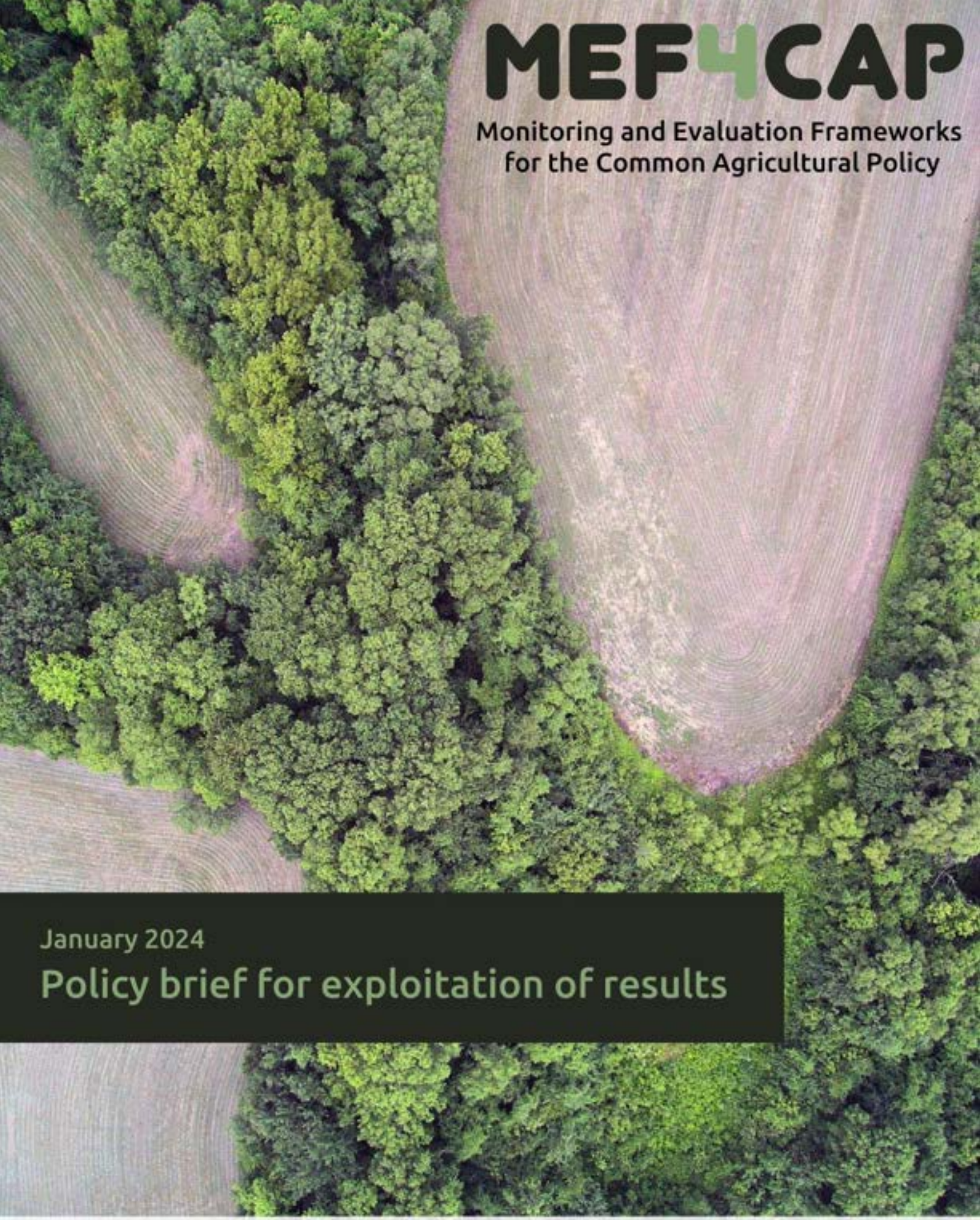

MEF4CAP

Monitoring and Evaluation Frameworks for the Common Agricultural Policy

January 2024

Policy brief for exploitation of results

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About MEF4CAP

MEF4CAP is short for 'Monitoring and Evaluation (M&E) Frameworks for the Common Agricultural Policy (CAP)', which in turn is a precise description of the project. MEF4CAP seeks to harness the benefits of digital technologies to meet the new data needs in the M&E of agricultural policies, prompted by the reform of the CAP, the European Green Deal, and the Farm to Fork Strategy. This requires new solutions which keep costs and administrative burden to a minimum, while optimising the value of the data collected.

The MEF4CAP project is designed to draw on the insights and perspectives of relevant stakeholders to identify best practices, ensure the inclusion of relevant developments and to discuss the potential of widening their application.

In this policy brief, we summarise the key outcomes of the project, including a Roadmap and Innovation Agenda for future M&E, where the needs of different stakeholders are met, and the potential of different approaches is fully and optimally exploited.

Foundation Roadmap and Innovation Agenda

M&E have so far been based on agricultural statistics and administrative data but with the new CAP requirements the use of digital technologies will be increasingly important (see 5th column in Figure 1). As a foundation for its Roadmap and Innovation agenda, MEF4CAP has (1) analysed policy M&E objectives, deriving priority indicators for future uptake and their data needs, (2) assessed existing and new data delivering technologies that could potentially support the data needs of these indicators, and (3) defined innovative *pathways* for those priority indicators that could benefit from such technologies.

