EO4I
Earth Observation for Agro-Insurance

esa
European Space Agency

Final Report

EO Best Practice – Agro-Insurance

D5.3 Final Report

09 September 2020

Prepared for:

European Space Agency (ESA)

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1 Introduction

1.1 Agro-insurance

Agriculture provides essential social benefits: supply of food and commodities, economic development and employment. About 37% of Earth's land surface is employed for agricultural purposes, about 11% of it used for growing crops and the other 26% for pasture. In turn, agriculture is under growing pressure arising from increased productivity requirements, soil erosion and sealing, water scarcity, effects of various natural hazards and weather extremes due to changes in climate patterns.

Earth observation is a powerful technique used to continuously provide geospatial information across the agricultural value chain, measure productivity and increase in efficiency of agriculture, identify sustainability of farming practices and strengthening the resilience of rural communities. Satellites can be applied to agriculture in several ways, initially as a means of estimating crop biomass and potential yields. Optical and radar sensors can provide an accurate picture of the acreage being cultivated, while also differentiating between crop types and determining their health and maturity. satellites can be used to discover and monitor impacts of extreme weather events on this sector.

Agricultural insurance is likely to have an increasing role as a risk management tool in arable crops, horticulture and livestock farming. Several common forms of insurance for the agricultural sector can be distinguished: indemnity-based, yield-based and index-based structures. Hail Insurance and the Multi-Peril Crop Insurance (MPCI) are often either indemnity-based or yield-based products.

Only in recent decades, new insurance solutions have been developed that do not only cover crop loss due to hail, but also warn farmers before and support them after natural hazards against other natural hazards. Changes in climatic patterns increase yield losses due to higher frequency and severity of extreme natural events forces, which pushes the insurance sector to address the negative effects of more natural hazards covered by various insurance products.

Given this, the insurance sector has a significant emphasis on identifying, gathering and aggregating data and getting access to local and regional information, including history of losses due to effects of relevant risks that could now be sourced from remote sensing and Earth observation data.

1.2 Earth Observation Best Practice for Agro-Insurance

The Earth Observation Best Practice for Agro-Insurance (EO4I) project brings together both sectors, the EO as well as the agro-insurance's sector, to find out more about agro-insurance's needs and how these might be addressed currently and/or in the future with EO capabilites. The overriding objective was to produce a roadmap for the development of agro-insurance guidelines with activities to follow up the current project.

EO Best Practice are user-oriented projects, thus the requirements of the users have a central focus.To find out about the needs and capabilities, the project involves three key industry partners from this sector: the Austrian Hail, Swiss Hail and Vereinigte Hagel – together forming the ASV working group. As shown in Figure 1 several surveys, workshops and user meetings with the working group as well as with other first and re-insurances now form the basis for this document.

The project started with a user workshop at the Living Planet Symposium in Milan in May 2019 (LPS19). Additionally, dedicated consolidation meetings with the key industry representatives from Austrian Hail Insurance, Swiss Hail Insurance and Vereinigte Hagel Insurance were conducted. The focus was to get a better understanding of and deepen the key issues and challenges within the agro-insurance industry initially developed at the LPS19 workshop. In parallel, an industry user survey with more than 50 participants was carried out covering representatives from direct insurance (31%), re-insurance (13%) and brokers (20%) as well as other insurance and agro-industry service providers. On 21 and 22 November a workshop was conducted to assemble key representatives from the agro-insurance as well as the earth observation industry. 23 representatives of global First- and Re-Insurances (including the project's key industry partners from Austrian Hail Insurance, Swiss Hail Insurance and Vereinigte Hagel Insurance), ESA and EARSC met at GeoVille in Innsbruck to discuss the challenges and fitting Earth observation solutions for the sector. A round table with all participants from Austria, Germany, Italy and Switzerland focused on the insurance's business processes to get deeper insights in the daily challenges and link them with possible Earth observation capabilities. Further user meetings with the ASV working group were performed to gain more insights during the entire project lifetime.

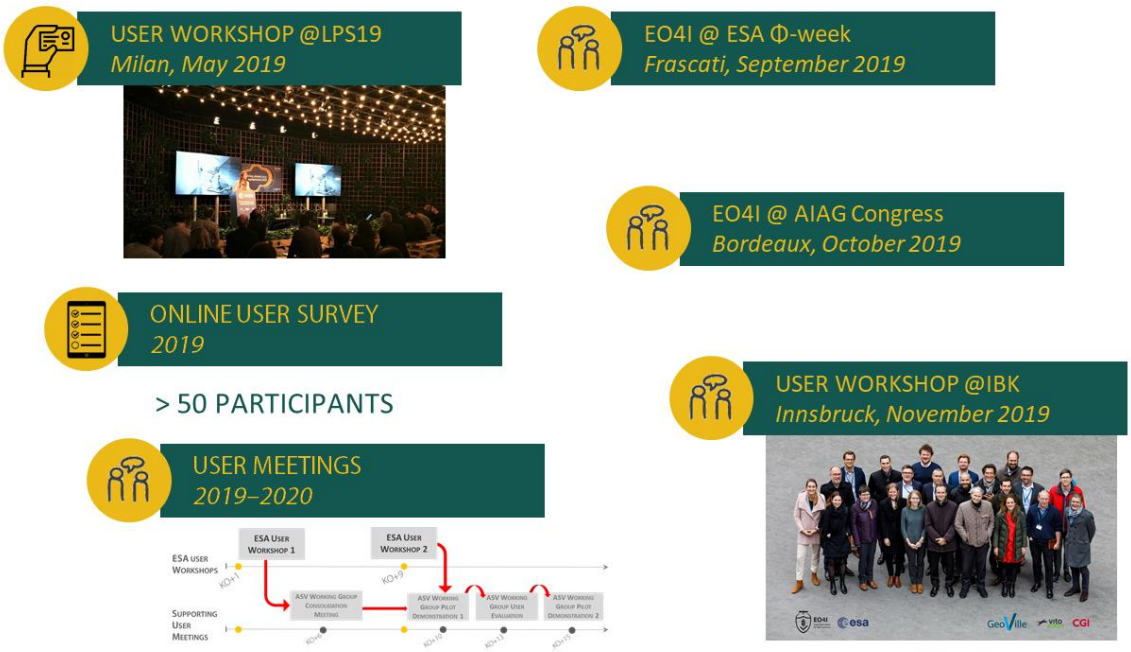

Figure 1: User engagement conducted throughout the project lifetime.

