Earth Observation and Digital Agriculture Technologies as data sources for the future CAP monitoring

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Abstract

This paper provides a short analysis on how and in what extend the satellite-based technologies and smart farming systems can act as new sources of information towards the realization of future CAP objectives. The report focuses on the integration of these new technologies in support of advanced decision making for the regional/national Integrated Administration and Control Systems.

Keywords

Agriculture, Earth Observation, Smart Farming, CAP Monitoring

1. Introduction

There is currently an EU wide effort aiming to achieve environmental protection and optimisation of agricultural practices in a combined manner. From a policy perspective, these interrelated objectives are mainly pursued through the introduction of regulations like the Common Agricultural Policy (CAP). One of the key parameters of CAP is the support of farmers income through a system of agricultural subsidies and programmes covering farming, environmental measures and rural development. The main building block of the management of payments system is the Integrated Administration and Control System (IACS) [1]. IACS consists of a number of computer-based information systems having as primary objectives to ensure that transactions financed under the area and animal-based aid schemes are carried out correctly and to prevent, discover and follow up on irregularities.

The new CAP, which is due to begin in 2023, aims to be the key instrument for securing the future of agriculture and forestry, as well as achieving the objectives of the European Green Deal paving the way for a fairer, greener and more performance-based policy implementation. [2] As agricultural policies are widening their scope to contribute to environmental objectives there is also an increase on the number of indicators and data sources for monitoring and evaluation of the policies. Consequently, there is an increased demand for new data sources to be integrated within the framework of policy monitoring.

Even since 2015, the EU has set the objective of integrating "farm level data with micro-data transmission, based on a modular approach with core variables, modules and satellites" [3] introducing satellite-based Earth Observation (EO) data products for a systematic and automated agricultural assessment in large scale. However, EO based monitoring comes with various limitations as it is mainly applicable for medium and large-sized parcels, affected by meteorological conditions, and it is not feasible to monitor precisely important sustainability related parameters in detail. With the current digital transformation trend in the agricultural production process, there is an enormous and underexplored potential for sensors and Farm Management Information Systems (FMIS) that are increasingly being deployed by service providers.

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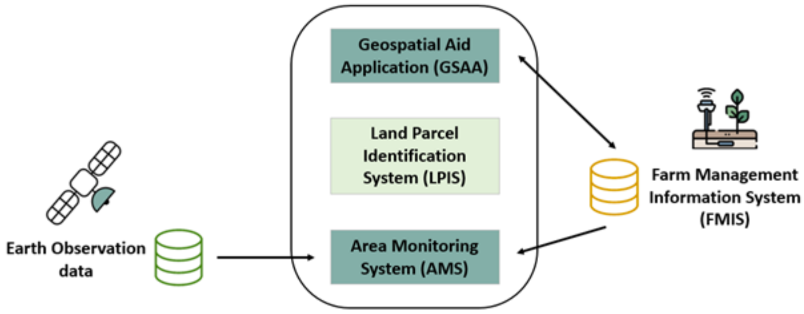

Figure 1. Complementary use of EO and FMIS data in support of CAP monitoring.

This paper provides the key outcomes and future directions towards the further interconnection of regional/national IACS systems with innovative information sources, based on the analysis conducted in the context of H2020 NIVA project [4]. According to these results the most prominent approach will be based on a synergistic utilization of EO based outcomes combined with in-situ farm level data from locally operating digital agricultural technologies (Figure1).

2. Earth Observation in support of CAP monitoring

The CAP monitoring through EO data has been made possible by the Sentinel missions that provide free and open high-resolution satellite datasets (spatial resolution of 10m) with frequent visits: the time series of Sentinel or other satellite images are a powerful mean to check farmer's declarations. However, accessing and pre-processing these big volumes of images in order to get ARD (Analysis Ready Data) is a complex task, raising many issues concerning computing performance, multi-temporal and multi-level analysis [5]. In the new monitoring approach, the analysis of EO data should provide 'traffic lights' or 'colored flags' (green, yellow or red) with regard to the eligibility status of the parcels. In case of yellow lights, i.e. in case of doubts, additional evidence has to be provided by farmers. [6]

2.1. Sentinel-2

Sentinel-2 provides optical images easy to be interpreted with valuable information and the pre-processed products are available as open data. They are the first candidates for crop monitoring. However, they suffer from the cloud contamination losing land surface information, creating gaps on the time-series. That depends on geographic location and it is more disturbing in northern or mountainous areas.

