

EXCEED-Excellence Center for Development Cooperation-Sustainable Water Management in Developing Countries

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Abstract-Water is among the 21st century's key development issues. The Project Exceed of Braunschweig University addresses the MDG 7/C 'Ensure Environmental Sustainability'. Based on the world-wide network of 35 partner universities in 18 countries on 4 continents, this Excellence Centre focuses on capacity building in developing countries through training and networking. To achieve these goals, the existing study programs at partner universities related to sustainable water management are analyzed and upgraded; new courses are initiated for further education of scientific and technical staff at universities, enterprises, and public authorities. Summer schools, international workshops, and expert seminars as well as an intense exchange of students, young scientists, and academic teachers in all directions, south-north, north-south, and south-south, are organized for capacity building. The same topics are also the subject of joint teaching and research activities at Exceed member universities and the International Exceed Guest Chair and Team established at the Braunschweig University.

Keywords- Sustainable Water Management; Developing Countries; Capacity Building

I. INTRODUCTION

Although 70% of earth's surface is covered with water, the freshwater reserves available for the mankind are vanishingly small. Of the 1.38 billion km³ water available on earth, 97.4% are made up of salt water of the oceans and only available for anthropogenic use after immense technical and monetary efforts. Of the remaining 2.6% of freshwater reserves, 2% are stored in polar, marine, and glacial ice, and are thus not available for economic and, predominantly, for ecological reasons. This leaves 0.6% (0.08 billion km³) in form of ground and surface water, and soil and air moisture for the usage of the rapidly growing human population. It is estimated that almost one billion people worldwide do not have access to clean drinking water, whilst around one third of mankind does not have suitable sanitary facilities or wastewater treatment. This situation becomes worse with the future scenario of climate change particularly in already drought regions. Therefore, the Millennium Development Goals of the United Nations claim in MDG 7/C 'Ensure Environmental Sustainability-Halve by 2015 the proportion of the population without sustainable access to safe drinking water and basic sanitation'.

Water is essential for all major socio-economic sectors, contributing to each of them in a different way. For instance, agriculture requires large quantities of water for irrigation and food production. Energy requires water for powering turbines, cooling power plants, and growing biofuels. Access to safe water supply and basic sanitation is necessary for maintaining public health. Water is needed to keep the ecosystems healthy which in turn provide crucial environmental goods and services. Benefits of each of these sectors are provided by water.

Managing water for all is not only a question of availability of resources and money, but equally a matter of public participation and good governance. Actually, water is a local issue and involves numerous stakeholders at basin, municipal, regional, national, and international levels. If effective public governance is missed to manage interdependencies across policy areas and between levels of governmental bodies, policymakers will face obstacles of designing and implementing measures for sustainable water management. Mitigating the impacts of natural disasters and extreme events following climate change like flash floods and inundations, recently occurring almost every year, is not only a problem of Developing Countries, but also of the developed ones. The catastrophic inundations of the River Elbe in the past two years 2013 and 2014 gave strong evidence that even Europe will suffer from the problems of a non-sustainable management of water resources. The majority of water resources have trans-boundary character. Rivers of Nile, Euphrates and Tigris, and Jordan in the Middle East as well as Rivers Elbe and Rhine in the heart of Europe deserve joint solutions of the riparian countries. Basin wide cooperation is essential for sustainable water management, for prosperity and peace in the respective regions. Many projects in development cooperation failed for ignoring the importance of socio-cultural aspects, and solely concentrating on technological problems. The end of the active involvement of experts from industrialized countries often leads to failure in the implementation stage of a project. Especially, projects related to water supply and use gain little recognition if the various political, cultural, and social meanings of water in different regions are not considered.

