Hydrogeological model for identifying ideal locations for groundwater wells

in Massailand in Tanzania

Graduate

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Initial Situation: The availability of clean drinking water is vital because it is essential for bodily functions, public health and food production. Water is a scarce and indispensable resource, which is why ensuring global access to clean water and sanitation is enshrined in the UN Sustainable Development Goals. Obtaining drinking water is a major challenge, particularly in arid regions such as Massailand (mean coordinates: -4.4°N, 37.2°E) in Tanzania. Since December 2020, the organization Global Aid Network (GAiN) GmbH, in cooperation with a local drilling company, has drilled numerous wells in the region. However, some of these groundwater extraction points could not be put into operation due to suboptimal hydrogeological conditions, which underlines the necessity of more precise planning. This work aims to develop a stationary, two-dimensional groundwater model for Massailand in order to identify optimal well locations and thus contribute to a sustainable improvement of the water supply.

Approach / Technology: The theoretical part of the thesis deals with the tectonic and hydrogeological fundamentals, as well as relevant mathematical models of groundwater modeling. The methodology includes the use of the software tools QGIS for geodata preparation and SPRING for the simulation of groundwater flows in complex hydrogeological systems. The geological data, hydraulic parameters and boundary conditions previously prepared in QGIS are entered into SPRING. Relevant input data are terrain surface, groundwater thickness, main and tributary watercourses, extraction wells, geology, fault zones, land use, soil type, precipitation (Fig. 1) and climate zone. By using a finite element method, SPRING can calculate, analyze and visualize the groundwater dynamics in detail.

Result: The results are presented in the form of a groundwater map (Fig. 2), flow net diagrams, depth-to-water maps and hydraulic conductivity distributions. A suitability map for well locations derived from these results, which uses the distance between the terrain surface and the groundwater table (depth-to-water) as a criterion, helps to identify optimal drilling locations (Fig. 3). The model calculation has shown that the groundwater table in the region is at an altitude of 455 to 1540 m above sea level and that the depth-to-water is therefore between 0 and 1050 m. Based on this model, an area of 8'629 km^2 was classified as very suitable or suitable, 6'151 km^2 as moderately suitable and 9'805 km^2 as poorly suitable or very poorly suitable for groundwater wells. The results should be used with caution due to considerable uncertainties in the input data. Based on the available groundwater level measurements, an uncertainty of the model of up to 30 m is assumed. It is therefore not suitable for deriving precise localizations for wells but can be used for identifying potentially suitable regions. The prediction accuracy could be further improved through more precise measurement data, the modeling of rivers as dynamic systems and refined boundary conditions.

Figure 1: Overview map of annual precipitation in mm/year
Own presentment

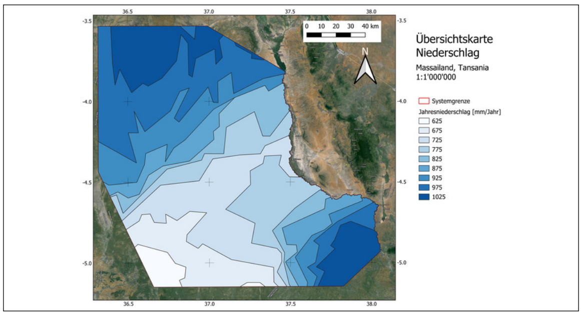


Figure 2: Map of the calculated groundwater potential in m a.s.l.
Own presentment

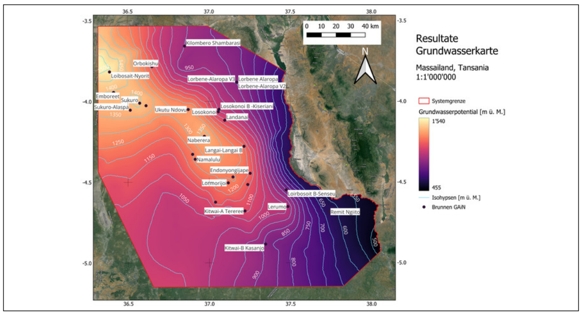
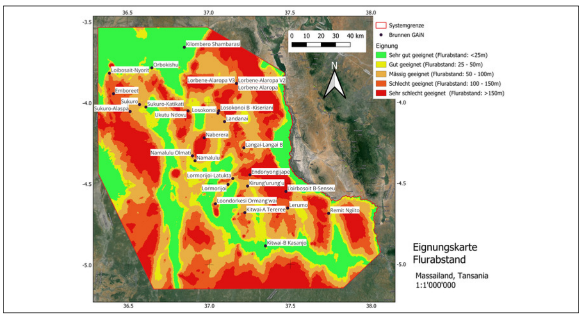


Figure 3: Suitability map for wells with classification based on depth-to-water
Own presentment



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