An Overview of Smart Irrigation Software

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Abstract— **Agriculture represents the biggest water user, with irrigation accounting for 70% of global water withdrawals. It is expected that, without improved efficiency, agricultural water consumption increases by about 20% by 2050 at global level. ICT technologies have been recognized as crucial in development of smart and sustainable agriculture. The paper represents an overview of some recent smart irrigation software solutions. The presented solutions exploit data obtained from different sensors, weather stations, satellite information, Internet or from the existing databases. Based on these data, the presented ICT solutions provide real-time decisions about the right irrigation time, prediction and plan for the irrigation in the future, as well as modeling of the irrigation scheduling and design of the irrigation systems based on offline data.**

Keywords-component: Irrigation management; Smart decision systems; Smartphones.

I. INTRODUCTION

Agriculture is the biggest water consumer, while the irrigation accounts for approximately 70% of global water consumption [1]. The domestic and industrial sectors account for 10% and 20%, respectively, although these percentages vary considerably across countries. In the world's least developed countries, agriculture usually accounts for more than 90% of water withdrawals. Around the world, the rainfed agriculture is the predominant agricultural production system, and its current productivity is, on average, little more than one half of the potential obtainable under the optimal agricultural management. Without improved efficiencies, agricultural water consumption is expected to increase globally by around 20% by 2050 [1].

ICT technologies have been recognized as crucial in development of smart and sustainable agriculture [2]-[7]. Numerous aspects of agricultural development and production highly depend on the usage of adequate ICT-based solutions. Efficient water supply and the expansion of irrigated areas have a vital role in the food production for the fast growing world population [2], [4]. ICT technologies applied in water supply and irrigation management along with automation technologies are recognized as an important factor which leads to increase of the efficient water exploitation, food production and certainly to higher profits to farmers. As it is emphasized in [2], ICT and automation technologies are applied together in order to achieve the efficiency in water use, higher production levels, lower costs, decreased manpower requirement and higher reliability in water supply.

The software developed for the purpose of smart irrigation management can be classified in several categories, but without sharp borders between them. The software used for a direct control of irrigation systems and water flow, including automatic valves and other active elements can be set into the first category. These software systems do not take control actions based on time scheduling only, but also use complex embedded expert systems. They usually provide a real-time monitoring of the whole irrigation systems, and thus malfunctioning and errors are easily detected. Another category includes a complex software which pulls together a large amount of information obtained from different sensors, weather stations, satellite information, and data from the Internet or from the existing databases. The sensors can be used to monitor air humidity, air temperature, solar radiation, soil moisture, soil temperature etc. Other sensors are used for monitoring plants, their response on irrigation, growth rate, chemical exchange etc. [3]. This kind of software uses sophisticated methods such as expert systems and artificial intelligence algorithms for further analysis and interpretation of the obtained data. Based on these data, it provides the real-time decisions about the right irrigation time, as well as the prediction and the plan for the irrigation in the future. In order to collect all the relevant data, adequate telecommunication technologies have to be applied, which are usually an integral part of this kind of software.

The first and second categories of software are usually combined, thus providing a completely automated and autonomous smart irrigation system. The third kind of software we have recognized in the analyzed context is the one applied for the modeling of the irrigation scheduling and design of the irrigation systems based on offline data. This kind of software encompasses contributions from different scientific areas including soil science, chemistry, physiology, climate etc. Usually, it also provides the simulation of water distribution patterns in the modeled system, taking into account all the relevant information, especially the complex relationship between the water consumption, soil, climate and specific plant cultures [3], [5].

Although information systems are fully integrated in the automation control, particularly interesting appliance of the ICT technology in the framework of the BIO-ICT project is the optimization of irrigation scheduling based on complex software from the first and second categories, which take into account the complete design of the observed irrigation system, topographical, aerial and GIS data, soil properties, climatic data, specific crop water requirements and other important data obtained from sensor networks, meteorological stations and numerous scientific databases. Of special importance are expert systems which can provide efficient real-time decision making. We have to emphasize that such systems usually provide a possibility of controlling not only the water supply process, but also the fertilization process. Thus, within the rest of this paper, description of some representative solutions will be provided.

