Crop Monitoring as an
E-agricultural tool in
Developing Countries

REPORT ON THE WORKSHOP OVER THE YIELD PREDICTION USING REMOTE SENSING

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EXECUTIVE SUMMARY

Objective:

The workshop is the first event of the E-Agri project. It aims to disseminate the methodology of crop growth monitoring and yield forecasting using remote sensing techniques. The two organizers of the workshop: INRA (Morocco) and VITO (Belgium) have developed and applied the main components of the methods.

Participants:

The workshop is jointly organized by INRA and VITO, the partner institutes including JRC and Alterra have joined the workshop. Many morocco's institutions such as the National Department of meteorology (DMN), the Department of Statistics and Survey of the ministry of Agriculture (DSS), Morocco Central Bank (Bank Al-Maghrib), and the Ecole Normale d'Agriculture. An expert from the University of Gadarif, Sudan was also present. The name list can be found at the end of the document.

1. Introduction

Crop growth can be assessed by using the coarse resolution imagery registered by synoptic earth observation (EO) systems, such as NOAA-AVHRR (active since around 1982), SPOT-VEGETATION (since 1998) and TERRA-MODIS. Such an assessment can usually be achieved by analyzing so called biophysical variables (or vegetation indices) retrieved from these systems. These indices can be used directly in statistical models to predict crop yield or to be used as input in various stages of a generic, most often agro-meteorological modelling process. In the later cases, the performance of these generic models can be readily improved when remote sensing data are integrated.

To be able to served as a crop monitoring tool, these EO systems cover the targeted areas at a relevant frequency allowing a ten daily synthesis. Moreover the systems should have a projected minimum lifetime of 8-10 years so that a accurate analysis with reference to historical data can be performed. Currently the variables from NOAA-AVHRR and SPOT-VEGETATION are main remote sensing information used in the context of European crop yield forecasting system.

Normalized Difference Vegetation Index is the oldest and simplest vegetation variable to be computed and applied in the European crop monitoring programme. Another approach to regional crop yield assessment is to estimate the biophysical variable fAPAR (for the fraction of absorbed photo-synthetically active radiation) based on inversion of canopy reflectance models. The third principal vegetation state attribute is described by the “Dry Matter Productivity” (DMP, in kg/ha/day) or the increase in dry matter biomass on a daily base is calculated following the Monteith approach. It takes into account the metrological conditions such as daily minimal, maximal temperature and solar radiation.

In addition, the long term average or so called historical year for these vegetation state variables at monthly and decadal steps is produced for the time series of NOAA-AVHRR and SPOT-VEGETATION. The long term average is used to compute difference images with the actual data and to determine the range of the values occurring and their probability respectively. This corresponds to the difference variable including VCI and VPI when applied to the NDVI. They are widely used by European researchers to evaluate vegetation condition in a historical context.

All these indicators were stored in different formats: images, quick-looks and Regional Unmixed Mean (RUM) databases and can be read or fetched from a dedicated FTP site. The variable RUM represents the mean values of a specific growth variable (NDVI, DMP…)

for a specific crop or land-use class (maize, forest…) within a specific geographic region (county, district, province…). RUM values are stored under the database format.

At European level, these remote sensing derived vegetation indicators are ingested into a global crop monitoring system such as CGMS for further statistical analysis and yield prediction. It has also been demonstrated that the vegetation state attribute NDVI is particularly useful for independent crop yield forecasting in semi-arid regions, where state of vegetation shows high variation at multi-annual base.

2. E-AGRI workshop on yield forecasting using remote sensing

The workshop is the first in series organized jointelly by INRA morocco and Vito. During the 3 year implementation of the project, other thematic workshops will be organized focusing on CGMS model, BioMA plateform and crop area assessment.

Figure 1: Folder of the Yield prediction workshop,

2.1. The preparation of the workshop

All the logistics and promotional activities were conducted by INRA. A dedicated folder (Fig. 1) including the agenda was prepared.

2.2. Agenda of the workshop

The agenda is presented on Table 1.

