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Quantifying available water supply in rural Mali based on data collected by and from women

Cara Shonsey [a,*], John Gierke [b]

[a] Department of Civil and Environmental Engineering, Michigan Technological University, MI, USA
[b] Department of Geological & Mining Engineering & Sciences, Michigan Technological University, MI, USA

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ABSTRACT

Water development planning requires both technical and social considerations. Water is gathered and used predominantly by women in rural areas of developing countries, yet they are not always included in the development planning. A hydrogeological study was undertaken to estimate the sustainable yield from a shallow aquifer while serving as a Peace Corps volunteer in a Malian village (population 1200). This study required "pumping" tests to determine the hydraulic properties of the aquifer. Village women provided assistance by hand-drawing (bailing) water from wells at a near constant rate. Local women also participated in water-use interviews that were used to identify community water needs. The pumping test and survey data were used in computational models of the subsurface hydrology to determine the effectiveness of pump installation. Two electrically powered pumps, atop drilled wells, separated by at least 500 m, could be used to supply the village water needs (50,000 L/day) instead of the 64 dug wells currently in use, many of which have poor quality and unreliable production. This study shows that local women can be a practical resource for water-related data in water resource planning.

1. Introduction

Everyone needs sustainable access to clean water. However, as of 2008, 13% of the world's population still did not have sustainable access to an improved water source; the majority being rural poor in developing countries (UNDP, 2010). There are many issues that impede the process of water resources development in poor rural communities, and one of them is the lack of collected or accessible hydrologic data. This lack of data is usually the result of the breakdown of a national framework caused by decentralization, political crises, high professional staff turnover, or the transfer of responsibility to private entities (United Nations, 2009; Robins et al., 2003; Braune and Xu, 2010).

In this study, we focus on improving access to sufficient quantities of water; however, the improvement of water quality is also very important. Providing access to water so polluted so as to be undrinkable is of no benefit. Water supplies can become polluted by means of natural geologic processes and human intervention. Examples of human intervention at the simplest level are such things as improper construction of wells and unsanitary water-fetching and handling practices. Kennedy (2006) conducted a thorough literature review of linkages between access and water quality and concluded that a strong linkage has not yet been identified, but rather that hygiene practices that take place in the home have the largest impact on quality of the water that is consumed in the home. The community survey results and literature reviews by Kennedy were confirmed by the recent work of Seib (2009). Readers interested further in water quality are referred to work discussed and cited in Kennedy (2006) and Curtis et al. (2000), both of which are the most recent reviews of which the authors are aware.

The rural communities of the world that are trailing behind the majority in terms of the development of improved water sources are those of Sub-Saharan Africa; ahead only of those in Oceania (UNDP, 2010). Groundwater is the main source for drinking water, serving 75% of the African population (Economic Commission for Africa, 2006). It also accounts for over 15% of Africa's total renewable resources (World Bank, 2005). One of the most common methods for improving groundwater supplies in rural areas of Africa is drilled wells equipped with pumps (Harvey and Reed, 2004). The advantage of drilled water wells is that they are often deeper than hand-dug wells and thus less susceptible to contamination (Sworobuk et al., 1987) and seasonal changes in the groundwater table. However, roughly 30% of all boreholes with hand pumps (most common) in Africa lay in disrepair as of 2004 (Sutton, 2004). A study in Mali found that almost 90% of all

* Corresponding author. Tel.: +1 307 637 8016.
E-mail address: cwshonse@mtu.edu (C. Shonsey).

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boreholes with hand pumps failed after the first year (World Bank, 2005). One of the reasons that these pumps fail is lack of attention to available yield (Harvey, 2004). Without hydrologic data and community information, it is unclear whether drilled wells can yield water at sustainable rates to meet their needs.

When records of hydrologic data are not available to estimate the available yield of a pump, measurements should be performed locally if possible. National aggregated statistics of hydrologic conditions, when available, are better than no data, but often contain significant errors due to spatial variability. Economic and social characteristics of the population can also change rapidly over short distances, which can dramatically influence estimates of water use (Sullivan et al., 2003). Examples of hydrologic data include: precipitation, evapotranspiration, well logs, surface water flows, seasonal changes in groundwater levels, community water use, etc.

Another benefit of using locally obtained data is the opportunity to involve the local community. Collecting data in cooperation with a community can facilitate a greater awareness of water resources and the need for monitoring hydrologic data and eventually a sustainable solution to improve a community's water resources. Examples of this include: a study by Roa Garcia and Brown (2009) in the Andean Mountains of Colombia, where researchers involved youth ages 9–17 in activities that identified water needs for rural families, water availability, and influences of land-use management on water quality; a study by Crane (2007) in Benin, West Africa, where research showed that accurate water quality data could be collected by local populations and those populations could continue to collect data without external help when provided with testing equipment (Silliman, 2011); a study by Ramirez et al. (2010) in Colombia and the Congo, where participatory methods were used during the instruction of well and sand filter construction; and a study by Bodorkós and Pataki (2009) in Hungary, where participatory methods were used for bottom-up sustainable development projects.

