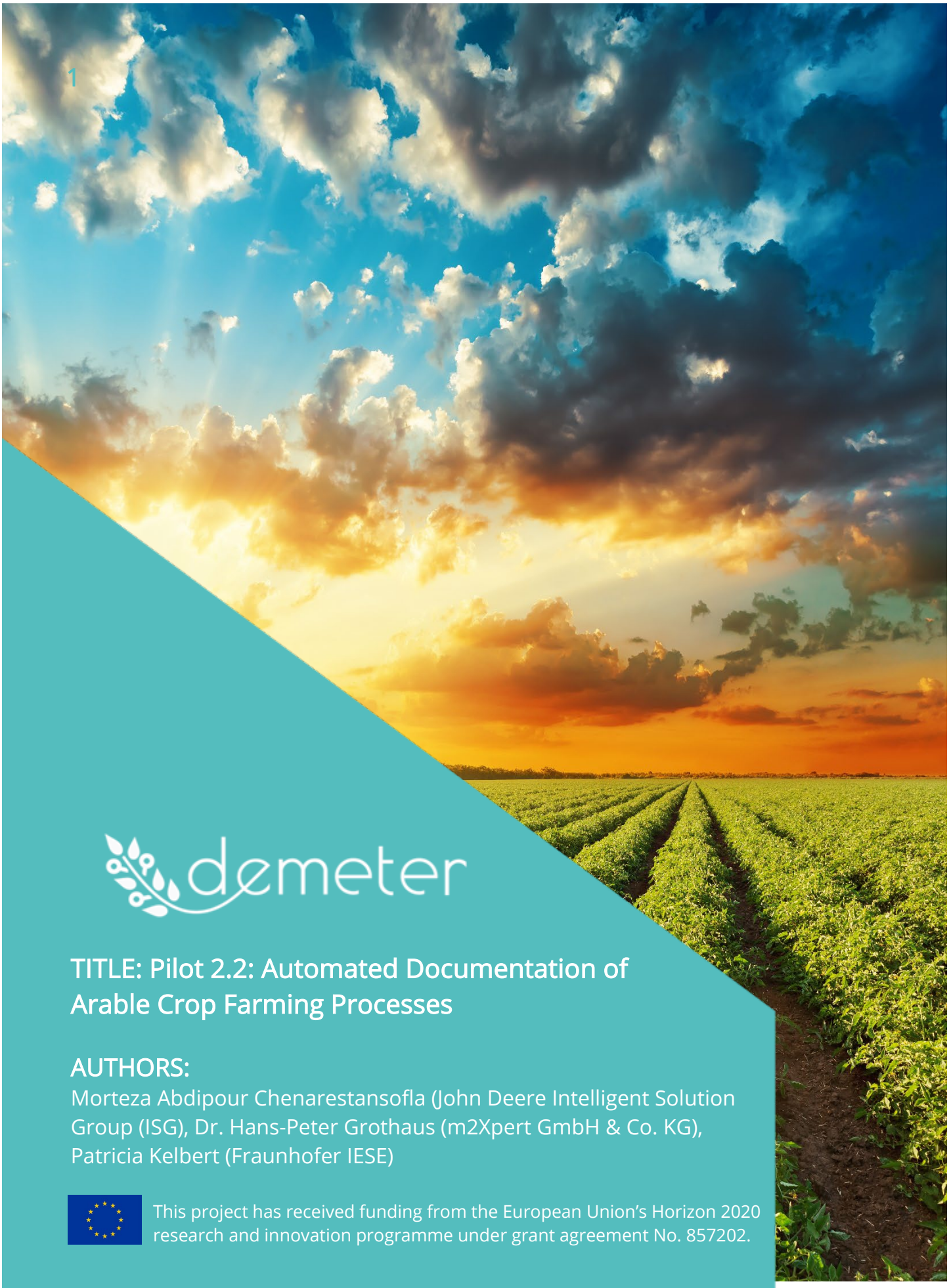

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TITLE: Pilot 2.2: Automated Documentation of Arable Crop Farming Processes

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Pilot 2.2: Automated Documentation of Arable Crop Farming Processes

1 Introduction

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 (DSS), 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.

Twenty real-world pilot projects, grouped into five pilot clusters, are running within DEMETER to demonstrate and evaluate how agricultural innovations and extended capabilities benefit farmers, technology providers, and society. The topics, scope and size of the pilots are diverse, from saving resources, such as water and energy, to a more environmentally compatible crop management with reduced application of fertilisers and pesticides, to improved animal welfare and the tracing of complete supply chains.

