MEF4CAP

Monitoring and Evaluation Frameworks for the Common Agricultural Policy

Lessons learned brief

Demonstration Case 1, The Netherlands: Robotic accounting and sensor data for sustainability indicators with low administrative burden

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Short summary of the Demonstration Case, its rationale and objectives

Monitoring and evaluation of the EU policy in the future cannot be carried out only from outside the farm (e.g., by satellite). Several relevant indicators can only be observed within the farm, and especially those that refer to the farm administration.

Examples are the use of pesticides, antibiotics but also the use of energy, material balances for nitrogen and phosphate and mass balances that must be provided in certification processes by organic farms. The latter indicators are the focus of this demonstration case.

This is not only the case of farms that participate in the Farm Sustainability Data Network (FSDN), but also for organic farms (mass balances) and potentially for farms in the CAP eco-schemes. It is also relevant in private eco-labelling schemes. However, this monitoring, which requires the collaboration of the farm, can quickly lead to an administrative burden instead of improving the management of the same farm.

A good farm dashboard with minimal data entry requirements is therefore essential. Financial management is now central in farm administrations: for paying bills, cashflow management and supplying data for the Value Added Tax (VAT) system. By integrating environmental data with the farm's bank account in a dashboard, the handling of invoices lead to a minimal extra burden and the data can be audited in a certification process to prevent fraud in claiming a certain level of environmental performance.

Sensor technology and satellite data also have potential for reporting environmental performance by farmers and we tested if it is possible, and it makes sense to add such data to the dashboard. We installed sensors for air quality measurement at 3 organic farms (on the barn and approximately 150 meters away in the meadow). As benchmarking is an important method in agriculture for interpreting performance and improving management, the farm dashboard has the function to share data among farmers or advisors, up- and downstream companies, the FSDN and public agencies.

In this demonstration case we tested two technologies:

- Robotic accounting based on the digitization of invoices
- Collection of sensor data and their integration it with accounting data in a farm dashboard

With these technologies we are able to collect a wide range of indicators from farm financial accounts and farm management information systems (both can be integrated with robotic accounting) as mentioned above. Sensor data reveal in this demonstration case farm level meteo data and measure data on a range of emissions (NH3, fine particles, CO2, NOx etc.), also in relation to open public measurements in the surroundings of the farm[1].

[1] For more information, see 3 scientific papers on the demonstration case:
Paper on the current data-landscape and the need for innovation:
http://centmapress.ilb.uni-bonn.de/ojs/index.php/fsd/article/view/92
Paper on robotic accounting: https://www.mdpi.com/2071-1050/14/11/6756
Paper on the integration of digital banking, farm financial accounting and farm management information systems: https://www.mdpi.com/2079-9292/12/6/1485

The important stakeholders involved in the application of these technologies are:

- Farmers (do they appreciate the farm dashboard, robotic accounting and are they interested in sensor data?)
- Up- and downstream trading partners in the food chain that send invoices to farmers (and would have to digitize them in formats like XML to employ the tested technologies)
- Data collectors in the FADN/FSDN, but potentially also in accounting offices and certification bodies that benefit from less manual data entry
- Software-vendors to extend their applications with these technologies

Reflecting on the technologies suggested and on the expected data and indicators, what is the "readiness" level (technological, social) of the technologies in this DC? Are these ready to be adopted? Or do they need more time for this?

Digitization of invoices and robotic accounting have a very high technical "readiness" level. It exists in some sectors (e.g. governments that require digital invoices in procurement) and is used for some invoices in the Dutch agriculture. However it is hard to convince up- and downstream suppliers to digitize, as it involves an effort without a clear benefit for them. In the cases where digital data is available, robotic accounting, including also bank account data (available under PSD2), is used for quite some time in the Dutch FADN. An obligation for a national digitization of paper invoices has been ordered in Hungary, but not in the Netherlands.
The integration of farm financial accounting and farm management information systems has been done in Enterprise Resource Planning software, but that focusses on companies with a high internal data need for management; the software is too burdensome for family farms where the data need (on environmental performance) is external, and software has to be much simpler. The integration has been designed in this project.
Farm dashboards do not require special hardware of software skills from farmers (other than smart phone skills). This means that the technical readiness of the robot accounting technology is very high and can be adopted by all commercial farmers in Europe, including the dashboard developed (with the caveat that the prototype has to be technically upgraded into commercial or public software). However, the social readiness is an issue subject to the willingness of the food chain partners to digitize.

