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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
(second interim report)**

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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 ¹ 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 European 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 second interim report is drawn up in view of a continuation of these measures within the framework of the 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.

¹ 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/EC² for the period 1999-2003 and its extension for the period 2004-2007 with Decision 2066/2003/EC³. 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.

More detailed information concerning the system and its outputs can be found in the accompanying Commission Staff Working Document.

(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 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.

³ 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.

(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 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)⁴.

(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

⁴ 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.

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.

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 European Commission, Member States and EU citizens.

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) Directive⁵: The spatial data are geo-referenced according to the INSPIRE projection, the metadata description follows the INSPIRE principles and will be further harmonized.

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. The following specific studies were prepared since Council Regulation (EC) No 78/2008 entered into force:

- Analysis of the impact of the spring-summer drought and the abundant rain in August 2008 on winter cereals production in Latvia
- Analysis of the impact on agriculture of extreme weather conditions during several days of July and August 2008 in Slovenia
- Water availability for rice growing in Spain in 2008 (analysis of cumulated rainfall)
- Analysis of the impact of 2009 winter frost events on winter cereals in Europe
- Analysis of the weather conditions during the spring/summer 2010 and their possible impact on agricultural production in Belgium
- Analysis of the weather conditions during the autumn and winter of 2009/10 and their possible impact on agricultural production in Spain
- Analysis of the weather conditions during the spring and summer 2010 and their possible impact on agricultural production in Hungary
- Analysis of the autumn and winter 2009/10 weather conditions and their possible impact on agricultural production in Italy

⁵ 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.

- Analysis of the weather conditions during the winter and spring in 2010 and their possible effect on agricultural production in Lithuania
- Analysis of the 2010 rainfall conditions and their possible impact on agricultural production in Romania
- Analysis of the weather conditions during the 2009/2010 crop season and their possible impact on agriculture in Luxemburg

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 densified 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 European Commission, 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.

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

Table 1. Use of financial resources under Council Regulation (EC) No 78/2008 in 2008, 2009, 2010, and 2011 (payment credits, in € * = committed, ** = paid until moment of writing)

	2008		2009		2010		2011 (preliminary)	
	Amount	Short description	Amount	Short description	Amount	Short description	Amount	Short description
LOT 1 / phase 1			1 016 084	Interim and final payment				
LOT 1 / phase 2			283 185	Interim payment	424 777	Final payment		
LOT 1 / phase 3					288 707	Interim payment	433 061	Final payment
LOT 1 / first renewal phase 3							302 544*	Interim payment
Additional meteorological stations for LOT 1			67 800	Near real time stations (more than 250)	0	NRT and archive stations	21 600**	Archive stations
LOT 2 / phase 1			387 720	Interim and final payment				
Lot 2 / phase 2			137 989	Interim payment	206 984	Final payment		
Lot 2 / phase 3					135 143	Interim payment	202 715	Final payment
Lot 2 / first renewal phase 3							141 620*	Interim payment
MARS Database and information technology (IT) support	97 298	MARS DB and information systems maintenance and development	477 562	MARS DB and information systems maintenance and development	359 239	MARS DB and information systems maintenance and development	333 196*	MARS DB and information systems maintenance and development
TOTAL	97 298		2 370 340		1 414 851		1 443 608*	

Lot 1 covers the procurement of meteorological and weather forecast data (including the densifying of network of meteorological stations). It covers the operational run and maintenance of the crop growth models operated within the MCYFS. Results in the form of database updates and maps are delivered to the database at the JRC daily or every ten days. Appropriate tools for exploitation of the results are maintained and developed. Maintenance and improvement of MARSOP website is also part of this lot together with overall coordination and management.

Lot 2 covers the processing of remote-sensing data. The work performed covers all data enhancement steps between the acquisition of the raw imagery and the delivery of 10-daily composites (data ingestion, calibration, etc.).

Mars database and IT support: the MCYFS calls for the provision of IT services to ensure a timely production of bulletins. Work performed covers the management and maintenance of the database with all the remote sensing data, the meteorological data and the agro-meteorological indicators. Development and maintenance of analysis tools and websites are part of this component.

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 Common Agricultural Policy (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.

The possible 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 would 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);
- (3) A more complete modelling of pasture systems able to provide quantitative estimates of biomass production.

As regard point 1, in 2011 DG AGRI launched a project called GLOBCAST (GLOBAL Crop Monitoring and ForeCASTing) through an Administrative Arrangement with the JRC that will end in 2013. The aim of the GLOBCAST project is to study the enlargement of the MCYFS to other areas of the world (Russia and CIS countries, Argentina, Brazil, China, India, Australia, Canada and the USA) and to other crops of interest, like soybean

and sugar cane. In the first year the JRC will re-visit the existing data and will adapt the software and modelling tools to organise and implement the future pre-operational system in the years 2012 and 2013. According to the assessment of the GLOBCAST project, the resulting activities could be thereafter included in the MARS programme for yield forecasts.

The GLOBCAST project aims to provide a major contribution of the EU to the recent 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"⁶ adopted by the G-20 Agriculture Ministers. An extended MARS Crop Yield Forecasting System will contribute to AMIS via the Group on Earth Observation (GEO), which has as an objective to reinforce the capacity to produce and disseminate timely and accurate crop production forecasts on a national, regional and global scale. The EC is committed to participate in those initiatives with data and information on markets, stocks and productions. Deliverables of the existing MCYFS implemented under Council Regulation (EC) No 78/2008 and results of the GLOBCAST project are already and could continue to be contributions to the AMIS system.

There are close links between the MARS Crop Yield Forecasting System and the Global Monitoring for Environment and Security (GMES) Programme activities. The possibilities for enhancing synergies between GMES and MARS Crop Yield Forecasting System activities are under discussion, in particular regarding the procurement and pre-processing of satellite data which could benefit from the GMES data and information.

⁶ http://agriculture.gouv.fr/IMG/pdf/2011-06-23_-_Action_Plan_-_VFinale.pdf