40th WEDC International Conference, Loughborough, UK, 2017

LOCAL ACTION WITH INTERNATIONAL COOPERATION TO IMPROVE AND SUSTAIN WATER, SANITATION AND HYGIENE SERVICES

Promotion of manual drilling in Guinea Bissau: mapping suitable zones and estimating the potential

F. Fussi, F. Asplund, M. Caruba, L. Fumagalli, M.Rotiroti & T.Bonomi (Italy)

PAPER 2760

Guinea Bissau has made large strides in water supply, but still 35% of villages have no access to safe water. UNICEF is promoting alternative solutions to ensure a proper water supply in these small communities, for example manual drilling. For these reason a mapping study to identify suitable zones for these techniques has been carried out in 2016, using existing groundwater data and the experience from local experts. 88% of Guinea Bissau is considered with feasible hydrologeogical conditions for manual drilling. In 63% of the regions where this technique is applicable, it is adequate for villages of small-medium size. Taking into consideration the results of this study, it seems evident that the promotion of manual drilling could be a valid alternative to improve the situation of access to safe water especially in rural areas.

Introduction

Guinea Bissau has made large strides in water and sanitation since 2000. According MICS 2014 (http://mics.unicef.org/surveys), 75% of Guinea Bissau's total population have access to an improved drinking water source. However, the available information is often not reliable and not updated. For this reason, UNICEF has started an assessment of the situation of access to safe water in 2016. The preliminary results showed that approximately 40% of existing hand pumps are actually not functional, as well as large difference in terms of safe water supply between remote rural areas and urban.

Around 35% of the villages mainly due to difficult access and small size, do not meet eligibility criteria for borehole drilling and alternative solutions need to be explored to improve access to water. Furthermore, even in villages where the hand pump is available, the use of unimproved wells as the family's primary water source often times continues. To improve the situation for the 35% of villages without access to safe water UNICEF is promoting alternative low cost techniques, such as manual drilling. Following the methods already applied in other countries, the first step is the identification of the suitable zones in the country and estimation of the potential of manual drilling at national level.

Aim of this study

The main goal of this study is the definition of the potential for manual drilling in Guinea Bissau, identifying those zones with suitable hydrogeological conditions, providing recommendations for the implementation and estimating the potentially target population.

Furthermore, this study want to contribute to the improvement of existing groundwater data and raise the awareness concerning the potential of well organized and high quality national groundwater database.

Description of the study area

Guinea Bissau is located in West Africa (Fig.1), with a total area of 36,120 square km and a population estimated in 2014 of 1,693,398. The capital is Bissau, located in the western part, with a population of almost half a million. Other important towns are Bafata' and Gabu', in the eastern part, with a population of less than 50,000 (Fig.2).

Guinea-Bissau has a hot, humid, typically tropical climate, with a rainy season that lasts from mid-May to mid-November and a cooler dry season occupying the rest of the year. The average temperature in the rainy season ranges from 26–28°. Rainfall generally exceeds 198 cm (78 in), but droughts occurred in 1977, 1979, 1980, and 1983. The rainiest months are July and August.

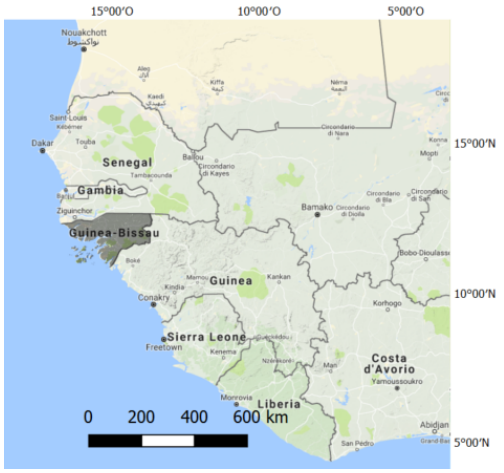

Figure 1. Position of Guinea Bissau

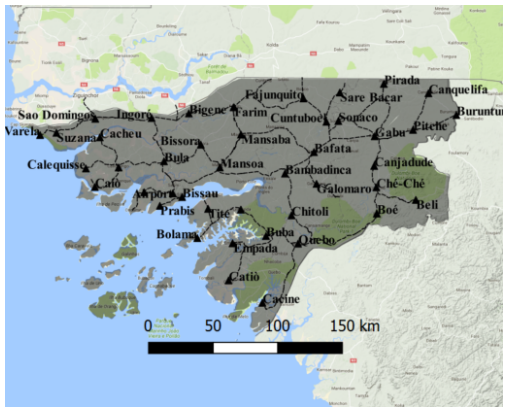

Figure 2. Guinea Bissau

Geology of Guinea Bissau is characterized by a division in two main sectors: the western part of the country is covered by Mesozoic and Cenozoic sedimentary rocks (including quaternary unconsolidated sediments), while the eastern part is formed by crystalline Paleozoic rocks. On top of these two main geological groups there is a continuous layer (Continental terminal) of mio-Pliocene sediments, composed by a 20-30 m thick sequence of sands, clay and loam. It is also relevant the presence of lateritic shallow hard layers discontinuously present across the whole country

Morphology of the country is generally flat or gently undulated. In the western part there are extended swampy areas surrounding water channels having an important effect in depth of water and salinity. The eastern part is occupied by a central plateau: The highest point (300 m) is located in the north-eastern part.

