Integrated Smart Decision Support Tool for ECO-efficient Inputs Management of MENA region Farming Systems (ECO-FARM)

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Water scarcity in MENA region is a leading constraint in the agriculture sector. The region is heavily dependent on seasonal rainfall; drought years reduce yields sharply and leave smallholders food-insecure. The shift towards irrigated agriculture to meet the countries" need for food needs to be managed very carefully in light of the scarce water resources.

In a countries facing such a significant imbalance between limited supplies and ever-growing demand, increasing water use efficiency is a must. This is especially true for the agricultural sector which consumes significant portions of the national water supply and is central to the counties economy. The National Water Strategies should include a comprehensive set of guidelines and approaches for supply and demand management, to balance the water deficit by applying new technologies, decreasing consumption and improving water management to increase the efficiency of irrigation. The implementation of these strategies is a high priority. Appropriate support to farmers would require mainstreaming access to knowledge on technologies and best practices and enable them to invest in more sustainable land and water management practices.

The Decision Support System (DSS) tool provides farmers with real-time weather and soil humidity data that enables them to make proper decisions related to selection of crops grown, irrigation scheduling, fertilizer applications and integrated pest management., that optimizes the use of farm inputs such as water, fertilizers and pesticides, improves crop productivity, increases farmers' incomes while preserving the environment by preventing chemical pollution.

In this context, the interest for research-innovation transfer into practice and development of new, 'integrated' tools to support both the farmers' decision process as well as the environmental impact assessment of farm production systems is expressed by a large range of stakeholders including local and regional policy makers, farmers, food producers and consumers, technicians and consultants. Accordingly, the ECO-FARM will promote an innovative farming approach based on the eco-efficiency concept with the objective to achieve more agricultural outputs, in terms of income, with less inputs of land, water, energy, nutrients, labor and/or capital.

The eco-efficiency of agricultural systems can be enhanced by choice of crops and farming practices which reduce negative environmental impacts while at the same time maintaining or increasing farm returns. Several scientific tools already exist to assess the environmental impact of production systems (Roy et al., 2009; Sadok et al., 2009; Cucek et al., 2012), but rarely they are integrated in real-time farm decision support systems. Consequently, the development of 'integrated' decision support tools to support the farm decision process within the eco-efficiency framework is considered to be a relevant research topic.

On the other side, several model-based DSS for farm management have started to be applied in agriculture worldwide, with the aim to support the decision-making process at both farm and district levels. A DSS can be defined as "an interactive software-based system used to help decision-makers compile useful information from a combination of raw data, documents, and personal knowledge; to identify and solve problems; and to make an optimized decision" (Rinaldi and He, 2014). Accordingly, the 'European Innovation Partnership on Agricultural Productivity and Sustainability' (http://ec.europa.eu/eip/agriculture/en) has identified as a relevant priority the need to develop innovative DSS for farm management through the integration of new 'smart' solutions, and to further address research and industries to develop innovative 'user-friendly farm management support systems'.

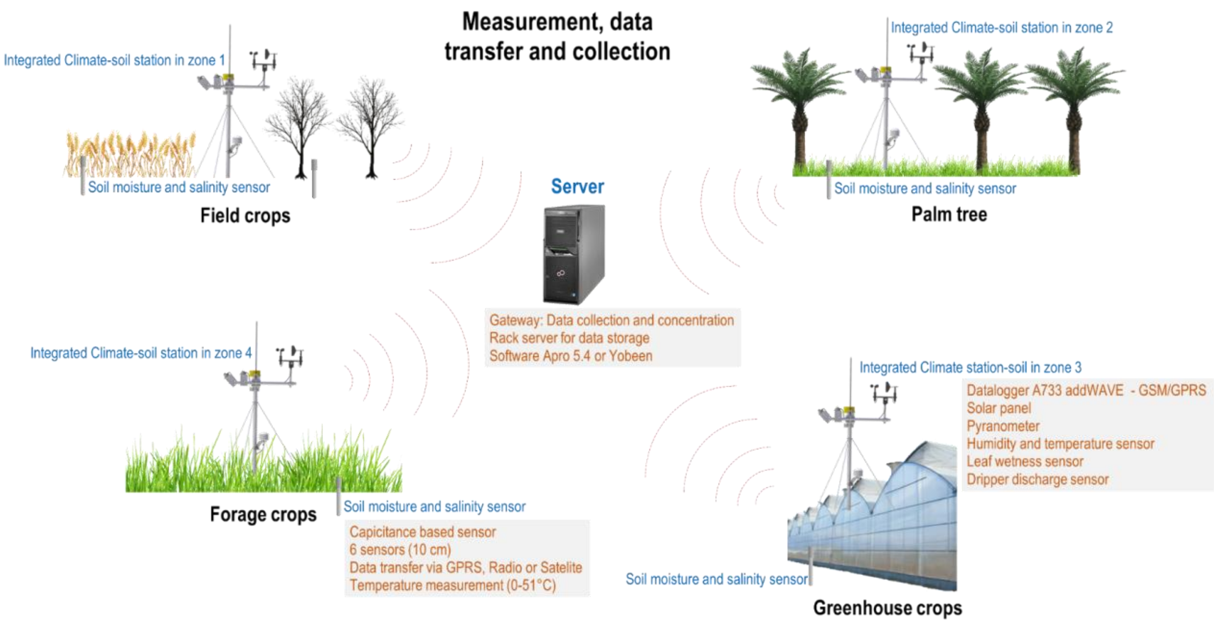
Computerized irrigation system and Irrigation controllers have been available for many years in the form of mechanical and electromechanical irrigation timers. These devices have evolved into complex computer-based systems that allow accurate control of water, energy and chemicals while responding to environmental changes and development stages of the crop.