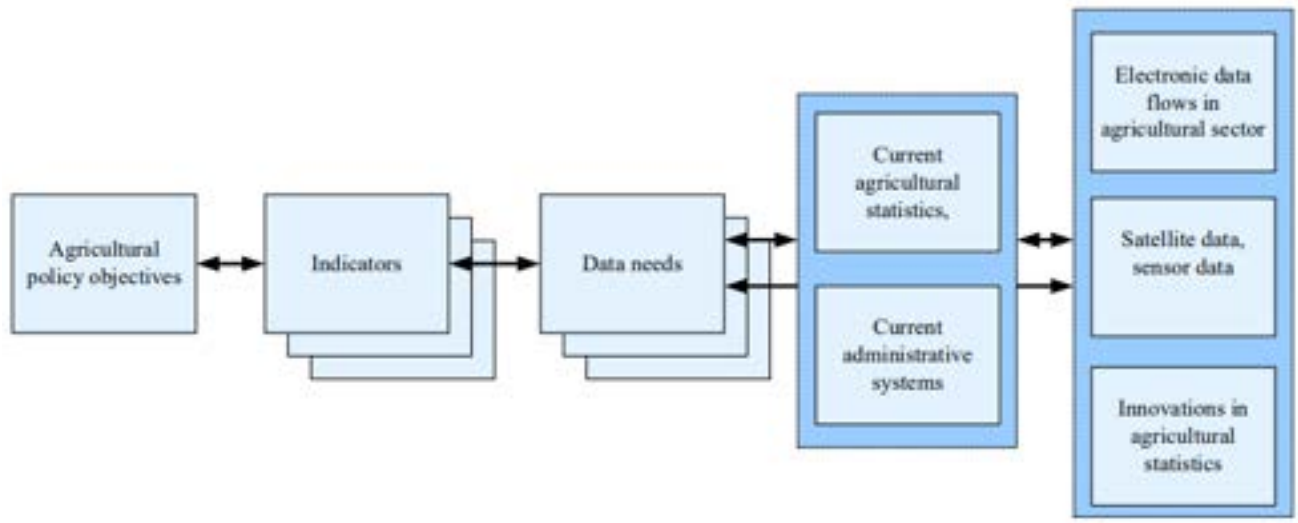

Figure 1: Background of MEF4CAP

Main features from the demonstration cases

To test and evaluate promising technologies with stakeholders, MEF4CAP developed six Demonstration Cases (DCs), applying data delivering technologies to different agriculture cases in several Member States (MS).

DC 1 | The Netherlands

DC 1 in the Netherlands investigated the use of innovative data delivering technologies to derive farm level agro-environmental indicators, while simultaneously lowering the administrative burden for farmers. In summary, this DC has tested: 1) Robotic Accounting based on the digitisation of invoices and other financial account data, namely to cross-check data for indicators on the use of pesticides, antibiotics, and nutrients. 2) In-situ sensor data specifically for air quality/emissions measurements. 3) the integration of sensor data with accounting data in a farm dashboard (called SITRA). Overall, in terms of scalability across farm types and MS, the solutions tested seem to be applicable to all commercial farms except for small farms and large agro companies (which usually already have their own digital solutions). A pre-requisite is that digital invoicing is in place. The main bottleneck in adoption is that the entire "ecosystem" (up- and downstream industries, software companies, accountants etc.) has to adopt the technology of digitised invoices in a certain time frame. Farmers also need a strong value proposition (organic certification, CAP eco-schemes, private eco-labelling schemes, etc.) for reporting environmental performance.

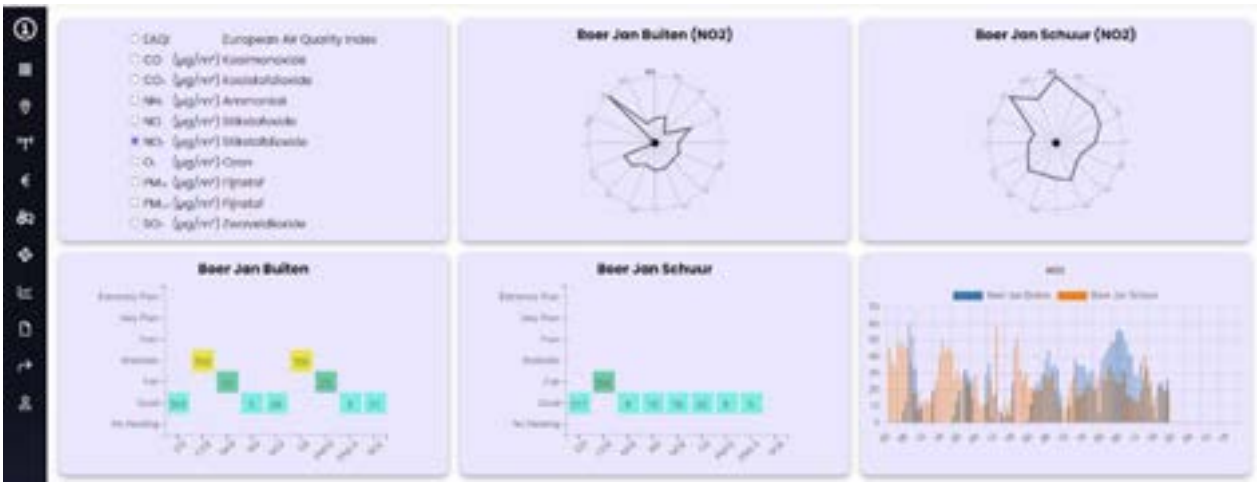

Figure 2: The SITRA dashboard

DC 1 | Poland

DC 1 in Poland looked at how to digitalise and integrate data streams from CAP and the farm accountancy data network (FADN), to support efficient and sustainable fertilisation practices. One of the major problems regarding agriculture in Poland is indeed related to the overuse of fertilisers which has a negative impact in terms of farm income and the environment. Optimal usage of fertiliser requires very specific information, on the one side the amount of direct applications of nutrients and the use of organic manures, and on the other side crop uptakes and losses to preserve the soil production capacity. The objective of the DC was to test the feasibility of collecting new information and generating new indicators related to soil fertility

management that could be used for M&E. Such new indicators can also support farm management. To minimise additional burden on farmers and their advisors in the collection of data for FADN, an automatic, direct transfer of digital administrative data was proposed. A key organisational problem found relates to the inconsistency between data collected at farm-level for FADN (e.g., on crop production), and administrative data collected for the Integrated Administration and Control System (IACS). There are other organisational and methodological issues related to data interoperability. Moreover, two obstacles were observed. One is farmers' ability to correctly interpret new indicator values. The other is trust related. Values that would suggest overuse of fertiliser could result in farmer unwillingness to provide data in the future. For farmers to share their data, we must ensure win-win conditions e.g., relating this to incentives that will encourage farmers to implement more environmentally friendly practises.

