Limitations in coastal aquifers – challenges for vulnerable communities

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ABSTRACT

A water resource can determine whether a specific community will prosper or not. This is because water is crucial to economic development, especially for poor communities in coastal areas with limited access to fresh water. This paper presents the case of Quissanga, a village of about 5000 people in northern Mozambique. The potential economic growth is limited by many factors, one of them being the water source, which is currently a thin, coastal, "island" aquifer vulnerable to salt water intrusion. Sustainable exploitation of the resource demands appropriate well design as well as careful management. Climate change induced reduction in rainfall and increased sea levels, will additionally shrink the available fresh water putting added stress on the water source. A careful assessment of the water source and management aspects has been carried out, and indicates that investments are needed for specifically and carefully designed production wells and an establishment of a solid management structure.

INTRODUCTION

Numerous communities have established their livelihood and their homes along the coasts in many countries and experience the exposure to both climate change induced sea level rise and extreme weather situations as a threat to their existence. Their need for water is extreme both in terms of a direct necessity for their living as well as a basic resource for developing their livelihood to a prosperous income. In addition, more and more tourists from well developed countries look for relaxation and often a luxurious lifestyle in coastal resorts and hotel cities.

Poor villages with limited access to development suffer from any type of limitation, especially those related to the very basic infrastructure such as water supply, sanitation services, health services and power supply. Often the complexity and limitation of coastal groundwater reservoirs restrict any further development and prosperity growth. This paper outlines the case of Quissanga, district centre in Cabo Delgado Province, northern Mozambique. It explores the complex challenges of a restricted water source, climate change, social and cultural aspects and the linkages between these aspects.

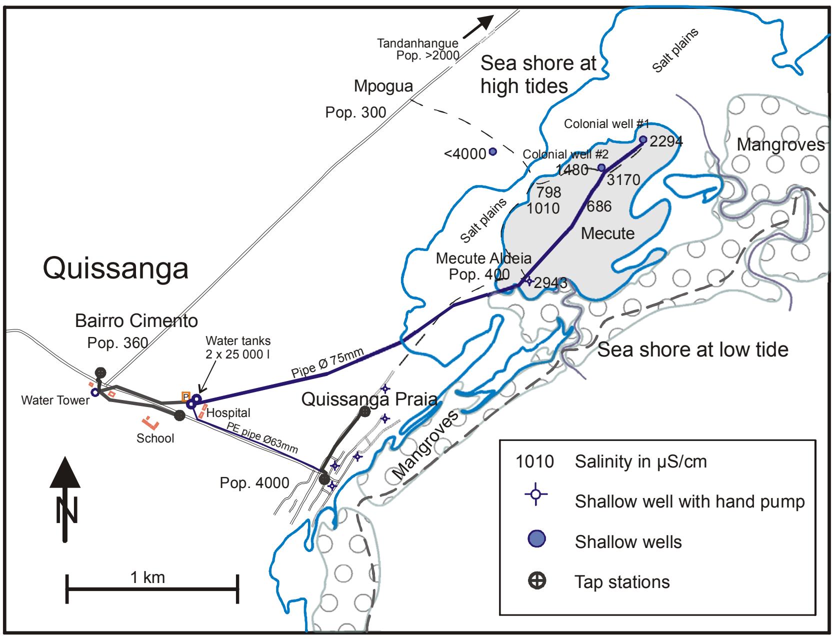
Groundwater is often the natural and immediate available source for water in coastal areas, however, is often limited in volume and accessibility, as well as exposed to potential pollution. Quissanga is a typical fishing village with some 5000 inhabitants about 100 km north of Pemba, northern Mozambique. The location becomes inaccessible during the rainy season, and does not have access to power other than a communal generator powering the administrative buildings a few hours a day. The main economic activity is fishing, however, bad roads and lack of access to ice and transport limits the potential of economic growth. Poverty, illiteracy and mal nutrition is widespread, especially in the dry season. When the project arrived, a number of private persons showed interest in the water, and since 2009 an ice factory and a new hostel have already been built. There is also high demand for water from the administrative buildings that manage the whole district. Poor water and sanitation have also resulted in yearly cholera outbreaks, again stifling growth. This shows that with availability of abundant water, this village would have a great potential for development.

