

## **Executive Summary**

**Specific Contract under the Framework Service Contract 89/PP/ENT/2011 – LOT 3**

**Assessing the Economic Value of Copernicus:  
“The potential of Earth Observation and Copernicus Downstream  
Services for the  
Agriculture Sector”**

## CONTENTS

1	CONTEXT .....	3
2	KEY ASSUMPTIONS AND ENABLING FACTORS.....	3
3	INTRODUCTION TO SECTORAL ANALYSIS.....	4
4	THE AGRICULTURE INDUSTRY: TRENDS AND CHALLENGES .....	4
4.1	Recent trends .....	4
4.2	Challenges.....	5
5	THE POTENTIAL USE AND BENEFITS OF EO DOWNSTREAM SERVICES.....	6
5.1	Use of EO information along the value chain.....	6
5.2	Benefits of EO information .....	7
6	DOWNSTREAM MARKET FORECAST .....	10
6.1	Relevant statistics and parameters.....	10
6.2	Market forecasts.....	11
7	IMPACT OF COPERNICUS DATA AND SERVICES.....	12
8	CASE STUDY .....	13
9	CONCLUSIONS.....	14
10	RELEVANT LITERATURE .....	15

## 1 CONTEXT

This document represents an annex to the report of the “**European Earth Observation (EO) and GMES Downstream Services Market Study**”, performed under the first Specific Contract of the Framework Service Contract 89/PP/ENT/2011 – LOT 3 (“Support to GMES related policy measures”).

It contains a high-level summary of key findings of the analysis of the potential market value for European Earth Observation and GMES<sup>1</sup> downstream services for the Agriculture sector.

As highlighted in the main report, the study and sectoral analysis is subject to a set of key assumptions and enabling factors, reported in the following chapter.

## 2 KEY ASSUMPTIONS AND ENABLING FACTORS

The study is subject to the following **key assumptions**:

1. **Catalytic effect of free and open data provision**<sup>2</sup>: GMES services are expected to enable and stimulate the downstream sector by freely and openly providing access to basic pre-processed data and modelling outputs, more cheaply than would be the case if companies had to undertake such basic processing and modelling themselves. The business case for GMES is that the services improve the efficiency of the downstream sector, allowing the industry to offer better value for money in products and services to end users.
2. **Full and assured continuity of GMES**: In order for the potential of future markets for Earth Observation downstream services to be realised, the continued long-term availability of GMES data services is assumed. The investment incentives are crucially tied to both political and financial commitments at an institutional level. This continuity of services presupposes the continuity and evolution of GMES infrastructure providing the necessary data. Without continuity, the "raison d'être" of GMES is put into question, as users will only rely on GMES if a sustained flow of data is ensured. Without appropriate funding, existing services will cease their activities.

Furthermore, a set of **enabling factors** has been identified, on which action and associated investments are considered necessary for the realisation of downstream market potential. Certain institutional conditions are necessary to enable and accelerate the market dynamics foreseen in this study, linked, *inter alia*, to market development and capacity building. They are summarised below:

- a. **Regulation**: Free and open data policy; assurance of data continuity; quality assurance and standards-building.
- b. **Data Availability and Access**: Simplified access to GMES Sentinel datasets at ready-to-use processing levels (L1)<sup>3</sup> for high-volume distribution, thereby responding to the needs of the value-adding industry, ideally avoiding the duplication of efforts at national level.
- c. **Demand/Market**: Continued dissemination efforts; regional/local demand incubation and communication schemes aimed at commercial users; federation / consolidation of user needs and industry requirements; further integration of EO information as a supplement to traditional systems.

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<sup>1</sup> GMES will hereafter be referred to as Copernicus, following the recent decision by the European Commission to change the name of the programme (as per [http://europa.eu/rapid/press-release\\_IP-12-1345\\_en.htm](http://europa.eu/rapid/press-release_IP-12-1345_en.htm)).

<sup>2</sup> This refers, in the first instance, to data derived from the GMES family of dedicated satellites, the Sentinels. The transitory phenomenon of Contributing Mission data will be dealt with in a follow-on study on the midstream, scheduled for 2013.

<sup>3</sup> L1 includes geometric and radiometric pre-processing.

