



INTERNATIONAL CONFERENCE
ON WATER, SOCIETY AND CLIMATE CHANGE

WASO 2020

PROCEEDINGS - Part II

CONCLUDING EVENT OF THE 7-YEAR NORAD-NORHED PROJECT
DECEMBER 15-16, 2020



PREFACE

Institutional Capacity-Building in Water Management and Climate Change Adaptation in Selected Countries in Asia and Africa – The WaSo project - is coming to an end after 7 years of a unique partnership between 8 countries from Asia, Africa and Norway. A collaboration among teachers and graduate students from 11 universities.

The project presented challenging ambitions and deliverables. Through innovative approaches and active collaborations, we achieved beyond these targets and expectations. We invite you to visit the project webpage www.wasoproject.org to learn more about our outcomes.

The WaSo 2020 Final Conference presents a bouquet of scientific results achieved by staff, students and alumni of the extended WaSo family. This document presents a collection of abstracts and manuscripts from the conference.

All addresses and presentations are recorded and available for your viewing on www.WaSo2020.net and the WaSo project webpage.

We would like to express our sincere thanks to all session chairs, session secretaries, keynote speakers and presenters, as well many others who contributed to the success of this conference. We also wish to thank NORAD, Norwegian Agency for Development Cooperation, for their generous support and encouraging follow-up throughout the project.

We are confident that the solid foundation created by this project will continue to build and strengthen our unique international network and reach new heights in the time to come.

The conference team.



Harsha Ratnaweera
Conference
Co-chairman



Tore Sætersdal
Conference
Co-chairman



Zakhar Maletskyi
Conference program
coordinator



Susann Andersen
Digital conferencing
coordinator

Table of contents

Preface	1
Table of contents	2
Welcome messages	8
Opening message from NORAD, Ms Solbjørg Sjøveian,	8
Prof Harsha Ratnaweera, Conference Co-Chair	9
Dr Tore Sætersdal, Conference Co-Chair	10
Prof S. B Weerakoon, Coordinator, WaSo- Asia project	11
Dr Ronald Semyalo, Coordinator, WaSo-Africa project	12
Closing remarks from NORAD, Vibeke Sørum	13
About the WaSo project	13
Conference information	24
Conference committees	25
Reviewers of submissions	26
Winners of the prizes for best presentations	27
IWA Water and Climate Change journal – Specail edition	28
Climate change impacts - Analysis	30
Tuesday, December 15, 7:30 AM-9:30 AM GMT+1	
Session Chair: Prof. Jarle Bjerkholt , University of South-Eastern Norway	
Secretary: Dorina Keji , University of Juba, South Sudan	
Keynote address: Climate Change impacts on water resources and adaptation - Prof. S.B. Weerakoon , University of Peradeniya, Sri Lanka	30
Presentations:	
• Mobile phone usage and access to climate variability information in Nakaseke district, Uganda. - Rashid Lukwago , Uganda	32
• Identification of Village Tank Cascade Systems (VTCS) in Vavuniya District as a Strategy for Climate Change Adaptation. - Ananthini Nanthakumaran , Sri Lanka	40
• Climate Change Impacts on Surface Runoff and Farmers' Perceptions of Climate Change: A Case of Mundeni Aru Lower River Basin in Sri Lanka. - Velmurugu Rajagobalasingham , Sri Lanka	45
Climate change impacts - Modelling	51
Tuesday, December 15, 9:30 AM-12:00 PM GMT+1	
Session Chair: Prof Sholihin As'ad , Universitas Sebelas Maret (UNS), Indonesia	
Secretary: Fahmida Akhter , BUET, Bangladesh(Hiroshiam University, Japan	