The colonial Portuguese explored the area for water and settled for a sandy area at the coast, Mecute. One, large-diameter (3m) shallow well was developed at a marginal point north on the island and managed to provide sufficient water for a limited number of people. Since the late 1970s, the pumping scheme has fallen apart, although the well could still be used. Fontes Foundation, a small Norwegian NGO specializing in water and sanitation was approached by Statoil, a Norwegian oil company, to carry out a corporate social responsibility (CSR) project aiming at improving water supply to Quissanga. In early 2009 in a first project phase, the well was rehabilitated and a pumping scheme re-established. The first phase has been fairly successful, however monitoring results indicate increasing salinity levels in the well. Thus, additional wells are deemed necessary to better distribute abstraction and to extract more water from the given aquifer. In January 2010 Fontes Foundation carried out a detailed study to better survey salt water intrusion into the shallow aquifer and to develop project plans for well design and construction.

The problem of fresh water on Mecute may in the long term be exacerbated by climate change through sea level rises and more extreme weather, i.e. less rainfall. It is imperative to prepare and support these vulnerable areas to adapt to these changes. While groundwater in Quissanga is limited and apparently the only readily available resource for drinking water in this area, careful abstraction and use through appropriate system design and effective management is the goal of this project to support the community in a sustainable way.

COASTAL AQUIFER OF MECUTE

The coastal belt at Quissanga is characterized by very flat muddy plains mostly covered with dense mangrove forests. Tidal fluctuations are in the range of 3 to 4 meters. The sediments of Q. Praia and Mecute consist of medium to fine grain dune sands 1 to 2 meters above sea level. Because of the mangrove forests' protection, the people can live very close to the sea and at very low levels. Therefore, houses may be found down to few decimeters above the level of highest tides. During storm tides seawater floods large areas covering the salt flats behind the Mecute dune area. These salt flats are used for both salt harvesting and, where the terrain is a bit higher, for rice paddies where small dams collect the rain water during the rainy season.



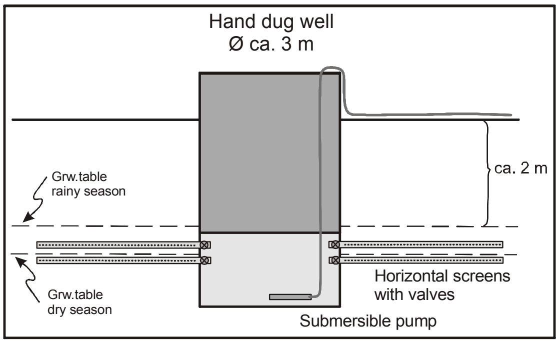
The storm tides make the Mecute area an "island" in terms of aquifer characteristics. The "island" consists of sand dunes a little bit more than one kilometer in length. Normal rainfall is in the range of 900mm. It is estimated that recharge to groundwater should be sufficient to supply the Quissanga community. The sandy soil has few fines and infiltration rates are assumed to be high. This can be seen during rainstorms and the absence of surface ponding. Abstractable groundwater based upon recharge can be calculated as follows: over an area of 700,000 m^2 and an annual rainfall of 900mm, an evaporation rate set at 70% gives on these input data results in about 190,000 m^3/year, while consumption by the communities is estimated to be 300 m^3/day (40 liters per person per day) or about 900,000 m^3/year. This gives roughly a 50% degree of exploitation, a figure that is rather high. However, 40 liters/ day is a fairly high figure given that the community has other water sources available for washing (body wash and clothes wash) and has to pay for the drinking water. Monitoring during the last year indicates rather that the consumption is at about 4 liters per person per day (l/p/d), due to low demand during the rainy season and low willingness and ability to pay. Applying lower consumption rates in the range of 20 l/p/d implies the water supply being sufficient as long as the rainy season continues to show the same pattern and amount of rain fall. Rainfall has however been lower along the Mozambique coast from 2007 to 2009, which makes a careful use and management of this resource even more critical.

Electrical Conductivity (EC) measurements are shown for various points on the map. EC is an indirect measurement for Total Dissolved Salts (TDS) and is used to evaluate groundwater and its salinity. Although TDS may be made up of a number of dissolved ions, at Quissanga it is safe to assume that Na and Cl are responsible for much of the elevated TDS and EC that have been registered. Salinity varies in shallow wells and open dug holes from about 600 µS/cm to <4000 µS/cm. The lowest salinities are found in open holes at the groundwater table where people dig holes. In dug wells in use EC is elevated. In the supply well salinity has clearly been rising during the last two years of use, from about 900 to 2200 µS/cm. Further, the last rainy season in early 2009 was so dry that almost all crops in the area were destroyed and the groundwater was not refilled. The groundwater table under the island fell with almost one additional meter, which is a lot in an area where sea water is intruding from all sides to limit the available fresh water.

