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The operational Crop Monitoring and Production Forecast Program (CROPMON 1997-) and other RS based applications

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ABSTRACT: The Hungarian Agricultural Remote Sensing Program led to a concise methodology that could further be applied operationally. First the main results of a substantial R&D investment and methodology plus validation results are summarized in the paper. The crops area assessment, through the processing of multitemporal Landsat and IRS-1C/1D data proved to be efficient at county level because of the accuracy of thematic classification. The novel combined high resolution images + NOAA AVHRR series based crop yield forecast methodology performed well for the major crops (8) at county level. Based on the experiences of the first 5 operational years (from 1997) a general evaluation on the Operational Crop Monitoring and Production Forecast Program (CROPMON) is given. The CROPMON system is a good platform for additional projects implementation as in the case of a serious waterlog assessment and impact analysis in spring, 1999 or flood monitoring in 2000, and the remote sensing control of national area-based agricultural subsidies (CwRS), which is carried out operationally for the third year in 2002 in Hungary.

1 BACKGROUND

Up to 1990 the crop production was based on some 1400 co-operative or state farms in Hungary. The crop information system used their reports that were obligatory by law. This information system worked fairly well. Because of the dramatic changes in the Hungarian economy and also in the agriculture, the former crop information system became inadequate. The land privatisation brought dramatic changes in the holdings and parcel sizes, the number of farm owners or operators, the agricultural technology and investments. In this very quick transition, the need for an efficient information system became even more imperative.

The priority Hungarian Agricultural Remote Sensing Program (HARSP) was launched in 1980 and has been implemented by FÖMI Remote Sensing Centre (FÖMI RSC). The final objective of the program was to introduce remote sensing to the operational agro information system in Hungary. The operational system was expected to be capable to monitor crops in the entire country, providing accurate, timely and reliable information on the area of the major crops, their development quantitatively. This should be accompanied by problems areas delineation (focusing to drought assessment), plus the provision of reliable yield forecast and final yield estimates. These data are to be available at the country as well as the counties (19) levels. The main users of the information includes, primarily the Ministry of Agriculture and Regional Development (MARD) and gradually the grain processing and trading companies and associations, the farmers and their different organisations, associations. Even in the sixth year of operations and having a lot of experience to meet the strict accuracy and deadline requirements there is a continuous improvement in the technology applied. This leads to a number of additional applications offered by this system.

2 THE TWO MAIN PERIODS OF THE PROGRAM

The HARSP (1980-) program can be divided to two main periods (Fig.1):

- the development of the methodology basis, the crop mapping and area assessment methods plus the yield forecast models and validation (1980-96) and
- the operational period (1997-).

The final, most intensive period (1993-96) was the break through in the development. This resulted in an operationally ready to use technology that had been validated prior to the operational phase on a 16

counties sample from quite a diverse crop years period: 1991-96 (Csornai et. al., 1998).

2.1 *The operational crop area assessment method*

The method was developed by FÖMI RSC. It applies high resolution satellite data series (e.g. Landsat, IRS-1C/1D, SPOT) in a multitemporal digital image analysis procedure for the crop identification and area estimation (Csornai et al., 1983). This approach was thoroughly tested by 1990 up to 3 counties region (Csornai et. al., 1990). It was found that the traditional agro information system in Hungary, can only be surpassed in accuracy if advanced digital image analysis was used (Csornai et. al., 1997). This approach also provides reliable crop maps, which are necessary to the crop development monitoring and production forecast models.

The performance of this approach in crop area assessment proved to meet the strict requirements (Figs. 3.a.b.) both for the validation period (1991-96) and in the operational one. The strong relationship in the Landsat TM derived (FÖMI RSC) and Central Statistical Office, Hungary (CSOH) data for the major crops proved, that this method was independent from the given year or the area, the different terrain and complexity of the counties.