DC 1 | Ireland

DC 1 in Ireland worked on modernising farm data collection, specifically for the dairy sector, exploring new ways of visualising them through a dashboard (making possible the interrogation of farm-level economic and environmental indicators, and to support learning in the achievement of improved farm sustainability) and developing digital data streams for the FADN. The two data streams considered were: 1) those developed for the FADN data collection agency entailing a transition from manual to digital data flows for some farm data (farm-level technical and financial data e.g., relating to purchased inputs and outputs sold) and 2) those feeding the dashboard for Key Performance Indicators (KPI) visualisation for use by farmers, advisors, and researchers. These would include metrics across the following themes: greenhouse gas emissions, ammonia emissions, water quality, biodiversity, innovation, soils, weather, farm structure, farm technical performance, production costs, profit, and balance sheet data. The main barrier consisted of concerns from dairy processors and farmers around data privacy and how the data will be used. This hampers buy-in and goodwill to facilitate data sharing. In terms of scalability at EU level this DC has broad applicability for both the development of digital data flows and farm sustainability dashboards and can be scaled across the FADN and MSs.

DC 2 | Greece

DC 2 builds on the fact that digital technologies (including Farm Management Information Systems or FMIS) demonstrate the potential to serve two objectives: 1) the implementation of good and sustainable agricultural practices that provide clear benefits for farmers and the climate, and 2) the provision of evidence gained through ground truth at farm-level of the applied agricultural practices and their impact. The above can potentially be utilised for the M&E of agricultural related policies. However, the second objective is not yet addressed. Above all mechanisms for aggregating and sharing datasets from FMIS are still missing. Therefore, a private service provider developed a "Farm aggregates" data platform integrating open-source satellite and other data with a digital registry for recording agricultural activities. The platform intended to provide advice to farmers (individually and in groups), as well as evidence of the applied agricultural practices and their impact. Users are therefore the farmers (as well as their organisations, cooperatives) and their advisors. Barriers include 1) data sharing issues (farmers' refusal to share data due to lack of awareness/trust on the potential benefits; 2) administrative burden/workload and 3) lack of training and technical capabilities for the advisors to use such a platform. In terms of

scalability, the technologies used in this DC can be applied by all types of farmers. However, in the case of small farmers, only under certain conditions, given limited digital skills and the necessary initial investment. The aggregation of farmers into clusters or cooperatives and the support of consultants, modalities explored in the DC, are a way to overcome this barrier.