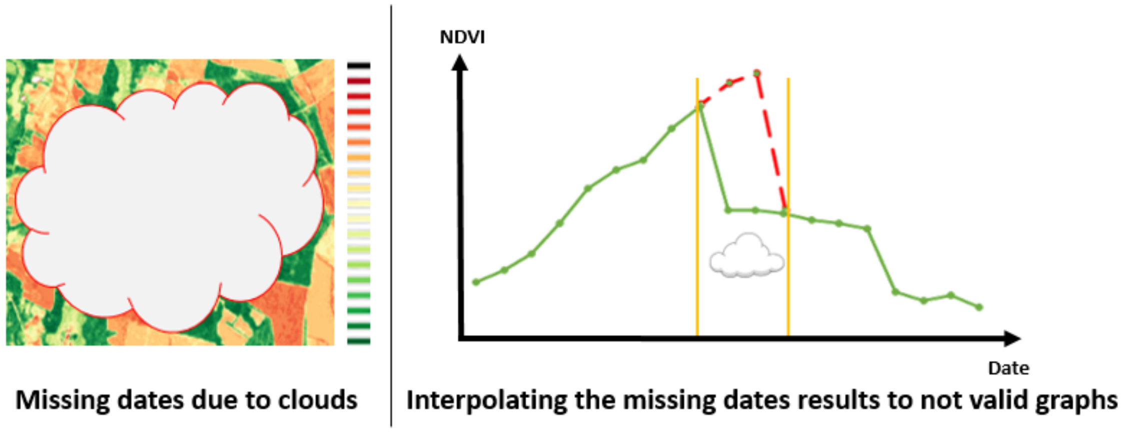

Figure 2. The risks of temporal series interpolation

Paying Agencies (PA) are usually accessing L2A products (atmospherically corrected); however, dealing with L1C products (Top of Atmosphere) may be envisaged if the PA has satellite image experts.

Even for the "standardised" product L2A, there are various options for atmospheric correction according to the way to access images: for instance, the Copernicus Open Access Hub [7] and the Sen4CAP European project [8] are using different cloud masking algorithms (Figure 2). In addition, the Copernicus Hub stores in Long Term Archive images older than a few months, making them more difficult to be accessed.

2.2. Sentinel-1

Sentinel-1 provides radar images that are powerful but complex products that are more difficult to be interpreted. The ARD products are not available as open data from the Copernicus hub. However, the ESA provides the SNAP [9] tool that can be used to perform the necessary pre-process operations. Despite of these difficulties, S-1 images are also widely used by Paying Agencies due to their power to provide useful information, even in case of bad weather conditions. Many case studies showed that radar imagery can improve the crop classification accuracy when used in combination with optical data. Further, radar images are proved to be very efficient in detecting mowing events in grassland farming as well as harvesting in specific crops (e.g., corn).

2.3. Dealing with small parcels

The resolution of S-2 and S-1 images is not sufficient to monitor all parcels as issues may occur for small parcels and also for parcels of specific shape (such as narrow parcels). Using High High Resolution (HHR) images such as Planet and SPOT-6/7 or even VHR images such as WorldView or Pleiades have been mentioned as potential solutions. [4]
The (paying) access to the HHR or VHR imagery used to deal with these specific parcels should be granted not only to the Paying Agencies (or their sub-contractors) but for transparency reasons also to the concerned farmer in order to enable him/her to understand the rationale behind the traffic lights.

2.4. Invest on IT infrastructure or outsource?

The Copernicus Hub offers free access to Sentinel images but in practice, this access is not so easy due to technical restrictions; the storage and handling of these big volumes of data require significant IT infrastructure investment as well as specialized employees that increase the overall cost. Extracting the information at pixel level means that users will have to get the entire image and will have to deal with huge volumes of data. Until now, this is the main available solution on the market. The investment on pre-processing and IT infrastructure may be done in the Paying Agency itself (through buying ICT material and training staff) or it may be outsourced (through buying predefined services and computation power, such as "Copernicus Data and Information Access Service" (DIAS) or other cloud infrastructures). It is mainly between being straightforward (lots of preliminary steps already done before PA accesses the image data) and being flexible (doing things yourself require more expertise but enable to decide on each step of the process).

