Chapter 10
THE IMPROVEMENT OF THE EFFICIENCY OF USING THE DATA OBTAINED FROM SOIL AND CROP VEGETATION STATUS SENSORS

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1. Introduction

The need of a performance management, the complex climatic, economic, biologic changes, imply the continuous and exact monitoring of the grown yield resources and the vegetation status for the crops.

The continuous monitoring of these parameters indicates, in real-time, the changes and the vulnerabilities of the agro ecosystem, enabling the adoption of an efficient set of strategies for conserving the degree of economic sustainability of the agricol holdings.

The study of crops based on the spatial diversity of the resources, has the scope to identify the spatial (local ï spatial differences in the agricol holding) and temporal (differences from year to year in the agricol holding) variability of the production factors [1].

In order to achieve the efficient management of crops, one has to use dedicate sensors which are able to measure in real-time the pedo-climatic parameters, with a high granularity. In this way one can obtain detail data about the crop environment, which have to be further analysed. Since the same set of measurements is applied for several times during the year, the persons who process the data have to repeat exactly the same analysis steps for several times [6].

We have developed a software application on top of R statistical environment, which can be used for running the analysis steps on newly acquisitioned data. Furthermore, the application is made generic and it can be extended at any moment with new custom made analysis procedures.

In the following chapter describes the main concepts of the precision agriculture. In chapter 3 are presented the main types of sensor [7, 8] which are used for monitoring the potato crops at INCDCSZ. Chapter 4 is dedicated for describing the software application used for analysing the data. The paper is finalised with the conclusion section.

2. Objectives

The precision agriculture system has the main strategy the determination of the spatial and temporal differences of the soil productive parameters. The continuous monitoring of the variability and its management using variable rate technology depend on local specific conditions [2].

The precision agriculture has as purpose the improvement of using the ground resources, water and the chemical inputs (fertilizer and pesticide) on specific local bases [3] and has as goals:

- The obtaining high and quality yields, durable in time and space;
- To optimize the economic benefits;
- The entire achievement of environment protection;
- The enlarging of lasting agriculture systems;
- Reducing the price of yields per product.

The study of crop variability has the following objectives:

The improvement and standardization of the following parameters observation and measurement:

- The vegetation mass and yield dynamic growth; the chlorophyll content dynamics; the canopy reflectance dynamics [5], NDVI vegetation index dynamics;
- The georeferenced acquisition and monitoring (GPS), in dynamics, of phenological data, growth and development, leaf area, chlorophyll content;
- Data transformation and georeferenced database update in GIS

system;

- Perform statistical calculations, their interpretation and geostatistical interpolation;
- The elaboration of final reports of the research results.

The precision agriculture asks for a systematically approaching of the biological, ecological and social ï economical elements, and there are distinguished through its space and time elements. The precision agriculture as a result for the necessity of streamlining the quantity of fertilizer and pesticide under the economical, legislative and environment protection pressure, benefits rising and control as agriculture systems. Methodological, the precision agriculture sums up all other methods of research and rendition of the experimental results, starting from the observation, experiencing, classic and geographical, systematically approach, the simulation of the process till the use of upscale geographical technology [3].

3. Sensors

In this section are presented the sensors used for monitoring of the production factors:

- monitoring "on the go" of soil resources (physical and chemical quality): Veris 3100 MSP Soil EC-NIR Spectrophotometer (Figure 1), Spectrum SC-900 Soil Compaction Meter (Figure 2), Spectrum TDR-300 Soil Moisture Meter (Figure 3), SPAD 502DL Plus

Chlorophyll Meter (Figure 4).

- monitoring "on the go" vegetative status (physiological condition and health, water stress and plant nutrition) in crops: CropScan MSR-16R Multispectral Radiometer (400-1500 nm) (Figure 5).

Fig. 1. *Soil electrical conductivity monitoring with VERIS (Mobile Sensor Platform)*

Fig. 2. *SC 900 Soil Compaction Meter*

Fig. 3. *TDR 300 Soil Moisture Meter*

All data collected by sensors mentioned are georeferenced (GPS coordinates) and acquired continuously in a Geographic Information System (GIS) to obtain spatial maps of favourability and risk used in performance management of crops.