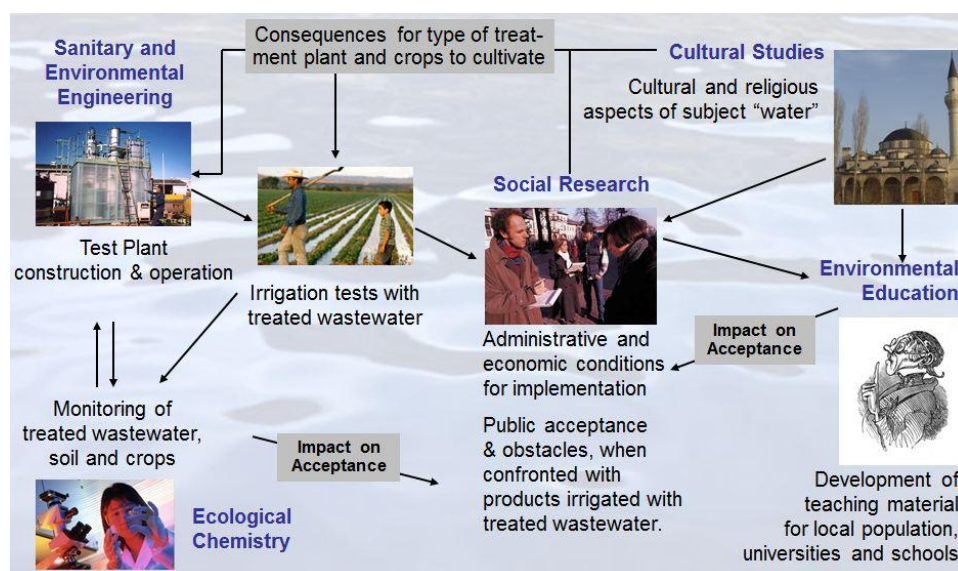


Fig. 1 A holistic approach for sustainable management and multiple uses of the limited fresh water resources

II. EXCEED SWM APPROACH AND OBJECTIVES

Against this background, an interdisciplinary research team at TU Braunschweig coming from civil and environmental engineering, environmental sciences, and social and political sciences developed a holistic approach for sustainable management and multiple uses of the limited fresh water resources (Fig. 1). Thereby, the engineering scientists take over the sound management of water resources, supply of fresh water to different users and treatment of the wastewater for the demands of downstream use, e.g. for irrigation in agriculture. Environmental scientists take care of monitoring and quality control of the treated wastewater as well as irrigation measures in terms of public and environmental health, and give feedback to the engineers for improving the technological measures if needed. The task of social and cultural sciences is investigating the administrative and economic conditions for implementation, and respective obstacles of public acceptance, when the public confronts with products irrigated with treated wastewater. Finally, the experiences made have to be introduced into educational material and disseminated at each level from primary schools to higher education institutions, governmental bodies, and stakeholders.

With this approach, TU Braunschweig applied 2008 to the Call for Proposals of DAAD for the Exceed Program. 'EXCEED-Excellence Centre for Development Cooperation-Sustainable Water Management in Developing Countries' is a project for capacity building through higher education and joint research. The Exceed SWM Project started 2009 at the TU Braunschweig. It is one of the five MDG Projects at German Universities that were awarded substantial funding for five years by the German Academic Exchange Service DAAD and the German Ministry for Economic Cooperation and Development BMZ. Selected in a strong competitive process, Exceed SWM conducts research and runs academic cooperation with partners from Latin America, Middle East, Sub-Sahara Africa, and South-East Asia for capacity building on sustainable and transferable solutions for each region's predominant water-related issues.

The objectives of the Exceed SWM are (i) capacity building in Developing Countries DC and Germany GER on Sustainable Water Management SWM, (ii) putting SWM on political agenda in DC and in GER, and (iii) establishing a cooperation at eye level with DC on Millennium Development Goals. Thereby, strategy to be followed is (iv) building a global network, (v) establishing and upgrading study programs, (vi) conducting joint research, (vii) providing suitable further education courses, and (viii) creating a pool of experts.

III. PARTNERSHIP CONCEPT

The global Exceed SWM Network comprises 35 partner universities in 18 countries on four continents and is organized in four Regional Networks Latin America, Middle East, Sub-Sahara Africa, and South-East Asia. A university each in Mexico, Turkey, Burkina Faso, and Vietnam coordinate all activities within their respective regions, whilst TUBS initiates and organizes the trans-regional measures (Fig. 2).

