Report

An overview on ICT developments in the Agri-food sector: a report from ERA-Net Cofund on ICT-enabled Agri-Food Systems funded projects seminar 2024

Ein Überblick über die ICT-Entwicklungen im Agrar- und Lebensmittelsektor: ein Bericht über das Projekt-Seminar 2024 des Programms ERA-Net Cofund zu ICT-basierten Agri-Food-Systemen

Una panoramica sugli sviluppi delle ICT nel settore agroalimentare: una relazione sul seminario di progetto 2024 del programma ERA-Net Cofund sui sistemi agroalimentari basati sulle ICT

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INTRODUCTION

ERA-NET Cofund is an initiative conceived within the Horizon 2020 framework that aims to increase the share of funding jointly dedicated by member states to challenge-driven research and innovation. ERA-NET Cofund actions have an average duration of 5 years, during which private and public stakeholders commit to launching and implementing a series of transnational calls for research and innovation projects. The calls are co-financed by the European Commission in the amount of 33% of the total call budget.

ICT-AGRI-FOOD is an ERA-NET Cofund initiative that was launched in 2019 with the aim of supporting the shift towards sustainable and resilient agri-food systems through the integration of ICT (Information & Communication Technology). The ICT-AGRI-FOOD consortium comprises 34 partners from 22 countries/regions. By organising and financing joint calls for transnational research projects, the consortium strives to integrate digital technology into the agri-food sector, leveraging resources to enhance Europe's research endeavours in terms of efficiency and effectiveness.

From 29.01. to 01.02.2024, Laimburg Research Centre participated in the 2024 ICT-AGRI-FOOD funded projects seminar in Warsaw. The seminar provided an overview of the current outputs from ICT-enabled agri-food systems projects funded since 2019 by the ERA-Net Cofund.

These findings represent the pinnacle of precision agriculture development across Europe, providing valuable insights to inform the ongoing evolution of Laimburg's Strategic Agenda for 2030, particularly within the Research Focus area of "Digital Innovation and Smart Technologies". This research direction seeks to advance cultivation and processing methods by integrating digitalisation and modern breeding techniques into practical applications. The Laimburg Integrated Digital Orchard (LIDO) is a cornerstone in this effort, offering two digital outdoor laboratories for testing and validating new digital technologies under field conditions, one in a vineyard and the other in an apple orchard. These trial fields, which reflect real conditions, have been equipped with state-of-the-art technology. Both fields are connected to electricity and fibre-optic communications systems. A remote-controlled, fixed spraying system for the application of plant protection products has been integrated. The outdoor laboratories are now available for companies, research institutions and interested parties to test their products and demonstrate them to the public.

Moreover, Laimburg, is part of the South Tyrolean European Digital Innovation Hub (EDIH) which provides companies with a local gateway to digital transformation, with a specific focus on Artificial Intelligence. Within this initiative, Laimburg supports local agrifood companies in their digitalisation journey through awareness-raising events, "test-before-invest" sessions, digital maturity assessments, and by connecting them with national and European innovation ecosystems. It also collaborates with other Digital Innovation Hubs to share best practices and promotes regional awareness of the benefits of digitalisation strategies for companies. The insights shared at the conference could serve as valuable inputs for future research within the LIDO framework and foster potential collaborations with other European partners.

THE ROLE OF ICT IN SUPPORTING SUSTAINABLE AGRICULTURE

The ICT-AGRI-FOOD Strategic Research and Innovation Agenda (SRIA) was published in 2019. The SRIA provides an overview of digital agriculture and food systems in the EU, outlining both challenges and trends. It serves as a roadmap for funding innovation and identifying barriers to the adoption of ICT and digital technologies in this sector [1].

The report aimed to guide research priorities during the ERA-NET period from 2019 to 2024, by encouraging the use of new technologies for competitive, sustainable, and environmentally-friendly food and agriculture systems.

According to the SRIA, across the food and agriculture sector, the adoption of Information and Communication Technology (ICT) varies, with distinct focuses and rates of integration [1].

