MEF4CAP

Monitoring and Evaluation Frameworks for the Common Agricultural Policy

[27 April 2022]

Deliverable **D3.2: Potential of current systems and ICT developments for future data needs**

Potential of current systems and ICT developments for future data needs

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Contents

Executive summary

The main objective of MEF4CAP's work package 3 (WP3), *Current systems and future pathways*, is to identify and define the most promising combination of data sources and technologies to achieve the prioritized data needs for CAP monitoring and evaluation. The deliverable actually confronts the data needs prioritized in work package 1 (WP1) with the technologies described in work package 2 (WP2) to identify their potential.

The final outcome of this report is the table presented in the Resources section of the MEF4CAP's portal[1], in which the potential of ICT developments to provide information for the metrics in the list of indicators proposed by WP1, has been identified.

In this regard, the new technologies identified to compute the metrics for the evaluation of the economic effects of The Common Agriculture Policy at farm level, are mainly based on the use of Farm Information Systems (FMISs). Robotic accountancy systems (e-invoicing) are able to collect economic information automatically. Farmers could decide to integrate this information in an FMIS which enables the possibility of sharing it for multiple purposes, among others CAP monitoring and evaluation. When farmers decide to do so, they would benefit from reducing the amount of data to communicate in personal interviews on the variables collected by these automatic systems. Nevertheless, statistical approaches to quantify such economic effects, may require additional information that FMISs are not be able to provide as such yet.

When looking at the table[1], environmental indicators are the most demanding in terms of data needs. One of the technologies with more potential for many indicators is Earth Observation (EO). It has some clear advantages such as the fact that it collects data at parcel level without the interaction of farmers. Both agricultural equipment and sensor on the field/farm collect valuable information for environmental indicators nowadays. This information needs to adopt ontologies defining formal names, categories, properties and relations as well as semantics describing the relationship between the different parts of Agriculture Information Models. Additionally, the information needs to follow data sharing protocols, for instance the European strategy for data.

Another issue that can be observed in the tables is that FMISs are becoming a system that centralize all data related to the various farm activities. These systems will help farmers with the management of their holdings and, if required, with the sharing of their information to any third party -administration, agri-food chain actors, certification bodies or research entities.

The analysis of the tables shows that there is a lack of suitable technologies providing data for most of the indicators under the social sustainability aspect of the Policy. The indicators under Health, Food and Anti-microbial Resistance are the exception to the former. In this case, the technologies identified are aimed at quantifying the use of veterinary antimicrobial agents.

Next deliverable (D3.3) will go into details on the combination of technologies providing data to compute the metrics of the indicators, that is, the pathways. The definition of these pathways is expected to bring forward the requirements for this information to be utilized for CAP monitoring and evaluation. These issues will span from the need of

[1] https://www.mef4cap.eu/resources

adopting models to estimate the metrics, to the way farmers participate (on a voluntary or mandatory basis) in sharing their data with third parties, among others administrators.

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Objectives and overview

MEF4CAP is a H2020 project with the main purpose of delivering an innovation agenda and roadmap for future monitoring of EU agriculture Policy. The Common Agricultural Policy (CAP) 2023-2027 is targeted towards a wider range of objectives covering broader domains –agriculture sustainability, agri-environmental, food security among others. This fact entails new data sources requirement to measure the effects and the performance of the Policy. Performance is the key concept in the new monitoring and evaluation framework of the CAP (PMEF). At the same time, new technical developments, are enhancing the capability of providing, retrieving and integrating new data that are called to achieve those data needs for CAP monitoring and evaluation. MEF4CAP brings together the expected needs for assessing the performance of future CAP and the newest technologies to address those data requirements.

MEF4CAP's WP 1 has carried out a thorough review of all global policy and societal demands that have influenced the widening of CAP's objectives. It also has explained the implications that data collection has for both administrators and data providers (farmers) and also has explored the potentially beneficial uses these data could deliver to them. Finally, WP1 has offered a short list of 41 indicators to help the assessment of the CAP 2023-2027 performance.

In other direction, MEF4CAP's WP2 has performed an extended review on the well-established legacy technology services and on the more advanced approaches currently in place for managing the necessary data flows in the agricultural sector. The technologies identified in WP2 are expected to support the data provision for CAP monitoring and evaluation framework.

The main objective of MEF4CAP's WP3, *Current systems and future pathways*, is to identify and define the most promising combination of data sources and technologies to achieve the prioritized data needs for CAP monitoring and evaluation. In view of this objective, this deliverable actually confronts the data needs detected in WP1 with the technologies described in WP2 to identify their potential.

Deliverable 3.2 is structed in four sections. Sections 1 through 3 summarize the main outcomes and key messages from previous deliverables in WP1, WP2 and WP3 (D3.1 Review of current monitoring systems). Section 4 is the core of the deliverable. After stablishing some considerations for interpreting the results, it actually identifies the potential of each technology to derive information for monitoring and evaluation requirements. The final outcome of analysis is the table which is available in the MEF4CAP's portal[2].

Finally, we draw some conclusions and findings on the most useful technologies and the most suitable type of indicators they address. These findings will be the baseline to build upon the pathways in next deliverable (D3.3).