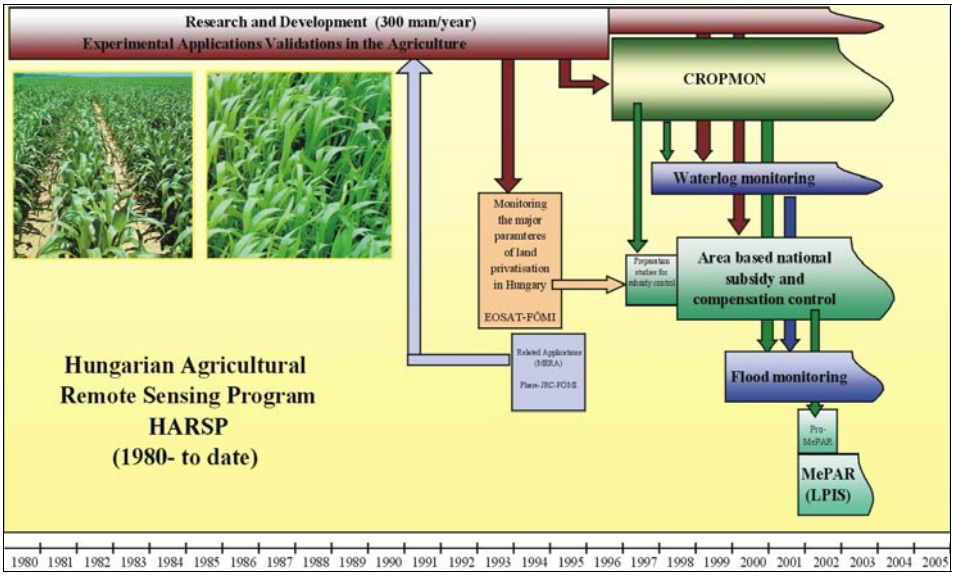

Figure 1. The background and history of remote sensing based agricultural applications in FÖMI RSC, Hungary

2.2 *Crop monitoring and yield estimation methods*

The novel result of HARSP are the purely remote sensing crop monitoring and yield forecast models. The models were developed by FÖMI RSC. They integrated NOAA AVHRR and high-resolution satellite data (e.g. Landsat, IRS-1C/D, SPOT). The models combine the benefits of both data sources: the frequency of NOAA AVHRR data and spatial resolution of high resolution images. This approach requires fairly accurate crop maps. Using these crop maps and pre-processed NOAA AVHRR time series a crop development assessment and quantitative yield forecast model was developed. The model was calibrated at the spatial units level of 400-500 ha. That is the guarantee for its good performance at the counties level (approx. 0,5 million hectare each, in Hungary) and further. That is also why it can produce a crop yield distribution map. The county wheat and maize yields predicted by the model compared favourably to the official data (Figs. 4 .a.b.) both in the pre-validation period (1991-96) and in the operational one (1997-) as well. The structure of the model is similar for different crops and it does not depend on the area and the given year's weather. It was also found that the timeliness requirement can be met by the yield forecast model.

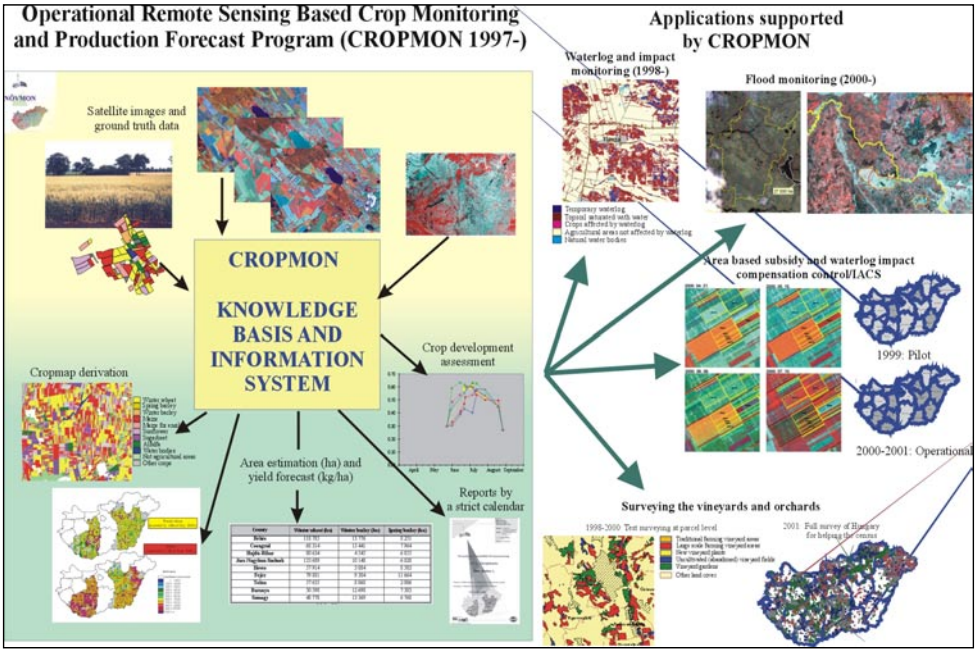

Figure 2. The overall structure of CROPMON and the application supported by it

3 OPERATIONAL CROP AREA ASSESSMENT AND YIELD FORECAST FROM 1997-

The substantial R&D and validation created a firm basis to move forward to an operational program: Crop Monitoring and Production Forecast Program (CROPMON 1997-). The crop data-reporting calendar was set by the customer, the Ministry of Agriculture and Regional Development.

