CROP IRRIGATION REQUIREMETS VALUATION THROUGH REMOTE SENSING
STIMA DEL FABBISOGNO IRRIGUO COLTURALE TRAMITE TELERILEVAMENTO

Filiberto Altobelli[1], Pasquale Nino[1], Silvia Vanino[1], Carlo De Michele[2], Francesco Vuolo[2]

[1] Istituto Nazionale di Economia Agraria (INEA),Via Nomentana, 41- 00161 Rome Italy
[2] Ariespace S.r.l Centro Direzionale, IS. A3 - 80143 – Naples Italy
* altobelli@inea.it

Abstract
Science-policy cooperation is one of the most challenges for Integrated Water Resources Management (IWRM) and Climate Change (CC) adaptation. The expected growing pressure on water resources, from human demand and CC, will require adaptation to increase water saving in many countries. Objective of this paper is to show how the tools, based on the operational implementation of Earth Observation (EO) technologies to manage irrigation in water scarcity environments and Information and Communication Technologies (ICT) for deliver the information generated to the end users, developed in the SIRIUS project can contribute to improve IWRM at farmer/river basin level allowing more efficient water use for irrigation.

Keywords: Remote Sensing; Crop Water Requirements; Crop coefficient; Irrigation Water Requirement
Parole chiave: Telerilevamento; Fabbisogno idrico; Coefficiente colturale; Fabbisogno irriguo

Introduction
Agriculture is the largest consumer of fresh water on the planet with about 70% of all fresh water withdrawals. In the EU as whole, 24% of abstracted water is used in agriculture raising to more than 80% of the total national abstraction in some regions of southern Europe [1]. Water scarcity is a growing concern for today's agriculture across Europe, where many irrigation areas have experienced in recent years a reduction in water availability due both to the decrease of water resources and an increased demand for water for domestic and industrial use. Future scenarios are expected to be worse due to climate change that might intensify problems of water scarcity and irrigation requirements in the Mediterranean region [2]. An accurate assessment of irrigation demands is therefore a key requirement for a more rational water management [3], and a large scale overview on European water use can contribute at developing suitable policies and management strategies. So far, the main policy objectives in relation to water use and water stress at EU level, set out in the 6th Environment Action Programme (EAP, 1600/2002/EC) and in the Water Framework Directive (WFD, 2000/60/EC), aiming at ensuring a sustainable use of water resources, resulting in the need to implement policies focused on the maximization of benefits for farmers and society as a whole, by ensuring food production and environmental sustainability.

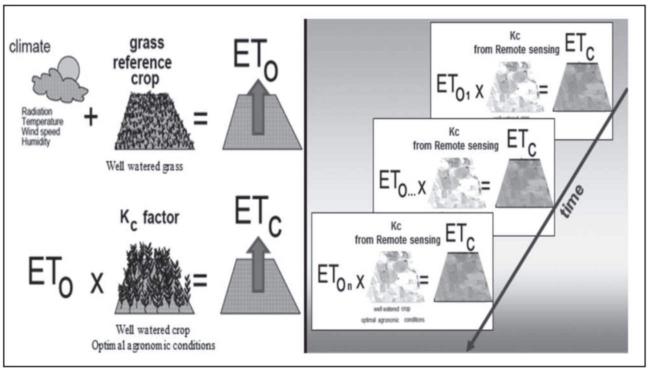

Fig. 1 - (a) CWR evaluation FAO paper 56; (b) CWR evaluation F.A.O. paper 56 modified.
Fig. 1 - (a) Stima del fabbisogno idrico sulla base del quaderno FAO 56 ; (b) Stima del fabbisogno idrico sulla base del quaderno FAO 56, modificato.

The SIRIUS project
SIRIUS aims to introduce innovative water management tools for supporting sustainable agriculture and promoting efficient irrigation management practices both at farm level and water basin scale. The project partnership consists of 18 public and private institutions widespread around the world. The study and analysis is carried out in eight pilot areas located in Spain, Italy, Romania, Turkey, Egypt, India, Mexico and Brazil. This paper is about the Italian pilot area locate in the Campania region (Southern Italy).

Methodology
A common methodology for evaluating the maximum Crop Water Requirement is defined by the FAO in paper 56 [4], based on the so called crop coefficient approach, resulting of the product between the reference evapotranspiration (ETo), and crop coefficient (Kc) - aggregation of the physical and physiological differences between crops - to estimate the crop evapotranspiration under standard condition (ETc) [Fig.1a]. Crop water requirement exclusive of precipitation give the Irrigation Water Requirement (IWR). Kc values are extremely variable, even within the same type of crop, depending on many factors, i.e. date and seeding density, intake of nutrients, nature of the soil, agronomic practices. In order to assess the spatial/temporal variability of the Kc, in the SIRIUS project a methodology based on calculation of Kc from Remote Sensing (RS) techniques is proposed [Fig.1b]. One important advantage crop coefficients from spectral measurements is that their values do not depend on other variables such as planting date and density, but on the effective cover; as such, the spectral values of these canopy parameters include implicitly the variability within the same crop type due to actual farming practices.
The basis of the SIRIUS project is established on the