Examples of relevant enabling activities, which already exist in Europe, include:

- Tools for GMES Sentinel data pre-processing, which are already being piloted in selected Member States.
- The provision of support to the promotion of Space applications-related ideas (e.g. GMES Masters) and business incubators.
- Easy access to credit for entrepreneurs willing to invest in the value-added service sector.
- Support to training programmes in geospatial sciences to ensure availability of necessary talents for these applications.
- The building of networks and the organisation of dedicated events to consolidate user needs and industry requirements.

These activities should be built upon, extended and promoted in order for the full potential of the market to be realised. Under the EU's Horizon 2020 strategy, *"it is expected that around 15% of the total combined budget for all societal challenges and the enabling and industrial technologies will go to SMEs"*<sup>4</sup>.

### **3 INTRODUCTION TO SECTORAL ANALYSIS**

Increasing global demand for food production raises the need for innovative agricultural practices, which have to be sustainable in the long-term and more resource-efficient. Earth Observation (EO) applications for Precision Farming can substantially improve productivity and efficiency in the agricultural industry by introducing economies in the application of fertiliser.

## **4 THE AGRICULTURE INDUSTRY: TRENDS AND CHALLENGES**

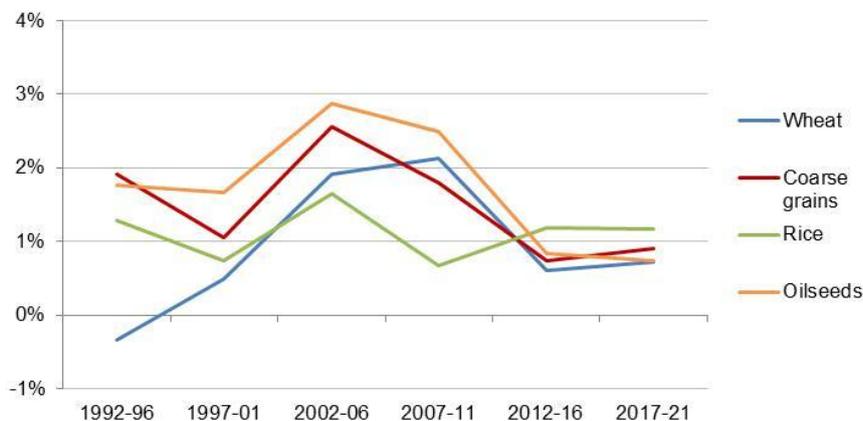
### **4.1 Recent trends**

While the demand for agricultural products continues to grow, there has been a distinct slowdown in yield growth rates in recent years, partly linked to the increasing pressure on resources.

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<sup>4</sup> COM (2011) 808, final, p. 10.

**Annual growth rate in yields for selected crops at world level, 1992-2021**



Source: OECD-FAO, Agricultural Outlook 2012-2021

**Figure 1: Annual Growth Rate in Global Yields for Selected Crops (OECD-FAO, 2012)**

However, yields are still well below their economically attainable potential. OECD refers to these losses as “yield gaps”. Improved crop management practices could, to some extent, close these gaps by addressing the suboptimal use of agricultural inputs. The farmers’ access to information and technical skills is crucial in this regard.

## 4.2 Challenges

The FAO estimates that agricultural production will need to increase by 60% globally (and nearly 77% in developing countries) by 2050 to cope with a larger, more urban and wealthier population. According to OECD, the necessary increases to future productivity in order to feed the growing population will depend on the protection of the resource base, on investments in research and development and on the industry’s ability to adopt the latest technologies.

The main challenge for the agriculture industry is to increase productivity and sustainability by means of **improved resource efficiency**, in other words, to produce using less water, energy, fertilisers (especially phosphorus and nitrogen) and pesticides.

