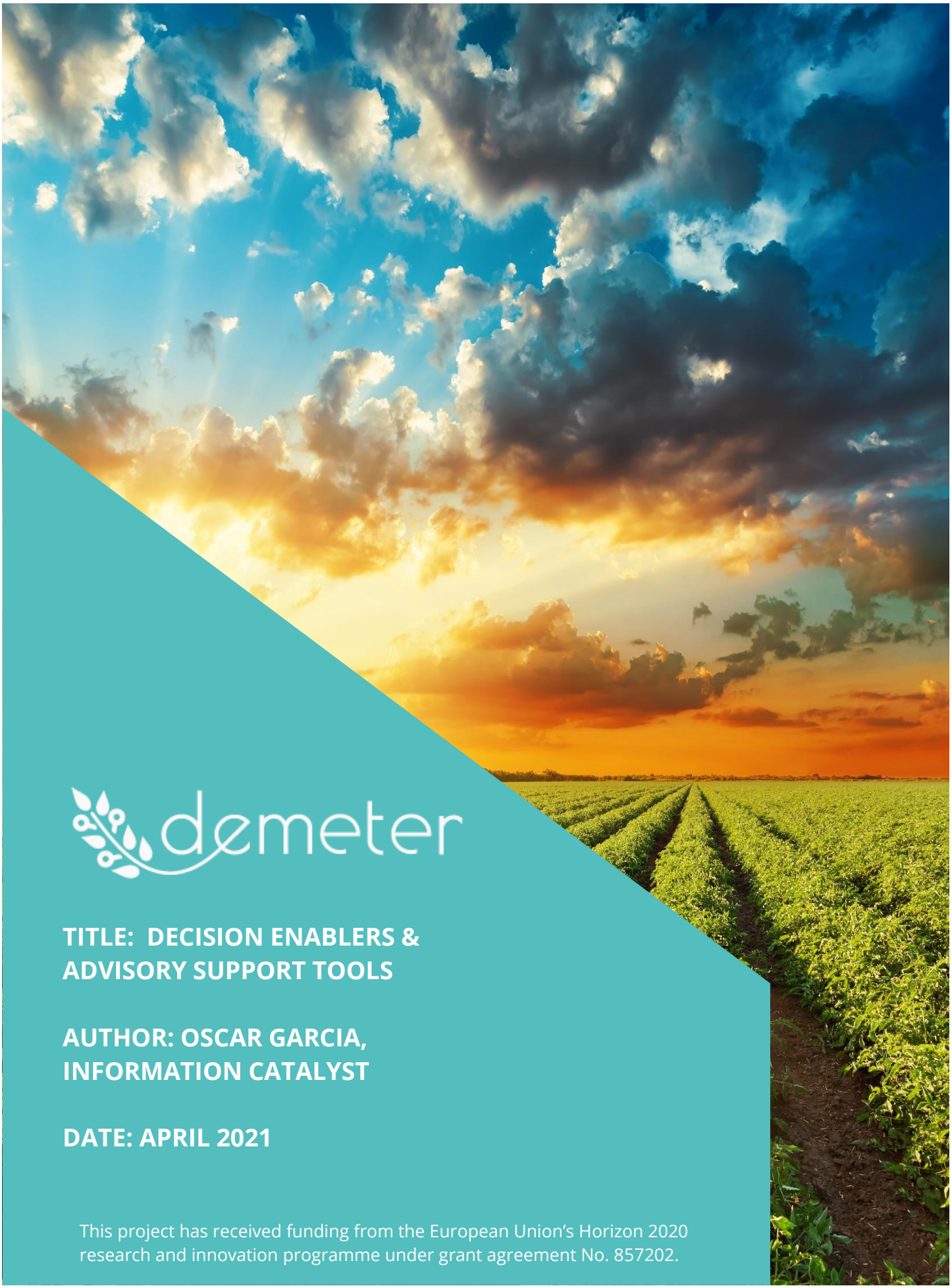

TITLE: DECISION ENABLERS & ADVISORY SUPPORT TOOLS

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DATE: APRIL 2021

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 857202.