It consists of four dates (three dates in 2000) from July 5 to October 1 in harmony with the existing traditional production forecast system of MARD. The area covered directly have been a characteristic subsample (6-9) of all the counties (19), so that 40-57 % of the total cropland in Hungary have directly been monitored. From 2002 the whole country is covered. The eight main crops monitored are winter wheat, winter and spring barley, maize, sugar beet, sunflower, alfalfa and maize to ensilage. These crops together represent the 78-82 % of the entire Hungarian cropland.

The crops area assessment is based on the quantitative analysis of multitemporal high resolution images (Landsat TM and IRS-1C/1D LISS III.) from early April (or earlier sometimes) through August, to compensate for the cloudiness. The comparison of the remote sensing results with CSOH data is obviously an indication only. The differences cannot be interpreted, by any means, as errors of the remote sensing technology. The difference of crop areas estimates of FÖMI RSC and the Central Statistical Office, Hungary (CSOH) is in the range of 0.8-3.7 % for the entire cropland in Hungary. The county crop area differences occurred in the interval of 1.5-21 % depending on the crop and county. However the area weighted average difference was 4.08 %.

This partially can be explained by the main differences in definitions, that is the ownership based sampling of CSOH and the administrative boundary based total coverage of cropland by the satellite images (FÖMI RSC). The actual standard crop maps derived were also provided to MARD.

The crop yield forecast was accomplished by the application of FÖMI RSC developed model which combines high-resolution satellite (Landsat TM and IRS-1C/1D LISS III. or SPOT) data and NOAA AVHRR time series. The reporting dates corresponded to those of the operative Production Forecast System of the Ministry of Agriculture and Regional Development. Both appeared prior to the harvest. The final official data are available after the harvest: by the end of August for wheat and barley and in December (January) for the rest. Until 2002 FÖMI RSC provided yield estimates for the counties (6-9) and expanded them to Hungary using a regional-historical correlation scheme. From 2002 all

the 19 counties are covered directly, so there is no need for extrapolation any more. The country average yield data compare favourably with CSOH preliminary values, that appear six weeks later. The differences are less than 1 % for wheat and 4.5 % for maize average yields in Hungary. The differences at county level averages are somewhat bigger. Because of the method applied, yield spatial distribution maps could also be reported for the major crops.

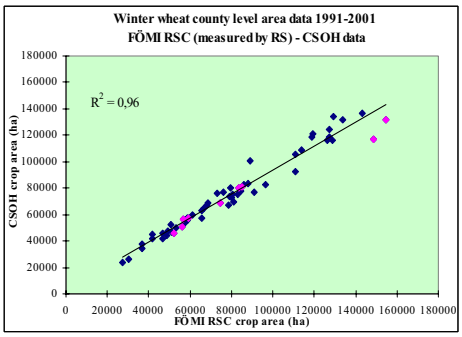

Figure 3.a The area estimation for winter wheat shows a strong relationship between the traditional (questionnaire) method and the remote sensing one

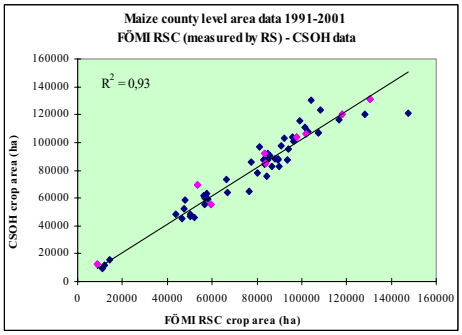

Figure 3.b The figures compare similarly to those of wheat. The relationship is somewhat affected by the practice and statistics of maize for silage

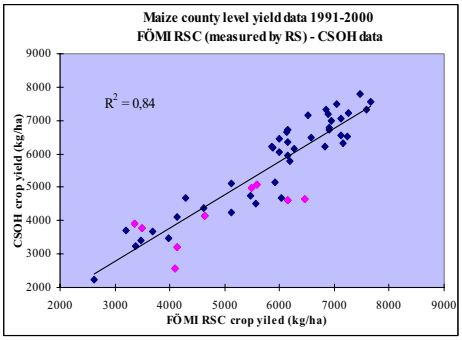

Figure 4.a. The wheat yields can be predicted by remote sensing prior to the harvest. The years covered comprise good and extreme bad ones as well