**The need for increased agricultural productivity is already being translated into action through EU directives and policies, i.e.:**

- Various EU directives and policies are linked to the objectives of sustainable agriculture, e.g.:
  - The Rural Development Policy 2007-2013 aims at the competitiveness of the agricultural sector as well as to the improvement of the environment and of the quality of life in rural areas
  - The Water Framework Directive (2000) stipulates that groundwater must achieve “good quantitative status” and “good chemical status” (i.e. not polluted) by 2015
  - The Nitrate Directive (1991) aims to prevent nitrates from agricultural sources polluting ground and surface waters and to promote the use of good farming practices

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- The European Commission (COM(2012) 79) has identified two main targets for the European Innovation Partnership “Agricultural Productivity and Sustainability”:
  - **Increasing total factor productivity by 2020**
  - **Secure soil functionality in Europe at a satisfactory level by 2020**

These objectives can be attained through the use of **Earth Observation information**. In particular, **Precision Farming** techniques can dramatically improve productivity and efficiency in the agricultural industry and can facilitate the monitoring of the productive capacity of soil.

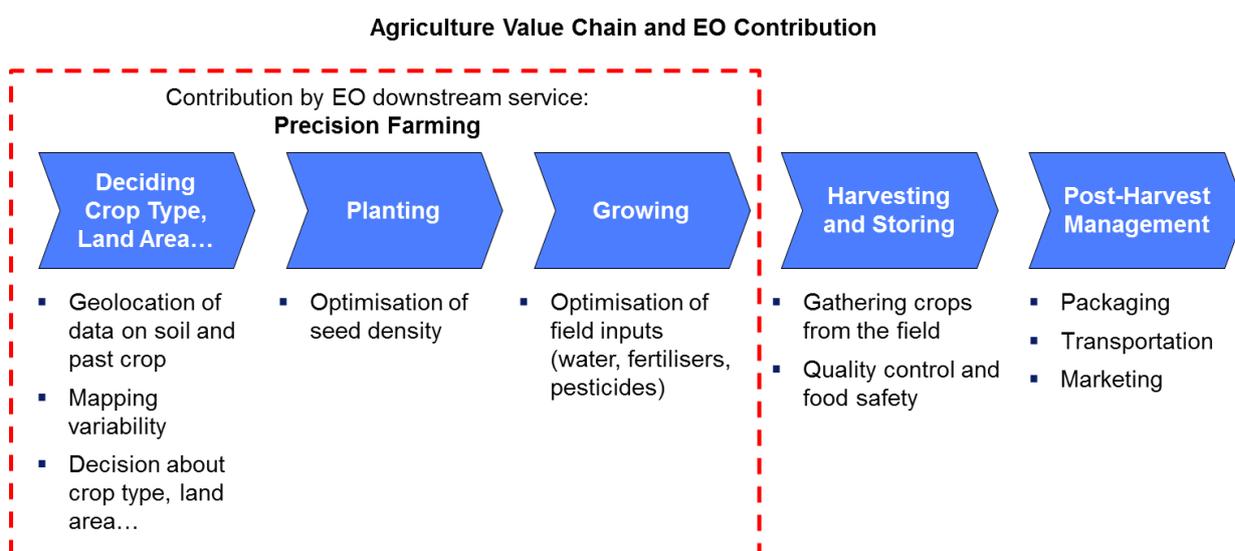
## 5 THE POTENTIAL USE AND BENEFITS OF EO DOWNSTREAM SERVICES

### 5.1 Use of EO information along the value chain

Precision Farming mapping products are the main application of EO in the agriculture industry. Precision Farming can be defined as a farming management system that utilises geospatial technology to support decision-making on a site-specific basis, allowing for more efficient utilisation of natural and anthropogenic resources (land, seeds, fertilisers, plant protection agents and water).

By precisely measuring the way in which fields reflect and emit energy at visible and infrared wavelengths, EO satellites can monitor a wide range of variables which affect crops, such as soil moisture, surface temperature, photosynthetic activity, and weed or pest infestations.

The map products resulting from EO applications are useful at several stages in the agriculture value chain. They allow the farmer to make better-informed decisions in planning, planting and growing the new crops, as shown in the following figure.