Data and methods

Source of information

The main source of information has been the existing database of water points. In details:

- A database of water points obtained from DGRH (5366 water points, from which a dataset of 4418 records are georeferenced and considered in GIS analysis). These data were used to analyze the general distribution of water points, their type, static water level and water quality parameters.
- A data set of 472 stratigraphic logs from mechanized boreholes (after cleaning and eliminating duplicated water points) was obtained through manual input from hard copy data by DGRH and UNICEF staff. Part of the information was extracted by existing hydrogeological data stored in ACTIF software at DGRH. This information was later integrated with 43 stratigraphic logs from manual drilled wells, producing a dataset of 491 logs georeferenced and available for GIS analysis. These data allowed the interpretation of lithological and textural characteristics of subsurface geological layers.

The geological map Guinea Bissau published by LNEG (Laboratório Nacional de Energia e Geologia, Portugal) has been taken as reference for this study, although other maps and geological studies have been consulted.

The qualitative experience of local hydrogeologists and water technicians resulted highly relevant to define the criteria for the interpretation of systematized data (like geological maps and water point data) and validate the results of this process. This source of information was obtained mainly through specific meetings during the field missions. In particular meetings were held with groups of local technicians in hand dug wells construction in Gabu and Bafata, with the team of the school for hand dug well technicians in Sao Domingo ("Escola de poceiros") and with hydrogeologists in Bissau from DGRH and different ngos. During

these meeting the discussion was focused on the characteristics of shallow geological layers in different zones of the country and the technical solution to break hard laterite.

Methods of interpretation

Suitability for manual drilling takes into consideration two main aspects:

- Feasibility – it is considered the possibility to drill a hole using manual drilling techniques and reach an exploitable saturated aquifer (i.e. within the range of depth achievable with manual drilling). It is related to depth of water and depth of hard rock;
- Potential – it means an indirect and qualitative estimation of potential yield that can be obtained from a manual drilled well in a specific area and consequently the size of population that can use it. It is related to thickness and texture of potential aquifers (in particular saturated layers constituted by coarse sediments, i.e. sand and gravel).

Hydrogeological data processing has been carried out using the method tested in the framework of the UPGRO project "Use of remote sensing and terrain modelling to identify suitable zones for manual drilling in Africa and support low cost water supply (Fussi, 2015). This method is based on the following steps:

1. The extraction of hydrogeological parameters from borehole logs through a semi-quantitative procedure (codification of stratigraphic description and extraction of textural characteristics at regular depth intervals). With this method the depth of water, depth of hard rock, thickness of coarse layers and thickness of hard lateritic layers have been obtained.
2. The combination of these hydrogeological parameters to assign a class of feasibility, potential and presence of laterite at borehole logs position. Class of feasibility was obtained from the thickness of exploitable layer (i.e. the difference between depth of water and depth of hard rock, with a maximum exploitable depth of 50 m): not feasible for saturated thickness less than 3 m and fully feasible for saturated thickness more than 10 m. Class of potential was assigned on the basis of thickness of layers with percentage of coarse fraction higher than 50%: no potential when there is no layer with this condition, excellent potential when these layers are thicker than 10 m, moderate or good potential when coarse layers have a total thickness between 0 and 10m.
3. The extrapolation to the whole territory through a geographic overlay of point classification of feasibility and potential with spatial units obtained from the intersection of Geological groups (derived from a grouping process of units from the geological map) and morphological/environmental units (obtained from a manual segmentation of the territory based on predominant landform, as observed on the digital elevation model). Each spatial unit has a specific combination of geology and morphology and it is expected to have similar shallow geological conditions in the whole area covered.

Results

In the whole territory of Guinea Bissau 88% is considered with feasible hydrologeogical conditions for manual drilling (fig.3); in 60% of the country manual drilling is considered potentially feasible to provide safe water to 75% or more of the population living there. Those areas where manual drilling is considered not feasible are concentrated in the eastern and southern part and are little populated.

Concerning the potential yield and size of village that could be supplied using hand drilled wells, in 63% of the regions where this technique is applicable, it is adequate for villages of small-medium size (more than 50 inhabitants). In the remaining feasible areas, manual drilling can be a solution only for water point used by one or few families.

North-East of the country (Sao Domingo, Bige, Cacheu) is considered the best region to develop manual drilling; here this technique is already applied at limited scale but it could be expanded. In other sectors (Chitoli, Buba, Empada) the implementation of manual drilling could give extremely positive results, although at the moment is almost not applied.

