- Groundwater Maya Project –

Groundwater systems constitute the predominant reservoir of freshwater storage on Earth. In regions with water problems and large aquifer systems groundwater is often used as an additional water source. However, the situation is different in places where groundwater is the only source of fresh water for the population. Example of this is the groundwater system in Yucatan, Mexico, which contains one of the world's largest karst aquifers, and takes up approximately most of the total area (138,000 km^2) of the Yucatan Peninsula. All groundwater exploitation made by societies results in some decline in the quality of aquifer water. In the case of Yucatan, this is also influenced by the calcareous nature of the soil that confers it characteristics of high porosity and permeability causing rapid rainwater evaporation and infiltration. In the area, the aquifer is susceptible to several problems like salt intrusion from the sea and contamination derived from an inadequate waste disposal. Consequently, the water situation there can quickly reach critical and vulnerable conditions, and even small disturbances may cause dramatic consequences. The project has been set up in the Social Ecological System framework (Ostrom 2009) for the study of common pool groundwater resources in Yucatan, Mexico. Its aims are to increase the understanding of groundwater system regarding pollution problems, and to develop a tool for the early recognition of human drivers affecting groundwater resources. The problems we are referring to are associated to a particular case study in the Circle of Cenotes in the Mayan area of Yucatan, in Mexico. In this place, where groundwater is the only source of freshwater, the inhabitants have to deal with water problems such as resource scarcity and degradation, groundwater pollution, climate change, and biodiversity loss. Due to its calcareous soil is easy to find groundwater caves plenty of fresh water. In the area there are thousands of these caves, called cenotes (from the Maya word ts'onot that means sinkhole) from which societies extract water for several uses. Increasing demands for sources of fresh water, combined with changing land use practices, growth, aging infrastructure, and climate change and variability, pose significant threats to this fragile ecosystem. Failure to manage this resource in an integrated, sustainable manner will limit economic prosperity and jeopardize human and aquatic ecosystem health. The specific objectives are: 1) to develop a model by analyzing the relevant fluxes of the groundwater system in the Circle of Cenotes, Yucatan, Mexico; 2) to analyze the experts' (local members) and non-experts' risk perception regarding groundwater use and management, by eliciting their mental models; 3) to develop underwater exploration to obtain insights about the current and real use and status of local wells and sinkholes; and 4) to include a bio-cultural approach for conservation and environmental activities with stakeholders spanning sectors such as: NGO's, local communities, and policy makers. These are central to the questions: What are the environmental impacts of human activities in the area of the Circle of Cenotes of Yucatan, Mexico? What is the structure and content of the mental models of experts and non-experts regarding the use and management of water? Are those mental models fragmented? Are those models shared? How behaviours, decisions, and governance will influence the ecosystem (e.g., water quality, irrigations)? The main elements of the methodology in this research are:

- Material Flow Analysis (MFA): to quantify relevant groundwater fluxes.
- Structural Mental Model Approach (SMMA): to determine mental models between experts and non-experts.
- Underwater exploration and speleological prospection: to obtain insights of the cenotes and caves in the area.

The structure of the project reflects the close cooperation of science and practice. The group consists of scientific management (MSc. Yolanda Lopez, Department of Geography, University of Munich, LMU), co-management and supervision (Prof. Dr. Claudia Binder, LMU, and Dr. Eduardo Batllori-Sampedro, SEDUMA), and 3 Bachelor students of the Department of Geography at LMU (graduated) [1]. The accompanying groups consisting of members and representatives of the Groundwater Technical Committee for the Metropolitan Zone of Yucatán, vocals of the municipalities, NGO's, and representatives of associations of different sectors. Results have been published and communicated in conferences at both, national and international level. The results of the project will have a high scientific value and will be useful for conservation programs and for people in the region.

---

[1] Two Diploma theses have been developed Title: Stoffflussanalyse des Wasserverbrauchs in Haushalten in Yucatán, Mexiko, LMU, 2014, and Modeling Groundwater Pollution: The Case Of The Ring Of Cenotes in Yucatan, Mexico, LMU, 2016.