Not only should community members be included in water development projects, but it has also been accepted globally that it is important for both women and men to contribute to design and management to increase the chances of sustainability. The inclusion of both genders was first recognized on a global scale by the 1977 United Nations Water Conference at Mar del Plata and more recently in the provisions for the "Water for Life" decade (2005–2015) established by the United Nations (UNGWTF, 2006). And if that is not enough, a study of 88 water and sanitation projects in 15 countries by van Wijk-Sijbesma and the International Water and Sanitations Center (IRC) (van Wikj-Sijbesma, 1998) concluded that projects were more sustainable and effective if both women and men were involved.

In this study of production rates for drilled wells, voids in hydrologic data were filled with technically appropriate methods performed in collaboration with local women in a small rural village in Mali, West Africa. Men in the village also provided assistance in collecting data; however, the assistance of local women was essential to conduct pumping tests and water-use interviews, which were then used in a groundwater flow model to produce detailed estimates of well production and aquifer response. The complete details (i.e., data collection and analysis, estimates of aquifer capacity) of the study are reported in Shonsey (2009). A summary of the methods and results are described herein.

2. Study area

The village of Horongo (N13°02′, W9°36′) is located in the Kayes region of Mali, West Africa, 14-km west of the city of Kita. It is the only village within the watershed under study. A personally conducted, year-long water and sanitation survey concluded that the village population was roughly 1200, of which 46% are adults and 47% are female and the main sources of water consisted of 64 hand-dug wells. A wetland, which usually forms in the rainy season in a low-lying area along the southern and western boundaries of the village, served as a secondary source of water. Fig. 1 shows the location of the village and watershed in Mali and the distribution of the wells inside and outside the village.

Detailed information about the wells was obtained from visually inspecting them (Fig. 2) and recording their location with a handheld GPS. Twenty percent of the wells were improved with a concrete surface retainer equipped with a metal door. The unimproved wells were crudely stabilized at the top with wood. Fig. 2 shows examples of an improved well (absent an access door) and an unimproved well. All the wells were thought to have varying levels of microbial contamination because of their crude construction and the behavior of the community regarding daily water extraction; however, this was never verified. During the latter part of the "dry" season, when it is also the hottest part of the year, many of these wells exhibit extremely low levels of water. The wells were approximately 3–4 m deep and nominally 1-m in diameter. Water levels in the wells varied from 0.5-m to 3.5-m below the ground surface, depending on the season.

Three seasons in Horongo have been defined based on temperature and precipitation records obtained from the meteorological station in Kita and were named using obvious descriptors to distinguish the general temperature and precipitation conditions. The rainy season spans July through October, during which an average of 800 mm of rain falls and temperatures range from 20–30 °C. The cold-dry season follows from November through February, with little or no precipitation and a temperature range of 15–35 °C. The rest of the year (March–June) is the hot-dry season, with little or no precipitation and a temperature range of 20–40 °C. Similar seasonal definitions, with variations due to geography, have been defined in a meteorological study in Southern Mali by Kanno et al. (2008).

The geology of the area was identified using data from national and regional government offices, and local observations. A geologic map of the region acquired from the *Development Industriel Direction Nationale de la Geologie et des Mines* (DIDNGM, 1982) classifies the underlying bedrock in the watershed as hematite, ferruginous siltstone and heterogranular sandstone. Sedimentary rocks such as these can store significant amounts of water (Walling, 1996) but may be non-renewable in arid regions (MacDonald and Davies, 2000). Borehole-logs, acquired from the Kita-*Direction Nationale Hydraulique du Mali* (DNH), suggest that the top of the underlying bedrock layer is approximately 5–30 m below the ground surface for areas adjacent to the Horongo watershed. According to direct observations during excavation of a hand-dug well, the top 15 m of soil above the bedrock is sandy silt loam or loamy sand. The excavated material was classified in the field using the "Guide to Soil Identification" in Davis and Lambert (2002).

3. Motivation

While serving in the US Peace Corps (USPC) in Horongo, the first author was asked by the community to help improve their water access. Through multiple village meetings, well attended by a variety of stakeholders in the village, it was concluded that a drilled well was the desired and trusted form of improvement due to examples in neighboring villages. Non-governmental organizations (NGOs) that specialized in well construction and community trainings on operation and maintenance of pumps were identified