Hydrogeology in The South-West of Madagascar – A Multi-Scale Approach

Andreas Englert[1], Linda Dworak [1], Jean Rasoloariniaina [2], Katja Brinkmann [3], Susanne Kobbe [4], Andreas Buerkert [3]

[1] Hydrogeology Department, Universitaetsstr. 150, 44801 Bochum, Ruhr-University Bochum, Germany, andreas.englert@rub.de Linda.Dworak@ruhr-uni-bochum.de

[2] Department of Zoology, University of Antananarivo, BP. 906, 101 Antananarivo, Madagascar ratsim17@yahoo.fr

[3] Section Organic Crop Production and Agroecosystems in the Tropics and Subtropics (OPATS), Steinstr. 19, 37213 Witzenhausen, University Kassel, Germany, brinkmann@uni-kassel.de buerkert@uni-kassel.de

[4] Institute of Zoology, Martin Luther King Platz3, 20146 Hamburg, University Hamburg, Germany, susanne.kobbe@uni-hamburg.de

The project „Sustainable Land Management“ (SuLaMa) aims at the participatory development and implementation of alternative land-use management practices to protect the ecosystem and its biodiversity and improve the livelihood of the local population in a sustainable manner. One critical aspect within this project is the availability of sustainable water resources. To approach reliable estimates about the availability and dynamics of the water resources, we studied in detail the hydrogeology of the South-West of Madagascar. As this area has an extend of about 40000 square kilometers, the study is based on a multi-scale approach, where rough large scale estimates are utilized to develop a general understanding of the hydrogeology in the South-West of Madagascar. At target villages of the SuLaMa project detailed investigations combined with boundary conditions derived from the large scale hydrogeological model allows for estimates of the local hydrogeology. Although several governmental and nongovernmental institutions have been working on the water resources of the South-West of Madagascar in the past, only few sources on the hydrogeology of this area can be found in literature. To improve the data base we installed automatic loggers in the area to measure groundwater levels as function of time. Additionally during two field campaigns we investigated in detail about hundred wells in terms of geometry, groundwater level and electrical conductivity.

Results of the study show that the large scale hydrogeology in the South-West of Madagascar is dominated by four major hydrogeological units: The low permeable fractured crystalline basement, the high permeable karstic plateau including localized intermediate permeable perched aquifers on top, the intermediate permeable porous aquifer within the paleo-channel of Itomboina and the intermediate permeable porous coastal aquifer. The semi circled shape of the Madagascar island in the South allows the large scale hydrogeology to be effectively analyzed under the assumption of a radial symmetric geometry. Groundwater flow is roughly directed from the center of the radial symmetric system towards the coast, to finally discharge into the Mozambique Channel. Groundwater levels are shallow in the crystalline basement in the center. In the area of the plateau groundwater levels in the karstic aquifer are estimated to be 50 m – 150 m deep. On the plateau only the perched aquifers, which lay on top the karstic aquifer, show accessiblae shallow groundwater levels. Within the channel of Itomboina, the depth to water level dips East-West and is shallow only in the western area of Maoarivo. In the coastal sandy aquifers, the groundwater levels are again shallow and easy to access. Large scale groundwater recharge is estimated based on river discharge analysis and is about 40 mm/a in the crystalline basement but only about 1 mm/a in the area of the plateau and the coastal area.

At small scale, our study shows that water resources on the plateau are scarce as the major karstic aquifer is only accessible through deep drilling and pumping operations. Relatively small and localized, but easy accessible are the perched aquifers. Exemplarily for the latter, we studied the aquifer at Andreamba. The annual hydrograph, measured in one of the Andremba hand duck wells, shows that during the rainy season the aquifer is recharged. During this time the groundwater level rises up to surface elevation, to drop successively in the dry season to a level of about 10 m below ground surface due to extraction of up to 10 m^3/d. The annual water level fluctuations in the coastal area are studied exemplarily at Itampolo. The hydrograph, measured in a well in Itampolo shows much less variations throughout the year. Groundwater levels rise in the rainy season to a level of 2 m and drops within two month to a level of 4 m below ground surface. The latter groundwater level than remain almost static until the next rainy season. Even tough easily accessible for the population, the groundwater in the coastal area is prone to salt water intrusion and shows already electrical conductivities of 7000 µS/cm indicating high salt concentrations.