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Preliminary results from a Water Economy and Livelihoods Survey (WELS) in Nigeria and Mali, sub-Saharan Africa: Investigating water security across a rainfall transect

Groundwater Science Programme

Open Report OR/11/018

BRITISH GEOLOGICAL SURVEY

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Groundwater, West Africa, Water security, Water Stress.

Front cover

Queuing at a hand pump in Zamfara State, Northern Nigeria [Lapworth D J 2010].

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Foreword

In 2010 the Department for International Development (DFID) commissioned a BGS-led team to undertake a one-year study aimed to improve understanding of the resilience of groundwater in Africa to climate change and links to livelihoods. As part of this project, the research team undertook hydrogeological field studies in West and East Africa, examined the linkages between water use and household economy, and developed an aquifer resilience map for Africa using existing hydrogeological maps and data. This is one of a series of technical notes which describes the studies carried out by the research team as part of this project.

This report describes the methodology and preliminary results from a simplified water, economy and livelihoods survey (WELS) carried out in West Africa at the same time as a groundwater residence survey (which is reported separately). Results from community discussions are presented for four case study areas in a transect across humid to semi arid conditions in Nigeria and Mali.

Acknowledgments

The Project Steering Group, for their general comments and helpful insight with this work – Guy Howard (DFID); Stephen Foster (GWMATE); Mike Edmunds (UoOx); Declan Conway (UAE); Richard Carter (WaterAid); Vincent Casey (WaterAid); Richard Harding (CEH) and Tamiru Abiye (Univeristy of Witwatersrand, Johannesburg).

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Nigeria fieldwork

Nigeria Geological Survey, for logistical support and field assistants in Nigeria

Mali fieldwork

Vinny Casey and Richard Carter, WaterAid London, for facilitating Mali case study work.

Adama Sanogo and others of WaterAid Mali for providing invaluable support in Mali.

Local Partners for local logistical support within Mali: GAAS (Bandigara), ARAFD (Koro), and ADDA (transport).

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ABBREVIATIONS

ADDA – Association for Sustainable Development in Africa

ARAFD – Association de Recherche-Action Femmes et Développement

GAAS – Groupe d'Animation Action au Sahel

DFID – Department for International Development (UK)

GWMATE – Groundwater Management Advisory Team (World Bank)

WELS – Water Economy and Livelihoods Survey

ANOVA – Analysis of Variance

NGSA – Nigerian Geological Survey Agency

NGN – Nigerian Naira (currency)

NGO – Non-governmental Organisation

UNICEF – United Nations Children’s Fund

CFA – Central African Franc

1 Introduction

A large proportion (47%) of people in sub-Saharan Africa live without access to safe water sources in rural areas (JMP, 2008). The need for sustainable development and management of water resources, particularly groundwater resources, remains a major priority, especially within the context of climate variability, population growth and pressures to increase food production (UN, 2000, Vörösmarty et al., 2000, JMP, 2008, MacDonald and Calow, 2010). In stark contrast to food scarcity, to date little systematic data collection has been done to investigate the role water scarcity has on livelihoods within rural communities in sub-Saharan Africa, particularly during droughts or periods of water stress (Calow et al., 2009).

A water, livelihoods and economy survey in West Africa was conducted as part of a one year DFID-funded research programme, aimed at improving understanding of the impacts of climate change on groundwater resources and local livelihoods http://www.bgs.ac.uk/GWResilience/. The main purpose of this survey was to investigate the access to and domestic use of a range of water sources (hand pumps, wells, springs, surface water sources and rainwater harvesting) within rural communities across a rainfall transect in sub-Saharan Africa. The seasonal water use and scarcity/stress patterns were investigated for rural communities, located on both sedimentary and basement settings, using community discussions and questionnaires based on a scaled down version of the WELS methodology (Coulter, 2010). Plate 1 shows a WEL survey being carried out in the Minna study area, central Nigeria.

The aim of this study is to investigate seasonal access to water supplies, by gathering information on the time taken to collect water, the different sources available at different times of year (wet and dry season) and the geological and hydrogeological conditions at each community. The hypothesis is that having a greater number of groundwater dependent water supplies in a community increases overall security of water access and reduces the time taken to collect water in the dry season. A secondary aim was to test whether a slimmed down WELS methodology based on that described by Coulter and Calow (2011) can be effectively applied to give useful information, Plate 1 shows a WEL survey being undertaken in Nigeria.

Plate 1 A WEL survey in the Minna study area, Niger State, Central Nigeria.

1.1 LINKS TO OTHER PROJECT COMPONENTS

This work is related to three of the main project tasks:

Case Study 1: assessing the mean residence times (MRT) of groundwater in shallow basement and sedimentary aquifers across different climate zones in Nigeria and Mali.

Case Study 2: the occurrence and sustainability of high yielding boreholes from crystalline basement aquifers in Tanzania and Uganda.

Case Study 3: WELS analysis Ethiopia – investigating water access and wealth

1.2 PARTNERS

Nigeria

Dr Tijani: Associate Professor, University of Ibadan, Nigeria – Groundwater sampling

Nigerian Geological Survey Agency – logistic support and field assistants in Nigeria

Mali

WaterAid: help with coordinating logistical support in Mali

GAAS – Mali: local logistical support in Mali

ARAFD – Mali: local logistical support in Mali

ADDA – Mali: provision of transport in Mali

1.3 STUDY AREAS

The community surveys were carried out across a climate transect, from a wet climate in southern Nigeria, to a semi-arid climate within central Mali. Surveys were only carried out in rural communities which relied on hand pumps and wells completed in shallow aquifers (<50 metres below ground) as perennial sources of water for domestic purposes (e.g. drinking, cooking, cleaning and washing). The study was carried out in rural locations where recharge is thought to be large compared to abstraction, so the survey results reflect unstressed aquifers.

Figure 1 shows the location of the case study areas across Nigeria (Abeokuta, Minna and Gusau) and Mali (Bandigara). These areas were chosen because they reflect four distinct climate zones (in terms of annual rainfall), and had suitable sample sites in both basement and sedimentary aquifers.

In the Nigeria case study the basement rock is comprised of gneisses and metasediments as well as other minor metamorphic lithologies. The sedimentary sandstone is of Cretaceous age in all three Nigerian case studies. The three Nigerian case studies had average annual rainfall of between 1800–2000 mm, 1200–1500 mm and 700–850 mm respectively.

Within the Mali case study the basement aquifer comprised fractured Precambrian Sandstone, whilst unconsolidated Tertiary Continental Terminal sand and gravel formations comprised the sedimentary aquifer. The Mali field area was the most arid sampled with an estimated annual rainfall of 350–400 mm. Table 1 summarises the climate, population and livelihoods from each study area.

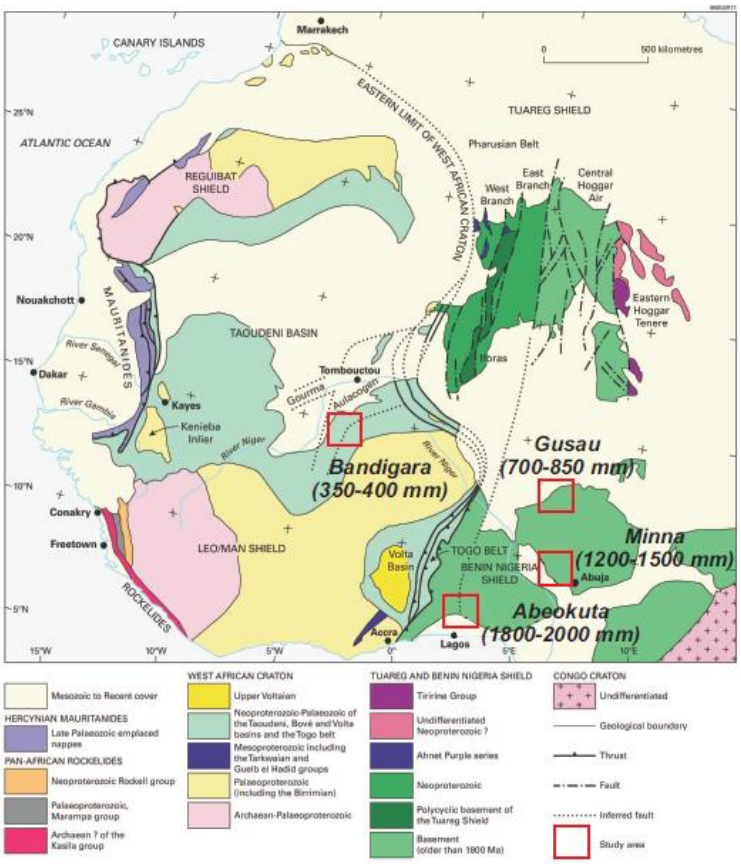

Figure 1 Location of study areas on rainfall transect

Table 1 Summary population and livelihood data from WELS surveys

Climate zone (Peel *et al.*, 2007)	**Country and region**	**Length of dry season**	**Average (range) village population**	**Av increase in village population, last 5 years**	**Main livelihood activity**	**Main source of income**
Equatorial Monsoon (1800-2000mm/yr	NIGERIA, Abeokuta	3-4 months (Oct-Jan)	2300 (200-5000)	34%	Arable farming	Cash crops: Cassava, maize, yams
Equatorial savannah (1200-1500mm/yr)	NIGERIA Minna	7-8 months (Sep-May)	1100 (100-2000)	40%	Arable farming	Cash crops: Tomatoes, peppers, maize
Arid Steppe (700-850 mm/yr)	NIGERIA, Gusau	7-8 months (Sep-May)	2300 (500-5000)	36%	Arable farming and livestock	Cash crops: Cotton, maize, tomatoes Livestock: Cows and goats
Arid desert (350-400mm/yr)	MALI, Bandigara	9 months (Aug-Jun)	2000 (420-7000)	14%	Arable farming and livestock	Cash crops: Onions, tomatoes, peppers Livestock: Cows and goats

2 Collection of Information on Water Access and Basic Socio-Economic Data for Each Site

The surveys were carried out in small (average population of <3000) rural communities within each climate zone and geology type. A total of 57 communities participated in the survey. Summary results were reported previously in Lapworth *et al.* (2010). Each village visited had a functional borehole equipped with a hand pump and other water sources such as wells (see Plate 2).

A slimmed down WELS approach (see Coulter and Calow, 2011), was applied systematically at each location. This methodology involved both wellhead discussions and community discussions with village representatives chosen by the village head. The following information was gathered:

- Basic information about village size, activities, and growth;
- Information on the most productive activities;
- Detailed information on: the number and type of water sources in a village, seasonal water collection times, use of the different water sources at different times of the year, and when each source is operational;
- Information on the borehole construction and functionality.

Comparison of answers to the same questions from wellhead and community discussions were used to assess the quality of the WELS data collected in each village. Where possible the community discussions involved a range of community members (both old and young, male and female) to ensure a range of users, across wealth and gender groups, were interviewed.

Example questionnaires are in Appendix A. A detailed summary from the questionnaires was completed for each community and are in Appendix B. The WELS questionnaires were carried out by BGS staff (Dr Alan MacDonald, Dan Lapworth and Helen Bonsor) and Dr M Tijani (University of Ibadan, Nigeria). The Nigeria surveys were carried out between 13th – 23rd April 2010; Mali surveys were carried out between18th–23rd August 2010.

Dr Adama (Bamako University) and local partners (GAAS and ARAFD) helped with translation (French to local languages – e.g. Mande, Dogon) for the surveys carried out in Mali. Dr Tijani and other NGSA staff helped with translation to Yoruba in southern Nigeria, a local counterpart from the NGSA helped with translation into Hausa in northern Nigeria. In total, discussions in each village lasted around 1 hour (in part due to translation efforts).

3 Data Analysis

Prior to carrying out analysis of the WELS data an evaluation of the quality of each survey was made and each questionnaire scored (1=very good, 2 = good, 3 = poor), based on the quantity and quality of the responses and consistency of answers from interviewees. Only those responses which were thought to have good quality results (ranked 1 or 2) were then used in the following sections. Of the 57 communities surveyed in this study only 46 surveys fulfilled the quality criteria and were used in subsequent sections.

Analysis of variance (ANOVA) was used to test for significant differences in mean access to hand pumps and wells (round-trip collection time was used as a measure of access) in the dry and wet season using two explanatory factors; i) along the transect (i.e. climate zone) and ii) aquifer geology, with two levels (sedimentary and basement geology). Prior to carrying out the

ANOVA analysis, outliers in the data were removed and homogeneity of variances was established (e.g. Fligner-Killeen test), and data was log transformed. Box-plots, bar graphs and cumulative probability plots were used to explore the data graphically. All data analysis was carried out using the open source statistical package R.

4 Summary observations from each study area

Figures 2-4 show graphical summaries of the average domestic water access profile for each area study area, and highlight the importance of different sources of water in both the wet and dry seasons and periods of water stress. Plate 2 shows a typical shallow hand dug well found across much of rural West Africa.

Plate 2 Water use for domestic purposes from a shallow hand-dug well in central Nigeria

4.1 NIGERIA

4.1.1 Abeokuta case study

The settlements in this area are quite large with an average population of 3000 for sampling sites although many boreholes are also located in larger towns (>20,000) that were not suitable for sampling, due to possible contamination, or for the WELs survey as they were generally privately owned. Across the sedimentary aquifer in this rainfall zone, there are a high proportion of large diameter hand dug wells fitted with submersible pumps suggesting that water accessibility and electricity supply are less restricted than other parts of Nigeria. Several of the boreholes sampled also had dedicated generators that were funded locally. There has been a significant increase (20-50%) in the population of most settlements in the Abeokuta region the last 5-10 years. This is reported to have put pressure on the local infrastructure, including water resources, but has also been a valuable source of labour. Figure 2 summarises the changes in water use and access for the Abeokuta case study area based on WELS data for both the dry and wet season. The plot does not aim to show temporal changes, which will vary considerable, but simply represents average values for the two contrasting seasons. The increased reliance on mechanised and hand pumps during the dry season is shown.

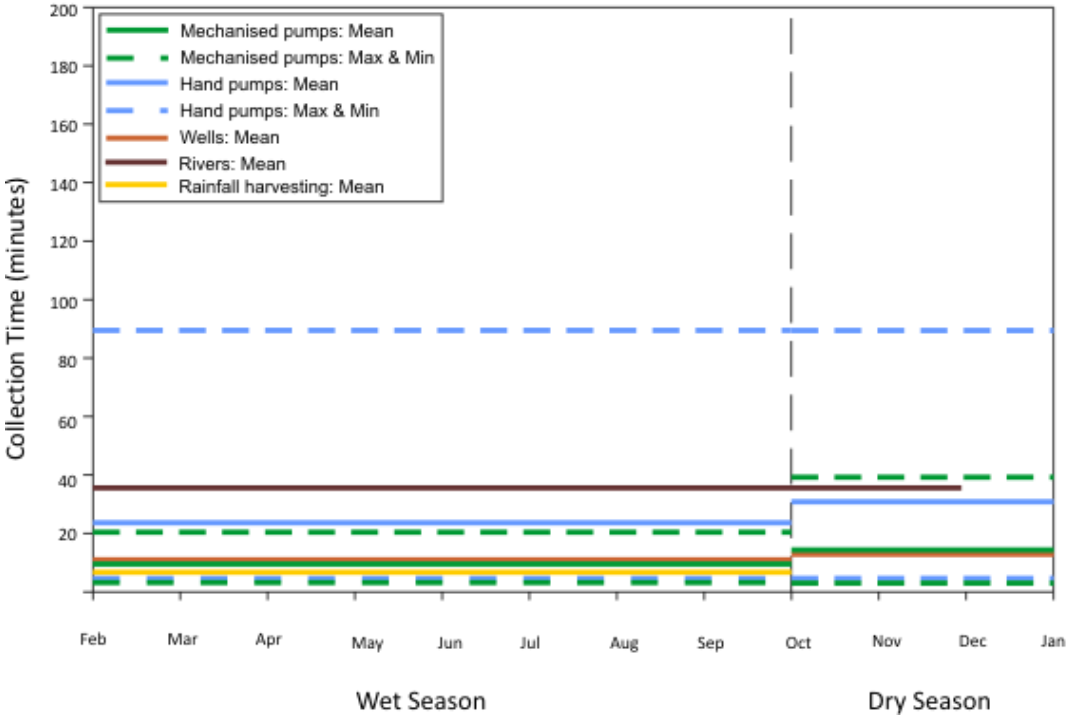

Figure 2 Changes in average water collection times and water sources in the wet and dry season for the Abeokuta case study, Nigeria.