IV. HIGHER EDUCATION AND CAPACITY BUILDING

The main objective of the Exceed Project is 'capacity building' through higher education. The project aims at conveying competencies and knowledge on SWM to future experts and decision-makers in order to qualify them to shape economic, organizational, and political change processes. The higher education concept of Exceed SWM is based on existing basic knowledge of participants already passed at least undergraduate study and provides them graduate and post-graduate education

opportunities through various exchange measures to another Exceed partner university, and organizes international summer schools, expert workshops, and conferences. For instance, the following international events were organized through Exceed partners in 2013:

- Summer School “New Alternative Sanitation Systems” (Braunschweig, GER)
- Summer School “Coastal Erosion and Management for Safer Coasts in a Changing Climate” (Recife, Brazil)
- Expert Seminar “Water Issues in Mega Cities” (Ho Chi Minh City, Vietnam)
- Regional Workshop “Management of Hydrological Systems in Arid and Semi-Arid Regions” (Karak/Amman, Jordan)
- Regional Workshop “Water and Energy” (Hanoi, Vietnam)
- Regional Workshop “Wastewater Treatment and Reuse” (Konya, Turkey)
- Expert Workshop “Trans-boundary River Basins in Africa - Example of the Volta River Basin” (Braunschweig, GER)
- Regional Training Course “Wastewater Management” (Zomba, Malawi)

An important international symposium was the UNESCO/DAAD/EXCEED Conference ‘Water in Africa’ October 2012 in Kisumu/Kenya. This conference, organized by the Exceed Sub-Saharan Africa Network, did not address only to the global Exceed community, but also to DAAD Alumni in Africa and the experts and guests of UNESCO Nairobi. With this event, Exceed SWM brought together the African and international audience in order to present and discuss the problems and solutions of various aspects of fresh water provision and wastewater management on this continent and best practices from elsewhere.

An international Guest Chair was founded at the TU Braunschweig with annual reappointments of guest professors and inviting an international guest student team to conduct joint research. Besides individual capacity building through advanced studies and PhD theses of participating students, the Exceed SWM concept considers predominantly an institutional capacity building through upgrading existing curricula and further education of the teaching staff at partner universities as multipliers of scientific knowledge and experimental skills. Students leave after exam, but the teachers remain at their universities for educating the next generation of youth.



Fig. 2 Partnership

V. CURRICULUM DEVELOPMENT FOR MASTER STUDIES IN SUSTAINABLE WATER MANAGEMENT

For implementing new study programs and upgrading or even adjusting existing study programs related to SWM at MSc and PhD levels a Curriculum Database CDB was established through collecting and analyzing the syllabi and course contents at all partner universities. This comprehensive relational CDB containing about 400 data sets helps the partners to get a

comprehensive survey of courses in engineering, natural, and social sciences teaching SWM. Further, the database facilitates students to search for a suitable hosting university that offers courses for accomplishing and consolidating graduate studies of students. Analyses of syllabi in the CDB help identify the gaps in own graduate courses in water sciences in general and in SWM in particular. Furthermore, the database serves as a source for structuring and developing new master curricula on SWM. On two workshops and a plenary meeting, dedicated to curriculum development, the Exceed members agreed on the following four pillars, of which a SWM graduate study program should be based on:

A. Water Science and Engineering

Hydrology, hydraulic engineering, hydrogeology, erosion & sedimentation, floods & drought, coastal engineering, river & coastal morphology.

B. Biological Aspects of Water, Health & Nutrition

Ecosystem degradation & resilience, water & health, ecology & ecosystem dynamics, eco-hydrology, ecosystem valuation, microbiological & biochemical aspects, ecotoxicology.

C. Chemical Aspects of Water, Environmental and Anthropogenic Aspects

Rural, urban and industrial issues, pollution analysis, wastewater treatment, planning design and construction, water quality & water chemistry, remediation, chemical and analytical methods.

D. Water Management, Social, Political, and Legal Aspects:

Water management and economic aspects, development studies, international water policy between conflict and development.