This white paper describes the pilot 2.2. "Automated documentation of arable crop farming process". This pilot will develop an automated job identification and documentation for fertilisation, tillage, seeding, and spraying applications, and job cost calculation for fertilisation and spraying applications as these two operations happened several times during the field. These solutions will eventually largely eliminate the need for manual documentation and save time spend on job cost calculation.

2 Importance of digital agriculture

With the advancement of precision agriculture, technologies automating documentation of field operations becomes vital. Pilot 2.2 focuses on jobs documentation, identification and cost calculation for spraying, and nitrogen applications at subfield level in arable crop farming. Its two components "Automated Documentation" and "Job Cost calculation" enhance farmers experience with new technology and reduce time spent on respective activities. In other words, it replaces manual documentation and cost calculation with automated process.
Moving from excel sheets to user centric dashboards can make a big difference in the realization of new technologies and their benefits to farmers, advisers, or any other beneficiaries of such solutions. This can facilitate a better allocation of resources in the future and can lead to sustainable cost reduction decisions, for example, by reducing the amount of chemicals used by the operation. Farmers are sometimes conservative and cautious when it comes to using digital technologies. This applies less to the technologies on the machines that support processes. Rather, it is a general scepticism about the use of data for downstream processes, especially when the data leaves the company for this purpose. More convincing of the direct benefits of the automation of data processing, such as documentation and traceability improvements, is needed.

3 Pilot Overview

This pilot develops two main components called *Automated Job Documentation & Identification* and *Job Cost Calculation*. These components enable automated digital documentation and cost calculation for a given field operation during the season for small grain, such as winter wheat and winter barley. The pilot runs on three farms in south-west Germany. The automated job documentation processes GPS-records which were collected during field operations, combined with background information to identify information about the job that has been done. It is aimed to answer the questions 'when' and 'where' a job has been applied as well as what has been completed. See Figure 1.

Figure 1 GPS hardware mounted on the several tractors for job identification and documentation.

Job Cost Calculation provides a geospatial cost map per hectare which refers to the cost of chemical product applied on the field, see Figure 2. The cost map can eventually be integrated with fuel consumption information as well as machine and equipment depreciation costs to reflect more granular cost information. Fixed cost such as insurance and labour costs also can be integrated and is mostly provided by the farmer during data entry.

Figure 2. The map on the left illustrates as applied Nitrogen application (calcium ammonium nitrate**- 27%N-Kg/ha**) for a given field and, on the right, a product cost map is generated out of the as applied map.

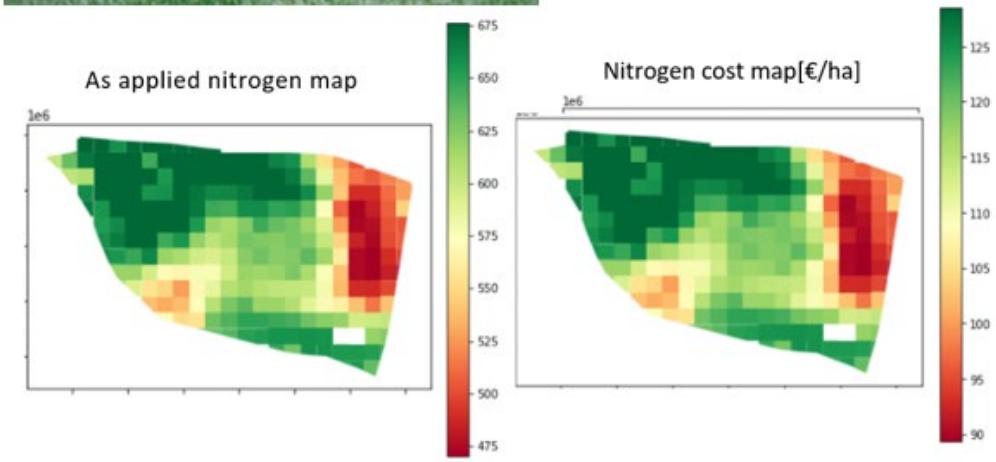

Figure 2 The map on the left illustrates the Nitrogen application (calcium ammonium nitrate 27%N-Kg/ha) for a given field. The map on the right illustrates the corresponding product cost.