Based on the identified needs of the agro-insurances (D1.2 Geoinformation Requirements Report), the current EO capabilities that fit those needs were defined (D2.1 EO Capabilities Report), as shown in Figure 2: Furthermore, existing gaps between the needs and the capabilities were identified and how these might be addressed in the coming years considering future missions, new data sources and technologies (D2.2 Gap Analysis Report). The outcomes of all these activities formed the basis for the Best Practice Roadmap (D4 Roadmap Report) which established recommendations and strategies for a potential future uptake and development of identified insurance's challenges and requirements and existing EO gaps.

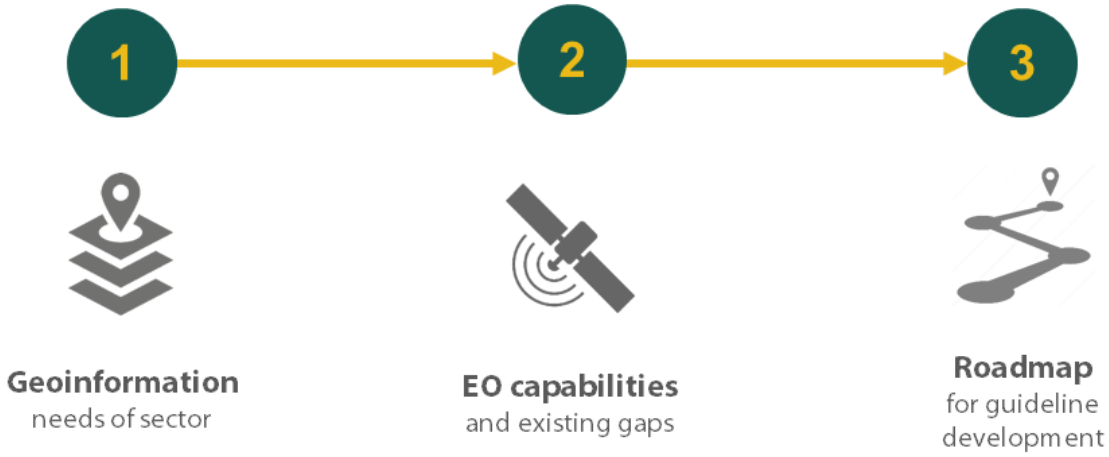

Figure 2: Project logic.

The next chapters provide the key findings of all the performed activities throughout the proejct's lifetime.

1.3 Business processes

Within this project, the following five "business processes" of the agro-insurance sector were identified and considered for the further activities, which are described in detail below:

- Product Development
- Product Sales
- Underwriting
- Loss Adjustment
- Claims Handling

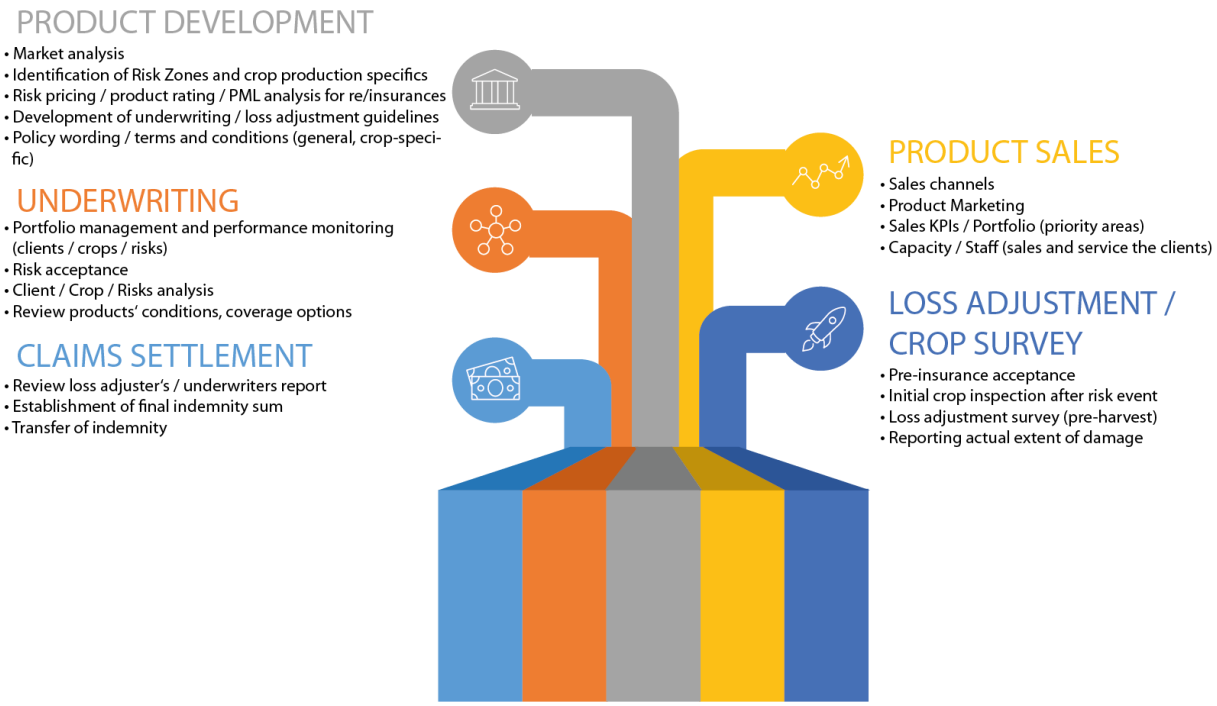

Figure 3: Business processes of the agro-insurance sector.

PRODUCT DEVELOPMENT

Product Development is a complex of activities that insurer undertakes to develop and introduce a new insurance product on the market. Product development activities include:

- *Market analysis*
  Before actual product development, it is necessary to assess the volume of defined crop(s)' production, production area per each year of production for the longest consecutive period of data available. Market analysis also includes the production landscape and farming structure for crops in focus, major producer groups (subsistent, small, commercial farmers). Analysis should also include change factors in production trends within a certain period time to assess business opportunities and possible risks for the future.

