EO4I
Earth Observation for Agro-Insurance

esa
European Space Agency

D1.2: Geo-Information Requirements Report

EO Best Practice – Agro-Insurance

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14 April 2020

Prepared for:
European Space Agency (ESA)

GeoVille vito remote sensing CGI

EO Best Practice – Agro Insurance

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Prepared for:

European Space Agency

Largo Galileo Galilei 1

Casella Postale 64

00044 Frascati

Italy

Prepared by:

Vito

In association with:

GeoVille

CGI

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Authors:	Roel Van Hoolst	
Reviewer	Michaela Seewald	
Approval	Ralf Ryter	
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1.2	14.04.2020	51	Update with description of business processes, challenges and requirements	3

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Acronyms and Abbreviations

API	Application Programming Interface
ASV	Austrian Hail, Swiss Hail, Vereinigte Hagel Insurance
EO	Earth Observation
ESA	European Space Agency
IT	Information Technology
LPS	Living Planet Symposium
MODIS	Moderate Resolution Imaging Spectroradiometer
R&D	Research & Development

1 Introduction

The ESA project "Earth Observation (EO) best practices for the agro-insurance sector" or "EO4I" project aims to consolidate a roadmap with guidelines for EO usage for the agro-insurance sector. To support this kind of activity, ESA works together with a working group of three European agro-insurance companies (Austrian Hail Insurance, Swiss Hail Insurance and Vereinigte Hail Insurance), hereafter named as the "Working Group ASV". The first milestone of the "Earth Observation (EO) best practices for the agro-insurance sector" project is to collect and consolidate the agro-insurance industry's geo-information requirements. This document ("Geo-information Requirements Report D1.2") aims to describe the sector's main challenges, the current usage of Earth Observation, their perception on EO capabilities and a number of technical requirements for different business processes. Furthermore, it consolidates detailed requirements derived from interviews with the ASV group.

Approach

In order to obtain the most recent insights from the sector and directly from the industry itself, four activities were undertaken that support this work:

1. *Agro-Insurance industry workshop at ESA's Living Planet Symposium 2019 (16/05/2019)*: In this workshop, representatives from the agro-insurance sector were brought together to share state-of-the-art usage of EO for agro-insurance and to discuss the industries' needs and challenges/opportunities of EO. In the workshop, three representatives of the "Working Group ASV" (see above) presented their current EO usage and geo-information requirements. Next, a Live Poll was organized to engage the audience in a discussion on geo-information needs and EO capabilities. The results of the Live Poll and additional questions and remarks from the audience were discussed with a panel composed of the Working Group ASV and two other representatives from the sector. In total, >50 participants joined the workshop, including >20 participants from the agro-insurance sector, mostly from European companies. At the end of the workshop, contact details from the audience were collected. More information in EO Best Practice Agro-Insurance D1.1 Workshop Report 1.
2. *Online user survey via SurveyMonkey (June 2019):* To broaden the scope of the above-mentioned workshop, a complementary online survey was organized. The content of this survey was inspired by the workshop discussions and targeted to agro-insurance companies worldwide. The survey was distributed via the consortiums network, contact details collected during the workshop in Milan and via the large international network of AgroInsurance.com. This yielded a response of more than 50 participants from the agro-insurance sector.
3. *ASV consolidation meetings (26/08 – 06/09/2019):* User calls were organized in a series of teleconferences with each ASV member separately to discuss their specific challenges, opportunities and geo-information wish list. The outcomes of these separate discussions were consolidated in a wrap-up call with all ASV members.

4. *Agro-insurance workshop in Innsbruck (November 2020):* Representatives from the agro-insurance and re-insurance sector as well as the EO sector were invited to discuss geo-information requirements of the sector and earth observation capabilities.

This report consolidates the insights gained in these four activities. It is the basis for a further identification of mature EO-based information products that are useful for the agro-insurance sector, for a gap analysis and eventually to identify prototype service(s) that could be implemented.

2 ESA's Living Planet Symposium: Agro-Insurance workshop

The agro-insurance industry workshop was the kick-off for the ESA project "Earth Observation best practices for the agro-insurance sector". It succeeded in its objective to get the agro-insurance industry on board to discuss the use and potential of earth observation (EO) data in their sector. During the workshop, several state-of-the-art applications of EO data were presented by the different companies of the ASV group (Austrian Hail, Swiss Hail, Vereinigte Hagel).

Following the presentation of the ASV group, a **live poll and panel discussion** was organized. First, the audience was presented a series of six questions on which they could vote online. The content and results of this live poll can be found in the Workshop Report D1.1. The result of the live poll was then discussed with a five-member panel, including representatives from the agro-insurance and re-insurance sector. Some remarks from the moderator, panel and the audience:

- In general, the audience did **appreciate the initiative that brings the agro-insurance and EO sector together**. A better communication between two sectors could bridge the knowledge gap that still exists and support the development of more targeted data products and services for the agro-insurance industry.
- Currently, **most agro-insurance companies start with in-house development** to exploit earth observation data in their company instead of buy-in services. The main reason is that the required geo-information is often very specific for a particular agro-insurance product and requires in-depth knowledge on the business processes. There are currently few off-the-shelf data products and services available from the EO sector, which can be implemented in their agro-insurance workflows. The **strengths and particularities of EO for agro-insurance should be investigated case-by-case.**
- The sector would appreciate if there is a wide range of EO data freely available. But **R&D and data processing is costly**. Most insurers and re-insurers do not have a lot of time and budget available for development of EO data and services. They prefer practical solutions.
- A number of specific requirements for the different business processes were discussed:
    - The main requirement for underwriting is the **sufficiency of long time series to assess the crop performance history at the parcel level**. This was considered currently as a challenge because Sentinel 1 & 2 provide data for only a few years.
    - The **detection accuracy of EO for crop damage is a challenge** as most crop damages have a loss ratio of 20-40%.
    - For loss adjustment, the timeliness of the information is very important to ensure a fast pay-out. The **information should be available within days after events such as hail, storms etc.**

- Successful examples were mentioned where high-resolution Sentinel 2 data was used to support field visits of loss adjusters.

- The perceived potential of EO in **micro-insurance programs in developing countries** is high because the fields are often remote and difficult to reach.

3 Online Survey results

3.1 Participants

About 50 persons participated to the online survey. Figure 1 shows the distribution of background of the participants and in which region their companies are active. The list below describes the distribution of the participants over the different backgrounds:

- Agricultural insurer: 31%
- Agricultural reinsurer: 13%
- Agro industry: 7%
- Insurance/reinsurance broker: 20%
- Loss adjustment service provider: 6%
- Other (22%):
  - Insurance development expert (international development)
  - Consultant in agriculture insurance and risk management
  - Agricultural Finance
  - Remote Sensing Provider

Most of the survey participants work in a company that operates at European scale (27 participants), followed by global scale (13) and Asia (12). There were also six companies working in Africa and a few working in different parts of the American continent.
About 60% of the participants indicated that their company had already experience with EO, 40% didn't have EO experience yet. This also defines the response rate for the following questions. Where the participants were asked to share their current experience with EO, the general response rate was about half of the participants. Other, more open questions (e.g. on the required spatial detail) were generally answered by about 4 out of 5 participants.

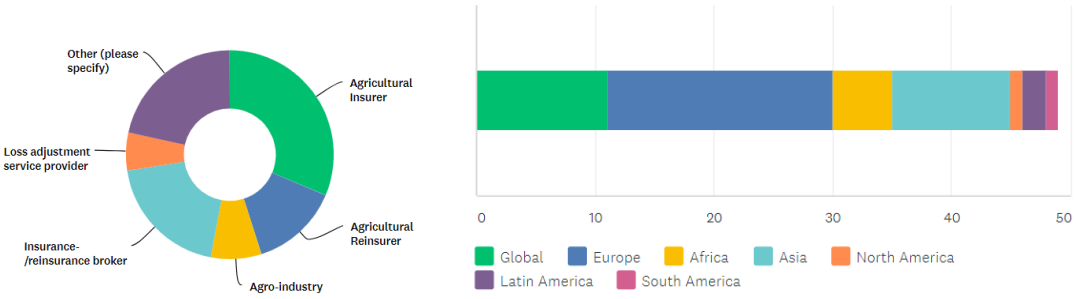

Figure 1: Details on online survey participants: background (left) and regions they are active (right)

3.2 Current use of earth observation based geo-information

This chapter describes the current use of EO data by the agro-insurance sector based on the results from the online survey. In order to address the actual use of EO, a number of questions were defined in the survey. In the first question, participants were asked to indicate their level of EO use for a number of business processes (Figure 2: Online survey question on the level of EO usage for several business processes.). According to the survey, **most experience** (defined as more than 50% of the participants answered having either operational or pilot phase experience) is already present in **product development and providing user services**. The highest percentage of **experimental use is found in loss adjustment**. The participants had least experience (more than 3 out of 10 with no experience) in portfolio management and underwriting.

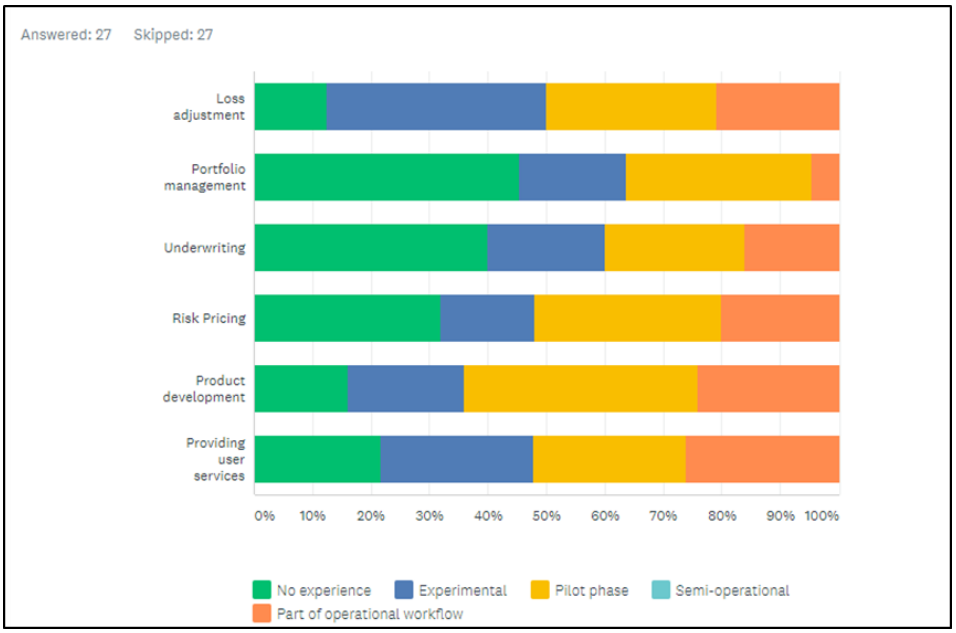

Figure 2: Online survey question on the level of EO usage for several business processes.

The second question provides more detail on the actual use of geo-information they retrieve from EO data (Figure 3). More than 50% of the participants answered they already have either **operational or pilot phase experience in field boundary identification, crop type identification, crop status monitoring and risk analysis**. The highest percentage of **experimental use is observed in crop status monitoring, crop damage analysis and crop yield forecasting**. More than 30% of the companies had no experience in grassland mowing cycle, infrastructure asset inventory & damage mapping and terrain structure analysis.