In the realm of research and development, there is a growing recognition of the importance of data and a keen interest in computer-related innovations. Efforts influenced by disciplines such as Life Sciences have led to the establishment of standards such as AGROVOC, a multilingual vocabulary facilitating the annotation of agrifood research and enhancing data integration [2] Additionally, there have been many advancements in crop modelling, which rely on extensive datasets for testing and validation [3] [4]. The recognition of the inherent value of datasets has stimulated the development of scientific initiatives promoting data sharing and reuse. Movements like Open Data and FAIR data principles have further catalysed this trend [5], mandating the open availability of research outputs, including datasets. Remote observation data from satellites, such as those from the EC's Copernicus and MARS project (Monitoring Agricultural ResourceS (MARS) - European Commission (europa.eu), have significantly supported crop prediction efforts. Moreover, genetic and germplasm data banks, play a crucial role in supporting crop biodiversity and breeding efforts [6]. Overall, these developments underscore the growing importance of ICT and data-driven approaches in enhancing agricultural research and development practices.

On-farm ICT development has witnessed significant advancements. Precision agriculture, with roots tracing back to the 1980s, has only recently become feasible due to the decreased costs of hardware components, notably through satellite guidance systems and sensors [7] [8] [9]. These technologies can be utilised in crop farming, horticulture (especially in greenhouse

Tab. 1: Major hardware and software developments and their applications in agriculture.

Hardware	
ICT technologies	Applications
Satellite navigation (GPS)	Navigation - farm machinery control for seed drilling, fertilizer, and pesticide application [8]
Satellite observation (Copernicus)	Remote observation for crop prediction, biomass estimates, soil moisture conditions [10] [11], crop insurance inspection, spread of diseases etc.
Drones	With hyperspectral (NDVI) snapshot cameras can calculate biomass, fertilisation state, soil variations, pest and fungi infestations, healthy vs. diseased plants, crop spraying [12] [13] [14].Possibility to collect thermal imaging data for crop performance [15]
Robotics	Autonomous mechanical weeding, fertilizers and pesticides application, crop harvesting, etc.
Proximal sensors	a) location sensors (using GPS and RTK) [16] [17]; b) optical sensors to measure soil properties such as soil reflectance, water deprivation and nitrogen shortages in plants, etc. [18] [19]; c) electrochemical sensors for soil properties such as pH and nitrogen values [20]; d) mechanical sensors to measure properties such as soil compaction [21]; e) dielectric sensors to measure soil moisture and soil composition [22]; f) airflow sensors measuring other soil properties; g) movement and temperature sensors usually for dairy or livestock [23] [24] [25], field weather stations measuring temperature, humidity, and air pressure [26].
Internet of Things (IoT)	Wireless network integration of these different types of hardware for real time monitoring [27] [28].
Software	
ICT technologies	Applications
Farm Management Information Systems (FMIS) & Decisions support systems (DSS)	On farm data collection and processing for decision making [7] [29] [30] on risk management and sustainable input management
Artificial Intelligence (AI)	Applications according to Wakchaure et al., 2023 [31]: a) Cultivation phase: planning of crop to be planted/land/irrigation [32], land preparation, seed sowing; b) Monitoring phase: monitoring [33], data collection [34], disease identification, weed control [35], fertilisation [36], spraying [37]; c) Harvesting phase: segmentation, cutting [38], picking, storing, selling
Social Media	Communication, knowledge exchange, promotion and customer relation management [39] [40]

settings), and livestock management, embracing both hardware and software developments.

Table 1 summarises the major hardware and software developments and their applications in agriculture.

ERA-NET ICT AGRI-FOOD FUNDED PROJECTS SEMINAR 2024

During the 2024 ERA-Net ICT Agri-Food funded project seminar, 19 projects covering a broad spectrum of innovative technologies were presented over two days.

A selection of six projects is described here due to their relevance for the Laimburg Strategic Agenda 2030 "Digital Innovation and Smart Technologies" and their potential development within LIDO.

PROJECT HALY.ID - *HALYOMORPHA HALYS* IDENTIFICATION

Consortium: Università degli Studi di Perugia, Italy; Università degli Studi di Modena e Reggio Emilia, Italy; Technische Universität Braunschweig, Germany; Tyndall National Institute, University College Cork, Ireland; University Polytecnica of Bucharest, Romania; One Planet Research Center, Imec, The Netherlands

Halyomorpha halys is an invasive species that has spread across most of Europe since 2004 and causes major economic damage to orchards due to its polyphagy on a wide variety of fruits and seeds. Chemical control has proved to be unsatisfactory and monitoring the pest is difficult and time-consuming. For this reason, the HALY.ID project developed various digital tools to facilitate monitoring. As part of the project, an autonomous field monitoring system was developed based on drone images and computer vision algorithms. The drones stop at certain points and scan the leaf wall. In addition, a sticky pheromone trap and a microclimate station were developed in order to produce an epidemiological model. Furthermore, a "ContractBox", a platform that enables data sharing between distrusting parties, was developed. NIR-HIS images of healthy and punctured pears were also taken to assess the marketability of fruit using algorithms and machine learning, which are then used to train the system. It was found that the drones do not disturb bugs and that the success of the algorithm in recognising bugs depends on the similarity of the images used to train the algorithm. Based on the results obtained, the machine learning method can be further developed to better facilitate the identification of punctured fruits [41].