Keynote address: A critical review of the skepticism in climate change science - Prof Francis Mutua , University of Nairobi, Kenya	51
Presentations:	
• Flow Regimes Alteration under Regional Climate Models in Stung Chinit River Basin, Cambodia. - Hok Panha , Cambodia	55
• Application of SWMM to Explore Possible Climate Change Impact on Urban Stormwater Drainage. - Doung Ratha , Cambodia	56
• Trend analysis of rainfall and temperature in Jaffna districts of Sri Lanka. - Thusyanthi Sellathurai , Sri Lanka	57
• Study on Variability and Linear Regression Analysis of Rainfall Data in Bangladesh. - Payel Chowdhury , Bangladesh	65
• Trend Analysis of Historical and Downscaled Future Climate Data in Deduru Oya Basin, Sri Lanka. - Isuru Bandara , Sri Lanka	67
GIS and remote sensing	74
Tuesday, December 15, 7:30 AM-9:30 AM GMT+1	
Session Chair: Dr. John Ariki , University of Juba, South Sudan	
Secretary: Saliya Sampath , University of Jaffna, Sri Lanka	
Keynote address: Needs Demands and Value additions of NSDI: Bangladesh Context - Prof. Mafizur Rahman , Bangladesh University of Engineering and Technology	74
Presentations:	
• Identification of Suitable Locations for Small Hydropower along Streams with Limited Discharge Data, Jubek State/South Sudan. - Adam Gudo , Sri Lanka	75
• Integrated application of GIS and Remote sensing in the Analysis of Groundwater Quality in Juba City, South Sudan. Moses Kamanga , South Sudan	85
• Urban Growth Effects on Surface Runoff with the Integration of GIS and Remote Sensing: A Case Study in Dhaka, Bangladesh. - Sajjad Hossain , Bangladesh	95
• Developing a landsat model to argument insitu monitoring of fresh water lakes in Uganda. - Esther Kataate Namakula , Uganda	103
• Development of a Tool for Prioritizing Erosion Vulnerable Zones using GIS, AHP and MOORA: A Case Study along the Left Bank of the Jamuna River. - TH Meem , Bangladesh	106
• Identification of Groundwater Potential Zones of Dhaka City using GIS and Remote Sensing Techniques. - Simlia Satter , Bangladesh	114
• Assessment of Groundwater Quality using Water Quality Index (WQI) and GIS in Dhaka City. - Rafina Tanzim , Bangladesh	116
Hydropolitics and water governance	118
Tuesday, December 15, 12:00 PM-3:30 PM GMT+1	
Chair: Prof Kassahun Alemu , University of Addis Ababa, Ethiopia	
Secretary: Dorina Keji , University of Juba, South Sudan	
Keynote address: Water restoration: Climate adaption and Policy innovation - Prof. Yacob Arsano , University of Addis Ababa, Ethiopia	118
Presentations:	
• The Techno-Politics of the Grand Ethiopian Renaissance Dam (GERD), Yonas Demisse , Ethiopia	120
• The Hydropolitics of the Baro-Akobo/Sobat Basin, Firehiwot Sintayehu , Ethiopia	133

• The novel Coronavirus (SARS-CoV-2/COVID-19) pandemic: Major lessons, Availability of water and Ethiopia's response to ongoing and other global crisis. Mangistu Sima , Ethiopia	139
• Risk Management in Foreign Funded Water Supply Projects in Sri Lanka, Shamal Iranga , Sri Lanka	147
• The Grand Ethiopian Renaissance Dam and Foreign powers, Yohannes Girma Wedajo , Ethiopia	149
• SDG 6, Water Resources and Possibility to Establish Community Based Water Governance for Natural Water Springs Conservation in Central hills of Sri Lanka, Dimuthu Daluwatte , Sri Lanka	157
• Household's Willingness to Pay for the Attributes of Piped Water Supply to House in Nallur Area of Jaffna District in Sri Lanka, Sooriyakumar Krishnapillai , Sri Lanka	174
• Emerging Hydro-diplomacy Between Ethiopia and Kenya, Arka Abot , Kenya	175
• The Governance conundrum in pursuit of the Human Rights to Water and Sanitation: Tracking the progress of Leave-No-One-Behind principle in Uganda. Gerald Z Ahabwe , Uganda	189
• Water resource conflict in Kenya, The Case of Turkwel Dam and Pokot-Turkana Relations, 1984-2015, Andreas Nandelenga , Kenya	197
Water Resources Management - Livelihood and Industry	
204	
Wednesday, December 16, 12:00 PM-2:15 PM GMT+1	
Session Chair: Dr. Sivakumar Subramaniam , University of Jaffna, Sri Lanka	
Secretary: Saliya Sampath , University of Jaffna, Sri Lanka	
Keynote address: Water- a blessing or a curse?. Dr. Denis Odubasa , University of Juba, South Sudan	204
Presentations:	
• Access to Water in Rhino Refugee Settlement Camp in Arua District- Uganda. - Dorina Gubek , Uganda	207
• Study of River Basins Yield and Operations of Irrigation Schemes to Propose an Operational Policy of Irrigation Schemes and River Basin Development in Northern Sri Lanka to Improve the Livelihood of Farming Community. - Sivakumar Subramaniam , Sri Lanka	215
• Assessing the Potential impacts of Land use and climate changes on hydropower reliability: A case study of Muzizi, Uganda. - Hillary Bahati , Uganda	221
• Assessing traditional methods of soil and water conservation in mountainous regions of Uganda. - Monday Gideon , Uganda	259
• Preliminary assessment of marine phytoplankton distribution and fishing in Sri Lanka. - Hansani Wathudurage , Sri Lanka	272
• Water resource: A source of livelihood. - Loice Komen , Kenya	273
• Flow characteristics of Vertical Slot fishway and Pool and Weir fishway for design optimization. - Prasadi Hitihamu , Sri Lanka	275
Water Resources Management - Hydrology and Pollution Management	
Tuesday, December 15, 12:00 PM-3:30 PM GMT+1	
Session Chair: Prof. K.P. Pathirana , University of Peradeniya, Sri Lanka	
Secretary: Daham Dias , University of Peradeniya, Sri Lanka	
Keynote address: Water Resources Management - hydrology and pollution in a climate change perspective. - Asst. Prof. Tone J Oredalen , University of South-Eastern Norway	282