When participants were asked to indicate their level of EO usage for different type of weather events (Figure 4), **most of the companies** (more than half) had either operational or pilot EO phase **experience for drought**. The highest percentage of EO experimental use was indicated for flood, hail and drought. More than 30% of the companies) have indicated that they had no EO experience for hail, frost, storm, spring freeze, late autumn frosts, winterkill, fire and pests.

In the next question, the survey participants were asked to select which satellite they use for agro-insurance (Figure 5). **Sentinel 2 had the highest usage** (more than half of the responses), followed

by MODIS, Sentinel 1 and Landsat. Very high-resolution data was used only by about 10% of the participants.

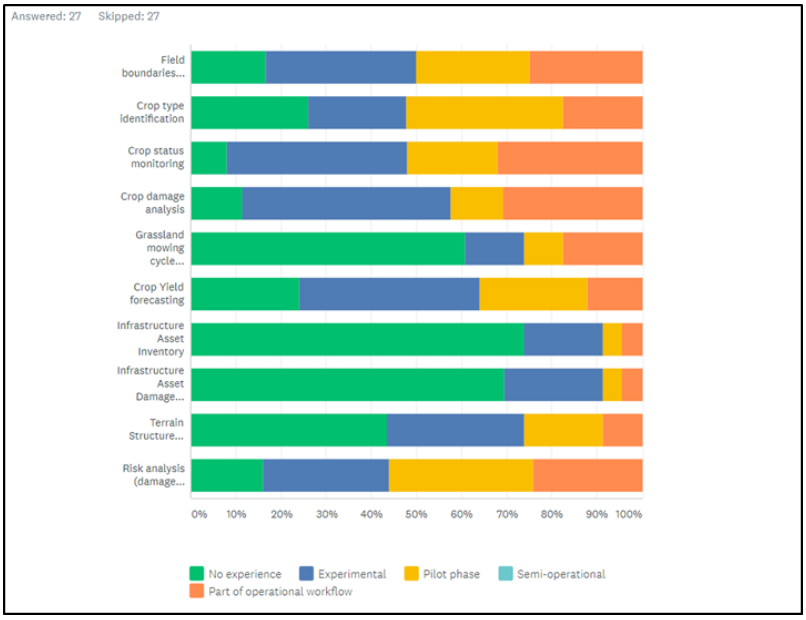

Figure 3: Online survey question on the level of EO usage for a number of geo-information layers.

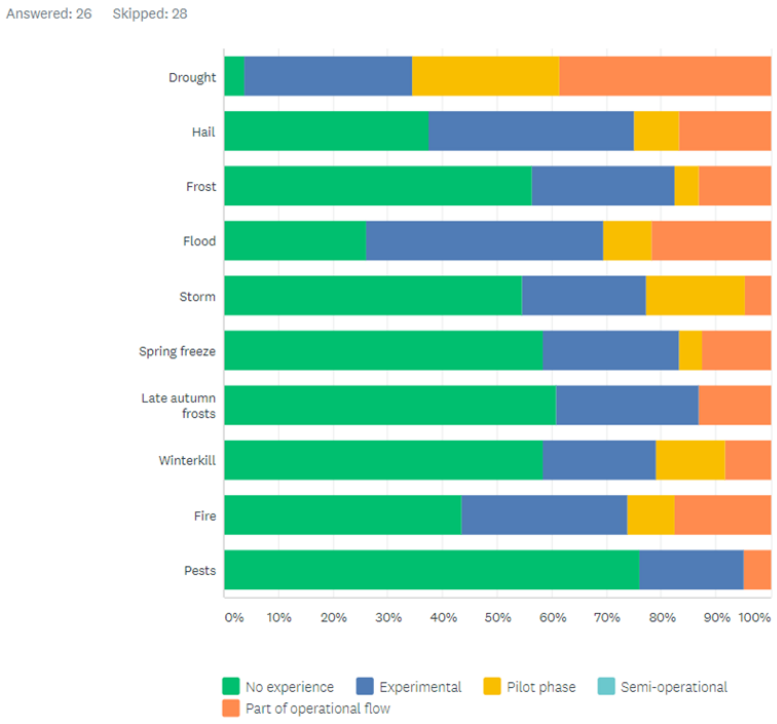

Figure 4: Online survey question on the level of EO usage for a number of perils.

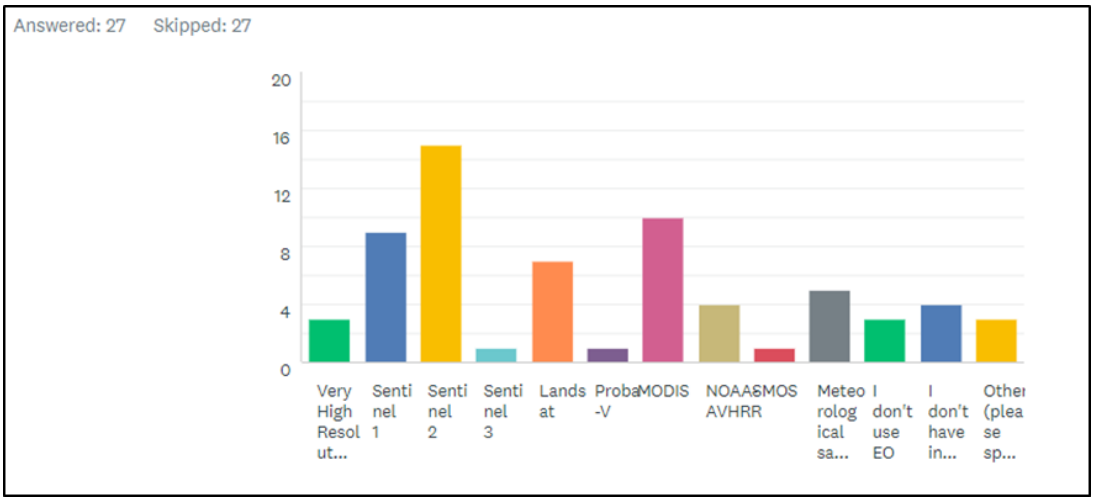

Figure 5: Online survey question on which satellite data is used for agro-insurance.

Based on the survey (Figure 6), **classic downloads via a data provider is currently the mostly used access point for EO data** (>60%). About 35% of the participants use API services and 25% cloud/web-based platforms.

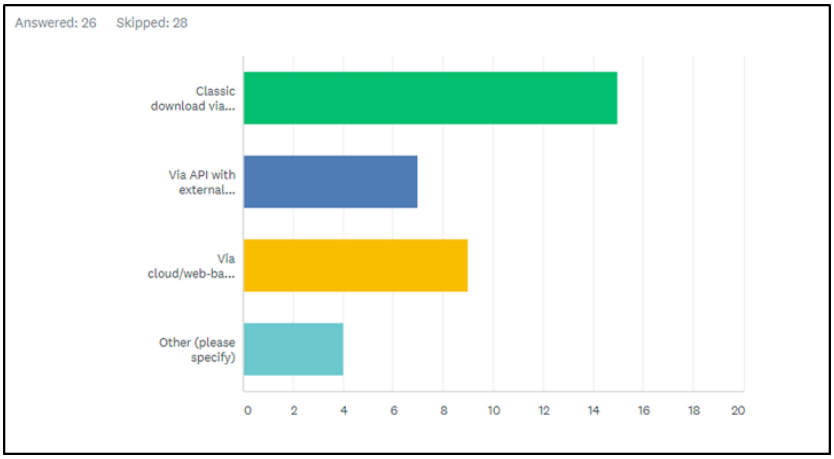

Figure 6: Online survey question on data access.

According to the survey, about **40% of the companies have set up in-house developments** to use EO (Figure 7). Buy-in services are used by 30% of the companies, 27% of the companies do operate EO developments in both ways.

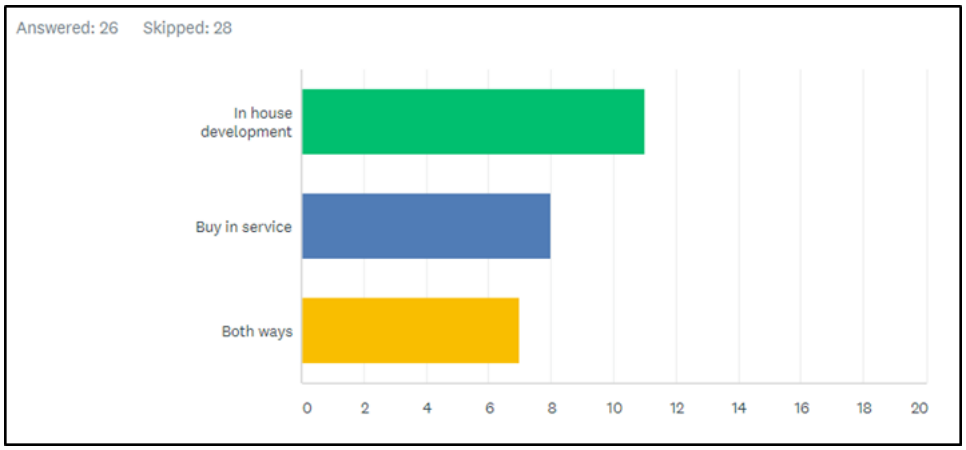

Figure 7: Online survey question on EO development capacity.

3.3 Industry's perspective on EO capabilities

3.3.1 Strengths

In the survey, the participants were asked to share their major motivation to start using EO for agro-insurance. **The development of new products, supporting field work, obtaining spatial information that is not available from another source and supporting field work** were considered as the top 3 main motivations.

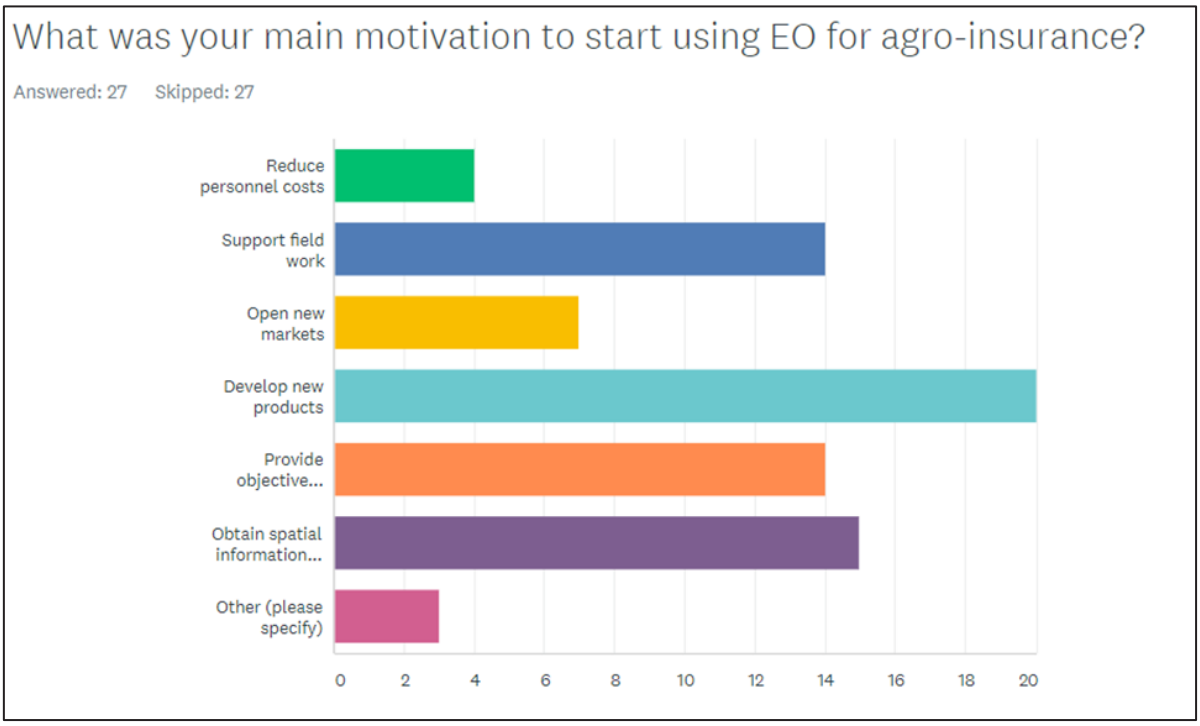

Figure 8: Motivation question from online survey.