- *Identification of Risk Zones and crop production specifics*
  Crop production is not homogenous in most countries. Depending on the production area, topographic and climatic conditions the crop's risk exposure may differ significantly. It is a common practice in agricultural insurance to identify risk zones with attributed premium rates reflecting on the actual risk level for the given area calculated by qualified actuaries.

- *Risk pricing / product rating / PML analysis for re/insurance*
  Product development includes analysis and estimation of the risk's frequency and severity. Agricultural insurance actuaries apply calculation models to estimate the risk price based on the crop-related datasets available. Probable Maximum Loss (PML) represents the largest loss believed possible for a certain type of crop/risk in a defined return period (e.g.: 50 or 100 years, or more).

- *Development of underwriting / loss adjustment guidelines*
  Each product should possess a set of required documentation that includes guidelines and methodologies. Mostly those relate to program administration, underwriting and loss adjustment activities being among the key in the insurance product cycle. Underwriting methodology and guidelines specify the way risk-taking decisions should be made, and factors to consider when taking crop/risk for insurance. Loss adjustment guidelines are aimed at facilitating transparent crop assessment process and calculation methodology for the estimation of the damage extent and the indemnity sum.

- *Application of Policy wording / terms and conditions (general, crop-specific)*
  Terms and Conditions of insurance could be general and crop specific. Policy wording is adjusted to the product structure and special conditions applied for insurance coverage of a specific crop/risk.

PRODUCT SALES

A range of activities for insurance product promotion on the market, that include:

- *Analysis and deployment of various sales channels*
  Sales channels are considered based on the objectives and market strategy of the insurer. Covering a portfolio of crops, regions, or types of farmers may require insurer to deploy selected channels, such as: farmers cooperatives, input suppliers, banks, etc. Special insurance coverage or bundled programs may be offered via specific channels (e.g.: Input Suppliers)

- *Product Marketing*
  Product marketing activities may be delivered via various media, exhibitions or workshops by corporate marketing department. However, sales agents and insurance partners (e.g. Banks) engaged in various insurance programs may agree on specific product-oriented marketing plan. Promo activities are usually directed to result in better sales to meet company's strategy goals.

- *Define and establish strategy to reach the company's sales KPIs / Portfolio (priority areas)*
  Key Performance Indicators (KPIs) in sales strategy are supposed to reflect on the company's business goals for agricultural insurance. Underwriting needs may require additional diversification of risks/crops and regions of interest to better reflect on sales KPIs attributed to a specific insurance product.

- *Plan and develop company's capacity / staff (service for the clients) to ensure future sales growth*
  Capacity needs require proper assessment and planning far before the product is offered on the market to the farmers. Sales agents require proper training on sales technics that may be required to address the insurance product specifics to the farmers.

UNDERWRITING

Selecting or rating perils for insurance purposes. Underwriting activities include (but not limited to):

- *Portfolio management and performance monitoring (clients / crops / risks)*
  Insurance Company's crop/risk portfolio is managed by insurance underwriters. Underwriters maintain and develop their portfolio of clients, crops and risk in the given country or region based on the strategic goals and business KPIs of the company.

- *Risk acceptance (assessment)*
  Risk acceptance is the main function of an underwriter. It is the task of an underwriter assess the client's property (crop) insurability prior to signing the insurance policy paperwork providing insurance coverage.

- *Client / Crop / Risks analysis*
  Each crop/risk brought by the client for insurance requires proper analysis for insurability and price match for the client profile and defined risk zone for crop location. Underwriter decides on the final premium rate/sum, based on guidelines and applicable underwriting limit for approval of risk portfolio for insurance. Variety of factors may influence the increase or decrease of the final premium rate for the farmer's policy: location in specific risk zone, agricultural technology adherence, available facilities and infrastructure (e.g.: irrigation), etc.

- *Products' conditions, pricing and coverage options reviews*
  It is one of the key functions of an underwriter to conduct product review after each season. Based on the review, the premium rates adjustments may be applied, or insurance coverage options may be modified. Proper modifications should be based on the product's performance in past seasons.

LOSS ADJUSTMENT

Determination of the extent of damage resulting from occurrence of an insured peril. Loss Adjustment activities include (but not limited to):

- *Pre-insurance acceptance for insurance*
  Depending on the type of insurance product the pre-insurance crop inspection may be required to assure the presence of the crop and record its actual conditions at time of insurance application. Such crop survey is conducted by the trained crop surveyor or may be performed by the underwriter if the decision on insurability is made purely based on the EO services or data.

- *Initial crop inspection after risk event occurrence*
  It is important to record the crop condition after the risk event occurrence. Physically inspection is conducted by the trained crop surveyor/loss adjuster indicating the scale and the character of damage caused to the crop insured. Among the surveyor's tasks are to identify the effect of insured and non-insured perils. In most cases such an inspection should be conducted within a limited period of time after actual crop damage (e.g. within 10 days). This

period may be specified for each crops/risk insurance product or applied as a standard period for all agricultural products within the insurance company.

- *Loss adjustment crop survey (pre-harvest)*
  Final loss adjustment survey report is regularly required for further indemnification of the insurance claim. Physical pre-harvest crop survey allows the surveyor to identify the regeneration or degradation of the crop and estimating of the final damage extent and/or potential yield loss.

- *Reporting on actual extent of damage subject for further indemnification*
  The final loss adjustment survey report with an indication of the defined extent of crop damage is provided to the underwriter for calculation and approval of the final indemnity sum with further claim transfer to the insurer's claims handling department for further pay-out.

CLAIMS HANDLING

Processing of insured farmer's application for indemnification due to loss of crop/yield caused by the insured peril, that includes:

- *Review loss adjusters' / underwriters report for possible inconsistencies*
  Review process is required as quality control measure to identify any inconsistencies or spot potential fraud for: field's location, area damaged, crops damaged, etc.