Fig. 4. *SPAD 502DL Plus Chlorophyll Meter*

Fig. 5. *CropScan MSR-16R Multispectral Radiometer (400-1500 nm)*

4. Data analysis software application

The main requirements of the application are the following ones:

- Implement various procedures (sequences of steps) of statistical analysis.
- Perform spatial interpolation of georeferenced data and automatically generate maps.

The procedures can include on or a combination of the following methods:

- Standard deviation;
- Variation coefficient;

- Analysis of variance;
- Mean, minimum, maximum.

Based on the above mentioned method one can create custom made scripts for the various types of crops and target analysis. After that all the scripts are directly integrate into and used by the software application.

Figure 6 depicts the main components of the software application.

The application is based on R statistical environment. As a result of that all the custom made script have to be developed using this programing language.

The data analysis procedures can be deployed before the application start and are going to be uploaded automatically during that session.

The central module is responsible for managing the R script and for making the connection to the R environment. In addition to that, it is the component which takes care of the work flow logic, as follows:

- The user selects a dataset;
- The user select and analysis procedure (statistical, interpolation or map);

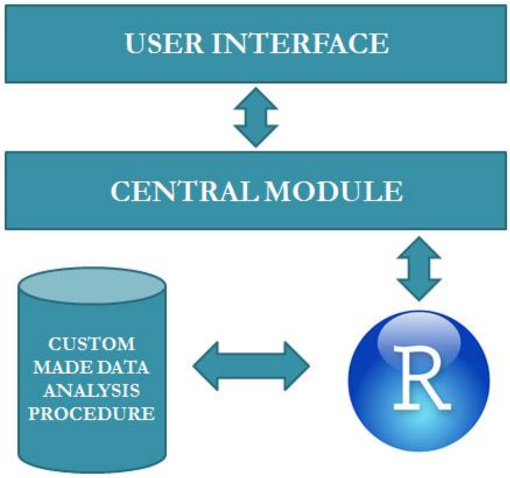

Fig. 6. *The main components of the software application*

- The application connect to the R environment for performing the computations;
- The application displays the results on the user interface.

Figure 7 depicts the user interface of the application. It contains an area dedicated for displaying maps, one area for displaying the text results and the needed buttons and control for making the appropriate requests.

Below are presented the mains scripts developed for testing the application:

- Crop homogeneity (it comprises the following steps: standard deviation, variation

coefficient, mean, minimum, maximum);

- Crop differences (it comprises the following steps: variance analysis);