3.3.2 Limitations

In the survey, the participants were asked to indicate what they perceive as the main limitations of the use of EO data for agro-insurance. The top 3 **strong limitations** derived from the response are **availability of ready-to-use products, processing costs and the temporal resolution**. From this question, also a top 3 of "no limitations" can be derived which are data costs, information on EO access and data access.

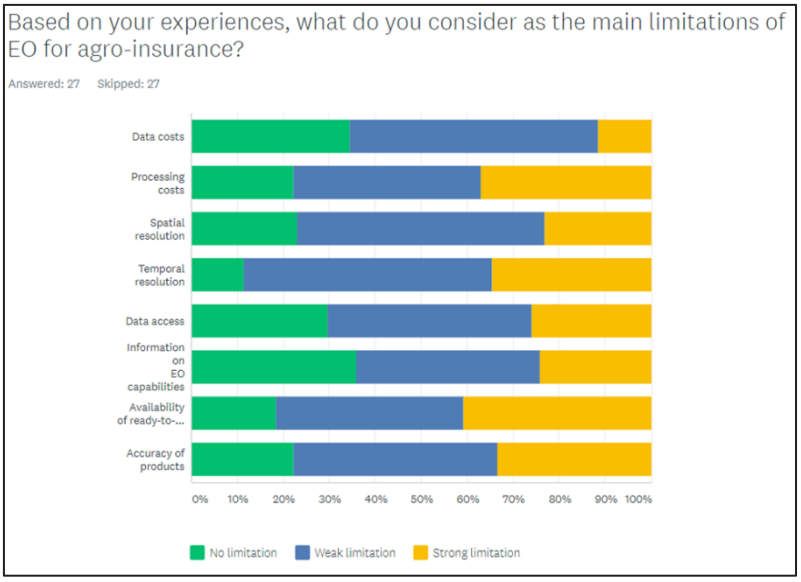

Figure 9: Online survey question on limitations of EO usage.

3.3.3 Opportunities

During the Living Planet Symposiums industry workshop, a Live Poll question was presented to the audience which asked for which insurance processes they would like to use EO. The result of this poll is discussed here as it complements the questions of the survey on the industries perception on EO. The top 3 of most votes were observed for **loss adjustment, providing user services and product development**.

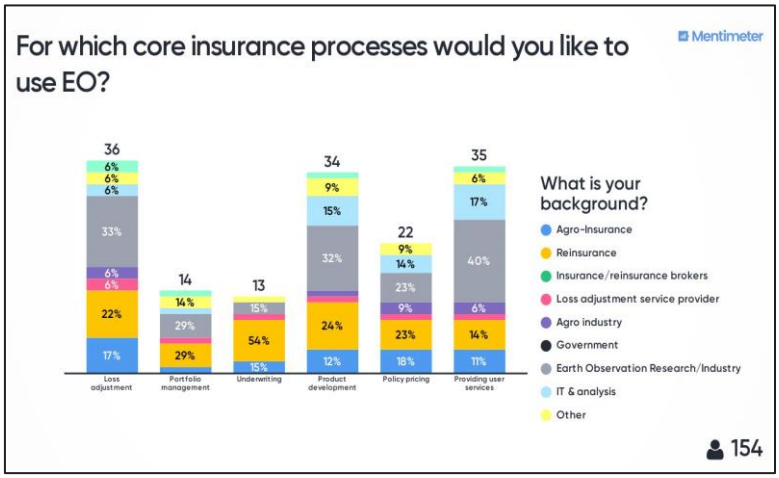

Figure 10: Agro-Insurance industry workshop at Living Planet Symposium Live Poll Question on EO opportunities for the sector.

3.3.4 Threats

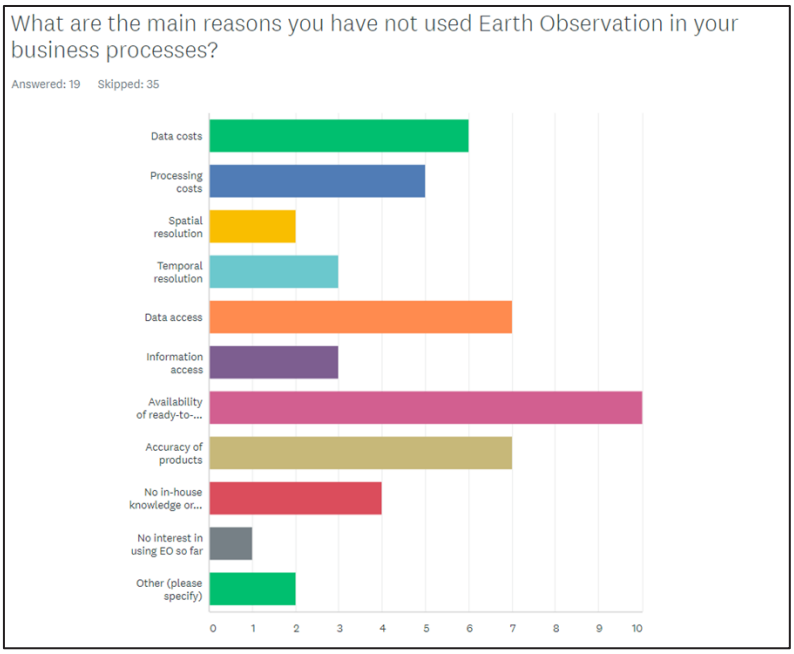

Figure 11: Online survey question on the reasons why companies don't use EO.

The three main reasons why the participants have not used earth observation in their business processes are **availability of ready-to-use products, data access and accuracy of products**.

3.4 Technical requirements

This chapter describes a number of technical requirements based on the survey's results.

3.4.1 Spatial resolution

In the survey, the users were asked to indicate what the required spatial resolution for their agro-insurance business processes would be (Figure 12). About **15% of the participants answered that for loss adjustment a spatial resolution of <1m is required, 30% answered 1-5m**. These required resolutions are higher than the resolutions of the currently available free EO data. For 30% of the participants, 5-10m is the required spatial resolution for loss adjustments. A high spatial detail is also needed to provide user services, 1 in 3 companies indicated that they require <5m resolution data to provide services to their users.

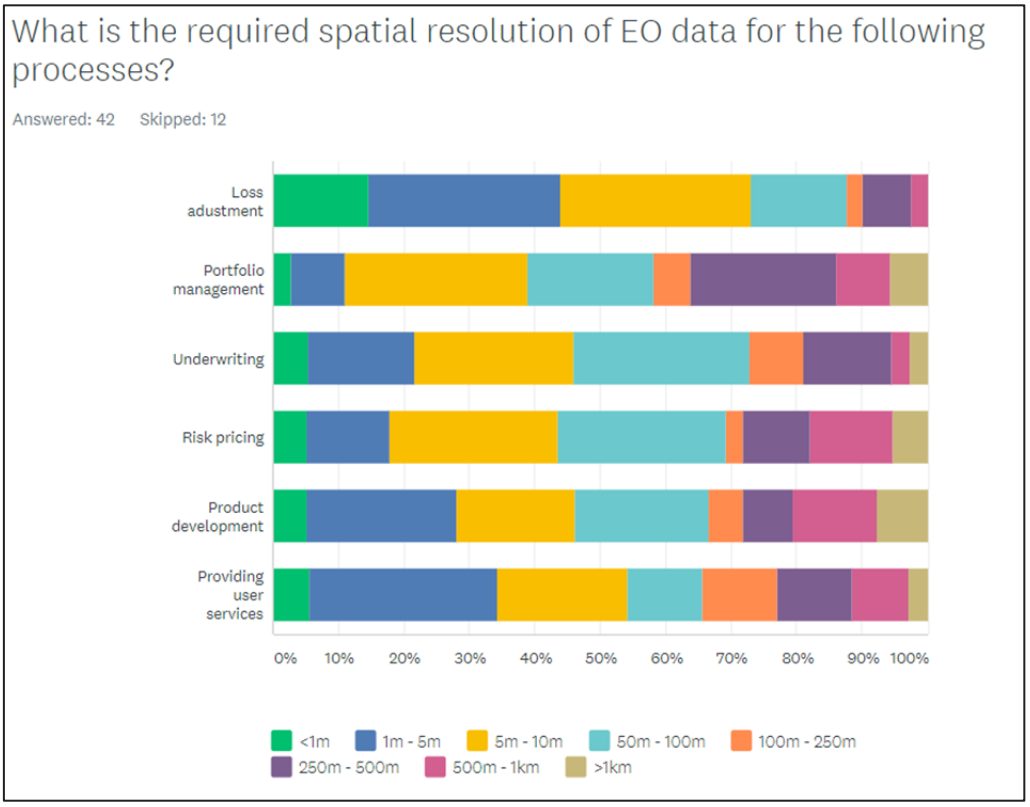

Figure 12: Online survey question on required spatial resolution for different agro-insurance business processes.

3.4.2 Temporal resolution

According to the survey, the required temporal detail is highest for loss adjustment. This is because the loss adjusters want to compare crop status before an extreme weather event with the situation directly after the event. **40% of the participants indicated they would like to receive EO information on a daily base for loss adjustment, about 10% even indicated sub-daily**. For the other half of the participants, a periodicity from 3-daily till monthly is required for loss adjustment. For providing user services about 1 in 4 participants indicated that a daily or sub-daily periodicity would be required.