Several examples of DSS can be found in the scientific literature (Rinaldi, 2014), and some commercial solutions starts to be available also on the market, but normally they provide support on single farming practices (e.g. irrigation) and rarely they consider multiple farming issues at the same time (e.g. water-nutrient-salinity-wastewater management) while including environmental impact and/or eco-efficiency assessment of production systems. Moreover, a very few examples of web-based DSS are available, while this technology offers the possibility to manage large amounts of data and integrate decision support tools from multidisciplinary sources, which can be located in a distributed computing environment and integrated together to support decision-making process.

Innovation Pilot implementation in South of Morocco

The DSS was successfully used for irrigation management on a large scale in south of Morocco in the region of Souss Massa covering over 18,000 hectares. The region was recording huge water deficits that threatened the livelihoods of over 1000 farmers growing citrus crops and export-oriented vegetables such tomato, melon, cucumber, pepper and beans. This pilot resulted in water saving of more than 20% equivalent to an annual saving of 80 million m3 (equivalent to the capacity of a medium-sized dam). Energy savings of up to 960 million MJ/ha/year; A 20% reduction in fertilizer application and a resultant reduction of the negative impact of certain fertilizers on soil fertility and fruit quality; improved product quality and an overall 20% reduction in pesticide application. Farmers in the region recorded and increase in their incomes. In another project, DSS was used for integrated pest management in the Massa region in Morocco allowing a 20% saving of pesticides. In Jordan, a pilot activity on a few farm lands that installed computerized irrigation system with tensio-meter and automatic ventilation of green houses for improving irrigation management showed water savings as high as 30%. Under the ECO-FARM Model, the DSS will be linked to the latest web, mobile phone and cloud applications to enable a wider reach of the DSS tool for an integrated management of irrigation and pests warning.

Figure 1
General layout of DSS System for water use efficiency



Test of Intellectual soil irrigation system (IRIS) in ICBA, Dubai

The idea brought by the IRIS system is quite simple and consist to couple tensiometer which were always considered as an efficient soil moisture measurement system to automatic system controlling irrigation including valve opening and closing. IRIS system was tested and was compared to ETo based method.

The principle of operation of "Automatic Irrigation System" is based on measuring water pressure in a soil and controlling electric valve. Controller measures water pressure from time to time then either open or close the valve. Also, GGI system has solar panels and accumulators which help to save energy and work efficiently. All data could be downloaded on a laptop wireless or sent on a server via GPRS. Analysis of data is operated automatically. The controller consists of three main parts- power system, water pressure measuring system, data storage and transfer system.

The general goal was to compare between IRIS soil tension based system, ETo based method (used in ICBA) in terms of agronomic performance of maize and irrigation water supply


Variation of biomass partitioning of maize is presented in figure2 below. Data indicate clearly with a significant difference (P<0.01) that IRIS set with 10 Cbar/10 cm depth and 5 Cbar/20 cm depth showed the highest biomass production compared to ETo method and 5 cbar/10 cm. more is the depth of the IRIS sensor more is the root weight and more is the set pressure more is the root weight. This finding indicates that increase the IRIS pressure up to 10 cbar or thedepth up to 20 cm resulted in more development of root system compared to above ground shoot which clearly shown when illustrating the variation of root to shoot ratio which was maximized under 10 Cbar/10 cm depth and 5 Cbar/20 cm.

Figure 2

Variation of biomass partitioning and root Ration of maize based on different Irrigation monitoring system