Groundwater is an important source of water for processing farm products, e.g. maize, cassava in the Abeokuta region. This is an important source of income for the rural community and adds significant value to the farm products. Settlement sizes are on the whole larger across the sedimentary aquifer (>5000) than on the basement aquifer (<1000). However, the time taken to collect water was less than 30 minutes at >90% of sites irrespective of aquifer or settlement size. Groundwater was generally not used for livestock in this area due to the plentiful supply of alternative sources. Water quality problems (fine silts/ cloudy water) are only encountered at a small proportion of the sites visited (10%) and this was usually after heavy rain. Pump use was rationed in only a small proportion of sites (<10%) to manage demand and minimise waiting times. In one case the water committee charge up to 5 NGN for 3 basins (approx. $ 0.03), and used this money to maintain and service the pump and borehole.

River water is also an important source throughout the year, as was rainfall harvesting, especially for less wealthy villages. Most villages have zinc roofs in this area making rainfall harvesting possible. The overall standard of living was quite high compared to the other case study areas, the availability of electricity was higher and there was a much higher proportion of mechanised boreholes. While boreholes are the dominant source of groundwater in the basement aquifer, large diameter hand dug wells were common in the sedimentary aquifer. Plates 3 and 4 show a village water supply from a mechanised borehole (see series of taps fed by a header tank), and a typical shallow borehole hand pump, hard standing and spill way in rural Nigeria.

Plate 3 Village water supply from mechanised borehole in Abeokuta study area.

Plate 4 Rural village hand pump in the Abeokuta study area (basement geology).

4.1.2 Minna case study

Of the three case studies in Nigeria this area had on average the lowest settlement population (c. 1000 people). The main source of income in this seasonally wet rainfall area is from selling cash crops (e.g. tomatoes, pepper, maize, yam, potatoes in some places). The settlements surveyed had smaller livestock holdings compared to the Gusau case study, mainly goats rather than cows, and borehole water was not usually used as a water supply for livestock. Figure 3 summarises the changes in water use and access between the wet and dry season for the Minna case study area based on WELS data.

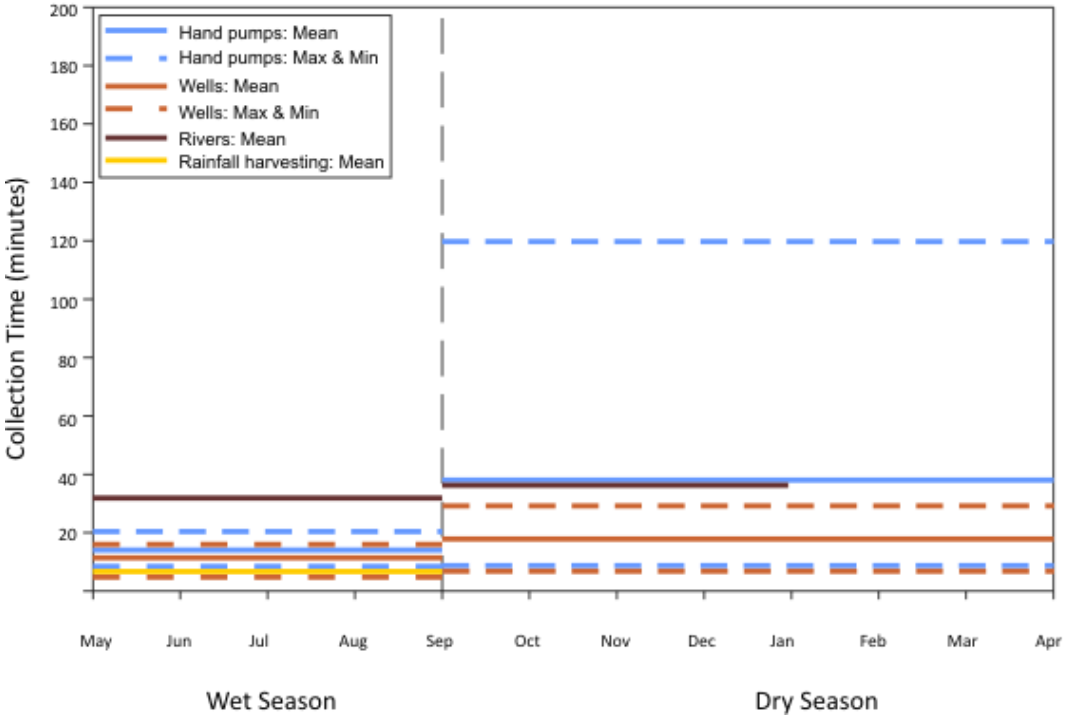

Figure 3 Changes in average water collection times and water sources in the wet and dry season for the Minna case study, Nigeria.

As with the other Nigerian case studies the population had reportedly increased in the last 5-10 years (20-50%) putting added pressure on the water resources. Collection times for water from hand pumps are greater than 30 minutes for more than half of locations in the dry season (November-April). All boreholes were used for drinking, washing and cooking all year, with a third of them also being used as sources of water for livestock during the dry season. A decline in yield was found to be an issue at 20% of sites during the dry season; there being a much larger demand on hand pumps in the dry season compared to the wet season. Survey results indicate that boreholes met demand in the dry season for only half the settlements that were visited, this was the case for both the basement and sedimentary aquifers. At around half of the site visited rationing is required during the dry season to manage demand. Boreholes in most of the villages visited are managed by a water committee, which organises rationing of water supplies, as well as the collection of donations if repair work needs to be carried out on the borehole. However, users of the hand pumps were not charged for collecting water. The boreholes and hand pumps in this area were for the most part donated by NGO's (between 3-10 years old), some were also funded by local government.

River water is an important source of water during the wet season (April/May – October) in the Minna area, and it is not uncommon for villages to still use river water for drinking during this period. Hand dug wells are also an important source of water during the wet season, but were not fitted with mechanised pumps as was the case in the Abeokuta area further south. Rainwater harvesting is used during the wet season across the Minna area, and large containers are used to store rainwater for later use to supplement the groundwater sources for drinking, cooking and washing. Early rains in 2010 had an impact on the quality of shallow groundwater (fine silts/muddy water) at half of the sampled sites in this study area.

Plate 5 Carrying out a WEL survey in the Minna study area.

4.1.3 Gusau case study

The settlements in this area are mixed arable and livestock farmers, in contrast to the other two areas in Nigeria which were dominantly arable farmers. The populations of the settlements sampled were of a comparable size to those in the Abeokuta case study with an average population of 2000. As with the other two areas in Nigeria there had been a reported marked increase in population during the last 5–10 years with villages almost doubling in size during this period. The main sources of income for this region is from selling livestock and cash crops e.g. cotton, corn, tomatoes and potatoes. In a few cases seasonal work was obtained in nearby towns during the dry season. There was a seasonal migration back to the rural areas during the farming season (June-September).

This is the driest of the three areas in Nigeria and there was a heavy reliance on groundwater sources, especially during the dry season (approx. October – June). Within the sedimentary aquifer in Gusau, hand dug wells were a very important source of water, and in several places are the main source, with yields generally being sufficient. Figure 4 summarises the changes in water use and access between the wet and dry season for the Gusau case study area based on WELS data.

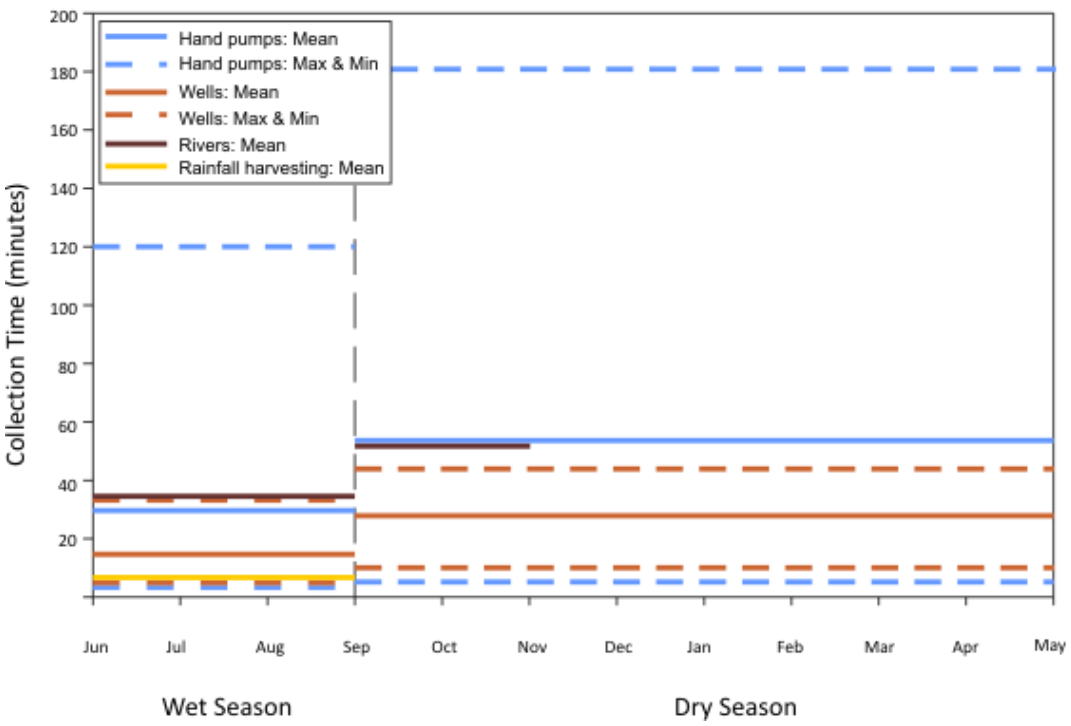

Figure 4 Changes in average water collection times and water sources in the wet and dry season for the Gusau case study, Nigeria.

Hand pumps have been used as an important source of water in this area for some time, particularly in the basement aquifer. Many of the boreholes sampled had been recently installed by NGO's (e.g UNICEF) and training had also been provided during the installation on borehole maintenance. A large proportion of the boreholes were managed by a water committee (>60%), and no contribution was required to use the hand pump. In most cases the hand pumps are used for livestock as well as drinking, cooking and washing. The time taken to collect water from the hand pumps is usually more than 30 minutes and in extreme cases up to 3 hours in the dry season. Borehole yields are usually stable throughout the year and met demand for around 70% of sites in this survey. Rationing is not common; it only happened at one site in this survey. No significant water quality problems were reported from the boreholes sampled, as a result of infiltrating fines during the early rains.

Groundwater is becoming an increasingly important source of water for irrigation in Zamfara and Sokoto in the Gusau region, on both a large scale (government/private run paddy rice and maize farms) as well as on a smaller scale for farming beans and vegetables. There is a large dam which is also used for irrigation in the Gusau area. A private scheme to irrigate using sprinklers from >20 high yielding (>10L/s) boreholes (for maize crops) is planned for the region with thee working boreholes and sprinklers. This is a government contract with technical support from USA, and there are other similar local schemes in this area. Plate 6 shows the very long queues that are not uncommon in moderately large settlements in Northern Nigeria in the dry season.

While this study focussed on small scale abstraction using hand pumps and wells there are a few sites in this study area where larger scale abstraction was encountered for irrigation purposes. This is clearly unsustainable in the long term as it is effectively mining groundwater, and could in time lead to reduced accessibility to drinking water from shallow, affordable groundwater sources.

Plate 6 Queuing for water in Zamfara State, Northern Nigeria

4.2 MALI

The Mali case studies represents the driest part of the WELs transect. Mean annual rainfall in the Bandigara and Koro area of central Mali (similar latitude to Mopti) is around 350-400 mm/yr. Two aquifer types – one basement, one sedimentary - were sampled: the sedimentary aquifer was surveyed in the Koro area, and the basement aquifer was sampled in the Bandigara area. Bandigara and Koro areas surveyed are geographically close to each other, and are treated as one case study area in the sampling transect. Figure 5 summarises the changes in water use and access between the wet and dry season for the Bandigara-Koro case study area based on WELS data. The following section details the observations from the basement and sedimentary areas that were surveyed as part of this study.

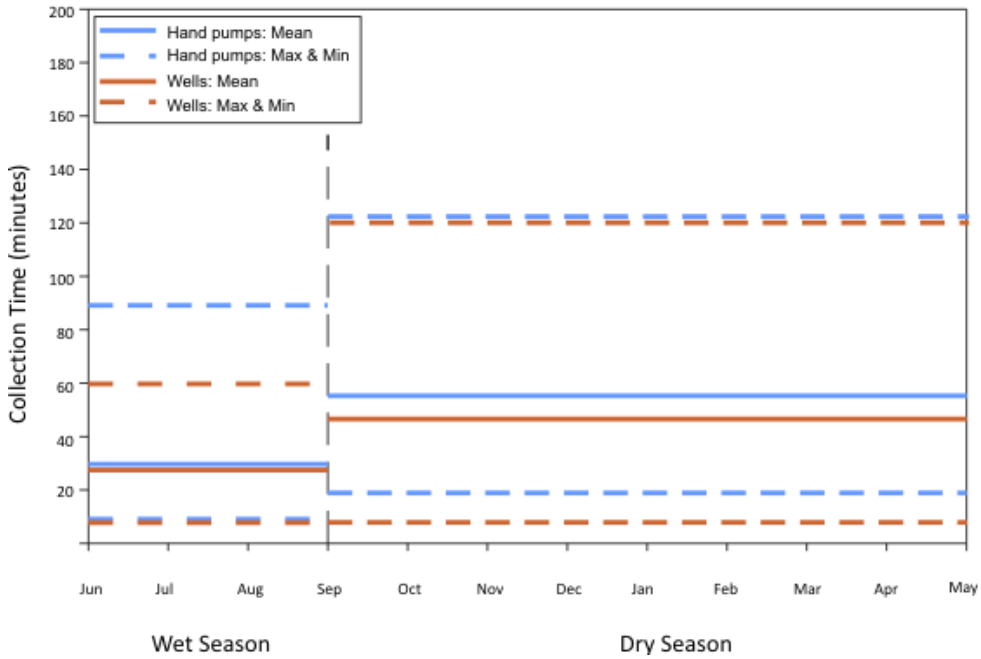

Figure 5 Changes in average water collection times and water sources in the wet and dry season for the Bandigara-Koro case study, Mali.

KORO CASE STUDY (SEDIMENTARY AQUIFER)

The Koro area has, on average, smaller settlement populations (1400) and fewer villages, than the basement aquifer area around Bandigara. The Koro area is relatively sparsely populated, with significant distances (several to tens of kilometres) between villages. The settlements were arable farming comminities, with most having a subsistence existence. Annual food shortages occur throughout August, in between the two harvest seasons. For most villages the main source of income remains the sale of cash crops in the wet season (e.g. onions, peanuts, beans, sesame seeds), when there is surplus. Income was therefore reliant on rainfall, and most villages have seen a decrease in yields over the last five years, as a result of declining rainfall and a shortened wet season. However, within the same period village populations grew by approximately 12%, which has placed a higher demand on food, and water resources.

The semi-arid climate and absence of surface water resources, means communities in the Koro area are heavily reliant on groundwater for all water year-round. Large diameter hand dug wells are the main sources to groundwater across the sedimentary aquifer in the region, and for most villages these were the only water source; very few villages in the area had a borehole/hand pump. The deepest large diameter wells (40–60m below ground level) within villages were generally of sufficient yield to meet demand year-round. Hand dug wells which are less than 20 m deep, generally failed by the middle of the dry season. None of the large diameter wells seen within the region were fitted with a mechanised pump.

Functional boreholes were a relatively new within this area, and half of the boreholes sampled were installed within the last 2–3 years by NGO's (e.g. UNICEF). Training had been provided on maintenance and good hygiene practice during installation of the boreholes, and most villages were able to carry out routine maintenance and minor repair work. The villages still relied on external assistance for major mechanical repairs. The mechanical functionality of the hand pumps sampled was generally very good, with most only failing once a year, or once every two years. All boreholes sampled were managed by a water committee.