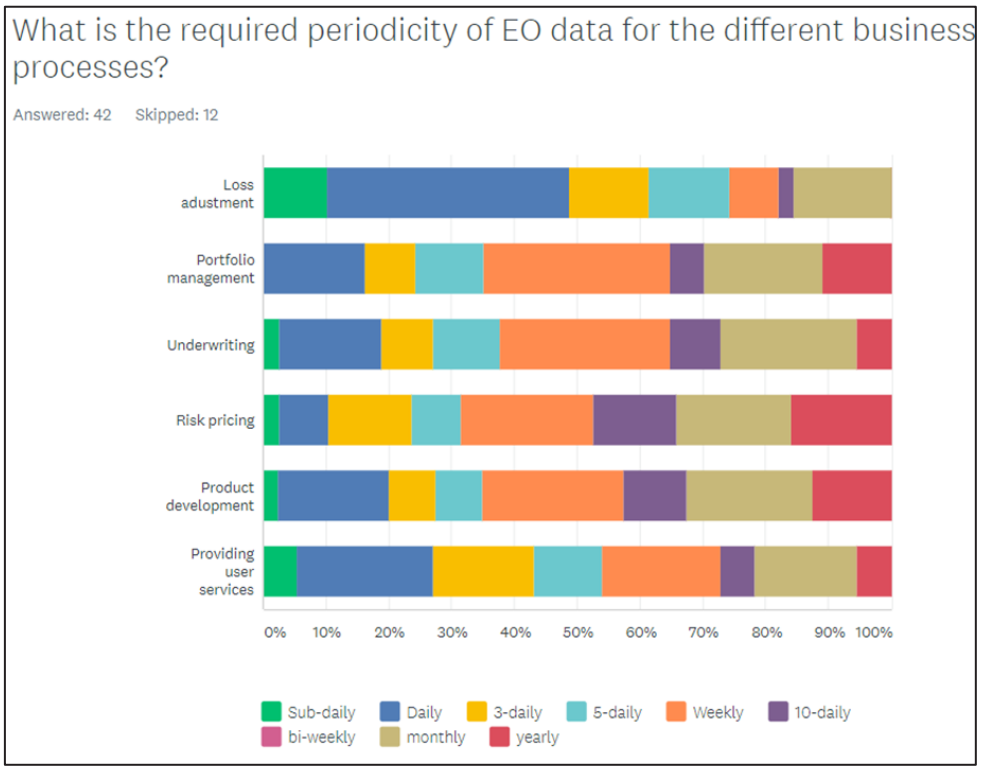

Figure 13: Online survey question on required temporal resolution for different agro-insurance business processes.

3.4.3 Timeliness

In the survey, the participants were asked to indicate the required timeliness (the time from acquisition to processed data delivery) for the various agro-insurance business processes. An update of data on a regular basis is highly required for all business processes; also, data provision within one to five days after acquisition is highly needed. For loss adjustment and providing user services, the timeliness is most critical with >20% of the participants indicated that they would require data within 1 day after the acquisition.

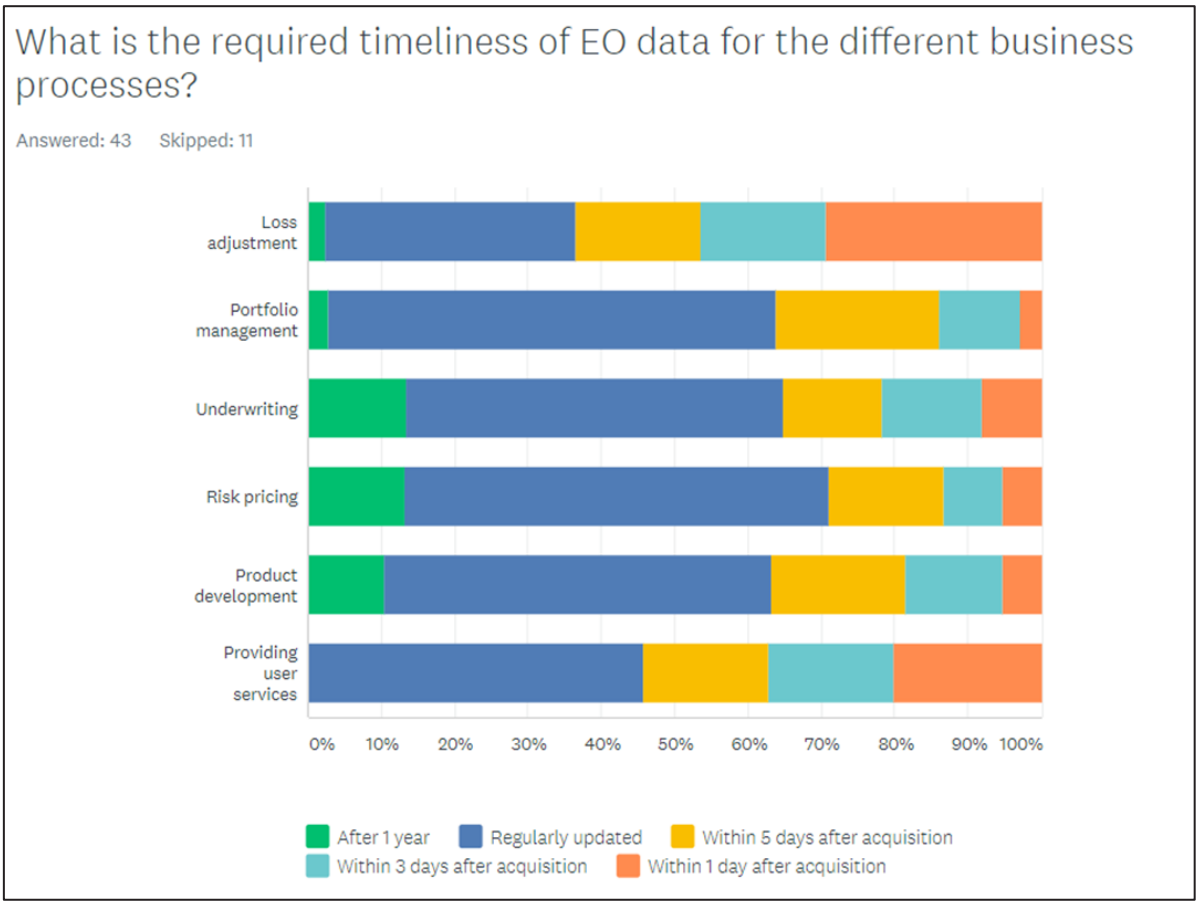

Figure 14: Online survey question on required timeliness for different agro-insurance business processes.

3.5 Awareness on EO capabilities

In this chapter we discuss the agro-insurance sector's awareness on EO capabilities. In the survey, participants were asked to indicate their level of awareness on the use of EO data in the agro-insurance sector (Figure 15). 1 out of 10 participants indicated they are not aware at all on the EO usage within the sector, about **half of the participants is aware of a few examples, and 1 in 3 participants have a clear overview of the EO use within the sector**.

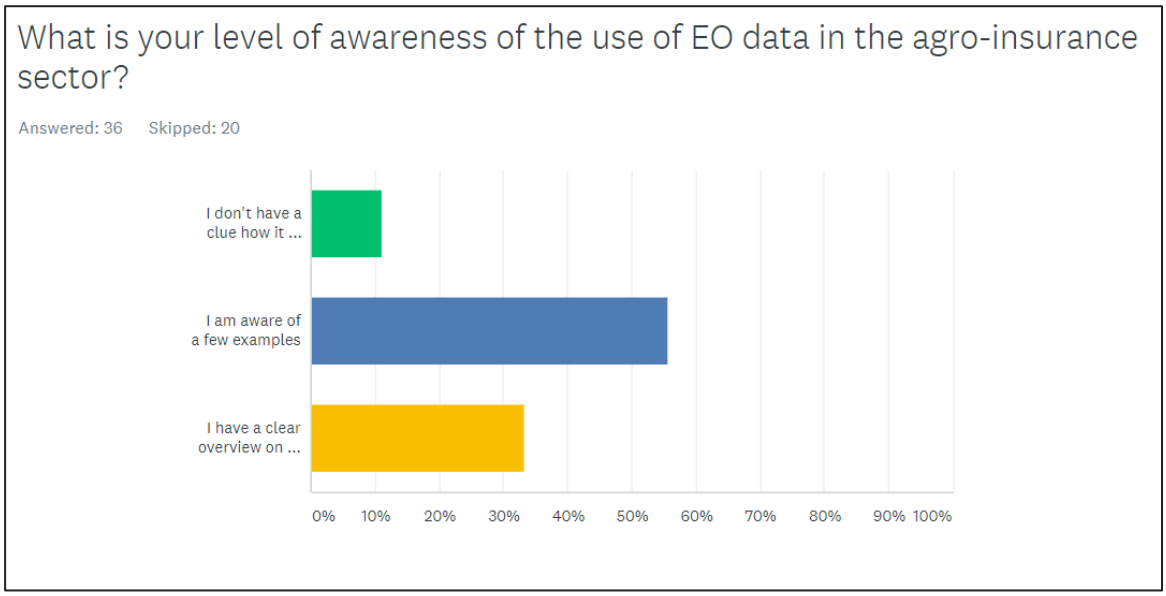

Figure 15: Online survey question on the level of awareness on EO usage in the sector.

In a next question, the participants were asked to indicate the effort that is required for finding information on available EO data. About 1 out of 4 participants indicated that it is very straightforward to find information on EO, for 2 out of 3 participant it would require an acceptable amount of effort, and about 8% finds it nearly impossible to find out what EO data is available.

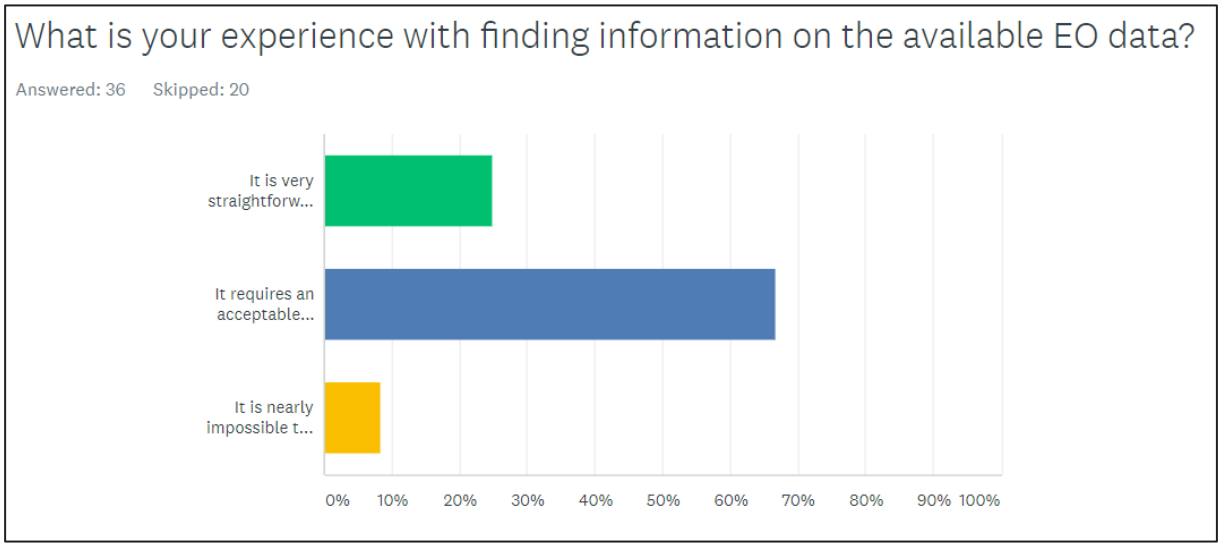

Figure 16: Online survey question on the experience of finding information on the available EO data.

