INNOVATION AND CAPACITY BUILDING: INTRICATE ISSUES OF SPECIAL CONCERN OF WATER RESOURCES ENGINEERING

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**ABSTRACT**

Socioeconomic development often causes environmental and water related problems. Any solution requires knowledge, willingness and sufficient financial and technical means. Such capacity is limited in many developing and threshold countries. To identify opportunities for strengthening capacity in water and environmental management, we analyzed University curricula, identified synergies between Universities and practice, explored the potential of vocational training and awareness raising, and developed regional concepts for risk communication. The results present ways how Universities can make capacity development in the water sector in Latin America more efficient. We recommend to modernize curricula, to strengthen vocational training, to intensify public involvement and cooperation with practice, and provide methodological advice for implementation.

**CHAPTER ONE**

**INTRODUCTION**

Globally, water resources are becoming increasingly vulnerable as a result of escalating demand arising from population growth, the need for increased food production, expanding industrialization due to rising living standards, pollution due to various anthropogenic activities, and climate change impacts. Due to water scarcity and poor water quality, it has been predicted that by 2050, at least one in four people are likely to live in a country with a shortage of freshwater. Consequently, ensuring availability and sustainable management of water has been adopted as part of the United Nations Sustainable Development Goals, Transforming Our World: the 2030 Agenda for Sustainable Development. The significance of the competition between the water demand for food production and other consumptive uses needs to be viewed in light of the fact that, according to the United Nations, it will be necessary to produce 60% more food globally and 100% more in developing countries by 2050. This needs to be viewed in the context that currently, about 70% of freshwater resources are used for agriculture. Furthermore, the predicted impacts of climate change on water resources are also significant. Based on long-term weather records and future climate projections, water resources are expected to be highly vulnerable, affecting water availability and quality, and in turn the reliability of supply for various consumptive uses. This situation is further exacerbated by poor management practices and the unsustainable extraction of water. Consequently, many regions around the world, particularly urban areas, are becoming increasingly water stressed and conflicts over access to water are becoming ever more common.

**CHAPTER TWO**

**LITERATURE REVIEW**

The publication by Chinnasamy et al., Understanding Groundwater Storage Changes and Recharge in Rajasthan, India through Remote Sensing, provides a study of how temporal and spatial data collected using remote sensing platforms can be utilized innovatively to bridge current knowledge gaps in relation to groundwater resources. The importance of such approaches needs to be viewed from the fact that the management of groundwater resources needs to take into account, hydrogeology, the agro-climate and demand. However, the development of policies at agro-climatic zone levels is commonly constrained by the paucity of temporal data. This paper specifically focuses on the Gravity Recovery and Climate Experiment (GRACE) mission in 2002, which now makes it possible to obtain frequent data at broad spatial scales and use it to examine past trends in rain-induced recharge and groundwater use. This in turn would help in the identification of suitable groundwater recharge methods and sites where there is potential to achieve enhanced groundwater recharge, thereby improving water availability for various consumptive uses. Wang et al. in their paper, Water Resources Compound Systems: A Macro Approach to Analyzing Water Resource Issues under Changing Situations, provides an innovative approach for Integrated Water Resources Management (IWRM), to enhance the sustainability of regional water resources. Using four cities in China, namely, Beijing, Fuzhou, Urumqi, and Lhasa, with diverse geographical, climatic, spatial and demographic characteristics as case study sites, the authors demonstrate how a water resources system can be considered as a water resources compound system that constantly changes under the combined action of development, resistant, and coordination mechanisms. These different subsystems which comprise the compound system have different development and resistant mechanisms, which are influenced by a range of influential factors inherent to a specific region. Therefore, comparing these mechanisms with the water quotient provides the platform for identifying appropriate measures for the sustainable management of water resources. The publication by Ding et al. is in the area of water allocation, which is a critical issue facing water resources managers, as the demand for freshwater resources can outstrip supply. Water allocation demands in-depth assessment to underpin prudent decision-making for determining the appropriate mechanisms for distributing water among different regions, sectors and users. Over the years, a range of methodologies have been explored which can be broadly classified as centralized and decentralized approaches. Each approach has its inherent advantages and limitations. The paper, which is titled Agent Based Modelling for Water Resource Allocation in the Transboundary Nile River, presents a parallel evolutionary search algorithm to introduce a mechanism in redistributing the central planner revenue value among the competing agents based on their contribution to the central solution as the basis for water allocation among competing demands. The case study is the Nile River basin, where broadly there are eleven competing users represented as agents in various sectors with upstream-downstream relationships and different water demands and availability. The publication by Nava et al., Existing Opportunities to Adapt the Rio Grande/Bravo Basin Water Resources Allocation Framework, further explores the challenges and opportunities for innovation in the area of water allocation. The case study area is the Rio Grande/Bravo (RGB) Basin, where a transboundary framework exists between the United States and Mexico for water allocation.