Based on this model curriculum (Fig. 3), Exceed partners developed a new MSc study program for the University of Mekelle in Ethiopia. In principle, students coming from undergraduate education in engineering, natural sciences, and social and economic sciences should be taught together with different focuses in the own discipline, together with overlapping educational sections for joint learning in an multidisciplinary environment to understand the SWM from different viewpoints (Fig. 3). This MSc program will serve Sub-Saharan Africa Network of Exceed to apply for a UNESCO Water Chair at the University Mekelle as a joint center of excellence for African scholars.

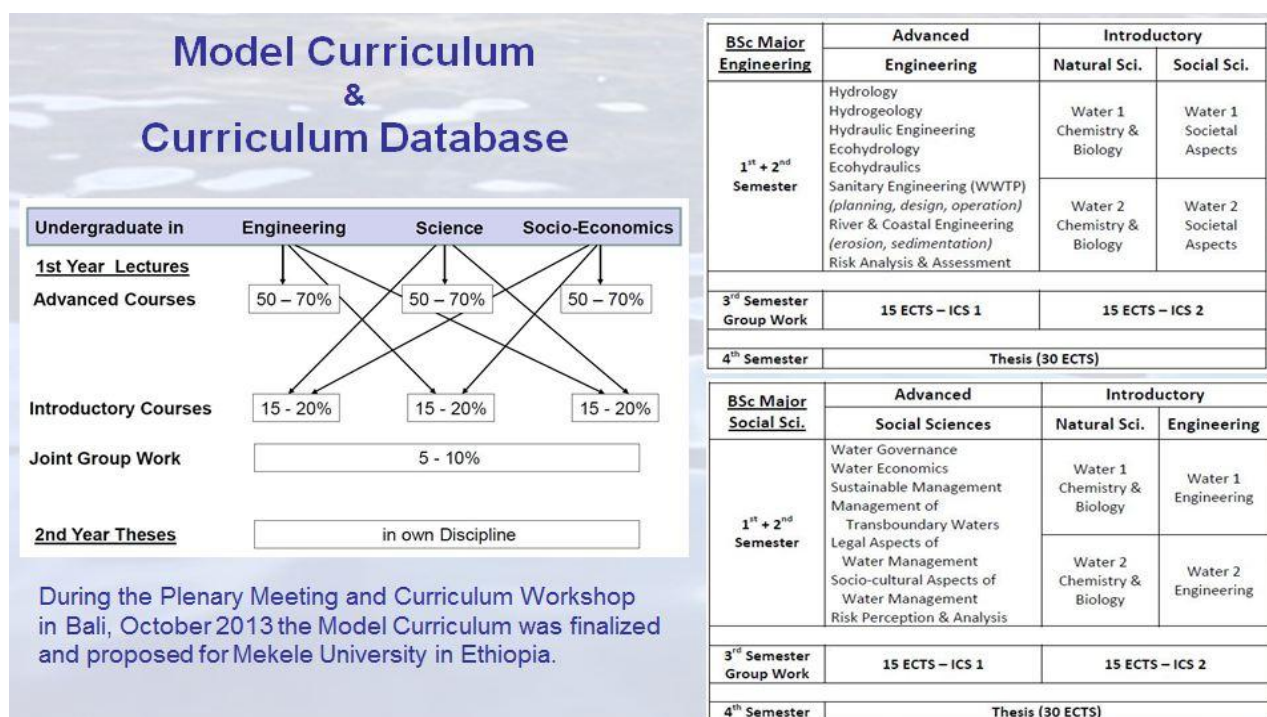


Fig. 3 Model curriculum & curriculum database

VI. RESEARCH CONCEPT

Exceed research concept is based on five crucial subjects and the joint research project are developed mainly in the fields of:

Water and Agriculture in arid and semi-arid Regions: (i) integrated water management, (ii) modeling methods, (iii) socio-economic conditions;

Water in Urban Environment: (i) sanitary engineering, (ii) urban water supply, (iii) numeric models, (iv) remediation measures;

Aquatic Ecosystems: (i) climate change, (ii) biodiversity, (iii) monitoring of aquatic ecosystems, (iv) micro pollutants, (v) floods and droughts;

