TITLE: Benchmarking and performance indicator monitoring tools

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Decision Support, Benchmarking and Performance Indicator Monitoring Tools

1 SUMMARY

DEMETER aims to lead the Digital Transformation of the European Agrifood sector based on the adoption of advanced technologies (e.g., Internet of Things, Artificial Intelligence, Big Data, Decision Support, Benchmarking, Earth Observation), to increase performance in multiple aspects of farming operations and to assure the viability and sustainability of the sector in the long term.

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.

To enable the achievement of such objectives, and to promote the targeted technological, business, adoption and socio-economic impacts, DEMETER is designing and developing a targeted decision support system (DSS) enabling the delivery of tailored advisory services to the agricultural sector. This DSS combines the data analytics from WP2 with AI-based expert system, machine learning and benchmarking techniques to provide precision decision support to the users.

In particular, benchmarking tools provide feedback to the pilots and farmers based on performance indicators to evaluate the agronomic, environmental and economic sustainability of the practises adopted. For this purpose, a minimum set of indicators to be calculated with data available at the pilot level, will be adopted. The benchmark tools implement a set of flexible rules to define the optimal list of farms with similar condition according with size, environmental, and economic conditions, type of farming activities.

2 Benchmarking on performance of farms, services, technologies and practises

2.1 INTRODUCTION

The benchmarking of farm performance, services, technologies and practises is carried out through the development of a system that can be used at farm level to evaluate the productivity and the sustainability of the practices adopted and to test and evaluate the efficacy of the developed digital solutions. The DEMETER shared benchmarking framework first step was the definition of a list of specific indicators addressing three areas of agricultural sustainability:

- **Agronomic**: indicators of crop yield (levels, variability in time and space, coping with climatic and environmental changes) and the quality of the production;
- **Economic**: indicators on the farm profit and profitability, and efficiency (technical and financial);
- **Environmental**: indicators of use of input, reduction of environmental risks.

To ensure the interoperability with other DEMETER components, indicators are defined using the Common Data Models.

2.2 Benchmarking Requirements of DEMETER Pilots

To implement the DEMETER benchmarking system as an interactive process, and to ensure the selection of suitable indicators for their implementation in the benchmarking system, a survey has been addressed to pilots' leaders, as they had a general knowledge about the type of farms engaged in the pilots. The survey aimed to collect the DSS requirements and to select benchmarking indicators, as well as to gather information on data availability at the farm/pilot level to calculate indicators.

2.2.1 Survey structure and results

The survey was structured in the following two main sections:

I. **DSS requirements** – to gather the perspective of pilots' leader about the general purpose of the benchmarking system and to collect their requirements about possible indicators;

II. **Data availability** – to assess the type of data needed for the benchmarking system and their availability in the different farms engaged in the pilots' activities. Availability assessment with pilot leaders addressed the following types of farm data: (i) general structure, (ii) input and output and (iii) economic data.

The survey was submitted on-line to the pilots' leaders and results were analysed assigning weights based on the answers selected (e.g., essential, desirable and unnecessary). For the majority of the respondents, the DEMETER benchmarking system should support farmers in evaluating (i) how the farm is performing after the adoption of a technology and (ii) how the farm is responding respect to the past.
The indicator with the highest score, among those proposed, was yield1 (e.g., crop production in ton/ha per crop, livestock production by type, etc.), while the second scored was water use efficiency (yield/total water).
Data availability at the farm/pilot level was investigated by providing a list of data according to the three types described above, asking pilots' leaders to evaluate the possible availability. For the farm general structure: the farm general data (e.g., total surface, main crops, reared animals) and farm location (geographical coordinates) were those considered most probably available.
Survey results outlined, for farm input – output data, that data on yield, pesticide general use and fertilizer general consumption were the data most probably available in the farms engaged in the pilot activities.
Finally, for the economic sector, data on farm revenue (e.g., average profit per year per farm) was evaluated as the most available.

3 DEMETER Decision Support

To design DEMETER Decision Support, the pilots' description and decision support requirements have been analysed and mapped to define required commons areas covering the main different types of decision-making subjects in the agri-food domain.
The requests from the pilots have been grouped in order to define a set of reusable components that could be integrated in a set of applications and shared across different pilots. A set of Decision Support Focus Areas were proposed and refined to group together all the components related to the same end users' decision.
Decision areas have been grouped in (i) crop farming, (ii) livestock farming and (ii) general decision about farm management (fig. 1).