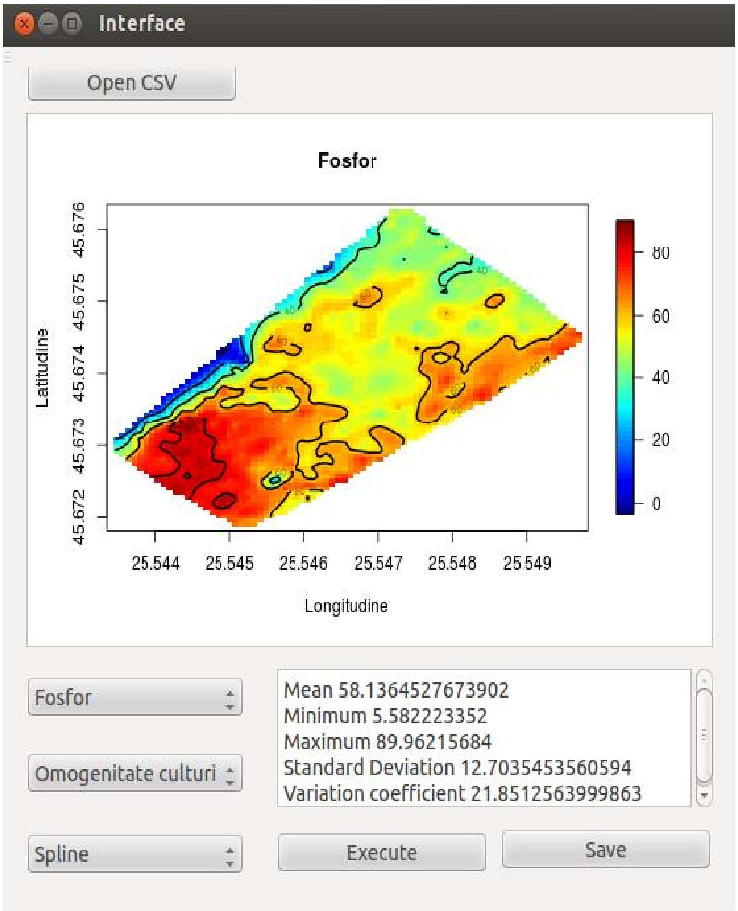

Fig. 7. *The user interface of the application*

-Uniform distribution (it comprises the following steps: mean, variance analysis, variation coefficient). Figure 8 depicts the textual results obtain after applying the uniform distribution procedure on a dataset.

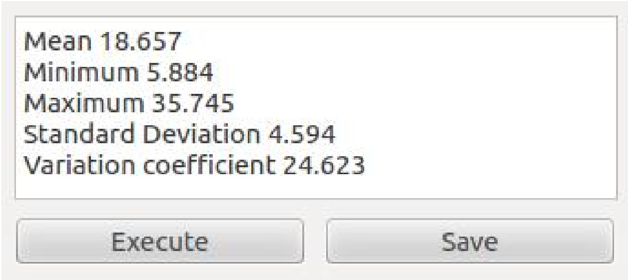

Fig. 8. *The results obtained after applying the uniform distribution script*

The spline method had been used for computing the soil parameter on the points where the sensors have not performed a measurement.

Figures 9 and 10 presents some sample maps produced by the software application after performing the interpolation step [4].

