PhD School on Agriculture, Environment and Bioenergy

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

(XXXVIII cycle, 2022-25)

Project draft

1.Field of interest

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

2.Project title

Agro-hydrological modelling and measures for a sustainable management of water resources in rice areas

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) 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 water availability. 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; as a matter of fact, the agricultural year 2022 can be undoubtedly taken as an example of the new situation that we may face in the next future.

In this context, a peculiar role is played by the rice sector where the use of water for flooding irrigation is huge, but the massive conversion of irrigation methods to more water-saving techniques may have a great impact on the water resources system that is characterized by a strong interaction between irrigation and phreatic groundwater levels. The high percolation fluxes from the extensive network of unlined irrigation channels and from the flooded paddies increases the phreatic groundwater level, which, in turn, increases the water discharge in rivers and in the irrigation networks. Thus, the conversion to more "water saving" techniques in certain areas can paradoxically decrease the availability of water for irrigation in others. Consequently, to optimize the irrigation use in rice areas, a good knowledge of the water resources system is primarily required, together with the development of appropriate technologies and techniques for the irrigation planning and management, which may include: the implementation of irrigation strategies such as the intermittent flooding after a water seeding (Alternate Wetting and Drying), the

implementation of winter flooding as an artificial groundwater recharge technique, the development and parametrization of appropriate agro-hydrological models able to simulate the current situation and scenarios.

5.Layout of the project (draft)

5.1.Materials & Methods:

In order to pursue the above-cited objectives, the following methodologies will be adopted:

1) Selection of the best methods for the estimation of soil hydraulic characteristics and crop parameters through PedoTransfer Functions and remote sensing techniques, starting from a data-base of measured data collected in rice areas in past projects by the research group of Agricultural Hydraulics - DiSAA;

2) Parametrization of a semi-distributed approach based on the SWAP model (Soil Water Atmosphere Plant model; Kroes et al., 2000, 2017) with the aim of simulating water dynamics in the atmosphere-soil-crop system at the irrigation district scale. The model, already developed in MATLAB, will be updated and validated using the newly collected data in two rice irrigation districts of about 1000 ha, located in Lomellina and prevalently cropped with rice. In these two districts, irrigation water discharges and phreatic groundwater levels will be monitored.

3) Development of a more conceptual model for rice areas, based on the IDRAGRA model (https://air.unimi.it/handle/2434/300698) and suitable for carrying out simulations in large areas for irrigation planning purposes. The modelling approach will be compared with results produced by SWAP for the two pilot irrigation districts and then applied to the whole Lomellina territory (about 124.000 ha).

4) Simulation of water dynamics and balances for the Lomellina area, considering both the current situation and "what-if" scenarios, with a particular attention at the impacts of "water saving" irrigation techniques and winter flooding on the water resources system of rice areas, also in a climate-change perspective.

5) Involvement of the Associazione Irrigua Est Sesia (AIES; https://www.estsesia.it/) managing irrigation in Lomellina, in the whole activities.

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, as well as of the most appropriate remote sensing method for estimating crop phenology and crop parameters (Year 1);*

2) *Selection of a second rice irrigation district of about 1000 ha in Lomellina, the first one being the San Giorgio di Lomellina irrigation district (about 1000 ha; 90% of rice in the agricultural surface) monitored by the research group of Agricultural Hydraulics – DiSAA from 2015. Instrumentation of the second pilot district for the measurement of irrigation water discharges and phreatic groundwater levels (Year 1);*

3) *Revision and adjustment of the 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);*

4) *Application of the semi-distributed model (MATLAB code) to the pilot districts, to simulate the current situation (Year 2);*

5) *Modification of the IDRAGRA code for the simulation of the irrigation of rice (with the support of the IDRAGRA developer). Application of the model to the pilot districts. Comparison with SWAP (Year 2).*

6) *Application of the IDRAGRA code at the whole Lomellina, for the current situation and for "what-if" scenarios focussed on the conversion of irrigation methods towards "water saving" techniques and winter flooding, also considering the climate change (Year 3).*

6. Available funds

MEDWATERICE - Towards a sustainable water use in Mediterranean rice-based agro-ecosystems (PRIMA Program-Section2-2018, aprile 2019 – marzo 2023); 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.

Contratto con Associazione Irrigua Est Sesia per la "Quantificazione del bilancio idrologico per la porzione del territorio comprensoriale denominata "Pianura irrigua novarese-lomellina" (2022); 17.191,09 for DiSAA.

Recently submitted for funding:

PRIN 2022 - SHYSTEMIC (Moving forward on soil hydrological processes assessment for mitigating environmental emergencies in agriculture); PI: UNIPA
BUDGET per UNIMI: 49.599,00 euro

Interreg Europe - REVERSAL CE (Water bodies negative quality trends reversing)
PI: Geološki zavod Slovenije (in English language: Geological Survey of Slovenia)
BUDGET per UNIMI: 178,362 euro

PRIMA Section2 2022 – the project has passed the first stage of the evaluation process and is now under the second.
PROMEDRICE (Effective farming practices to protect water resources in Mediterranean rice-based agroecosystems); PI: Universitat de Girona
BUDGET per UNIMI: 349.891,50 euro

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.

Kroes et al., 2017. SWAP 4 - Theory including user manual.

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