allows decision support solutions through visualization dashboards, with integrated alarms, and autonomous action through commands for equipment in the field are now possible.

The processing of data, using Artificial Intelligence, will serve as a basis for the construction of a digital platform that will serve as a decision support system, and where these will be oriented towards a set of principles, such as the optimization of productive activity, in terms of efficiency and effectiveness, considering local conditions and resources, agriculture system specificities, costs of production factors in terms of productivity, optimization of the use of production factors such as fertilizers, irrigation or energy consumption. This information feeds the local computation (edge) that can perform a set of actions, such as pest control, fertigation management, opening and closing of greenhouses, etc.

Keywords: Agriculture 4.0, sensors, monitoring agroecossistemas,

AI on the Ground: Implications of AI use for Agriculture in India

Vikrom Mathur[1]

[1] Transitions Research

* Corresponding author: vikrom@transitionsresearch.org

Abstract

Rapid advances in AI technologies in recent years has generated widespread interest and growing investments towards the use of AI in Indian agriculture. At present, the Indian agriculture landscape has more than 1000 agri-tech start-ups that use AI to optimise supply chains, provide agri-advisory, predict demand, and enhance market efficiency - aimed at both farmers and consumers. Besides private corporations, the government in India has also announced its commitment to leveraging AI in agriculture through policies and initiatives, often touting AI as a promising technology to address an ailing agriculture sector. However, the implications of AI use for Indian agriculture continue to be under-explored. Whether the benefits of these technologies will materialise is far from clear, and at the same time, the use of AI in agriculture can also give rise to novel risks.

This talk employs a "speculative futures framework" to construct two fictionalised use-case studies, focusing on the utilisation of AI within the Indian agricultural sector, in order to explore their present application and how they might evolve in the future.1 Using these two use-case studies, and drawing from a comprehensive study of the emerging landscape of AI use and its implications in India2, the talk provides an examination of the various social, ethical and environmental challenges. The talk calls for a critical examination of AI's role in shaping the future of agriculture. Ultimately, the talk seeks to address the question of responsible AI use – what must various stakeholders involved in AI development and deployment take cognisance of when rolling out AI 'on the ground'?

Keywords: AI technologies, agri-tech start-ups, agriculture landscape

A systematic scoping review of the sustainability of blockchain, vertical farming, plant-based alternatives and food delivery service in food systems

Bunge, Anne Charlotte [1]*, Gordon, Line [1]

[1] Affiliation Stockholm Resilience Centre, Stockholm University

* Corresponding author: annecharlotte.bunge@su.se

Abstract

Food system technologies (FSTs) are being developed to accelerate the transformation towards sustainable food systems. Here we conducted a systematic scoping review that accounts for multiple dimensions of sustainability to describe the extent, range and nature of peer-reviewed literature that assesses the sustainability performance of four FSTs: plant-based alternatives, vertical farming, food deliveries and blockchain technology. The included literature had a dominant focus on environmental sustainability and less on public health and socio-economic sustainability. A wide range of literature describes, but not analytical assessed, the ecological and social benefits of applying blockchain to the food sector. Gaps in the literature include empirical assessments on the sustainability of blockchain technology, plant-based seafood alternatives, public health consequences of food deliveries and socio-economic consequences of vertical farming. The development of a holistic sustainability assessment framework that demonstrates the impact of deploying FSTs is needed to guide investments in and the development of sustainable food innovation.

Keywords: Novel Food Tech, Sustainability Assessment, Blockchain Technology