[2] https://www.mef4cap.eu/resources

1. Review of the performance of the Common Monitoring and Evaluation Framework and the data sources utilized

This deliverable reviews the elements that set up the Common Monitoring and Evaluation Framework (CMEF) for the CAP 2014-2020. The main data sources involved are identified and described briefly. Additionally, the deliverable extracts the findings from the EC's report assessing the CMEF performance, as well as the conclusions from three European Court of Auditors' (ECA) report. The report covers the efficiency of the data sources utilized to quantify the effects of CAP on various aspects such as farmer's income, the effectiveness of Basic Payments Schemes and Greening measurements and, finally, the use of new imaging technologies to monitor and control the area-based direct payment aids.

The data sources involved in the computation of CMEF's indicators can be classified, in general terms, as statistical databases and administrative databases. The latter keep records of the individual beneficiaries' information applying for CAP support (the most paradigmatic example could be the Integrated Administration Control System, IACS) while the former gathers the information from samples of farmers who are surveyed following statistical methods. The Farm Accountancy Data Network (FADN), Eurostat's Economics Accounts for Agriculture (EAA), and Eurostat's Farm Structure Survey are examples of statistical data sources employed in CMEF.

The European Commission (European Commission, 2018b) highlights the impact on the timing and frequency of data (indicators) availability for monitoring and evaluation. The Commission gives some insights on what the new Performance Monitoring and Evaluation Framework will require in terms of data acquisition. The future indicators set is expected to be better focused "*to reflect as closely as possible whether the supported interventions contribute to achieving the objectives*", and therefore it should prioritize the use of more accurate data to assess the contribution of CAP interventions.

The Commission also expects that data sharing between existing sources and new technologies will enhance future data availability. Regarding the use of new technologies for data acquisition the ECA (European Court of Auditors, 2020) highlights the potential benefits they could bring, not only to the administration (in the scope of the report Paying Agencies) by reducing administrative burden but also to farmers. The latter, in addition to this burden reduction, could benefit from obtaining up-to-date information on their holdings. Nevertheless, this report also concludes that there is a "*Slower progress in meeting the challenge of using new technologies to monitor environmental and climate requirements*".

Deliverable 3.1 summarized the following conclusions:

- Data sources and data acquisition technologies must provide adequate information for the established indicators to capture well the effects of the Policy they are aimed at, otherwise the indicator value could lead to wrong conclusions.
- To be useful for evaluation and monitoring purpose, data sources must provide not only adequate information but also provide it timely for indicator reporting requirements.
- Statistical data sources, even when delivering valuable information for monitoring and evaluation, need to enhance their scope and methodologies to better address the new data needs in the PMEF.

- Administrative databases need to be ready to store new data coming from different new data acquisition technologies and spanning different domains (economics or environment, for instances).
- Improving the interoperability and, to the extent possible, the harmonization of administrative and statistical databases would exploit the synergies between them for monitoring and evaluation purposes while reducing the collection burden in terms of time (for farmers and surveyors) and costs.

2. Summary of data requirements for future data needs.

2.a. The evolution of the CAP and related policies.

This section extracts and summarizes key findings from WP1's Deliverable 1.1 (Donnellan & Dillon, 2021a). The first idea that is pointed out is that post 2020 CAP reform is being influenced by the emerging civil society concerns and, subsequently, by several international and European policies relating to environmental sustainability, among others:

- UN Sustainable Development Goals.
- Paris Climate Agreement.
- The European Green Deal.
- The EU Farm to Fork Strategy.
- The EU Biodiversity Strategy.

Therefore, the new objectives of CAP 2023-27 reflect this change towards a more environmentally sustainable agricultural policy while, at the same time, promoting the modernisation of the agricultural sector. The adoption of these new aims will also require a change in the way that the Policy is monitored and evaluated. It will need both a set of quantifiable targets and transparency in measuring progress towards such targets. This change is materialized with the shift towards a performance/results-based model in the CAP along with the introduction of MS CAP Strategic Plans, with tailored policy objectives to be measured in the same way.

Deliverable 1.1, in view of how the former CMEF has performed, considers that there is value in developing an indicator framework with high level of spatial details, that may be scaled up to provide regional and national aggregate level information of the policy impacts.

The report concludes that there is a need at EU MS level for:

- A considerable amount of additional environmental data that would include GHG emissions and sequestration, fertiliser use, pesticide use, organics, other less intensive agricultural systems that can deliver high environmental benefits, forestry and bioenergy.
- Some additional data for the social dimension. In this regard, quality of life measures: social isolation, access to facilities and broadband, work life balance, stress, mental health, physical health, and gender inequalities.
- Some additional data for the economic dimension: risk management and the distribution of value added in the food chain.
- If possible, some data on innovation in line with the ambitions of the Farm to Fork Strategy.

Additionally, (Donnellan & Dillon, 2021a) state that indicators for monitoring and evaluation of food demand and food waste as well as those related to the food chain beyond the farm gate are not part of this deliverable.

2.b. The future CAP developments and their impacts on administrative use and data providers.

