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**REPORT FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT AND  
THE COUNCIL**

**on the implementation of the remote sensing applications and on the use of the financial  
resources made available to it under Council Regulation (EC) No 78/2008**

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### 1. INTRODUCTION

Detailed information on the use of agricultural land and the conditions of arable crops is essential to the quality of yield and agricultural production forecasts. Such information is of particular use for market monitoring and the management of related market measures under the single Common Market Organisation. In this context, the European Union has made substantial efforts to develop and improve innovative technologies and models specifically related to remote-sensing applications. The experience accumulated has shown that remote-sensing provides independent information of high quality which cannot be obtained from traditional agricultural statistics and forecasting systems.

Council Regulation (EC) No 78/2008<sup>1</sup> provides the legal framework for these remote-sensing activities for the period 2008-2013.

The remote-sensing applications supported under this framework provide useful information to the Commission, to interested Member States, to research institutes and to other users, through the dissemination of different products. Since its creation, the system has been continuously improved. Additionally to the primary objective of producing yield and harvest forecasts, the system also provides useful insights into other fields relevant to EU agriculture such as climate change.

Article 4 of Regulation (EC) No 78/2008 provides that the Commission shall submit a final report no later than 31 July 2013 on the implementation of the remote-sensing measures and on the use of the financial resources made available to it under the Regulation. This report is drawn up in view of a continuation of these measures within the framework of the Common Agriculture Policy (CAP) beyond 31 December 2013.

The report elaborates on a possible scenario for continuation of the existing MARS Crop Yield Forecasting System for the EU and of an extension to a wider global coverage with the objectives of further improving yield forecasts for the EU and of contributing to the international initiatives launched by G20 agricultural ministers.

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<sup>1</sup> Council Regulation (EC) No 78/2008 of 21 January 2008 on the measures to be undertaken by the Commission in 2008-2013 making use of the remote-sensing applications developed within the framework of the common agricultural policy, *Official Journal of the European Union*, L 25 of 30 January 2008, p. 1.

## 2. THE MARS CROP YIELD FORECASTING SYSTEM

The Mars Crop Yield Forecasting System (MCYFS) started in 1988 as a 10-year pilot project to produce crop yield and harvest forecasts. The activity, which was then called Monitoring Agriculture with Remote Sensing (abbreviated MARS), concentrated on the assessment of crop yields and production volumes of various crops within the EU, on the basis of meteorological analysis, agro-meteorological simulated crop growth indicators, low-resolution satellite data and statistical analysis.

From 1999 onwards this activity was carried out under the legal basis of Decision 1445/2000/EC<sup>2</sup> for the period 1999-2003 and its extension for the period 2004-2007 with Decision 2066/2003/EC<sup>3</sup>. Since 2008 and until 2013, the activity is implemented under Council Regulation (EC) No 78/2008. The MCYFS is operated within the AGRI4CAST Action in the Institute for Environment and Sustainability (IES) of the Joint Research Centre (JRC).

The MCYFS is a complex, integrated analysis tool addressing the objectives set in the Regulation, more specifically the monitoring of crop conditions, yields and agricultural production.

The system consists of several independent modules, which are integrated to monitor crop behaviour and to produce crop yield forecasts. From a technical point of view, the MCYFS includes: 1) the maintenance of a meteorological database (see Article 1(2)(a) of the Regulation); 2) the application of agro-meteorological models (see Article 1(2)(d)); 3) the processing of low resolution satellite data (see Article 1(2)(a)); 4) statistical analyses and yield forecasts of the main crops at national level across the EU (see Article 1(2)(b)) as well as visualization tools. The MCYFS is run operationally covering the whole European Continent, the Maghreb countries and Turkey. The crops covered by the simulation models are soft wheat, durum wheat, winter and spring barley, grain maize, rapeseed, sunflower, potato, sugar beet, pasture, rice, and other cereals.

### *(1) Meteorological database*

Meteorological data are collected from meteorological stations throughout Europe, then quality checked and further processed, and finally analysed. As such this meteorological database can be used to trigger risk warnings (e.g. detection of abnormal weather conditions during a given month). Furthermore weather forecast data from the European Centre for Medium-Range Weather Forecasts are analysed to prepare outlooks on weather conditions affecting agricultural land.

### *(2) Agro-meteorological models used for crop growth simulation*

Agro-meteorological models are run to convert the meteorological data into estimations on crop biomass production. The tools used are the Crop Growth Monitoring System (the

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<sup>2</sup> Decision 1445/2000/EC of the European Parliament and of the Council of 22 May 2000 on the application of aerial-survey and remote-sensing techniques to the agricultural statistics for 1999 to 2003, Official Journal of the European Communities L 163 of 4 July 2000, p. 1.