Borehole yields are usually stable throughout the year, and met demand. Rationing did not occur at any of the sites, but the hand pumps could only be used at morning and night and some (40%) villages charged for use of the borehole (50 CFA/20 L bucket). A decline in yield was found to be an issue at 30 % of the sites during the dry season, and survey results indicate that within half the villages, the drinking water demand in the dry season was only met by people increasing the use of hand dug wells as a secondary drinking water source/people using less water. No villages had storage containers to increase the storage capacity of the groundwater sources, - perhaps in part reflecting the lack of development work so far conducted within the area, rather than hydrogeology.

The time taken to collect water from the hand pumps is reported to be between 30 minutes to 1 hour in the dry season, but in extreme cases people have been known to queue overnight. Most of the boreholes sampled are community boreholes, only used by the immediate village, and therefore distances travelled to the collect the water are rarely over 500 m in the region. Some villages reported deterioration (discolouration) of groundwater quality from the hand pumps towards the end of the dry season when the water-levels dropped.

Water from the hand pumps are the most important source of drinking water in the villages visited – however, even in these villages there is still a heavy reliance on traditional hand dug wells as a secondary water source.

There are very few rivers within the Koro plain region, and seasonal ponds are the only form of surface water resource. Within the wet season, surface ponds form an important source of water for washing, livestock and brick construction. Rainfall harvesting is very rare within the region, due to the lack of metal roofs. None of the villages have electricity and the overall standard of living was quite low. Plate 7 shows a rural settlement within the centre of the sedimentary aquifer on the Koro plain.

Plate 7 Rural Mali – Central Gondo plain, Koro – typical community hand pump supply in the sedimentary aquifer.

BANDIGARA CASE STUDY (BASEMENT AQUIFER)

The populations of the settlements sampled within this region are generally larger than on the sedimentary aquifer in Koro, with an average population of 2600. The area is still, however, relatively sparsely populated, with significant distances (several kilometres) between villages on the Precambrian basement plateau. The settlements are again mainly subsistence arable farming communities. Food shortages reportedly occur for a longer periods than in the Koro region, with villages reporting hunger throughout August and September, in some cases it was suggested that this was a direct result of changes in rainfall in this region over several decades. The main source of income in the area are cash crop sales (e.g. onions, tomatoes, peppers), when surplus exists during the wet season, and the sale of livestock. Most villages had seen an increase in income over the last five years in this region, due to higher market prices and demand for produce. Tourism within the area does not seem to have brought significant increased income to the rural villages surveyed. Village populations in the region have increased significantly in the last 5 years with most communities reporting a 16% increase in size.

Despite the presence of some seasonal rivers and streams upon the Basement plateau, the region is still heavily reliant on groundwater sources, particularly during the dry season. As in the sedimentary aquifer around Koro, large diameter hand dug wells form the main groundwater sources for most villages, and were the only water source for some villages. Hand-dug wells in the basement aquifer are generally shallower (<20 m below ground level) than in the sedimentary aquifer, and have slightly larger seasonal water table fluctuations (5–15 m), than the wells within the Tertiary sedimentary aquifer at Koro. However, the hand dug wells were usually of sufficient yield to meet demand year-round in villages. The success of the hand dug wells was very localised –adjacent wells within metres of each other, could have very different yields. Water quality from the wells was variable with many villages reporting a deterioration of water quality in the dry season as a result of dust blowing into the uncovered large diameter wells, and incidences of guinea worm when the water-level dropped – although the sources of the guinea worms reported are likely from surface water sources. To mitigate these issues several villages filtered water from shallow hand dug wells in the dry season.

Plate 8 WEL survey and groundwater sampling at a hand pump within the basement aquifer on the Bandigara plateau.

In contrast to the Koro region, boreholes had been used as an important source of water within the basement aquifer for some time (>10 years). Most of the boreholes sampled had been donated and installed 14–15 years ago by the Japanese International Cooperation Agency (JICA). All boreholes sampled were managed by a water committee, who organised the collection of donations if repair work was required. Rationing or charging did not occur at any of the villages visited, and hand pumps were used on a first come, first served, basis. Most villages required external assistance with all but very minor repair work to the hand pumps. Plate 8 shows a typical hand pump within the basement aquifer, near Bandigara.

In most of the villages visited borehole yields showed a slight decline towards the end of the dry season, but most (60%) met demand. Very high demands at the end of the dry season were only met in 30% of the villages visited by the increased use of hand dug wells as a secondary source of drinking water or by using less water.

Across the basement aquifer, hand pumps are generally reserved for drinking water, and all other water requirements (cooking, washing and livestock) were met by secondary water sources (hand dug wells and seasonal surface water). The time taken to collect water from hand pumps was longer than within the Tertiary sedimentary aquifer region, with queuing times generally reported to be 1–3 hours in the dry season, and in extreme cases hand pumps were used continuously over-night. The mechanical functionality of the hand pumps sampled was much poorer than that observed in the Koro region, with most failing 2–5 times a year, and some failing up to 10 times a year.

Boreholes sampled were community boreholes, rather than private boreholes, used only by the immediate village, and distances travelled were usually short (less than 1km) in the region. Groundwater quality was generally reported to be good.

There are few seasonal rivers within the basement aquifer region, which exist for 4–5 months during the wet season, and are important sources of water for washing, animals and irrigation. In many of the villages, micro-dams had been constructed along small seasonal rivers in the last 5 years by local NGOs (e.g. GAAS), to facilitate small-scale cultivation, and to provide irrigation water for other crops. These schemes have lengthened the growing season, and led to increased crop yields through small-scale irrigation, however, the long-term effect of the micro-dams on the groundwater resource is unknown. Rainfall harvesting was not conducted within the region, due to the lack of metal roofs. Only one of the villages visited in the region had

electricity and the overall standard of living was quite low, despite growing tourism within the Bandigara region in the past 10–15 years. Plate 9 shows an example of a recently improved large diameter well near Bandigara, Mali. Strict hygiene protocols (e.g. no shoes allowed) are used on the hard standing surrounding the wells and hand pumps in Mali.

Plate 9 GAAS funded improved large diameter well near Bandigara, Mali.

5 Results and Discussion

Table 2 summarises the seasonal water access data collated from community and wellhead discussions for each rainfall zone, following the abbreviated WELS methodology (Coulter and Calow, 2011). Table 3 summarises the water use data for different water sources in wet and dry seasons from WELS surveys, for each rainfall zone. Figures 6-13 show graphical statistical summaries of the water access (round-trip collection times) for the different climate zones and geology for both hand pumps and hand dug wells, as well as the occurrence of rationing of water, which is another clear indicator of water stress.

5.1 KEY QUESTIONS

(i) How does access to water vary within and along the transect and do factors such as rainfall, season, aquifer type, population or number of sources have a significant effect on access along the study transect?

HAND PUMPS AND HAND DUG WELLS:

Figures 6 and 7 show box-plots of access to hand pumps and hand dug wells in the wet and dry season. There is an overall increase in median collection times with decreasing rainfall along the transect in both the wet and dry season, although there is a more marked difference in the dry season. Figures 8 and 9 show the variation in access to hand pumps and hand-dug wells along the transect for both the basement and sedimentary sites.

Table 2 Summary water access data from WELS surveys

Climate zone (Peel *et al.*, 2007**)**	**Country and region**	**Water sources accessible (% villages with access)**	**Important water sources**		**Estimated use of BH sources (Av. L/d)**		**Av. dry season BH collection times (min)**	**Av. depth of BH (mbgl)**	**Reliance on traditional wells for drinking water in dry season**
			Wet season	Dry season	Wet season	Dry season	Av. (range)	Av. (range)	% villages
Equatorial Monsoon	NIGERIA, Abeokuta	BH(100), RH (57), W (35), R (30)	BH>RH>>W =R	BH>>W	5500	5900	32 (5-90)	37 (20-70)	20
Equatorial savannah	NIGERIA Minna	BH (100), R (85),RH (70),W (30)	BH>R=RH>> W	BH>R>W	4500	4600	44 (10-120)	30 (20-40)	20
Arid Steppe	NIGERIA, Gusau	BH (100), W(60), RH (60),R (45)	BH>W>RH> R	BH>W	8000	8100	56 (5-180)	35 (20-90)	60
Arid desert	MALI, Bandigara	BH (100), W (100), P (86), R (20), RH (13)	BH>W>P	BH>W	5400	7600	57 (20-120)	23 (15-30)	70

Sources: BH = borehole, W = traditional well, RH = rainfall harvesting, R = river, P = seasonal ponds, Av. = average

Table 3 Summary water use data for different water sources in wet and dry seasons from WELS surveys

Climate zone (Peel *et al.*, 2007**)**	**Country and region**	**Boreholes: Uses and average collection times (min)**		**Traditional wells: Uses and average collection times (min)**		**Rivers: Uses and average collection times (min)**		**Rainfall harvesting: Uses**	**Seasonal Ponds: Uses**
		Wet	Dry	Wet	Dry	Wet	Dry	Wet	Wet
Equatorial Monsoon	NIGERIA, Abeokuta	D,C,W (25)	D,C,W (32)	D*,C,W (11)	D*,C,W, A (13)	D*,C*,W*,A (34)	W*,A (34)	D,C	N/A
Equatorial savannah	NIGERIA Minna	D,C (15)	D,C,A (44)	D,C,W (8)	D,C,W,A (18)	D*,W,A (31)	W,A (30)	D,C	A,W,C,B
Arid Steppe	NIGERIA, Gusau	D,C,W (33)	D,C,A (56)	D,C,W,A (16)	D,C,W,A,I* (29)	D*,W,A (35)	N/A	D,C	D*,A, W,B
Arid desert	MALI, Bandigara	D,C,W (30)	D,C,W, A* (57)	D,C,W,A (29)	D,C,W,A,I* (48)	N/A	N/A	D*,C*	D*,A, W,B

Uses: D = drinking, C = cooking, W = washing, A = animals, I = irrigation, B= building * = few instances

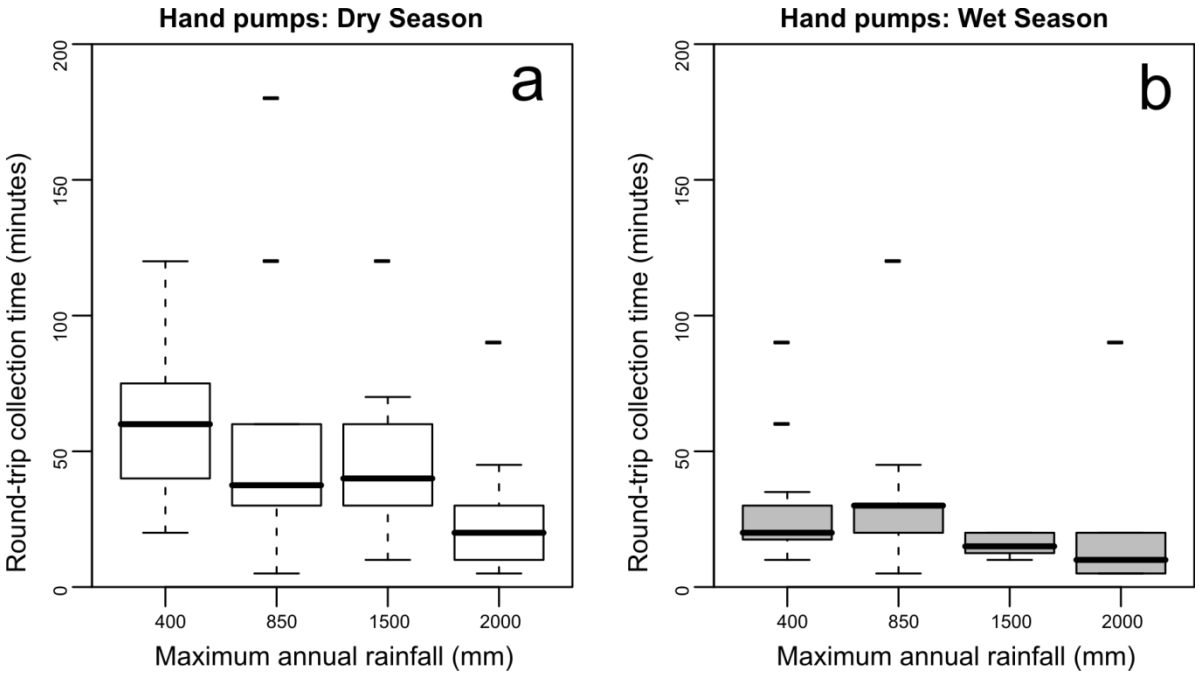

Figure 6 Box-plot of round-trip collection times to hand pumps in both the a) dry and b) wet season. The four climate zones in the study are shown on the x-axis.

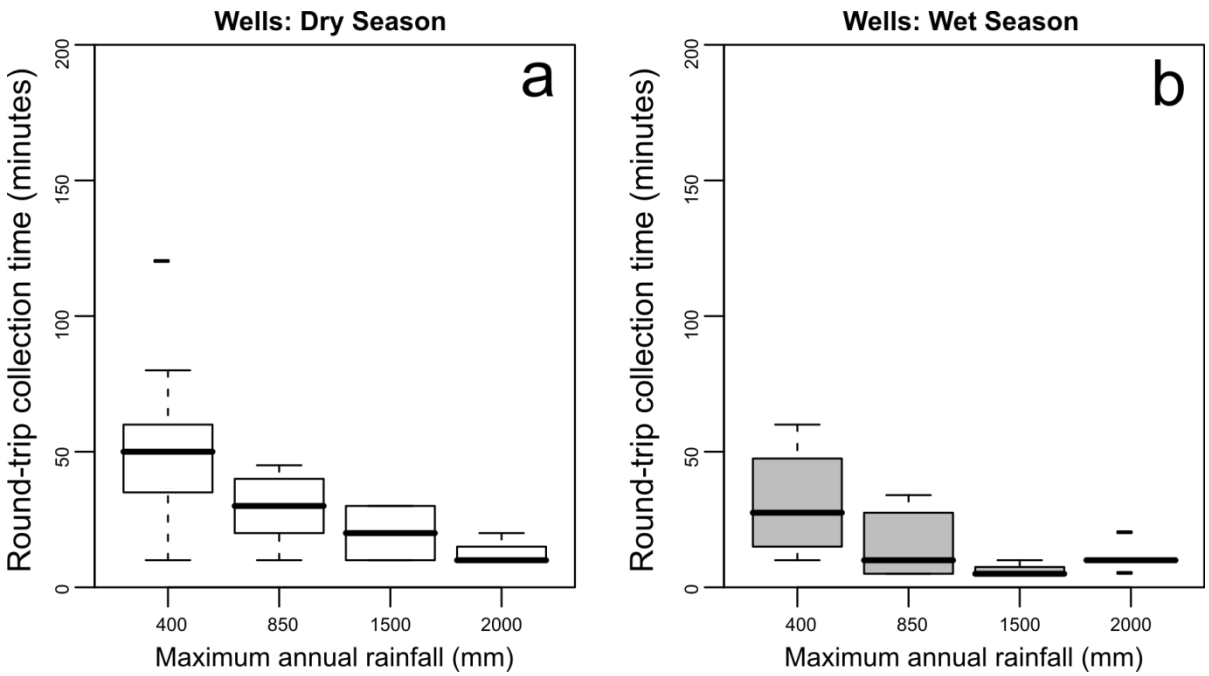

Figure 7 Box-plot of round-trip collection times to hand-dug wells in both the a) dry and b) wet season. The four climate zones in the study are shown on the x-axis.