PROJECT UTOPIA

Consortium: Dennis Kooijman - Intelligent Autonomous Mobility Center (I-AM Center), The Netherlands; Sinan Öncü, Bogazici University, Istanbul; Steve Vanlanduit, University of Antwerp, Belgium; Haris Ahmad Khan, Wageningen University & Research, The Netherlands; Ivo W. Wieling, Aqitec Projects BV, The Netherlands

The UTOPIA project aims to develop an open framework for storing precision agricultural data in the cloud, which will be accessible through a user-friendly interface. This system allows users to easily set paths and monitoring strategies for robotic devices such as drones, unmanned surface vehicles (USVs), and autonomous guided vehicles (AGVs). Stakeholders, such as farmers, can specify missions without additional labour or time investments. The system is designed to be operated without the need for re-education, eliminating the requirement for programming or engineering skills. The framework harmonises robotic paths and data formats for various use cases (terrestrial, marine, aerial) in low-bandwidth environments, utilising high-bandwidth data sources like camera imagery and processed sensor data to enhance autonomous performance. By providing an open framework, the project aims to reduce development costs for agricultural equipment companies. The project objective is to enable farmers to adopt precision farming affordably by offering an open data platform that integrates with mapping, planning, and measurement technologies. [42].

EFFICIENT COLLABORATIVE MAPPING IN ORCHARDS USING 3D OBJECT TRACKING AND A FACTOR GRAPH WITH GAUSSIAN BELIEF PROPAGATION

Consortium: David Rapado-Rincoh, Dennis Kooijman, Eldert J. van Henten, Gert Kootstra

Mapping of large agricultural fields remains a challenge due to the computational complexity of traditional representations like point clouds. In the project an efficient object-based mapping based on a factor graph with Gaussian belief propagation and a 3D multi-objected tracking to map the individual trees in an orchard was used. A Clearpath Husky robot platform with RTK GPS, AHRS and an RGB-D camera was used for mapping in pear and apple orchards in autumn and winter. The algorithm of YOLO-v8 was trained to detect the trunk of the trees. The system was finally able to accurately map trees under real conditions with an error of 11 cm.

PROJECT FINDR - FAST AND INTUITIVE DATA RETRIEVAL FOR EARTH OBSERVATION

Consortium: Fraunhofer Institute for High-Speed Dynamics, Ernst-Mach- Institut, EMI; Helmholtz Center Potsdam German Research Center for Geosciences, GFZ; eLEAF; ACK Cyfronet AGH; constellr GmbH

The only globally applicable solution for monitoring the health status of crops is satellite-based earth observation (EO). As more and more data are incompatible with each other and there is an increasing number of data providers, this is becoming an increasingly complex task. FINDR provides universal and standardised access to EO data. It also enables accurate forecasting of data availability in the near future to manage data ingestion and a homogenisation approach that enables the smooth integration of EO data from different providers. The platform provides a graphical user interface (GUI) and an application programming interface (API) [43].

PROJECT IMPPEACH - INTEGRATED MODEL AND PLATFORM FOR HARVEST PREDICTION FOR CANNED PEACHES

Consortium: Agrostis SA, Greece; Geocledian GmbH, Germany; Sigrow B.V., Netherlands; Agricultural University of Athens, Greece; ALMME SA, Greece

The project's objective was to deliver accurate prediction of yields and harvest dates on a large scale. The benefits from improved harvest and yield prediction accuracy include a) an increase in production efficiency, b) added value for the products, c) more efficient and targeted marketing/gains in market share and d) increased profit margins. These benefits affect not only the canning business itself but are shared with all stakeholders including a larger number of smallholder farmers/suppliers. Better harvest and yield forecasting can improve efficiency, achieve more efficient and targeted marketing and higher profit margins. This 3-year project was carried out on a large area of 100 km² and a prediction model was developed using AI and ML. Historic production data, remote sensing data and climatic, soil and cultivation data were used. The historical yield data showed that the start of harvest of all varieties correlates with the climate data and the variety. More accurate results were achieved by using weather data from locally installed sensors than by using data from weather services. Remote sensing was not able to detect the blossom date due to insufficient temporal and spatial resolution. The harvest date and yield prediction model is not sufficiently precise for practical use. Farmers, cooperatives and agricultural companies must invest in the collection and maintenance of data from their farms [44].