The conclusions of Deliverable 1.2 (Donnellan & Dillon, 2021b) remark two aspects, the first one on the possible impact that the New Delivery Model (NDM) could have at both MS level and EU level. The second one is on the obstacles that need to be overcome for administrators, policy makers and farmers to benefit from the great amount of data collected for CAP monitoring and evaluation purposes.

As for the first set of conclusions, the report finds that apart from the expansion of the CAP objectives, the proposal of CAP reform establishes the creation of the NDM that aims to streamline governance, improve delivery and decrease bureaucracy and the administrative burden (European Commission, 2018a). The NDM will move from a compliance to a performance-based approach through the PMEF. This new framework links the eligibility of payments to actual delivery on the ground. MSs will be directly responsible for scheme design, implementation and evaluation of the Policy according to this new model. MSs are to draw up a National Strategic Plan (NSP) as key stone to the new performance-based delivery model. A NSP set target values and benchmarks for all common and specific indicators. Following, the PMEF requires MSs to submit an annual performance report to show progress towards the targets in the form of output, results and impact indicators.

Deliverable 1.2 gathers the point of view of several papers showing some disadvantages when the NDM is in place:

- There are some concerns that some MSs may chose not to be overly ambitious in setting goals due to their desire to ensure successful delivery.
- Two over-arching objectives of CAP proposals were simplification and modernisation. Nevertheless, some authors have concluded that the strategic planning approach will result in a substantially greater administrative burden at the MS level (Matthews, 2018; Carey, 2019 and Erjavec et al., 2020).
- Due to the increased organisational effort that NSPs required on the part of MSs (especially where a regionalised model is present) this approach may indeed be overly complex (Cagliero et al., 2021 and García Azcárate and Folkeson, 2020).
- The NDM provides some prospects for simplification (Emil et al., 2018 and Erjavec et al., 2018), but given an inherently unchanged governance system (Jongeneel et al., 2019).

As for the conclusions regarding data needs for the new monitoring and evaluation framework, the report finds that even though multiple sources of agricultural data now exist, there are obstacles to the integration of such data that need to be overcome. These obstacles regard legal issues relating to data ownership, certification and commercial secrecy, amongst others.

In Deliverable 1.2 the following issues are also highlighted:

- The lack of trust between farmers and data collectors needs to be addressed and overcome.
- Users of farm data need to approach the issue of data sharing in a way that returns benefits to farmers.

- Farmers themselves need to better understand the value which the analysis of such data can deliver to them. The benefits of such data would come from both farm advisory services and farm management decisions support.
- A last aspect remarks the benefits derived from merging various data sources. It would maximise the amount of information available for the individual farm, individual field or even a part of a field. Moreover, the upscaling of such data facilitates territorial benchmarking and strategic planning and investment and, by the pooling of data from multiple farms, more comprehensive analysis would be enabled.

2.c. Monitoring and Evaluation Needs of different stakeholders and Associated Indicators.

The main outcome of this Deliverable 1.3 (Donnellan & Dillon, 2021c) is a list of 41 indicators addressing economic, environmental and social topics. As it is explained in the report, the long list of thematic areas developed in Deliverable 1.1 is refined in D1.3 to produce a wish list of indicators. This list reflects priority data needs that are either not currently satisfied via existing national data sources or are not already adequately accounted for within FADN. The metric for each indicator, where possible, is also provided although it is recognised that expert input from relevant disciplines could be required to further refine these definitions.

Some topics have been excluded from the short list of indicators:

- Those where data already exists in some form.
- Those where a greater degree of granularity (e.g., at farm level) is unnecessary.
- Those where the required data may not yet be available or possible to collect.
- Those where there is uncertainty over what is required.
- Those where the requirement from a policy monitoring and evaluation perspective is of lesser priority (than those prioritised) or not of widespread relevance at an overall EU level.

The paper also recognises that some sustainability indicators may have a relevance for more than one CAP objective.

Donnellan & Dillon (2021b) consider the outcomes from a stakeholder engagement workshop held to gather perspectives on future policy demands and associated data requirements. These outcomes confirmed that an increase in the range of environmental sustainability indicators relating to agriculture is required. Therefore, the focus of the list is concentrated on environmental aspects.

Regarding economic sustainability indicators, relatively few of them have been selected reflecting the fact that there are already many economic indicators in existence, given that the collection of economic data relevant to the CAP has been the practice for several decades through the FADN, national data sources and other mechanisms.

The report remarks that it is now better appreciated that social indicators are important on their own right and therefore, several social indicators have also been selected. It also recognises that social sustainability indicators are also relevant as a mean to measure the impact of agriculture on wider societal objectives of all citizens and not just of those engaged in farming. Nevertheless, the deliverable points out that there remain challenges

around collecting some of this data, either due to its subjective nature or to difficulties in ascertaining such data outside of traditional survey methods.

The wish list of 41 indicators is the practical outcome of WP1 and configures one of the axes of the Table available in MEF4CAP's portal[3].

[3] https://www.mef4cap.eu/resources

3. Summary of ICT development deriving data.

3.a. Overview of the Landscape of agri-food ICT technologies within EU

Deliverable 2.1 (Kalatzis et al., 2021) describes the landscape of agri-food ICT technologies from three linked points of view. The first is from the perspective of technologies that increase the capabilities of data acquisition at different scales. The second point of view shows the agricultural information models which establish formal definitions of common names, categories, properties as well as their relationships (semantics and ontologies). This definition can be considered a prerequisite for the actual data exchange. The third view is on the data sharing aspect at EU level. Figure 1 summarizes these dimensions.

