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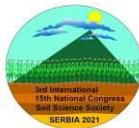
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PROMOTING THE APPLICATION OF SMART TECHNOLOGIES IN AGRICULTURAL WATER MANAGEMENT IN BOSNIA AND HERZEGOVINA

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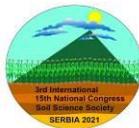
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Abstract

The adoption of smart agricultural water management in Bosnia and Herzegovina (BiH) is becoming a priority due to overall increase of water demand by different sectors, pollution of the resources and impact of climate change, which resulted higher frequency and intensity of extreme weather events and loss of agricultural production. Therefore, the necessity to promote a more efficient and sustainable use of resources in agricultural sector is a must to stabilize agricultural production. In this context, a new project "Promoting the application of smart technologies in agricultural water management in Bosnia and Herzegovina - SMARTWATER" is funded by the European Commission (EC) under the Twinning HORIZON 2020 program. The project is coordinated by the University of Banja Luka with the aim to promote the application of smart technologies (cloud-based and remote sensing) in the agricultural water management. The project partners are University of Sarajevo (BiH), Mediterranean Agronomic Institute of Bari (Italy), Consejo Superior de Investigaciones Científicas (Spain), Instituto Superior de Agronomia (Portugal), and SYSMAN PROGETTI & SERVIZI SRL (Italy).

The project overall and specific objectives along with the adopted methodology and expected results are presented. The project activities focus on the reinforcement of networking, research and science and technology cooperation capacities of the University of Banja Luka (UNI-BL), the University of Sarajevo (UNSA) and other connected national institutions in the field of sustainable agricultural water management. The aim is to increase their competency and fund rising skills for a successful participation in the European Union (EU) Research Programs.

Key words: HORIZON 2020, Agricultural Water Management, Smart Technologies, Cloud based technologies, Remote Sensing monitoring, European Union (EU) Research Programs.



INTRODUCTION

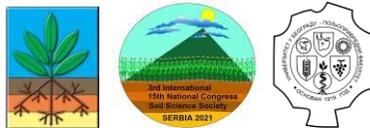
The agricultural sector is of strategic importance for Bosnia and Herzegovina. The country is a net food importer (FAO, 2017) and agricultural production is mainly based on rainfed cultivation. The climate is semi-arid Mediterranean on the South and humid continental on the North. Most of the country experiences hot and arid summers, which limit agricultural production. Bosnia and Herzegovina has a relevant irrigation potential estimated at 74,000 ha. However, only 4,630 ha (6.3%) are equipped for irrigation (World Bank, 2012). The agricultural production has been seriously affected by severe droughts and drastic losses of agricultural production, with relevant socio-economic and political consequences. In the recent years (2007, 2011, 2012, 2015, 2017 and 2021) the situation of the agricultural sector has become aggravated due to climate change impact.

In the last few years, several scientific papers dealing with the issues of climate change impact on the variation in yield and water requirements of strategic crops in the Balkan area have been published (Stričević et al., 2014; Jancic et al., 2015; Mihailović et al., 2015; Stricevic et al., 2017). These studies revealed that climate change would contribute to an increase in irrigation demand and concluded that in the period up to 2030, the average yield will not be reduced significantly under rainfed cultivation. However, the increase in temperature and reduction in precipitation expected by the mid of the 21st century, will have a negative impact on yield and will increase irrigation water requirements (Zurovec et al., 2015; Knezević et al., 2018).

Sustainable agricultural water management requires reliable and easy-to-use methods to support real-time irrigation scheduling. This requires a comprehensive knowledge of weather, soil, crop and irrigation system characteristics to determine ‘when’ to irrigate and ‘how much’ water to supply in respect to the specific environmental conditions and management strategies. On-farm irrigation scheduling can be supported by means of several technical and scientific methods based on the evaluation of soil plant water status and/or on the simulation of crop soil water balance (McCarthy et al., 2011; Romero et al., 2012; Stambouli et al., 2012).

A number of European countries are devoting intense efforts since the turn of the 21st century to optimize the Water-Energy-Food nexus. In the agriculture of southern Europe, the most complete illustration of this nexus can be found in irrigation systems. Taking these challenges into consideration, many recent research works have focused on improving the energy efficiency of irrigation facilities, optimizing pumping stations and irrigation network design (Rodriguez-Diaz et al. 2009; Moreno et al. 2010; Lamaddalena and Khila, 2012; Zapata et al., 2017). Additional research efforts paid attention to the possibilities at the farm-level end-of-pipe: the irrigation emitter. As energy costs increase, there is a need to find ways to operate sprinkler systems (solid-set and sprinkler irrigation machines) at reduced pressure, without reducing the sprinkler spacing and maintaining high irrigation uniformity. Kincaid (1991), Robles et al. (2017) and Zapata et al. (2018) recently analyzed a reduction of the working pressure at the sprinklers from 300 to 200 kPa, concluding that the pressure reduction did not affect crop yield.