Presentations:	
• Effect of three water impounding structures on fodder productivity of Grewia Tenax (FORSK) under-fed water harvesting and supplementary irrigation in semi arid regions. - Augustine Bongo , South Sudan	283
• Irrigation water management for the command area - under left bank canal of Kaudulla Reservoir. - Mahinda Wijenayaka , Sri Lanka	291
• Simulation of Surface Runoff using SWAT Hydrological Model for Un-gauged River Basin of Kanakarayanaru of Northern Srilanka. - Navaratnam Suthakaran , Sri Lanka	305
• Estimation of source of a Pollution in a river. - Padmanathan Kathirgamanathan , Sri Lanka	313
• Estimation of Soil Erosion in MundeniAru River Basin in Sri Lanka. - Lingga Kalai , Sri Lanka	314
• Modelling and Forecasting Reservoir Sedimentation of Irrigation Dams in the Guinea Savannah Ecological Zone of Ghana. - Thomas Apusiga Adongo , Ghana	322
• Sediment bypass tunnel option for sediment management of Rantambe reservoir analyzed by two-dimensional flow modelling. - Dilshan Wasala , Sri Lanka	337
Water Resources Management - Regional Perspectives	344
Wednesday, December 16, 12:00 PM-2:15 PM GMT+1	
Session Chair: Dr Milan Gocic , University of Niš, Serbia	
Secretary: Esther Kataate , Makerere University, Uganda	
Keynote address: Attainment of SDG 6 targets: Emerging and persistent challenges in Water Resources Management in Sub Saharan Africa - Dr. Ronald Semyalo , Makerere University, Uganda	344
Presentations:	
• Drivers of Wetland Degradation in Mindiari Wetland of Central Equatoria State, South Sudan. - Christopher Lotiyo , South Sudan	346
• Evolution and Spreading of Water Scarcity Problems in the Manthai West Divisional Secretariat Division of Mannar, Sri Lanka. - Piratheeparajah Nagamunthu , Sri Lanka	355
• Modelling and Forecasting Reservoir Sedimentation of Irrigation Dams in the Guinea Savannah Ecological Zone of Ghana. - Thomas Apusiga Adongo , Ghana	363
• Water resources management education in the Western Balkan region. - Milan Gocic , Serbia	378
• The Challenges in Striving to Achieve the Water-related SDG2030-Indonesia. - Dwita Sutjningsih , Indonesia	384
• Global Challenges. - Muhindin Jemal Kebirhusien , Ethiopia	392
Water supply technology	406
Tuesday, December 15, 9:30 AM-12:00 PM GMT+1	
Session Chair: Prof. Shameen Jinadasa , University of Peradeniya, Sri Lanka	
Secretary: Daham Dias , University of Peradeniya, Sri Lanka	
Keynote address: Managing next decade's challenges in water supply. - Prof. Harsha Ratnaweera , Norwegian University of Life Sciences	406
Presentations:	
• Clarification efficiency of Plate settlers and Tube settlers analysed by CFD modelling. - Lakma Abeyratne , Sri Lanka	409
• Impact of water safety on nutritional status of children under five years. - Hellen Yose , South Sudan	416