Table 1. Agenta of the workshop

Wednesday 12 **Opening session**	**Moderator : R. Balaghi (INRA)**
14.00 - 14.30 Welcome address	Secrétaire Général, **El Idrissi Ammari**
Presentation of the program	R. Balaghi (INRA)
14:30 – 15.00 Overall presentation of E-AGRI Project	Q. Dong (VITO/E-AGRI coordinator)
15.00 – 15.30 Presentation INRA cooperation with JRC	M. El Aydam (JRC)
15.30 – 16.00 Presentation of crop yield forecast for Morocco with CGMS with highlight on operational aspects and improvements foreseen	M. El Aydam (JRC) and R. Balaghi (INRA)
19:00	Welcome Dinner
Thursday 13 **Crop yield forecasting session**	**Moderator : Q. Dong (VITO)**
9.00 -10.30 LECTURE 1: Remote sensing indicators for yield estimation	H. Eerens (Vito)
11.00 – 12.00 STUDY CASE 1-2: Remote sensing indicators for yield estimation in Morocco and in HuaiBei plain	R. Balaghi (INRA)
14.00 – 15.00 LECTURE 2: Spatialisation of meteorological data.	T. El Hairech (DMN)
15.30 – 16.30 STUDY CASE 3: Meteorological indicators for yield estimation in Morocco	M. Jlibene (INRA)
16.30 – 17.30 Study case 4: CGMS Statistic Tool - Regression analysis of CGMS indicators computed for Morocco.	M. S. Hoek (Alterra)

Friday 14 **Crop area estimation**	**Moderator :** M. El Aydam (JRC)
9:00 – 10:00 Lecture 3: Crop area monitoring in Morocco	M. Tahiri (DSS)
10.00 – 11.30 Lecture 4: Crop area monitoring in EU	J. Gallego (JRC)
11:30 – 12.30 STUDY CASE 5: The state of crop forecasting in Kenya	C. Situma (DRSRS)
14:00 -17:00 Conclusion and Social Programme	Q. Dong (VITO) and R. Balaghi (INRA)

2.3. Minutes of the workshop

The Wednesday afternoon is essentially dedicated to the official welcome from INRA (Morocco) with the welcome address by the Secrétaire Général, **El Idrissi Ammari (INRA)**. The local organizer **Dr. R. Balaghi (INRA)**presented the programme of the workshop.

Q. Dong (VITO, coordinator of the project) explained the frame and the six constituent parts of the projects (work-packages).

Local organizer **R. Balaghi** and **M. El-Aydam (JRC)** introduced the collaboration between the INRA morocco and the JRC of the European Commission in terms of data transfer, CGMS simulation for Morocco and the publication of the Bulletins, as well as the training of experts. The cooperation agreement implemented for 3 years is to be extended. The E-Agri project provides to both side an excellent opportunity and financial support to concretizing this collaboration.

The Thursday and Friday were dedicated to the technical parts of this workshop. **H. Eerens** (**VITO**) gave a lecture of basic principles on low resolution remote sensing and its application on agriculture, including major LR sensors, their pre- and post-processing, the main vegetation indices derived from these sensors and applied for crop monitoring. A case study using the indiex SIMILARITY was shown the on the region of Morocco. Questions are raised:

- on the relation between the similarity of yield and the technical trends (varieties of cultivars); suggestions on taking into account several similar years
- on the selection of crucial decades (the month of March might be too early for simulation since heat-wave, heavy rain or insect disease can occur in later April or even May
- on the application of the approach in the data from other sensors such as NOAA (long time series) or MSG (availability on “water-limited” products);

- on the importance of semi dates
- on the distinction between the yield forecasts (early in the year) and the yield estimation (once per year)

R Balaghi explained how he used these vegetation indices to simulate the crop yield in the two target area in Morocco and on the Huaibei Plain in China and inter-compared best correlated indices for each region. For Morocco, the first analysis indicated that the DMP is the best remote sensing indicator (although previously the CGMS simulation produced closest estimates with the published official yield figures after 2009-2011 harvests). For the Huaibei plain, the first analysis showed that DMP is the best RS indicator and decadal indicators from April and May are more important. Questions are raised on:

- Inclusion of the variables such as rainfall may produce better linear regression. However the correlation exists between the rainfall and vegetation indices. In case of a combined use of two types of variables, these variables have to be derived from different dekads.
- Use of non-linear regression is possible but confuse for decision makers.