- *Establishment of final indemnity sum*
  Based on the application review the final indemnity sum is approved (or cancelled).

- *Approve the transfer of indemnity to for the farmer*
  After the indemnity is approved according to insurer's procedures, the indemnity sum is transferred to the bank account of the insured (farmer). This closes the policy for both the insurer and the insured.

1.4 EO in support of addressing key challenges

The above mentioned business process can be supported by numerous remote sensing products and service available to the agro-insurance sector. Nevertheless, there is a major gap between the perceived potential and the actual uptake by the sector. Too often, the remote sensing community focusses on the possibilities and appropriateness of certain techniques, without consideration of the impact for the customer value and productivity and profitability of the industry. However, EO methods, products and services need to be adaptable to the agro-insurance's business needs. To stimulate the uptake of earth observation based data, it was essential within this project to start from the perspective of the agro-insurance's business processes.

Remotely sensed data are not yet being used to their full potential for insurance. One bottleneck is the lack of awareness, understanding and trust in the EO products and services for the agro-insurance

sector. Three opportunities can thus be defined within this project and within the agro-insurance sector, as illustrated in Figure 4:

- Opportunity 1: Currently available EO technology which is known to be suitable for addressing particular agro-insurance requirements
- Opportunity 2: Currently available, but unrecognized EO capabilities which could give enhanced performance to the agro-insurance sector
- Opportunity 3: EO technology, not currently available, which could solve agro-insurance's challenges

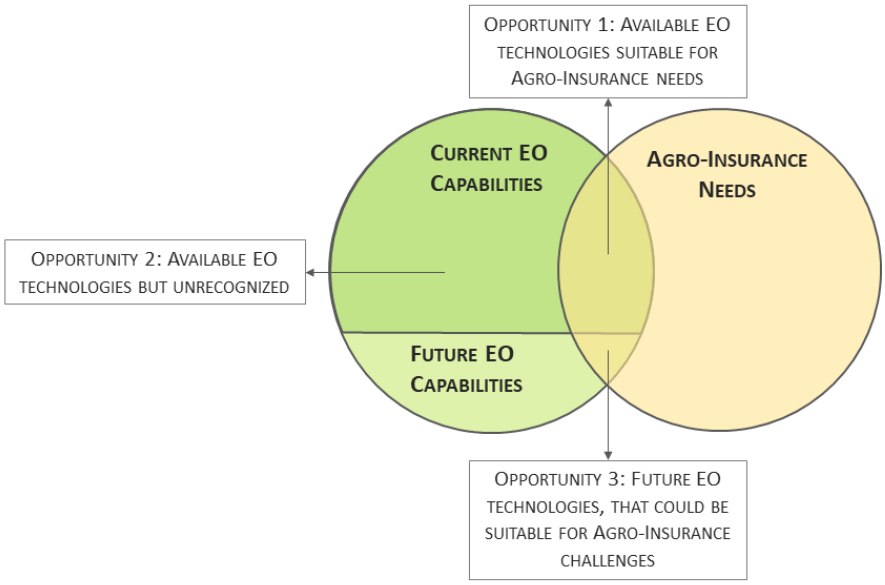

Figure 4: Opportunities for the EO technology within the agro-insurance sector.

The over-riding objective of this project was to establish a roadmap for the development of agro-insurance guidelines for the use of EO data by the agro-insurance sector. To meet this objective, it was necessary to fully understand the needs and requirements of the agro-insurance's sector. As part of the project, already existing technologies and capabilities which address these needs were identified. However, some products may need some refinement to fully meet the needs and make it an agro-insurance product; some of the challenges cannot be addressed at the moment. This might be due to various reasons, such as missing technologies and methodologies or rather just finding the right format to fit into the existing, daily workflows of agro-insurances.

To improve and enhance current EO products as well as to develop new products that fit into the agro-insurance's daily business, this project was an important step to analyse the status quo. All these findings on agro-insurances requirements and challenges as well as existing EO capabilities and gaps inbetween these two sectors now work as a basis for the development of the guidelines in this roadmap. With all the information, further steps to support the challenges and needs will be defined in this report. This, however, is not meant to be a complete list of activities that will close all the gaps. The workpackages as defined in chapter will serve as an outline of the next steps towards a better procurement of EO-based solutions, having the guidelines as a reference of the next steps.

2 Challenges and needs of the agro-insurance sector

The starting point of the project was to identify the challenges and needs of the agro-insurance sector. As can be seen in Figure 5, with this information, the challenges were translated into geo-information requirements. Based on the geo-information requirements, an analysis and research on current EO capabilities and future capabilities was then conducted to identify any gaps.

