Broad Adoption of AI by SMEs in the Agriculture and Farming Sector Report

I&C Working Group

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This report was developed by Experts and Specialists involved in the Global Partnership on Artificial Intelligence's project on the Broad Adoption of AI by SMEs in the Agriculture and Farming Sector. The report reflects the personal opinions of the GPAI Experts and Specialists involved and does not necessarily reflect the views of the Experts' organizations, GPAI, or GPAI Members. GPAI is a separate entity from the OECD and accordingly, the opinions expressed and arguments employed therein do not reflect the views of the OECD or its Members.

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Context

This new project (project 3) of the I&C WG commenced in February 2022 with a co-chaired leadership team composed by Inma Martinez (Spain), Digital Pioneer and AI Scientist, and Daniela Rus (USA), Deputy Dean of Research, Schwarzman College of Computing at Massachusetts Institute of Technology.

It derived from Project 1, Broad Adoption of AI by SMEs, to address the specific needs and sector dynamics of agriculture and animal farming, which in many aspects, continue to deploy outdated methods and labor-intensive practices that make agriculture ineffective, unsustainable, pollutant, and of low-paid (economically unattractive), and unnecessary duress for its workers.

The Agriculture industry is currently undergoing an incredibly transformational and innovative moment in history thanks to digitalization and AI-driven technologies. If the 20th century agricultural industrialization created the mass-production of crops and animal farming in order to feed a growing population, the 21st century is forcing the Agriculture sectors to address radical challenges such as the demand for specific products on a global scale and out of season, climate change, the erosion of arable land due to antiquated and ineffective practices, and the preservation of potable water. In addition, a growing reversal of human eating habits towards more plant-based produce is contributing to the need to reconsider animal farming under its existing practices, not just on the moral grounds of their welfare, but because of the exorbitant use of arable land needed to feed them and the greenhouse effects that eating grain rather than grass causes in many of them. 20th century models that sought cheap routes to tackle agriculture are today lambasting the food value chains and our need to create a sustainable, climate aware, green economy.

Project 3 is documenting AI deployments in agriculture and animal farming in the last 5 years to present evidence in an easy-to-use web portal that will showcase the potentiality and benefits of AI across a wide variety of agricultural sectors, geographies and the industrial development stages of the various GPAI Members. The purpose of Project 3 is to incentivize independent farmers and agricultural co-operatives to deploy AI and complementary digital technologies with clear return on investment, and sustainability practices.

Project Resources

Project 3 has also incorporated a first set of high-caliber sector Specialists from USA, Canada, and Japan, (with other Specialists from Australia/New Zealand and European nations providing their expertise off-line) with the objective of delivering the sector expertise that this project requires. Such Specialists include:

- Vikram Adve (USA), Donald B. Gillies Professor of Computer Science at University of Illinois at Urbana-Champaign, Director of the AIFARMS National AI Institute and Co-Director of the Center for Digital Agriculture;
- Cyrus Hodes is a co-founder of the World Climate Tech Summit (Q1 2023, Miami), a cofounder of Duckweed Bio, an Agtech/climate tech startup based in south Florida and is a contributor to Blockchain Web Services (BWS) a Web3 P2P cloud computing platform for Machine Learning which enables resilient computation on a distributed network. Cyrus is a Partner at FoundersX Ventures, a cross-stage Silicon Valley VC firm focusing on AI, biotech, digital healthcare, enterprise SaaS, quantum computing, Fintech and Foodtech;
- Dr. Noriyuki Murakami (Japan), Deputy Director-General of Research Center for Agricultural Information Technology (RCAIT) and Deputy head of Research Center for Agricultural Robotics (RCAR) at National Agricultural Research Organization (NARO), Japan's national laboratory for agriculture https://www.naro.go.jp/english/centers/index.html;
- Marc André Sirard, DMV, PhD. (Canada), Director of the Center for Research in Reproduction, Development and Intergenerational Health (CRDSI) at the Institute on Nutrition and Functional Foods (INAF), Center for Nutrition, Health and Society (NUTRISS), Department of Animal Sciences

at Université Laval, Québec[1].