The sensor technology itself has a lower readiness level, as standardization of data collection and calibration protocols are not available and sensor data quality at low levels of emissions is still problematic with the type of sensors that would be more or less affordable at a farm level. Although there have been suggestions from the policy sphere to base environmental policies on this technology, it seems to us that much more work is needed in the next years to make this feasible. Nevertheless, sensor networks in environmentally sensitive areas or meant to manage collective goods like clean air or water resources, have potential. Given the current Dutch policy environment there is clear interest with farmers and agribusiness to pursue this pathway.
Concerning our objective to bring such sensor data together with accounting data in one dashboard, no problems have to be reported. That turned out to be possible, even if the

frequency of the data is quite different between the data sources and demands good database management. The readiness of such an integration is high and this holds also for other sensor data (like those from spraying machines or robots, where farm management information systems already have examples of sophisticated applications).

Can the technologies be adopted by all type of farmers or different ones should be used depending on farmer types (small scale, large scale, etc.)?

The reflections above lead to the conclusion that in principle the farm dashboard and robotic accounting technologies that we tested could be used by all commercial farms (e.g., those with more than € 25.000, - sales) that have a bank account and are (or could in theory be) under the VAT system. Very large farms (big horticultural farms, large agro-companies in parts of Eastern Europe) would probably also be served by ERP systems that are available in the market and use these to show their environmental compliance. In principle this is also the case for the sensor technology once additional work on the solution is carried out.

What are the data and the indicators used and generated in this DC?

- Sensor data on air pollutants: AQI (Air Quality Index), NH3, CO, CO2, PM10, PM2.5, NO, NO2, O3, SO2 and meteo data
- Environmental accounting data: use of pesticides, use of antibiotics, N-surplus/ha, P-surplus/ha, energy use (and implicit GHG emissions). At farm level and crop/field level (if financial accounts and farm management systems are integrated)
- Certification data: mass balances for organic farms
- Economic / financial accounting data (as in FADN; non-farm income)

What motivates the stakeholders involved to adopt the proposed technologies? And what are the barriers?

The drivers for adoption are as follows:

- Farmers want less administrative burdens
- Many farmers are interested in their emissions (if not yet sanctioned because of them)
- Farmers want control over their data
- Accountants want digital invoices in a tight labour market
- Software companies might be interested in new features
- Food companies and banks are interested in the farm data for several reasons.

The main bottleneck in adoption is that the full socio-economic environment of the farm (Up- and downstream industries, software companies, accountants etc.) has to adopt the technology of digitized invoices in a certain time frame. And farmers need an external demand (organic certification, CAP eco-schemes, private eco-labelling schemes, CSRD-scope 3 demands from retail) for reporting environmental performance.

The technologies could also be used directly in the FSDN that is created out of the FADN. The demonstration case shows that a lot of indicators are available in invoices that are already handled by data collectors and that their software could be upgraded. However, it is unlikely

that up- and downstream industries will digitize the invoices only for a small sample of farms, and this would mean manual input (as some countries currently do). [2] It should be realized that there are some indicators on environmental performance that cannot be generated from invoices by robotic accounting. The use of surface or ground water for irrigation is an example, although sensor technology might help here too. Biodiversity is another one.

Given these barriers, which actions do you think should be in place to overcome them? By whom?

Regarding the use of sensor data on emissions, some actions have been identified in research projects where regional sensor networks are set up for monitoring and data collection protocols as well as calibration methods are developed. The purpose of those networks would then be to gain knowledge on the interpretation of the data and relating this to actions of the farmers (or other emitters).