Decision Enablers and Advisory Support Tools

SUMMARY

DEMETER aims to lead the Digital Transformation of the European Agrifood sector based on the rapid adoption of advanced technologies, such as Internet of Things, Artificial Intelligence, Big Data, Decision Support, Benchmarking, Earth Observation, etc., to increase performance in multiple aspects of farming operations, as well as to assure the viability and sustainability of the sector in the long term. It aims to put these digital technologies at the service of farmers using a human-in-the-loop approach that constantly focuses on mixing human knowledge and expertise with digital information. DEMETER focuses on interoperability as the main digital enabler, extending the coverage of interoperability across data, platforms, services, applications, and online intelligence, as well as human knowledge, and the implementation of interoperability by connecting farmers and advisors with providers of ICT solutions and machinery.

DEMETER focuses on the deployment of farmer-centric, interoperable smart farming-IoT (Internet of Things) based platforms, to support the digital transformation of Europe's agri-food sector through the rapid adoption of advanced IoT technologies, data science and smart farming, ensuring its long-term viability and sustainability.

To achieve these objectives, and promote the targeted technological, business, adoption and socio-economic impacts, DEMETER will develop decision support system (DSS) components that will enable the delivery of tailored advisory services to the agricultural sector. These will combine data analytics with AI-based expert system, machine learning and benchmarking techniques to provide precision decision support to the users. This white paper describes the AI-based analytic functions, benchmarking techniques and performance monitoring tools that serve as building blocks of the DEMETER DSS.

2 Area A – Crop Growth, Status and Yield

Yield estimation is one of the most important topics in precision agriculture. Accurate and timely forecasts are required for marketing, storage, and transportation decisions. The following components provide this functionality:

- **Plant Yield Estimation** estimates the yield for the plants in a field.
- **Plant Phenology Estimation** estimates the date of a phenology stages of a crop.
- **Plant Stress Detection** detects the plant stress status caused by burns (very high temperatures), lack of water, lack of nutrients in the soil, etc.
- **Detect Crop Type** detects different crop types on the fields by performing satellite-based crop classifications.
- **Estimate Beehive** estimates the number of beehives required to pollinate a particular field.

3 Area B – Irrigation Management

The increasing shortage of resources is forcing the agricultural sector to adopt more efficient, technology-based irrigation and water management systems, which determine the actual needs and schedule irrigation accordingly. The following components address this need:

- A crop **Water Balance Model** estimates crop soil moisture and the irrigation requirements of crops.
- **Data Fusion for Irrigation** combines data from different sources to estimate current soil moisture and plant water status providing all the important information needed to support farmers in daily decision making on irrigation management.

4 Area C – Nutrition Management

Nutrient Management is required to maintain farm profitability and minimise the harmful effects on the environment with Nitrogen management being one of the most critical components. The optimisation of fertilisation requires knowledge of the actual crop uptake across different areas of fields. The following components address these issues:

- A crop **Nitrogen Balance Model** estimates crop nitrogen' requirements and provides the scheduling of fertilisation, avoiding nitrogen excess.
- **Nutrient Monitor** analyses the nutrient layers following agricultural field mapping and correlated with satellite images and production plans.

5 Area D – Machinery and Field Operations

Increases in size of tractors and other farm machinery have contributed to higher machinery investment per farm and more efficient use of labour. The quality of work performed by farm machinery has also risen dramatically resulting in improved seed and fertiliser placement, and less loss during harvesting. Farm management systems are evolving towards real-time programs based on artificial intelligence, helping farmer make decisions and take effective action. The data used by these systems is generated by a wide variety of sensors which provide a better understanding of the operational environment (field conditions) and of the operation itself (machinery data). Using this with more accurate machinery and global positioning systems have spawned a new set of practices known as precision agriculture. The following components apply to this area:

- **Emission** uses on-board sensors for in-service monitoring and testing, as an alternative to Portable Emission Measurement Systems (PEMS) while considering aspects of data management.
- **Field Operation** establishes a trust-based and compliant data market for agricultural enterprise data (e.g., Telemetric, Machine CAN, Current and historic meteorological, etc.) that sits between the owners and operators of agricultural data Clouds and the farmer. This data market will consist of both a technical platform and advisory services that will ensure the easy adoption of data and technology by farmers.
- **Variable Rate** uses a raster image of parameters derived from Sentinel-2 satellite images to produce a shapefile for a field showing specific rates for variable rate fertilisation.

