COMMISSION OF THE EUROPEAN COMMUNITIES

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REPORT FROM THE COMMISSION TO THE COUNCIL AND THE EUROPEAN PARLIAMENT

on implementation of Decision No 1445/2000/EC on the application of aerial-survey and remote-sensing techniques to the agricultural statistics

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1. INTRODUCTION

Decision No 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[1], which was continued until 2007 by Decision No 2066/2003/EC of 10 November 2003[2] and extended to the new EU-10 Member States by Decision No 786/2004/EC of 21 April 2004, required the Commission:

- to implement an areal-survey project at Community level in agricultural statistics (the "LUCAS" project); and

- to continue the use of remote-sensing, in particular with the agrometeorological system being made operational (the "MARS" project).

This report has been drawn up pursuant to Article 6 of Decision No 1445/2000/EC and deals separately with implementation of both these measures, with the resources used and with proposals on how areal-survey and remote-sensing techniques could continue to be used.

2. THE LUCAS PROJECT

The main aim of the LUCAS pilot project is to test the feasibility of an areal survey at Community level, specifically to:

"– collect data needed to implement and monitor the common agricultural policy and analyse interactions between agriculture, the environment and the countryside,

– provide estimates of the areas under the principal crops."

It is therefore designed to obtain harmonised information on land use and land cover, especially on agricultural land, with satisfactory precision at EU level. It also aims at collecting territorial information on the environment.

2.1. Implementation

2.1.1. Activities undertaken

The following activities have been undertaken since 2000:

LUCAS surveys have been undertaken in 2001/02, 2003, 2006 (with a preparatory survey in 2005), and 2007. The Member States covered are listed in Table 2.

The initial LUCAS survey, split into two phases (an areal survey in the spring and a follow-up farm survey in the autumn), was carried out on around 100 000 points.

A new methodology (new sampling design based on an EU grid in line with the INSPIRE recommendations) was defined in 2004 when it was decided to abandon the follow-up farm survey in autumn, in the light of the negative experience in 2001-2003.

For the sampling design of the survey (169 197 points in 2006), it was necessary to stratify by photo-interpretation the master sample points in the 2 km grid covering the territory of EU-25 in 2005. The survey focuses on agricultural land, with an initial sampling rate of 50% for

[1] OJ L 163, 4.7.2000, p. 1. Decision as last amended by Decision No 786/2004/EC (OJ L 138, 30.4.2004, p. 7).

[2] OJ L 309, 26.11.2003, p. 9.

arable land and for permanent crops and of 40% for grassland (all non-agricultural strata are also covered, with a sampling rate of 10% each).

Following this methodology, surveyors observe the parameters on each geo-referenced survey point in the field, using GPS technology, orthophotos and maps to localize and reach the points on the ground. Depending on the focus of the survey, other characteristics besides the key parameters can be gathered (such as mapping transects or taking soil samples).

A further LUCAS survey focusing on environmental variables such as erosion risk, irrigation and landscape features was carried out in spring 2007 on a sub-sample of points covered in 2005/2006.

Several studies have been launched on analysis of the survey results, on the potential of the LUCAS data for agri-environmental indicators, on the potential of aerial photo-interpretation for data collection, on use of photographs for landscape categorisation, on preparatory work for the future of LUCAS and on technology watch to improve the data-gathering process.

2.1.2. Main results

The main results of these activities, in response to the requests made in the Decision, are summed up below:

The pilot surveys carried out in the Member States over the period 2001-2007 demonstrated the feasibility of this project on a Community scale. General advantages of the LUCAS survey methodology approach are (1) high thematic precision, (2) high representativeness, (3) harmonized survey approach, (4) accurate change detection, (5) flexible survey structure, and (6) fast execution (up-to-date information).[3]

LUCAS data have been collected in all the Member States listed in Table 2. The 2001-2003 survey, carried out in EU-15, includes land cover, land use and environmental parameters (linear elements along transects, erosion, noise and hazards). The new methodology applied from the 2005 survey onwards and the reasons for the changes were described at length in the 2005 special report on LUCAS[4].

The data collected over the period 2001-2007 allow analysis of time series for monitoring the common agricultural policy, within the restrictions due to changes of methodology and the limited coverage of the data samples. Interactions between agriculture, the environment and the countryside can be studied by evaluating changes in land cover/land use over time and along the mapped transects, but also by analysing the environmental parameters surveyed (landscape recognition, erosion risk, irrigation, structural and linear elements, as surveyed in 2007).