consideration that a rational management of water resources for irrigation requires information characterized by high temporal and spatial variability, which cannot be monitored with traditional field inspections. Remote Sensing is a mature technology, ready for being transferred to operational applications in agricultural water management. Detailed data on crop development and irrigation needs are timely distributed to final users by means of modern Information and Communication Technologies. The methodology proposed in the project to calculate the CWR is based on two different approach, both based on the strong relationship between the spectral response of cropped surfaces and the corresponding values of crop coefficient Kc [5], tested and validated the first time during the DEMETER project in 2005 [6], and further consolidated in the PLEIADES project. The first procedure is based on the relationship between the Normalized Difference Vegetation Index (NDVI) and the value of the basal crop coefficient ("Kc-NDVI" approach) [7]. The second procedure, named "Kc-analytical", is based on the direct application of the Penman-Monteith equation with canopy parameters estimated from satellite imagery [8], in analogy to the direct calculation proposed by FAO. [4].

Both approach follow the same methodological steps as depict below:

• Acquisition and analysis of high resolution satellite images in the visible and infrared spectrum;
• Local agro-meteorological data acquisition;
• Field validation through measurements in selected areas;
• Elaboration of RS based products (Kc maps);
• Data quality check and integration in a dedicated Geographical Information Systems (SPIDER GIS) for irrigation management from field to district and hydrological basin scale;
• Real-time distribution of personalized irrigation advices on a weekly basis directly to farmers by means of different communication systems (Internet, text and graphical messages by using GSM/UMTS).

5. Results and conclusion

In order to apply the methodological approach described in the previous paragraph, an operational campaign have been carried out in 2012 organized as following:

• Direct involvement of farmers. Inside the pilot area sample farms were selected of which providing the irrigation advise (usually transmitted via an SMS message), main crop monitored have been Maize, alfalfa and orchard.
• Acquisition and processing of satellite images (13 rapid eye images have been acquired, from July to September with a frequency of about 1 week), and agro-meteorological data, field measurements, and delivery of the irrigation advise to the farmer.
• Measurement of the amount of water delivered by the Sannio Alifano Consortium to the selected farms during the 2012 irrigation season.

The data collected shows different response of farmers in the use of irrigation advice (actually the analysis is related of 6 farms with irrigated corn silage). In fact, against three farmer who have used a smaller amount of water than indicated by the irrigation advise two farmer used much higher amounts, while not getting better production performance and supporting higher costs for water, energy, time and effort. In continuation of project activities will be carried out a more detailed analysis, aimed at identifying the costs and benefits (economic and environmental) associated with different behaviors of farmers.

Reference

[1] EEA Report No 2/2009. "*Water resources across Europe-confronting water scarcity and drought*". ISSN 1725-9177.

[2] IPCC, 2007. *Climate Change 2007: The Physical Science Basis – Summary for Policymakers*. Contribution of WGI to the 4th Assessment Report of the IPCC. Geneva.

[3] Maton, L., Leenhardt, D., Goulard, M., Bergez, J.-E. (2005). *Assessing the irrigation strategies over a wide geographical area from structural data about farming systems*. Agricultural systems 86, 293-311, doi:10.1016/j.agsy.2004.09.010.

[4] Allen, R.G, Pereira, L.S., Raes, D. Smith, M. (1998). *Crop evapotranspiration. Guidelines for computing crop water requirements*. UN-FAO, Rome, Italy.

[5] Richter K., Vuolo F., D'Urso G. (2009). *Estimation of potential evapotranspiration:empirical versus physical approaches of crop characteristics*. IX Convegno Nazionale dell'Associazione Italiana di Ingegneria Agraria, Ischia Porto, 12-16 settembre 2009, memoria n. 2-32.

[6] D'Urso, G. and Calera, A. *Operative Approaches To Determine Crop Water Requirements From Earth Observation Data: Methodologies And Applications*. Earth observation for vegetation monitoring and water management. AIP Conference Proceedings, vol 852, p.p. 14-25, 2006.

[7] Cuesta A., Montoro A., López-Fuster P., Calera A., Jochum A. (2005). *Metodología operativa para la obtención del coeficiente cultivo desde imágenes de satèlite*. Information Técnica Económica Agraria. ITEA, 101 (3), 212-224

[8] D'Urso, G. (2001). *Simulation and Management of On-Demand irrigation system: a combined agrohydrological and remore sensing approach*. Doctoral Thesis Wageningen University. ISBN 90-5808-399-3

Acknowledgements

This study was developed in the framework of projects SIRIUS Grant agreement No 262902 financed by U.E.-VII F.P.).