II. Representative Solutions

A. Dacom Irrigation Advice

The Dacom from Netherland is a high-tech company that provides different interesting solutions for smart agriculture [8]. These solutions include hardware (different type of sensors), software and a kind of online advisory service. All these products are developed in order to serve to small farms and agribusiness around the world. Products that are developed at this company are Sensetion package, TerraSen package, Weather Station, Weather forecast & Spray conditions, Irrigation Advice, Crop recording, Fungal Disease Control, Insect Control, Food processing industry, Advice Organizations & Sypplying companies, Governments.

Here, we will focus on few of the above mentioned products:

- A Sensetion package consists of five soil moisture sensors and of mobile applications for Android and iOS. This package provides optimal irrigation advice for all crops and fields belonging to user. It is easy to use/install and it can be accessed any time via smartphones. This package contains high quality smart sensors and is powered by solar energy.
- A TerraSen Station is one more product that provides optimal irrigation advices. It measures soil moisture conditions, soil temperature, rainfall and irrigation and sends it automatically to user. It is advisable to use it in combination with Irrigation Advice software that will be explained next. This station is also supplied by solar energy.
- Irrigation Advice software is designed to be used in combination with the TerraSen sensor station. Parameters obtained by the TerraSen station are analyzed and software recommends optimal time and amount of irrigation. This prevents excessive watering and stress due to drought. Generally, advice module shows the amount of water through different soil layers and based on that analysis makes appropriate advice. The software screenshot is given at Fig. 1.

B. Irris Scheduler Software

Developed at the Purdue University Department of Agronomy, Irris Scheduler Software [9] is a small, simple and free desktop application which provides an estimation of irrigation water needs for about twenty different crops, as well as soil nitrogen losses and availability. This application is a representative example of decision support software, based on an expert system.

Figure 1. Screenshot of the Dacom Irrigation Advice software.

This expert system uses large amount of relevant data provided online and/or by a software user, combined with embedded expert's knowledge about specific crops, physical, chemical and physiological rules for assisting the crop producers with the irrigation scheduling and nitrogen application decisions.

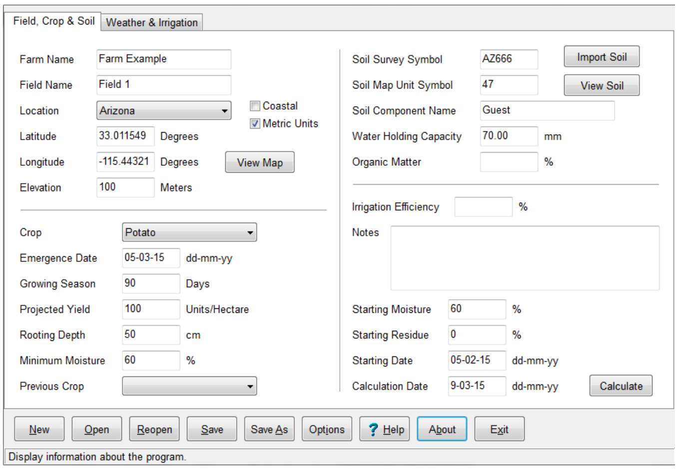

Figure 2. Screenshot of the main panel of the Irris Scheduler Software.

Since the software is free for download, we were able to test its functionality, by setting a fictive farm and field location in Arizona, and selecting one of the offered crops, as well as production dates and other production-relative information. We have chosen the USA state as the location of the farm because the software database possesses relevant information about weather stations, soil structure, climate and other parameters for locations at the USA and Canada. Other locations are provided via the category *international*, but the database does not include relevant information about the same parameters for Montenegro. After selecting a specific location and setting specific information about the considered agricultural production, the application provides the possibility of automatic information import from online sources. Unavailable or more precise information can be imported manually by the user (producer).