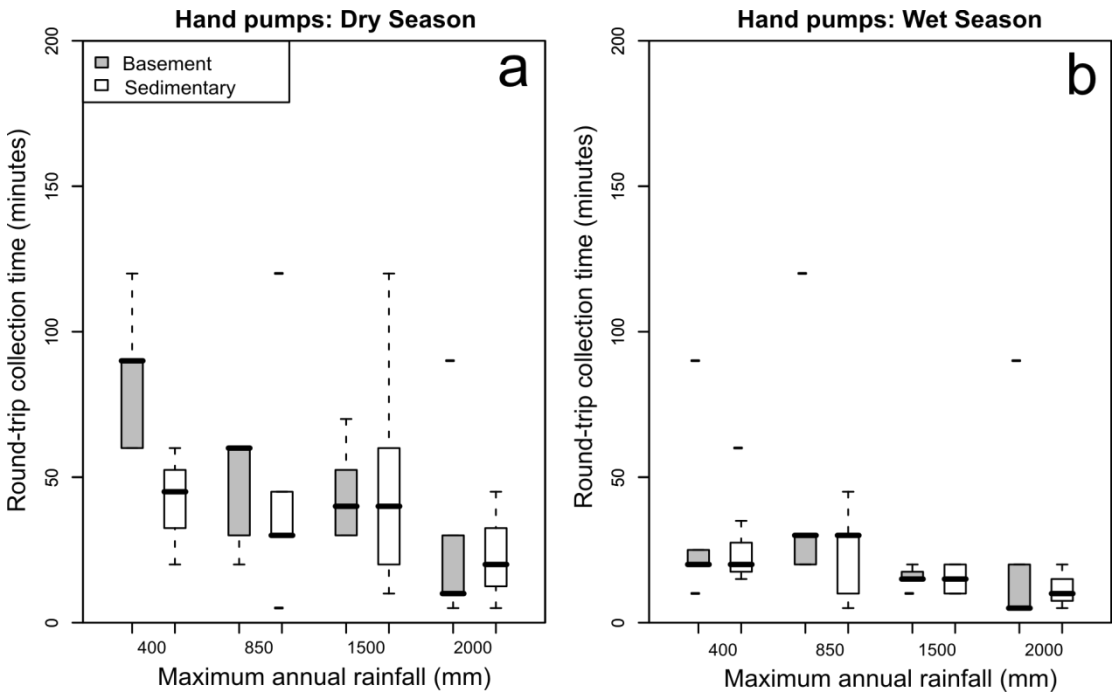

Figure 8 Box-plot of round-trip collection times to hand pumps in both shallow basement and sedimentary aquifers in both the a) dry and b) wet season. The four climate zones in the study are shown on the x-axis.

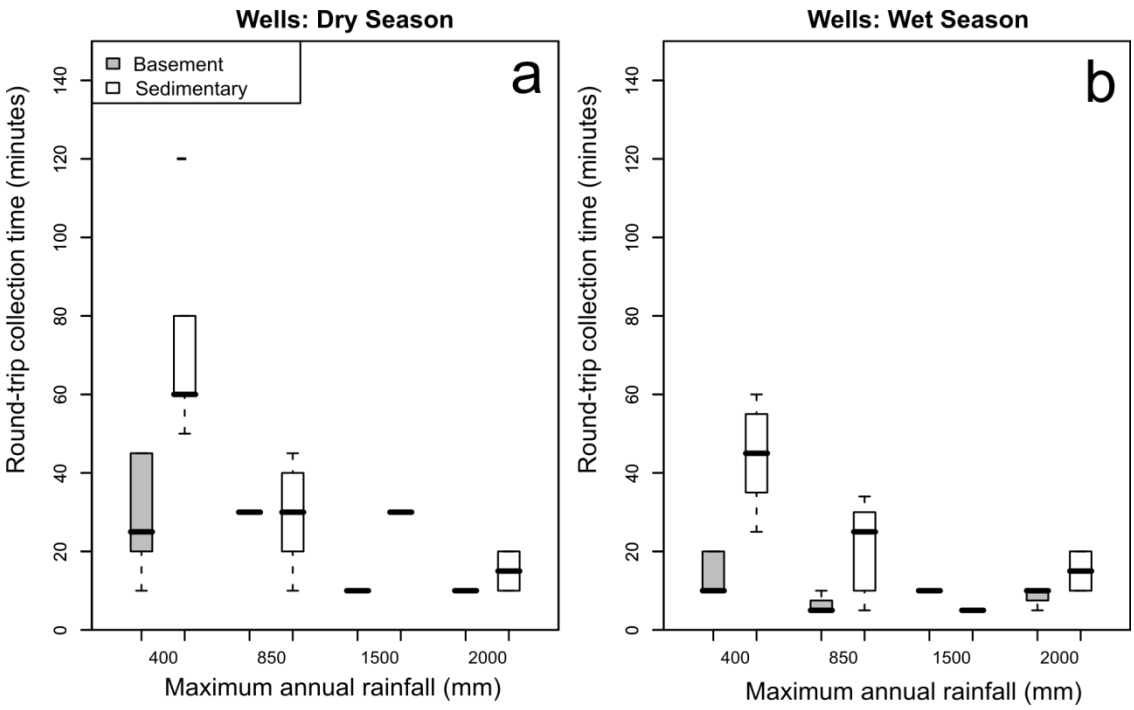

Figure 9 Box-plot of round-trip collection times to hand-dug wells in both shallow basement and sedimentary aquifers in both the a) dry and b) wet season. The four climate zones in the study are shown on the x-axis.

The ANOVA analysis shows that there were significant differences ($p<0.05$) in access (round-trip collection times) from hand pumps and wells in the different rainfall zones in both the wet and dry season. Overall collection times from groundwater sources are significantly different along the climate transect, but are not found to be significantly different for the sedimentary and basement sources. Based on discussions with communities it is evident that shallow hand dug wells are not always functional for the duration of the dry season. The number of users are not found to be significantly different ($p>0.1$) along the transect or between the sedimentary and basement aquifers.

(ii) How does rationing and charging at hand pumps vary along the transect?

Charging only occurs in around 10% of villages surveyed. Four of the five villages (80%) which had introduced charging are from the most arid case study in Mali.

Rationing is found to occur in the dry season in around 20% of the villages surveyed. Around 60% of the instances of rationing are in the seasonally wet Minna case study in Nigeria which has a rainfall of 1500 mm/y. Figure 10, shows the instances of rationing by rainfall zone, and Figure 11 breaks down the instances of rationing across the different aquifers in a single rainfall zone (Gusau – semi-arid). Figure 12 shows a box-plot of access (collection times) for rationed and non rationed hand pumps across the whole transect. There is no significant difference (t-test, $p>0.5$) between mean access times in the rationed sites compared to the non rationed sites. There is also no significant difference ($p>0.5$) between the average number of sources in the rationed and non rationed sites.

Results from the WELS interviews suggest that rationing is predominantly used to reduce waiting times and diffuse tensions in the village during the dry season when the demand is highest and there are fewer alternative sources of drinking water. Charging for hand pump water is not common in Nigeria (only one instance in this study), but is more common in Mali where it had been used for some time to provide the water committees with funds to repair the hand pumps.

(iii) What is the overall distribution of collection times across the transect?

Figure 13 shows the cumulative probability plots (note log scale) for collection times in both sedimentary and basement sites in the wet (Figure 13a) and dry (Figure 13b) seasons. It can be seen that the data has an approximately log normal distribution for most data sets except that of the basement locations in the wet season. The stepped nature of the curves is due to the fact that interviewees tend to round up or down to the nearest 5 or 10 minutes when responding to questions about waiting times. It can be seen that the median (50th percentile) for the basement sites (50 minutes) is around twice that of the sedimentary sites (30 minutes) in the dry season. The two distributions converge towards the upper 20th percentile with waiting times of more than 60 minutes. It can be seen that waiting times are also overall greater during the wet season within the basement sites, however the two populations appear to diverge around the 85 percentile – this is due to individual locations from the Abeokuta, Gusau and Bandigara study sites (see Figure 8b) that have anomalously high collection times within the basement sites, and may be considered outliers compared to the majority of the data population.

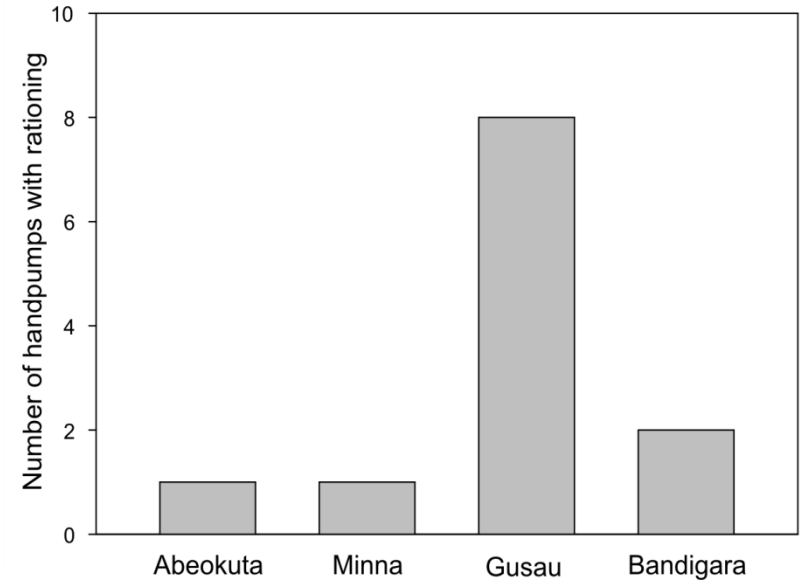

Figure 10 Bar graph of the instances of rationing by study area. The four climate zones in the study are show

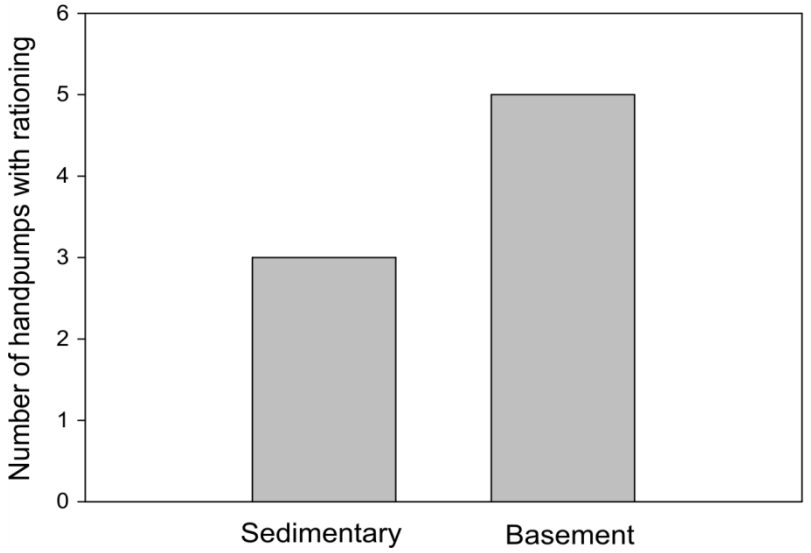

Figure 11 Bar graph of the instances of rationing in the Gusau study area in the sedimentary and basement aquifers.

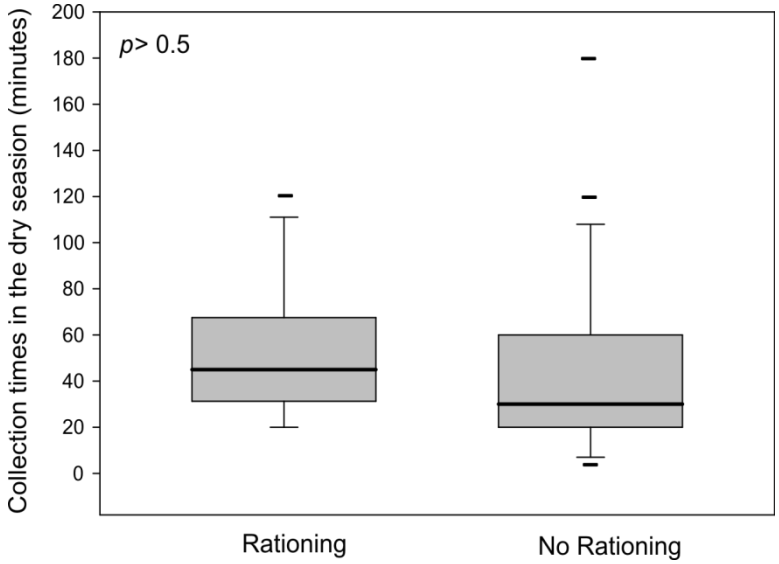

Figure 12 Box-plot of collection times for rationed and non rationed hand pumps across the whole transect.

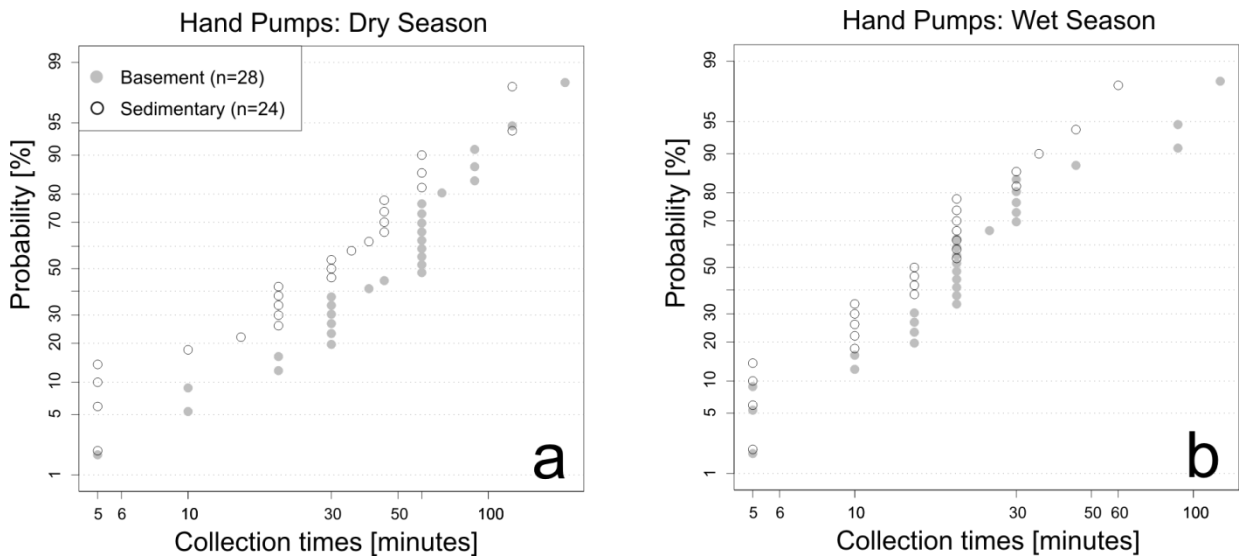

Figure 13 Cumulative probability plot of hand pump collection times for sedimentary and basement aquifers in both the a) dry and b) wet season.

(iv) Does the hand pump use in the dry season meet basic needs for water?

Figure 14 shows a cumulative probability plot for estimated hand pump use (L/capita/day) across the transect in the dry season. It can be seen that there is higher water use from hand pumps from sites on the basement geology compared to the sedimentary geology for most study areas. The water use from hand pumps is consistent on the sedimentary geology across the transect. This is likely due to the fact that there are many more hand dug well sources in the sedimentary areas due to the ease of digging wells in sedimentary aquifers, while on the basement geology hand pumps are effectively the only source of water for domestic use in the dry season. It is also interesting to note that the water use did not vary systematically across the rainfall transect – for example, within basement aquifers the wettest and driest areas have similar median water use (c. 12 L/capita/day) while the Minna case study in central Nigeria has the lowest median water use (5 L/capita/day).

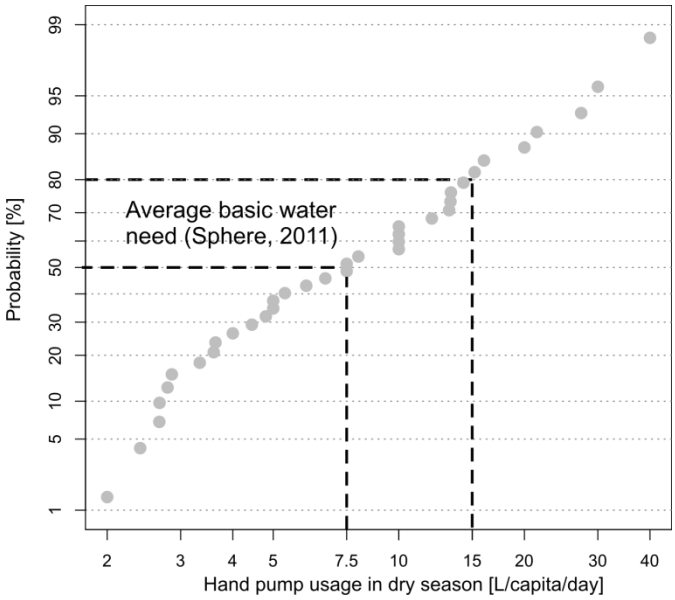

Figure 14 Cumulative probability plot of hand pump use in the dry season for all data. Dashed line shows mean usage value for all data, close to the average basic water need of between 7.5-15 L/capita/day (Sphere, 2011).

