

## End of project popular science description

### Introduction

This project had an overall goal of providing the scientific basis to facilitate groundwater resources development for agricultural activities in the White Volta Basin, Ghana. Within the White Volta Basin, the project was concentrated within the Nasia sub-catchment. The choice of this sub-catchment was made after the first stakeholder meeting and a preliminary assessment of data availability. The project had the following specific objectives:

- *To strengthen the research capacity of the involved Ghana institutions through knowledge and expertise sharing with counterparts in Denmark.*
- *To foster and strengthen long term collaborations between geophysicists, geologists, hydrogeologists, scenario analysts, agricultural planners and stakeholders within Ghana, and between Danish and Ghanaian researchers.*
- *To use regional airborne datasets, originally collected for mineral exploration, to provide information on the geology useful for water resources management in agricultural planning*
- *To develop a transient groundwater flow model for the Nasia River Basin for assessing responses to various scenarios of groundwater abstraction for irrigation schemes as well as of climate change impacts*
- *To develop design recommendations for sustainable, resilient and cost-effective irrigation schemes using groundwater resources to enhance efficiency in agricultural practice in areas geologically similar to the Nasia River Basin*
- *To improve groundwater resources governance and efficient management in line with the Ghana Water Policy Document and associated regulation so that small scale beneficiary farmers are assured of continuous (but sustainable) access to groundwater resources to increase food security and reduce poverty*
- *To provide the necessary scientific basis to assist in effective management and governance (e.g.: groundwater level monitoring by using existing and new wells, estimation of optimal abstraction rates, etc.)*

### Results

The main results of this project are presented below:

#### **3D Geological Model**

A 3D Geological model has been developed for the Nasia Basin. The model reveals essential aspects of the stratigraphy of the Voltaian Supergroup in general and has revealed lithological information for hydrogeological purposes. It has been documented that application of geophysical wireline logging of old as well as new exploration boreholes drilled with “Down-the Hole-Hammer” method is needed if proper and detailed lithological records shall be obtained. Furthermore, geophysical logging data provide possibility for correlation in between the boreholes, which is of great importance for the establishment of the 3D Geological model.

#### **3D Transient Groundwater Model and Groundwater Resources Assessment**

The Salient findings from the model are:

- Given the demographic characteristics of the basin, groundwater development for irrigation purposes should be focused on the regolith
- Recharge rates estimated from the model indicate a range of 1 % to 6.2 %, with an average of 3 %, of the total rainfall. These rates translate into 62.00 M m<sup>3</sup>/ year, 367 M m<sup>3</sup>/year and 176 M m<sup>3</sup>/year respectively. This is consistent with groundwater recharge rates estimated for similar basins in West Africa
- Climate change/variability will affect groundwater recharge and its distribution in space and time
- This rate of groundwater recharge appears to indicate relatively limited potential for groundwater resources development for Agricultural purposes.

- Furthermore, the potential is highly variable in space due to the variability in the geological conditions for storage of groundwater, i.e. the Regolith has variable potential for storage due to variability in clay content and thickness.
- Whereas additional data has been generated in this project to increase understanding of the regolith and the underlying geology, much more fieldwork is required in the area to define the geological and geophysical parameters which indicate promise for potential groundwater abstraction for irrigation and other purposes
- The project has documented a need for improvement of the use of various geophysical groundwater exploration techniques, and a need for more attention to the geology when interpreting the geophysical data.
- The project also finds that groundwater quality is generally acceptable for irrigation purposes, though groundwater pockets do exist with too high salinity for irrigation purposes.

### **Capacity Development for research**

- 4 PhD-students have been successfully trained in the areas of geology and hydrogeology to boost research capacity in Ghana – hitherto the PhD has been awarded to three of them.
- A groundwater monitoring system has been established to obtain transient groundwater data for effective resources governance
- A modern Liquid Water H-O isotope analyzer has been acquired for research in hydrogeology
- Groundwater modeling software have been procured for teaching and research: Groundwater Modeling System, Watershed Modeling System, and FEFLOW
- A borehole geophysical logging equipment has been procured for research and teaching purposes

### **Conclusions**

The major conclusions from the project are:

- Research capacity in the areas of hydrogeology and groundwater development in Ghana has been enhanced through the training of 4 PhDs and the procurement of research equipment and software for research
- The groundwater monitoring system will provide data to improve upon groundwater governance and effective management in the Nasia Basin
- Interpretation of airborne geophysical data has provided more insights on the geology and stratigraphy of the basin. Such insights are useful for guiding further fieldwork on the development of groundwater resources of the basin
- Insights gained from the interpretation of airborne geophysical data will be useful in updating the stratigraphy of the Voltaian Basin
- Improved success in groundwater development in the area requires an integrated geological and geophysical approach. A combined application of Electromagnetic and Resistivity methods, conducted and interpreted with adequate consideration to the underlying geology yields much more positive results and improve success rates
- Groundwater can be accessed through high yielding dugouts in depressions, for small scale irrigation activities especially in the dry season.
- Groundwater is generally of sufficient quality for irrigation activities in the Nasia Basin apart from certain pockets with highly saline groundwater
- Estimated groundwater recharge suggests promise for restraint groundwater resources development for many purposes. However, sufficient success in developing groundwater resources for agricultural purposes rests with adequate knowledge of the thickness and character of the regolith.

### **Recommendations**

These are the recommendations from the research:

- The research has provided the framework for further fieldwork towards improving understanding of the regolith and the bedrock. Further field-based geological, geophysical and hydrogeological investigations are required to properly define the characteristics and thickness of the regolith to assist in groundwater development for irrigation purposes.
- The monitoring system that has been established should be maintained and expanded to cover the entire White Volta Basin. The resulting data will be used for a much more robust decision support system for groundwater management
- Much more detailed studies of the local stratigraphy of the Voltaian Supergroup in the Nasia Basin and of its relation to development of Regolith in order to properly build an adequate hydrostratigraphy for an improved groundwater model
- It is recommended that an integrated surface-groundwater model is developed to better characterize the water resources of the basin so that a better assessment can be made in resource sustainability amidst changing climate
- Future development research of this nature should give much more attention and resources on fieldwork and data gathering since the current state of data in the region is too weak to support any useful research.
- In future hydrogeological and groundwater development projects, it is necessary to combine several techniques to complement each other in order to enhance confidence in the final outcomes.