• Potential of Granular Activated Carbon Filters for Iron removal from groundwater - Thinojah Thiruchelvam , Sri Lanka	422
• Investigating the adsorptive characteristics of raw and modified fly ash in the removal of calcium. - Pamodithya Wijewardana , Sri Lanka	430
• Synthesis and characterization of fly ash zeolite for water treatment applications. - Jayani Ranasinghe , Sri Lanka	433
• Removal of fluoride from water using locally available materials. - Lashitha Rathnayake , Sri Lanka	435
• Analysis of flow in stirred tank with pitched blade impeller for design optimization in flocculation tanks. - Piyumi Weerasinghe , Sri Lanka	437
Wastewater treatment - Nutrients	
444	
Wednesday, December 16, 9:30 AM-12:00 PM GMT+1	
Session chair: Dr Kabera Telesphore , University of Rwanda	
Secretary: Payel Chowdhury , Bangladesh University of Engineering and Technology)	
Keynote address: Nutrient recovery from wastewater: Opportunities for sustainable solutions . - Dr. Kethesaan Balachandran , University of Jaffna	444
Presentations:	
• Applicability of vertical subsurface flow constructed wetlands for greywater treatment using locally available plants. - Nisansala Dayarathna , Sri Lanka	445
• Status and quality analysis of rotation wastewater lagoon in Juba City. - Kapuki Lado , South Sudan	452
• Feasibility of using a microalgal-bacterial consortium for treating parboiled rice mill wastewater. - Kirujika Athithan , Sri Lanka	453
• Performance of Moving Bed Biofilm Reactor to treat wastewater with high Nitrogen loading and low BOD/N Ratio. - Danushka Deegala , Sri Lanka	459
• Experimentation on Solidification/Stabilization Treatments Methods for Water-Based Drilling Mud in DPOC Oil Fields, Upper Nile State, Republic of South Sudan. - Paul Lado Demetry , South Sudan	467
• Domestic wastewater treatment by small-scale horizontal subsurface flow constructed wetlands. - John Ladu , South Sudan	469
Wastewater Treatment - Heavy metals & leachtes	
472	
Wednesday, December 16, 7:00 AM-9:30 AM GMT+1	
Session Chair: Eng. Mwalimu K. Musau , Machakos University , Kenya	
Secretary: Dr Doung Ratha , Institute of Technology, Cambodia	
Keynote address: Water-smart circular economy: enabling technologies. - Dr Zakhar Maletskyi ; Norwegian University of Life Sciences	472
Presentations:	
• Removal of Mercury in Wastewater by Bacteria originated from Industrial Effluents. - Indeewari Abeykoon , Sri Lanka	473
• Comparison of the performance of MBR and SBR for the treatment of landfill leachate. - L. M. L. K. B. Lindamulla , Sri Lanka	474
• Hybrid constructed wetlands for landfill leachate treatment in tropics. - Tharaniya J. Sri Lanka	482
• Using Permeable Reactive Barriers to Remediate Heavy Metal-Contaminated Groundwater through a Laboratory Column Experiment. - Somean Yin , Cambodia	484

<ul style="list-style-type: none"> Leachate Treatment Using Stabilization Ponds in Tropical Environments. - Pubudu Rathnayake, Sri Lanka 	496
Water disaster management	505
Wednesday, December 16, 7:00 AM-9:30 AM GMT+1	
Session Chair: Prof. Dwita Sutjiningsih , University of Indonesia	
Secretary: Dorina Keji , University of Juba, South Sudan	
Keynote address: Being prepared – adapting to climate change, pandemic and changing politics – can we prep for the unexpected? - Dr Tore Sætersdal , University of Bergen, Norway	505
Presentations:	
<ul style="list-style-type: none"> Reconstruction of flood characteristics for historical period (1980 – 2009) in the Mpologoma River basin. - Loyce Kukunda, Kenya 	507
<ul style="list-style-type: none"> Application of HEC-RAS for Flood Inundation Modelling in Greater Colombo Region. - E. M. N. T. Edirisooriya, Sri Lanka 	514
<ul style="list-style-type: none"> Forecasting Large Precipitation Events in Badulu Oya, Mahaweli Basin, Sri Lanka. - Panduka Neluwala, Sri Lanka 	520
<ul style="list-style-type: none"> Flood Potential in Urban Area (Case: Surakarta, Indonesia). - Rintis Hadiani, Indonesia 	522
<ul style="list-style-type: none"> Soil hydrological characteristics underpinning landslides in Manafwa Catchment, Mount Elgon. - Moses Kutosi, Uganda 	529
<ul style="list-style-type: none"> Flood Modeling and Simulation Using 1D-2D Coupled Model: Nilwala River Basin, Sri Lanka. - Lanthika Dhanapala, Sri Lanka 	530
Gender and Climate Change	533
Wednesday, December 16, 9:30 AM-12:00 PM GMT+1	
Session Chair: Prof. Gordana Kranjac-Berisavljevic , University for Development Studies, Ghana	
Secretary; Susann Andersen , Norwegian University of Life Sciences	
Keynote address: Living with Uncertainties: Coping Mechanisms to Water Insecurity. – Elsa Ouma , University of Nairobi, Kenya	533
Presentations:	
<ul style="list-style-type: none"> Gender Roles in Climate Change Adaptation: A case study of the Livestock Water Provision in Wabinyonyi Sub-County, Nakasongola District: Uganda. - Prossy Nakibengo, Uganda 	534
<ul style="list-style-type: none"> Gender vulnerability and resilience to climate variability impact among water stressed agro-pastoralist in Terekeka State-South Sudan. - Dora Lero, South Sudan 	543
<ul style="list-style-type: none"> Gendering the design, implementation and operation of sanitation-hygiene programs under RWSP in Karamoja. - Prossy Nambi, Uganda 	545
<ul style="list-style-type: none"> Fuel Wood Use and Accessibility in Forestry Communities: Gender Implications for Gender Mainstreaming National Forest Policies and Sustainable Forest Management. - Peter Funna, Uganda 	554
<ul style="list-style-type: none"> Gender Differences in response and coping capacity to drought among pastoral households in Nakaseke District. - Winfred Ndagire, Uganda 	564
<ul style="list-style-type: none"> Gender and Rural water resources management. - Robinah Olga Namwanje, Uganda 	565