Further relevant results obtained in the pilot phase include:

- a sound methodology, harmonised at EU level, proposing two-phase sampling of unclustered points, with stratification after the first phase[5];

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3 EFTAS, SADL, LUXspace (2007): Prospective Study on potential use of LUCAS. Final report of Contract N°61103.2005.001-2006.157.

4 Report from the Commission to the Member States on implementation of aerial-survey (LUCAS) and remote-sensing techniques (MARS) to the agricultural statistics. COM (2005) XXX.

5 The systematic sample (**base sample**) is linked to a 1 km grid based on the INSPIRE recommendations and corresponds to around 4 million points for the entire European Union.
The LUCAS **master sample** is a subset of the base sample corresponding to a 2 km grid created by using all the even points in the base sample and therefore consists of around 1 million points.

- a considerable volume of data and photographs (1.2 TB), which can be used to measure changes in land use and land cover over time or as a sampling base for specific surveys;
- IT infrastructure which is operational and ready to be used for future surveys, consisting of hardware systems, a data warehouse, along with the software needed to collect the data, to check the data against the photographs and controlling their quality, to generate the samples and to calculate the estimates as well as to recognize landscape diversity on the photographs taken, and to compare different grids used for areal surveys;
- solid experience in management of areal surveys.

2.1.3. Lessons learned from the pilot project and from the studies launched

Estimates can be provided with the required precision at EU level.

LUCAS provides information on agricultural areas but also on other land cover and uses, such as urban or forest data, in a consistent form for the whole of the EU. Precision is expected to be around or better than 2%[6] for the main categories like wheat, cereals, arable land, permanent grassland, permanent crops, forests, urban areas or inland waters. Comparison with national statistics shows good consistency for arable land in general. At lower levels, the consistency remains satisfactory for all cereals, common wheat, barley and maize (apart from in 2006 due to the late season and late sowing period). On smaller areas, the differences are proportional to the dispersion of the crops on the territory.

Table 1 – Precision obtained by LUCAS for main land cover classes in 2001, 2003 and 2006

	2001		2003		2006	
	Surface in %	**Precision error: CV (%)**	**Surface in %**	**Precision error: CV (%)**	**Surface in %**	**Precision error: CV (%)**
ARTIFICIAL LAND	4.80	2.7	4.80	2.2	5.62	1.07
CROPLAND	25.80	1.3	25.08	1	30.92	0.26
WOODLAND	35.00	1	35.23	0.8	28.83	0.40
SHRUBLAND	8.30	2.9	8.18	2	5.69	1.35
GRASSLAND	15.70	1.4	16.06	1.1	23.25	0.42
BARE LAND	3.10	5.3	2.49	3	3.42	1.29
WATER	7.30	3	7.29	2.1	1.70	1.76

NB: Surface changes of the land cover classes from 2001/2003 to 2006 are due to the different Member States covered by the respective surveys.

Ground photographs are of utmost importance for validation of the data.

During the quality tests conducted in the various surveys, it became clear that ground photographs taken by the surveyors (i.e. photographs of landscape, the point and the cover) were extremely useful for checking, validating and, possibly, correcting the data gathered on the field.

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[6] Each point in the master sample is photo-interpreted and then assigned to one of seven strata ("arable land", "permanent crops", "permanent grassland", "wooded areas, shrubland", "bare land and low or rare vegetation", "water" or "artificial land"). From the stratified master sample, a sub-sample of points (**field sample**) is extracted to be classified by a field visit based on the established nomenclature. To allow comparison with the results provided by Council Regulations (EEC) No 959/93 on other crop statistics and (EEC) No 837/90 on cereals production.

It is difficult to carry out field surveys before May.

During the 2006 survey an attempt was made to move the usual survey period between May and mid-July forward to March-June in order to provide crop area estimates by 15 June. Even if early estimates can be supplied by mid-June, the results are heavily influenced by the weather conditions and the stage of the agricultural season. Data inconsistencies could occur as a result of confusion between cereals in their early stages, over-representation of bare soil (on late sown or fallow land) or flooding or inaccessibility making it impossible to survey certain points.

Points can be found again on the ground.

With the help of GPS technology, photographs from earlier surveys and maps and orthophotos, it was possible to find all the points correctly surveyed in 2006 on the ground once again in 2007.