**Figure 2: The Role of EO Data in the Agriculture Value Chain**

## 5.2 Benefits of EO information

The benefits of using EO information in the Agriculture sector stem from cost reductions (through optimising the consumption of field inputs), profitability (through increased yield) and potential competitive advantages. The benefits are summarised in the table below:

<b>Cost reduction</b>	<ul style="list-style-type: none"> <li>• Savings on seed through optimising seed density during planting</li> <li>• Savings on water, pesticides and fertilisers</li> </ul>
<b>Profitability</b>	Increases to overall crop yield through variable rate nitrogen application
<b>Competitive advantage</b>	<ul style="list-style-type: none"> <li>• Improvements to the quality of crops due to increased protein content</li> <li>• More informed decision-making on crop type and land use</li> </ul>

**Table 1: Benefits of EO for the Agriculture Industry**

One of the most widespread applications of remote sensing information in Precision Farming is the production of Variable Rate Nitrogen Application maps. Nitrogen (N) is one of the main chemicals used for winter wheat fertilisation and comprises 15–25% of total operating costs. The nitrogen requirements of a growing crop can be assessed by monitoring the biomass and the colour of its canopy via remote sensing satellites.

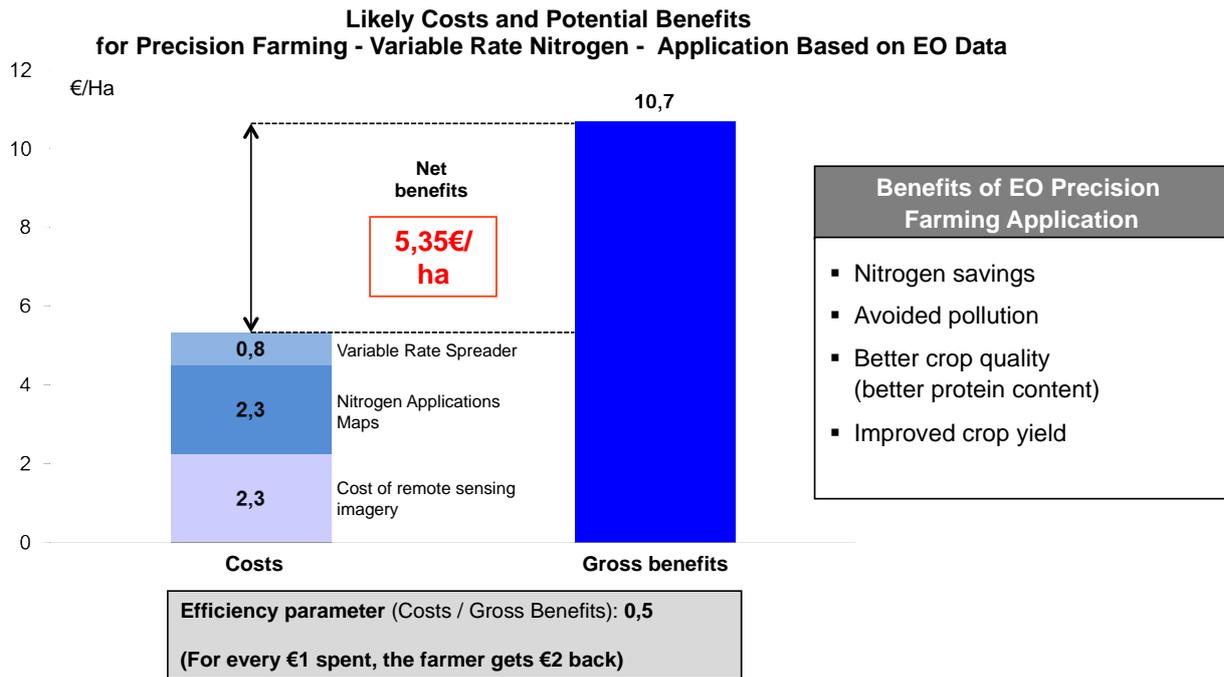
The benefits of using maps, which prescribe the appropriate fertiliser rate to the farmer’s machinery, are both of an economic and of environmental nature. The optimal application of nitrogen allows savings on the costs of fertilisers, better crop quality (thanks to the increased protein content) and improvement of the overall crop yield, yielding net economic benefits of more than € 5 per hectare.