For digitizing invoices and rolling out robotic accounting, next actions seem to be collective ones carried out in specific sectors to create a shared vision / mission of sector data management. This asks for leadership by e.g., a sector organization, a farmers' organization, or the government. It depends on the size of the software market if this is enough for vendors of farm management information systems or farm accounting software to adopt robotic accounting and provide the dashboards, or if a collective or public action is needed as these markets are very small (due to language, regional environmental rules that have to be coded, etc.) and do not have much competition of software vendors. An intermediate solution is to organize the development and maintenance of the algorithms in robotic accounting as a shared service (or white label software).
FADN/FSDN managers can adopt the technology of collecting environmental data from invoices directly (with manual input) and provide a dashboard to farmers to foster cooperation.

Any other comment or insights from the national workshops ?

The National Workshop in the Netherlands had a first session focussed on the three farmers that installed our sensors. Given the Dutch political issues around ammonia emissions, they welcomed the effort and were very interested in comparing their data with those from public sources in the neighbourhood as well as those from other farms. Having at the same time the data for available nitrogen from mineral balances seems logic. They found the method for data sharing logic as it gave them control over their own data. The option of making annotations (e.g. with a calendar function) in the graphs was suggested (and implemented). The integration of digitized invoices and financial management in one screen that would result in most of the reports needed (like mass balances for their organic certification), is seen as a desirable method over the current method. The latter envisages only financial VAT accounting or scanning invoices and sending them by mail to an accountant, and manual mass balance calculation at the moment of a farm visit by an inspector for organic farming.

[2] For more information, see the results of the FLINT project: https://www.flint-fp7.eu/

There were about 30 participants from the stakeholder groups mentioned earlier as well as persons from the Ministry of Agriculture, the Paying Agency and the Organic Certification Authority. This led to a lively discussion and brainstorming on the data flows in Dutch agriculture. Five topics were discussed in more detail:

- Next steps with sensor data on air pollutants

The workshop showed a clear interest in the presentation of this part of the dashboard. A regional project as well as a farmers' organisation showed interest in discussing a follow-up in a larger test on monitoring regional pollution management and the impact of farmers' actions to reduce ammonia emissions.

- Digitizing invoice data

Several workshop participants pointed out the importance of this development. Support for digitizing invoices could come from accounting offices that face labour shortages for data entry. They view digitalisation as very beneficial. The current practice that staff of the accounting office holds the passwords of the farmer to download his invoices from a company's website is seen as very undesirable from a data protection point of view. However, a clear incentive for the food chain trade partners of the farmer to digitize the paper flow is missing. It was suggested to have a strong central organisation, probably backed by the farmers' organisation and the government, that would concentrate on the 20% of the companies that supply 80% of the relevant (most important) invoices and "do a lot of talking and coffee drinking" to convince trade partners. The fact that they also need the farmer's data for logistics, branding sustainable products and CSRD-scope3 should help in the conversation. "Naming and shaming" (i.e., producing a list of companies that are the biggest bottleneck for robotic accounting, based on the FADN data handling processes) of regulations where option not yet favoured.

- Governance and business model of the proposed dashboard

The discussion was introduced with an explanation of the issues at stake. The prototyped dashboard with robotic accounting and sensor data, that would integrate farm accounting processes, digital payment processes and data recording with farm management information systems, can be created and supported by software companies, or by a collective action. In most Dutch sectors there are only a few software companies that supply farm management information systems; they are now part of international organisations, and it is not clear if the Dutch markets are large enough to make an investment in the proposed direction, attractive. That also holds for the potential of a start-up, that would also need backing of angel and venture capital. An alternative is a collective action, either by farmers (or farmers' organisations) or a branch organisation, perhaps with the financial support of the government.

In the discussion some critical remarks were made on the market-based solution: in a small market this could quickly become a monopolistic situation. Some attendees are not so much afraid of the prices in such a market, but the governance of the data: data could be exploited by the company against the indirect interests of the farmer. Others refer to the code of conduct that has been developed. The need for an independent authority (government agency or branch organisation) as a patron or principal to an IT service provider for realising the dashboard was seen as a good safeguard for proper data management. The importance of

sharing data in study groups of farmers and the role of advisors was also stressed and thought to be coherent with such a mode of organisation of data as a mean for reaching environmental targets.