WATER RESOURCES MANAGEMENT EDUCATION IN THE WESTERN BALKAN REGION WRM EDUCATION IN THE WB REGION

*Milan Gocic**

* University of Nis, Faculty of Civil Engineering and Architecture, Aleksandra Medvedeva 14,
18000 Nis, Serbia, milan.gocic@gaf.ni.ac.rs

Abstract: Water as the most precious resource needs strong cooperation across countries and different sectors and requires an innovative and interdisciplinary approach. On the other hand, water resources are under constant pressure produced by climate change, urbanization, and population growth. According to the European Integration Facility reports, the Western Balkan (WB) countries should above all develop new or improve the existing education in this field, raise technical capacity, and accomplish the creation of more efficient systems in the field of water resources management.

In order to be competitive in the world scientific area, the WB higher education institutions should introduce an advanced teaching and learning process as well as new and up-to-date laboratory equipment, library units, and software necessary for performing of study programmes, continue creation of the internship programmes in cooperation with the industry and the SME sector, involve experts from the industry in the education process, and enhance teaching and learning activities using digital technologies and tools.

Keywords: competence, education, water resources management, water sector, Western Balkan region

Highlights: 1. Water resources management education is important in the Western Balkan region.
2. Defining competences in water resources management is a starting point for the course development in this field.
3. Course content should be in line with the developed competence, course objectives and learning outcomes.
4. More activities should be done to help higher education institutions in the Western Balkan with their digital capacity building.

1. INTRODUCTION

Carefully manage water as a limited resource is urgent due to plenty of statistical facts such as 1.8 billion people will live in water-scarce regions by 2025, and by the year 2030, the global demand for water will increase by 30 percent (UN-Water, 2007; Watkins et al., 2006). Also, water resources are under increased pressure produced by climate change, urbanization, and population growth (Haener et al., 2018; Moro et al., 2019; Northey et al., 2019; Schmidt et al., 2018). According to the IPCC (Intergovernmental Panel on Climate Change) predictions, the number of people living under water stress in Europe will rise from 28 million to 44 million by the 2070s (WWAP, 2012). Therefore, sustainable management of water resources is needed requiring strong cooperation between diverse countries and sectors. At the same time, to be effective the water resources management (WRM) should incorporate an interdisciplinary and trans-boundary approach. Also, the tailor-made and innovative solutions should be applied in the water sector.

Interwoven nature of water-related issues is reflected in global socio-economic development and can cause socio-economic imbalance. Sustainable water solutions as a product of public-private research funding in water and investing in technology should be found ranging from basic water safety, through water quality and sanitation, to food supply and generation of renewable energy (Barraque, 2011; Kazner et al., 2012). Required solutions should be global in character considering also national idiosyncrasies and have to be based on the most up-to-date scientific knowledge, strategies, and action plans.

Water resources management should be based on preventive and precautionary actions and hence is a major focus on EU Strategy 2020, General Union environment action programme to 2020, Strategic plan 2016-2020 for the environment, EU Water Framework Directive, Urban Waste Water, Drinking Water, Groundwater, or Water Quality Standards directives. Also, further action towards more efficient water use and coherent policy approaches is urgent. EU policy in the field of WRM is particularly necessary and productive at the regional level especially in developing countries.

Strategic Plan 2016-2020 for environment suggests that candidate countries in its pre-accession acts must “make gradual progress towards transposition and implementation of the EU acquis”. Western Balkan (WB) countries on their path to EU accession should harmonize procedures with EU water management requirements in line with Chapter 27 - to converge national rules and standards towards a single framework of EU water legislation. EC Progress Reports states that the WB national strategies and action plans on water protection should be adopted and carefully implemented. Also, further substantial efforts in the areas of water management, water protection, and wastewater treatment should be done. Thus, it is important to develop and implement public awareness campaigns and LLL courses for professionals in the water sector, with the intention to educate them on how to use up-to-date water technologies and inform about trends in the EU water sector and legislation. Early identification of all aspects of WRM will allow the national experts more time in preparing Western Balkan countries’ position in the transitional period. It requires strengthening of knowledge base and scientific domain dealing with WRM by introducing advanced courses that promote EU water management regulatory environment.