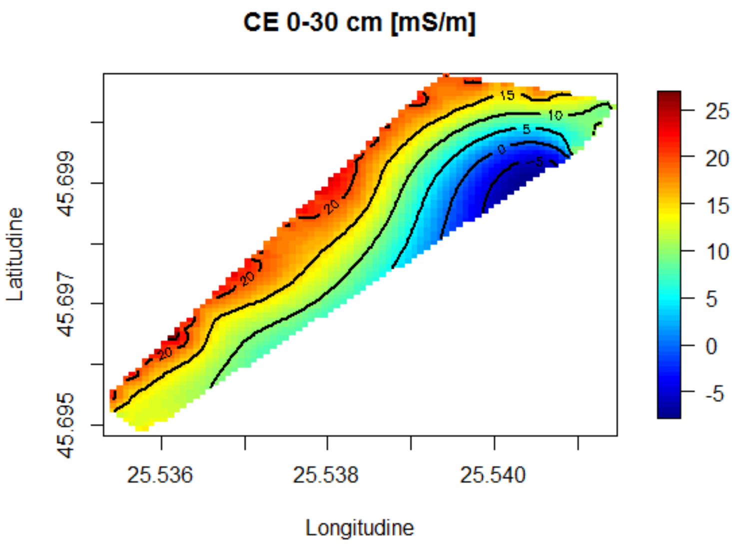

Fig. 9. *The map of the electrical conductibility*

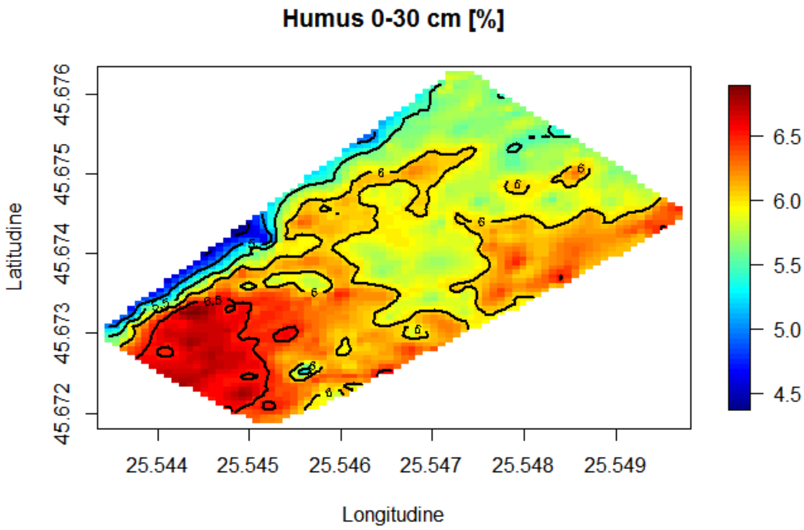

Fig. 10. *The map of the percentage of humus from the soil.*

5. Conclusions

We have compared our software application with other existing solutions and below one can find the result briefly presented.

Microsoft excel is a good environment for performing statistical analysis but it cannot generate interpolations of data and maps.

SPPS is very popular among the statisticians but it cannot generate maps or use scripts for running various sequences of operations.

R has a lot of libraries for performing statistical analysis, interpolations and maps but it cannot be easily used by persons with a weak background on programing.

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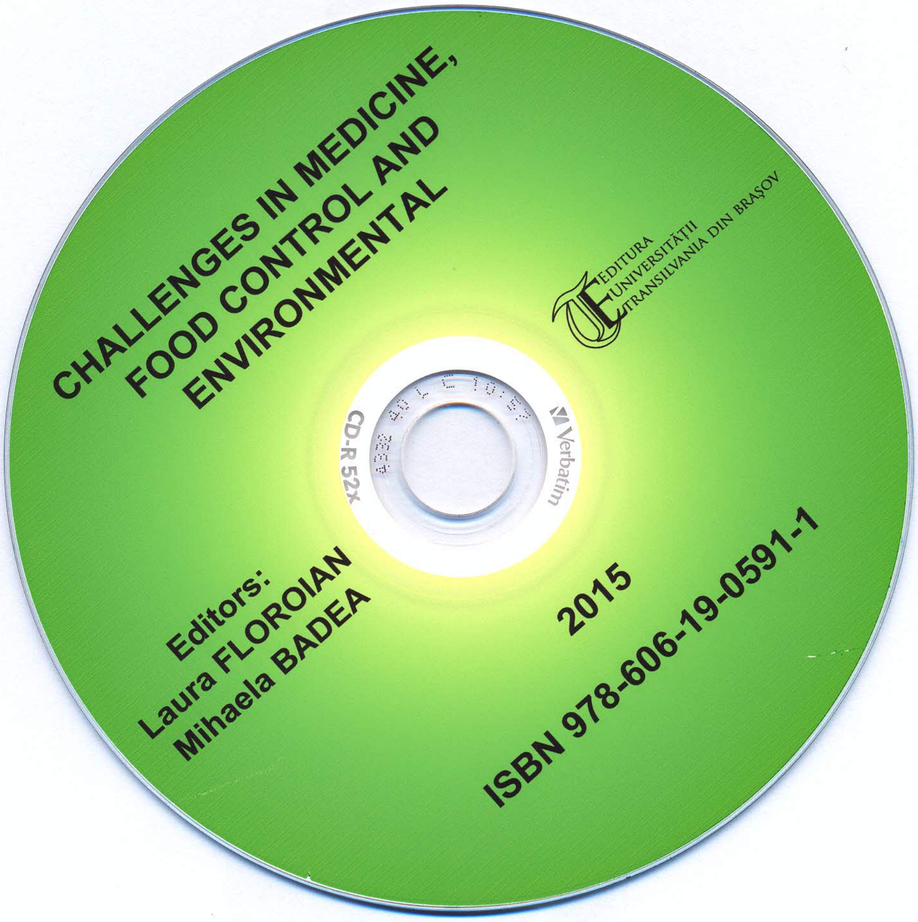
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