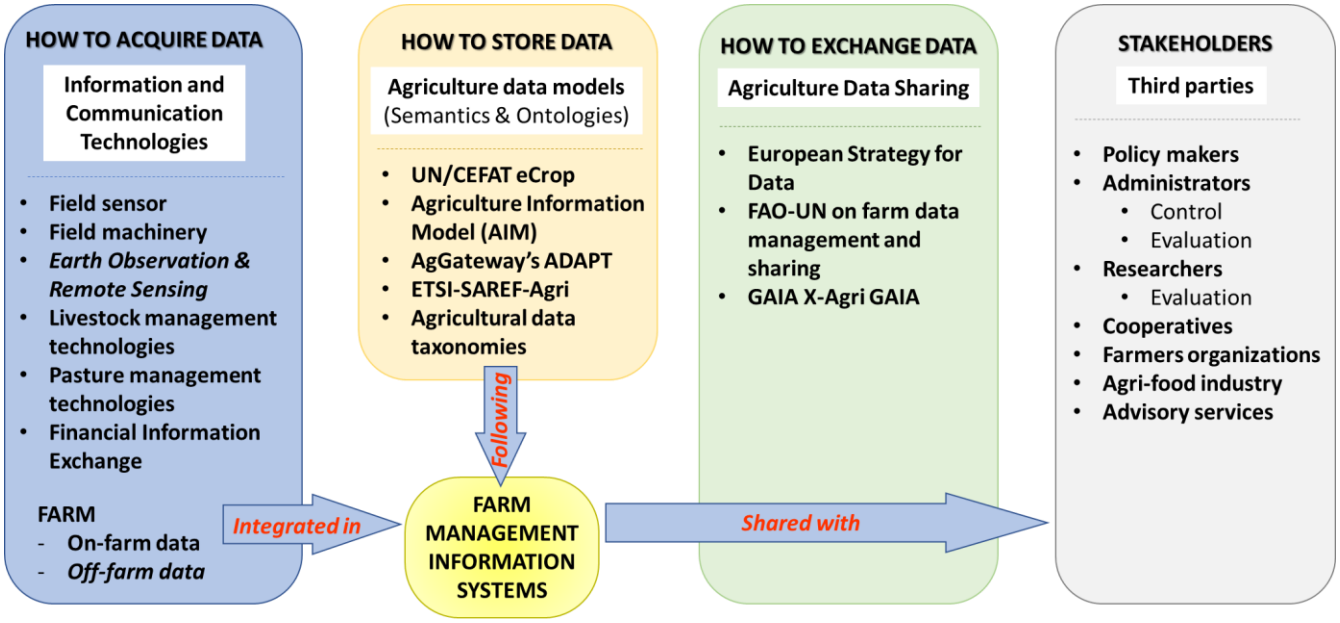


Figure 1: Scheme of the outcomes of Deliverable 2.1.

Going into details on the findings, Kalatzis et al. (2021) point out as a first outcome that there is no one-fits-all technological approach that is capable to provide all the necessary data for CAP monitoring. It is more a synergetic/complementary use of generated datasets that needs to be facilitated. In addition, they state that even when the various information items are made available by the various ICT technologies, it is also necessary that these are shared in a meaningful manner. Therefore, addressing the issue of "agricultural data sharing" is a necessary requirement for achieving the needed synergies with any third party. In this regard, Deliverable 2.1 remarks that the appropriate regulatory environment is still under formulation.

With regards to the data modelling of the datasets to be shared, the deliverable concludes that the overall ecosystem for agricultural data modelling is highly fragmented without having yet a dominant data harmonisation approach. It observes that, on the contrary, there are parallel data modelling standards which impose the need for cross standard interoperability mechanisms.

3.b. Best practices on the adoption of ICT agricultural solutions

This section summarizes the main findings of Deliverable 2.2 (Kalatzis et al., 2022). Since this deliverable also incorporates the outcomes presented in Deliverable 2.3 (Identified new technological opportunities from collaboration with EU projects and initiatives) as inputs, its conclusions are considered implicitly in this section.

Kalatzis et al., (2022) analyse several practical cases that make use of the following technologies:

- Field machinery: Variable Rate Application technologies (VRT).
- Farm level data monitoring through agricultural decision support systems (FMIS).
- Pasture management.

As for VRT, D2.2 remarks that although these technologies show a significant potential for CAP monitoring and evaluation, there are still some shortcomings for them to fully address the monitoring and evaluation needs. The first deficiency relates to ISOBUS which is an open standard for interconnecting electronic systems developed to support agricultural machinery operations. In this regard, Deliverable 2.2 states that ISOBUS needs to be semantically enhanced with additional information elements. The second one is that there is still no dominant approach for communicating generated ISOBUS datasets with third parties and the last one is that there are still no mechanisms to verify the actual composition of the inputs (fertilisers, pesticides, seeds) that are applied through the agricultural machinery.