<b>Problem description</b>	<ul style="list-style-type: none"> <li>• Nitrogen (N) is one of the main chemicals used for winter wheat fertilisation and forms about 15–25% of total operating costs</li> <li>• N is removed from the soil by plant growth; farmers replace it by applying mineral fertilisers, often in larger quantities than can be absorbed by new crops</li> <li>• Excessive N surpluses are dispersed into the water, air and soil, causing major environmental damage, a financial loss for the farmer and potential diseases for the crop</li> </ul>
<b>Solution logic</b>	<ul style="list-style-type: none"> <li>• N losses can be avoided by considering the heterogeneity related to the geomorphological features of the field and by matching the application of fertilisers with crop needs</li> <li>• High-yield areas have different N requirements than low-yield areas: thus, efficiency can be substantially increased by applying fertiliser at variable rates, selected to coincide with crop production potentials</li> </ul>
<b>Contribution of EO and Expected Key Benefits</b>	<ul style="list-style-type: none"> <li>• The yield potential of a growing crop (and, consequently, its nitrogen requirements) can be assessed by monitoring the biomass and the colour of its canopy via remote sensing satellites</li> <li>• It is estimated that the net benefits of using Variable Rate Nitrogen Application techniques are equal to more than € 5 per hectare using remote sensing imagery.</li> </ul>

**Figure 3: Key Highlights of Variable Rate Nitrogen Application**

The following case study illustrates the potential for EO value-added services in precision farming applications. Using satellite images to monitor growing crops allows the production of digital maps that serve as pattern for the appropriate fertiliser rate to be applied as required to a section of a field.

A cost-benefit analysis<sup>5</sup> shows that net economic benefits of more than € 5 per hectare can be achieved, thanks to savings in nitrogen, better crop quality (increased protein content) and increases to overall crop yield. A positive environmental impact is also gained by avoiding the dispersal of excessive nitrogen into the water, air and soil.



Sources: Knight, Miller and Orson (2009), An up-to-date cost/benefit analysis of precision farming techniques to guide growers of cereals and oilseeds, Home-Grown Cereals Authority (HGCA) Project No 3484

**Figure 4: Example of Expected Economic Benefits of Variable Rate Nitrogen Application**

<sup>5</sup> Knight et al., 2009.

The following table shows other examples of Precision Farming applications based on remote sensing information:

Application	Service Description	Example
<b>Yield mapping</b>	Ground Cover Map Assessment of growing crop Assessment of yield potential NDVI (Normalised Difference Vegetation Index) Map Soil Brightness Map	
<b>Input management</b>	Relative Chlorophyll Map Lodging risk estimate Variable Rate Nitrogen Application recommendation	
<b>Farm management recording</b>	Final crop assessment	

Table 2: Example of Applications of Remote Sensing Data in Agriculture

European institutions have launched initiatives related to the use of Earth Observation for the Agriculture sector, for example:

- The Joint Research Center (JRC) started the **Monitoring Agricultural ResourceS (MARS)** Project in 1998.
  - The project is made up of four Actions (GeoCAP, AGRI-ENV, AGRI4CAST and FOODSEC)
  - It provides information to European policy-makers in the agricultural field in order to support policy development, implementation and review
- ESA launched the **TalkingFields** initiative in 2010, which is currently in the third and final year of the demonstration phase
  - The service combines Navigation technologies with Earth Observation to deliver spatial information about the development of the crop, providing decision support for the farmer based on his individual needs.
  - The service provider prepares the specific products which assist the farmer with his management decisions; the farmer, based on his personal experience as well as on Navigation information, performs the necessary actions in the specific location

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- The Copernicus Land Monitoring service (through FP7 **geoland2**) provides AgriEnvironmental Services to improve the timely and accurate monitoring of agricultural land use
  - Objectives: to develop and improve agri-environmental indicators assessing (i) agricultural land use and trends; (ii) farming pressure on water and soil resources; (iii) impact of agricultural land use changes on biodiversity and landscapes.
  - These indicators will be generated simultaneously on four selected demonstration sites and at two scales (the national scale to provide an overview of the general status of the site and the hot spot areas scale requiring more specific monitoring techniques)
- In addition, **the potential for EO use in Precision Farming is recognised beyond the EU:** for example, a Bavarian-Russian Industrial Research project (GEOFARM) is testing the application for use in the large “black-earth” Wheat Belt of Russia, thereby enabling exports of “intelligent” agri-equipment made in Germany.