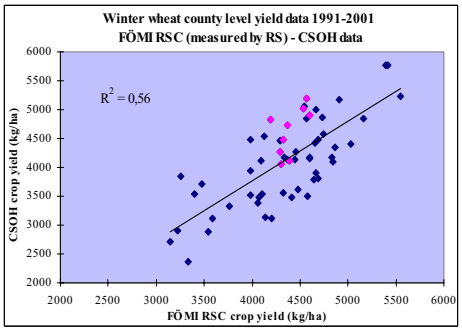

Figure 4.b. The maize yields can be predicted early prior to the harvest. The sample comprises diverse years. No CSOH yield data are available to date for 2001.

4 WATERLOG, FLOOD AND IMPACT MONITORING

In the past years flood and waterlog hit very seriously the country. On the methodology and infrastructure basis a thorough monitoring program was launched. This covered the most affected 4 (1998) and 8 (1999) counties of about 4 million hectares. Reliable waterlog maps and areal measures were derived. Beyond the static status assessment of the areas under water or having saturated soil impact analysis on the crops was also performed. This assessment made use of high and mid resolution optical data, that is Landsat TM, IRS 1C/1D LISS III. and WiFS as well. Because of the vast contiguous areas under water (approx. 0.6 million hectare in spring, 1999) WiFS data could also be used. The lack of mid infrared channel in WiFS data could be compensated. The resulted GIS data base and printed maps were utilized by MARD intensively.

Building on the CROPMON infrastructure we could also help the combat against flood that hit the country in April, 2000. We could detect the extent of flooding in the neighbouring Romania, and this way helping the local water management authorities in planning the necessary steps to be taken to avoid a serious disaster.

Spring 2001 unfortunately also started with serious flood situation along the upper part of Tisza river. The dike along river Tisza was breached by the water at midday on 6th March. On the morning of 6th March 2001, FÖMI started its operational flood monitoring using NOAA AVHRR satellite images acquired by its own receiving station and followed the availability of other medium and high resolution satellite images for the region. The extent of flooded areas was evaluated both on the Ukrainian and the Hungarian side and the high-, low- and medium resolution flood maps were forwarded to the central and local management authorities through electronic transmission (Lelkes et. al, 2001).

5 AREA-BASED SUBSIDY CONTROL BY REMOTE SENSING (1999-)

The principal national crop area based subsidy program has been operative in Hungary, for many years now. Both the crop subsidy and the ad-hoc partial loss compensation programs that are responses to extreme natural disasters (as e.g. for waterlog/flood damages), work in sound legal framework. In 1997 FÖMI Remote Sensing Centre (FÖMI RSC) initiated to MARD the introduction of remote sensing into the control of the subsidy and partial compensation programs. The subsidy controls were performed on the CROPMON basis. Using FÖMI RSC's operational remote sensing based technology, a 3 counties sample was controlled by in a pilot project in 1999.

The target area for RS based subsidy control was extended to a 7%, 4% and 5% ample of all the dossiers in 2000, 2001 and 2002 respectively (Fig. 30). On the basis of CROPMON the automatic control can be an important part of the control of area based subsidies in Hungary.

6 CONCLUSION

Both the validation of the developed remote sensing based crop area assessment and yield forecast methods plus the first Operational Crop Monitoring and Production Forecast Program (CROPMON 1997-) in Hungary have clearly demonstrated that these methods can be efficiently applied. Substantial background and investment was certainly needed. About 300 man/year was invested by FÖMI RSC in the framework of the Hungarian Agricultural Remote Sensing Program (1980 to date). The CROPMON reporting calendar is very strictly set up by the Ministry of Agriculture and Regional Development, Hungary, to be in synchron with its existing farms' reports based operational production forecast and monitoring system.

Remote sensing could be very efficiently used for precise crop area estimation and provision of crop maps. The results suggest that the necessary classification performance can be obtained in most of the cases, therefore the analysis could be cost effective. The investment to achieve this seems to be worthwhile.

The new primary combined AVHRR and high resolution images based crop monitoring and quantitative yield prediction model performed properly and efficiently in a more counties' area application and also for the entire country. This model produces spatial distribution map for the predicted yields.

Being in the sixth operational year of CROPMON in 2002 the extension of the directly observed counties from 9 to 19 was achieved. Parallel to this, many other applications can efficiently be added similarly to the waterlog assessment and monitoring and the remote sensing control of national area-based agricultural subsidies.

ACKNOWLEDGEMENT

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