Water and Health: (i) resources protection, (ii) wastewater reuse, (iii) risk perception and assessment;

Water in a Global World: (i) climate change, (ii) distribution of water reserves, (iii) protection of inland and coastal waters;

Joint research projects of Exceed partners are developed and conducted through different approaches: (a) In the frame of the guest chair founded at TU Braunschweig, the guest professor and her/his guest team coming from different countries, (b) through integrating exchange scholars at different education levels into the running of research projects at Exceed partner universities, and (c) successful project proposals granted from external organizations. One of these research projects is shortly described below; others will be listed only with their titles.

VII. REUSE OF UNTREATED WASTEWATER IN AGRICULTURE

Due to water scarcity in MENA countries, the reuse of wastewater WW before or after treatment for irrigation in agriculture is a common practice meanwhile. This is in Konya Region since 1975 as well. WW of the city was collected in the sewerage system and discharged without treatment to an open canal. The farmers around this canal pump the water out of the canal and use for flood irrigation of their fields, since the annual precipitation is 320 mm while evapo-transpiration of 300 mm does not meet the demand of agriculture. WW reuse in the agriculture is also in Braunschweig, but in a modern full-stage wastewater treatment plant WWTP and strong quality control.

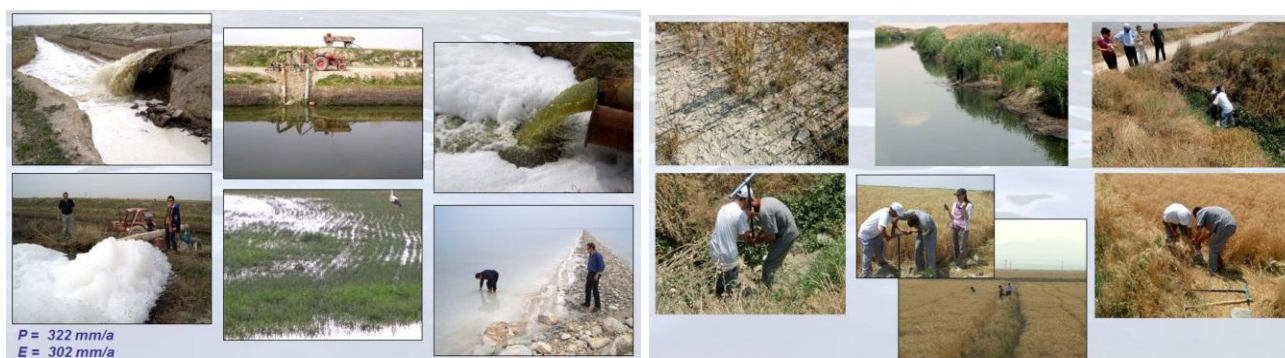
In a joint research project, the Exceed partners at the Konya University and at TU Braunschweig investigated the pollution status from the WW source (untreated discharge in Konya and WWTP outlet in Braunschweig) over the distribution systems to the fields and partly crops. While doing this, students and post-docs from Konya University samples jointly to Braunschweig and analyzed them with the modern analytical equipment partly missed at their home department. Students and young researchers were trained in Braunschweig in trace analytical methods of environmental samples and principles of reliable data acquisition from sample taking, storage, clean up, calibration and maintenance of analytical equipment to data interpretation considering the technological and socio-economic environment of pollution sources (Figs. 4 and 5).

Expectedly, pollution persistent organic pollutants POPs and heavy metals in Braunschweig insignificant due to the much cleaner treated WW compared with the untreated WW in Konya and sandy soils the predominant soil type in Braunschweig region. Surprisingly, the agricultural soils in Konya were even not highly contaminated and the bioavailable portion of the pollutants was small due to the soil characteristics as being of heavy clayey soil type. Uptake of pollutants by wheat was insignificant. In the meantime, Konya has erected a modern WWTP and WW reaching the discharge canal is no longer polluted significantly.