Tarik El Hairech (DMN, the National Department of Meteorology) introduced un approach called "AURELHY" to interpolate the meteorological station data into grid dataset. The application is particularly suitable for Morocco to establish a meteo data grid needed in the CGMS application. The most merit of the method is its consideration or integration of the effect of topography for T_{min} and T_{max} interpolation.

Dr Ahmed DOUAIK (INRA) gave a presentation on his research on using NDVI time series and step wise multi linear regression to establish the crop fraction maps in the region of West Nizamabad.

M. Jlibene (INRA) introduced the crop phenology and the impact of climate (especially the rainfall) on different development stages of wheat in Morocco and the consequence on the yield.

K. Bensaid from **Bank Al Maghrib**, the central bank Morocco (http://www.bkam.ma), came to present his research on forecasting agriculture production in Morocco. His team includes about 70 statisticians and economists and the methodology is essentially based on the historical rainfall data.

On the domain of crop area assessment, **M. Tahiri** from **Statistical department of the Ministry of agriculture** (DSS) introduced his approach using area frame sampling and remote sensing to carry out the crop acreage statistics. His department developed a tool to perform the automated zoning and generation of segments.

J. Gallego presented the approaches used in the European Union (or more exactly in its member states) for performing acreage statistics. No standardized methodology is agreed among the member states. However the European Union through its EUROSTAT assesses the land use and land cover through the so called LUCAS survey (Land Use and Cover Area frame Statistical survey) every three years. He explained also the major "mistake" occurred in the MARS ACTION4 "Rapid estimates of crop area change": believing that the crop area can be estimated from satellite images without intensive ground survey.

Finally, **Charles Situma (DRSRS)** explained his department's operation on crop monitoring. They perform the area survey using the aerial photography. With the experienced photo interpreters and well distributed sampling, the area estimation is quite accurately performed. Instead they used quite traditional (or obsolete) method to measure the vegetation reflectance using a radiometers and perform a linear correlation with the historical yields. For this reason, they are particular keen to use the method focused in this workshop, using the remote sensing indicators to simulate and forecast the crop yield.

Discussion and proposed actions

The most striking impression from all participants of the workshop is the great synergy has been produced in the case of Morocco with the involvement of other institutes outside of the project consortium such as the National Department of Meteorology and the Department of Statistics and Survey. Even a department of the Morocco Central Bank participated in the workshop and gave a presentation of their research. The meteorological department will collaborate together with INRA for setting up a CGMS system in Morocco using their meteo grid interpolation method. The discussion afterwards are groups to three study areas.

The study area of Morocco:

- The collaboration between three Morocco institutes are formalized after the kick-off of the E-AGRI project. The Morocco partners expected a CGMS system, which could be named as M-CGMS can be installed in the National Department of Meteorology. The calibration can be started after the physical installation of the system. (***This point needs to be discussed in the workshop of Anhui***).
- The field experiments are carried out in 3 regions in Morocco for calibration use for CGMS as well as in BioMA systems.
- The collaboration between Alterra and DMN needs to be strengthened. The meteo datasets can be compared with that used by Alterra and that derived by DMN using Aurelhy method. The downscaling of the meteo data to the daily level needs to be further investigated.
- The future M-CGMS should allow to include both agro-meteorological data and the remote sensing derived indicators in the 3rd level using the statistical tool box.

- The statistical tool box which can integrate the RS indices will be further developed and delivered to INRA within month for test purpose.
- The expert from the Central bank of Morocco requested to have low resolution RS data to be integrated into their study. This point needs to be discussed with INRA (as intermediate). The forecasts made by the Central Bank can be compared with those by INRA. The forecasts made by the Bank for the region West African can be exchanged with other institutions (JRC for example).
- Concerning the monitoring system BioMa which was not discussed during this workshop.

2.4. Participant list

Participants to the first BioMA workshop are presented in Table 1 and Figure 4.

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2.5. Workshop photos

2.6. Media impact

The event was reported by several journals and press. (Fig. 2)