The main application panel is shown in Fig. 2. After inserting the farm and field location information, the selected farm field can be viewed online by automatic redirection to Google maps. Specific crop information should be inserted manually by users. The information about the soil can be imported automatically from online surveys, which are automatically detected by the application, and chosen by the user. If the user possesses more precise information about its fields (obtained for example from personal sensors etc.) they can be also easily inserted. All the obtained information about the soil can be viewed and easily corrected by the user, as shown in Fig. 3.

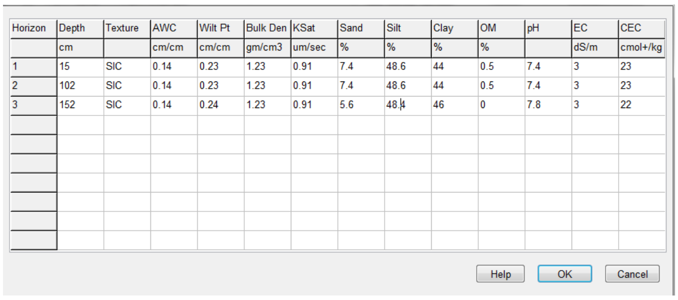

Figure 3. Viewing and editing the soil information in the Irris Scheduler Software.

The other important part of the application directly concerns the weather and irrigation information. The application provides the automatic searching of the nearest weather stations as well as online forecasting services, based on the farm location, as it is shown in Fig. 4.

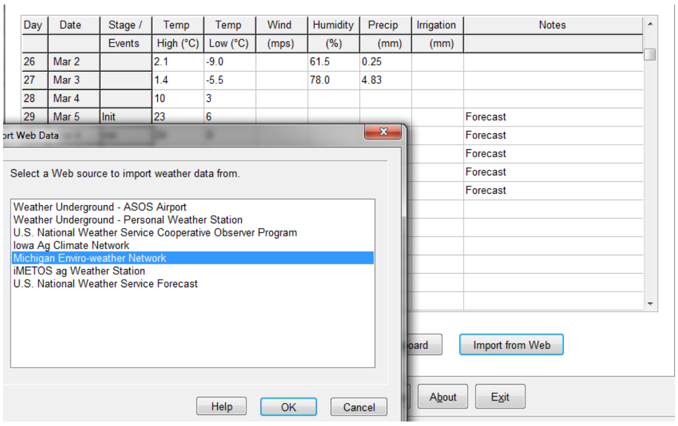

Figure 4. Viewing and inserting the weather information in the Irris Scheduler Software.

Based on the data obtained online or by users, the application finally provides the irrigation and nitrogen scheduling, by combining these data with the embedded facts about the observed crop and other relevant information (soil properties, previous crop information etc.). The obtained scheduling and other information can be automatically exported to Microsoft Excel with automatically generated graphics. An example of the provided scheduling is shown in Fig. 5.

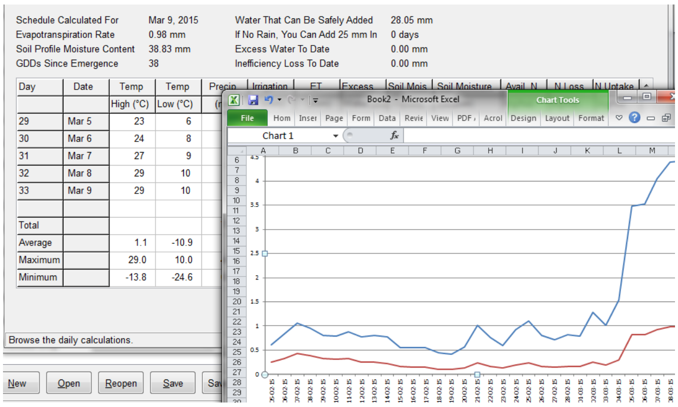

Figure 5. Irrigation and nitrogen scheduling provided by the Irris Scheduling Software.