- Governance of sharing data for mass balances in organic farming

This discussion partly overlapped with the previous one. It was pointed out that this data concentrates on volume (technical) data, not on financial data, although invoices are an important source of the data for a mass balance. Farm management information systems might be a good source and have options to share data with the certification authority SKAL. Accounting software in use with the accounting offices could also calculate mass balances and forward this (with permission of the farmer) to SKAL. There is a large number of trading partners in organic, as well as farm sales. That makes it less attractive to collect the data from the trade partners, although at the other hand they have to be certified too. Based on such dataflows SKAL could work like the Dutch tax authority, fill in the mass balances as much as possible and ask farmers to complete them. If farmers would have a dashboard as proposed by MEF4CAP, it could generate the mass balances at a quarterly / yearly basis, in line with the VAT declaration. There seems to be enough trust in the organic sector to make more use of digitalisation.

- Options for a shared service for robotic accounting

The coding of invoices and other documents or data sources is based on memorized or computerized algorithms (e.g., product '91654 Round Up 5 liter' from company Z is an herbicide; it is part of the indicator herbicide use / ha). These conversion tables and algorithms are maintained at many places: with the FADN, with accounting offices, with farm management information systems. Workshop participants welcomed the idea to investigate if a shared service would be possible.

Such a service could start with standardisation in data flows, a service for quality management to check the correctness of the structure and content of the digital messages and robotic coding of data in the messages like products, volumes (e.g. convert grams into kg to harmonise between suppliers), using a common chart of account and where possible an allocation to profit centres (e.g. feed for cows, feed for pigs). A next step could be to add an attribute that shows that invoice has been checked with the bank account and the calculation of key performance indicators like a material balance.

Such services should be managed by an independent organisation. Results have to be usable for farm accounting, farm management systems and other applications. It was suggested in the workshop that the development of such a service is realistic (it builds on earlier activities in the 1980s in the Information Stimulation Plan) and that reference can be made to the work of AgroConnect/AgGateway and JoinData. The real challenge is the maintenance of the service that not only has to be done in real time, but also needs a business model that goes beyond a one-time project subsidy.

Challenges are in the change from paper to digital messages (see above), standardisation of product codes (see codes for fertilizer and manure with NMI or GS1 coding; material passports in the construction industry might be an example too). The EAN coding might be a useful example: what were its driving forces?

The calculation of indicators also leads to data that are confidential, which asks for a clear governance and good procedures to guarantee that only the farmer and his trusted advisors have access to the data. Using the performance indicators for better prices or lower interest / rent payments in case of sustainable performance could convince farmers to overcome their reluctance for sharing data or using the service but only to a certain extent. The shared coding service or a platform with a dashboard as developed by MEF4CAP could also provide the option not to share all the data, or certain reports, but just the result that, based on the indicators, the farm falls into a certain predefined category ('yellow level of sustainability' 'no offence of organic rules', 'certified in eco-label Y on 24 March 2023'). The current requests for high volumes of farm data leads to anxiety of too much transparency and 'big brother is watching you'- feelings. On the other hand, transparency is an important aspect of themes such as circularity, sustainability, material passports etc.

Any reflections on the applicability of the DC to other contexts (other users, other member states, other indicators)?

The solutions seems to be applicable to all commercial farms in the European Union (and beyond). Very small farms (e.g. with sales less than € 25,000.-) that sometimes have not a bank account or smart phone or are, perhaps, less attracted by this solution. Large agro-companies might be using an Enterprise Resource Planning system for internal management, that makes our solution less attractive.

We could add a couple of policy recommendations:

1. Many indicators can be collected in the context of the FSDN, based on invoice data (see also the FLINT project), although this means manual data entry in dedicated software (already available in some Member States)
2. Environmental accounting as a basis for certification of all commercial farms is feasible and can be promoted via the CAP or CSRD-scope3. However, this needs some form of government support (or another policy intervention) because in the current situation there is no incentive for up- and downstream companies to digitise invoices and some software markets may be too small to guarantee that the technologies and derived solutions are developed through a healthy competition.
3. Sensor networks to manage emissions in a region are promising solutions but need further investment in R&D projects.