PROJECT STAR - GIVING SMELL SENSE TO AGRICULTURAL ROBOTICS

Consortium: Politecnico di Bari, Italy; TODOS Technologies, Israel; Fraunhofer IAIS, Germany

The STAR project combines various sensor modalities, including standard sensors (e.g. RGB-D cameras) with new types of sensors (e.g. gas sensors), methods for creating precise maps, artificial intelligence algorithms for data processing and decision support. The objective is to distinguish healthy fruits/plants from diseased/-damaged ones and to selectively initiate harvesting in order to make it more efficient and save resources. An autonomous robot was developed to monitor the health status of the vineyards. The gas sensor on the robot is used to record gases and thus the fruit freshness level and health status of the plant. A decision support system for the creation of application maps for applying plant protection products is also to be developed, combined with AI. With the use of these maps, variable rate applications can be carried out and pesticides can be applied only where they are needed, crop monitoring and yields can be predicted, and qualitative and morphometric parameters related to crop composition and development can be predicted. The robot is also supposed to adapt its driving characteristics in real time by detecting the features of the terrain and adapting the tyre pressure and suspension to the ground, for example. The data collected with the robot is fed into standardised cloud services, allowing data that has already been collected and existing systems to be integrated [45].

PROJECT SHEET - SUNBURN AND HEAT PREDICTION IN CANOPIES FOR EVOLVING A WARNING TECH SOLUTION

Consortium: Leibniz Institute for Agricultural Engineering and Bioeconomy (ATB), Germany; Hungarian University of Agriculture and Life Sciences (MATE); Hungary, University of Bologna - Department of Agricultural and Food Sciences (UNIBO), Italy; macio GmbH (MACIO), Germany; HK Horticultural Knowledge srl (HK), Italy

The SHEET project aims to address the escalating risk of heat damage in fruit production due to global radiation and temperature rise. This includes developing risk prediction models and transferring them into a mobile application for smartphones. The project collected experimental data on apple, grape, and sweet cherry production under varying environmental conditions. SHEET utilised terrestrial remote sensing methods such as LiDAR, photogrammetry, thermal imaging, and microclimate sensors to gather high-resolution data on fruit surfaces and canopy architecture. This data informed the development of temperature distribution models and neural network models to predict fruit damage. The project delivered a free mobile app for growers to access climate and output data.

The social impact of SHEET included attracting young people to agricultural technology and supporting rural transformation. The involvement of students, small and medium-sized enterprises (SMEs), and startups contributed positively to stakeholder viewpoints and education on new methods [46].

FUTURE RESEARCH DIRECTIONS

The exploration of precision agriculture within the European context has highlighted several significant challenges. Foremost among these are the substantial costs involved, alongside the considerable task of integrating data from various sensors, hindered by a lack of interoperability stemming from the absence of universally accepted standards. Moreover, confidentiality concerns pose an additional obstacle to seamless collaboration and data sharing. However, despite these challenges, there remains ample opportunity for further advancement and innovation in the field.

According to the European Partnership on Agriculture of Data (2023), within the European context, major future research goals can be summarized as the following:

- firstly, there is a critical need to enhance agri-environmental monitoring tools and capacities to assess agri-environmental and climatic conditions. This involves integrating data sets from various platforms and networks to provide comprehensive insights;
- secondly, there is a need on increasing the uptake of digital and data technologies in agriculture by offering tailored, accessible end-user-oriented solutions based on Earth Observation (EO) and environmental data able to leverage on AI algorithms for enhanced data analysis and prediction accuracy;
- additionally, achieving synergies between data-based solutions for the agriculture sector and policy monitoring/evaluation is essential;
- finally, facilitating the use and reuse of EO, environmental, and other data to create easily adoptable tools and services for farmers, organizations, and businesses is vital for widespread adoption and the rapid realization of their benefits.

These research goals underscore the necessity for collaborative efforts to overcome challenges and drive innovation in precision agriculture, ultimately contributing to sustainable agricultural practices.

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