<sup>3</sup> Decision 2066/2003/EC of the European Parliament and of the Council of 10 November 2003 on the continued application of areal-survey and remote-sensing techniques to the agricultural statistics for 2004 to 2007 and amending Decision 1445/2000/EC, Official Journal of the European Union L 309 of 26 November 2003, p. 9.

World Food Study model - WOFOST - adapted to the European scale), the pasture model LINGRA and the rice model WARM (Water Accounting Rice Model).

Additional information, such as soil parameters, crop calendars, crop practices and crop parameters, is utilised to produce the simulations. At this level, many crop specific indicators/predictors (e.g. potential biomass) are produced and transferred to the statistical analysis for the production of quantitative yield forecasts. These elements also contribute to the assessment of crop conditions (Article 1(1)(b) of the Regulation). Outputs include maps indicating extreme temperature at a given crop stage, simulations of biomass and grain production, estimations of actual soil moisture reserve, the crop development stage in a given month, and the divergence from the long-term average at a given decade or period within the growing season for any agro-meteorological indicator.

### *(3) Low resolution satellite data*

Remote-sensing applications feed into the system at all the levels and contribute to improve the agricultural forecasting models as well as to establish regionally-based models. Information from meteorological satellites is used in addition to the data delivered by meteorological stations (e.g. radiation measured by satellites at the resolution level of 5 km). The remote-sensing information is processed to produce “measured” vegetation indicators, which can be compared with the agro-meteorological indicators and used for the statistical analysis. Low to medium resolution satellite sensors are utilised: SPOT Vegetation/NOAA-AVHRR (about 1 km resolution) and MODIS (about 300-500 m resolution)<sup>4</sup>.

### *(4) Statistical analysis*

The indicators obtained from the meteorological database, the agro-meteorological database and the remote sensing database are compared to the yield time series and analysed with statistical methods (e.g. regression or scenario analysis). The final results are quantitative yield forecasts which, together with the analysis of the abovementioned outputs, are published in the MARS bulletins. Data available in the system cover a long period of time, starting in 1975.

### *(5) Visualization tools and dissemination of outputs*

The databases (meteorological information, agro-meteorological information, remote-sensing information) can be explored by users via information tools. AGRI4CAST maintains a web portal where remote-sensing data can be screened and downloaded and a portal where the meteorological and agro-meteorological information can be viewed and downloaded in the form of electronic maps. It is also possible to download the analysis on crop conditions and yield estimates. All elements listed above are utilised for the preparation of bulletins and specific studies on climatic conditions (see Article 1(2)(c)). They provide the analyses of the crop situation in different regions of the EU, maps of weather and crop indicators and yield expectations. The MARS Bulletin is published regularly during the main growing season on paper and on the internet.

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<sup>4</sup> The abbreviation SPOT stands for "Satellite Pour l'Observation de la Terre", NOAA stands for National Oceanic and Atmospheric Administration and AVHRR for Advanced very high Resolution Radiometer, MODIS stands for Moderate Resolution Imaging Spectroradiometer.

### **3. IMPLEMENTATION**

#### **3.1. Overall implementation**

For the continuation of the operational services from 2008 until 2013 according to Council Regulation (EC) No 78/2008, a new project, called MARSOP3, has been launched. It focuses on the provision of operational near-real time products to the JRC for the monitoring of agricultural production and yield in Europe. In August 2007 a call for tender (Operational activities for MARS actions -MARSOP3- 2008-2013, Contract Notice N° 2007/S 154-191094) was published in the supplement of the *Official Journal of the European Union*. After the evaluation of the offer for Lot I (meteorological data) and Lot II (acquisition and processing of satellite data) and the favourable opinion of the Public Procurement Advisory Group, a contract was signed with a consortium led by Alterra BV. On the basis of the operational products delivered within this contract, the JRC analyses crop conditions and prepares yield and production estimates. This information is made available to the Member States and the general public.

#### **3.2. Implementation with regard to Article 1 of Council Regulation (EC) No 78/2008**

Article 1 of Council Regulation (EC) No 78/2008 sets the objectives for the implementation of remote-sensing measures (Article 1(1)) and provides details on the measures to be undertaken (Article 1(2)). For ease of reference, the description of the implementation of the measures follows the structure of Article 1.