At 50% of locations sampled in the dry season the estimated water use from hand pumps is less than the lower limit average basic water usage of 7.5 L/capita/day, and 80% of sites are using less than the upper limit of average usage i.e. 15 L/capita/day (Sphere, 2011) from hand pumps. On the basement sites this would likely reflect the total water use for domestic use as there are very few alternatives in the dry season, while for the sedimentary site this may only reflect a proportion of the total water use.

The quality of the shallow hand-dug wells in sedimentary areas is often reported as poorer and more susceptible to contamination compared to boreholes, and often dried out in the dry season due to their shallow construction. The cumulative probability plot (Figure 14) shows a distribution with multiple populations (at least two breaks in distribution) reflecting the complex nature of water use from hand pumps in the dry season in relation to geology, water access, management practices, as well as different social practices and preferences.

For a significant proportion of hand pumps in basement geology this preliminary water use data suggests that the hand pumps did not meet the average basic water need for domestic use of between 7.5 and 10L/capita/day. This likely reflects the inadequate numbers of functional hand pumps to meet peak demand during the dry season, associated mechanical failure due to constant use, as well as the relative difficulty in finding suitable sites on the basement geology due to the complex local hydrogeology. It is also clear from the generally lower hand pump uses for sedimentary sites that alternative sources, e.g shallow hand dug wells, continue to be important sources of water for domestic use during the dry season.

6 Conclusions

- The slimmed down WEL survey has been shown to be an effective way of rapidly gathering useful information on water access in West Africa.
- There is an overall increase in median collection times (access) with decreasing rainfall along the transect in both the wet and dry season, although there is a more marked difference in the dry season.

- Significant differences between access (collection times) in the sedimentary and basement sources are only found in the dry season across the transect for hand pumps while for hand-dug wells significant differences were found in both the wet and dry season.
- Rationing is found to occur in the dry season in around 20% of the villages surveyed. Around 60% of the instances of rationing were found in the Minna case study in Nigeria, and there is no consistent trend in the level of rationing with climate across the rainfall transect.
- Rationing is predominantly used to reduce waiting times and diffuse tensions in the village during the dry season when the demand was highest and there are few alternative sources of drinking water.
- Charging is only found to occur in around 10% of villages surveyed, and is most common within the most arid region of the transect - four of the five villages (80%) which had introduced charging were found in Mali.
- Median collection times for the basement sites in the dry season is around 50 minutes, around twice that of the sedimentary sites. This is a key indicator of poor water access and far exceeds the Sphere (2011) indicator value of around 20 minutes for waiting and collection of water from community sources.
- Results from this study show that at around 50% of sites, in the dry season, communities accessed less than the lower limit of recommended water use of 7.5 L/capita/day from hand pumps (Sphere, 2011).
- Hand pumps are critical sources of water for rural populations during the dry season, but waiting times and water use data suggest that they are under stress during these periods, particularly on the basement geology where there are few alternative sources of drinking water.

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Appendix A

Example questionnaire used in this study - Kuzawa Kwara, Nigeria, site A12.

(i) Community mapping questionaire

SCHMT.

A12

Community mapping and seasonal calendar

Village:	KUZAWA KWARA
District:	MARU
Region:	ZAMFARA.
Rainfall:	
Dry season months, duration:	6–7
Wet season months, duration:	5–6.
Hungry season?	IF FOOD RUNS OUT CAN SELL ANIMALS - NOT OFTEN.
Households (now & 5 yrs ago):	100–120 (80).
Population (now and 5 yrs ago):	550 (400)
Main livelihood activity:	FARMING, ANIMALS. MAIZE, CORN, MILLET
2ndary activities:	OUTSIDE WORK IN TOWNS
Main sources of income %: (check against above)	FARMING, ANIMALS. MAIZE, CORN. OUTSIDE INCOME FROM WORK OUT IN MARU.
Changes:	UNRELIABLE RAINFALL. 2008 OK, 2009 POOR YEAR.
Additional info: (e.g any big differences in livelihood activities between richer and poorer households?)	8-10 JERRY CAN PER HOUSEHOLD/d. 100 x 8 x 20. L/d. BH INSTALLED 1979. >10 < 20 pipes ~ 17 installed.

OTHER VILLAGES USE IN DRY SEASON

(ii) Seasonal calendar of water use

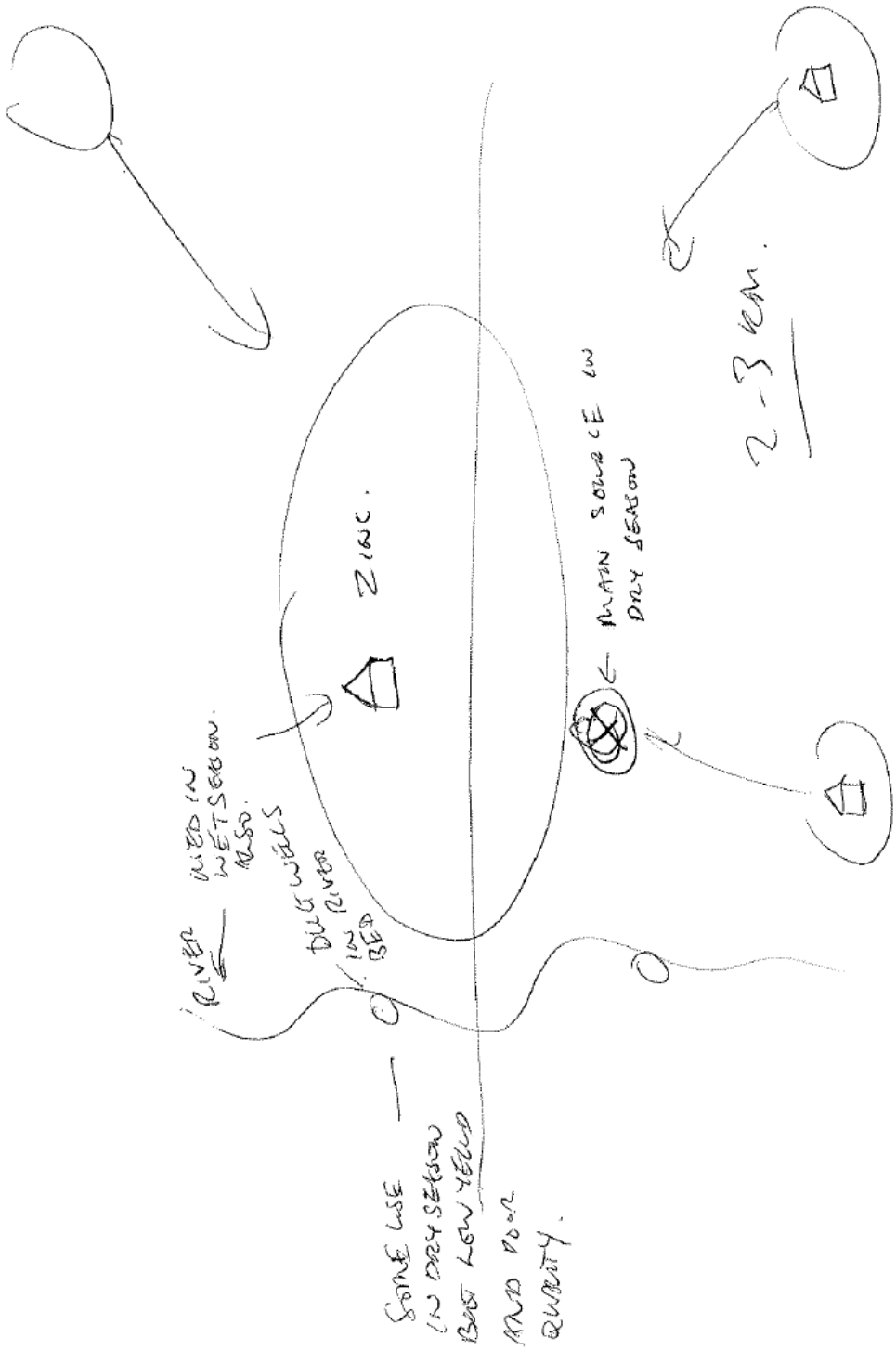
A12

OK → ← LOWER YIELD 5-10 buckets - wait 30 min to start again

ok

		Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Source 1 BOREHOLE	Availability? (yes/no)	←											→
	Quality? (good/bad)	←				GOOD							→
	Collection time (hrs round trip)	←				10 min - 30 min							→
	Drinking & cooking use						YES						
	Washing & laundry						YES						
	Irrigation						NO						
	Livestock						YES						
	Notes												
Source 2 RIVER / DUG HOLES	Availability?		←	←					→				
	Quality?		←			GOOD							
	Collection time (hrs)		~~[illegible]~~ min	←			5 min	→		DON'T LIKE	→ TOO LONG / IN DRY SEASON FINISHES.		
	Drinking & cooking						YES						
	Washing & laundry						YES						
	Irrigation						YES.						
	Livestock						YES						
	Notes												
Source 3 ZINC.	Availability?			←					→				
	Quality?			←		GOOD			→				
	Collection time (hrs)												
	Drinking & cooking					YES							
	Washing & laundry					YES							
	Irrigation					NO							
	Livestock					NO.							
	Notes												

(iii) Water use map, also drawn in sand during community discussion



(iv) Hand pump questionnaire

Site Name	Date	Field Ref:
Kugawa Kwma	18/04/10	A12

When was the borehole completed? 1982 (likely)

Measured depth (m)	Condition of well head	Comments
<5 5-20 20-50 >50	Concrete (Y) N Status (1) 2 3 Ponded water <2m Y (N) Fenced Y (N)	WELL OUTSIDE VILLAGE > 800m.

Yield in dry season b/d	Yield in wet season b/d
5 x 100 x 20 L/d	100 x 10 – 15 x 10 L/d.

Pump type Hand Pump INDIA m III/IV

Functionality (1) 2 3 | Comment:

Location of closest latrene NON

	Landuse	Contamination?
10m 50m 200m	Bare Land Natural/Agric.	SMALL POND > 5m away. / WASHING NONE AT ALL ELSE

Committee? (Y) N

Water uses	Drinking ✓	Washing ✓	Cooking ✓	Irrigation	Animals ✓	Other

	Number	Distance	Time taken
Users in dry season	550 +	200 – 500m 2-3km other villages.	10 – 30 min
Users in wet season	–"–		

Changes in use in the last five years

MORE PEOPLE ONLY.

Does it meet demand all year round?

NO

Has it met demand in very dry years?

NO

Is water ever rationed?

NO

If rationed who organises this?

—

If rationed why is it rationed?

—

Is the quality adequate?

YES.

COMMUNITY USES OWN FUNDS TO REPAIR – SOMETIMES SELL CROPS TO REPAIR, 2/3 months may need to

NO COMMITTEE

Appendix B

Quality controlled questionnaire results

Field No	Study	Geology	Village name	Region/State	Users	Dry season	HP-Dry	HP-Wet	W-Dry	W-Wet
					(n)		Round trip collection times (minutes)			
A1	Minna	Basement	Gbalipa	Niger	600	Jan-April	45	20	10	10
A2	Minna	Basement	Kitikpa	Niger	1500	Jan-April	70	10		
A3	Minna	Basement	Gurusu	Niger	100	Jan-April	30	15		
A4	Minna	Basement	Sabon Gida	Niger	900	Jan-April	60	20		
A5	Minna	Basement	Godna	Niger	2000	Jan-April	30	15		
A6	Minna	Mesozoic	Essa	Niger	2000	Jan-April	10	10		
A7	Minna	Mesozoic	Ndabisan	Niger	2000	Jan-April	N/A	20		
A8	Minna	Mesozoic	Gbakogi Kasara - 1	Niger	1000	Jan-April	20	10		5
A9	Gusau	Basement	Kadaddaba	Zamfara	700	Oct-May	30	20	30	5
A10	Gusau	Basement	Dangamji	Zamfara	700	Oct-May	20	20		
A11	Gusau	Basement	Kadauri	Zamfara	4000	Oct-May	60	30		10
A12	Gusau	Basement	Kuzawa Kwara	Zamfara	550	Oct-May	60	30		5
A13	Gusau	Mesozoic	Gidan Kano	Zamfara	5000	Oct-May	N/A	30		
A14	Gusau	Mesozoic	Dolenmoriki	Zamfara	5000	Oct-May	45	45	45	25
A15	Gusau	Mesozoic	Badarawa	Zamfara	3000	Oct-May	5	5	20	5
A16	Gusau	Mesozoic	Tungan Gurguri	Zamfara	5000	Oct-May	30	10	40	34
A17	Abeokuta	Mesozoic	Ishaga	Ogun	5000	Jan-Oct	5	5	10	10
A18	Abeokuta	Mesozoic	Iboro	Ogun	5000	Jan-Oct	45	10		
A19	Abeokuta	Mesozoic	Ibara-Orile	Ogun	5000	Jan-Oct	20	20		
A21	Abeokuta	Mesozoic	Igan-Okoto	Ogun	4300	Jan-Oct	20	10	20	20
B1	Minna	Basement	Kadna	Niger	600	Jan-April	30	15		
B2	Minna	Basement	Vemu	Niger	300	Jan-April	40	15		
B3	Minna	Mesozoic	Kalachi	Niger	2000	Jan-April	40	15	30	5
B5	Minna	Mesozoic	Kudugi- Tswachi	Niger	700	Jan-April	60	20		
B6	Gusau	Basement	Matankari	Zamfara	750	Oct-May	30	20		
B7	Gusau	Basement	Fakai	Zamfara	1000	Oct-May	N/A	N/A		
B8	Gusau	Basement	Danmanau	Zamfara	1000	Oct-May	60	30		
B11	Gusau	Mesozoic	Damri Private Health care centre	Zamfara		Oct-May	N/A	N/A	30	30
B12	Gusau	Mesozoic	Badamma Dangara	Sokoto		Oct-May	30	30	10	10
B13	Abeokuta	Basement	Sekere	Oyo	1250	Jan-Oct	N/A	N/A		
B16	Abeokuta	Basement	Ojo-Oluno	Ogun	500	Jan-Oct	30	20		5
B17	Abeokuta	Basement	Akintobi	Ogun	250	Jan-Oct	10	5		
B18	Abeokuta	Basement	Abule-Ode	Ogun	300	Jan-Oct	10	5		10
B19	Abeokuta	Basement	Adulu	Ogun	200	Jan-Oct	5	5	10	10
M1	Bandigara	Tertiary - Continental Terminal	Ene	Koro	2500	Nov-May	60	20	120	45
M2	Bandigara	Tertiary - Continental Terminal	Togotina	Koro	1800	Nov-May	35	15	60	40
M3	Bandigara	Tertiary - Continental Terminal	Karakmba	Koro	750	Nov-Apr	20	20	60	60
M4	Bandigara	Tertiary - Continental Terminal	Bene Bana	Koro	1000	Nov-June	45	35	80	60
M5	Bandigara	Tertiary - Continental Terminal	Tere	Koro	450	Dec-July	30	N/A	60	30
M6	Bandigara	Tertiary - Continental Terminal	Yanda Tougo	Koro	1000	Nov-June	60	20		25
M8	Bandigara	Tertiary - Continental Terminal	Guinedia	Koro	525	Oct-May	45	15	50	50
M10	Bandigara	Precambrian sandstone	Sinkarmma	Bandigara	400	Oct-Jun	60	10	45	10
M11	Bandigara	Precambrian sandstone	Kema	Bandigara	300	Nov-Jun	120	20	10	10
M12	Bandigara	Precambrian sandstone	Sokolo	Bandigara	1000	Oct-Jun	90	20	20	20
M13	Bandigara	Precambrian sandstone	Sibi-Sibi	Bandigara	3000	Oct-Jun	60	25	25	10

Field No	Study	Geology	Village name	Region/State	Users	Dry season	HP-Dry	HP-Wet	W-Dry	W-Wet
M14	Bandigara	Precambrian sandstone	Bendiely	Bandigara	7000	Oct-Jun	90	N/A	45	20

HP = hand pump, W= well, Dry=dry season, Wet=wet season

Continued:

Field No	R-Dry	R-Wet	RH-Wet	Ven	Abs.	*Rat.	*Char.	*YL	Use	HP	W	Total
	Round trip collection times (minutes)				L/d(dry)				L/capita/day	Sources (n)		
A1		25		1	6000	1			10	1		1
A2	30	30			10000	1			6.6	1		1
A3		80	1		4000				40	1		1
A4		80	1		2000	1			4.4	2		2
A5	60	45	1		10000	1			5	1	2	3
A6		35	1		10000				10	2		2
A7	20	20	1		6000	1		1	12	4	4	8
A8			1		2000	1			2	1	6	7
A9	20	20			3000				21	5	3	8
A10		30	1		10000				14	1		1
A11			1		10000			1	7.5	3	2	5
A12			1		2000				3.6	1	2	3
A13	90	90	1		10000				6	3	2	5
A14		10	1		12000	1			4.8	2	1	3
A15			1		10000				3.3	1	1	2
A16			1		10000				8	4	2	6
A17	15	15	1		4000		1					
A18	40	40	1		12000							
A19	60	60	1		6000	1						
A21			1		12000							
B1	10	10	1					1				
B2	25	25	1		800	1						
B3	30	30			1000							
B5	45	45	1		2000	1						
B6	60	20	1		4000							
B7				1	10000							
B8		40			10000							
B11										1	1	2
B12					3000					1	1	2
B13			1		1500	1		1				
B16					2000							
B17					4000							
B18					4000							
B19	20	20			6000							
M1	N/A	N/A	1		22800		1		27.3	3		3
M2	N/A	N/A			1400	1	1		2.4	3	1	4
M3	N/A	N/A			2000				2.6	1	5	6
M4	N/A	N/A	1		1200		1		3.6	3	3	6
M5	N/A	N/A			3400		1		7.5	1	2	3
M6	N/A	N/A								1	2	3
M8	N/A	N/A			4000			1	15.2	2	2	4
M10	N/A	N/A			2000				5	1	2	3

Field No	R-Dry	R-Wet	RH-Wet	Ven	Abs.	*Rat.	*Char.	*YL	Use	HP	W	Total
	Round trip collection times (minutes)				L/d(dry)				L/capita/day	Sources (n)		
M11	N/A	N/A			4000			1	13.3	1	2	3
M12	N/A	N/A			10000				20	2	1	3
M13	N/A	N/A			20000				13.2	2	3	5
M14	N/A	N/A			10000				1.4	1	1	2

R = rivers, RH = rainfall harvesting, Ven= water vendors, abs. =abstraction, Rat.=rationing, Char.=charging, YL= Yield limiting, W=Well, * 1=did occur (otherwise blank)

Appendix C

SUMMARY DATA SHEETS FOR ABEOKUTA STUDY AREA, NIGERIA

A17 - ISHAGA (Ogun State)

Hungry season: never

Population now: 3-4000

Population 5 years ago 2000

Livelihood: farmers – cassava, yam, maize, corn

2ndary: trading garrie, civil servants in towns

Main source of income: selling cassava products, eubo (yam powder)

Comments: The village has grown in recent years and there has been a new hospital built which has a borehole, but this is not for general use by the village. It was only recently completed and the samples from the drilling were still on site. The material was loosely consolidated sands. There is a very clear distinction between the rich and poor in village. Those that can afford one have a borehole and also sell the water to others around. There are about 8-10 boreholes dotted around the village. The water from the borehole and river is very important in the production of garrie and eubo. There is a government borehole that was installed but this is not currently working, the cost of maintaining is high and not affordable to most. Waiting was common at the government borehole so people still use the river as it is quicker. There no problem with using the river water according to the people we asked.

Source 1: Borehole

Available: all year round

Quality: Good all year and enough yield to supply a large proportion of the village (sell)

Collection time: <5 minutes, it is also sold in cans to the rest of the village 5 N/20L

Not all the villagers are using the borehole water for drinking due to cost. The borehole water was also used for fish farming for a while but this has been stopped now.

Source 2: River

Available: All year flow

Quality: good according to the village but the government advised against using river water and put in a borehole.

Collection time: <20 minutes

Drinking and cooking, washing etc, used for livestock too.

Source 3: Rainfall harvesting

Available: Jan-Oct

Quality: Good mostly but dirty at the start of the rains

Used for domestic purposes and is used by lots of people in the village in the wet season

A18 - IBORO (Ogun State)

Hungry season: never

Population now: 5000

Population 5 years ago: 4000

Livelihood: farmers – cassava, yam, maize, rice, cocoa, cashew

2ndary: garrie, maize cakes,

Main source of income: selling maize cakes, cocoa and cashew nuts

Comments: This borehole was donated by the government, and the pump relies on NEPA electricity to run. A local water board borehole also supplies part of the village (not available) as well as nearby villages/towns. It has a larger yield and is a larger diameter borehole installed in 1960. The borehole water is important in producing garrie and maize cakes providing income for the village (Women). The population of the village has grown in recent years through births as well as influx of farmers from Benin (Ketu). The major source of water for the village is still the river water, there are four streams that are used locally.

Source 1: Rivers

Available: all year round

Quality: Good all year and there is no illness at all.

Collection time: >30 minutes

The river water is the most easily available source for the village but it is quite along way to go and fetch water.

Source 2: Borehole

Available: All year

Quality: good quality all year

Collection time: Can wait for up to 1 hour when there is high demand, dry season. Can be as little as 10 minutes depending on demand and less in the wet season.

Drinking and cooking, washing.

Source 3: Rainfall harvesting

Available: Jan-Oct

Quality: Good

Used for domestic purposes and is used by lots of people in the village in the wet season

A19 - IBARA ORILE (Ogun State)

Hungry season: never

Population now: 5000

Population 5 years ago: 4000

Livelihood: farmers – cassava, yam, tomato, plantain, maize

2ndary: maize cakes (eko)

Main source of income: selling maize cakes, garrie, cassava and amala

Comments: The borehole is very important for processing farm products for sale. This adds value to the products and increases income for the community. Rich individuals in the village are traders in farm products as well as building materials e.g plumbing and blocks etc. The village population has expanded over recent years due to influx of farmers from Cotonno (Benin Republic) as well as births. There are two boreholes in the village but this is the best one out of

the two, the other is too shallow with a poorer yield. Everyone in the village comes and uses this borehole instead. The users pay a fee of 5N for 2 large basins. About 3-500 basins are collected each day. This is organised by the water committee and the proceeds used to maintain the pump and pay for fuel. The pipe work was recently replaced as it had become dirty. The cost of the water is not limiting the use.

Source 1: Borehole

Available: All year

Quality: good quality all year with no changes since installation, pipes did need to be replaced recently though due to build up of gunk.

Collection time: 5-30 minutes, 30 for those furthest away in the village

Drinking and cooking, washing, livestock – used for making maize cakes and garrie

Source 2: River

Available: Feb-Nov

Quality: Good all time

Collection time: 1 hour as it quite far away

The river water is along way away but is used by the village to wash clothes and bathing as well as for livestock.

Source 3: Rainfall harvesting

Available: March-Nov

Quality: Good

Only a limited amount can be stored so mostly use the borehole water which is available all year. Used mainly for washing and bathing.

A20 - AIYETORO (Ogun State)

Hungry season: never

Population now: >10000

Population 5 years ago: >6000

Livelihood: farmers – cassava, yam, cocoa

2ndary: maize cakes (eko), garrie

Main source of income: selling maize cakes, garrie

Comments: This site is located at the very edge of a small town and the borehole water is also used to sell locally as pure water. The pure water is treated using a sand filter and a carbon filter. The water is used locally to process cassava and maize. The borehhole water is used by a very large number of people and is privately owned, there are many such boreholes across the town. The local hospital also has its own borehole. All are motorised and high yielding.

Source 1: Borehole

Available: All year

Quality: good quality all year with no changes since installation

Collection time: <10 minutes

Drinking and cooking, washing, – used for making maize cakes and garrie. The water is also packaged and sold as pure water

Source 2: Rainwater harvesting

Available: Feb-Nov

Quality: Usually good but sometimes dirty, especially at start of rains

Used for all domestic purposes and is stored inside for use.

A21 - IGAN-OKOTO (Ogun State)

Hungry season: never

Population now: 4300

Population 5 years ago: 3000

Livelihood: farmers – yam, rice, cassava, palm oil, coconut

2ndary: maize cakes (eko), garrie, palm oil, amala, cola

Main source of income: selling cola nuts, cocoa, maize cakes, garrie, cassava and amala

Comments: This was the only working hand that we saw during 3 days of fieldwork in this area. It was installed by UNICEF but there are at least two other mechanised boreholes in the village. These rely on nepa to run and are run by a committee as is the handpump. The handpump is the main source of water for the village as most cannot afford to run a mechanised pump, it is also nearer for one half of the village than the other working boreholes. River water is not used as it is too far away. People used to use hand dug wells but these have now been abandoned. It is an important source of water for processing farm products, garrie, eko and palm oil.

Source 1: Borehole

Available: All year

Quality: good quality mostly good but it can get turbid in the dry season.

Collection time: 10 minutes in wet season, 20 for those furthest away in the village and in the dry season when demand is higher.

Drinking and cooking, washing, livestock – used for making maize cakes and garrie etc

Source 2: Mechanised borehole

Available: All year

Quality: Good all time

Collection time: 10-30 minutes depending on where you live.

Not the main source of water for the village as it is expensive to upkeep.

Source 3: Rainfall harvesting

Available: March-Nov

Quality: Good

Stored for use, used for domestic purposes.

A22 - FOLAFEM (Ogun State)

This source is privately owned and is located on a palm plantation, away from any major urban influence. It is used for farming, oil processing and selling to tankers for commercial use. It is used by a handful of people for domestic use. The borehole is very high yielding and is generally used more in the dry season, at times up to 20,000 L/day is used to fill tankers. The borehole is mechanised and uses a large diesel pump.

Source 1: Borehole

Available: All year

Quality: good quality all year

Collection time: <10 minutes good yield all year

Drinking and cooking, washing locally as well as watering plantation. It is used commercially in dry season to sell to water tankers.

A23 - OWODE (Ogun State)

This borehole is located on the very edge of Owode a fair sized town (10-15,000). Most of the water supply for the town comes from private hand dug wells, many of which are mechanised. The local water board also supplies to town and surrounding area and has 8 borehole's in total, this is located about 3 km away from the site. The borehole is privately owned and is used for pure water (4000L/d) and for block making as well as building. It is a very high yielding borehole and is around 70 m deep. It is used domestically locally also, but is not a community borehole as such. The borehole is pumped for around 4-6 hours a day.

B13 - SEKERE (Oyo State)

Hungry season Feb-April before onset of rainy season

Population now: 650-1300

Population 5 years ago 400-800

Livelihood: farmers – cassava, yam, melon, maize,

2ndary: Some artisans that work in the local quarry site

Main source of income: selling cassava, yam and maize

Comments: The income of the village is affected by the variability in rainfall, impacting on planting time and hence harvest in recent years. The crop yield is also limited by the availability of fertilizer. There are four neighbourhoods 2 fetch water one day and the other two fetch the next day. This is due to the high competition for water and the limited yield from the borehole. About two years ago the decision was made to stop using the borehole water for processing cassava and this has denied the women from generating their main source of income, as a result the men now sell the cassava raw with less resulting income for the community. Water is limiting the potential income of the community through processing the farm products and adding value to them.

Source 1: Borehole

Available: all year round

Quality: Good all year and used for all domestic purposes all year

Collection time: it takes about 1-2 h/d and there is no difference between the rainy and dry seasons.

Rationing is used by dividing the village into two groups that use the water every other day. This is because of the relatively poor yield of the borehole, need to wait for the borehole to recharge often.

Source 2: Rainwater

Available: May to November

Quality: good

Collection time: minutes

Drinking and cooking, washing etc: May to November used for all domestic uses, and all the households in the village use this source. Both rainwater and borehole water is used for processing cassava

Source 3: River

This source is largely abandoned now as it is polluted by the quarry activities. It is also quite a distance but was once an important source before the boreholes and rainfall harvesting was possible. There are no hand dug well in the village as the bedrock is quite shallow and the basement is too hard to dig through.

B14 - AKERORO (Oyo State)

Hungry season Jan-march before onset of rainy season

Population now: 500-600

Population 5 years ago: 450

Livelihood: farmers – cassava, yam, maize

Main source of income: selling cassava, yam and maize

Comments: There is a complaint that the rains used to start in March but in recent years (particularly this year) the rains have arrived late and disrupted the normal planting time. This has affected the planting and field preparation and therefore the production of farm crops which are the main source of income for the village.

Source 1: Borehole

Available: all year round, constructed for the local maternity unit but used by the villages now

Quality: Good all year and used for all domestic purposes and processing cassava for consumption.

Collection time: it takes about 5-10 minutes for those near to the borehole but 30min-1h for all users

The yield and availability is ok it is only the distance and coverage of users that is a problem. The borehole use is not rationed at all and there is no period of low yield. The borehole was constructed for a local maternity unit and there is a fear that the use will be limited when the unit is fully operational – there is demand to repair the old borehole and also for a second one for the adjacent community that use it for water.

Source 2: Old borehole

This is no longer operational due to mechanical faults and has not been fixed.

B15 - LDI-OPE (Oyo State)

Hungry season March-May before onset of rainy season

Population now: 1000

Population 5 years ago 500

Livelihood: farmers – cassava, yam, melon, maize, cocoa, pepper

Main source of income: selling cocoa

Comments: Rainfall variability has caused changed in the production of crops, lower yields and there is a need for more fertilizers to increase yields.

Source 1: Borehole

Available: all year round, but low yield in the dry season

Quality: Good all year and used for all domestic purposes all year

Collection time: 10-30 minutes usually but occasionally there are long lines

Rationing was used before the second borehole was installed, now this is no longer needed.

Source 2: Borehole 2

Available: May to November

Quality: good

Collection time: 10-30 minutes also

There is occasional breakdown of the pumps which caused problems.

Source 3: River

This source is largely abandoned since the borehole construction and rain harvest for washing only is in practice. The second borehole was out of operation until two months ago after breaking down.

B16 - OJO-OLUNEO (Ogun State)

Hungry season Dec-March

Population now: 300

Population 5 years ago 500

Livelihood: farmers – cassava, yam, veg

2ndary: Traditional medicine and hunting bush meat

Main source of income: selling cassava, yam

Comments: There has been a shift in rains from March to April with short supply of fertilisers for crops. This is limiting yield from farming.

Source 1: Borehole

Available: all year round

Quality: Usually good but occasionally it suffers from foaming or degassing

Collection time: it takes about 10-20 minutes from near houses up to 30 minutes from further away houses in village.

Used for domestic uses only.

Source 2: Dug well (wl = 4.2 m)

Available: May to November

Quality: good

Collection time: minutes

Used more extensively before borehole construction but still important now for domestic use.

B17 - AKINTOBI (Ogun State)

Hungry season March-May before onset of rainy season

Population now: 250

Population 5 years ago : 200

Livelihood: farmers – cassava, yam, pepper, maize,

2ndary: Cassava processing for women

Main source of income: selling cassava and garrie

Comments: Some years ago the demand for garrie dropped and this had a serious impact on the income of the village but this has been reversed in recent years. The late rains this year is a problem as the preparation and planting has been delayed. The village is very happy about the increased demand for processed cassava but would like to use fertilisers and pesticides to possibly improve the yield. The increased sales of pepper and cassava have helped maintain incomes but some have been forced to move out of farming.

Source 1: Borehole

Available: all year round

Quality: Good all year and used for all domestic purposes all year

Collection time: Max 5 minutes as there are many active boreholes in the village, there is no waiting to collect water

The rivers and hand dug wells have been totally abandoned after the installation of the boreholes in the village. Adjacent villages use the boreholes too, but usually only during the dry season when other sources are not available.

Source 2: Another 3 boreholes

Available: May to November

Quality: good

Collection time: minutes

As a whole the boreholes are underutilised during the rainy season when adjacent villages have other sources of water.

B18 - ABULE-ODE (Ogun State)

Hungry season March-June

Population now: 300

Population 5 years ago 200

Livelihood: farmers – cassava, yam, maize, pepper

2ndary: preparation of garrie

Main source of income: selling cassava is the main source of income

Comments: Late rainfall has affected early planting this year.

Source 1: Borehole

Available: all year round

Quality: Good all year and used for all domestic purposes all year

Collection time: 5-10 minutes max.

Used for domestic reasons only, there has been no change in the yield of the borehole since completion.

Source 2: Well

Available: May to November

Quality: moderately good

Collection time: about 10 minutes

Only used for washing and laundry not drinking and cooking. It is also an important source for garrie processing.