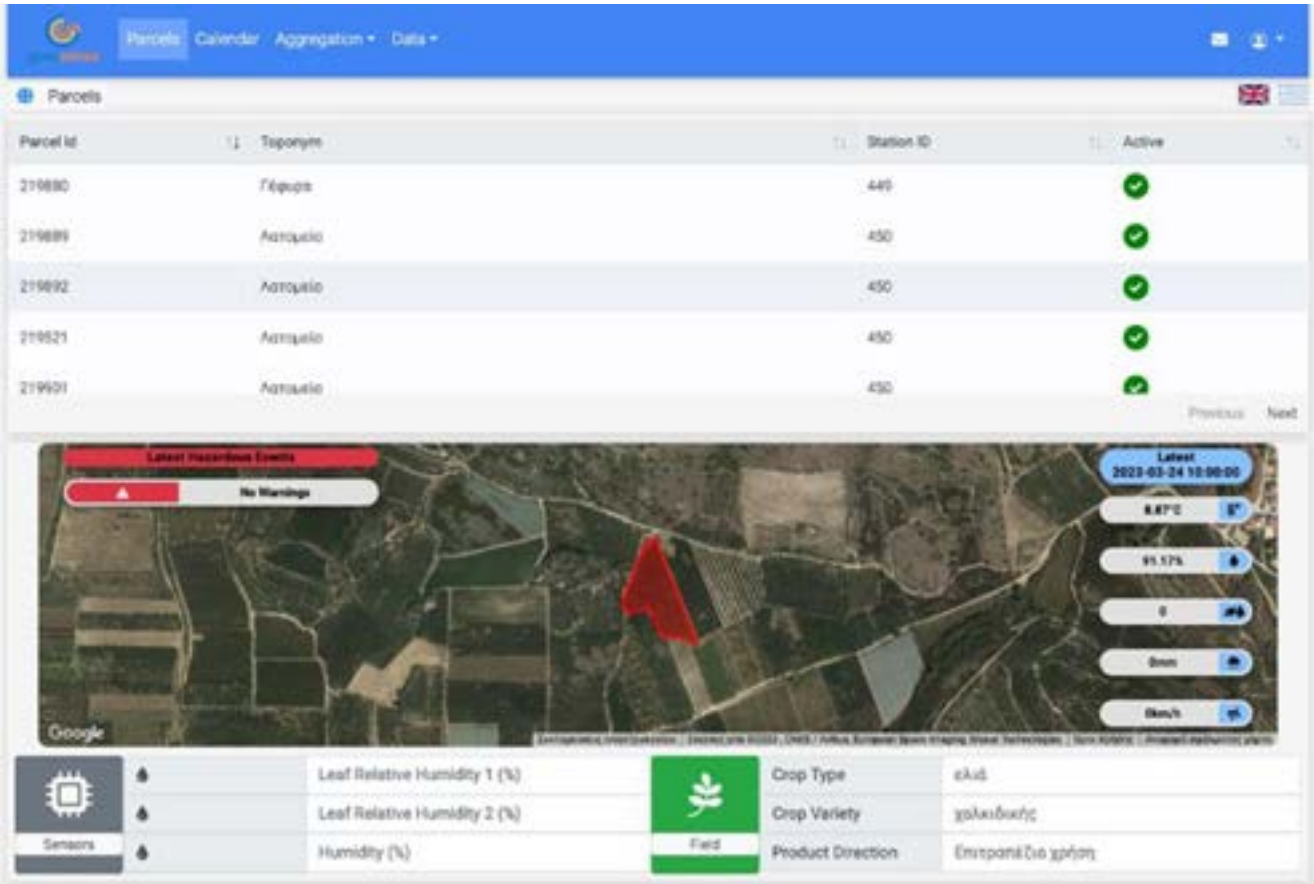

Figure 3: The landing page of the "Farm Aggregates" dashboard

DC 2 | Spain

DC 2 in Spain made an important contribution to the development of the "digital farm book" (DFB), a technology that will allow farmers across the country to keep records and monitor input, use, and management practices. Its use will be made compulsory from 2025 onwards in the context of the Agrarian Holding Information System (SIEX). The DFB allows the transmission of mandatory information requested, i.e. for the IACS e-declarations, as well as a more detailed tracking of farm operations and use of fertilisers, pesticides, and water consumption, to also respond to the EU Farm to Fork Strategy. A Geographic Information System (GIS) connected to the DFB integrates data streams derived from various sources (e.g., earth observation services, in-situ detection networks, and farm-level data). The DFB also allows cooperative members (farmers) and their advisors to monitor in real-time their performance in terms of fertiliser use and phytosanitary products, as well as the implementation of sustainable practices (eco-schemes) set within the new CAP (2023). The DC worked towards generating a bond of trust with farmers, who play a leading role, through a contract for the exchange of non-personal data. In addition, farmers should benefit from this information e.g. by monitoring their performance in the use of phytosanitary products,

fertilisers, and irrigation and ensuring compliance with CAP measures. The realisation of the digital farm book has been postponed several times. Due to the complexity of developing interoperable public applications for both national and regional systems (and across providers, who play a key role in the process), the many actors involved (seventeen regions), its introduction has been delayed. The protection of farmers' data and the system's security is also sought; from dedicated authentication mechanisms. There has been strong opposition from farmers' organisations to the enforcement of these new obligations, as these are perceived as adding a new administrative burden (at least while they learn to deal with these new digital technologies). All these reasons have led to a slower and more gradual development than initially expected.

Figure 4: Picture of a technician from the Cuatro Rayas cooperative advising a farmer-member based on the Digital Farm Book (La Seca, Valladolid). Source: Spanish Co-ops.

DC 3 | The Netherlands, Ireland and Poland

This DC demonstrated the Federated Learning (FL) technology, also referred to as the data train, to protect privacy while enabling organisations to develop sound statistical models using distributed data sources stored at different locations (and applied for distributed FADN data). The focus of this demonstration case was on the dairy industry by enriching the FADN data with additional variables collected by FADN Liaison Agencies on a national level. The results showcase the potential of semantic interoperability within the FADN network, with a specific focus on assessing the FADN variable off-farm income, which is understudied in previous efforts. This federated setup demonstrates its ability for agricultural economic analysis and enables the exploration of off-farm income's relationship with chosen FADN

variables. To reduce adoption barriers, several actions can be taken. First, as mentioned earlier, interoperable data sharing in the agricultural sector is challenging due to the lack of commonly accepted and shared vocabularies and ontologies. Therefore, we argue that the data train needs its semantic rails. Moreover, the integration of other datasets besides FADN data could be a possible future direction to investigate. This could lead to more types of sustainability analyses, especially in line with the current discussions on FSDN.

DC 4 | Spain

DC 4 tested modalities for integrating open-source satellite data, LPIS and farm-level data acquired through GPS trackers/collars sensors, for sustainable sheep herd management in view of specific eco-schemes. Among the main motivations regarding the technologies proposed in the DC, farmers mentioned facilitating decision-making and the benchmarking of farms. They also consider that the use of GPS trackers allows farmers to control their herds remotely, reducing costs and time (farming burden reduction). To reduce adoption barriers, the administrative burden could be lessened through the support of the cooperatives' advisory services to help breeders, through the implemented technology, to easily demonstrate to payment agencies that their herds comply with the requirements of the Eco-Schemes. In terms of scalability at EU level, the technology is easy to implement, although awareness of the benefits and possibilities needs to be improved to make it more attractive to farmers. In addition to the environmental indicators needed to comply with the eco-scheme requirements, it is advisable to provide farmers with information that is of interest to them, and which can support with the daily management of their herd, thus producing a kind of compensation for the farmer's burden.

While DCs are very relevant for the overall MEF4CAP objectives, they should be seen as a research tool, covering only part of all technologies, indicators, and pathways.

More details on the DCs can be found in the Lessons Learned Briefings, and in the MEF4CAP Deliverables D4.3 ("Description of design and results of demonstration cases" and D4.4 ("Description of design and results of demonstration cases"). See MEF4CAP.eu for further details.

Innovation directions from MEF4CAP Demonstration Cases

The findings from the MEF4CAP demonstration cases can be translated to future recommendations for research and innovation, providing innovation directions to be integrated into an Innovation Agenda:

- The implementation of robotic accounting to allow automated collection of data on inputs and outputs based on digital invoicing. This will allow the broad collection of reliable, high-quality (and if required auditable) data while decreasing administrative burden for their collection and processing
- The integration of farm registries into the M&E system, allowing the use of farm management data to generate monitoring data and indicators on the farm level and integrating that into national M&E systems

- The setup of regional sensor networks, and the integration of IoT data (from sensors, machines) to allow the use of detailed data on operational actions to generate management data and derived monitoring
- The use of digital solutions (e.g. dashboards) to avail farmers with actionable information derived from new data streams and technologies for their own benefit, and as an incentive to collect and share that data for M&E
- The deployment of federated computing approaches (compute-to-data, federated learning, multi-party computing) to allow downstream (e.g. Member State, farmer) processing of data for upstream purposes to protect personal and otherwise sensitive data

A Roadmap for future M&E of agricultural policies

Using and further analysing the results of the forementioned work, MEF4CAP has composed a **Roadmap** for **future M&E of agricultural policies**.