## 6 DOWNSTREAM MARKET FORECAST

### 6.1 Relevant statistics and parameters

The Farm Structure Survey (FSS) is conducted every two to three years by Eurostat. The latest data available (2007) show that the number of agricultural holdings across Europe is constantly decreasing, whereas the Utilised Agricultural Area (UAA) has been relatively stable (revealing only a slight decrease of 0,5% from 2003 to 2007) - occupying one third of the territory of the European Union. The average size of a holding for the EU-27 is 22 ha, but large discrepancies exist between Member States: the average UAA per holding in Slovakia is 110 times larger than in Malta. There is a general tendency towards an increase in the average area of farms, related chiefly to the decline in the number of holdings.

Regarding the size of the labour force, there has been a clear reduction in the number of persons working in agriculture from 2003 to 2007 (-11,8 %). According to an ESA study on the EO service industry, the agriculture sector accounts for around 8% of European revenue from EO product and services.

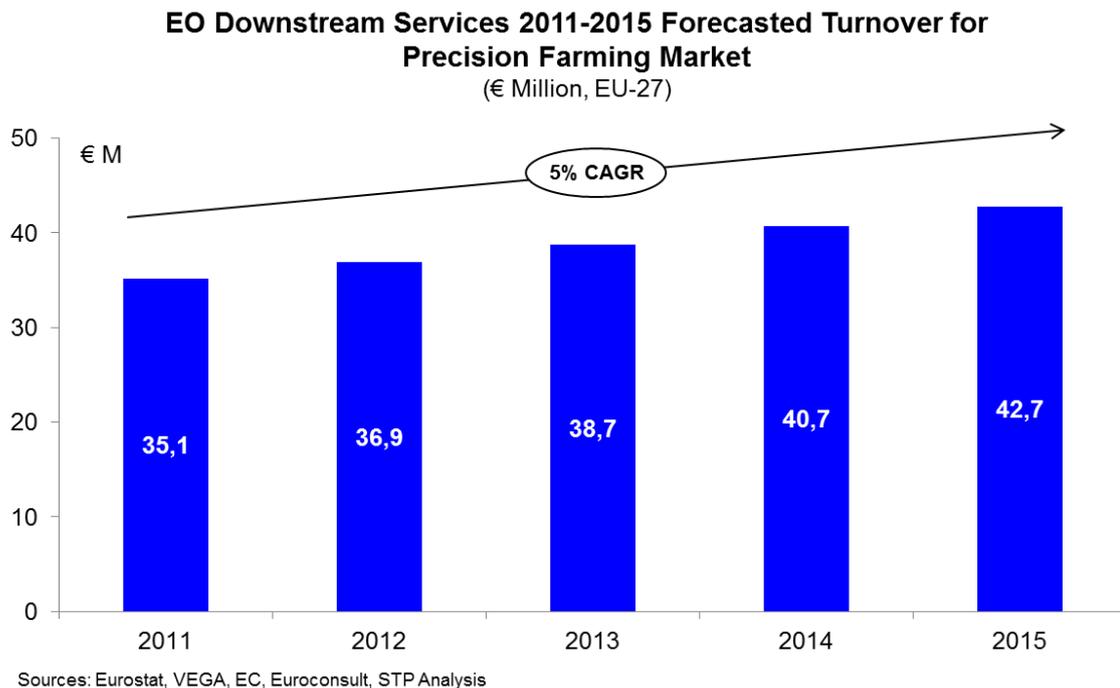
The following table summarises relevant figures on the European agricultural sector.

<b>Number of agricultural holdings</b>	10,4 Mn
<b>Utilised agricultural area (UAA)</b>	172,4 Mn ha
<b>Number of employees</b>	13,7 Mn
<b>Value of crop production</b>	€ 186 Bn
<b>Purchase of goods and services</b>	€ 213 Bn
<b>European revenue from EO product and services to agriculture sector as a % of total EO VAS market</b>	8%
<b>% of EO downstream services spend on total purchase of goods &amp; services in 2011</b>	0,02%

**Table 3: Relevant Statistics and Parameters on the Agriculture sector (Eurostat; ESA, 2008; Euroconsult, 2011)**

## 6.2 Market forecasts

The European market for commercial applications of EO downstream services in agriculture is estimated to be approximately € 35 million in 2011 and approximately € 43 million in 2015<sup>6</sup>.



