ANNEX 2: MAIDUGURI

Introduction

The study was carried out in the city of Maiduguri, which sits across two Local Government Areas (LGA): Maiduguri and neighbouring Konduga, in Borno State, north eastern Nigeria (Figure A2.1).

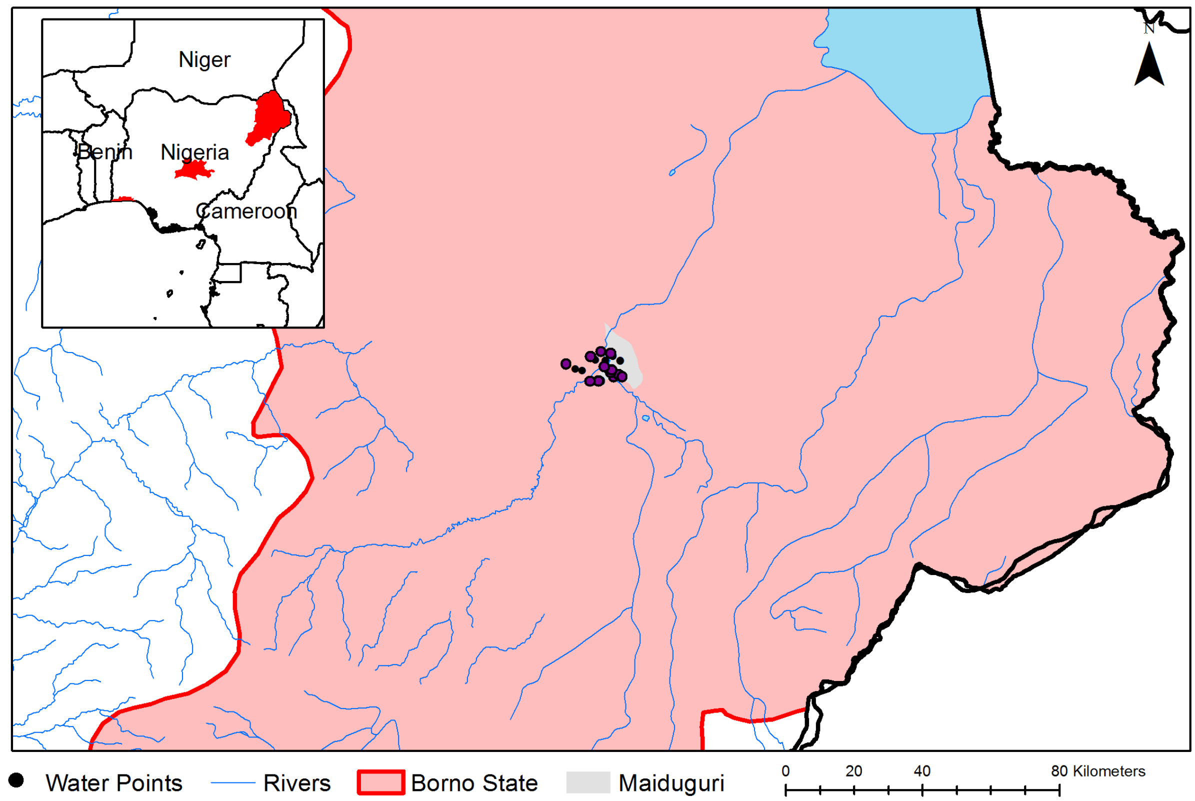


Figure A2.1 Location map of Maiduguri Study Area in north east Nigeria; inset shows the 3 pilot study regions

Maiduguri and environs lies in the semi-arid region of Nigeria, which is characterized by low rainfall of approximately 600 mm per annum and high evapotranspiration of over 2000 mm per annum. Surface water is largely seasonal with rivers flowing for around three months of the year. The Alau dam holds water throughout the year; its water is treated for public supply but only extends to around 30% of the population of Maiduguri and its environs. Groundwater therefore provides the dominant (perennial) supply of water to the inhabitants of Maiduguri and its surrounds.