PROPER RESOURCE MANAGEMENT FOR OPTIMIZING WATER ABSTRACTION

The water supply to the population of Quissanga has been interrupted for many years due to damaged pumps and pipelines. The water supply project has deemed the scheme as a good one and has chosen the same approach as the Portuguese engineers. The technical parts of the water pumping scheme have been repaired and replaced bringing water from Mecute to Quissanga and from there to distribute it to a number of distribution points. After the old large diameter well was rehabilitated by Aga Khan Foundation in 2008, Fontes Foundation replaced the long pipeline from the well to the water tanks with a 75mm HDPE pipe, and installed a generator and submersible pumps. The set-up also allows for using either solar panels or to connect the system to power lines at a later stage. The pump capacity is estimated at 10 m^3/hour.

The old Portuguese well, however, showed that infiltration from the aquifer into the well is only in the range of 10 cum per 8 hours, which is far below what is needed. The well is a concrete, large diameter well (Ø 3m) about 4m deep. In addition, the well (called #1, see map) is situated very close to the edge of the fresh water aquifer. It was probably placed there because the local population traditionally fetched water from shallow open pits in that area. Increasing salinity in the well during the last year of production have made it necessary to map the aquifer more in detail and to proceed with planning more wells with better well design. Salinity mapping at points of access to the groundwater in combination with exploration digging (the water level is usually only 2 meters below surface) resulted into sufficient data to design and locate a new well. Constraints on abstraction must be engineered into well and supply designs if sustainable use of the aquifer is to be reached. Collector wells are proposed that are sealed in the bottom part of the caisson, and that are outfitted with two or more levels of slotted radial pipes, one for normal use and others for dry periods. The depth of the slotted pipe constrains the amount of draw-down that is allowed in the well. Pre-drillings to determine collector wells sites with lowest salinity levels was strongly urged. The new location has been chosen to be in the central area of the "island" to allow larger draw-down without affecting the edge of the freshwater lens. Detailed well siting should be preceded by drilling that investigates water quality and sediment coarseness. This may be done with hand-drilling small-diameter, well points, stopping at meter intervals to test pump and measure drawdown in the pumped well-point. Results are then used to determine well viability and depth of the radials in the collector well.



There are also social and institutional aspects to be considered in order to enhance sustainability. Particularly, a sound and competent management of the water source is necessary in order to ensure optimal use, and to prevent over-pumping. A management structure in the village has been set up with a voluntary water committee, paid technicians and a local water manager. They collect funds and are responsible for operation and maintenance. The establishment of this management structure has proven to be even more complex than the technical challenges uncovering intrigue, corruption, and not the least limited capacity and political will to cooperate. The scarcity of the water resource, however, makes it necessary to use extensive resources in terms of money and time to make sure that the management of the water supply is in good and competent hands. This includes capacity building, periodical follow up, and also the creation of an ownership feeling both in the local community and in local and provincial governments.

In addition, the example shows that although demand for water is high, willingness and ability to pay is low. It is, therefore, necessary to sensitize people about the dangers of using unprotected water sources in order to increase the water sales. Without enough collected money, the operation and maintenance cannot be ensured, and the salaries of the people safeguarding the aquifer cannot be paid. Although the water price limits the quantities used by people, improved health and hygiene is crucial for poverty alleviation in this village. In addition, the water price needs to be low enough to allow for all social groups to access water. It is therefore necessary to strike a balance between demand management through the water tariff and the needs of the population in terms of hygiene and improved health.

CONCLUSION

The example of Quissanga shows how a limited fresh water resource can limit potential economic growth, and how water supply has more different aspects than only improved health or improved convenience. However, when the strong demand for water is combined with a limited and fragile coastal aquifer, it is necessary to put in place mechanisms to manage this water source carefully in order to ensure sustainability. Knowledge about the aquifer and its properties is crucial to adopt appropriate technology and optimize water quantity and improve quality. This example shows how it is necessary for an organisation to consider all factors of a water project, including technical, financial, social and institutional ones in order to ensure the proper management of a delicate water source.

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