**CHATPTER THREE**

**METHODOLOGY**

**pWEM** stands for “Capacity Development in Water Engineering and Environmental Management “in Latin America. From 2011 to 2014, six Latin American Universities (Asuncion, Paraguay; Bahia Blanca, Argentina; San José, Costa Rica; Santa Maria, Brazil; San Salvador, El Salvador; and Talca, Chile) and two European Universities (Lisbon, Portugal; Siegen, Germany) worked together on the analysis and improvement of capacity development in Latin America, funded by the EU-ALFA program. To achieve the above-mentioned goals (describe the status quo of capacity development, understand the limiting frame conditions, and identify tailored ways for an improvement), a methodological framework was developed (figure 1). Literature reviews, different kinds of

surveys, interviews and workshops served the collection of information on the status quo of the different aspects of capacity development in the respective countries. They also gave insight into the limiting frame conditions. Surveys among the eight partner Universities were carried out by the completion of

questionnaires. The central aspects queried in the surveys are summarizes in

Information was collected on:

• Structures and contents of undergraduate curricula (Steinbrecher et al., 2014a);

• The organisation of the individual PhD-programs (Steinbrecher et al., 2014b);

• The relation of the Universities to media and to potential interest groups (Gonzalez et al., 2014);

• Risk perception, risk awareness and risk management in Latin America (Portela and Ramalheira 2014a);

• Implementation of water and environment related laws in Latina America and Europe (Althoff and Bormann 2014).

**CHAPTER FOUR**

**RESULTS**

The comparison of the study program structures and durations of undergraduate study programs in the field of water resources engineering revealed significant differences between the involved European and the Latin American Universities. While in Europe Bachelor and Master programs are designed for 3 years (Bachelor) plus 2 years (Master) due to the homogenization of the study programs required by the Bologna Process, the Diploma do in

Latin America usually takes 5 years. Although both curricula end up in about five years duration (assuming a consecutive Master program), the obtained credits are not fully acknowledged.

Regarding content and credits, the different study programs were analyzed on the following subjects: Basic knowledge in water science (hydrology, hydraulics); planning and

management (environmental management, water resources management); water supply and sanitation (urban water management, wastewater treatment). The study revealed that the different civil engineering study programs are characterized by significantly differing contributions of the three above mentioned themes to modules and credit points (Steinbrecher et al., 2014a). While in Latin America the three topics cover only 10% of the modules, in

Europe, they cover about 20% of modules and credit points in Bachelor and more than 35% in Master programs. A review on water related curricula of different study programs in Germany confirmed the above-mentioned tendency but also showed a significant scatter among different disciplines which are taught at German Universities (Haberlandt and Müller, 2013).

Workshops and structured interviews in Argentina, Brazil, Chile and Costa Rica analyzed the available contents and modules of Magister, Diploma do and PhD programs at the involved Latin American Universities. They revealed that postgraduate programs and curricula require a strengthening of methodological, technical, and soft skills. These findings seem to be applicable to Latin American Universities in general. Deficiencies were found concerning practice-oriented teaching, including case studies and integrative projects. Based on the inventory of modules available in postgraduate study programs, modules were identified which could be suitable for a new Magister program on Water Resources Management in Costa Rica, a Diploma do program on Risk Management in Paraguay and a joint PhD program in the field of Water and Environmental Management. In Costa Rica, a strengthened Magister program on Water Resources Management was set up by combining suitable contents and water related modules from different existing study programs in the

fields of Economics and Agricultural Engineering. This was realized during a workshop integrating professionals and University representatives. Concerning a joint PhD program in water and environmental engineering, six relevant subjects were identified for teaching, covering hydrology, hydraulics, water management,

**CONCLUSION**

International programs such as the ALFA program of the European Union can significantly contribute to strengthen the role of Latin American Universities towards capacity development. The investigations in the framework of the CapWEM project revealed that Universities can play an increasing role for the capacity development in water resources engineering and environmental management. Higher Education Institutes have the knowledge, the ability and the means to take a leading role in capacity development. Based on the collected information, tailored solutions were developed related to study curricula, vocational training, awareness rising and risk communication. However, the results obtained in this project for selected Latin American countries also showed that a huge potential is still available for strengthening the role of the Universities in Latin America in capacity development. This concerns undergraduate and graduate programs, vocational training, collaboration with the practitioners, and the contribution to an increased environmental awareness as well as to environmental regulations. Review and revision of programs and procedures as carried out in the framework of CapWEM are not yet standard procedures at Higher Education Institutions in Latin America. Limited data availability and accessibility are crucial obstacles for a smooth cooperation of Universities, governmental agencies and practitioners.

**RECOMMENDATION**

Curricula should be regularly strengthened according to new requirements (see also instead of simply adding contents and modules. Compared to Europe, water and environment related contents and modules are still underrepresented and should receive more attention. Curricula should be strengthened by including integrating topics such as management and planning, considering the requirements of recent environmental challenges. In agreement with Lebel et al. (2013) and Pearce et al. (2013), interdisciplinary and even transdisciplinary contents and modules should be developed in order to account for the integrative character of environmental issue.

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