Project 3 has additionally engaged the innovation labs of the University of Loyola Andalusia (Spain), a research University with deep experience in Agro AI. Innohub has been tasked with the delivery of the technical milestones of Project 3: digitization of all case studies into data sets to be fed into the same OS database that Project 1 uses for their web portal (MariaDB) and support for the administrative parts of the Experts' and Specialists' reviews of all case studies to create an initial approach to standardization practices, methodologies and protocols that could be turned into white papers or informational content of the future Agro AI web portal.

Given the economic impact on Agriculture when AI solutions are deployed, there have been discussions with Roxana Mihet, Tenure-Track Professor of Finance at HEC Lausanne and Faculty Member of the Swiss Finance Institute. Her research is at the intersection of macroeconomics, finance, and information economics. She is currently researching the economic impact of AI in industrial sectors and is interested in analyzing the Agriculture sector and collaborate with the project. There are also discussions of Danny Hillis, co-founder, Applied Minds, responsible for a number of deployed AI solutions for optimizing fertilization and weather predictions, to join the Agro Committee's project in their next phase.

Protecting Activities Delivered & Insights Gained To-Date (April-August 2022)

(a) Formulation of industry questionnaires for the gathering of the initial sets of case studies by the Experts and Specialists of this group. These questionnaires cover the various commercial deployments of AI in agriculture and farming, delivering solutions around precision, prediction, optimization, detection and tracking and tracing. Additionally, they specifically request information on the commercial objectives of all AI deployments so that factual data can be gathered on the economic and business benefits that AI delivers to Agriculture;

(b) Gathering of the first sets of AI in Agro data based on Satellite Vision Data, Meteorological Data, Radio Wave Signals, Robotics, LiDAR and other IIoT (Industrial Internet of Things, e.g. Industrial Sensors). The case studies presented solutions for: prediction of potential pests; optimization of irrigation; geolocalized phytosanitary treatments; precision harvesting (phenotyping and machinery use); production of high-quality citruses; prediction of consumer demand for specific produce; improved animal welfare and better farm performance; produce quality sorting; stored grain inventory monitoring;

(c) Initial conversion of data into database taxonomies to assess informational hierarchies avoiding redundancy of terminology and future scenarios of information consultation in the web portal. This is an important development that will assure that all data will be consistently categorized across multiple terminologies in use;

(d) Discovery of business models that could potentially be deployed in countries in development. Case studies presented by NARO, Japan's National Agricultural Research Organization, have revealed how agricultural co-operatives organize access to farming technologies, such as harvesters and other expensive machinery, by way of sharing such resources amongst farmers who need them. Small farmers can thus book and use machinery without the need to individually purchase such equipment, a business model that should be expected for the deployment of AI robotics and edge computing machinery in Agriculture in developing countries or small farming cooperatives.

(e) AI-driven technologies are not creating unemployment in the Agriculture sector, but facilitating tasks and delivering insights that allow farmers to increase their ROI. Just like Industrial IoT (IIoT) is allowing floor factory workers to perform their tasks with higher degrees of informational accuracy, Robots and Autonomous Systems (RAS) in Agriculture perform tasks that deliver precision and

[1] In its original Fench : *Centre de Recherche en Reproduction, Développement et Santé Intergénérationnelle (CRDSI) at Institut sur la Nutrition et les aliments fonctionnels (INAF), Centre Nutrition, santé et société (NUTRISS), Département des Sciences Animales at Université Laval, Québec.*

optimization of farming activities that field workers are either reluctant to perform (e.g. planting cover crops to prevent de-fertilization), or humanly incapable of doing (accurate crop management, reporting, prediction of pests, irrigation optimization, etc.) because of their computational challenges.

(f) With the increasing digitalization of farming methods, it will be possible to obtain products derived from plants and animals more efficiently and with less impact on the environment, a goal that many GPAI Members have committed to in their roadmaps towards sustainable, green economies. Furthermore, arable land currently used to grow crops to feed farmed animals must be reduced in order to recover deforested areas that will help fight climate change, and greenhouse emissions. Current innovations in the food industries point towards a human population increasingly fed with less animal proteins which will require the Agriculture industry to grow plant crops that will feed humans directly.