WB countries should above all develop new and improve the existing education in WRM, raise technical capacity, and accomplish the creation of more efficient WRM systems applying innovative water technologies. Thus, motivated by this idea, the University of Nis made a consortium involving 14 partners and got the grant for the realization of Erasmus+ capacity building project titled “Strengthening of master curricula in water resources management for the Western Balkans Higher Education Institutions (HEIs) and stakeholders (SWARM)” in 2018 (www.swarm.ni.ac.rs). The consortium of the SWARM project was put together because the higher education institutions (HEIs) from WB identified the need to invest in upgrading their existing capacities in WRM improving technical innovations and equipment, infrastructure, information and technological systems based on EU standards and constantly strengthening the personnel competences by education and training. As a result, this will reduce inadequate professional qualification and the lack of specialized personnel in the water sector in WB countries.

The research presented in this paper is based on the reports created during the realization of the SWARM project co-funded by the Erasmus+ programme of the European Union.

2. IMPORTANT AND RELEVANT ACTIVITY OF WATER RESOURCES MANAGEMENT EDUCATION

Water resources management requires well-developed professionals with appropriate knowledge, competences, skills, and expertise. It is the responsibility of national institutions including universities to educate the mentioned specialists. In order to ensure that state-of-the-art knowledge is brought to bear on the problems in the water sector, the HEIs should be in direct connection with water-related companies, while experts from the water sector should be involved in the education process.

WB HEIs lack the necessary skills to build state-of-the-art laboratories supporting higher education in WRM as well as adequate financial resources which could significantly raise their maturity level. Therefore, it is necessary to transfer innovative and newly developed technologies, know-how best practices achieved in modern laboratories for simulating WRM solutions, and rich experience in development and modernisation of study programmes from EU to WB HEIs in WRM developing comprehensive curricula in the WB region. Transfer of experiences from EU to WB HEIs is the necessity to speed up the introduction of up-to-date courses in curricula in the WB region.

Requirements for employees dealing with water resources management are wide-ranging and demanding. They should have knowledge and understanding of science in conjunction with applied and practical skills. Dealing with the complex topic of WRM, future master curricula should include knowledge about water phenomena, specific modern and innovative technologies, and balance the social and economic needs. The graduated students with acquired applicable knowledge, skills, and competences will be directly involved and what is more important they will improve the process of solving problems in the water sector using advanced technologies. They should take advantage of opportunities to benefit from connection to other EU HEIs that should be open and transparent in all aspects of their operations (European Commission, 2020). Using laboratories equipped with up-to-date equipment will allow the students to gain hands-on experience directly transferrable to the water sector. The COVID-19 situation has highlighted the importance of the digital education including development of digital teaching materials, providing access to virtual learning platforms both to teachers and students, and strengthening of quality of digital infrastructure (European Union, 2020).

The theoretical part of master curricula in WRM should critically follow the very rapid pace of innovation in WRM related to the scientific and technical domains. In addition, graduates with a civil

engineering background should have a technical understanding of planning, prevention, designing, construction, or damage assessment that are a significant part of the development of different water resources systems. Also, the graduates should be aware that measures for dealing with water resources are part of a wider scope and have to consider that in planning processes.

In general, the modernisation of WRM education in the WB region is achievable through I) the advanced approach to curricula development using interdisciplinary communication, analysing the society and enterprises needs and problems, mobilising university resources and capacity for their solving, II) the creation of new educational topics harmonized between WB and EU HEIs, III) the introduction of innovative teaching and learning methodologies, IV) the promotion of excellence in the use of ICT in HE purchasing the most advanced laboratory equipment.

3. COMPETENCES IN WATER RESOURCES MANAGEMENT

Holistic approach to water resources management requires professionals with multiple competences. After the conducted analyses of the water sector and the needs of water-related companies, the catalogue of competences was developed including three types of competences i.e. generic, engineering, and water resources management competences (<http://www.swarm.ni.ac.rs/activities?id=43>). The competences were identified by the heterogeneous team consisting of stakeholders such as curriculum developers, teachers, educational managers, WRM experts, and representatives from the water sector. The competences were obtained based on the required competences by the labour market in the WB countries i.e. researching the existing water sector competence models and job profiles.

The generic competences are needed for the application of academic knowledge, cognitive abilities and technical skills to situations in the field of WRM. The students will gain some of the generic competences such as critical and strategic thinking, working in multidisciplinary teams, generation of new ideas, experience-based critical decision making, staying up-to-date with technological development or development of professional ethics and responsibility. Also, the students can be in a position to achieve some of the engineering competences such as using appropriate equipment competently and safely, preparing, processing, and interpreting data, developing innovative solutions to complex issues, mastering methods, procedures and processes of risk identification or using computer systems to access learning resources. They will be able to optimize and manage available resources in WRM systems, use mathematical models for the simulation of water-related processes, identify and analyse problems in WRM or implement water supply and water efficiency plans and programs.