##### *3.2.1. Aims of the implemented measures (Article 1(1))*

###### *Article 1(1)(a): management of agricultural markets*

The activity delivers independent, timely, scientific and traceable crop yield forecasts for all Member States and EU neighbouring countries for selected arable crops. This information is utilised by the Commission services for the following main purposes: 1) update of crop supply balance sheets; 2) assessment of climatic conditions and potential impacts of particular weather events in the Member States or regions (e.g. impact of a late frost event); 3) monitoring of crop conditions in third countries. AGRI4CAST yield forecasts are also provided to the Early Estimate System of Eurostat. Independence and reliability of the outputs prepared by AGRI4CAST are viewed as important assets by the Commission services. The statistical analysis performed with the crop growth indicators is transparent, traceable and stored for all crop simulations and years. A set of statistical indicators (e.g. root mean square error for different confidence intervals, standard deviation) is provided for each of the models. At the end of the forecasting campaign, an error analysis compares the crop yield forecasts with the actual observed yields to quantify the forecast error and to evaluate the forecasting performance.

For information, the overall error, measured as the mean absolute percentage error of the end-of-campaign forecast for the EU-27 across all months and for all cereals together, has been 1.6 % for 2007, -3.3 % for 2008, -1.2 % for 2009, and 1.2 % for 2010, respectively, with negative values indicating an underestimation, positive values an overestimation of reported yields (reported yields of 2009 and 2010 are still preliminary).

*Article 1(1)(b): monitoring of crop conditions and estimates*

Besides yield forecasts, crop conditions are closely monitored throughout the growing season. Meteorological and remote-sensing information is analysed and linked to relevant crop information based on the results of biophysical modelling (e.g. impact of a heat wave, a dry spell, or a cold shock at certain crop development stages). Furthermore, outputs of the crop growth model are directly used to assess crop conditions (e.g. simulated leaf area index or simulated biomass). This monitoring covers the EU and applies to all the included crops.

*Article 1(1)(c): promotion of access to the estimates*

An open access to the various outputs is guaranteed by the websites maintained by the JRC and by the MARSOP3 consortium. The MARSOP website offers a wide range of information (results from the applied remote-sensing measures, crop growth model outputs, links to the bulletins). Satellite data and images are organised into an image server where the data can be viewed and downloaded. It is also possible to request and download meteorological data from the MARSOP website.

*Article 1(1)(d): ensuring the technological follow-up of the agro-meteorological system*

The JRC performs a constant technical follow up to ensure the continuity of the system and to guarantee the scientific robustness of the methodologies applied. These methodologies include the interpolation of the meteorological data onto a raster, the derivation of remote sensing measures to describe the growing behaviour of crops or the statistical analysis performed to obtain the crop yield estimates.

3.2.2. *Measures to be implemented (Article 1(2))*

*Article 1(2)(a): collection and purchase of meteorological and satellite data*

The collection and purchase of meteorological data comprises more than 3500 stations delivering information on weather parameters, which are fed into the MCYFS on a daily basis. This service is permanently maintained. Freely available remote sensing data from low and medium resolution satellites (1 km to 300 m pixel resolution) devoted to vegetation monitoring are also acquired, stored, further processed and analysed.

*Article 1(2)(b): spatial data infrastructure and website*

Spatial data infrastructure comprises the technology, standards, human resources and related activities necessary to acquire, process, distribute, use, maintain and store spatial data. This infrastructure has been put in place with the MCYFS, involving teams at the JRC and under the MARSOP3 contract. It covers spatial data sets for the whole of Europe at different scales. The data are processed to account the needs of crop condition monitoring and forecasting of crop production. The outputs and information resulting from the different sources (e.g. remote-sensing) are available via different websites and web portals.

The infrastructure complies with the framework set by the Infrastructure for Spatial Information in the European Community (INSPIRE) Directive<sup>5</sup>: The spatial data are geo-referenced according to the INSPIRE projection, the metadata description follows the INSPIRE principles and will be further harmonized. The MCYFS will share, through an INSPIRE compliant Geoportal, the spatial resources available in the Data Base on selected data of the MCYFS on weather, crop information and remote sensing

*Article 1(2)(c): specific studies on climatic conditions*

The system allows the preparation of specific studies on the climatic conditions thanks to the large array of information available covering all relevant aspects. Reports on impacts of extreme weather events on crops at EU level but as well on more specific regions, were prepared and delivered to the Commission under Council Regulation (EC) No 78/2008.

*Article 1(2)(d): updating of agro-meteorological and economic models*

Besides the operational running of the system, models and related databases are updated continuously. The database contains currently three terra bytes of information. Since the Council Regulation entered into force, major improvements have taken place: The meteorological station network has been increased to ensure a better monitoring system; the resolution of the former 50 km x 50 km grid for the spatial analysis has been improved to 25 km x 25 km; new crop calibrations have been performed; and a new database and software version has been released.

#### **4. DELIVERABLES AND OUTPUTS**

The Commission, the Member States and other interested stakeholders receive the different deliverables; reports and bulletins on the one hand and information services and data on the other hand. All products are available electronically (Article 2 of the Regulation) and partially on paper format.