B19 - ADULU-MOFUSEJO (Ogun State)

Hungry season April-July

Population now: 200

Population 5 years ago 150

Livelihood: farmers – cassava, yam, pepper, maize, cocoa, orange

2ndary: Traditional medicine, garrie and palm oil

Main source of income: selling cassava and cocoa

Comments: The village has noticed that the yield from the orange and cocoa has dropped. This could be due to lower fertiliser use but I suspect is could be that the trees are now getting old and need replacing (Dan) this is a common problem all over this area. The villagers are also affected by the late rains which seem to be more variable in recent years.

Source 1: Borehole

Available: all year round

Quality: Sort of ok but the water is turbid so the taste is not too good

Collection time: <10 minutes

Not all the villagers are using the borehole water for drinking. Used for all other domestic purposes.

Source 2: River

Available: March - October

Quality: good

Collection time: 20 minutes

Drinking and cooking, washing etc: due to the turbid nature of the borehole water the village still uses this as an important source of water

SUMMARY DATA SHEETS FOR MINNA STUDY AREA, NIGERIA

A1 - GBALIPI (Niger State)

Wet season is April - October

No hungry season

Population now: 600 (> 20 HH)

Population 5 years ago 400 (about 15 HH)

Livelihood: farmers – yam, guinea corn, maze, rice, millet, beans

Main source of income: selling yam (75%) selling other crops the rest

Comments: not much change in the village in last 5 years

Source 1: Borehole

Available: all year round, but not enough water in the borehole (debate – but possible only 30 * 50 l buckets in a day?)

Quality: good all year, but sometimes rotten particles first thing in the morning

Collection time: in rainy season less than 20 minutes, Jan to April: wait for longer; they have to ration the water

Drinking and cooking: all year round

Washing and laundry; never

Livestock: never

Not enough water to be used for other purposes

Source 2: River

Available: July to February, intermittent for March through June

Quality: poor – see photograph

Collection time: not long – < 30 minutes

Drinking and cooking: all year

Washing and Laundry: all year

Not sure why they use this source for drinking– didn't really get to the bottom of it. I think because sometimes they don't get their turn.

Another village upstream dammed the river water to use to irrigate sugar cane last week. This caused a major incident, but has now been sorted out.

Source 3: Hand dug wells

Available: some water all the year round, although less in the dry season, not very many wells

Quality: Ok

Collection time: not long

Source 4: water vendors

Have to use if other sources have dried up. They are in a nearby town and very busy. They have to be booked and recently put the price up from 20 to 30 Niara for 25 l jerrycan because of shortage. Wastes a lot of time using the vendor, can take 6 hours.... Unsure how often they have to be used.

A2 - KITIKPA (Niger State)

District: Abaji, Region FCT

Wet season is April - October

No hungry season

Population now: > 1000

Population 5 years ago: less people, but still more than 1000

Livelihood: farmers – yam, guinea corn, maze, rice

Main source of income: selling yams – they have very good yams

Comments: not much change in the village in last 5 years apart from growth in numbers

Source 1: Borehole

Available: good all the year round

Quality: good all year

Collection time: in rainy season less than 15minutes, November to April: wait for longer; it takes more than 1 hour, it is quicker to fetch water from the river. People prefer to wait for the borehole water though, since better quality. It takes longer in the dry season because many more people are around – back from working on the farm

Drinking and cooking: all year round

Washing and laundry; never

Livestock: never

Not enough water to be used for other purposes

Source 2: River

Available: water available all year round

Quality: poor

Collection time: not long approx 30 minutes

Drinking and cooking: no – the quality is too poor

Washing and Laundry: all year – people bathe and take clothes there

Livestock: Fulani take their cattle there to drink, November through April

A3 - GURUSU KUTA (Niger State)

No hungry season

Population now: 1500

Population 5 years ago 1000

Livelihood: farmers – yam, corn maze

2ndary: some work in Minna

Main source of income: selling yam

2ndary source of income: selling other crops

Comments: saw some evidence of malnutrition in the children.

Source 1: Borehole

Available: all year round, but declines in March and April

Quality: good all year

Collection time: in rainy season less than 20 minutes, March April: wait for 30 minutes, so much slower

Drinking and cooking: all year round

Washing and laundry: all year round

Source 2: rainwater

Available: May to September

Quality: good

Collection time: minutes

Drinking and cooking: May to September

Washing and Laundry: May to September

Source 3: river

Available: May - December, Intermittent to February, dry Mar April

Quality: Poor

Collection time > 1 hour

Only use if borehole is broken

A4 - SABON GIDA (Niger State)

No hungry season

Population now: 700

Population 5 years ago 350

Livelihood: farmers – yam, corn, maze, millet, groundnut

2ndary: some work in Minna if educated

Main source of income: selling corn and yam

2ndary source of income: selling other crops

Comments: All farmers in village but there are many Fulani that come to the village for water

Source 1: Borehole

Available: all year round, but may decline when the demand is too high (it gets slightly muddy), mostly in dry season, this has only been a problem in recent years as the demand from the larger population has grown

Quality: usually good but if pumped too long then it goes muddy, often muddy by the end of the day. The quality recovers over night.

Collection time: in rainy season less used and little waiting as they collect rainwater mostly, October - April: wait for up to 1 hour

Drinking and cooking: September – May, little used in wetter months

Washing and laundry: September – May, little used in wetter months

Water is used by Fulani for animals also

Source 2: Rainwater

Available: May to September

Quality: good

Collection time: minutes

Drinking and cooking: May to September

Washing and Laundry: May to September

Source 3: River

Available: May to October

Quality: Poor

Collection time up to 1 hour+, 2.5 km away not used often

Only used to do washing and laundry

Water is used by Fulani for water

A5 - GODNA (Niger State)

No hungry season

Population now: 2000

Population 5 years ago 700

Livelihood: farmers – yam, corn, maze

2ndary: other crops, beans, rice, groundnut

Main source of income: selling yam and maize

2ndary source of income: selling other crops

Source 1: Borehole

Available: all year round, but yield declines in dry season - October to April

Quality: good in dry season but sometimes poor after rains, muddy

Collection time: in rainy season less than 20 minutes, Jan to April: wait for 30 minutes, so much slower

Drinking and cooking: all year round

Washing and laundry: all year round

Not routinely used for anything else as the yield in the dry season is low

Source 2: Rainfall

Available: May - September

Quality: ok

Collection time: minutes

Used May – September for washing and laundry as the yield in the borehole is low

Source 3: River

Available May – September, the borehole is used at other times

Quality : poor do not drink

Collection time: 45min – 1 h

Used only for washing and livestock

A6 - ESSA (Niger State)

People now: 1500 people

People 5 years ago: 1000 people

Hungry season is really rare, only in dry season

Livelihoods: farming: corn, potato, cassava, maize, groundnut, pepper, beans, melon

2ndary: Make soap and make groundnut oil and sell

Income, mainly from selling corn and melon

Have diversified the crops they grow in the last 5 years greatly

Source 1: Borehole (two in village)

Available: all year round good yield

Quality: good all year, but occasionally coloured in the rainy season. They use less soap in the rainy season which may indicate that the borehole taps a shallow and deeper source. May be prone to contamination,

Collection time: around 10 minutes unless the other borehole in the village is broken then it can take up to an hour.

Drinking and cooking: all year round

Washing and laundry: all year

Irrigation: yes, the water is used to water plants when needed

Source 2: River

Available: May - September

Quality: Poor

Collection time: 30-40 minutes

Drinking and cooking: yes – when borehole coloured

Washing and laundry: Yes

Animals for drinking: Yes, also irrigation

Source 3: Rainfall Harvesting

Available: May to September

Quality: good

Drinking and cooking: yes

Washing and laundry: yes

Note: not used for anything else

A7 - NDABISAN (Niger State)

Hungry season: they have enough food all year round

People now: 2500 people (33 large households)

People 5 years ago: 2000 people

Livelihoods: farming: rice; guinea corn, millet, maize, groundnut, melon

2ndary: Fishing, animals

Income: selling farm products

Change in population, and demand for water. The boreholes are the only source of potable water during the dry season, sometime need to boil water from wells in compounds in dry season.

Source 1: Borehole (several available)

Available: all year round

Quality: good all year

Collection time: 10-20 minutes usually unless the other boreholes have problem then it can take 1 hour and sometimes 2 – 3 hours

Drinking and cooking: all year round

Washing and laundry: Yes

Animals for drinking and irrigation, the water is used to water plants in the dry season

Source 2: Rain

Available: May - September

Quality: very good

Drinking, cooking, Washing and laundry: Yes

Animals for drinking and irrigation: yes some

Source 3: River

Available: All year but less in dry season, large river

Quality: good in rainy season but poor in dry season

Collection time: 20 minutes

Use the river for everything as they have done for years. The borehole is not easy to get to for some of the village (near to the river) and they therefore use the river instead especially in the wet season.

A8 - GBAKOGI KASARA-1 (Niger State)

Hungry season: they have enough food all year round

People now: >1000 people (50 households)

People 5 years ago: only 10 households, many have moved in from other areas

Livelihoods: farming: yam, rice , melon, corn

2ndary: some work as civil servants in towns, Minna, Bida

Income: selling farm products

Large change in population recently, rationing of water needed to control use. Village split into 5 groups each with 3 hours use a day for borehole.

Source 1: Borehole

Available: all year round; looks as if it has a low yield in the dry season, strictly rationed: 5 groups use it for 3 hours a day each

Quality: poor quality in the dry season good in the rainy season, low yield and muddy in dry season.

Collection time: 10-20 minutes usually in the dry season, there is less demand in the wet season.

Drinking and cooking: all year round

Washing and laundry: Yes

Animals for drinking and irrigation: No

Source 2: Rain

Available: May - September

Quality: ok but don't like taste as much as borehole.

Drinking, cooking, Washing and laundry: Yes

Not used for anything else.

Source 3: Wells

Available: May - September

Quality: poor

Collection time: some minutes only

Use: it is not used for drinking often unless the borehole is not working. Washing.

B1 - KADNA (Niger State)

District: Siroro

Dry season Nov – April

Wet season mid April to November

Hungry season: beginning of rains

People now: 600 people

People 5 years ago: 400 people

Livelihoods: farming: yam, maize, corn beans

Income, mainly from selling yams, and other farm produce

Increase in population has meant that farming has increased – and hence income...

Source 1: Borehole

Available: all year round, but declines in march and April, have to let it rest of 10 – 15 minutes

Quality: good all year, but sometimes initially bad when they pump in wet season

Collection time: in rainy season less than 20 minutes, Jan to April: wait for 30 minutes, so much slower

Drinking and cooking: all year round

Washing and laundry: wet season, not so much in dry season

Animals for drinking: all year – fetch for them

Source 2: River

Available: all year round

Quality: poor

Collection time: < 30 minutes

Used in Jan – April for washing and laundry because quicker than waiting for the borehole

Source 3: Dug well

Available May October

Quality : moderate to poor

Used for drinking, washing and livestock

NB – not sure if well still used for drinking now that borehole is there.

B2 - VEMU (Niger State)

People now: 300 people

People 5 years ago: 250 people

Livelihoods: farming: yam, maize, guinea corn, rice beans

Income, mainly from selling yams, and other farm produce

Things are better now than they were 5 years ago

Source 1: Borehole

Available: all year round, but declines in March and April,

Quality: good all year, but coloured Jun to September

Collection time: in rainy season less than 20 minutes, Jan to April: wait for 30 minutes, so > 30 MINUTES

Drinking and cooking: all year round

Washing and laundry: no

Animals for drinking: no

Source 2: Rainwater harvesting

Available: May - October

Quality: better than borehole during rains

Collection time: minutes

Drinking and cooking: yes – when borehole coloured

Washing and laundry: Yes

Animals for drinking: no

Notes: everybody has some zinc house.

Source 3: Stream

Available: flowing May to January, dugouts February to April

Quality: poor

Collection time: < 30 minutes: quicker than the borehole during the dry season since you don't have to wait

Washing and laundry: all year round, when no rainwater harvesting

B3 - Kalachi (Niger State)

Hungry season: they have enough food all year round

People now: 2000 people (50 families)

People 5 years ago: 700 people

Livelihoods: farming: rice; guinea corn, yam, beans, some civil servants

Income, mainly from selling rice

Not much change in 5 years except (increase in population (description of what marriage leads to !)

Source 1: Borehole

Available: all year round – does not decline

Quality: good all year, but red sometimes when you first collect

Collection time: in rainy season less than 20 minutes, Feb to April: wait for more than 30 minutes, you can go to the river 3 times in the time you wait or your turn

Drinking and cooking: all year round

Washing and laundry: Yes

Animals for drinking: 20 animals get their drinking water in dry season

Source 2: Well

Available: all year round

Quality: good all year, equivalent to borehole

Collection time: often quicker then borehole in dry season, for people who live close

Washing and laundry: Yes

Animals for drinking: some animals

Source 3: River

Available: all year round, but less water in February to April – have to dig a little for it.

Quality: less good than borehole, but OK

Collection time: quicker than borehole in dry season (approx 30 minutes), in wet season it is longer collection time than borehole

Drinking and cooking: Yes

Washing and laundry: Yes

Not sure – but could be easier to wash clothes in the river water

B4 - Aliyu (Niger State)

No English spoken – no translater; Falani living very closeby

People now: 300

Livelihoods: farming: guinea corn, rice, yam, cassava

Income, mainly from selling guinea corn

Source 1 Borehole

Available: all year round

Quality: not very good – smell and colour

Collection time: < 20 minutes all year round

Drinking and cooking: Yes

Washing and laundry: Yes

Source 2 Well

Available: all year round

Quality: same as the borehole – has colour and smell

Not sure what they use it for – its close to the borehole

Source 3 River

Available: until about February

Quality is OK

Used: for farm when planting

Not sure what else its used for.

B5 - Kudugi (Niger State)

Hungry season: they have enough food all year round

People now: 700 people in 8 compounds and about 80 families

People 5 years ago: 500 people

Livelihoods: farming: sugar cane, rice, yam, some civil servant

Income, mainly from selling sugar cane – some people get about 30 000 NGN from the sugar cane

Not much change in 5 years

Source 1: Borehole

Available: all year round – does not decline, but more people use it in dry season

Quality: generally good, sometimes goes white and has sour taste, generally don't like the taste

Collection time: in rainy season less than 20 minutes, Jan/Feb to April: wait for more than 30 minutes, or an hour – and there can be fighting. You can go to the river 2 times by the time you wait for your turn

Drinking and cooking: all year round

Washing and laundry: Yes all year round

Source 2: River

Available: most of the year, but not in march April, although there may be water in a few dugouts

Quality: good

Collection time: greater than 30 minutes, often quicker than borehole in dry season while the water lasts

Drinking and Cooking – yes when available

Washing and laundry: Yes when available

Animals for drinking: some animals

Source 3: Rainwater harvesting

Available: during rainy season (June to September)

Quality: good

Collection time minutes

Drinking and cooking: Yes when available

Washing and laundry: Yes when available

SUMMARY DATA SHEETS FOR GUSAU STUDY AREA, NIGERIA

A9 - KADADDABA (Zamfara State)

Hungry season: 2008 was a bad crop and had to buy food

People now: 700 people in 20 compounds

People 5 years ago: 500 people

Livelihoods: farming: millet, corn, pepper, maize and beans

2ndary: animals and selling tea on the road.

Income: mainly from selling some milk and tea on roadside

UNICEF installed borehole and trained someone to fix.

Source 1: Borehole (1 of 5 working boreholes in larger community of 2000)

Available: all year round

Quality: good

Collection time: 2-30 minutes depending on time of day

Drinking and cooking: yes

Washing and laundry: yes

Not used for irrigation at all, but used for building.

Water is used for animals also

Source 2: Well

Available: all year from hand dug wells

Quality: good

Collection time: 2 – 30 minutes

Drinking and Cooking – yes

Washing and laundry: Yes

Animals for drinking: only in dry season

These sources are available all year and there is generally less waiting, they are inside the compounds

Source 3: River

Available: all year: flowing in the rainy season, dugouts in the dry season

quality: good

Collection time: 20 minutes

Drinking and cooking: no longer used to drink or for cooking.

Washing and laundry: Yes and livestock drinking water.

A10 - DANGAMGI (Zamfara State)

Dry season : 7 months

Wet season: 5 months usually

Hungry season: no

People now: 600 people in 70-80 households

People 5 years ago: 300 people increase mainly from more children

Livelihoods: farming: corn, groundnut, rice, cotton, maize

2ndary: beans, pepper

Income: sell cotton, beans, maize, groundnut

Cotton is the main cash crop for the village.