The current cooperation of the two universities focuses on the optimization of WW management through avoiding the pollution of WW at source, regulating this, monitoring the sewerage with passive sampler, and quality control of the treated WW before discharge into the environment. The Braunschweig example serves hereby as a 'Best Practice'. Consequently, the two WW authorities in Konya and in Braunschweig (KOSKI, BS-SE/Veolia) are cooperating closely as well, initiated through the Exceed Partners in the two cities. So the Exceed partners could link the stakeholders at two locations the benefit of both sides.

Other joint research projects of Exceed partners conducted or in preparation are (inter alia):

- Soil amendment with super absorbing polymers for use of reclaimed WW in Jordanian agriculture
- Drug residues in WWTP outlets and in dam water in Jordan
- Water and Health in Egypt - Bladder cancer prevalence due to water pollution in the Nile Delta Region
- EMPOWER Tunisia - Emerging Pollutants in Water and Wastewater for Irrigation
- SASAR Tunisia - Sustainable Agriculture in Semi-Arid Regions
- Petrobras + Surf - Coastal zones management in Latin America
- Water Pollution and Risk Assessment in Volta Basin, West Africa



Sustainable Water Management in Saigon Dongnai River Basin, Vietnam

Fig. 4 Field irrigation with untreated wastewater in Konya (left)

Fig. 5 Sampling of wastewater irrigated farmland in Konya (right)

In order to enhance joint proposals and cooperation in running projects a Research Information Platform was launched on the Exceed website and the Exceed members can search for suitable research projects or even for likely interested partners. The students interested in exchange stays abroad can contact the chair people of these projects and figure out working opportunities.

VIII. PIN-OFFS, DISSEMINATION, AND POLICY ADVICE

The research topics of Exceed SWM enabled to extend the cooperation of Exceed members with scientists' further dealing with similar topics of environmental protection. The two projects with Tunisian scientists, already listed above, are direct spin offs of the Exceed SWM project. These two projects are initiated within the Transformation Partnership Program of German Foreign Office and granted by DAAD. In particular, the SASAR Tunisia project aims at bringing in German agronomists and their counterparts in MENA countries for supporting the agricultural research and practice through transferring recent results of the Federal Agricultural Research Institutes 'Thünen' and 'Julius Kühn' in the fields of plant production and sustainable irrigation. Methods of monitoring are also the subject of knowledge transfer.

As the research projects are usually conducted with participation of public and economic stakeholders, the outcomes of the joint work are disseminated in the respective community through well-organized media coverage. Usually, mayors or ministers come to opening sessions that attract local and regional media, whose report about the events is often rather detailed. The topics of the conferences and workshops initiate lively debates in the respective regions. This often initiates further measures of stakeholders in terms of SWM and Good Governance Structures in the respective regions.

The outcomes of Exceed research projects are published in peer-reviewed international journals and are listed in the 'References' section. Moreover, two Special Issues in ISI journals are already published about Exceed outcomes and two further are almost finalized.

Politicians at partner countries as well as in Germany realized the importance of the scientific links through the project. Before German Ministers visit Exceed countries they often ask in advance for making contacts with Exceed members and for organizing scientific visits in order to learn the local situation from an insider. Ministers, Government Authorities, and Mayors in partner countries ask for advice and support while planning or upgrading environmental services in the competence fields of Exceed SWM.

IX. CONCLUSION AND OUTLOOK

Global problems do not stop at national borders. The worldwide migration of people from least developed countries is often caused by bad living conditions and lacking prosperity at home. As a consequence of climate change, even European Countries will be confronted soon with similar problems like in Developing Countries. A global networking and knowledge transfer might help to find suitable solutions for the global problems. Exceed SWM project aims to develop sustainable solutions for urgent problems through research, education, and capacity building in partner countries and beyond, because international events organized and scholarships for exchange are open also for participants from non-member developing countries. With this, the Exceed SWM project has a wider impact than just on the member institutions.

The Exceed SWM project is extended after five years through DAAD for another five years from 2015 to 2019 under the acronym Exceed SWINDON-Sustainable Water Management in Developing Countries and will be conducted under the chair of Prof. Dr.-Ing. Norbert Dichtl.

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