The new automated decision support system Bluleaf (Todorovic et al., 2016), which integrates the results of scientific achievements and technological innovations (software and hardware components) in the fields of crop water requirements and irrigation



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scheduling, on-field data acquisition, transmission and management, and application of web and app tools for real-time irrigation management, was already tested at several locations as in Southern and Central Italy, Malta and Lebanon. Its robustness has been confirmed and also its capability to save water and energy when compared to traditional irrigation practices (Abi Saab et al., 2019).

The Earth Observation (EO) - based methodologies for estimating K_{cb} and related crop growth parameters (e.g., fraction of vegetation cover) are already tested with Sentinel-2 data (Mateos et al., 2013; Pôças et al., 2015). Additionally, several models for irrigation scheduling and crop growth are in use and tested (calibrated and validated) under specific pedo-climatic conditions as SIMDualK_c water balance model (Rosa et al. 2012) and AquaCrop (Steduto et al., 2009).

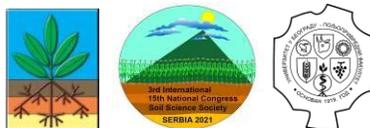
The integration of products derived from Sentinel-2 data and derived from irrigation scheduling and crop growth models will be further tested to provide timely-available information, throughout the crop cycle, to support irrigation management. Remote sensing data has been increasingly used for assessing several crops biophysical parameters, including leaf area index, fraction of vegetation cover, actual evapotranspiration, crop coefficients and leaf water potential (Paço et al., 2014; Pôças et al., 2015; Verrelst et al., 2015). Such remote sensing-derived parameters provide spatially and temporally distributed information about crops conditions, thus considering within field variability, and therefore greatly contribute to support management tasks in precision agriculture.

Finally, the concept of eco-efficiency is used to assess the ratio between the economic benefit and produced environmental impact, especially in terms of global warming potential (Todorovic et al., 2018). Hence, the adaptation measures could be seen also from the mitigation point of view in water management resources.

The reinforcement of research and science and technology capacity of BiH institutions to adopt innovative and sustainable water management strategies is of paramount importance in order to stabilize and improve agricultural production in the country. The modern strategies for sustainable agricultural water management aim to optimize the use of resources, while respecting the interest of numerous stakeholders in a complex context of interactions, overlapping of responsibilities, policies and legislation (EC, 2013; EC, 2014a,b; OECD, 2010).

The SMARTWATER project pursues sustainable agricultural water management strategies based on smart technological solutions and integration of technical (agronomic and engineering), socioeconomic and environmental issues. On one side, irrigation performance can be improved by adopting proper agronomic practices, such as the selection of crops/varieties and the cropping pattern, planning of sowing/planting date and growing cycle period, land/soil preparation, application of fertilizers and plant protection measures. On the other side, the performance of irrigation structures can be enhanced by implementing several engineering measures including reduction of water conveyance losses from withdrawal/storage to irrigation district/farm, on-demand-based design of water distribution network and adequate selection and design of on-farm/plot irrigation systems.

The main objective of SMARTWATER is to reinforce, or implement new, networking, research and science and technology cooperation capacities of the University of Banja Luka (UNI-BL), the University of Sarajevo (UNSA) and other connected national



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institutions, in the field of sustainable agricultural water management, as well as to increase their competency and fund rising skills for a successful participation in the European Union (EU) Research Programs.

The UNI-BL, UNSA and other BiH institutions are particularly interested in reinforcing the networking and science and technology capacity for optimizing the use of water, land, energy and fertilizers; focusing on the development of modern irrigation methods and management practices; applying the latest technologies and tools for water management, promoting the climate change adaptation and mitigation strategies/measures and eco-efficiency as the main contemporary indicator of sustainability and balanced and rational use of natural resources. All these topics will be promoted by strengthening the involvement of early-stage researchers i.e., those who are at the beginning of their professional carrier and have not yet been awarded a doctoral degree.

The specific objectives of the project are the following:

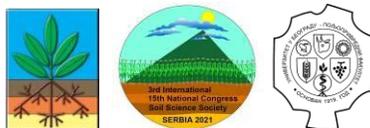
- a) Enhance the capacity building and human resources development of the UNI-BL, UNSA and other BiH institutions for research and science and technology improvement and cooperation in terms of sustainable agricultural water management, facilitating their access to competitive research funding;
- b) Strengthen networking between UNI-BL, UNSA, the EU institutions and other BiH and regional (Balkan) institutions through staff exchange, joint workshops/conferences, research themes/studies and exchange of knowledge, data and experts on specific topics of agricultural water management;
- c) Setting-up a smart scientific strategy in the field of sustainable agricultural water management for stepping up and stimulating scientific excellence and innovation capacity of UNI-BL, UNSA and other BiH institutions on the short and long-term basis;
- d) Adoption/accomplishment of an effective smart communication/dissemination strategy for adequate promotion of twinning activities and ensuring the expected impacts at regional, national, EU and global level.