C. *Smartirrigation Project and Apps*

Fresh water supply shortages are increasingly common in the Southeast US, which is mainly due to the growing population, as well as climate variability and change. By 2050, projections are that much of Florida will be at *high* to *extreme* risk of water shortage, whereas Georgia will be at *moderate* to *extreme* water shortage [10]. The irrigation takes a substantial part of fresh water supplies in the Southeast, both for agriculture and urban applications, and as such it represents a potential source of water savings under the assumption that the irrigation practice can be improved.

Staff from University of Florida - The Institute of Food and Agricultural Sciences (UF-IFAS), in cooperation with the US Department of Agriculture - National Institute of Food and Agriculture (USDA-NIFA) and University of Georgia, have used smartphone technology for managing urban and agricultural irrigation [10]. In specific, they have developed models that require minimum input using real-time weather data to improve irrigation practices in citrus, cotton, peanut, strawberry, and urban lawn environments. The developed irrigation models were converted into smartphone (Android and iOS) applications to be used by stakeholders. The applications are as follows:

- The *Citrus App* provides users with an irrigation schedule based on a water balance and real-time weather and forecasted data intended to conserve water while minimizing nutrient leaching from the root zone.
- The *Urban Lawn App* provides users with an estimate of irrigation run times needed to meet current lawn turf water demand using a simplified approach for automated irrigation systems.
- The *Strawberry App* provides users with an irrigation schedule based on a water balance and real-time weather and forecasted data intended to conserve water while minimizing nutrient leaching from the root zone.
- The *Cotton App* provides users with a mobile interface for determining cotton irrigation needs. Instead of delivering

irrigation application recommendations, the application provides notifications when irrigation is needed.

In the applications, producers can register their fields and receive notifications regarding irrigation schedule changes due to differences in the expected evapotranspiration for the next few days. A simplified water balance calculation has been used that considers field capacity, rooting depth, evapotranspiration, rainfall, minimum allowable depletion, and irrigation system characteristics. Meteorological data (daily mean temperature, wind speed, relative humidity, and solar radiation) for these calculations are obtained from Florida Automated Weather Network (FAWN) and Georgia Environmental Monitoring Network (GAEMN).

The applications include both real-time and forecasting components, and they are being tested by stakeholders. Further modifications are to be made in accordance with the stakeholders' suggestions and comments in order to improve their performance. Also, the applications are currently being tested in experimental plot studies throughout Florida and Georgia.

D. ENORASIS

ENORASIS is the pseudonym for a project entitled "Environmental optimization of irrigation management with the combined use and integration of high precision satellite data, advanced modeling, process control and business innovation" [11]. It is an FP7 project whose aim is to develop a decision support system for the optimized irrigation management by farmers and water management organizations. The idea it to provide quality service to farmers and water management organizations through the use of advanced technologies and by developing appropriate models. It is consisted of pilots which will be held in order to make adequate models. Pilots cover eight crop types (corn, cotton, potato, maize, apple, sweet cherry, grapefruit and raspberry) and four climate zones.

The overall system comprises four parts, namely meteorological analysis tools, decision support system based on GIS, field hardware and irrigation management system. Pilots include experiments such as yield monitoring when there is no irrigation, when irrigation is performed without decision support system and finally when decision support system is used. The results obtained from this experiment and other similar experiments (other pilots within ENORASIS) are used to improve and build smart decision support system.

III. CONCLUSION

The paper considers the use of advanced ICT technologies in agriculture, especially the effect of irrigation to yields. The considered systems are used worldwide in order to improve the irrigation process. Four solutions are explained, although many others exist. The first one is the irrigation advice system developed by the Dacom company from Netherlands. It is a commercial product which offers complete solutions from sensors to software.

Figure 6. Enorasis pilot farm at North Central Europe.

The second is the Irris scheduling software, a freeware application which provides expert system based irrigation advices using automatically collected or manually inserted data. The third one is Smartirrigation project which considers the smartphone technology for managing urban and agricultural irrigation. Finally, the ENORASIS project has the aim to develop a smart decision system for irrigation based on data from pilot experiments organized within the project.

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