The acquired competences should meet both students' goals and societal needs. On the other side, the teaching staff should be equipped with the necessary digital competences in order to enhance teaching and learning activities using digital technologies and tools, and prepare future students to dive into a digital society. Digital competences should be developed in line with the Digital Competence framework for Educators (Redecker, 2017) that defined 22 competences in 6 areas.

4. DEVELOPED COURSES IN WATER RESOURCES MANAGEMENT

Seven WB higher education institutions have agreed to adapt their academic teaching to the requirements of the water sector and related industry in order to ensure that their graduates are the most employable and to increase their competitiveness in the international education market. Therefore, they selected a competence-based approach to reduce the gap between the labour market i.e. water-related companies in the WB countries that will employ the SWARM students and the current WB curricula in the field of WRM. Creation of competence-based master study programs in WRM focused on core learning areas and outcomes perceived the following requirements: I) the specificity of the topic on water resources management, II) European Higher Education Area requirements, III) WB HEIs conditions, IV) social and economic needs, V) students' needs for better employment, and VI) national legislation, strategies, and action plans.

Developed or modernized master curricula are in line with the European Credit Transfer System (ECTS) and the European Standards and Guidelines for ESGs for Quality Assurance. The number of credits is 60 ECTS for one year master programme or 120 ECTS for two year study programme that are recognised by the national agencies for accreditation and co-financed by the national ministries for education. The curricula are integrated into national efforts for regulation and improvement in the field of WRM through the national legislative, strategic and institutional framework which are in the process of harmonizing with EU strategies and legislations within the WB countries' accession. Also, they are based on the integration of ICT in the

teaching and learning process and focused on student-centred learning and innovative teaching methods. The water resource graduate programs are interdisciplinary and allow students to choose a track and courses most suited to their career goals. Students interested in this type of graduate degree should have a strong background in the natural, physical, and social sciences related to the field of water resources in order to be competitive in the graduate school admission process.

The total number of courses presented as a SWARM unique set of courses is 32 out of which 20 have been developed and will be taught for the first time. A form for courses description was used to describe course status, number of ECTS, course objectives, learning outcomes, course content, literature, number of classes of active teaching, teaching methods as well as pre-exam and final exam requirements. In the design of courses, competences and learning objectives took priority. The Bloom's taxonomy (Bloom, 1956) was used i.e. a verb that determinates an action that student should be able to perform in order to achieve defined competence. Also, a matching matrix between developed courses and competences was created.

The main words that the courses contain in their titles are water resources management, groundwater use, water and wastewater treatment, water quality, water protection, drinking water, water supply, technologies in the water sector, water policy, hydraulic or river engineering.

All master students will carry out internships as a mandatory part of the curricula. They will acquire the competences that are in accordance with policy and operational frameworks, have the capabilities for managing multidisciplinary holistic approaches, and capable of developing and executing mid-term or long-term strategies necessary for coping with the different problems in WRM. The students can search for, collect, process, and apply the information critically and systematically, and use different ICT tools for critical thinking, creativity, and innovation. Up-to-date laboratory equipment will support teaching and work especially practical exercises.

Each of the curricula will be evaluated twice per school year (in autumn and spring semester) collecting the data regarding student's expectations, quality of teaching and teaching material, access to literature, learning obligations, laboratory equipment used in teaching activities and developed practical exercises. According to Jones et al. (2002), each competency-based curriculum can be evaluated based on assessment of learning activities that helps students to achieve competences and learning objectives, learning resources used to achieve defined competences, accessibility and usability of learning materials.

5. RELATIONSHIP BETWEEN COMPETENCES, OBJECTIVES AND LEARNING OUTCOMES

The relationship between competence, course objectives, learning outcomes, and course content is presented in Table 1. As an example of competence in the area of wastewater treatment, the following example is given: *The student should be able to implement treatment methods and technologies to solve a wastewater problem.* Starting from this competence, four course objectives and three learning outcomes are derived. It is evident that the learning outcomes specify what it is expected that the student will be able to do after the end of this course. In the end, the course content is defined as a connection with previously defined terms.