Regarding FMISs, D2.2 points out their potential to support farmers in optimizing farming practices. FMISs generate extensive logs that can act as farm level data sources for the need of CAP monitoring and evaluation specially in those aspects related to measure the effect of agricultural practices on environment. Nevertheless, some key challenges towards a large-scale realization of such a monitoring approach are reported. In this direction, D2.2 states that FMISs as farms e-gateway need to improve their technical readiness for data exchange and that there needs to be a unified and harmonized standard of agriculture semantics for them to store and exchange information.

Apart from these conclusions on the technologies as such, D2.2 presents some issues concerning farmers' interactions with FMISs. The first issue relates to accuracy of FMIS data logs. Some FMISs require entering some data manually which is prone to intentional or unintentional errors, therefore a cross-check validation is somehow advisable. Finally, the last limitations refer to farmers' acceptance and consent on sharing their data. In this regard, the issue to deal with is farmers' concerns about the fact that the data collected and shared by FMISs could act as evidence for penalties. On the contrary there should be clear incentives and benefits encouraging the sharing of data.

The conclusions on pasture management technologies go mainly in line with the ones derived from previous technologies. Nevertheless, some additional considerations are presented in the Deliverable. The first consideration remarks that "*to understand and characterise grass-based farming at national and farm level, data from EO provision and Digital Paddock management services need to be combined with official databases such as AIM (Animal Identification and Movement), FADN and LPIS*". Another consideration is on the limitation of using some technologies in the same way in different MSs. For instance, how remote sensing technologies are used to assess grassland and pasture biomass cover in a Mediterranean country could be different from the use of the same technology in a Northern European country.

The second set of findings is related to farmers' engagement. D2.2 describe some private pasture management services that can be contracted by farmers. In view of these services, the deliverable presents some issues in the verification of the information provided directly by farmers that should be addressed. Besides, as some of the services explained in the deliverable are entirely voluntary and self-selecting the use of data from them may

not be appropriate for population level statistics – and hence CAP monitoring and evaluation – until a certain penetration is achieved. A couple of final conclusions are that 1) the use of such data as a replacement for existing farm level monitoring and compliance checks may be acceptable to individual farmers as a way to reduce administrative burden based on the principle of prior consent. 2) Additionally, the widespread collecting of such data to provide statistics on compliance on a national level (essentially national compliance monitoring) will need to be done in such manner that farmers know exactly what information they are sharing and the purpose of this exchange.

Kalatzis, et al. (2021) incorporate the outcomes of D2.3 in D2.2. The former deliverable identified new technological opportunities from collaboration with EU projects and initiatives in line with MEF4CAP's objectives. Figure 2 gives an overview of each project/initiative within the EU agricultural data collecting and data sharing landscape and the different stakeholders that could benefit from accessing these data.

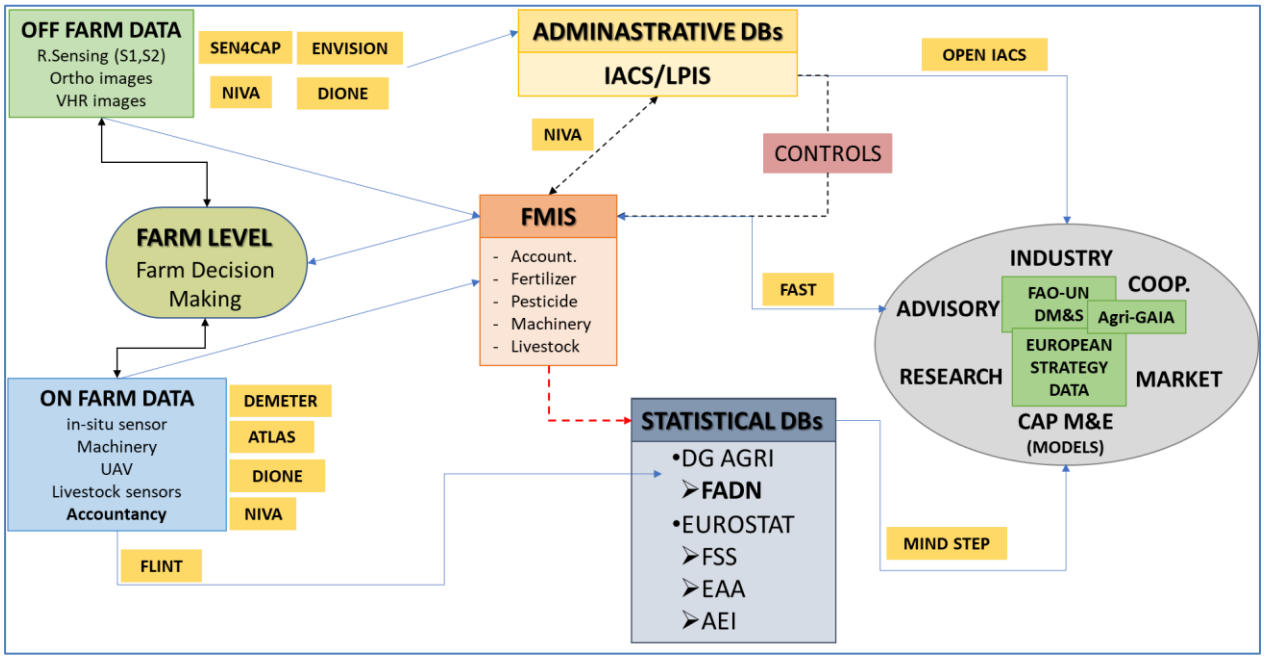


Figure 2: Location of EU projects/initiatives collaborating with MEF4CAP within the European agriculture data collecting and data sharing landscape.