*Reports and Bulletins*

The crop monitoring bulletin for Europe offers, in near real time and operational context, information and analyses on crop growth monitoring and yield forecasting. Countries covered are those of the EU and neighbouring regions (Maghreb, Black Sea area). The crops covered are soft wheat, durum wheat, winter barley, spring barley, grain maize, rapeseeds, sunflower, sugar beet and potato. A full analysis is published on the internet six times per year and supplemented by updated yield estimates two or three times per year. Special bulletins are prepared for pastures and rice in the EU. Updates and reviews of agro-meteorological conditions are provided between the full analysis bulletins (10-12 times per year). All these publications are available in the internet or in paper format upon request.

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<sup>5</sup> Directive 2007/2/EC of the European Parliament and of the Council of 14 March 2007 establishing an Infrastructure for Spatial Information in the European Community (INSPIRE), Official Journal of the European Union L 108 of 25 April 2007, p. 1.

### *Information services and data*

A large variety of information about the current agricultural production season in Europe and other important agricultural areas in the world is offered on the MARSOP web viewer and pages. Available products include graphs and maps of weather indicators based on observations and numerical weather models, graphs and maps of crop indicators based on agro-meteorological models and graphs and maps of vegetation indices and cumulated dry matter based on remote sensing images.

## **5. BUDGET RESOURCE USE**

Expenditure 05.080300 implementation of regulation 78/2008

2008	€7,298
2009	€2,370,340
2010	€1,414,851
2011	€1,443,813
2012	€1,449,048
2013 (planned)	€1,570,734
TOTAL	€8,346,084

## **6. CONCLUSIVE REMARKS AND FUTURE OF THE ACTIVITY**

The MARS System has provided effective and timely information and objective data in support to the decision making process for the deployment of the CAP. Beyond the primary objective of producing harvest yield and production forecasts, the system also provides useful insights into other fields relevant to EU agriculture such as climate change issues. Moreover, the MARS agro-meteorological system and remote-sensing applications have provided useful information not only to the European Commission but also to interested Member States, research institutes and other users, through the dissemination of products.

Therefore the Commission has proposed to continue the MCYFS via article 22 of the draft Regulation of the European Parliament and the Council on the financing, management and monitoring of the common agricultural policy COM(2011) 628 on which a political agreement among Institutions was reached on 26<sup>th</sup> June.

The continuation of the MARS Crop Yield Forecasting System could include new activities to follow the needs of the CAP, which evolves and adapts to a changing global economic environment. In this context, independent and reliable information at world level is a basic requirement to ensure the correct and effective decision-making process within the EU. The new activities might include:



- (1) A MCYFS enlarged to other main production areas of the world and to additional relevant crops;
- (2) A modelling tool extended to EU crops other than those currently covered (e.g. to rye, oats, triticale, sugar cane, soy bean);
- (3) A more complete modelling of pasture systems able to provide quantitative estimates of biomass production.

As regard point 1, a project called GLOBCAST (GLOBal Crop Monitoring and ForeCASTing) will end in 2014. The aim of the GLOBCAST project is to study the enlargement of the MCYFS to other areas of the world (Commonwealth of Independent States' countries, Argentina, Brazil, China, India, Australia, Canada and the USA) and to other crops than the ones already covered by the MCYFS, (wheat, barley, rape seed, sugar beet and potatoes), such as other crops of global interest and impacting our internal market i.e. soybean, rice and sugar cane. The GLOBCAST project includes a cost analysis of the extension of the system to other areas of the world and crops upon which a possible extension of the MCYFS will be decided. The legal basis to cover the extension is the same that will be used for the MCYFS, i.e. article 22 of the Regulation of the European Parliament and the Council on the financing, management and monitoring of the common agricultural policy COM(2011) 628.

Extending MARS Crop Yield Forecasting System to production areas beyond Europe and to additional crops of importance for EU food security but also for international responses to food shortage would improve the quality of information needed for the management of the internal market management. Besides it would provide a major contribution to the G-20 initiative on food security and price volatility, in particular to the Agriculture Market Information System (AMIS), included in the "Action Plan on Food Price Volatility and Agriculture"<sup>6</sup> adopted by the G-20 Agriculture Ministers. This would in particular contribute to reinforcing the capacity to produce and disseminate timely accurate crop production forecasts on a national, regional and global scale.

Synergies are in development with the COPERNICUS Programme (Land Component) regarding the procurement and pre-processing of satellite data which could benefit the MARS Crop Yield Forecasting System.

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<sup>6</sup> [http://agriculture.gouv.fr/IMG/pdf/2011-06-23\\_-\\_Action\\_Plan\\_-\\_VFinale.pdf](http://agriculture.gouv.fr/IMG/pdf/2011-06-23_-_Action_Plan_-_VFinale.pdf)