The achievement of the project objectives is planned through a series of twinning activities, which will be carried out within a period of 36 months. The monitoring of project achievements will be done through a set of clear and measurable indicators for each specific activity.

METHODOLOGY

The methodology adopted by the project includes a series of collaborative activities and measures designed to guarantee the achievement of the overall and specific objectives of the project related to the field of sustainable agricultural water management. Hence, SMARTWATER will focus on substantial stepping up of the research excellence and innovation capacity of UNI-BL, UNSA and other BiH research institutions, and on the sustainability of project results.

This requires improving the scientific capacities of early stage researchers and other personnel involved by: 1) creating an environment favorable to the creation of research/business partnerships and market research services; 2) facilitating the participation of BiH institutions in research and innovation networks; 3) improving the



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capacity of BiH institutions to access national, international and EU funding; and 4) ensuring quality in science and technology performance and in the delivery of research and innovation goods.

To increase the scientific capacities of UNI-BL, UNSA and other BiH institutions on the thematic areas of agricultural water management, the project will organize:

- Three advanced specialized training courses abroad (Italy, Spain and Portugal) where participants (mainly early-stage researchers) from UNI-BL, UNSA other BiH institutions will be trained by the scientifically excellent partner institutions;
- Three post-graduate international Master of Science (two-year lasting) courses on topics related to agricultural water management addressing young early stage researchers from UNIBL, UNSA and other institutions, to give them the opportunity to accomplish MSc degrees;
- Three summer schools on the topics of sustainable agricultural water management combining scientific theory and practice with the acquisition of skills to use innovative technologies in water management;
- Three workshops targeting access to EU funding resources for research and innovation, and using a hands-on approach;

Summer schools will be open to all interested local professionals from agro-businesses, farming companies, decision makers, extension officers, agricultural high school teachers, etc. In this way, except for the transfer of knowledge, SMARTWATER will ensure the connection between actors from different agro-sectors and close the existing gap between the university/research, extension sector and farmers.

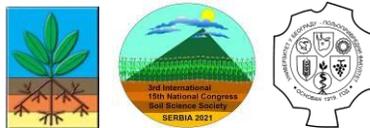
THE MAIN CHALLENGES

The main limitations towards a more efficient water use in agricultural sector in BiH include:

- 1) Lack of reliable and consolidated data concerning crop water requirements for different pedo-climatic conditions of the country;
- 2) Lack of data on quality control and the procedures for soil/weather/crop/management data acquisition and transfer from the fields to labs for elaboration and interpretation;
- 3) Lack of adequate IT tools (and trained experts) for monitoring/optimizing on-farm irrigation scheduling and agricultural water use;
- 4) Lack of implementation of research and technological development agendas on the performance of irrigation systems, optimization of water, energy and fertilizer use, and control of agricultural pollution.

EXPECTED IMPACTS

To strengthen networking, improve knowledge sharing and increase the participation of the BiH institution (coordinating and partners) in international scientific networks the project will:



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- Establish an international network on sustainable agricultural water management with key institutions and researchers from the neighboring countries and the EU. Furthermore, SMARTWATER project will strengthen the relatively weak links between experts and researchers in the field of water management in BiH and those who already leaved the country and work abroad. The objective of the network is to establish joint research initiatives and enhance the exchange of research results and opportunities for cooperation in the area of sustainable agricultural water management.
- Establish joint experimental/demonstration fields and studies to support scientific research capacities on sustainable agricultural water management and related topics of particular importance to the specific pedo-climatic conditions of BiH.
- Support mutual exchange of scientists and research staff between the BiH and the EU partner institutions on the specific topics of interest for agriculture and water management.
- Identify a set of research questions to support development of research proposals, set up of students' projects and thesis, co-author teaching material and scientific publications, therefore facilitating the acquisition of skills on how to generate high-impact research and maximizing publication visibility within the scientific community.

The development of a new research proposal represents a final achievement of the project, which will guarantee its sustainability after the completion of the project activities. This new research proposal embraces all results achieved during the realization of the project (i.e. the results of experimental studies, MSc thesis and development of decision support system (DSS) for irrigation scheduling and satellite images elaboration). The setting-up of the smart national scientific strategy for stepping up and stimulating scientific excellence and innovation capacity of the BiH institutions on the short and long-term will provide a strong basis for the continuation of research and innovation initiatives after the completion of the project.