**Figure 5: EO Downstream Service Short-term Forecast for Precision Farming**

The long-term market potential for the sector has been assessed through the concept of the Total Addressable Market (TAM). This concept expresses hypothesised market penetration, under specific assumptions and within certain limitations. It serves as a metric of the underlying revenue potential of a given opportunity, and should be treated as a “bounded theoretical maximum”.

Based on information about the European Agriculture market collected through Eurostat and DG AGRI publications the estimated EO Downstream Services Total Addressable Market (TAM)<sup>7</sup> for the Agriculture sector amounts to approximately € 0,4 billion<sup>8</sup>. This result is hinged on the assumption that only larger and more profitable farms are likely to be able to afford the service, thanks to the economies of scale possible in large agricultural operations.

<sup>6</sup> The 2011 market size has been computed using data from Euroconsult (2011) and from ESA-VEGA (2006) about the total European EO VAS market for the agriculture sector; the 2015 estimate is computed by applying a 5% Compound Annual Growth Rate to the 2011 market size.

<sup>7</sup> This concept expresses hypothesised market penetration, under specific assumptions and within certain limitations. It serves as a metric of the underlying revenue potential of a given opportunity, and should be treated as a “bounded theoretical maximum”.

<sup>8</sup> To estimate the Total Addressable Market for EO VAS services, the price of VAS products per hectare (€ 6) has been multiplied by the total hectares of Utilised Agricultural Area of all those farms that have an Economic Size larger than 16 ESU and that are larger than 100 ha.

## 7 IMPACT OF COPERNICUS DATA AND SERVICES

While the use of space technologies for the implementation of agriculture policies (CAP) or for monitoring the environmental impacts of agricultural activities is now quite consolidated, the market for EO value-added services for the agriculture private sector is still limited. The widespread use of satellite imagery in the actual planning, production and growth stages of the agriculture value chain has so far been hampered by the non-availability or non-affordability of data. The Copernicus programme, by providing free, open and easily accessible EO information, can help in overcoming some of the factors that inhibit the widespread use of Precision Farming techniques. The following table showcases the contribution of the Copernicus programme in enabling the development of the market for EO services in agriculture.

Obstacle	Copernicus enabling capacity	
<b>Technological factors</b> Serviceable area is currently limited by acquisition capacities; Leaf Area Index (LAI) estimates not accurate	4	Sentinel 2 increasing acquisition capacities and providing enriched services to monitor crops in their late cycle phase
<b>Socio-economic factors</b> Less educated farmers are less likely to adopt Precision Farming techniques	2	User uptake initiatives providing training and raising awareness
<b>Agro-ecological factors</b> Smaller farms with lower soil quality cannot afford Precision Farming techniques	4	Cheaper downstream services affordable for smaller farmers with poorer fields as well
<b>Institutional factors</b> Not all farmers face the same pressure for improving the environmental sustainability of their activities	1	Contributing at EU level to political awareness of the need for sustainable agriculture
<b>Informational factors</b> Not all farmers can easily find local providers of Precision Farming products	4	Easily accessible downstream services, delivering timely and high quality products (Sentinel 2)
<b>Farmers' perception</b> Farmers need to be convinced of the profitability of Precision Farming techniques	3	Cheaper downstream services combined with user uptake initiatives raising awareness
<b>Technological factors</b> Not all farmers are familiar with farm management technologies	2	User uptake initiatives providing training and raising awareness
<b>Legend:</b> 1 Low contribution; 2 Medium contribution; 3 Medium-high contribution; 4 High contribution		

**Table 4: Obstacles to Diffusion and the Enabling Capacity of Copernicus**

### 8 CASE STUDY

An example of a commercial Precision Farming product based on satellite imagery is FARMSTAR, made available in France since 2003 by Astrium Services. By 2011, coverage was 440.000 hectares and 10.000 farmers had subscribed to it. The average price for FARMSTAR services to the farmer is € 10/ha, generating approximately € 4,4 million in turnover for Astrium Services in 2011.

More than 20 agricultural cooperatives and three Chambers of Agriculture distribute the information to farmers; in this way, smaller farmers are also able to afford the service (the average size of the farms which receive FARMSTAR recommendations is 44 ha).