With this ground delivered in its first year of operations, Project 3 will be in a prime position to deliver the first key performance indicators by the November 2022 GPAI Summit and lay the foundations needed for the completion of the project in 2023 (subject to GPAI Council approval at the 2022 Tokyo Summit), which shall be a period of technological and usability-testing of the web portal as well as AI vendor qualification.

Objectives and Impact

From the various case studies gathered, it is worth mentioning three that deploy the top AI-driven technologies: AIoT (Agro Internet of Things), Satellite Data, and RAS.

Case Study 1: How To Guarantee Contractual Agreements Between Growers (South & Central America) and Produce Buyers (Europe)

Perishable crops such as fruits and vegetables require computational methods of crop harvesting that allow for the ripening of such produce while transport bound for distant countries where buyers expect seamless "from container to supermarket shelf" supply chains to guarantee optimal consumption. High demand for tropical fruits from distant developing countries has allowed Hispatec (Spain) to develop ripeness prediction algorithms and monitoring IoT devices that ensure that all cargos contracted by buyers are accepted and paid for upon arrival at destination. The harshness of the analogue reality sadly allows supermarkets to refuse produce by just looking at it. Buyers many times order increased amounts of a given produce to later on reject it upon arrival for reasons that are never revealed. There is nothing that the growers can do but to lose income and dispose of the unwanted produce. Many GPAI Members already demand that supermarkets tackle food waste, so there is enormous value in this specific AIoT technology. With Hispatec's ripening sensors, the optimal maturity of products is confirmed with "hard data" that cannot be denied by supermarket buyers, who are contractually obliged to pay for and take their entire order.

Innovation and Transformative Value: data reporting allows growers to prevent buyers from reneging from their purchasing obligations. Strengthening contractual obligations in the agriculture chain from field to table supports sustainability practices as well as the economic value of growing fresh produce (especially when the produce growers and exporters are developing countries).

Case Study 2: Satellite Data to Predict Pests and Manage Crop Development

Satellites are able to detect changes in below ground temperature, humidity levels, as well as other data sets that allow farmers and field technicians to carry out precision farming. Outdated methods that treat farmland as a flat, 2-dimensional environment, for example unnecessarily fumigating an entire field, or being unable to predict the formation of pest larvae, prevent small and medium sized farmers from managing their field with accurate information. In fact, they sometimes cause more harm than benefit by still deploying antiquated farming methods. TUPL, Inc. (USA) has created a desktop dashboard and a mobile notification system using data from ESA's Earth Observation satellites. TupleAgro's *Agro Advisor* tool provides farmers with agronomic recommendations based on field conditions or events, for example, the sighting of a specific pest within a geofenced location in a field. The company has built the product around real needs, for example delivering notifications via Whatsapp (a local preference) and suggesting potential actions to repel pests or tracking soil tension (amount of water available to plants) that truly personalize field management for each client. Onboarding is straightforward as all arable land is registered in every country, not only with

numerical identification, but also geographical coordinates that allow satellite imagery to be correctly matched. Data shows the good evolution or deterioration of crops by color mapping plots and additional data sets such as weather (temperature, rain fall, humidity, etc.). Metrics are divided into 5 levels: Health (measures the vegetative density of an entire farm by each plot); Nutrition (dose of chlorofilactic mobility by the reflection of lights on the leaves); Humidity index of the plot; Comparative view of the same plot over chosen dates; Table of metrics that can be exported for reporting in CSV or Google Earth files.

Innovation and Transformative Value: Over 100 startups worldwide[2] are currently building AI-data solutions for Agro ERP (Enterprise resource planning). Some of them deploy AIoT sensors and others productize satellite data, which is much more cost effective. It is one of the fastest growing innovation arenas in Agro tech which can be seen creating real business transformation in Agriculture in the next 5-10 years.