The various technologies analysed in WP2 and the data derived from them configure the second axis in the table, while the wish list of indicators provided by WP1 sets up the first axis of this table.

4. Evaluation of the potential of the technology

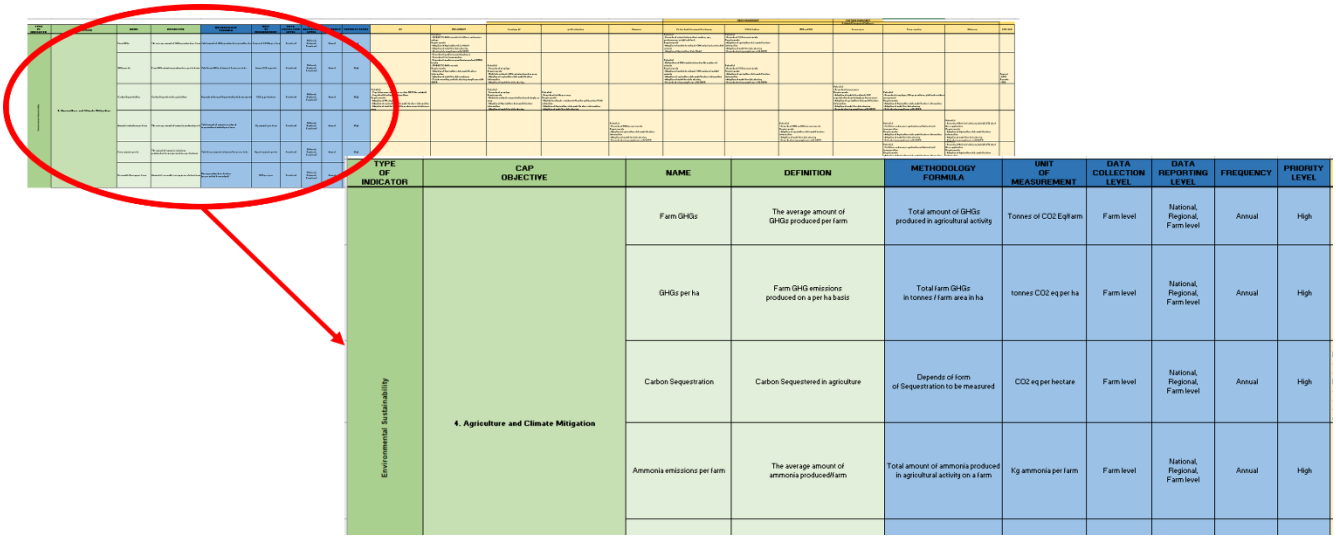
This section aims to address the main objective of Deliverable 3.2, as it describes the potential of the technologies identified in WP2 to compute the metrics of the indicators identified in WP1. The ultimate outcome of this section is the table available in the Resources section of the MEF4CAP's portal[4] , in which the potential of each technology is assessed. Besides this table, WP4 has developed an interactive web portal easing the consultation of the technologies considered for each indicator [5]. To fully understand this assessment following, we present some considerations related to the outcomes of WP1 and WP2.

The short list of 41 indicators delivered by WP1 is the starting point to identify the most suitable digital solution deriving data which in turn allow computing the needed metrics. This list of indicators, as stated in Deliverable 1.3, "*reflects priority data needs that are either not currently satisfied via existing national data sources or are not already adequately accounted for within FADN*". In this regard, we assume that these indicators also address the information needs for administrative databases to assess whether farmers meet the requirements to obtain CAP subsidies. Moreover, WP1 remarks that environmental sustainability concerns, which encompass agriculture and climate mitigation, efficient soil management and biodiversity and enhanced eco system services, are becoming a key element in the definition of the Policy. Therefore, significant attention is paid to those indicators under this theme.

Another consideration that WP1 points out is that "*there is value in developing an indicator framework with a high level of spatial detail that may be scaled up to provide regional and national aggregate level information of the policy impacts*". In line with this, the technologies considered in this deliverable are focused on those providing data at farm level and are suitable to be either scaled-up to different aggregation levels for statistical purposes or integrated in administrative procedures to carry out CAP monitoring and controls.