4 DEMETER Integration

In this pilot, we use the **Data Quality Assessment** (DQA) tool which is available on the DEMETER Enabler Hub (DEH). The DQA enabler from WP2 is integrated in the data pipeline to ensure adequate data quality before the actual analysis starts. Poor data quality would have dramatic effects on the pilot's outputs. The completeness of the records plays an important role. Therefore, one should check the presence (or absence) of missing values. The DQA tool has been adjusted to the pilot specific data: it can take as input structured files (shapefiles and csv files) and is highly configurable. To date, 17 metrics have been implemented to assess the quality of structured data. For each metric, the percentage of occurrence of problematic values is determined. Four metrics have been specifically developed for the validation of the shape files generated by this pilot, making it possible to have a fast analysis of the completeness of the metadata and homogeneity of the units of the applications, plus a validation of the geocoordinates system. The DQA tool is a REST-API, developed in python as an open-source solution.

Another enabler "**Detect Crop Type**" provided by WP4 could improve the documentation process. The field's crop type as one aspect can restrict the possible job types and can therefore enhance the job identification for automated job documentation. For automated documentation, APIs (Application Programming interfaces, a software intermediary technology) are used to manage the documentation of field operations. It supports the WP2 "**DEMETER Agricultural Information Model (AIM)**" which can be used for standardised data exchange and interoperability with other DEMETER services. The John Deere Operation Centre platform is used as a proprietary service to pull operational data "spraying and nitrogen applications" for Job Cost Calculation. This application uses APIs to interface the result of cost calculations to the end user. Diverse environmental knowledge is critical to the identification of current jobs.

5 Feedback from farmers

In this pilot three farmers, each representing an individual farm with approximately +100-hectare size, are involved.
For the Job Cost Calculation aspect, we interviewed farmers and agronomists. During different interview sessions we acquired information relevant to technical aspects, such as how the operations are executed, what are the processes involved, how the end user would like to interact with the application interface in terms of data entry etc. After the first round of the project, an initial result of job cost calculation has been presented to pilot farms and the feedbacks were positive in terms of the usability of the solution and approximation of cost calculation accuracy. In addition, further inputs are provided by the farmers for enhancing the solution in the next steps, such as integration of product cost as variable cost along with other variable costs.
For the Job Identification and Documentation aspect, two workshops were held with a total of three farmers. First, the possibilities and limitations of automated identification of agricultural work processes based on movement data and other automatically generated information were discussed. After the creation of a prototype and the evaluation of generated data on more than 100 ha, the results were presented to the farmers, suggestions for improvement were taken up and incorporated into the further development of the algorithms.
Also, DEMETER enablers such as the DQA tool and detect crop type can help in enhancing pilot solutions.

6 Benefits

The pilot solutions support the farmers in saving time and enhancing field operations documentation. Overall, this pilot eliminates the need for manual documentation and pen and paper and/or excel sheet approach for computing and documenting costs. Such tools not only support them in saving time but also make it possible to provide better decision systems for future. See Table 1 below.

KPI values for Automated job documentation and identification			KPI values for job cost calculation component		
Achieved values after R1	Achieved values after R2	Target	Achieved values after R1	Achieved values after R2	Target
25	TBD	75	35	TBD	85

Table 1 KPIs table for the pilot 2.2 solutions

Our technical partner from WP2 supports in assessing data quality. Data quality issues for machinery agronomy data have not been investigated enough; therefore, we study the quality issues of such data and needs in the DEMETER project. Based on the first requirements, a series of reviews and workshops were conducted between 2019 and 2022. Discussions were carried out with the pilot experts to identify which dimensions of data quality are most likely to be relevant for machinery agronomy data. After analysis, we implemented data quality metrics based on the ISO25012 standard and we developed a tool that can help farmers or software developers of farming solutions: the **data quality assessment** tool.

The Job Cost Calculation aspect is still in the phase of proof of concept and demonstration of cost calculation results to the farmer. Next steps are still interacting mostly with farmers to understand how and where all the pieces of cost related data can be collected. For instance, the prices of chemical products applied on the field is only available after few weeks since the provider issues the bill after the purchase time, as expressed by the pilot farmers. Furthermore, identifying relevant benchmarks for accessing the reliability of calculated cost must be foreseen as a next step.

The Job Identification and Documentation aspect is in a prototype state. We will continue the intensive dialogue with farmers and further develop the solution iteratively. The full automation of documentation involves some challenges, as similar processes allow for misinterpretation. Further integration of external information will improve the clarity of process interpretation.

7 Conclusion

This pilot facilitates field operation documentation efforts and supports farmers to save time and invest more into decision making rather than documentation. The pilot can benefit from the technologies developed in the DEMETER cross collaboration space through integrating enablers such as AIM and DQA. Additionally, the DEMETER space enables farmers to interact with developers and other providers for developing new solutions and tackle existing challenges.

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