Case Study 3: RAS (Robotic Autonomous Systems) for Precision Tasks

Monitoring crops or detecting defects unseen by the naked eye are computational activities not suited for or unable to be performed by humans. Data extracted from direct observation is the basis of any prediction and detection activity that results in the prevention of events and the optimal harvesting and irrigation of a field. Unbiased and precise detection of faults by image diagnosis RAS is also an activity that allows companies to guarantee product assurance. Companies such as Earthsense, Inc. (USA) provide unprecedented field phenotyping and trait analysis that allows farmers to better understand crop genetics and their health as well as calculating the yield reliability of their crops. These small and robust autonomous robots will soon represent an additional piece of technical equipment that even small farmers and cooperatives will be able to deploy to assure the quality of their crops with accurate data never gathered before. Likewise, RAS are used in quality control environments, such as the case study presented by NARO (Japan) for mandarin orange juice quality control. Using AI predictive algorithms, the Brix (acidity and sugar ratio) can be calculated to harvest the fruit on the optimal date, ensuring that growers achieve the highest price for their produce. RAS are also being deployed in animal farming addressing one of the new 21st century challenges: animal welfare in industrial exploitation (Faromatics (Spain) acquired by AGCO (USA) in 09/2021). These RAS capture thermal sensation, air quality, light and sound as well as using AI to identify risks to health, welfare and farm equipment. Preventing disease in farmed animals and quickly reacting to any event that can endanger them is the top priority for livestock farmers, especially when the food industry is restricting 20th century practices that affect the human food chain, for example the untargeted use of antibiotics in farmed animals.

Innovation and Transformative Value: RAS come to market to perform tasks unattainable to humans, especially when they gather data that allows for algorithmic modelling that result in insights or actions that assure precision. There is a misconception that RAS come to supplant human laborers in the fields. There are tasks that only humans are able to perform, especially fruit picking, and tasks that still performed by humans, will allow for data gathering thanks to AR/VR technologies[3], just like it is occurring in industrial manufacturing and IIoT. The aim of RAS is to gather data, an incredibly powerful tool to innovate agriculture, and to avoid errors to assure the value of crops.

Activities and Objectives for 2023

The I&C Working Group has proposed this project in the 2023 Workplan, subject to GPAI Council approval at the 2022 Tokyo Summit

Having set the foundations of data-gathering and methodologies in 2022, that the project would be in an excellent position to achieve the following 2023 milestones:

a) Reach out to AI solution providers in the Agriculture and Livestock farming sectors – issuing an RFI to establish the qualification process of AI vendors;

b) Run checks on AI-readiness of small and medium sized farmers that could benefit from how similarly sized counterparts in other geographies have achieved successful AI deployments;

[2] https://www.precisionfarmingdealer.com/articles/5178-10-ai-companies-paving-the-way-for-precision-ag-in-2022
[3] Augmented Reality and Virtual Reality technologies

c) Construct the hypotheses around the various ways in which all the informational data gathered from the case studies and the AI vendors could be queried by the future web portal users, which we assume will be fundamentally farmers, farming associations, startups and innovators wishing to discover the gaps in the sector where they could build future value, and other members of the ecosystem;

d) Build a user-friendly, natural-text based, as well as an information retrieval query facility in the web portal and launch a minimum viable product (MVP) version in December 2023.

The Benefits

This project would empower the A&F (Agriculture and Farming) sector and its AI developments with a solid ground to:

- Standardize existing methodologies and protocols within proven and successful projects that improve resource efficiency, productivity, environmental processes, animal health and welfare, and provide tools to mitigate climate change;
- Identify the commercial synergies within the A&F data exchange ecosystem: (a) Data Originators (farmers), (b) Data Providers (usually IoT/Sensor companies, e.g. tagging companies for either pest control or animal IDs), and (c) Data Beneficiaries (the ultimate recipient of the value of the processed/AI handled data, e.g. in precision feeding projects, the feed manufacturer who needs to alter the formulation of the feed for the best optimal nutrition);
- Establish a collaborative relationship and support between A&F associations and their service providers as well as expand the collaborations with the value-chain participants of the A&F industries: from veterinarians and animal husbandry experts, to food manufacturers and retailers in order to deliver commercial benefits to all sector stakeholders.

Conducting the project in GPAI

This project is aligned with GPAI's principles of inclusion, innovation, and economic growth:

- Inclusion: The outreach effort to organizations within the SME classification which present different needs and synergies;
- Innovation: The project helps industry organizations drive the adoption of AI, both sector associations and service providers in the IoT/Sensor and Agro/Farming Data Analytics;
- Economic Growth: The project can address the challenges of rural communities that are hindered by unemployment, unattractiveness for young people, and low quality of life prospects if they remain analogue in nations that produce and depend on A&F products and services.