In the survey, the participants were asked to indicate where they usually get information on EO for agro-insurance (Figure 17). "Conferences" and "online" was most selected, but also "workshops" and "own experts" was chosen frequently. Three participants also indicated other sources, including "Various business partners", "Through ministry headquarters" and "via project".

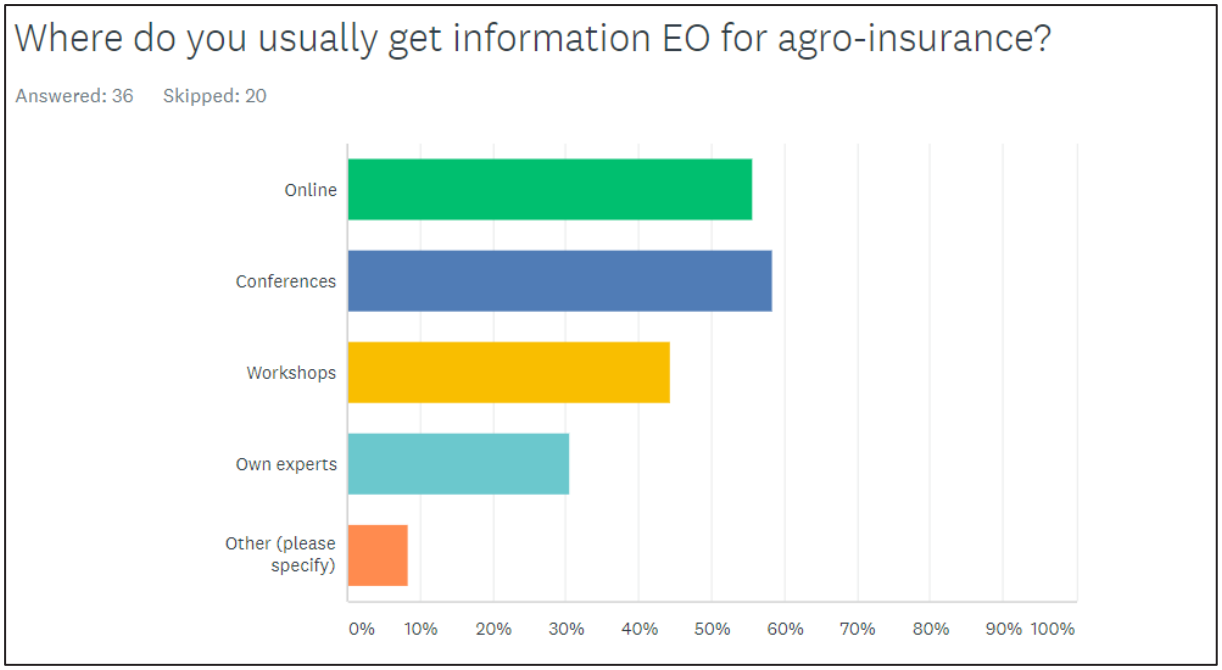

Figure 17: Online survey question on how the participants are informed on EO for agro-insurance.

4 ASV consolidation meetings

In order to discuss the specific challenges and geo-information requirements of the ASV (Austrian Hail, Swiss Hail, Vereinigte Hagel) group, a round of user calls was organized. First, each ASV member was interviewed separately to discuss their particular experiences and interests on obtaining geo-information. From each interview, the main challenges and a number of priority geo-information layers were defined. In a wrap-up call with all ASV members all the defined geo-information layers were discussed and ranked from the EO perspective according to their technical readiness, and from the industry's perspective according to their business importance. A table describing the geo-information with its technical readiness and business importance was elaborated and is presented in this chapter. First, the main outcomes of the interviews are described for each ASV member.

4.1 Austrian Hail

Current EO usage

To support their current business processes, Austrian Hail Insurance uses **tablet computers with a geo-information system that accesses Sentinel 2 data**. Sentinel 2 data are used during field visits in support of **loss adjustment.** Loss adjusters use the images to obtain an overview of the field, to assess differences before/after the event, to check the temporal development of the crop (e.g. by automated classification of crop phenology), and to calculate the area and distribution of sample points. To support user services, they have developed a tool called AgraSat that uses Sentinel 2 observations to derive spatial information on the status of crop parcels. Also, before the field assessment, EO data is used to detect when/what was planted, to get information on management practices and past events and to support management and planning of the field visits. EO is also used to **upscale field measurements**, whereby reference measurements of one area are transferred with machine learning techniques to similar areas. This results in a more precise loss assessment and a faster pay-out. Experimenting is done with radar-based soil moisture estimates for index-based insurances.

Challenges

- *Acquisition of cloud-free satellite imagery*

  The majority of their EO applications depend on Sentinel 2 imagery. The irregular availability of cloud-free images is considered as a major challenge. The impact on their EO applications depends on the type of damage to be analysed. For one-time events such as a storm or frost, imagery should be available just before and just after the damage occurred. For example, for hail damage, they operate a service where the pay-out is done within 4 days after the damage. In order to support such a service with EO data, cloud-free images should be available directly after the damage occurred. For damages caused by drought or excessive rainfall, this is often less critical, as these weather events are spread over a longer period and the chance of obtaining sufficient cloud-free imagery is much higher.

- *Processing costs for long time series*

  In order to develop new products or services, sufficient EO images are needed for testing and evaluating their value for this new product or service, especially over large regions. The data itself is often free (as in the case of Sentinel 2), but the processing costs to analyse large datasets is considered as a challenge.

- *Crop dependent accuracy*

  Most of their EO applications are done with field crops. For horticulture crops and fruit, they consider field visits as better suited and more accurate to obtain information on these crops.

- *Scale effects*

  Crop damages often occur over large areas (especially for drought) but the loss assessment is done at local scale. These scale effects are a major challenge to obtain the relevant geo-information. It is also one of their motivations to start using EO for loss adjustment.

- *Temporal & spatial resolution*

  For loss adjustment, sufficient temporal and spatial resolution is required. The 10m Sentinel 2 imagery is currently being used for loss adjustment applications. The temporal resolution depends on the weather event (see above, "Acquisition of cloud-free satellite imagery").

- *Suitability of radar information for loss adjustment*

  Despite its ability to "look through the clouds", radar data is considered less suited for loss adjustment for two main reasons. First and most important, it is less related to the crop damages that should be observed on the field. Secondly, it is less intuitive which could hamper the uptake from a user's perspective.

- *Information Credibility*

  Information credibility could be an issue when developing your own EO based products as an insurance company. Hence, developing products via a third party buy-in service can be perceived more credible than own products.

Geo-information wish list

- Gap filling of Sentinel 2 imagery (e.g. with S1)
- Field boundaries (country dependent)
- Highly accurate yield maps
- Crop/grassland maps for risk assessment for new markets

4.2 Vereinigte Hagel

Current EO usage

Vereinigte Hagel currently operates a web-based application WEB-AV for field and loss declaration, including geo-referenced field data. Another digital platform, MODIS, is used to guide loss adjusters. They currently use EO only in some pilot studies, not in operational workflows. They see opportunities in using EO for loss assessment, development of new products (index, drought), underwriting and portfolio management (monitoring, risk analysis/insurance pricing, alarming maps for frost and drought).

Challenges

- *Overview of the actual situation on the field*

  Getting an overview of the crop damages during field visits is considered as a geo-information challenge. Especially for crops which are difficult to access such as maize and rape seed. This is most important for storm damages that leave small local damages.

- *Very high-resolution*

  Very high-resolution is often required (especially for storm crop damages). Drones are suitable to detect this spatial detail, but they can only be applied to a small area, have a complex workflow and are costly.

- *Temporal resolution*

  The timelines on the information is 1-2 days after damage for loss adjustment and 5 days or more for index products.

- *Information at field level*

  Loss adjustment is done at the parcel level hence the required geo-information should also provide crop damage information at this scale.

- *Damage and yield are not equal*

  There is not always a direct relation between the observed damage and the actual yield loss.

- *Coarse resolution meteo data*

  Most of the meteo data is available at coarse resolution which doesn't reflect always the local weather conditions.

- *Cadastre data*

  Available cadastre data which provides information on the ownership of parcels where insurance companies are interested in the fields on which production is ongoing.

- *Accuracy*

  The tolerance (preferably 5%) should be less than deductible (20%).

Geo-information wish list

- Yield prediction (yield loss at field level)
- Damage assessment
- Inter-field variations
- Field segmentation of damage zones
    - Should be able to distinct natural with damage related field variability
    - Change detection required for hail, storm
- Biomass (for pasture)
- Soil moisture
- Field boundaries (should be available in spring)

4.3 Swiss Hail

Current EO usage

Swiss Hail Insurance currently operates a service called Swiss Agro Index, to provide customers with information on extreme weather events such as drought. The service uses precipitation and evapotranspiration-based indices as input. MODIS data was used before but is now replaced with daily meteo data. Derived variables such as daily fluctuations in precipitation, precipitation sums and drought indices over Switzerland are stored in an online database and made accessible for the customers via the Swiss Agro Index service. Swiss Hail Insurance also uses drones as a tool for loss adjusters. For example, to assess crop damage in corn, which can have a plant height of 2-3 meter, making it difficult to check damaged areas in the field.

Challenges

- *Small croplands*

  Swiss Hail is often working on small croplands. This makes it difficult to accurately detect 20-40% crop damage rates with existing EO data.
- *Highly cloud coverage*

  Because of the abundant cloud coverage, they tend towards a solution with radar data or a mixture of radar and multispectral data.
- *Prompt delivery of data*

  The timeliness of the data is crucial for the various business processes.

Geo-information wish list

- Detection of start of season (plant emergence) and end of season (harvest)
    - Information relevance depends on crop type (corn vs. sugar beet)
- Plant growth monitoring
    - Detection of plant growth status
    - Agricultural management

    - Yield estimation
    - Crop height
- Soil characteristics
    - Type (they have other sources of info available)
    - Moisture (radar data)
- Insights into plant processes
    - Early plant stress detection before damage occurs & visible in classic vegetation indices (e.g. hyperspectral, LST or SIF)
- Field parcel boundaries & crop type:
    - Will be delivered by existing platforms

4.4 Consolidation ASV group requirements

From each interview, the main challenges and a number of priority geo-information layers were discussed. The geo-information layers of the three individual companies were then compiled into a table. The consortium rated each geo-information from an earth observation perspective on its technical readiness via a score from 1-5. For example, index-based vegetation growth monitoring is very mature (score 5), compared to yield estimates (score 2), which often lack the required accuracies. This table was discussed in a follow-up call with all ASV members. The three companies were asked to rate the business importance for each geo-information, also via a score from 1 (lowest) – 5 (highest). Combining the technical readiness with the business importance could give an indication on the potential uptake of the different geo-information layers.

Table 1: Geo-information requirements table derived from ASV consolidation meetings. The business importance was rated by the ASV group. The EO technical readiness was rated by the project consortium. The total score is the sum of these two and is a potential indicator for the readiness for the uptake of a specific geo-information layers via EO.