Accordingly, the project will:

- Create a multi-stakeholder dialogue platform to support exchange of knowledge and information and facilitate research/business partnerships. This will be done through two project meetings and several roundtables and public debates involving a wide range of stakeholders bearing an interest in sustainable agricultural water management and related issues.
- Establish a Scientific External Advisory Board (SEAB) for the periodical review and monitoring of the quality of the research coordination activities conducted by the different teams, and providing recommendations for future activities and for the development of the national scientific strategy.
- Design a modern and realistic national scientific strategy based on multi stakeholder dialogue and assessment of the present research and development situation in BiH, the EU and worldwide.

The approach of the consortium to strengthen the agricultural water management research area will be participative, involving a wide range of stakeholders, including researchers, water professionals, policy makers, private/business sector representatives, farmers and consumers. A trans-disciplinary approach will be ensured to account for all the multiple facets that characterize sustainable agricultural water management in the scope of the proposal and in the conditions of BiH.



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Additional activities will be organized to further develop the research management and administration capacity. The specific training-capacity building on the practical application of BLULEAF DSS and elaboration of satellite data is foreseen during the advanced short courses and summer schools that will be organized. Moreover, the joint demonstration and experimental studies will be fully based on the testing of DSSs and specific app.

THE LINKS TO THE EU FRAMEWORK PROGRAMMES

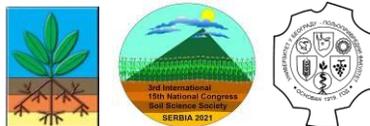
The SMARTWATER project relates to the topic WIDESPREAD-03-2018: Twinning, as set out in the call H2020 WIDESPREAD 2018-2020, Spreading Excellence and Widening participation. The project addresses the specific challenges identified by the Twinning for improving the overall scientific and innovation capacity of low-performing associated countries by collaborating with internationally leading counterparts.

These challenges include: a) capacity building for research, science and technologies development and fund rising; b) networking and strengthening links with internationally leading research institutions in the EU countries; and c) setting of smart research strategy for the promotion of excellence and innovation in the field of sustainable agricultural water management.

The project will boost the research and science and technologies capacity of the UNI-BL, UNSA and other BiH institutions through a series of capacity building and human resources development actions like advanced training courses, joint MSc program, summer schools and research and innovation funding workshops. In this context, the project will particularly promote the involvement of early-stage researchers (ESR) and support their research and fund-raising capacities as well as those of other stakeholders interested to increase their competence in the field of sustainable agricultural water management.

The project addresses the networking gaps and deficiencies between the BiH institutions and leading EU partners. The project foresees a series of joint activities promoting networking, joint experimental/demonstration studies on specific research themes, smart water management tools, and exchange of knowledge and experts on specific topics of agricultural water management. SMARTWATER foresees the publication of joint research documents at international conferences and peer review journals. This will raise the research reputation of UNI-BL, UNSA and other BiH institutions as well as the research profile of ESR and other staff.

A technical assistance and expertise to improve the research and innovation systems of UNI-BL, UNSA and other BiH institutions and to delineate adequate research strategies and policies for the future will be provided. The strategy will follow the principles of sustainable development, actual research and science and technologies achievements, and responsible research and innovation process that will step up and stimulate scientific excellence and innovation capacity of UNI-BL, UNSA and other BiH institutions on the short and long-term basis. This will imply the engagement of a wide range of stakeholders, the design of a policy roadmap for decision makers and the establishment of a Scientific External Advisory Board for the review for existing strategy and monitoring of the quality of research conducted in the field of agricultural water management.



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The participation in the EU Framework Programs is increasingly dependent on the research and science and technologies capacity, networking and staying connected with partners across the EU. SMARTWATER will approach the above challenges through the accomplishment of activities, which will help the fund rising capacity of the UNI-BL, UNSA and other BiH institutions.

CONCLUSION

The SMARTWATER project focusses on the reinforcement of networking and science and technologies capacities of BiH by involving researchers from other relevant institutions covering different regions and pedo-climatic conditions. Moreover, the SMARTWATER project will pursue the multi-stakeholders approach and will engage wider civil society and citizens to participate in the debate, definition and implementation of a research and innovation policy agenda and related activities.

A modern strategy for stepping up and stimulating scientific excellence and innovation capacity will be outlined. This strategy will endorse the sustainable development objectives in agricultural water management, which should be based on the principles of eco-efficiency, i.e. increasing the economic benefit of the agricultural sector while reducing negative environmental impacts. In this context, the principles of Responsible Research and Innovation (RRI) will be encouraged as a process of aligning research and innovation to the values, needs and expectations of society, which allows to identify and to deliver new eco-efficient solutions to the societal challenges.

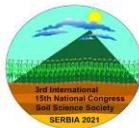
Therefore, it is expected that the realization of the above-mentioned activities will create synergic effects in the enhancement of agricultural water management sector and effective application of innovative technologies in agricultural sector of Bosnia-Herzegovina.

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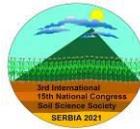
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