PhD School on Agriculture, Environment and Bioenergy

(http://sites.unimi.it/dottorato_aab/)

(XXXVII cycle, 2021-24)

Project draft

1.Field of interest

*Indicare **il/i** settore/i scientifico disciplinari: **AGR-08***

2.Project title

Agro-hydrological models and measures to improve the environmental sustainability of agroecosystems

3.Tutor (membro del Collegio dei Docenti): ***Prof.ssa Arianna Facchi***

- Eventually: co-tutor/s

4.Relevance of the topic and state of the art:

Improving the use of water resources is currently a crucial issue in agriculture, especially where the sector has a strong economic value and makes use of large water volumes. The Water Framework Directive (WFD, 2000/60/EC) has established the main policy objectives in relation to the use of this resource, in order to ensure a more sustainable approach to water management in Europe (Wriedt et al., 2009). As agriculture exerts the main pressure on renewable water resources (European Environment Agency, 2018), it is important for the scientific community to support the development and demonstration of technologies and techniques addressed at reducing the use of the water resource in agriculture, in order to fulfil the requirements of sustainable water resources policies, especially in areas characterized by a scarce availability of water. This becomes particularly true in a context of increasing water scarcity due to the climate change, in which policies and tools to optimize water use are key components for a sustainable development. Also in Italy, due to the recurring periods of water scarcity occurred in many areas - not only in the southern regions - in recent years, these issues are becoming increasingly topical. In this regard, many Regional Authorities have implemented within their RDP (Rural Development Programs) 2014-2020 measures aimed at granting funds to agricultural enterprises adopting technologies which were demonstrated to reduce irrigation water needs. In order to optimize the use of water resources, whatever the irrigation method adopted, it is necessary to map the soil variability in agricultural areas, identify effective methods to characterize soil hydrological and crop properties, and support the irrigation planning and management with soil-crop hydrological models of sufficient detail.

In the aforementioned context, the following aspects become particularly important: a) the identification of techniques for investigating soil hydraulic and crop properties, with the aim of obtaining effective parameters to be used in the agro-hydrological modelling activity; b) the selection and application of appropriate agro-hydrological models to simulate water dynamics in different soil-crops systems, able to support, from one side, the irrigation scheduling at the field and farm scale and, from the other side, the irrigation planning at the irrigation basin level.

5.Layout of the project (draft)

5.1.Materials & Methods:

In order to pursue the above objectives, the following methodologies will be adopted, considering at least two very different agro-ecosystems (a rice irrigation district in Lomellina-Pavia and a maize district in the province of Brescia):

1) Using a large data-base including soil hydraulic characteristics and crop parameters collected in past projects by the research group of Agricultural Hydraulics - DiSAA, the best methods for their estimation through PedoTransfer Functions and remote sensing tecniques will be selected;

2) Data will be used to parametrize a semi-distributed approach based on the SWAP model (Soil Water Atmosphere Plant model; Kroes et al., 2000), with the aim of simulating water dynamics in the soil-crop system at the field and farm scale in a sufficiently accurate way. In order to assess the performance of the simulation approach, a number of soil profiles instrumented with probes for monitoring the soil water status at different soil depths in two pilot farms will be considered. The two farms have different characteristics: the first one is cropped with maize and sprinkler-irrigated through pivots and rangers; the second is a rice farm in which the traditional irrigation method (continuous flooding) was converted to AWD (alternate wetting and drying). At the farm scale, the semi-distributed model will be used to support the optimization of irrigation scheduling;

3) Once validated at the field and farm scale, the semi-distributed model will be used to simulate water dynamics at the irrigation district scale, considering both the current situation and "what-if" scenarios (conversion to "water saving" irrigation methods also in a climate change context).

5.2.Schedule and major steps (3 years):

The PhD program will be articulated in the following main tasks:

1) Organization of the database of soil hydraulic parameters and crop biophysical parameters collected in past projects by the Agricultural Hydraulics group of DiSAA. Identification of the most suitable set of Pedo-Transfer Functions for the estimation of soil hydraulic parameters in the pilot areas, as well as of the most appropriate remote sensing method for estimating crop phenology and crop parameters (Year 1);

2) Revision and adjustment of a semi-distributed MATLAB code (already developed by the Agricultural Hydraulics group at DiSAA) based on the SWAP model to make it suitable for the simulations to be carried out within the PhD project (Year 1);

3) Application of the semi-distributed model (MATLAB code) to pilot farms, for the current situation and in the case of optimized irrigation strategies (Year 2);

4) Application of the code to pilot districts, for the current situation and for "what-if" scenarios considering the conversion of irrigation methods towards more "water saving" techniques and the climate change (Year 3).

6. Available funds (source and amount)

MEDWATERICE - Towards a sustainable water use in Mediterranean rice-based agro-ecosystems (PRIMA Program-Section2-2018, aprile 2019 – marzo 2022/23); 200,000.00 euro for DiSAA.

RISWAGEST – Verso una gestione innovative dell'acqua in risaia (Regione Lombardia, Progetti Ricerca 2018, giugno 2020 – maggio 2023); 160,119.00 for DiSAA.

SOS-AP – SOluzioni Sostenibili per l'Agricoltura di Precisione in Lombardia: irrigazione e fertilizzazione rateo-variabile in maidicoltura e viticoltura (Regione Lombardia, PSR 2014-20, giugno 2020 – maggio 2022); 207,794.00 for DiSAA.

6. Literature:

European Environment Agency, 2018. Use of freshwater resources. https://www.eea.europa.eu/data-and-maps/indicators/use-of-freshwater-resources-2/assessment-2.

Kroes J.G., Wesseling J.G., van Dam J.C. (2000) Integrated modelling of the soil–water–atmosphere–plant system using the model SWAP 2·0 an overview of theory and an application. Hydrol. Process. 14, 1993 – 2002.

Wriedt, G., Van der Velde, M., Aloe, A., Bouraoui, F., 2009. Estimating irrigation water requirements in Europe. Journal of Hydrology 373, 527–544. https://doi.org/10.1016/j.jhydrol.2009.05.018