6 Area E – Pest and Disease Management

Insects of economic significance and plant pathogenic fungi represent important threats for crop production which can cause a dramatic yield loss if not managed correctly. Their management is a highly challenging problem requiring early warning programs and the use of interdisciplinary technologies for sustainable control strategies, which implies the optimisation and the reduction of pesticide use. Farmers need to protect their crops in a cost-effective way, with high ecological, environmental, and socially aware solutions. The following components apply to this area:

- **Computer vision-based counting module** counts the number of appearances of a given element on an image using a model trained with similar images.
- **Estimate temperature-related pest events** estimates the date and extension of a pest development event.

7 Area F – Animal Yield

Rapid technological development has resulted in the availability of digital data from a wide range of sensors integrated into the technical solution e.g., sensors in a milking robot can provide information on production, milk chemical composition, fertility, and animal health.

The following components make use of some of these sensors:

- **Estimate Milk Production** forecasts milk yield using data from milking robots in dairy farms. The dairy farms will provide basic cow data (age, lactation no., days in milk, breed) and milk production (milking frequency, milk yield).
- **Poultry Feeding** monitors food level in a silo bin and notifies feed supplier when food level reaches the threshold level. By combining all inputs notifications are created thus providing optimisation of delivery routes and forecasting of order requirements.

8 Area G – Animal Welfare

Precision livestock farming is aimed at providing better animal welfare, increased productivity, and reduced negative environmental impact. Improvement of animal welfare became possible by using sensors for monitoring animal weight, temperature, blood pressure, digestion, respiration rate, monitoring reproduction cycles, food, and water intake, thus supporting decision making.

The following components aim to help improve animal welfare:

- **Estimate Animal Welfare Condition** classifies animals' welfare condition by categories such as healthy or sick.
- **Stress Recognition: Support Vector Machine for Poultry Stress detection** recognises stress in poultry, an important factor in the well-being of the chicken, allowing the farmer to increase production and meat quality.

9 Area H – Traceability

Traceability has become one of the most important topics in the food supply chain, receiving worldwide attention as consumers get increasingly interested in understanding and accessing all the details about the products they purchase. At the same time, the consumers expect producers to have in place effective practices to ensure such detailed descriptions can get to them and are accessible for consulting.

Traceability is also paramount to food safety, due to the need to trace chemicals, such as pesticides and fertilizers for crops, drugs for farm animals and food additives in general, which could be harmful to human health or degrade the overall quality of the final product or its raw elements or concerning food safety the recall of those products deemed unsuited, dangerous, or toxic for the consumers.

This area is composed of the following components:

- **Traceability** ensures the integrity of the data and the traceability of the product throughout the supply chain.
- **Transport Condition** collects environmental parameter information from transport companies about deliveries of both feed and meat produced to be able to determine the transport condition across the whole supply chain.
- **Field Book and FaST** digitises the farm's field book which records information about the farm, including information related to phytosanitary treatments.

10 Area I – Benchmarking

Benchmarking allows comparing performance and learning from comparison against a reference value, to improve performance. In the Agrifood sector, benchmarking allows farms to raise productivity and sustainability performance. Benchmarking provides a way to learn from other, more successful, farms in specific target areas.

The following components are used for benchmarking:

- **Indicator Engine for Benchmarking Purpose** allows the identification of indicators to assess the current agronomic, economic, and environmental sustainability at the farm level.
- **Generic Farm Comparison** provides a set of basic economic indicators to define a general benchmark of the farm's activities.

- **Neighbour benchmarking** allows a group of farms (e.g., cooperatives, consortia, other organizations belonging to a specific area) to share data and compare performance.
- **Technology benchmarking** establishes a mechanism for benchmarking the agricultural technology solutions that are being used (or tested) at the participating farms.

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