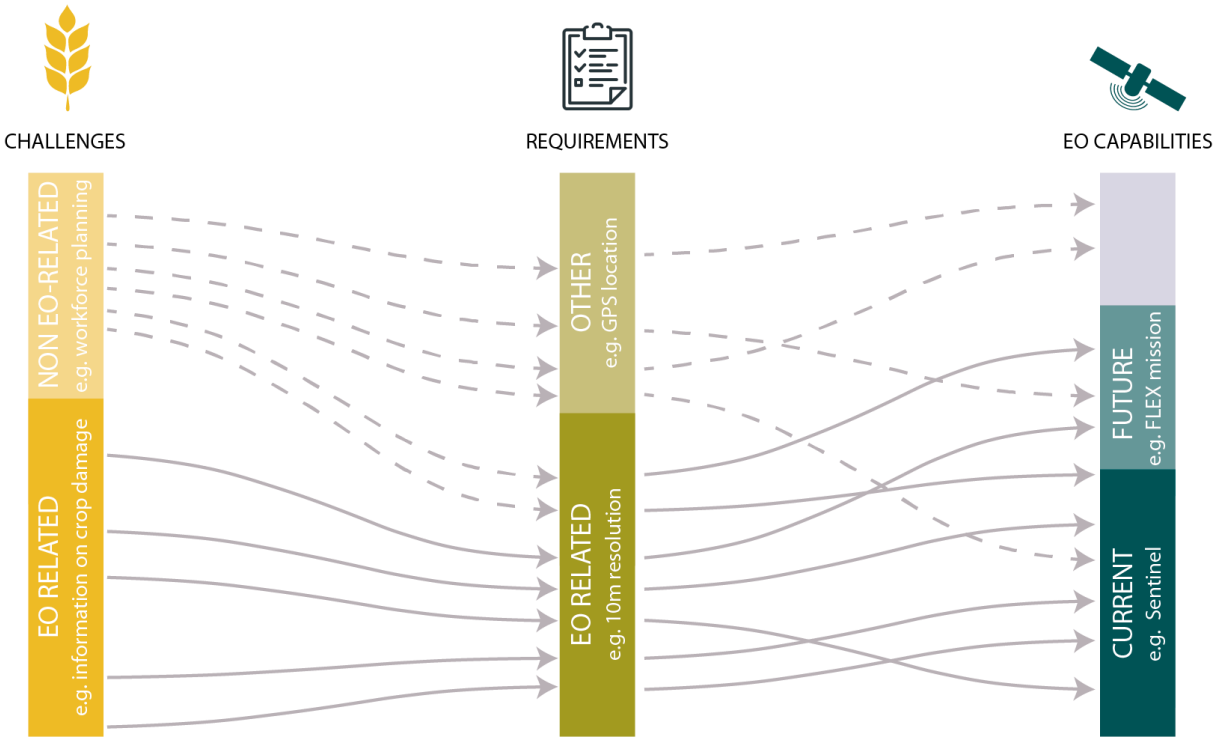

Figure 5: Expanding the view.

Finally, a list with 61 challenges, each connected to one of the core business processes. For a detailed list, please refer to D1.2 Geoinformation Requirements Report. A few important challenges are the following:

- **Market analysis:** Assessment of the volume of production, area put to a certain crop per each year of production, number of farmers, major producer groups (small, commercial large) and change in production within a certain time-period.
- **Time series availability:** There is a high need for time series which is needed for several insurance products. An archive of up to 10 or 15 years – the more the better – is needed; it depends however also on the risk that should be modelled.
- **Index insurance:** Index insurance is a growing sector within agro-insurance and there are a few aspects where EO could help. However, time series are currently often too short fo developing precise indices. A regularly available standardized layer on a global basis is needed.
- **Damage assessment:** Identify the potential causes of damage (insured/non-insured perils), area and the extent of damage. It is important to consider crop conditions before the insured event and after.

3 Key geoinformation requirements

In a further step, the 61 challenges were translated and grouped into geo-information requirements. These key requirements are necessary to address the various challenges (see Figure 5). With this information in mind, the EO capabilities were

The following 26 key geo-information requirements were extracted from the challenges:

1 Obtain uninterrupted consistent long data series (high temporal/spatial resolution)

It is advised to apply at least 10 years of data for agricultural insurance needs, especially at time of product development, risk rating and product pricing. The longer and the more consistent the data the higher correlation is obtained for the risks' frequency and severity.

2 Obtain detailed topographic characteristics

Topography data is required to capture micro-zones that may represent higher risk due to terrain specifics, and proximity to water bodies and micro-climatic specifics.

3 Obtain detailed imagery of the surface

Imagery details allow better fields' identification, building actual areas under agricultural production, damaged area, infrastructural objects, etc.

4 Identify soil types (mineralogy, structural properties of near surface)

Soil types are important to consider for production and yield potential of specific crops. Example: Soil salinity may drastically affect production of corn when applying centre-pivot irrigation technology

5 Identify soil moisture contents

Soil moisture is among the key parameters to consider for crops' health and yield potential. Various crops require different levels and depths of soil moisture to produce the expected yields. Excessive moisture may indicate inundations, while the lack of moisture for extended periods signifies drought effects.

6 Obtaining information on parcel location and boundaries

Parcel location and identification of boundaries of the actual area under production allow to identify possible deviations from the data provided by the farmer, making proper and better underwriting decisions.

7 Identify crop type

Crop type identifications is an important function for agricultural insurance underwriting. It allows to map the crop portfolio and better analyse the risk exposure and concentration in

certain areas. Crop identification also allows to analyse the farmer's past production experience and application of proper crop rotation technologies to ensure higher yields and lesser infestation with weeds and pests.

8 Obtain historical crop production (crop, area, yields)

Analysis of the historical crop production, with consideration of crop types, area and yields obtained allows making better underwriting decisions. Such an analysis helps in identifying possible additional risks for the insurer, as well as spotting the inconsistencies (possible fraud) in data provided by the farmer, etc.

9 Crop vegetation monitoring

Monitoring of vegetation allows identifying crop's risk exposure at a certain period of the year. In many countries certain months are attributed with exposure to certain perils. Depending on the crop's actual vegetation stage crop may have different exposure to certain perils.

10 Monitoring stress in vegetation

Vegetation stress may signify potential yield loss or total crop damage, which depends on the risk type and duration of its effects.

11 Identify the crop emergence and harvest date

Comparing the actual emergence and harvest dates allow comparing the farmer's practice to the recommended technology dates and practices applied by other producers in the same area. This will help to identify the possible additional underlying risks for the crops.

12 Crop yield monitoring

Yield monitoring allows identifying possible deviations and risks at early stage. This capability is important for the f underwriter to better understand their portfolio and actual situation at fields insured.

13 Estimating yield losses

Yield loss estimation allows identifying the estimate on the actual extent of the damage. It is important that this data gets proper calibration with the data taken by the loss adjusters and crop surveyors at fields.

14 Identify crop damages

Allows identification of the areas of crop damage. The most challenging for insurance industry is to identify if the damage has been caused by the insured, or non-insured risk event, which triggers the possible indemnity pay out or claim declinature.

15 Identify effects of various risks (frequency, severity, area covered by each risk event)

See above, number 14.

16 Obtain detailed land use information (crop production landscape, etc.)

Land use information allows better assessment of the farm and its capability to produce certain crops with the yield indicate in the insurance application.

17 Identifying agricultural practices (irrigation, fertilisation)

Identifying agricultural technologies application (tillage, spraying, application of certain inputs, etc.) allows better assessment of the farm and its capabilities to produce claimed yields for crops insured.