The evaluation of the potential of each technology is assessed by means of the above-mentioned tables. In these tables, the whist list of 41 indicators configures the rows. Apart from the metrics, the table shows the additional requirements defined in WP1 (Figure 3)

[4] https://mef4cap.eu/
[5] https://portal.mef4cap.eu/



TYPE OF INDICATOR	CAP OBJECTIVE	NAME	DEFINITION	METHODOLOGY FORMULA	UNIT OF MEASUREMENT	DATA COLLECTION LEVEL	DATA REPORTING LEVEL	FREQUENCY	PRIORITY LEVEL
Environmental Sustainability	4. Agriculture and Climate Mitigation	Farm GHGs	The average amount of GHGs produced per farm	Total amount of GHGs produced in agricultural activity	Tonnes of CO2 Eq/farm	Farm level	National, Regional, Farm level	Annual	High
		GHGs per ha	Farm GHG emissions produced on a per ha basis	Total farm GHGs in tonnes / farm area in ha	tonnes CO2 eq per ha	Farm level	National, Regional, Farm level	Annual	High
		Carbon Sequestration	Carbon Sequestered in agriculture	Depends of form of Sequestration to be measured	CO2 eq per hectare	Farm level	National, Regional, Farm level	Annual	High
		Ammonia emissions per farm	The average amount of ammonia produced/farm	Total amount of ammonia produced in agricultural activity on a farm	Kg ammonia per farm	Farm level	National, Regional, Farm level	Annual	High

Figure 3: Details of the additional requirements for the indicator.

The technologies described in WP2 are the columns of the table. This way, each cell shows whether a certain technology delivers data for the calculation of the indicator's metric or not. Additionally, each technology is classified as follows:

- No potential: Technology does not provide data for the indicator requirements.
- Some potential: The raw outputs derived by the technology don't achieve directly the metric of the indicator but they could turn into useful information by applying additional processes. These processes would span from the simple combination of these outputs with any other data to using them as inputs for sophisticated algorithms.
- Proven technology: Technology does provide data for the indicator requirements.

In those cases where the ICT development shows either some potential or the technology is proven, we describe two additional items (Figure 4):

- Source: The raw data or output that the technology delivers.
- Requirements: These are the requisites or processes needed for the raw data to provide useful information for the computation of the metrics of the indicator. These requisites would range from the adoption of models that enables the estimate of the metric to the need for farmers to agree on sharing their data.

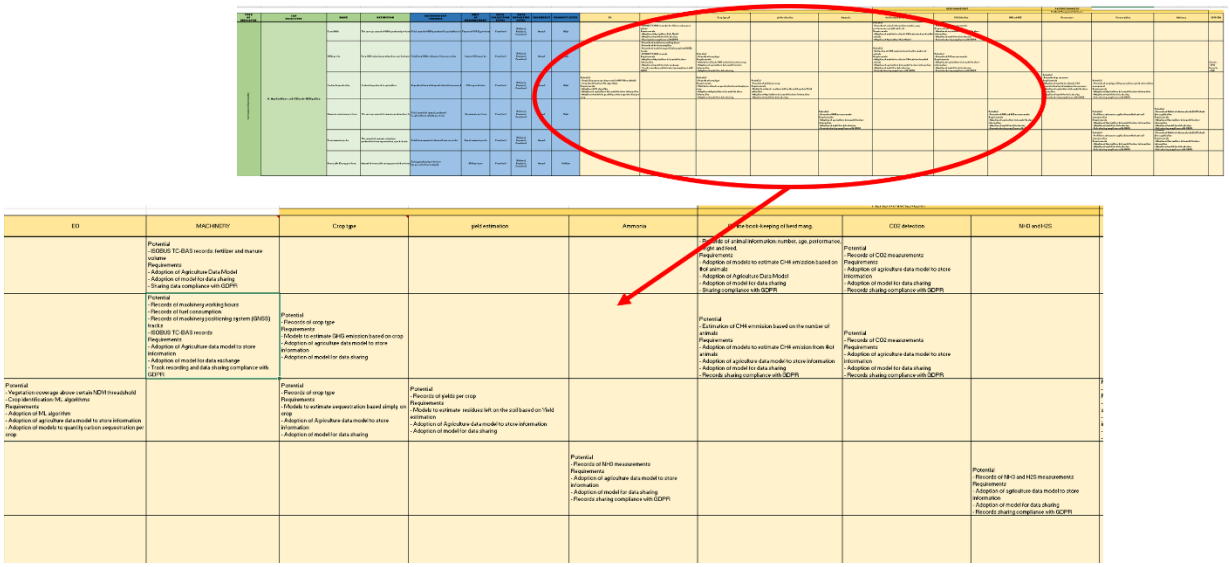


Figure 4: Detail of the data sources and requirements in the table available in MEF4CAP's portal

The last consideration is about Farm Management Information Systems (FMIS). We consider FMISs to be a modular system that can collect, store and exchange information on the various aspects of farm activity. Based on the type of data that a FMIS is aimed at, we establish the following nomenclature for the modules:

- A Farm registry, which would store data on the assets in the farm such as machinery type and equipment.
- A Farm book, farm calendar or field book, which would store information related to farm labour. It could integrate the information collected by other technologies, for instance, machinery logs.
- FFA (Farm Financial Accounting) module, that would gather the information related to purchases of inputs and sales of outputs including taxes and subsidies. We have placed this this type of accounting systems under the umbrella of FMIS though they might not need to transfer their data through an FMIS as it is highly probable to operate on an autonomous manner and even already being connected with a centralised information systems (e.g. for tax purposes).
- A Herd management system, which would store the information on livestock assets and their conditions and associated practices. This could cover the number of animals, to their performance and feeding as well as health among others.
- Advisory modules would integrate the information delivered by any advisory service that farmers could utilise. These services could be either the service given by any specialized personnel or the advice obtained from official Web services. In both cases and ideally, these reports would need to follow standard formats so that they could be ingested into an FMIS automatically.