2.2. Resources used

Table 2 - Expenditure incurred for the LUCAS surveys (in €)

Description	2001-2002	2003	2005 (Phare 2003 budget)	2006	2007*
Quality assurance and documentation	262 777	199 713	71 875	271 651	NN
EU-25 stratification			900 000		
Belgium and Luxembourg	62 475	47 361		65 065	NN
Czech Republic				66 830	NN
Denmark	98 803	112 692			
Germany	403 936	339 329		747 000	NN
Greece	115 499	100 084			
Spain	227 149	228 053		530 318	NN
France	419 295	237 074		983 528	NN
Italy	180 488	147 028		232 500	NN
Latvia			44 597		NN
Lithuania			45 000		NN
Hungary				238 727	NN
Netherlands	97 957	107 338		61 400	NN
Austria	157 808	129 669			
Poland			78 254	451 000	NN
Portugal	110 808	92 801			
Slovak Republic				94 640	NN
Finland	248 377	197 511			
Sweden	511 470	329 470			
United Kingdom and Ireland	255 791	156 340			
Estonia, Hungary and Slovenia (Phare 2000)	447 500				
TOTAL	**3 600 133**	**2 424 463**	**1 139 726**	**3 742 659**	**700 000**

** Breakdown by Member State not yet available*

Table 3 - Expenditure incurred for the LUCAS methodological analyses (in €)

Description	COST
Methodological analysis of the results of the 2001 LUCAS survey	90 200
Study of the role of photo-interpretation in the LUCAS survey	50 000
Study of the use of data from the Community's LUCAS survey (2002-2004)	463 790
Improvement of Phase 2 sample	3 000
Multi-dimensional cross-analysis of LUCAS data (landscape classification)	280 000
Prospective study on potential use of LUCAS	150 000
Combination of multiple data sources	42 500
Technology watch	70 000
Total	1 149 490

Table 4 - Expenditure incurred for the LUCAS IT infrastructure (in €)

Description	COST
Servers, disk storage and backup system	109 813.22
Workstations, screens, printers	8 203.77
Development of the data entry tool	111 830.00
Image processing software	36 587.00
Database development, data warehouse	251 732.00
Total	518 165.99

2.3. Proposals on how areal-survey techniques could continue to be used

Main EU policy domains identified on which LUCAS can contribute are land cover/land use, landscape diversity and structure, soil erosion and quality, or land management. For policy domains such as air pollution, water quality and forest monitoring, LUCAS may support the legal obligations of the Member States through data harmonisation and accessibility with relatively minor effort involved.[7]

2.3.1. The available LUCAS data are potentially useful for a range of purposes:

(a) Gathering agricultural and environmental data

LUCAS could provide crop area estimates, independent of farm declarations, which could be of importance for CAP market management once fully validated and operational and when the other crop statistics are not fully developed or not fully reliable.

It can also be used as a sampling base for more specific surveys linked to agricultural and environmental issues.

It is one of the very few identified contributors to the agri-environmental indicators on landscape and on changes in land cover. One major information gap that LUCAS can bridge is about the presence of linear features and landscape diversity all over Europe.

[7] As concluded in: EFTAS, SADL, LUXspace (2007) see above.

It can be considered a unique source of basic information for modelling erosion risk, for surveying irrigation use and map landscape elements and for other environmental variables.

(b) Providing data for landscape analysis

The historical archive of landscape elements, environmental information and photographs is a valuable source of baseline information for future trend analysis. LUCAS provides data for long-term monitoring of agricultural and environmental issues on a European scale.

Another added value is the possibility precisely to compare the observations made in successive surveys in order to detect differences and changes in land cover and land use.

Combined with orthophotos and remote-sensing data, LUCAS provides insight into the spatial organisation of agriculture and the balance between agriculture/nature conservation/cultural heritage/green areas, etc. It provides an understanding of the size, location, connectivity and fragmentation of habitats, thereby supporting conservation and management of landscapes.

(c) Linking the data with Earth observation projects

LUCAS is expected to be one of the main "in situ" data providers needed for GMES (Global monitoring for environment and security[8]). *In situ* data at EU-27 level to support satellite research are required for the space work programme under the 7th R&D Framework Programme.

The CORINE exercise being carried out by the EAA has made and is making extensive use of LUCAS data and photographs.

LUCAS provides harmonised information on land cover and land use in a consistent form across the whole territory of the Union. Such land management information systems could turn into the backbone of the future European Spatial Data Infrastructure (ESDI).

2.3.2. The strength of the LUCAS survey is based upon providing data for combined agricultural and environmental policy needs rather than delivering crop estimates only:

Each individual purpose listed above can hardly justify a LUCAS survey on its own. In particular, crop area estimates based on traditional farm declarations exist in most EU Member States;

and the landscape indicators have not yet been properly defined and the Commission was asked by the Council to take close account of the costs and resource implications of any new data collection initiative that goes beyond the existing legal requirements.