GPAI is the appropriate body to take this specific project forward as it can embody and spread GPAI's values and principles in the proposed online platform:

- Creating an international and independent repository of best practices and case studies that can be trusted;
- Attracting AI suppliers to qualify to be listed and show case their case studies;
- Offering sector industry bodies and associations a centralized source of resources.

Potential for collaboration

Project 3 presents attractive opportunities to collaborate with other GPAI Working Groups and other external organizations. So far, a collaborative ground for information exchange has been established with the Data Governance Working Group in regards to how data sharing in Agriculture can generate social benefits through data trusts (i.e. case study “Small Shareholder Farming in India”) and the widespread use of Satellite Data in Agriculture that productizes weather data into predictive models to detect pests and

manage irrigation of fields.

Objectives for the Agro Committee

Targeted Objectives Planned	Objectives Achieved
Exploring the issues of data-sharing practices in the A&F sector that enhance and optimize its data analytics practices as well as derive better business models and growth from it.	So far, a collaborative ground for information exchange with the Data Governance Working has been established in regards to how data sharing in Agriculture can generate social benefits through data trusts (case study “Small Shareholder Farming in India”)
Examining the issue of traditional data (RWD) to merge with field data (RWE) in order to enrich the use of AI in A&F.	ESA’s Earth Observation department (ESRIN) has given support in providing further evidence and business models on the use of Satellite Data in Agriculture. Rochelle Schenider Dos Santos, AI Applications Lead and Michael Marszalek Research Fellow at ESA’s ϕ-lab, have joined as Specialists to share ESA’s developments in AI for Agro.

The aim is to expand similar collaborations with the Responsible AI and Future of Work Working Groups in 2023 where it comes to how AI in Agro should be deployed ensuring sustainable and equitable practices with agriculture workers and small farmers, and ensure that it contributes to the formation of a Green Economy in countries that deploy it.

Responsible AI

Establishing the values of optimized practices that deploy AI to derive better yields without damaging the environment, biological ecosystems, animal welfare and human health;

Future of Work

Demonstrating that A&F can become a technology vertical able to attract young people to work in the service provisioning of these industries as new sectors of digital innovation;

Gentrifying rural areas in order to balance their current negative net migrations towards urban centers.

Deliverables and milestones

The I&C Working Group has proposed this project in the 2023 Workplan, subject to GPAI Council approval at the 2022 Tokyo Summit

This mandate and the objectives can be achievable as a short-term project because it can be built on skills existing within the Working Group Experts and with the support of Members who have AI in Agriculture projects as a government objective.

The plan for 2022 was to develop Phase I and II during the first semester and propose a web template for the Members to adopt by the 2022-23 year.

As it progresses, it could be possible to expand the capabilities of this resource website as each Member wishes to enhance its features, e.g. creating templates for accessible and shareable A&F data repositories at a local level, etc.

The proposed **milestones and deliverables for 2023 are as followed:**

- Reach out to AI solution providers in the Agriculture and Livestock farming sectors – issue an RFI (Request for Information) to establish the qualification process of AI vendors;
- Establish the criteria for vendor selection based on Usability, Scalability and success in sector optimization;
- Run checks on AI-readiness of small and medium sized farmers that could benefit from how similarly sized counterparts in other geographies have achieved successful AI deployments;
- Establish scalability criteria for AI solutions to be deployed in other geographies;
- SWOT of the ecosystem of AI vendors and local farmers and incorporate into the web portal other key players or elements of success that should support it;
- Construct the hypotheses around the various ways in which all the informational data gathered from the case studies and the AI vendors could be queried by the future web portal users, which we assume will be fundamentally farmers, farming associations, startups and innovators wishing to discover the gaps in the sector where they could build future value, and other members of the ecosystem;
- Run Usability test cases that will optimize the value of the web portal for both farmers and sector participants. Consider navigation and search modes that are likely to be used by people accessing the informational sections;
- Build a user-friendly, natural-text based, as well as an information retrieval query facility in the web portal and launch a minimum viable product (MVP) version in December 2023;
- Define a set of users in enclosed environment (Experts, Specialists, Farmers, Associations) that will test the first version of the portal and optimize the features as per their feedback.