The southern coastal area is covered by unconsolidated sediments that make manual drilling feasible, but the predominance of clay could be a limiting factor in terms of potential yield, Therefore in this area it could be possible to supply only small group of families.

Another aspect to consider is salinity. Manual drilling could provide a protected water source with limited depth; in this sense it could give an interesting solution to decrease the risk of salt intrusion (as frequently observed in deep wells) and the risk of contamination with surface pollutants (typical of traditional unimproved hand dug wells). Salinity is a major factor to consider in the development of water supply especially in the coastal regions of Nhiacra, Bissora and Sao Domingo.

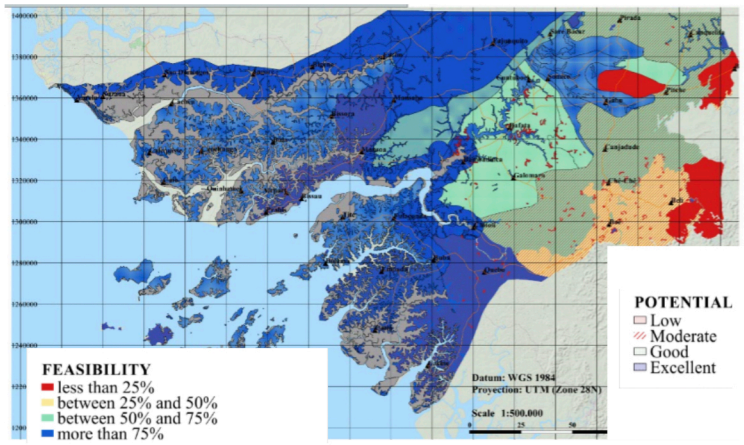

Figure 3. Map of suitability for manual drilling

Conclusion

The present study shows that manual drilling is a valid low cost option that can help Guinea Bissau to cope with some of the major problems concerning access to safe water. In particular to supply water to small communities which are difficult to access and with small population. Such communities are generally excluded from mechanized drilling because this solution is very expensive relative to the population size.
Since manual drilling is still new in Guinea Bissau, it is difficult to estimate the average cost. To date, hand drilled wells in Guinea Conakry cost between 980 and 2300 euros (without pump), which is much cheaper then mechanically drilled boreholes.
Two aspects are considered important for adequate promotion of manual drilling in Guinea Bissau:

- Skills in manufacture of drilling tools and drilling and well completion are required. There is need for a training program to be developed and run.
- Giving that the hand pump is currently particularly expensive and pump failure is a major problem in the country, the introduction of a simple less expensive pumping equipment, which is easy to repair, is important for scaling up manual drilling and improving the sustainability of water supply.

In the last decade manual drilling raises more and more interest in West Africa; some countries have already developed positive experience in the different aspects (e.g. Guinea Conakry and Chad) and international agencies are funding large programs. In this sense, DRGH and UNICEF can work together in Guinea Bissau, taking the best practices already applied in other countries and adapting to their context. The impact in terms of living conditions and improvement on access to safe water could be huge.

Acknowledgements

The authors would like to extend thanks to the staff of DGRH (Direccao Geral do Recursos Hidricos) and UNICEF in Guinea Bissau, who collaborated in the data collection and organization. He also wants to thanks Paulo Hagendorn from LNEG (Lisboa) who provided useful advises and information concerning the availability of geological data.

References

FUSSI, F. & al. 2014: *Estimation of suitability for manual drilling in Northern Senegal from textural and hydraulic parameters of shallow aquifers*. 37th WEDC International Conference, Hanoi, Vietnam

FUSSI, F. 2015 *Integration of hydrogeological investigation, remote sensing and terrain modeling for the analysis of shallow aquifers in West Africa and the identification of suitable zones for manual drilling*. PhD Thesis, University Milano Bicocca

LNEG - DGGM. Lisboa 2011. *Carta Geológica da República da Guiné-Bissau, escala 1:400.000*.

UNICEF – GUINEA BISSAU COUNTRY OFFICE. Water, Sanitation, Hygiene. Internal brief report

Contact details

Fabio Fussi is public health engineer, hydrogeologist and GIS expert. He has been working in international cooperation programs with different ngos and UN agencies. Since 2008 he has carried out mapping of suitable zones for manual drilling in 15 countries with UNICEF: Between 2012 and 2015 he coordinated the UPGRO research program concerning use of remote sensing and terrain modelling for the identification of suitable zones for manual drilling (joint program between Italy, Senegal and Guinea).

Fabio Fussi
Email: Fabio.fussi@usa.net

Fredrik Asplund
Email: fasplund@unicef.org

F. Fussi*, F. Asplund**, M. Caruba,
L. Fumagalli*, M.Rotiroti*, T.Bonomi*

*University Milano Bicocca – Italy
** UNICEF Guinea Bissau