3. Farm Management Information Systems

The concept of "Farm Management Information Systems" (FMIS) is an umbrella term that refers to a set of computer-based information systems operating at a farm level which are able to receive data streams, store and process them and provide output useful to the various stakeholders (individual farmers, farmers associations, advisors, etc.). FMISs are usually offering, the functionality related with the digital recording of agricultural activities (also called "Farmer's Calendar", "Farm Log", "Field book") that demonstrates the potential to contain various relevant to CAP monitoring information (e.g.

use of pesticides, irrigation, fertilizers, harvested yields). There are currently hundreds of FMISs available on the market that can support decision making by finding the best practices for farm management [10]. The fact that with the help of digital technologies [] it is feasible to monitor new data items and create new information streams allows the introduction of new CAP indicators but also the more efficient monitoring of existing ones. Although the primary functional objective of FMISs is to support farming activities they are also a valuable source of information for the needs of CAP monitoring. However, the integration of FMIS and digital agricultural technologies in general with the IACS systems is a challenging task.

3.1. Data availability by FMIS

"Digital field book" - usually as part of a FMIS- is potentially one of the most valuable information sources for IACS. Unfortunately, FMIS are not yet used by a wide range of farmers, the situation varying a lot depending on countries and regions. However, the use of digital means for recording applied practices is expected to be continuously adopted by more farmers during the next years due to introduced legislation but also because it is more efficient for the everyday activities of the farmers. Typically, recordings of pesticides applications are more mature to be captured and shared with various administrative entities. Similar policies and tools are currently under development for the collection of data on utilized irrigation water and soil nutrition status.

3.2. Data exchange & data interoperability

The semantics utilized for recording the various information items maintained by FMISs are still heterogeneous. However, there are various efforts towards harmonization based on existing well-known approaches especially with code lists (e.g. Agrovoc taxonomy, EPPO glossary, code lists for agrochemicals). NIVA proposed the use of the eCrop standard [12] as a common data model for data exchange between FMIS and IACS and proposes the introduction of "Farm Registry" as a component of the new IACS with the role of recording in a continuous way the information provided (Figure 3).

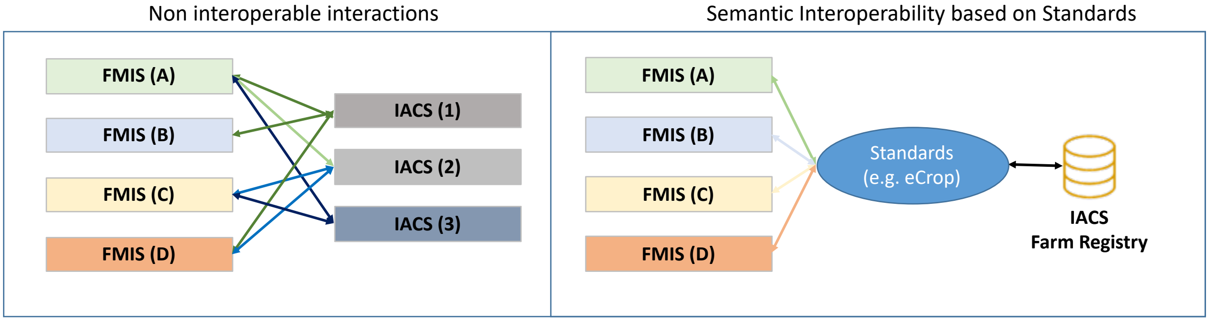

Figure 3. Data exchange complexity between FMIS and IACS is significantly reduced with the use of standards

3.3. Quality and reliability of FMIS data

Although in some cases record keeping in "Field Book" is even mandatory the recording of information is still fragmented and prone to intentional or unintentional errors. Data related with cultivation practices are not reliable given that it is manually imported to FMISs. An approach to mitigate inconsistency of manually imported records is to escort them with data derived from additional sources (e.g. farm machinery, geotagged photos, environmental sensors and hard copies of invoices). Interesting approaches have been recorded including the "building of trust with farmers" [13], the combined use of FMIS data with "on the spot checks" [4], and the "provision of rich data sets and additional evidences for cross-checking including data from farm machine, sensors and scanned copies of invoices" [14].

3.4. Organisational interoperability

The majority of the FMISs are not considering -yet- the public administrative agencies (e.g. Paying Agencies) as potential 3rd party entities that are useful to interact with, either to provide data or to retrieve data. This means that currently there are few or even no data exchange mechanisms by FMISs explicitly established for connecting with IACS systems. Paying Agencies consider that change in legislation is required to enable data exchange from FMIS to IACS. [4]

4. Conclusions

This paper presents the key findings on the use of EO and FMIS in support of future IACS operation and future CAP monitoring and evaluation based on the analysis of the NIVA project. The overall outcomes show that there is high potential for further assisting IACS operations with innovative digital technologies but legal, technical and organizational challenges need to be addressed.

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