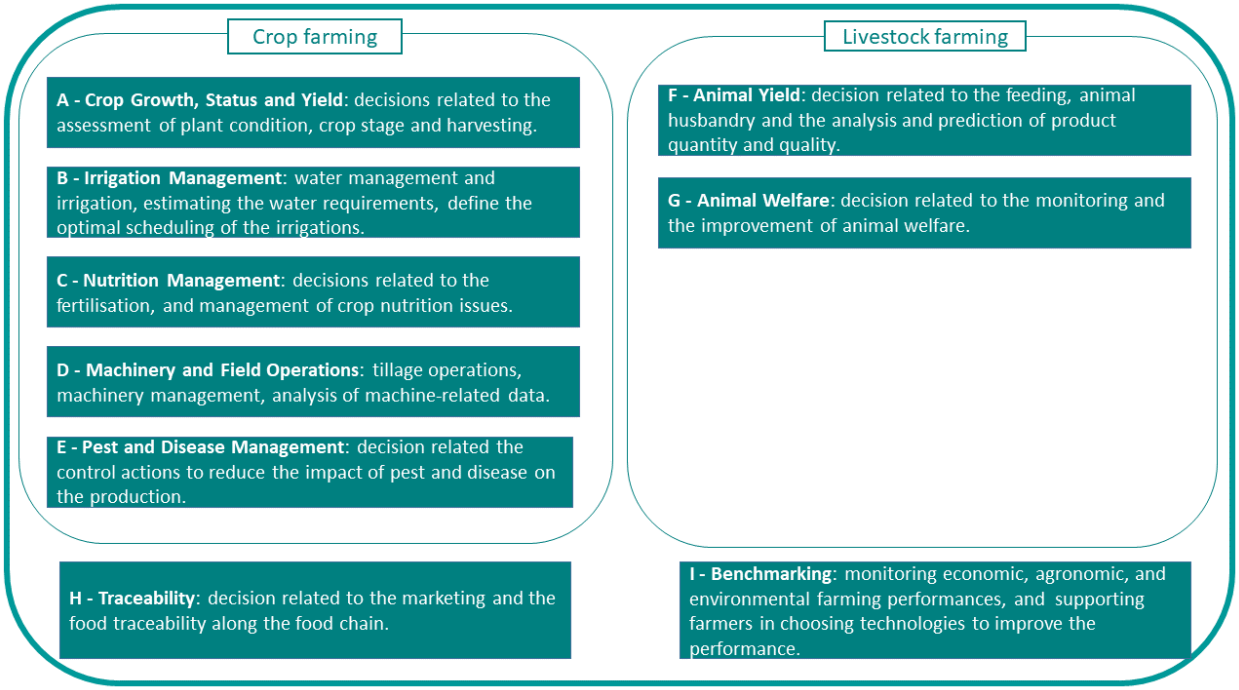

Figure 1: DEMETER Decision Support Focus Areas

For each area, a set of required common components has been defined and described, mapping each component with a set of pilots.

Each pilot request, within a decision area, has been associated with a potential general component, dedicated to support the farmers in taking one type of decision and with a fixed data structure for input and output.

Table 1 lists all the general components selected for the development, within WP4, including those pre-existing components to be modified to match the DEMETER architecture and the private components which only applied to a particular pilot.

Table 1: Proposed General Components

Area	**General component**				
A – Crop Growth, Status and Yield	A.1 Plant yield estimation	A.2 Plant phenology estimation	A.3 Plant stress detection	A.4 Detect crop type	A.5 Estimate beehive

B – Irrigation Management	B.1 Water balance model	B.2 Data fusion for irrigation			
C - Fertilisation Management	C.1 Nitrogen balance model	C.2 Nutrient monitor			
D – Machinery and Field Operations	D.1 Emission	D.2 Field operation	D.3 Variable rate		
E – Pest & Disease Management	E.1 Computer vision-based counting module	E.2 Pest prediction	E.3 Pesticide monitoring		
F – Animal Yield	F.1 Estimate milk production	F2 Poultry feeding			
G – Animal Welfare	G.1 Estimate animal welfare condition	G.2 Poultry stress recognition			
H – Traceability	H.1 Traceability	H.2 Product preference	H.3 Transport Condition		
I – Benchmarking tool	I.1 Generic benchmarking	I.2 Neighbour benchmarking	I.3 Technical benchmarking		

4 BENCHMARKING

4.1 Aims and type of benchmark

The aim of the benchmarking tools is to support farmers in improving productivity and sustainability, both on economic and environmental aspects.
Within DEMETER, the benchmarking system is meant to capture data from different sources, in order to make them available on farm in an integrated way (interoperability), to develop tools for data comparison and to generate clear and self-explanatory advice in decision support.
In implementing benchmarking tools, the first step was to identify indicators to assess economic, environmental, and agronomic performance; indicators require quantitative measure or accurate estimation. The indicators describe the competitive performance achieved, they have to focus on those aspects that are more critical for

the current and future success, thus influencing productivity, profitability, sustainability, in the mid-to-long term.
In the DEMETER benchmarking system, the indicators comparison follows the following approach: (i) internal – to compare a farm performance with its historical data (e.g., before the adoption of a technology) and (ii) external-generic – to compare farm performance with a group or regional/area average, with the same size and type of farming, or individual data of other farms in that area.
The benchmarking systems start from a set of homogeneous, comparable farms, and bring together data from farms that have similar changes in their farm system (e.g., adoption of technology, use of field sensors, etc.) at different stages. Indeed, comparisons should be done within a homogeneous group of farms, according to the type of farm and its economic size (i.e., cultivated crop, animal bred, geographical area, farm asset). Homogeneity is difficult to reach, if we consider all the farms engaged in all the pilots, since they differ markedly, even within a cluster, and because of intrinsic straits of farming business.