This roadmap is a narrative and visual representation that ties together a strategy ("why"), the actions needed to achieve the intended goals ("what"), the modalities ("how") and a timeline for completion and monitoring ("when"). While the **why** (the objectives of the M&E of EU agricultural policies) and the **when** (the future CAP cycles: 2023-2027 and especially the post-2027 CAP) are, at least to some extent, known, the specific actions and modalities to get there (the **what** and **how**) they are only partially known and constitute some of the questions that MEF4CAP should address.

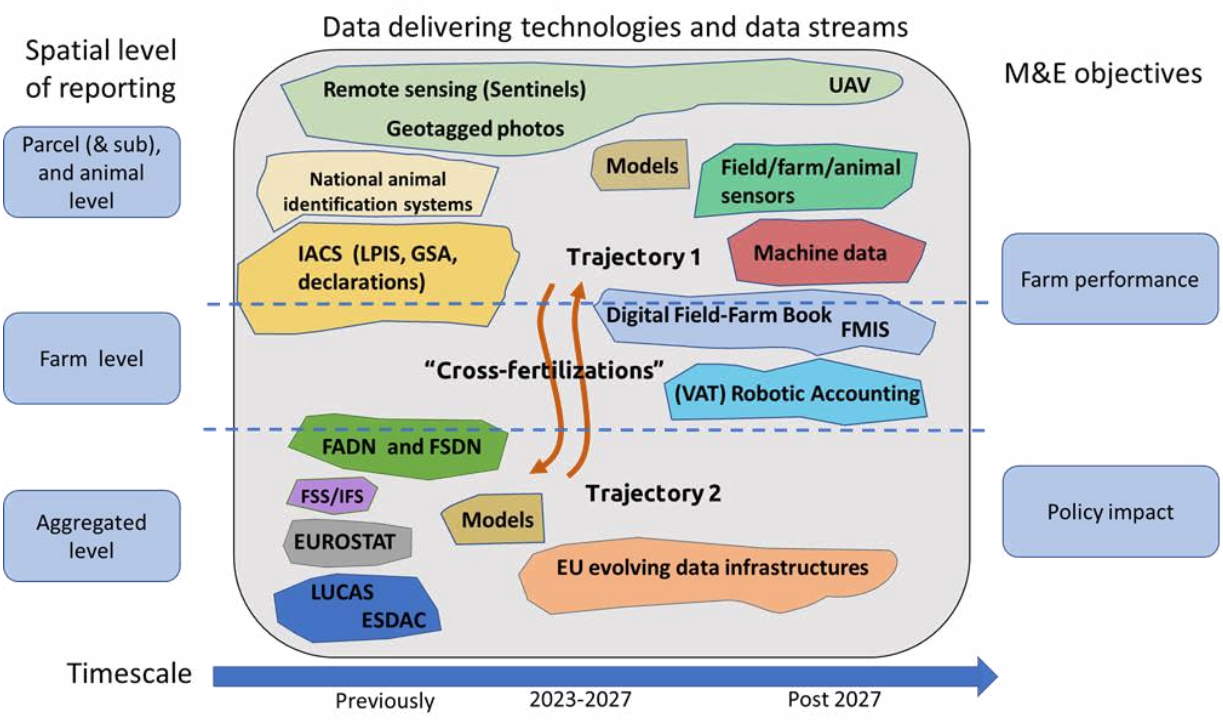

Figure 5: Schematized visualization of the MEF4CAP Roadmap

The MEF4CAP Roadmap for future M&E of agricultural policies describes two distinct trajectories, visualised as Trajectory 1 and 2 in **Error! Reference source not found.**, with, as

entry points, two groups of data delivering technologies generating indicators that ultimately respond to different M&E objectives, as well as added-value linkages between them in the form of "cross-fertilisations".

The figure shows a schematic visualisation of the Roadmap. A full description of the developed Roadmap and underlying trajectories, which are also provided with details relating to different types of indicators (e.g. greenhouse gas (GHG) emissions, land cover, crop nutrients), is available as part of the MEF4CAP deliverable D6.2 "Synthesis and Roadmap". See again MEF4CAP.eu.

- **Trajectory 1** focuses on data streams that report indicators at a high spatial resolution scale (farm, parcel and in principle also sub parcel) originating from IACS (Land Parcel Identification System (LPIS), Geo-Spatial Application (GSA), farmers declarations when it comes to land based systems, the animal-based application system in case of livestock based systems) and Earth Observations (EO), primarily the Sentinels and Sentinel Expansion missions. This responds to the current requirements of operational CAP performance monitoring at farm level (i.e. related to their compliance with eco-schemes and related agricultural practices). However, the same data streams can also be usefully applied for broader M&E purposes, always with a view to having individual farms as reporting units.

- **Trajectory 2** primarily aims at the evaluation of the impact of agricultural policies at higher level (MS and EU) using more aggregated data streams, among others from FADN, currently transitioning towards the Farm Sustainability Data Network (FSDN), in combination with other EU statistical and other data sources (the Farm Structure Survey - FSS/IFS and the Livestock survey, Eurostat, LUCAS, ESDAC, etc.).

- **Cross-fertilisation**, linking existing data sources and technologies between these trajectories and introducing new ones will create important synergies. On-farm data (e.g. coming from farm/livestock registries, FMIS) could reinforce the methodological development and validation of impact evaluation methods. Vice-versa, data currently used to support impact evaluation (e.g. automatically collected accounting data) could fill data gaps for farm-level performance monitoring.