Source 1: Borehole

Available: all year round, and does not decline

Quality: good all year

Collection time: 20 minutes all year

Drinking and cooking: all year round

Washing and laundry: all year round

Animals use water also

Source 2: River

Available: May/June-September, dig holes in river bed to collect small amounts of water in dry season (see below for uses)

Quality: good

Collection time: 30 minutes

Used in wet season drinking, washing and laundry as well as for animals, as the quality is good. This source is nearer for some villagers than others, some still prefer to use the river water.

Source 3: Rainfall harvesting

Available May/June - September

Quality : good

Used for drinking, washing, cooking and livestock

A11 - KADAURI (Zamfara State)

Dry season : 6-7 months

Wet season: 5-6 months usually

Hungry season: no

People now: 4-5000 people in 300 households

People 5 years ago: 3500 people increase mainly from more children in 200 households

Livelihoods: farming and animals: maize, corn, cotton

2ndary: other crops and panning for gold

Income: sell cotton, maize and corn

Cotton is the main cash crop for the village. The village like rain water in the wet season for consumption – this is stored for later use.

Source 1: Borehole (one of several in village)

Available: all year round, and does not decline

Quality: good all year

Collection time: <30 minutes May – September, up to one hour in dry season and longer by the peak of the dry season as this is the main source during this period

Drinking and cooking: all year round

Washing and laundry: all year round

Not used for irrigation at all.

Livestock use water also all year round

Source 2: Wells

Available: May/June-September, lower yield in the dry season used less in this period

Quality: ok

Collection time: 10 minutes in wet season

Used for drinking, washing and laundry as well as for animals in wet season

Source 3: Rainfall harvesting

Available May/June – September

Quality : best quality

Collection time: minutes

Used for drinking, washing, cooking and livestock not irrigation

A12 - KAZAWA KWARA (Zamfara State)

Dry season : 6-7 months

Wet season: 5-6 months usually

Hungry season: not often, if food runs out we sell animals to buy food

People now: 550 people in 100 houses

People 5 years ago: 400 people increase mainly from more children

Livelihoods: farming: maize, corn, millet

2ndary: some outside work in towns selling farm products

Income: maize, corn sometimes sell animals

Other villages are reliant on the borehole and travel from up to 3 km away. Borehole was installed in 1979.

Source 1: Borehole (one of two in area)

Available: all year round, but there is lower yield in the dry season, have to let the borehole rest after 10 buckets for about 30 minutes

Quality: good all year

Collection time: 30 min – 1 hour minutes all year, the water is collected throughout the day

Drinking and cooking: all year round

Washing and laundry: all year round

Livestock – only in the dry season

Users from further away use motorbikes and donkeys to collect water

Source 2: River and dug well in the river bottom

Available: May/June-September river ok, dig holes in river bed to collect small amounts of water in dry season, it often is not possible to collect water throughout dry season

Quality: good

Collection time: 5 minutes

Used in wet season drinking, washing and laundry as well as for animals, and some minor irrigation of plants in dry season

In the dry season it takes a long time to get water out of the river

Source 3: Rainfall harvesting

Available May/June - September

Quality : good

Used for drinking, washing, cooking, not used for livestock

A13 - GIDAN KANO (Zamfara State)

Dry season : 6-7 months

Wet season: 5-6 months usually

Hungry season: august

People now: 5000 people in 500 houses

People 5 years ago: 3500 people

Livelihoods: farming: maize, millet, corn, animals and fishing

2ndary: some outside work in towns selling farm products

Income: corn, maize, selling meat and fish to Abuja and Lagos

Source 1: Borehole (1 of 3 in the village)

Available: all year round – does not decline in yield

Quality: good all year

Collection time: minutes in the wet season – its not used much. In the dry season 30 mins to 2 hours because of the long queues

Drinking and cooking: all year round

Washing and laundry: all year round

Livestock in dry season

Source 2: Rainwater

Available: May/June-October

Quality: good

Collection time: 5 minutes

Used in wet season drinking, washing and laundry as well as for animals,

Source 3: River

Only source of water in dry season before borehole.

Available all year

Quality : ok

Time to collect: 1 – 2 hours

The river is not used much today but a lorry does fill up with water to bring to the village sometimes when demand is high

A14 - DOLEN MORIKI (Zamfara State)

District: Zurmi

Dry season November – April

Wet season: June – September

No hungry season

People now: 8000 people

People 5 years ago: 6000 people increase mainly from more children, also some returning with new wives

Livelihoods: farming: millet, guinea corn and cassava, potato, some livestock

Income, mainly from selling livestock, corn and potato's. During the dry season men work in nearby town to earn money also.

3 working BH in the village, 20 wells (20-25 m deep) – the borehole is repaired by the school teacher in the village.

Source 1: Wells

Available: all year round, and does not decline

Quality: good all year

Collection time: 20-30 min in dry season, <20-30 min in wet season

Drinking and cooking: all year round, use less for drinking now

Washing and laundry: all year round

Animals for drinking: Yes

Source 2: River

Available: May-October

Quality: good

Collection time: 10 minutes

Drinking and cooking: Yes

Washing and laundry: Yes

Animals for drinking: Yes

Source 3: Borehole

Available: all year round, and does not decline

Quality: good all year

Collection time: >30 min

Drinking and cooking: Only used for this

Rationed so that they collect after school

A15 - Badarawa (Zamfara State)

District: Shincafi

Dry season November – April

Wet season: June – September

No hungry season

People now: 3000 people

People 5 years ago: 2000 people increase mainly from more children, also some returning with new wives

Livelihoods: farming: millet, maize, guinea corn, some livestock

Income: mainly from selling livestock.

Source 1: Borehole (3 that work)

Available: all year round, but sometimes lower yields in dry season

Quality: good all year – some boreholes in the village are not good quality

Collection time: 2-5 minutes

Drinking and cooking: all year round

Washing and laundry: all year round

Animals for drinking: Yes

Source 2: Wells

Available: All year, sometimes need to wait to recharge in dry season

Quality: good

Collection time: 2-5 minutes

Drinking and cooking: Yes

Washing and laundry: Yes

Animals for drinking: Yes

Source 3: Rainfall harvesting

Available: June-Oct

Quality: ok

Collection time: minutes

Drinking and cooking: Yes

Washing and laundry: Yes

Only about 25% of the village use this borehole as others are nearer to them

A16 - Tungan Gurguri (Zamfara State)

District: Shincafi

Dry season November – April

Wet season: June – September

No hungry season

People now: 5000 people

People 5 years ago: 2-3000 people increase mainly from more children, also some returning with new wives

Livelihoods: farming: millet, maize, guinea corn, cotton, potato, veg, some livestock

Income: selling animals, tomatos, potatoes, cotton.

Source 1: Borehole

Available: all year round

Quality: good all year

Collection time: 20-30 minutes

Drinking and cooking: all year round

Washing and laundry: all year round

Animals for drinking: Yes

Source 2: Wells

Available: All year, sometimes need to wait to recharge in dry season

Quality: good

Collection time: 35-40 minutes

Drinking and cooking: Yes

Washing and laundry: Yes

Animals for drinking: Yes

Source 3: Rainfall harvesting

Available: June-Oct

Quality: ok

Collection time: minutes

Drinking and cooking: Yes

Washing and laundry: Yes

B6 - MATANKARI (Zamfara State)

District: Kaura Namuda

Dry season Nov – April

Wet season mid May to October

Hungry season: March – May – only start to use grain in silos once rain has come.

People now: 700 people

People 5 years ago: 400 people increase mainly from more children, also some returning with new wives

Livelihoods: farming: millet, guinea corn and groundnut, some livestock, up to 100 per household

Income, mainly from selling livestock, also groundnut

Reduction in yields due to lack of fertiliser

Men and children collect water

Source 1: Borehole

Available: all year round, and does not decline

Quality: good all year, but first pump of the day can be reddish

Collection time: in rainy season about 20 minutes, Jan to April: not much of a wait _ maybe 5 people waiting

Drinking and cooking: all year round

Washing and laundry: all year round

Animals for drinking: no

Source 2: River

Available: flows until November/ December then have to make dugouts in it – generally lasts through the dry season, but not in drought. Was their source of all water before borehole

Quality: Not so good since animals drink from it.

Collection time: < 30 minutes in rains, > 1 hour in dry season when was their main source – since they had to wait.

Used in rainy season for drinking and cooking by those staying close

Used all the year round for livestock

Source 3: Rainwater harvesting

Available: through rainy season May – October Most households will have some zinc.

Quality: not as good as borehole

Collection time: minutes

Used: drinking, cooking, washing laundry (some prefer to only use borehole water)

B7 - FAKAII (Zamfara State)

District: Zurmi

Dry season November to may

Wet season mid May to October

Hungry season: March – May – August

People now: 1000 people

People 5 years ago: 700 people increase mainly from more children

Livelihoods: farming: millet, guinea corn and groundnut, beans some livestock, 400 cows and sheep in total

Income: livestock main source of income, also from selling beans an d groundnuts

Reduction in yields due to lack of fertiliser

No zinc rooves in the village

Men and children collect water

(Had visited several boreholes before this, and many had large dug out 10 m away for the animals to drink and also for getting water for brick making

Source 1: Borehole

Available: all year round, and does not decline good yield. Its possible that it is in granite

Quality: good all year,

Collection time: January to April /May it can be 1 – 4 hours. It's only 15 minutes walk, but there are long queues in the dry season. This is because many more people use the borehole. 30 water vendors come from a nearby village where all their sources dry up. They sell the water for 20 Niari a 25 l Jerry can. Sometimes there is a little tension between the villages but quickly sorted out. The other village have no alternative. People collect every day.

Drinking and cooking: all year round

Washing and laundry: all year round

Animals for drinking: November to April (dry season only). They put containers down next to the borehole for them

Source 2: Man made ponds

Available: not particularly good, just ponds to allow rainwater to pond, only available May to October

Quality: Not so good since animals drink from it.

Collection time: minutes

Used only for livestock

B8 - DANMANAU (Zamfara State)

District:

Dry season: June to October/ November

Wet season mid June to October

Hungry season: March – September, food is scarce

People now: for whole village 8000 (570 HH) using the pump 100 HH

People 5 years ago: estimate 5000 people 5 years ago

Livelihoods: farming: millet, guinea corn, maize and beans t, some livestock (estimate 1000 cows and 2000 goats among 100 HH)

Income, mainly from selling millet (dry season) beans (wet season) and less from livestock

Reduction in yields due to lack of fertiliser and also a reduction in rainfall

Men and children collect water

Source 1: Borehole

Available: all year round, and does not decline can collect 1000 jerrycans

Quality: good all year, but turns red if left for 30 minutes

Collection time: in rainy season about 30 minutes, can be 1 hour in dry season Jan to May?

Drinking and cooking: all year round

Washing and laundry: all year round

Animals for drinking: Jan to June

Source 2: Wells

Available: generally available JULY to February, and also some throughout the year. Not that many people use them...

Quality: OK

Collection time: easy

Used all year round by some for washing and laundry. They tend to use the borehole water for drinking.

Wells are private affairs in their own compounds. Only some have...

Source 3: Ponds

Available: through rainy season July to November

Quality: not as good as borehole

Collection time: 40 minutes

Used – they take the animals there for drinking

Other parts of the village have other sources: one more hand pump, and another solar powered tank system

B9 - ADC – BATURA (Zamfara State)

Handpump next to the road in no mans land. Don't think it is anybodies main source.

USERS: some come from the town to fetch water

Nearby college sometimes use it when their own pump is not working.

It seemed to be fairly busy when we were there.

No one seems to take much ownership of it.

It is pretty close to the river, 500 m or so, which was flowing when we were there.

We had tried to sample a nearby village (10 km), but the water from the hand pump was not particularly good, and people did not tend to use it. They had their own wells which worked fine.

Conductivity was roughly the same as the ADC borehole.

B10 RUFAI FARM (Zamfara State)

Large circular spray irrigation scheme.

Its a federal contract. They have drilled three boreholes, and have got three sprayers in operation at the moment. They plan to drill another 20 boreholes.

American company involved. Met the American drillers and also the American agriculturist ericshumate@hotmial.com.

I asked him if he knew much about the water if it was good quality or if he was worried about it drying up. The reply was "Heck I don't know much about the water – it's sure growing the maize"

At the moment it is experimental, so not too bothered about markets. But hope to sell to local markets within the next few years.

He will send through information about the scheme if I email him.

Each sprayer takes 800 gpm (50 l/s) Seems about right from the size of the sprayers. I think they sprayed during the day and night for about 4 months for the crop. Hopefully confirm the figures from him.

Intersting contrast with the local irrigation 20 km away where boreholes drilled locally.

The area was used as a haven by birds...

Speaking to the drillers

Measured the SEC of the water from the borehole in their yard.

40 (same as the sprinkler)

BOREHOLE 31 812041 1394813 Altitude 315 m.

Depth 90

1000 gallons per minute.

Drawdown < 10 m

Water table in the area about 30 ms

Geology:

Fairly unconsolidated sands of different colours.

They encounter a hard ferrecrete layer everywhere, usually less than 30 m under the ground. Above that, the water can be not very good quality. The water tends to be a lot better at depth.

Red and white and grey sands

Aquifer: they encounter a white sugar sand, below that is a black peppercorn sand which has the most water in it. Wherever they find this they find a lot of water.

They have drilled many boreholes in the area:

Use reverse circulation

B11 - DAMRI (Zamfara State)

Had looked at many villages to find suitable place to sample for CFCs, and this clinic seemed the best. However, it was hopeless for a community discussion, so interview two men at the clinic who came from a rural village about 8 km away on the same geological environment.

Name of village: Tungar Maikidi

Name of discussant Osma Mohammad

Dry season: October: December to June

Wet season July to November

Hungry season: April to May to October

People now: 1800 (200 HH) using the pump 100 HH

People 5 years ago: estimate 1100 people 5 years ago

Livelihoods: farming: millet, rice, guinea corn,

Animals: cows, sheep, goats, camels

Income, mainly from selling millet animals (8 – 10 sold yearly by household); they also sell rice

Not many changes

Men and children collect water

Source 1: dug wells (several throughout the village – about 15m deep)

Available: all year round, and does not decline : can collect 300 jerry cans.

Quality: good all year,

Collection time: 30 minutes, it is the same all year round

Drinking and cooking: all year round

Washing and laundry: all year round

Animals for drinking: none

Source 2: dug well for animals

Available: all year round

Quality: OK

Collection time: 30 minutes

Used November to may

Some people also use it for drinking since closer to them, but most people prefer to go for other wells

Source 3: Small River

Used for animals in wet season

Source 4: Borehole

They have a borehole in the village which they used to use for drinking. It yielded well all the year round, but occasionally would break. The last time it broke they decided not to fix it, since the wells gave enough good water.

B12 - BADDAMMA DANGARA (Sokoto State)

Dry season: October: December to June

Wet season May to November

Hungry season: April to September

People now: 7000 (600 HH)

People 5 years ago: estimate 350 HH 5 years ago big increase as new people coming in and babies

Livelihoods: farming: millet, guinea corn, beans, rice, maize

Animals: per HH 10 – 50 cows, 100 sheep and goats

Income, mainly from selling beans. They don't sell cows

Men and children collect water

Source 1: hand pump (not the main source in the village)

Available: all year round, and does not decline : currently collect about 150 jerry cans

Quality: good all year,

Collection time: 30 minutes, it is the same all year round not much queues

Drinking and cooking: all year round

Washing and laundry: all year round

Animals for drinking: yes – falani come here for water. Seen as an open source for people to come and use if they don't have their own wells.

Source 2: Dug well for animals

Available: all year round

Quality: OK

Collection time: minutes, never much queues for it, but water level deep – 15 m

Drinking and cooking: all year round

Washing and laundry: all year round

Animals for drinking only dry season Jan to May

Source 3: Ponds

Cows drink from ponds (nearby) during rainy season June – December)

Source 4: Irrigation boreholes

About 7 people in the village have had shallow boreholes drilled in the farm, using a wash method (see sort movie and pictures).

This cost about 100,000 naira to have drilled and installed with a suction pump. They tend to be about 15 m deep and are in the low lying area

Last year someone drilled and made 800,000 naira from selling beans in one season.

They reason everyone can'd do it is that they don't have the access to capital to get the borehole put in.