4.2 Performance indicators in DEMETER benchmarking

As pointed out by the survey results, indicators to be calculated and implemented in the benchmarking system, need to assess agronomic, environmental and economic performance of farms.
Agronomic indicators are related to yield and quality of the production. Yield is a fundamental parameter and the ultimate goal of any agricultural practice since it gives information on productivity per area unit. Yield is the amount of production reflecting the current state of soils and climate, farmer's skills, and technology. As indicator can be used (i) real yield value, (ii) estimated value (e.g., with remote sensing, with models).
Environmental indicators are related to sustainability aspects and are able to describe environmental concerns for agricultural production processes. Principal aspects taken into account are: (i) the use of water for irrigation, (ii) the use of agrochemicals in pest management, (iii) the nutrient management.
Economic indicators are related to the comparison of farm profit, farm technical efficiency and economic efficiency. The Farm Accountancy Data Network (FADN), a database of microeconomic data managed by the European Commission, will be used for a generic comparison of farms.

4.3 Benchmarking component in DEMETER

The benchmarking system development consists in the implementation of a set of DEMETER compliant components that can be demonstrated in the pilot activities. As a result of the analysis of pilots' requirements, three types of benchmarking were selected to be applied in the specific components:

I. I1 - Generic Farm Comparison: a generic tool usable by all UE farms with a minimum set of requested inputs;
II. I2 - Neighbour Benchmarking: a tool usable by a group of farmers wishing to share anonymously a set of data to create indicators allowing local benchmark;
III. I3 - Technology Benchmarking: a tool helping farmers and stakeholders in evaluating the impact of a technology.

The three components share a common component that is the I0 – Indicators Engine. This component receives a set of farm-related inputs and produces the set of indicators that can be calculated according to the data available in the farm.
The data flows for the benchmarking systems is reported in figure 2.

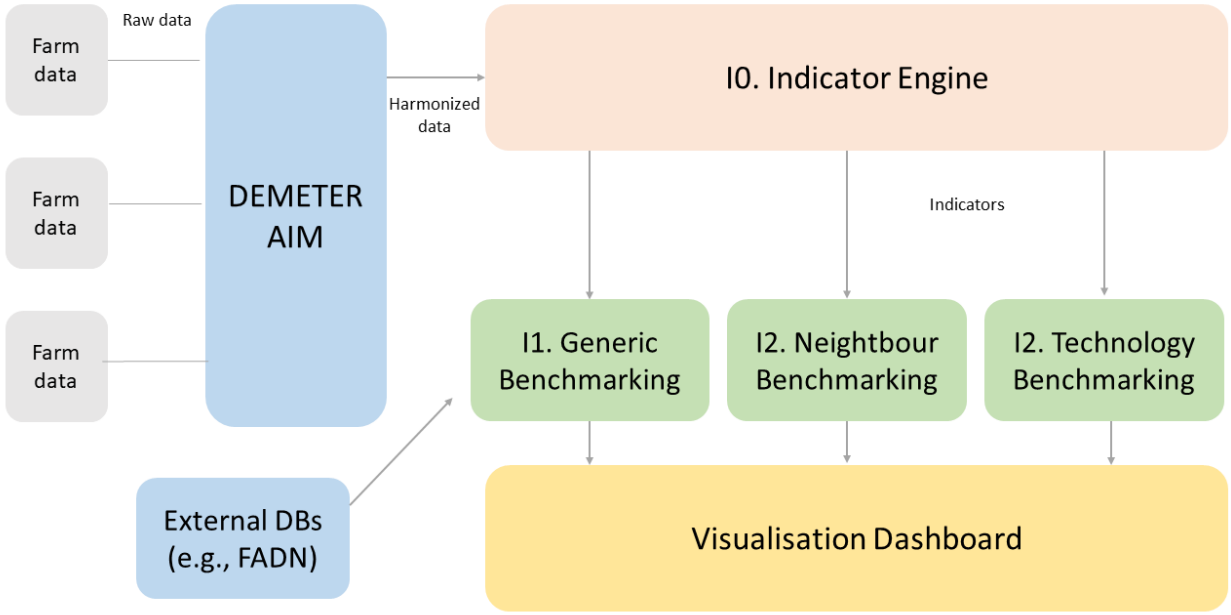

Figure 2: Benchmarking system data flow.

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