18 Obtain detailed imagery of assets (property, machinery, other field infrastructure)

Farm's property and existing infrastructure assessment allows underwriter to make better decisions on the capabilities of the farm to produce certain crops assuring yield potential indicated by the farmer. For value chains it is also important to assess the storage capacity and processing facilities in place.

19 Identify location and condition of infrastructure objects (irrigation, greenhouses, water wells, etc.)

See above, number 18.

20 Identify water boundaries (flooded areas, etc.)

Water bodies identification (swamps, rivers, lakes, sea/ocean proximity) allows better assessment of exposure to certain risks (inundation/flood, flash flood, landslides, etc.) of the areas considered for insurance.

21 Identify livestock movements

Livestock movements allow tracking the animals and identifying the places for feeding. It also allows to assess the concentration and location in case of contagious diseases and possible epidemics.

22 Identify pastures biomass (yield potential)

Pastures biomass data provide opportunities for insuring farmers' grasslands with index-based covers. Underwriters may use actual real-time data to assess the portfolio's structure and risk exposure.

23 Identify waves height, currents' energy and thermal data

Required for fisheries producing agricultural outputs in open waters. Example #1: High waves pose a risk of fish escape from cages causing severe losses to producers. Example #2: Change in water temperatures may pose a risk for production of certain varieties of fish or clams.

24 Identify water flora/fauna (algae, etc.)

Helps in identifying pathogens and water organisms affecting to oxygen and other elements balance in sea waters to prevent possible loss of aquacultures produced due to pandemics or suffocation.

25 Identify forests characteristics (area, boundaries, timber type, etc.)

Applied in forestry insurance. Provides better precision on understanding of risk exposure of forestry portfolio for the insurer.

26 Monitor and forecast weather events

Weather monitoring and forecasts allow underwriters and farmers identifying proper non-insurance risk mitigation activities to lessen the effects of possible risk effects.

4 EO Capabilities

Based on the above-mentioned challenges and requirements, an analysis of current EO capabilities from a technical as well as a thematical view was conducted. The most relevant EO satellites and EO products were described in more detail in D2.1 EO Capabilities Report. The identified EO services relevant for agro-insurance's needs were also summarized in several Product Sheets. The product portfolio can be found in the annex of the report (D2.1) as well as on the EARSC working area.

The following chapters present a summary of the main findings:

4.1 Summary of relevant EO satellites

Currently, numerous freely and commercially available earth observation satellites are relevant and suitable for developing products for the agro-insurance sector. The following overview presents some of the widely used techniques.

As part of the Copernicus program, ESA provides a range of different satellite techniques in high spatial resolution that are freely available. The main objective of this program is to monitor land and ocean surfaces. Sentinel-2 can be considered as the satellite with the highest impact on agro-insurance applications, providing the temporal and spatial detail required to generate crop monitoring products at the parcel level. It is an optical satellite, compared to the Sentinel-1 mission with a SAR instrument. The advantage of radar is the independency of weather conditions as it also provides good imagery on cloudy and foggy days. Furthermore, the Sentinel-3 mission provides data especially useful for observing the ocean. These ESA missions are intended to provide long and consistent time series within the next years.

The longest available archive of optical based satellite data is provided by NASA's Landsat mission. Since 1972 the satellites provide medium and high resolution imagery which are freely available. Landsat 7 and 8 are the current missions. In 2021 the start of the next mission, Landsat 9, is planned to continue the time series.

The Proba-V satellites provide optical medium resolution imagery since 2013. The mission will end in 2020, however, CubeSats will be launched the same year continuing the observations in the visible and thermal part of the spectrum. Medium resolution data is also available through NASA's MODIS (Moderate Resolution Imaging Spectroradiometer) mission, covering a long archive of data with the first satellite launched in 1999. The data is freely available and highly relevant for monitoring the Earth's biosphere.

An even longer archive reaching back to 1981 is available from the satellite mission NOAA-AVHRR (National Oceanic and Atmospheric Administration Advanced Very High-Resolution Radiometer). The radiance information is especially important for cloud investigation, snow and ice extent, surface temperatures. However, the resolution is coarse compared to the aforementioned satellites. The data is freely accessible as well.

ESA's SMOS (Soil Moisture and Ocean Salinity satellite) satellite mission provides data with a spatial resolution of 50km and a temporal resolution of 3 days. The data is freely available since 2010 as well. The satellite was designed to make global observations of soil moisture over land and salinity measurements over oceans.

Additionally, very high resolution data is available through several commercial satellites operators. Planet Labs operates different satellite constellations (PlanetScope, RapidEve, Skysat) at a (very) high spatial and temporal resolution which makes it useful for monitoring of the earth's surface at high precision. Deimos Imaging provides very high resolution imagery by its satellite DEIMOS-2. Fast access to the imagery can be provided based on user request. Imagery from Pléiades 1A/1B is available since 2011/2012. The data is commercially available through the provider Airbus. Due to the fact that the acquisition program can be changed dynamically, the satellites are suitable for emergency mapping. Pléiades Neo will be launched in 2020 and continue the time series. SPOT 6/7, continuing former SPOT missions, use weather information for the image tasking and therefore the number of cloud-free images could be improved. The satellite data is automatically processed and immediately online delivered allowing rapid data provision in case of emergency.

4.2 Summary of EO Capabilities

Analysis identified 21 EO products that already address the needs and challenges of the insurance's sector. The technical readiness level of the earth observation products described in this report cover operational products (e.g. crop type mapping, field delineation, etc.) and products in development (e.g. crop growth zone detection). The products are state of the art and commercially available. However, even though the products fit the needs of the agro-insurance's sector thematically, sometimes the technical specifications are not detailed enough as would be required. Furthermore, an adaptation of the products to fit into the daily workflows of insurers would still be needed in case of a few products.