Both trajectories link currently operational, less mature, and new data streams as well as technologies over a **future timeline** from today, via the 2023-2027 CAP period, towards the post-2027 period. Trajectories should also ideally be **articulated by MS** and with consideration of the **different agricultural sectors and farm types** to capture specific conditions of "readiness". Although this was beyond the scope of MEF4CAP, it may constitute a recommendation for future research.

Towards Roadmap implementation in an Innovation Agenda

MEF4CAP has assessed the future needs for M&E innovation, the potential of various (combinations of) data streams and technologies through desk research as well as through interaction with stakeholders. Moreover, through the demonstration cases, several real-world experiments have been deployed and tested. This section shortly summarises the main findings that formed the foundation for formulating priorities and actions in the Innovation

Agenda:

- The demonstration cases and other interactions with a diversity of stakeholders have yielded a set of barriers and drivers for innovation of the M&E system through novel data streams.
- As part of the MEF4CAP Roadmap, six main implementation challenges were identified, which are broad and diverse, and include social, governance, infrastructural and technical aspects.
- The analysis of commonalities with regard to data, methodology and technology over the defined "pathways" (priority M&E indicators with innovation potential), led to a clustering into different indicator groups. Due to their commonalities, these clusters of indicators can benefit from joint approaches, using similar data and technologies and, in the end, also benefiting from similar, synergetic innovations. For the Innovation Agenda this allows for innovations to focus on topical themes, rather than just on technological and data related challenges.
- The MEF4CAP DCs explored the opportunities and challenges of using combinations of different data streams, working processes and technologies in real-world situations over different EU Member States. The specific perspective (e.g. a specific M&E objective, sector, working process, type of data and technologies) makes their outcomes and experiences valuable. Therefore, they have been translated to innovation directions for integration into the Innovation Agenda.

Drivers and barriers for Roadmap implementation

Drivers for innovation

According to the MEF4CAP pathway analysis, a large part of the novel data that could support future M&E innovations is generated at farm-level. Although a lot of that data is currently collected in business or government managed (cloud) environments, respecting EU laws and regulations and following the EU code of conduct on agricultural data sharing, the consent for further usage and control over its use is with the farmer. Thus, it is important to have a view of what farmers see as drivers that could take away some of their current concerns, and that would motivate them to share their data for M&E purposes. The MEF4CAP research, and specifically the demonstration cases, have yielded a range of such drivers. They can generally be summarised as follows:

- Support for improved decision making and better economic results, including farm advice, benchmarking etc.
- Decreased administrative burden
- Support with delivering proof of performance and compliance for the purpose of certification, subsidy application, etc.

Besides farmers, other stakeholders also expressed specific incentives that would motivate them to adopt new developments:

- Opportunities to create new market spaces (service providers)
- Reducing administrative burden (paying agencies)
- Gaining trust of beneficiaries (paying agencies, managing authorities)
- Improving digitisation of the value chain (upstream/downstream value chain partners)

Barriers for innovation

From the farmer perspective several relevant barriers were observed, that might keep them from sharing their data for M&E and other purposes. Several of these barriers mirror the drivers mentioned in the previous section:

- Increase of administrative burden
- Fear around losing control of data access and usage
- Lack of awareness and/or skills on data sharing and digitalisation in general
- Fear of non-compliance, and being penalised
- The need for long timeframe and/or large technological investments

Moreover, several of the observed barriers are broader, ecosystem related, rather than specifically linked to (and observed by) farmers. They are rather connected to the complexity, fragmentation, and heterogeneity of the current data ecosystem in agriculture, which hampers broader innovations in the data economy:

- Lack of interoperability and limited opportunities for data sharing (service providers, paying agencies, managing authorities)
- Fear of increased burden (farmer advisors, farmer organisations)
- Complexity of digitalisation of the whole interconnected value chain (upstream/downstream value chain partners)
- Limitations of national legal frameworks (paying agencies, managing authorities)

Further implementation challenges

Readiness and maturity of novel data streams and technologies

MEF4CAP has identified a range of promising data sources that could add to the M&E system for monitoring of agricultural policies. At the same time, many of the technologies that generate these data and the data itself are still not *technologically* mature[1] enough to support the process.

Often mentioned data sources and technologies, required for implementation were:

- Farm management data coming from farm and value chain registries
- Data from IoT devices (sensors, machines etc.)
- AI/ML models and data analytics supporting various M&E tasks
- Off-farm data (e.g. weather, soil, digital elevation models, temporal series of Earth Observation (EO) images)

Reciprocity and value of M&E for decision making

Reciprocity to data providers, somehow returning value can be an important incentive to share data. Many of the drivers for sharing data for M&E as observed by MEF4CAP, directly relate to being able to make use of the resulting information, e.g. receiving insights on individual performance, including benchmarks, to management advice and proof of performance for subsidy applications and certifications. While reaching future M&E objectives is an important aim, the importance of providing valuable feedback to data providers as an incentive can hardly be overestimated. Taking account of such incentives will increase the

[1] MEF4CAP has assessed the readiness or maturity of the different data delivering technologies identified, from different perspectives: technological, societal, organisational, and legal.

motivation to share data for M&E and ease the implementation and adoption of any new data stream.

Data Sharing Infrastructure
Integrating the multitude of new data streams into M&E requires that actors within the sector are willing and able to share data. This requires a well-designed data sharing infrastructure that allows stakeholders to easily share data for different purposes. This obviously requires technical infrastructure, but most and for all, it requires technical and non-technical measures to increase trust in data sharing, support data sovereignty and to ensure protection of personal and otherwise sensitive data.