5. Previous considerations on the technology potential

In this section, we present some previous considerations on the potential use of the groups of technologies identified to derive data for CAP Monitoring and Evaluation. Next deliverable (D3.3) will go into details on how each technology can be employed in each pathway.

Starting with Earth Observation, the main benefit of this technology is that it could takes data at parcel level with no interaction of farmers and at the same time, these data can be scaled-up from local to regional, national or even EU level. Despite of this, the information requires the application of algorithms and models to process EO raw data to fully exploit its potential. The cost of the services that run these processes and algorithms needs to be assessed as well as the willingness and knowledge of the final user for using these data whoever they could be that is, farmers, Paying Agencies, researchers or policy makers.

New developments in agricultural machinery provides clear advantages not only for farmers to control their input expenses but also to reduce the environmental impact of the agricultural operations. One of these advantages is the adjustment of inputs like fertilizers and pesticides by means of Variable Rate Applications. Nevertheless, the cost of this kind of devices could make them unaffordable to small holdings and therefore hamper the broad adoption of these technologies. In other direction, the data recorded by machinery such as the type of agricultural labour performed, its locations or the volume of products applied could be stored in the FMISs. This way, when data are analysed, this information could deliver beneficial information not only for farmers to get a better knowledge of the performance of their farms but also for CAP Monitoring and Evaluation purposes. As for the latter case, the information that farmers are sharing with the administration or any other third party and how this information is exchanged need to follow the legal requirements under GDPR regulation.

The technologies considered under sensors on the field and on the animals usually provide data at farm level that would ease the farmers' decision-making process such as irrigation management, diseases prevention, animal production and animal health problems detection. This information, at first sight doesn't seem to have a direct use in the CAP Monitoring and Evaluation process, nevertheless they could be used as inputs for various scientific models which estimate the value (or a proxy) of the metric sought for some indicators. The maximum potential of this technology could be achieved when the date provided by these sensors are combined to improve the estimation of the models they are used in.

Finally, Farm Management Information Systems, as explained previously, have a central role and act as an information gateway for farm related data including cultivation activities, data from sensors and from machinery. Nevertheless, until today agricultural related technologies are not designed to exchange data with centralised administrative systems (e.g regional government administration).

Conclusions and recommendations

This deliverable has identified the potential of the ICT developments described in WP2 to provide the required information to compute the farm level metrics of the indicators proposed in WP1.

The evaluation of the economic effects of the Policy at farm level has usually relied on surveys on selected farmers and follows statistical methodologies such as in FADN or Eurostat FSS among others. The new technologies identified to compute the metrics serving the purposes above, are mainly based on the use of FMISs. These systems should be also able to integrate information gathered by e-Invoicing or robotic accounting systems. This way, farmers would be released from providing data on the variables already collected by these automatic systems. Nevertheless, statistical approaches may require additional information that FMISs cannot provide.

The metrics of indicators aimed at measuring the agriculture impact on the environment are demanding in terms of the data variety they need for their computation. One of the technologies that potentially derives data for many of the needed indicators is earth observation. This technology on the one hand, has some clear advantages such as that it collects data at parcel level without the interaction of farmers and that it derives information suitable to be scaled-up from parcel to national or even EU level. On the other hand, some of the requirements for this technology to derive suitable information are based on the application of algorithms or models to process EO raw data. Even though these processes can be run automatically by several services, the cost of these services needs to be assessed as well as the readiness for the different stakeholders (farmers, Paying Agencies, researchers, policy makers, etc.) to utilize the products derived from them.

The information automatically collected by machinery is valuable for environmental indicators. Nevertheless, this information needs to be collected, stored and communicated following standard protocols. This requirement can also be applied to the information coming from sensor on the field/farm. The adoption of ontologies and semantics within the agriculture sector (Agriculture Information Models) and the definition of data sharing protocols (European strategy for data) are paramount not only for CAP monitoring and evaluation purposes but also for farmers to benefit from the analysis of this information. Additionally, there are legal barriers that need to be solved as, for instance, secrecy of manufactures. FMISs are called to play a role in this regard, becoming a system that centralized all data related to the farm. These systems will help farmers with the management of their holdings and if this is required, with the sharing of their information with whatever third party -administration, agri-food chain actors, certification bodies or research entities. In this regard, a legal framework is needed for Paying Agencies to certify the information coming from these systems and farmers to be sure that their data won't be utilized in an inappropriate way.

The analysis of ICT developments shows that there is a lack of suitable technologies that could help measuring the effects of the Policy in its social aspect. Apart from the indicators related to animal health, no technology collecting information at farm level has been identify for these indicators.

Next Deliverable (D3.3) will show how a technology or a combination of them can provide data for the metrics of the indicator, that is, the pathways. In those case where the combination of technologies doesn't give directly information for the metric, a discussion on how it can be addressed will be presented.

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