Table 1. Relationship between competence, course objectives, learning outcomes and course content in the area of wastewater treatment

Competence	The student should be able to implement treatment methods and technologies to solve a wastewater problem.
Course objectives	By the end of this course, the student will be able to (I) determine the environmental impact of the pollutant, (II) forecast the transport of pollutants, (III) calculate treatment lines, and (IV) use various treatment methods and technologies.
Learning outcomes	After the course student should be able to (I) apply innovative technologies for new systems and improvement of old systems to get better function,

	(II) operate and optimize treatment plants, and (III) manage different processes involved in sustainable water and wastewater treatment.
Course content	Introductory definitions (concept of pollution and water protection). Legislation and limits of water pollution. The characteristics of wastewater (physical, chemical, and biological). Classification of water (the water I, II, III and IV class). Fundamentals of wastewater treatment processes (mechanical, chemical, and biological). Basic methods of sludge treatment and sludge disposal. Different processes in water and wastewater treatment in natural and constructed systems, biological treatment processes particularly for the removal of phosphorus and nitrogen, processes based on filtration. Sludge treatment technologies. Systems and methods for recovery of nutrients from sewage. Methods for process control and optimization.

6. CONCLUSIONS

Modernised curricula based on transfer best practices from EU to WB HEIs, trained teaching staff through the theme-based training for acquiring new teaching and learning methods, educated professionals in the water sector through the organised LLL courses, equipped laboratories with the up-to-date laboratory equipment and software where the students will gain practical knowledge that can be immediately applied, and in general improvement of quality in teaching will strengthen not only the WB HEIs but also the water sector in the WB region.

In this paper, the water resources management courses developed based on the competences are explained. Three different types of competences i.e. generic, engineering and WRM are analysed and the relationship between competence, course objectives, learning outcomes, and course content is highlighted.

Future activities will be oriented to the development of an open online platform (in English and local mother tongues) including e-learning courses with virtual laboratories that can be used by students, teaching staff, and water professionals not only in the WB region but worldwide. It can be used especially in situations such as the COVID-19. The various e-learning platforms including gamified content and applications are expected to play a pivotal role in the public's behavioural modification and awareness. Due to the fact that using digital tools for teaching and learning is a challenge, more activities should be done to help HEIs in the WB with their digital capacity building.

ACKNOWLEDGEMENTS

The presented research is a part of two Erasmus+ projects: "Strengthening of master curricula in water resources management for the Western Balkans Higher Education Institutions (HEIs) and stakeholders" (Ref. no. 597888-EPP-1-2018-1-RS-EPPKA2-CBHE-JP) and "EU water policy and innovative solutions in water resources management" (Ref. no. 620003-EPP-1-2020-1-RS-EPPJMO-MODULE).

REFERENCES

- Barraque B. 2011 Urban Water Conflicts. Urban Water Series – UNESCO-IHP. CRC Press.
- Bloom B. S. 1956 Taxonomy of Educational Objectives, Handbook I: The Cognitive Domain. New York: David McKay Co Inc.
- European Commission/EACEA/Eurydice 2020 The European Higher Education Area in 2020: Bologna Process Implementation Report. Luxembourg: Publications Office of the European Union.
- European Union 2020 Education and Training Monitor EU analysis 2020, volume 1. Luxembourg: Publications Office of the European Union.
- Haener P., Filali-Meknassi Y., Amani A., Meyer C., Verbist K., Argent R., Berod D., Pecora S. & Abrate T. 2018 The Handbook on Water Information Systems. Administration, Processing and Exploitation of Water-Related Data, INBO/UNESCO.

Jones E., Voorhees R. & Paulson K. 2002 Defining and assessing learning: Exploring competency-based initiatives. Washington, DC: Council of the National Postsecondary Education Cooperative. Publication NCES 2002159.

Kazner C., Wintgens T. & Dillon P. 2012 Water Reclamation Technologies for Safe Managed Aquifer Recharge, IWA Publishing.

Moro M. A., Andersen M. M., Smets B. F. & McKnight U. S. 2019 National innovative capacity in the water sector: A comparison between China and Europe. *Journal of Cleaner Production*, 210, 325-342.

Northey S. A., Mudd G. M., Werner T. T., Haque N. & Yellishetty M. 2019 Sustainable water management and improved corporate reporting in mining. *Water Resources and Industry*, 21, Article 100104.

Redecker C. 2017 European Framework for the Digital Competence of Educators: DigCompEdu. JRC Science for Policy Report.

Schmidt G., Bauer S., Baur T., Fleischmann N., Kaltenbock M., Leeuw E., Matauschek C., Nanu C., Thurner T., Misiga P., Capitaio J. & Schroeder R. 2018 The European Innovation Partnership on Water (EIP Water): approach and results to date (2012–2015). *Journal of Cleaner Production*, 171, s147-s148.

UN-Water 2006 Coping with water scarcity: challenge of the twenty-first century, FAO.

Watkins K., Carvajal L., Coppard D., Fuentes R., Ghosh A., Giamberardini C., Johansson C., Seck P., Ugaz C. & Yaqub S. 2006 Human Development Report 2006, United Nations Development Programme, New York, USA.

WWAP (World Water Assessment Programme) 2012 The United Nations World Water Development Report 4: Managing Water under Uncertainty and Risk, UNESCO, Paris, France.