ID	Required geo-information	Scale	Business Importance				EO Technical Readiness	Total Score
			A	S	V	Average		
A	**Crop Status**							
A1	Emergence and Harvest	Parcel	3	4	4	3,67	5	8,67
A2	Vegetation growth monitoring (Index)	Parcel	4	5	4	4,33	5	9,33
A3	Early Vegetation Stress (direct observation via e.g. SIF, Hyperspectral, LST)	Parcel	2	3	2	2,33	2	4,33
A4	Yield Estimation	Parcel	5	5	5	5	2	7
A5	Crop Height	Intra-field	1	1	2	1,33	n.a.	n.a.
B	**Parcel information**							
B1	Field boundaries	Parcel	4	2	3	3	4	7
B2	Field boundaries (data sparse regions)	Parcel	4	4	4	4	4	8
B3	Crop type detection (early)	Parcel	3	2	4	3	3	6
B4	Crop type detection (early - data sparse regions)	Parcel	3	4	4	3,67	3	6,67
B5	Crop type detection (normal)	Parcel	3	2	3	2,67	5	7,67
B5	Crop type detection (normal, data sparse regions)	Parcel	3	4	3	3,33	5	8,33
B6	Crop growth zone detection	Intra-field	3	3	3	3	4	7
C	**Soil**							
C1	Soil Type	Parcel	3	3	2	2,67	n.a.	n.a.
C2	Soil Moisture	Parcel	5	5	5	5	4	9
C3	Soil Moisture	Regional	4	3	3	3,33	5	8,33
D	**Crop Damage**							
D1	Damage within field	Intra-field	5	5	5	5	3	8
D2	Yield loss detection	Parcel	5	5	5	5	2	7
D3	Damage zones - change detection	Intra-field	5	5	5	5	3	8
E	**Agricultural Management**							
E1	Irrigation (Y/N)	Parcel level	2	2	3	2,33	3	5,33
E2	Fertilisation - Nitrogen	Parcel level	3	3	2	2,67	1	3,67
F	**Gap filled time series of high-resolution EO data**							
F1	Field level	Parcel	4	3	3	3,33	4	7,33
F2	Pixel level	Intra-field	5	5	4	4,5	3	7,5

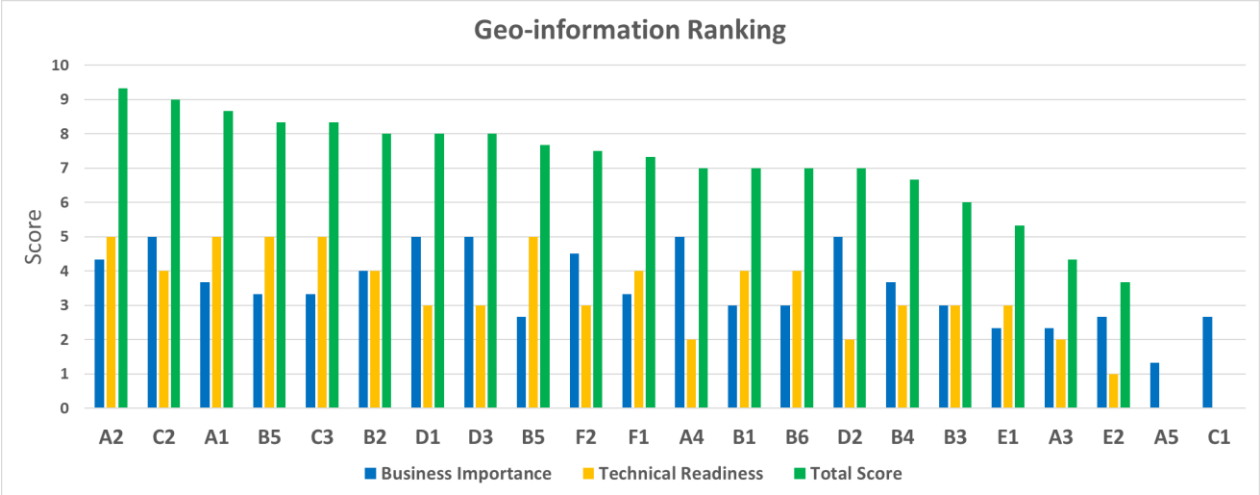

Figure 18: Ranking of the different geo-information layers.

5 Challenges within Business Process and Key Requirements

5.1 Introduction & approach

A priori – Terminology: A "challenge" is considered as an element or activity within the workflow of the agro-insurance business processes which could be supported by geo-information (e.g. "Upscale field observations"). A "key geo-information requirement" is defined as a thematic source of geo-information (e.g. "Obtaining information on parcel location and boundaries"). Each challenge could be supported by one or multiple key geo-information requirements.

The goal within this Agro-Insurance project is basically to find out the needs of the users, the current and future capabilities of the EO sector and to link those needs with the capabilities in order to engage users of the agro-insurance sector using the proper capabilities of the EO sector. However not every need or challenge is related to EO capabilities at first site. Therefore this chapter provides an overview of identified challenges and key requirements from the business process perspective of the agro-insurance sector which complements – in a structured way – the information and insights previously described in the report, that are more focused on EO requirements of the users, while this chapter shall broaden the view into the "daily-life" challenges of the agro-insurances.

The basic inputs for this chapter were obtained during a workshop with the consortium, ESA and representatives from the agro-insurance and EO industry that took place in November 2019 at GeoVille's premises in Innsbruck. The details of this workshop are recorded in the deliverable D2.3 "Workshop II report" provided to ESA. At this workshop, round table discussions and dedicated sessions on user-requirements, EO-capabilities and products were organized to identify the major challenges for the different agro-insurance business processes. The overview of the business processes (please refer to the next chapter for a description of the business process), as described in Figure 19 was used as basic structure to map the challenges and is adopted in this report. The identified challenges were further matched to key geo-information requirements with the support of the consortium's expertise of the agro-insurance sector. These key requirements will be used in the gap analysis to compare them to existing earth observation capabilities.

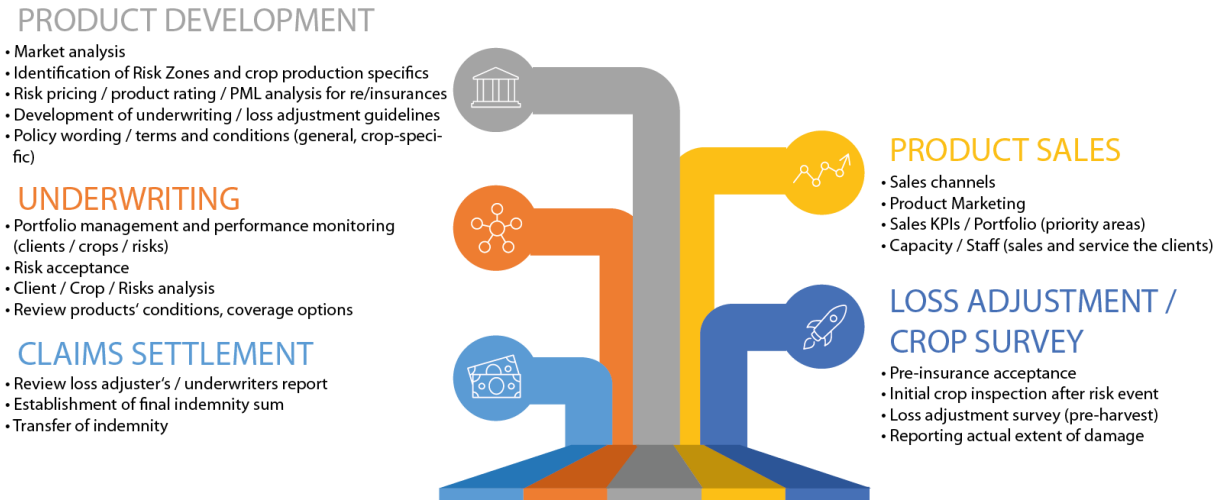

Figure 19: Overview of agro-insurance business processes

5.2 Overview of business processes and challenges

This chapter gives an overview about the identified business processes in the agro-insurance sector and their respective challenges, defined by the users. For these challenges, specific corresponding geo-information requirements can be identified, that enable the users to conquer those challenges. Usually a challenge cannot be addressed by just one geo-information requirement, but by several. Therefore, the geo-information requirements have not been listed with full name, but as a coded domain that can be decoded using Table 7.

5.2.1 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.

Table 2: Overview of identified challenges and related key geo-information requirements for product development.

ID	Geo-information challenge	Linked key geo-information requirements
PD-1	Market analysis	1, 2, 3, 4, 6, 7, 8, 12, 13, 14, 15, 16, 17, 18, 19, 20, (21, 22, 23, 24, 25 - depends on insurance product)
PD-2	Index insurance: Toolbox for indices	1, 5, 9, 10, 11, 12, 13
PD-3	Index insurance: Risk / Crop modelling (Correlation of EO data with in-situ data)	1, 6, 7, 8, 11, 12, 13, 14, 15
PD-4	Index insurance: Relation between weather events and impact on crop productivity	1, 7, 8, 9, 10, 11, 12, 13, 14, 15
PD-5	Index insurance: Functionalities of plants, chemical reactions, early stress detection	1, 7, 9, 10, 11, 12
PD-6	Index insurance: Parcel/Field and regional yield statistics	1, 7, 8, 12, 13, 15
PD-7	Index insurance: Platform for crop health products	1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 19, 26
PD-8	Elaboration of crop profile: Field crops, vegetables, horticulture, greenhouses	1, 2, 3, 4, 6, 7, 8, 11, 12, 13, 14, 15, 16, 17, 19, 20 (21, 22, 23, 24, 25 - depends on insurance product)
PD-9	Information on crop rotation	1, 4, 6, 7, 8, 12, 16, 17, 19
PD-10	Information on crop (seasonal) calendar	1, 6, 7, 8, 11
PD-11	Elaboration of livestock profile: Cows, sheep, pigs, poultry	1, 2, 3, 15, 16, 17, 18, 19, 20, 21, 22
PD-12	Detect Livestock: Track Animal tags	1, 21
PD-13	Livestock: Information on disease location and spreading	1, 16, 17, 18, 19, 21
PD-14	Aquaculture: Waves/currents energy	1, 23
PD-15	Aquaculture: Algae	1, 24
PD-16	Aquaculture: Monitor Thermal data	1, 23
PD-17	Information on forest health and production at different temporal scales (realtime monitoring, historical development)	1, 2, 6, 14, 15, 16, 17, 18, 19, 25

PD-18	Monitoring regular cleaning and application of required technology activities for defined wood type and its designation	25
PD-19	Identification of specific stresses and vegetation problems and their underlying causes	15, 25
PD-20	Forestry: Infrastructure & Management	1, 2, 3, 6, 16, 17, 18, 19, 25
PD-21	High accuracy of crop-specific yield for smaller crop parcels	1, 2, 7, 8, 11, 12, 13
PD-22	Radar data (eliminated cloud cover effects)	1, 5, 7, 9, 10, 11, 12, 14, 15, 16, 17, 19, 20
PD-23	Risk exposure (product design and customer communication)	1, 2, 6, 7, 8, 10, 11, 12, 13, 14, 15

PD-1 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.

PD-2 Index insurance: Toolbox for indices

An online platform allowing insurer to select specific datasets for designing an index product. The structure and operational functionality for the services on the platform are supposed to contain the list of available datasets with data processing and interpretation functionality. API access to be considered for their data on the platform for any insurer to be able to export/integrate the data into their operational flow.