Data Interoperability
Future M&E will more heavily rely on the combination and integration of different data streams. A multitude of open and closed-source (big) data processing and analysis tools are currently readily available and are successfully applied in a large variety of data processing chains. However, such tools require that data is machine readable and machine interpretable. With agrifood being a fragmented, siloed and multi-disciplinary domain, the interoperability over the data ecosystem is still on a low level and asks for serious efforts in the harmonisation of different existing data models and their semantics.

Digital Infrastructure & Skills
The MEF4CAP roadmap builds strongly on the exploitation of new technologies delivering data for M&E. The foundation of digitalisation and the adoption of (new) digital technologies by the agriculture community lies in the wide availability of the basic digital infrastructure and the knowledge and skills to understand and use digital tools. At the same time, basic skills to work with those technologies and (rural) infrastructure are still lacking.

Digital divide among MS and among farmers
To what extent and in what form the sketched Roadmap can be implemented depends highly on the different dimensions of readiness. This concerns different types of farms / farmers, e.g. large farms versus small scale producers with limited investment capacity for new technologies, or high versus less technically skilled farmers. It is also indirectly related to differences in the state of play in technology and the national data ecosystem between EU Member States. Depending on the context, specific innovations and support might be required to implement parts of the proposed roadmap.

Topical clustering of indicators

MEF4CAP identified five topical clusters, that can benefit from joint approaches, using similar data and technologies and, in the end, also benefiting from similar, synergetic innovations:

- Land use and land cover
- Carbon budget: carbon sequestration and GHG emissions
- Nutrients and pesticide use
- Economic and social indicators
- Indicators of remoteness

For the Innovation Agenda this allows for innovations to be focused on topical themes, rather than just on technological and data related challenges. The clusters can also be positioned in the framework of the MEF4CAP Roadmap, with respect to their alignment with the

trajectories, and their expected development over time.

Table 1: Indicator clusters and position in the MEF4CAP Roadmap trajectories

Cluster	Trajectory positioning
Land use and land cover	Trajectory 1, currently already well developed using national monitoring systems and statistics and earth observation with opportunities to fill gaps with extended and enhanced (similar) data streams
Carbon budget	Trajectory 1, now using national monitoring systems and statistics, earth observation with opportunities to improve using novel data streams on farm management and accounting
Nutrients and pesticide use	Trajectory 1, now using national monitoring systems and statistics with opportunities to improve using novel data streams on farm management and, through cross fertilisation, also accounting
Economic & Social Indicators	Trajectory 2, now using FADN, and survey statistics with opportunities to improve using novel data streams on accounting and through cross fertilisation, also farm management and farm financial accounting
Indicators of remoteness	Trajectory 2, with little opportunities to scale out to novel data streams

An Innovation Agenda for M&E of agricultural policies

MEF4CAP's activities and the derived strategic directions presented in the Roadmap and the underlying trajectories have inspired the establishment of an Innovation Agenda. A full description of the Innovation Agenda is available as part of the MEF4CAP deliverable D6.3 "Innovation Agenda" (see MEF4CAP.eu).

The Innovation Agenda can form the basis for innovations in the next decade to improve and extend M&E for agricultural policies by integrating novel data sources and technologies into new data streams. It also takes aboard a critical analysis of these outputs, informed by feedback from various workshops organised through the project, including National Workshops held for the demonstration cases, the Interactive Reflection Workshop, the Innovation Agenda Workshop, and the MEF4CAP Stakeholder Advisory Board interactions.

To signal opportunities for potential synergies, but also to avoid duplication or conflicting activities, the Innovation Agenda takes account of relevant innovation initiatives that are currently operational or being initiated in various EU and national programmes. Particular programmes that were considered are:

- Horizon Europe – Cluster 6 - Food, Bioeconomy, Natural Resources, Agriculture and Environment
- European Partnership "Agriculture of Data"
- EU Common Data Spaces
- FADN/FSDN related research
- EU Space Programme
- EU Mission: A Soil Deal for Europe

The Innovation Agenda builds on what MEF4CAP has identified as the key areas for future innovation. Several of those key areas are relevant to advance the use of new data streams in general. These cross-cutting themes follow from the innovation challenges identified in the MEF4CAP Roadmap, and particularly those that are closest to the nexus of M&E needs and the data sources and technologies explored in MEF4CAP. They represent some of the important mechanisms to be implemented and data ecosystems to be disclosed:

- Improving interoperability and data sharing
- Data from farm registries and advisory systems
- Integration of IoT data
- Advancing M&E using federated approaches for data processing

Another dimension of the Innovation Agenda is organised around themes that share a common M&E topic. These topical themes are based on the MEF4CAP M&E pathways: those priority indicators that have innovation potential and the data sources and technologies needed to deploy them. They are clustered along commonalities with regard to their data needs and technology requirements and could be developed using similar approaches. These topical themes are:

- Land use and land cover
- Carbon budget: carbon sequestration and Green House Gasses (GHG) emissions
- Nutrients and pesticide use
- Economic and social indicators
- Remoteness and accessibility