The following products were identified as services that address the needs of the insurances:

- Biomass Production Estimation
- Crop Damage Zone Detection
- Crop Growth Zone Detection
- Crop Type Detection
- Date of Emergence

- Digital Elevation Model
- Drought Indicators
- Early Vegetation Stress
- Evapotranspiration
- Field Boundaries
- Gap Filled Time Series
- Grassland Mowing Cycle
- Greenhouse Early Warning
- Irrigation Mapping
- Monitor and Forecast Weather Events
- Near Real Time Service
- Soil Moisture
- Vegetation Growth Monitoring
- Vegetation Indices
- Water Bodies Detection
- Yield Estimation

More Details about those products can be found in the Current EO Capabilities Report of this project (Deliverable 2.1) and on the project website hosted by EARSC:

https://earsc-portal.eu/pages/viewpage.action?pageId=75892355

4.3 Prototype Service User Feedback

The EO4I service demonstrator is currently available at https://eo4i.eoss-cloud.it/app/#/. Access credentials can be requested from the project.

The demonstrator is adapted from CGI's EOPaaS platform, which has been used as the basis for operational ESA projects such as the Food Security TEP. There are two key motivations for this activity:

- To produce a prototype which will give key users a practical demonstration of how a service will perform in real cases, showing both the advantages and the limitations, and hence allowing them to assess the utility of and requirements for a full operational service.
- To raise interest in EO capabilities within the Agro-Insurance community by having an interactive visual demonstration that can be shown to users at suitable events.

There is a clear desire from the agroinsurance user community to receive some of the services which have been demonstrated in this project. In particular the following are of interest:

- Crop type maps
- Soil moisture over time
- Key vegetation parameters over several growing seasons.

These would need to be combined with improved analytics, especially to allow easy extraction of values and time series either at a point or over some area, as well as adding the capability to extract such features into a report.

Given that the requirements for the underlying platform are very similar to those for related platforms, and that there is no obvious host organisation for the current platform, it is recommended to investigate whether these services could be provided as hosted services through the Food Security TEP or similar platforms.

The key next steps are:

1. Iterate with the users to confirm their detailed requirements for an operational service, in light of their experience with the demonstration service.
2. Discuss with ESA how best these requirements can be met, whether through the continuation of a dedicated platform or by merging with an existing platform.
3. Propose a way forward to ESA for further implementation.

5 Gap Analysis

To identify whether the agro-insurance's challenges and key geo-information requirements can be met with the current EO capabilities and to identify current limitations a gap analysis was performed.

The main conclusions:

- Most of the geo-information requirements have corresponding EO products, which can be matched at a thematic level. But it often requires insights in the business processes in order to assess the actual fit. E.g. EO based "crop type mapping" matches the "Identify crop type" requirement. But the timing within the growing season defines the actual relevancy of these EO products for the sector. Crop type maps can be accurately produced from the moment there is a decent coverage of the field of the specific crop. But the sector could be most interested in this information very early in the season, even before the emergence of the crop.
- In order to assess the suitability for an actual uptake of the earth observation products in the agro-insurance business process, a case by case analysis is required. The project activities, which involve the interaction with the ASV group and service demonstration aim to trigger discussions on how existing earth observation products could fit into their workflow.

A detailed analysis can be found in D2.2 Gap Analysis Report.

6 Future EO Capabilities

There are quite a few missions by ESA which are planned as well as candidate missions. Those were considered to analyse which ones could be useful to address and/or close the gaps identified. The following planned missions will contribute in this matter:

- The major contribution to the current EO capabilities in the coming years will be the continuation of the high-resolution Sentinel-1 and Sentinel-2 missions. ESA's Sentinel missions include radar and optical sallites which are very useful for land cover monitoring. In terms of agro-insurance applications, Sentinel-1, Sentinel-2 and Sentinel-3 are the most important ones. Follow-up missions are planned to guarantee data continuity until at least 2030.
- The BIOMASS mission can contribute to agro-insurance on forestry by providing measurements of global forest biomass. Planned launch by ESA is 2023.
- The FLEX (Fluorescence Explorer) mission will contribute to larger scale analysis, e.g. to evaluate the impact of major droughts in a region. A launch is planned for 2023 as well.

- NASA's has planned the start for Landsat 9 in March 2021. With a spatial resolution of 30m this mission will contribute to the long historical archive of the Landsat legacy and thus support historical analysis.

Furthermore, some of ESA's candidate missions would furthermore contribute to close some of the identified gaps:

- The CHIME (Copernicus Hyperspectral Imaging Mission) mission would support agriculture and biodiversity monitoring, as well as soil property characterization.
- The LSTM (Copernicus Land Surface Temperature Monitoring) mission could provide parcel level information on evapotranspiration that could be used e.g. for irrigation mapping and drought analysis.
- Supporting the capabilities of Sentinel-1, the ROSE-L (L-band Synthetic Aperture Radar) mission would contribute to forest biomass and soil moisture mapping.

A more detailed description of the missions can be found in D2.2 Gap Analysis Report.

7 Best Practice Roadmap

Based on the previously mentioned results, a roll-out strategy with activities for a further potential uptake and to further expand the work already conducted within this project's lifetime, including recommendations and strategies for future work was defined. The actions identified contribute to the following four aspects:

Demonstrate value for a potential uptake of EO within the agro-insurance sector

Currently, project activities prioritized the identification of future possibilities and opportunities for the EO industry. Soon it became clear that available EO products need to be adapted into agro-insurance solutions to fit into the daily workflows of insurers ('From EO products to insurance solutions'). It is important to demonstrate that EO can provide suitable and valuable solutions for the sector ('Development of new products, i.e. agro-insurance solutions).

Enable utilisation of EO solutions by the agro-insurance sector

Agro-insurances are sometimes not aware of existing EO capabilities that might be suitable for their purposes. Therefore, it is important to increase the visibility ('Increase visibility within the agroinsurance's sector'). It was also noticed that sometimes there is a lack of knowledge for the techniques and usability of EO products, services and solutions ('Provide training and support').

Communication to increase the visibility of EO within the agro-insurance's sector

Current activities and future efforts can only be effective if they are well communicated, therefore existing capabilities should be publicised ('Enhance EARSC working area'), as well as industry-related workshops, conferences and meetings ('Increase visibility within the agro-insurance's sector').

Identify opportunities beyond this project's focus

Current project activities mainly focused on First Insurers. However, there are other stakeholders that need to be taken into account ('Requirements of Reinsurances', 'Additional Stakeholders'). Furthermore, new opportunities might come up, especially with regard to the current Covid-19 pandemic ('New Opportunities').