PD-3 Index insurance: Risk / Crop modelling (Correlation of EO data with in-situ data)

Comparison of an individual farm data with EO data. Identification of correlation and/or differences with the purpose of establishing the level of basis risk, correlation of index structure with crop vegetation cycle and fine-tuning the index coverage structure

PD-4 Index insurance: Relation between weather events and impact on crop productivity

Certain risks have clear seasonality (e.g. spring frost), as well as each crop's susceptibility to certain risks at various phenology stages. Combining and modelling of those provides the underwriter with better understanding on insurability of the crop/risk and relevance of index structure to farmer's needs.

PD-5 Index insurance: Functionalities of plants, chemical reactions, early stress detection

Detecting anomalies, attributed to specific risk factors, that may be affecting a specific crop at various phenology (development?) phases. Crops are able to cope with negative risk

factors to certain extent. The purpose is to identify the level of severity of a certain risk factor that may significantly reduce crop yield.

PD-6 Index insurance: Parcel/Field and regional yield statistics

Identifying crop yields deviations at the smallest granular level (parcel / field) to compare with other production sites/fields/regions. Many factors affect crop's yielding capacity and yields may significantly vary even at one parcel/field.

PD-7 Index insurance: Platform for crop health products

A platform allowing insurer and the farmer monitoring of crop's health and possible correlation with certain weather factors (insured/non-insured)

PD-8 Elaboration of crop profile: Field crops, vegetables, horticulture, greenhouses

Crop/risk profile includes production landscape, crop rotation calendar, technologies applied, seasonality of production and risks affecting the crop – all considered for further decisions on insurability of crops/risks.

PD-9 Information on crop rotation

Crop rotation is important to control pest and weeds infestation to estimate the yield potential based on the technology (crop-rotation) applied.

PD-10 Information on crop (seasonal) calendar

Crop calendars are required, especially for the areas able to produce 2-3 cycles in 1 calendar year (e.g. India, South-East Asia, etc.) This helps to map the risks by production season and to set specific insurance coverage for each season

PD-11 Elaboration of livestock profile: Cows, sheep, pigs, poultry

Depending on the livestock type and purpose of production (meat, milk, wool, eggs, etc.) the production cycle differs significantly. It is necessary to analyse the periods, overlapping the calendar seasons, risks associated with each type of livestock, as attributed to certain periods of the calendar year.

PD-12 Detect Livestock: Track Animal tags

Identify the livestock location, movements, location and feeding patterns/habits, etc.

PD-13 Livestock: Information on disease location and spreading

Identifying the high-risk zones for possible contamination control needs

PD-14 Aquaculture: Waves/currents energy

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

PD-15 Aquaculture: Algae

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

PD-16 Aquaculture: Monitor Thermal data

Thermal data allows to forecast disease spreads and changes in habitat for produced aquaculture

PD-17 Information on forest health and production at different temporal scales (realtime monitoring, historical development)

Forestry's full production cycle may differ depending on the purpose of the timber (building, paper, etc.) and quality requirements. In average 25-30 years production cycle requires long-term data series to see the plot's development, specifics stresses and vegetation problems, defining the cause (insects, diseases, etc.), monitoring regular cleaning and application of necessary technological operations, etc.

PD-18 Monitoring regular cleaning and application of required technology activities for defined wood type and its designation

Technology adherence control for insurance underwriting and forest management needs.

PD-19 Identification of specific stresses and vegetation problems and their underlying causes

Identifying the stress and potential causes to link those to weather perils, pests or other natural/human/technogenic factors

PD-20 Forestry: Infrastructure & Management

Identification of required infrastructure (storages and processing facilities / fire brigades / aerodromes / helipads / water reservoirs, etc.) for insurance underwriting and forest management needs.

PD-21 High accuracy of crop-specific yield for smaller crop parcels

Identifying crop yields deviations at smallest granular level (parcel / field).

PD-22 Radar data (eliminated cloud cover effects)

Availability of the long term and consistent dataset with no limitation for areas with high cloud cover.

PD-23 Risk exposure (product design and customer communication)

Data reflecting on the needs of the farmers to match their risk exposure with the respective insurance cover (history of past events (3-5 years) and their effects). Used to explain to the farmer the level of premium rate based on the risk events - their frequency and severity, as well as the benefits for the farmer from having the insurance cover.

5.2.2 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.

Table 3: Overview of identified challenges and related key geo-information requirements for product sales.

ID	Geo-information challenge	Linked key geo-information requirements
PS-1	Client Outreach	1, 2, 4, 6, 7, 8, 11, 12, 13, 14, 15, 16, 17, 18, 19, 26
PS-2	High accuracy of crop-specific yield for smaller crop parcels (penetration)	1, 2, 7, 8, 11, 12, 13
PS-3	Pre-contractual Consulting (show-case risk exposure)	1, 6, 7, 8, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 26
PS-4	Landowner Identification	3, 6, 16, 18, 19
PS-5	Farm Structure / Management Practice (linking to Cadastre)	2, 4, 6, 7, 16, 17, 18, 19
PS-6	Greater acceptance of index covers by farmers	1, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 26
PS-7	Regular market penetration review	2, 7, 8, 11, 12, 13, 14, 15, 16, 17, 19
PS-8	Risk alerts	7, 9, 10, 11, 13, 14, 15, 26

PS-1 Client Outreach

Data allowing better client segmentation based on crop production, risk events, specific production areas, etc.

PS-2 High accuracy of crop-specific yield for smaller crop parcels (penetration)

Identifying crop yields deviations at smallest granular level (parcel / field). Using the data for enhancing client portfolio (marketing).

PS-3 Pre-contractual Consulting (show-case risk exposure)

Providing understanding of the area, crops and risk exposure. At time of communication with clients the platform may allow visualization of the historic data in the risk events and crops in the region to showcase on the past experience to prevent future events of the kind. If such a platform allows such an analysis, this should match with the farmer's experience, possibly generating more trust to EO data, possibly leading to the successful sales results.

PS-4 Landowner Identification

Assists in segmentation of client portfolio (e.g. offer different insurance products to different farmers (crops, areas, production size, etc.))

PS-5 Farm Structure / Management Practice (linking to Cadastre)

Understanding better the infrastructure and farmer's common production and management practice, technology applied.

PS-6 Greater acceptance of index covers by farmers

Assure data continuity, consistency and reliability, with lowest possible basis risk exposure. Higher EO data correlation (e.g. over 90% for individual farm, or per field) with actual events experienced by farmers in the past generating a higher level of farmers' trust to the EO data and index products in the future.

PS-7 Regular market penetration review

Understand the client portfolio, trends and markers of a change in crop production landscape in the area.

PS-8 Risk alerts

Weather forecasts and risk alerts are important for underwriters and farmers, allowing timely application of non-insurance risk mitigation activities to protect the crop and attaint the yield expected.

5.2.3 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.

Table 4: Overview of identified challenges and related key geo-information requirements for underwriting.

ID	Geo-information challenge	Linked key geo-information requirements
UW-1	Seasonal portfolio monitoring	2, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19 (21, 22, 25 - depends on insurance product)
UW-2	Online platforms or easy-to-use interfaces integrating various data sources (e.g.: vegetation stress, field boundary changes, comparison, etc.)	1, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 19
UW-3	Risk / crop zoning	1, 2, 4, 6, 7, 8, 11, 12, 13, 14, 15, 16, 17, 19, (21, 22, 25 - depends on insurance product)
UW-4	Actual crop health (vegetation)	9, 10, 11, 12, 13, 14, 15
UW-5	Global/regional production trends (e.g.: monitoring specific crop acreages of surrounding regions/countries)	1, 6, 7, 8, 11, 12, 13, 14, 15
UW-6	Procure better reinsurance terms/capacity from enhanced insurance practice	6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 19
UW-7	Trustful historical data for agro-insurance indemnity pay-outs	1
UW-8	Identification of farmer's production practice (technology, infrastructure, property, machinery, etc.)	1, 2, 4, 6, 7, 8, 11, 16, 17, 18, 19
UW-9	Identification of productive units	6, 16, 17, 19
UW-10	Identification of crops grown	7
UW-11	Identification of vegetation stages (identify most sensitive stages when crop is most vulnerable to a certain risk, e.g.: flowering stage)	1, 7, 9, 10, 11
UW-12	Weather forecast tool	1, 7, 8, 9, 10, 11, 12, 26
UW-13	Crop calendar and practices	6, 7, 11, 12, 13, 14, 15, 16, 17, 19
UW-14	Regular assessment of risk pricing and product rating	1, 8, 11, 12, 13, 14, 15, 16, 17, 19

UW-1 Seasonal portfolio monitoring

Portfolio monitoring and management are the key functions of agricultural underwriters. Seasonal portfolio may differ, as well as each year's portfolio may also change in crop/risk exposure due to market situation, technology shift and underwriting policy of the insurer.

UW-2 Online platforms or easy-to-use interfaces integrating various data sources (e.g.: vegetation stress, field boundary changes, comparison, etc.)

E.g.: Web based services that include the necessary functionality required by the underwriter, based on the portfolio managed. In this case no raw data is required, but it is important to get visual interpretation of the data: vegetation stress, field boundary changes, comparison, etc. All major functionality of the interface in one shell is something many insurers worldwide are looking for.

UW-3 Risk / crop zoning

Understanding of the risk/crop zones allows better balanced underwriting portfolio. Each insurance product is supposed to properly address the higher and lower risk areas considered for a specific crop/risk. This is reflected in elaborating several risk zones that are attributed in a defined premium rate for that area (zone) reflecting on the actual level of exposure to the risk insured.

UW-4 Actual crop health (vegetation)

Required to monitor actual portfolio to consider possible risk exposure and measures to limit risk effects. Actual crop health considers the close to real-time vegetation data monitoring that will reflect on the crop's health conditions, indicating the estimated deviations for crops conditions (better, normal or worse that the multi-year average) for the area considered.

UW-5 Global/regional production trends (e.g.: monitoring specific crop acreages of surrounding regions/countries)

Monitor possible trends in current and future crop portfolio in the country, benchmarking with neighbouring countries to spot the possible needs for new insurance products and changes in insurance cover structure to address these production trends and farmer needs. This activity mostly relates to the strategy of the future underwriting portfolio of the insurer/reinsurer.

UW-6 Procure better reinsurance terms/capacity from enhanced insurance practice

Balanced portfolio may provide better loss ratio leading to lower reinsurance premium rates and better coverage conditions. Depending on the past performance of the insurer's portfolio, the reinsurer may adjust the conditions of the treaty providing the lower

reinsurance premium rate or offering higher reinsurance level (retention) for the risks within the existing or future reinsurance treaty.

UW-7 Trustful historical data for agro-insurance indemnity pay-outs

Damage data has to reflect on the closest to the actual extent of the damage. This may require extensive calibration and random calibration tests for satellite data to reflect better correlation of EO data to the actual loss of the given farmer. The major issue withing the agricultural insurance practice is when the EO data does not properly reflect on the losses experienced by the individual farmer in the given area, which is generally referred as the Basis Risk. The lover the basis risk - the higher the farmer's trust to the data and index products offered to the farmer.

UW-8 Identification of farmer's production practice (technology, infrastructure, property, machinery, etc.)