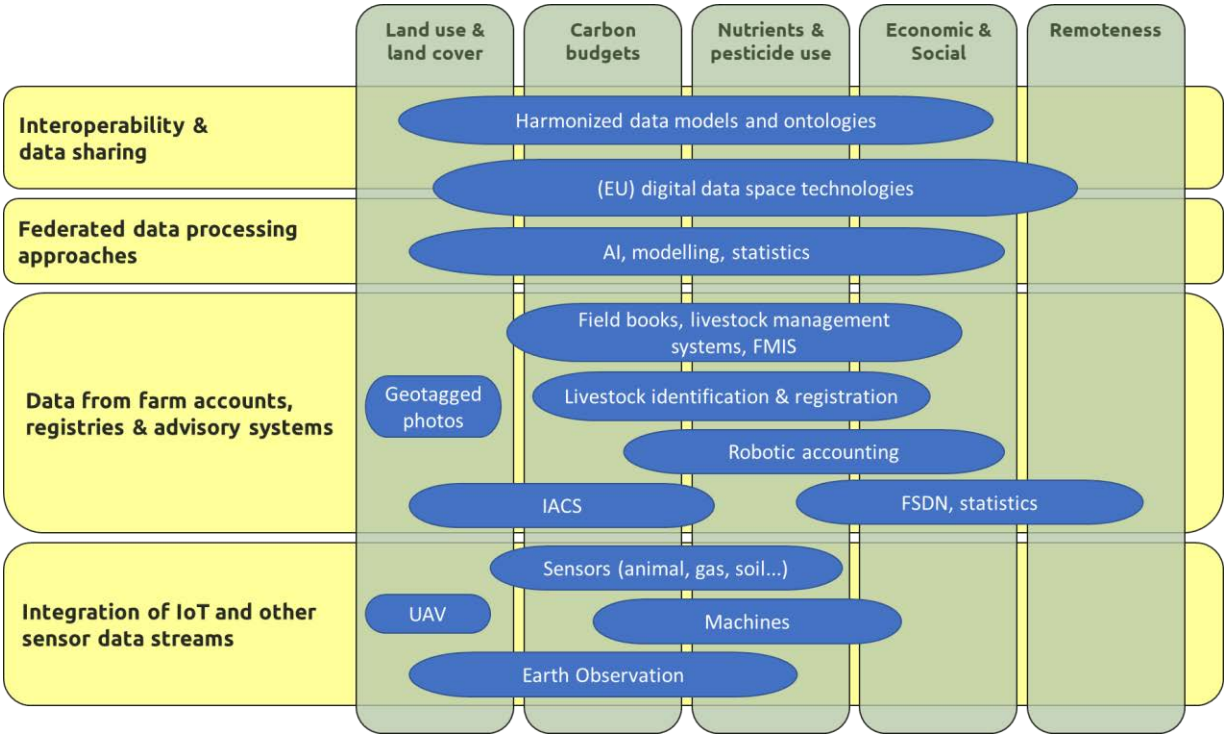

Figure 6: Innovation domain for M&E with novel data and technologies

Figure shows the innovation domain for the future M&E system as a cross-section of these two dimensions (topical and technical/cross-cutting themes), and projects on it the data technologies that are most relevant to specific areas of the overall domain.

The Innovation Agenda identifies the innovation actions in this domain that support with advancing the M&E system through the integration of novel data streams. Per (technical as well as topical) theme it provides a listing of innovation subjects, that can be translated to calls for innovation, including a comprehensive description of the rationale behind the subject. Where possible an indication of the implementation format and type of innovation programme that are most suited is proposed. Also, a rough indication of a feasible timeframe for their execution is given, aiming to support further integration into future programmes.

While it might be tempting to approach innovations for the M&E of agricultural policies from the perspective of single themes or topics, it is important to note and anticipate the many interrelations, especially between horizontal and cross-cutting themes as well as each thematic topic. Focussing on specific indicators without taking account of the required innovations and existing gaps in, for example, interoperability and data sharing will almost certainly lead to failure as important pre-conditions will not be met. Therefore, further implementation of the proposed Innovation Agenda requires a holistic approach, mixing and matching work on topical themes with advancing horizontal challenges. The following aspects should in that respect be considered:

- Innovation calls and resulting proposals should aim to build on a good understanding of the state of the art and ongoing developments in EU and national data spaces and particularly the agricultural data ecosystem.
- An innovation programme focusing on the exploitation of novel data streams for M&E should consider delegating aspects of dedicated M&E innovations in the broader context of EU and national innovation programmes on data sharing and the data economy. This could take the form of dedicated projects or use cases. It will allow the embedding and testing of specific mechanisms in more generic environments, offering readily available knowledge and solutions for (horizontal) challenges.
- Vice versa, the embedding of specific activities to further develop and embed work on horizontal cross-cutting challenges into topical innovations should be encouraged. This is particularly important for the aspects that are so specific that they cannot be fully delegated to other broader innovation areas, e.g. standardisation and harmonisation or the integration of farm registries. But it could also include building M&E test cases on evolving infrastructure that allows (federated) data sharing.

Key messages

A summary of the main messages that emerged from MEF4CAP research activities:

- Evolving and broadening policy needs lead to new demands for M&E, with a specific gap when it comes to indicators, data, and capacity in the agri-environmental field.
- There is value in developing an indicator framework with a high level of spatial details, that can be scaled up to provide national and EU aggregate-level information on the policy impacts.
- There are promising technologies that can deliver such data for M&E purposes. At the same time, there is no one-size-fits-all technological approach to provide all the necessary data for monitoring EU agricultural policies. It is rather a synergetic/complementary use of available and new data delivering technologies and relevant data streams that needs to be facilitated.
- The MEF4CAP Roadmap for future M&E of agricultural policies describes how such data delivering technologies can evolve to power the future M&E system.
- Two distinct trajectories underlying the MEF4CAP Roadmap are identified as well as added-value linkages between them in the form of "cross-fertilisations". Trajectories have, as entry points, different data delivering technologies generating indicators that ultimately respond to different M&E objectives (CAP performance monitoring at farm level on the one hand and sectoral policy impact analysis on the other).
- Development of new M&E data streams must go hand in hand with improving data interoperability and facilitating reliable and safe data sharing, that protects privacy and data secrecy and creates trust with data holders, especially the farmers, through improved data sovereignty.
- It is a wide-spread idea that integration of new data sources will lead to additional burden for data collection, processing, and validation. Smart automatisation therefore seems, together with trust with data holders, another key element for the adoption of the proposed technologies.
- Merging novel data streams into the M&E system to meet future needs requires a large variety of interrelated changes and improvements over the larger agricultural data ecosystem. MEF4CAP therefore proposes an Innovation Agenda from a holistic approach, mixing and matching work on topical themes with cross-cutting challenges in the data ecosystem.