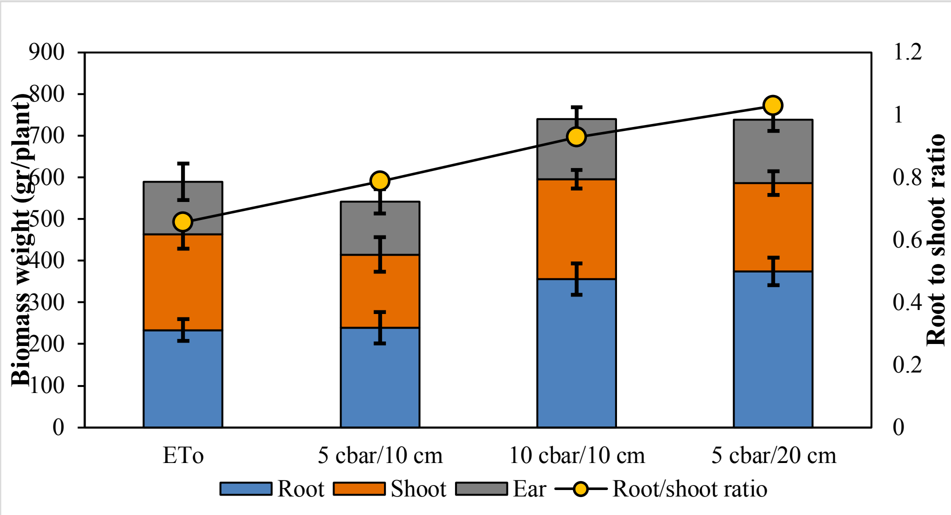
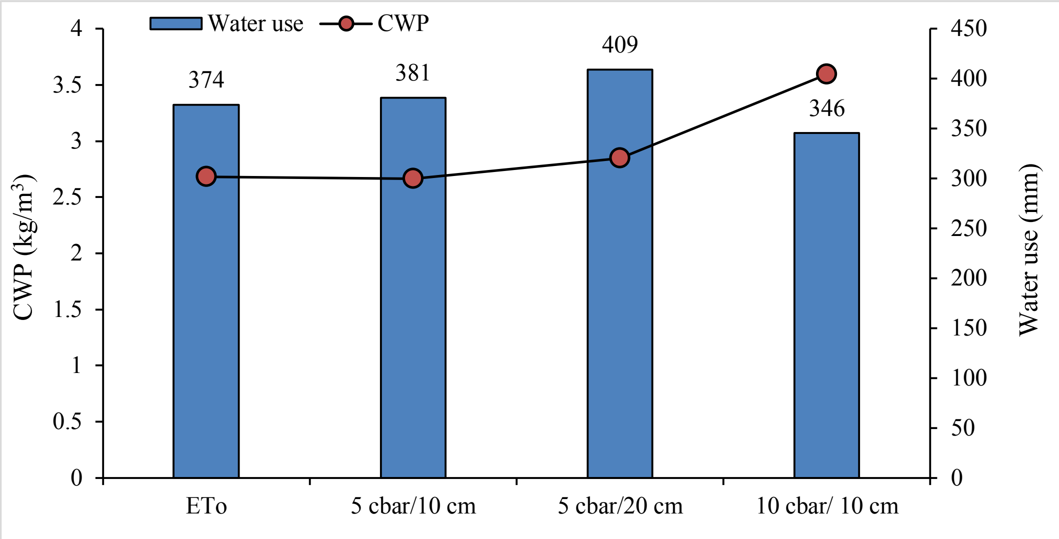


Figure 3 below shows the water use expressed in mm during the growing period and the Crop Water Productivity (CWP) expressed as the ration between yield and water consumption. Presented data indicate obviously that water use has been reduced under IRIS set at 10 cbar /10 cm. however the highest water use was recorded under treatment 5 bar/20 cm and this can be explained by the high relative quantity needed to reach and feel the soil reservoir up to 20 cm depth in order to reach the sensor vacuum.

As the treatment 10 cbar/10 cm produced more in term of yield and consumed less in terms of water, CWP was tremendously improved and maximized. However, the lowest CWP was observed under 5 cbar/10 cm treatment.

Figure 3
Water use expressed in mm during the growing period and the Crop Water Productivity (CWP) based on different Irrigation monitoring system



Conclusion

Fresh water scarcity is a growing challenge in the Middle East and North Africa region that is intensifying with climate change. UN's latest projections predict that most of the region will become hotter and drier, threatening the livelihoods of over 3 million horticulture farmers. The deployment of water efficient technologies in agriculture stands to make a huge contribution to water security in the region. Providing farmers with access to timely and smart decision making tools will empower them to make SMART choices that go beyond water saving to increased production and higher incomes. The growing number of export oriented contract farmers in MENA Region urgently need water saving solutions that will decrease their water use and maximize profits to enable them to stay in business. ECO FARM provides these farmers with a smart tool to reduce water, fertilizer and pesticide use, improve crop productivity and increase profits as demonstrated in the deployment of DSS in Morocco. IRIS irrigation system allowed to maximize the CWP as well as yield. However, the recommended combination of pressure and sensor depth to maximize crop water productivity is to set the system at 10 cbar pressure and 10 cm depth. This combination allows to the plant to develop its root system and therefore more yield.

Bibliography / More information

- Cucek L., et al., 2012. A review of footprint tools for monitoring impacts on sustainability. Journal of Cleaner Production, 34, 9-20.
- Pretty J., 2008. Agricultural sustainability: concepts, principles and evidence. Phil. Trans. R. Soc. B.: 363, 447-465.
- Rinaldi M. and He Z., 2014. Decision Support Systems to manage irrigation in agriculture. Advances in Agronomy, 123: 229-279.
- Roy P. et al., 2009. A review of Life Cycle Assessment on some food products. Journal of Food Engineering: 90, 1-10.
- Sadok W., et al., 2009. MASC, a qualitative multi-attribute decision model for ex-ante assessment of the sustainability of cropping systems. Agronomy for Sustainable Development: 29, 447-461.
- Thysen, I., Detlefsen, N.K., 2006. Online decision support for irrigation for farmers. Agric. Water Management. 86, 269–276.