Farm's property and existing infrastructure assessment allows underwriter to make better decisions on the capabilities of the farm to produce crop yield as requested by the farmer. For value chains it is also important to assess the storage capacity and processing facilities in place to correspond to the season production volumes.

UW-9 Identification of productive units

Check on the farm's management structure and actual areas under production of crops insured.

UW-10 Identification of crops grown

Portfolio monitoring and management are the key functions of agricultural underwriters.

UW-11 Identification of vegetation stages (identify most sensitive stages when crop is most vulnerable to a certain risk, e.g.: flowering stage)

Certain risks have clear seasonality (ex.: spring frost), as well as each crop's susceptibility to various perils at certain phenology stages. Combining and modelling of those provides the underwriter with better understanding on insurability of the crop/risk.

UW-12 Weather forecast tool

Weather forecasts and risk alerts are important for underwriters and farmers, allowing timely application of non-insurance risk mitigation activities to protect the crop and attaint the yield expected. It may also lead to a discount for famers applying effective management practices maintaining their historical losses at low levels.

UW-13 Crop calendar and practices

Crop calendars are required, especially for the areas able to produce 2-3 cycles in 1 calendar year (e.g. India, South-East Asia, etc.). This helps to map the risks by production season and adjust insurance coverage for each season

UW-14 Regular assessment of risk pricing and product rating

Should be a regular procedure, at least once a year or by-season by matching the risk data with portfolio location, registered events, plans for future portfolio development with a better diversification.

5.2.4 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.

Table 5: Overview of identified challenges and related key geo-information requirements for loss adjustment.

ID	Geo-information challenge	Linked key geo-information requirements
LA-1	Workforce allocation and planning	2, 3, 6, 7, 9, 10, 11, 13, 14, 15, 16, 17, 19
LA-2	High accuracy of crop-specific yield for smaller crop / land parcels	1, 2, 7, 8, 11, 12, 13
LA-3	Regularly updated consistent long-time series of reliable data for index insurance	1, 5, 7, 8, 11, 12
LA-4	Benchmark physical field observations against yield loss detection (e.g. product calibration)	2, 4, 6, 7, 10, 11, 13, 14, 15
LA-5	Risk-mapping against crop's vegetation stages	1, 2, 4, 6, 7, 8, 11, 12, 13, 14, 15, 16, 17, 19, (21, 22, 25 - depends on insurance product)
LA-6	Increase credibility of loss adjustment (e.g. show EO data/visualization to support loss adjustment communication to farmer)	3, 6, 7, 8, 9, 11, 12, 13, 14, 15, 16, 17, 18, 19, 26
LA-7	Enhance field survey (better precision with EO data support)	1, 4, 6, 7, 8, 9, 10, 11, 13, 14, 15, 26
LA-8	Detect crop damage at field level	1, 7, 9, 10, 11, 12, 13, 14, 15
LA-9	Assess crop damage at field level	1, 7, 9, 10, 11, 12, 13, 14, 15
LA-10	Distinct field heterogeneity with crop damage	1, 7, 9, 10, 11, 12, 13, 14, 15
LA-11	Pasture biomass data	1, 22
LA-12	Soil type data	4, 5

LA-1 Workforce allocation and planning

Allocate qualified seasonal staff, as well as the regional workforce to the areas requiring additional capacity at peak season for crop assessment / loss adjustment work (e.g.: large area affected by frost / drought / storm, etc.)

LA-2 High accuracy of crop-specific yield for smaller crop / land parcels

Identifying crop yields deviations at smallest granular level (parcel / field). Using the data for better estimation of area damaged and the extent of loss.

LA-3 Regularly updated consistent long-time series of reliable data for index insurance

Consistent long-term datasets are required to structure the index covers. Data from most statistical agencies in many countries is not always trustful or sufficient. Satellite data is not always showing regular revisit of the same spot, which causes an issue for its usability.

LA-4 Benchmark physical field observations against yield loss detection (e.g.: product calibration)

Compare the in-situ damage estimations made by experts at fields with the loss estimates made by specific algorithms applied by automated loss detection instruments.

LA-5 Risk-mapping against crop's vegetation stages

Certain perils have clear seasonality (e.g. spring frost), as well as each crop's susceptibility to various perils at different vegetation stages. Combining and modelling of those provides the underwriter with better understanding on insurability of the crop/risk.

LA-6 Increase credibility of loss adjustment (e.g. show EO data/visualization to support loss adjustment communication to farmer)

An index structure/product has to provide a range of reliable information that could be used by the loss adjuster while communicating with the farmer on estimating the final extent of the damage.

LA-7 Enhance field survey (better precision with EO data support)

Enhance crop condition survey with various satellite data making such a survey more precise and specific to the production of the given farmer with the specifics of the technology applied, crops grown, risks exposed to, etc.

LA-8 Detect crop damage at field level

Identifying the difference of crop yield within the insured field due to the related risk event. Use the EO data for estimation of yield loss at a given field.

LA-9 Assess crop damage at field level

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.

LA-10 Distinct field heterogeneity with crop damage

Estimate the area damaged and causes of damage (insured / non-insured perils). Some fields may have specific issues with the terrain, elevation, proximity to other fields or object that may cause additional risk exposure. Some crop damage could be caused by the insured perils, while some damages may come from effects of non-insured perils (e.g.: (1) landslide

(if not insured), (2) negative effects of spraying with herbicides of neighbouring fields by another farmer).

LA-11 Pasture biomass data

Pastures biomass data provide opportunities for insuring farmers' grasslands with index-based covers. The biomass would be considered in this case as the "estimated productive yield of the grassland insured"

LA-12 Soil type data

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

5.2.5 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.

Table 6: Overview of identified challenges and related key geo-information requirements for claims handling.

	Geo-information challenge	Linked key geo-information requirements
CH-1	Identification of actual damage size (tones (volume) / ha (area) / price (yield value)	6, 8, 13, 14, 15, 16, 17, 19
CH-2	Quality control assessment of claims before pay-out	6, 8, 13, 14, 15, 16, 17, 19
CH-3	Fraud detection	6, 8, 13, 14, 15, 16, 17, 19
CH-4	Timely, reliable and consistent data to speed-up the indemnity pay-outs	1, 12, 13, 14, 15

CH-1 Identification of actual damage size (tones (volume) / ha (area) / price (yield value)

Check on the results of loss adjuster's estimations of the damage extent. In case the loss adjuster's report on physical crop inspection shows a too high difference between his conclusions and the EO data report, an additional physical crop survey would be normally requested. If such a survey is not possible due to crop being already harvested, the investigation may be requested to qualify the adjuster's report and photo materials as trustful ones to be used for further indemnification. Benchmarking with EO reports and detailed historical crop conditions analysis may be of assistance in proper underwriting decisions.

CH-2 Quality control assessment of claims before pay-out

Depending on the internal procedures of the insurer, the financial department may conduct a separate (security) check to match the details in the claims settlement package. A quality-control measure.

CH-3 Fraud detection

Detect possible deviations and misrepresentation of facts by the farmer, that may pose the case for declining the claim or reducing pay-out sum. (e.g. the farmer declared field to be irrigated but due to lack of water, irrigation was not performed in a current season.

CH-4 Timely, reliable and consistent data to speed-up the indemnity pay-outs

Reliable and consistent data allows to trigger pay-outs and speed up the process of farmers getting the money as fast as possible. The faster farmer gets money, the less his production is interrupted, the better sustainability the farmer and the whole program will have.

5.3 Overview of Key Geo-information Requirements

As described in the previous chapter, challenges within the business processes can be translated into geo-information requirements that are necessary to address those challenges. In the following table, the geo-information requirements that address the identified challenges of the users, are listed. The ID of each requirement can be used as a link to the corresponding challenge as listed in 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.

Table 2 to 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.

Table 6.

Table 7: Overview table of identified key geo-information requirements

ID	Key Geo-Information Requirement
1	Obtain uninterrupted consistent long data series (high temporal/spatial resolution)
2	Obtain detailed topographic characteristics
3	Obtain detailed imagery of the surface
4	Identify soil types (mineralogy, structural properties of near surface)
5	Identify soil moisture contents
6	Obtaining information on parcel location and boundaries
7	Identify crop type
8	Obtain historical crop production (crop, area, yields)
9	Crop vegetation monitoring
10	Monitoring stress in vegetation
11	Identify the crop emergence and harvest date
12	Crop yield monitoring
13	Estimating yield losses
14	Identify crop damages
15	Identify effects of various risks (frequency, severity, area covered by each risk event)

16	Obtain detailed land use information (crop production landscape, etc.)
17	Identifying agricultural practices (irrigation, fertilisation)
18	Obtain detailed imagery of assets (property, machinery, other field infrastructure)
19	Identify location and condition of infrastructure objects (irrigation, greenhouses, water wells, etc.)
20	Identify water boundaries (flooded areas, etc.)
21	Identify livestock movements
22	Identify pastures biomass (yield potential)
23	Identify waves height, currents' energy and thermal data
24	Identify water flora/fauna (algae, etc.)
25	Identify forests characteristics (area, boundaries, timber type, etc.)
26	Monitor and forecast weather events

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.

6 Conclusion

This report is focused on the collection of the key challenges and geo-information requirements of the agro-insurance sector. To obtain the most recent information directly from the agro-insurance companies, four activities were undertaken: a dedicated workshop with representatives from the sector at ESA's Living Planet Symposium, an online survey which was distributed via the extensive network of the project partner AgroInsurance.com, a round of dedicated interviews with the ASV group members and a workshop with key experts from the agro-insurance as well as the EO sector in Innsbruck. This report summarizes the major findings of all these activities. Below we describe the most important observations:

- 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.
- Depending on the agro-insurance business process, the survey showed that between 10%-30% of the companies already use EO in an operational way. But most of the usage is still in experimental or pilot phase.
- According to the survey, the mostly used satellite imagery by agro-insurances are Sentinel 1 & 2, Landsat & MODIS.
- Developing new products, supporting of field work, providing objective information and obtaining spatial information that is not available from another source, were considered as the main motivations to start using EO for agro-insurances.
- Processing costs and availability of ready-to-use products are considered as strongest limitations of current EO usage for agro-insurance. In small specialized companies, there is often limited budget available for training, education and IT infrastructure.
- The timeliness and spatial resolution are also considered as a challenge to use EO for loss adjustment. Some companies prefer to use drones to support loss adjustment, others such as the Austrian Hail Insurance are using Sentinel 2 to support and upscale field-based surveys.
- A majority of the sector is quite well aware of available EO products/services and example usages for agro-insurances. There is however a gap between the perceived capabilities of EO services which are often generic and the sector's specific needs.
- Chapter 5 provides an overview of key geo-information requirements which can be considered as the thematic building blocks that support the development of earth observation-based solutions for the identified challenges.

This report shall enable EO industry to provide proper services and products that address the challenges that the agro-insurance sector is facing. A further analysis of the current challenges of the users and the corresponding EO capabilities will be provided with deliverable D2.2 "Gap Analysis Report" that not only links challenges with capabilities but which also identifies gaps in the current EO capabilities portfolio. These gaps represent requirements that can be addressed by future missions of ESA and furthermore derived products from service providers.