Table 1 provides a summary of the proposed next steps. Detailed descriptions of the activities, their objectives, targets and tasks that need to be performed to pursue the actions are provided in D4 Best Practice Roadmap.

Table 1: Summary of proposed activites.

	Activity	Short description
1	From EO products to insurance solutions	Identify solutions that perfectly fit into the daily life and can best be used by the insurances
2	Development of new EO products, i.e. agro-insurance products / solutions	Develop case studies to demonstrate the business case of EO at both an organisational and asset level
3	Increase visibility within the agro-insurance's sector	Obtain uninterrupted consistent long data series (high temporal/spatial resolution)
4	Provide training and support	Offer training and support to increase usability of EO products within the agro-insurance sector
5	Enhance EARSC working area	Make concise supporting resources widely available, including an update of EO capabilities
6	Requirements of Reinsurances	Analyse the geo-information requirements of Reinsurances
7	Additional Stakeholders	Engage complementary industry bodies to identify collaboration opportunities
8	New Opportunities	Analyse the geo-information requirements with regard to the Covid-19 pandemic

8 Further Project Activities

During the project's lifetime the project was presented at several occasions.

In selected agro-insurance related workshops, conferences and meetings the project, its current status and the outcomes so far have been presented to raise attention for the project activities. Furthermore, workshops have been conducted by the consortium to get detailed insights in the agro-insurance sector.

Agro-Insurance user workshop, Milan, May 2019

On 16th May 2019, the first user workshop was organized at the ESA's 2019 Living Planet Symposium in Milan, Italy to find out more about the Agro-Insurance geo-information needs. Representatives of the Agro-Insurance sector were invited to share their experiences with EO usage. The presentations were followed by a productive discussion about the industries' current use and perception on EO capabilities, a Live Poll and a Panel Discussion. Results of this session were gathered and are a first step towards the EO best practice roadmap and insurance industry guidelines.

EO4I @ ESA Φ-week Frascati, September 2019

From 9 – 13 September 2019 the Φ-week, organized by the European Space Agency (ESA), took place in Frascati with a focus on EO Open Science and FutureEO. Some of the EO4I partners were present there to discuss the latest developments and trends. Amongst other projects, the EO4I team was invited to join the ESA-EARSC Joint session "Modernising Farming: Earth Observation to Support Crop Growth Cycle" on September 10th. Nikolaus Neugebauer (Austrian Hail Insurance) and Ralf Ryter (GeoVille) presented the project in Session 1 "Earth Observation Supporting the Farming Cycle".

35th AIAG Congress, Bordeaux, October 2019

The 35th AIAG Congress took place at the Palais des Congrès in Bordeaux from 6 to 9 October 2019, organised by the International Association of Agricultural Production Insurers (AIAG).

The EO4I project was presented by Johann Fank, the Director of Loss management at the Österreichische Hagelversicherung, in the frame of a joint presentation on 'Loss adjustment of drought damages on crops (Österreichische Hagelversicherung) and on maize (Schweizer Hagel). Both, the Österrreichische Hagelversicherung and Schweizer Hagel, as well as the Vereinigte Hagel are key users in this ESA funded activity. Eva Haas (Head of Agriculture Services, GeoVille) was present as technical

	expert on behalf of the project team as well as the project consultant Yan Shynkarenko. The program showed state of the art topics in the world of agro-insurance and the high interest in Earth observation based solutions.

2nd Agro-Insurance user workshop, Innsbruck, November 2019

23 representatives of global First and Re-Insurances, ESA and EARSC met at GeoVille in Innsbruck on 21 and 22 November to discuss current challenges and fitting Earth Observation solutions for the Agro-Insurance sector. Participants from Austria, Germany, Italy and Switzerland discussed challenges of their daily business life to get a better understanding of both, the Agro-Insurance as well as the Earth Observation sector. A round table with all participants at the end focused on the insurance's business processes to get deeper insights in their daily challenges and link them with possible Earth Observation capabilities.

Furthermore, a presentation of the project was also planned at the CISAR Symposium (Munich, March 2020) and the AgroInsurance Conference (Tbilisi, April 2020); however, due to the Covid-19 pandemic, these events were postponed.

9 Conclusion

The agro-insurance sector has evolved significantly over the past years, in terms of the number of products they offer, but also in the number of farmers insured. The increased complexity of the products/services and number of fields that need to be assessed after a peril are determining the sectors growing geo-information needs. Developing new products, supporting of field work, providing objective information and obtaining spatial information that is not available from another source, are considered as the main motivations to start using EO for agro-insurances. A majority of the sector is quite well aware of available EO products/services and example usages for agro-insurances.

The EO industry already provides techniques (satellite missions) and products that fit the needs and challenges of the sector. However, on the one hand there is sometimes a lack of awareness for certain already available EO products. On the other hand, there is a gap between the perceived capabilities of EO services which are often generic and the sector's specific needs. Many geo-information requirements have corresponding EO products which – from a thematic level – meet the needs; however, there is sometimes a technical gap, such as the spatial resolution or the timing of delivery.

Considering future missions, the time series from ESA's Sentinel missions as well as NASA's Landsat 9 mission will continue the long available time series of land monitoring. Some gaps, thematical as well as technical, will possibly closed, at least partly, with other future planned missions. Selected ESA's candidate missions would furthermore contribute to agro-insurance's challenges.

To encourage further adoption of EO in the agro-insurance sector, the following main activities were defined as a guideline to expand the work already conducted within this project's lifetime:

- Demonstrate value for a potential uptake of EO within the agro-insurance sector
- Enable utilisation of EO solutions by the agro-insurance sector

- Communication to increase the visibility of EO within the agro-insurance's sector
- Identify opportunities beyond this project's focus

As could be seen, EO offers many opportunities to the agro-insurance sector and there is a high potential for EO industry for an actual uptake. It seems there is a major gap between the perceived potential and the actual uptake by the sector. Therefore, some activities to improve a mutual understanding are needed. With this in mind, in the future the EO industry will be able to better address the identified challenges and needs of the agro-insurance sector.