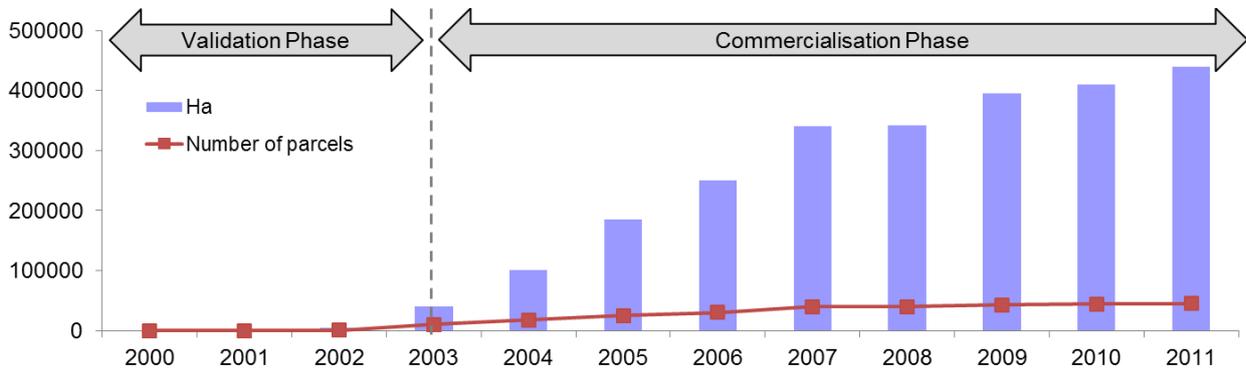


Figure 6: The Growth of FARMSTAR from 2000 to 2011

FARMSTAR uses a multi-step approach to generate crop recommendations for farmers. Satellite images, weather data and ground-based information are integrated into agronomic models developed by Arvalis-Institut du Végétal and CETIOM. The ‘recommendation or advice cards’ produced are ready to be used by the farmer.



Figure 7: The Value Chain of the FARMSTAR Product

## 9 CONCLUSIONS

Increasing global demand for food production raises the need for innovative agricultural practices, which have to be sustainable in the long-term and more resource-efficient. While the demand for agricultural products continues to grow, there has been a distinct slowdown in yield growth rates in recent years, partly linked to the increasing pressure on resources.

The main challenge for the agriculture industry is to increase productivity and sustainability by means of **improved resource efficiency**, in other words, to produce using less water, energy, fertilisers (especially phosphorus and nitrogen) and pesticides. Earth Observation (EO) applications for Precision Farming can substantially improve productivity and efficiency in the agricultural industry

The benefits of using EO information in the Agriculture sector stem from cost reductions (through optimising the consumption of field inputs), profitability (through increased yield) and potential competitive advantages (through improvements to crop quality and more informed decisions on crop type and land use). The net economic benefits<sup>9</sup> of using EO-based Precision Farming techniques, such as Variable Rate Nitrogen application maps, have been estimated at over € 5 per hectare. A positive environmental impact is also achieved by avoiding the dispersal of excessive nitrogen into the water, air and soil.

GMES Sentinel-2 can contribute to overcoming certain service limitations in existing precision farming products, thanks to increased acquisition capabilities, larger swath offers and more accurate leaf area index estimates.

The current market for commercial applications of EO downstream services in agriculture is estimated to be approximately € 34 million. The estimated EO Downstream Services Total Addressable Market for the agriculture sector amounts to € 0,4 billion. This result is hinged on the assumption that only larger and more profitable farms are likely to be able to afford the service, thanks to the economies of scale possible in large agricultural operations.

The fulfilment of market potential and the time required for this potential to be fulfilled are subject to a set of important enabling factors:

Regulatory factors, including a free and open data policy and assurances of data continuity;

- Supply side factors such as data processing, access and availability;
- Market development activities, such as out-reach and user engagement and federation and consolidation of user needs and industry requirements.

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<sup>9</sup> Knight et al., 2009.

## 10 RELEVANT LITERATURE

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- Presentations from the “Sentinel-2 Preparatory Symposium” (sessions “Agriculture I” and “Agriculture II”), organised by ESA and held in Frascati (IT) on 23-27 April 2012 (<http://www.s2symposium.org/>)
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