On the other hand, results of modelling efforts or remote sensing cannot replace in-situ (or ground-truth) monitoring such as that performed by LUCAS. LUCAS could be defined as one of the European in-situ standards (e.g. within the INSPIRE initiative).

2.3.3. Future LUCAS surveys

A LUCAS survey is planned in BG and RO in spring 2008 as part of PHARE 2006.

Additional specific LUCAS surveys might be carried out on request using the general LUCAS surveys as a sampling frame.

Triennial LUCAS surveys could be carried out in 2009 and 2012 covering the whole EU in order to meet most of the needs identified above, avoiding double fieldwork.

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[8] http://www.gmes.info/.

3. THE MARS PROJECT

3.1. Purpose of the project

The purpose of the agro-meteorological system of monitoring crops and forecasting yields, developed by the Joint Research Centre (JRC) as part of the MARS (Monitoring Agriculture with Remote Sensing) project within the Agriculture Unit of the Institute for the Protection and Security of the Citizen, is to provide the evidence necessary for understanding how climatic events have an impact on harvests and to forecast the yields of the main crops. The main result of this activitiy is the MARS Crop Yield Forecasting System which is operational since 1998.

In line with the implementing procedures provided for in Decisions No 1445/2000/EC and 2066/2003/EC, the activities are aimed at activating both the agro-meteorological model and the chain for processing low-resolution satellite data from the NOAA and VEGETATION. These data are used to analyse, monitor and forecast European field crop yields. The JRC has taken on the task of maintaining the models and software and providing overall project supervision. The MARS activities include other specific tasks covered by the Research Framework Programme, which are not further reported in this context.

3.2. Methodology

The MARS Crop Yield Forecasting System comprises four activities:

- purchase of weather data and processing, calculation, interpolation and storage of derived weather data;
- use of the weather data in the agro-meteorological model of the Crop Growth Monitoring System (CGMS). The results consist of a series of indicators for simulating growth of the main crops. These indicators are stored in a geo-referenced database which allows production of thematic maps of weather statistics and indicators for each crop;
- acquisition of NOAA-AVHRR and SPOT-VEGETATION satellite images and processing of these data by systems defined and developed by the JRC. Indicators of the state of vegetation are calculated by incorporating CORINE Land Cover (CLC) data; use of CORINE makes it possible to calculate vegetation indicators at land cover class level. This improves the analysis of agriculture vegetation classes using low-resolution satellite indicators;
- establishment, at the JRC, of a group of experts on statistical analysis of the data and quantitative forecasts using previous indicators and publication of short-term crop yield analyses and forecasts.

The operational activities mentioned in points 1, 2 and 3 have been privatised. The contracts were awarded to an external consortium for the period 2000-2003 (MARSOP) and continued under a new legal basis in the form of the MARSOP2 contract for the period 2004-2007. The fourth activity referred to above (establishment of a group of experts on statistical analysis of the quantitative forecasts) has been managed directly by the Commission at the JRC, in coordination with DG Agriculture. The most notable result of this activity is the MARS Bulletin, of which 94 issues were published in the period 1999-2006, with twenty-one planned in 2007. The MARS Bulletins include analysis of the impact of climate on the main EU crops, including short-term weather forecasts, and are regularly used by DG-AGRI's Outlook group of analysts. **The information and data provided are used to support the CAP decision-**

making process: i.e food balance sheet estimates, budgetary forecasts and follow up of expenditures, stock interventions and management, export tenders, definition of set aside rates and use, support to EU Markets, etc. Special issues on *ad-hoc* analyses are produced on request by DG-AGRI. The results emerging from the operational data processing are publicly available on the site http://www.marsop.info.

As a consequence of the enlargement process and in order to scale up the MARS Crop Yield Forecasting System to cover 25 countries operationally and to make it more professional, a number of activities were launched in 2004 under the ASEMARS project (Actions in support of the Enlargement for the MARS Crop Yield Forecasting System). These will continue up to 2008. The project is divided into seven objectives, which correspond to seven lots:

- Update of the CGMS: to complete and reinforce the Crop Growth Monitoring System on the new EU-10 Member States, calibrate the missing crops, include the new European soil map, use the Corine 2000 data set and introduce further automatic procedures in the statistical module of the CGMS.
- New meteorological data sets: additional weather stations, data based on numerical weather models, both as re-analyses and as forecasts (ten-day, monthly and seasonal) and agro-phenology data to complete and reinforce the MARS database used for the analyses.
- New medium- and low-resolution satellite data to complete and reinforce the MARS database used for the analyses, to calculate more precise satellite-based indicators, to produce Meteosat second-generation data, to improve estimates of the impact of frost and health stresses and to produce MODIS and MERIS data with better resolution (200-300 m instead of 1 km).
- A new operational CGMS, based on ensembles probabilistic weather forecasts, to make the CGMS system operational to run crop simulations on 10 days for intra-seasonal and seasonal weather forecasts and able to produce probabilistic crop yield forecasts.
- CGMS-Wofost and Lingra calibration platform to implement crop calibration systematically and in a controlled way in order to update and maintain the models both on crops and pasture and grassland.
- CGMS sensitivity analysis platform to implement a sensitivity analysis tool for system validation and sensitivity analysis, with the purpose of improving modelling.
- Finally, a lot has been launched in the form of CMI in 2006, with the purpose of collecting agro-phenological data from the existing national services. The data are needed to improve calibration of models and consequent analysis of the simulations obtained.

Table 5 (see Annex 1) shows the use of Community funding for the MARS-STAT projects in the periods 2000-2003 and 2004-2007.

3.3. Evaluation of the results

3.3.1. The MARS Crop Yield Forecasting System

The MARS Crop Yield Forecasting System has made it possible to evaluate the impact of the climate on yields at EU-25 level, in an independent and homogeneous manner throughout Europe.

The yield forecasts from the Bulletin are used by DG AGRI as input data to compile the estimated balances for field crops for the European Union and for the applicant countries.

Evaluation of the forecasts issued is a permanent activity at the JRC's MARS unit. The *a posteriori* errors in the quantitative yield forecasts are calculated from the final official data. For the period 1999-2003, the forecasting errors are not more than the average errors from the MARS system published in previous years (source: QUAMP report, outcome of a study financed by the JRC and carried out by an independent external company in 2003-2004). The root mean square error (RMSE) calculated for cereals showed an increase in the error in the forecasts after enlargement (from 0.6 q/ha to 1.5 q/ha). However, the trend in the RMSE has been sharply downward since the first few years of the ASEMARS projects (in 2005 the error decreased to 0.1 q/ha).

3.3.2. Additional research activities carried out by the JRC under its own research budget and related to the reinforcement of land cover estimation methodologies (Institutional support to EUROSTAT for the LUCAS project)

Besides the agro-meteorological activities, other research projects limited to technology watch and methodological support to LUCAS are carried out by the JRC and financed by its own budget.

In order to optimise the efficiency of the LUCAS sample design within the same budget constraints, a modified methodology was tested in Greece, in response to a request from the Greek Ministry of Agriculture.

The results confirmed the expected improvement in precision (coefficients of variation improved by a factor of three), following the adoption of the modified point frame methodology. Consequently, the survey served as a reference for drafting the specifications for the LUCAS 2005 and 2006 surveys.

A second activity was the development of software for calculating the LUCAS estimates in accordance with the new point frame methodology (CAESAR software). The software was used for the LUCAS 2005 and 2006 campaigns.

3.4. Conclusions

In the light of the usefulness of the information and data provided in support of CAP deployment by the JRC in relation to MARS in recent years, the Commission wishes to continue this activity over the period 2008-2013.

3.5. ANNEX 1

Table 5 - Expenditure incurred for the agro-meteorological system (MARS-STAT) (in €)

Lot/phase	Phase 1	Phase 2	Phase 3	Total (all 3 phases)
Period	**2000/2001**	**2002**	**2003**	**2000/2003**
LOT 1	*151 812*	99 650	99 650	**351 112**
LOT 2	*204 900*	87 500	90 100	**382 500**
LOT 3	*207 294*	160 010	162 310	**529 614**
LOT 4	*259 372*	197 468	200 567	**657 407**
Coordination	*74 220*	29 500	30 400	**134 120**
Total/phase	***897 598***	**574 128**	**583 027**	**2 054 753**

Table 6 - MARS expenditure from DG-AGRI budget line (commitment appropriations) based on renewal of the Council Decision for the period 2004/2007 and on the MARS OP II and ASEMARS projects schedule

MARS commitments						
Project/year	**2003**	**2004**	**2005**	**2006**	**2007**	**TOTAL**
MARS OP II phase 1	850 000					
MARS OP II phase 2		595 751				
ASEMARS phase1		649 800				
MARS OP II phase 3			557 233			
ASEMARS phase2			650 000			
MARS OP II phase 4				600 000		
ASEMARS phase 3				551 924		
ASEMARS phase 4					647 492	
MARS OP II	850 000	595 751	557 233	600 000		
ASEMARS		649 800	650 000	551 924	647 492	
Total MARS	**850 000**	**1 245 551**	**1 207 233**	**1 151 924**	**647 492**	**5 102 200**