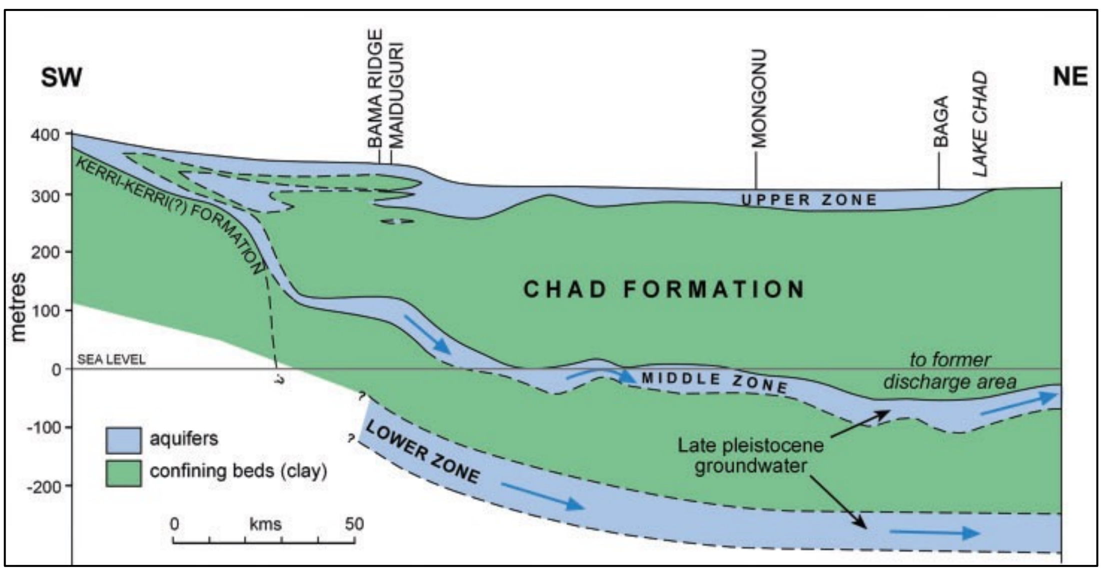
Despite efforts by the Government, often in collaboration with UNICEF and other international NGOs, access to safe drinking water continues to be one of the critical issues currently facing Maiduguri. The situation has been exacerbated by the insurgency, which has almost doubled the population of the area, with corresponding increases in demands for water supply.

In this region, four fieldwork activities were undertaken:

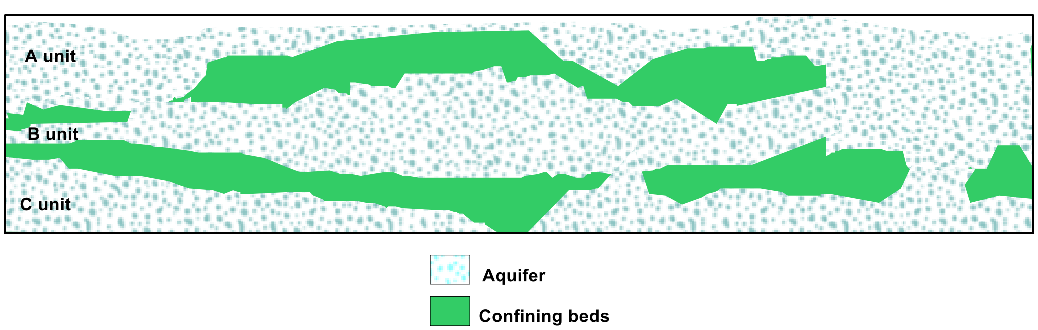
1. Household Surveys: to determine how different water sources are used at the household level and what users' perceptions of these sources are in terms of quality, reliability, and resilience
2. Community Discussions: with groups of men and women living in 2 IDP (internally displaced people) camps in northern Maiduguri
3. Water Point Surveys: water point description, water quality sampling, and vulnerability assessment
4. Stakeholder Interviews: with key actors involved in water supply, including the Rural Water and Sanitation Agency (RUWASA), private drilling companies, NGOs, and the media

Geology & Hydrogeology

In the Maiduguri area, groundwater occurs in the Plio-Pleistocene Chad Formation, under water table, perched, semi-confined, and confined conditions. Three well-defined arenaceous horizons within the argillaceous Chad Formation constitute the aquifers, and were named by Barber & Jones (1960) as the Upper, Middle and Lower Aquifers (Figure A2.2a).



(a)



(b)

Figure A2.2 (a) Geological cross section of the Chad Formation in the Nigerian sector of the Chad basin; (b) Sketch cross section of the Upper aquifer system in Maiduguri, showing the A, B and C units.

The Upper Aquifer in most of the study area is within the superficial deposits, and extends across the entire outcrop of the Chad Formation. It is composed of alluvium and aeolian sand and gravels, deposited during recent times. However, around the type locality (Maiduguri) the Upper Aquifer includes not only a surface zone of recent sands with an unconfined water table, but deeper sand layers of the Chad Formation complexly interbedded with confining clay horizons. Beacon Services Limited (1979) called the Upper Aquifer a system, because of the three definable units, which they termed A, B and C units (Figure A2.2b): A is the unconfined aquifer largely within the superficial deposits at depths of about 40 m; B is artesian to leaky artesian at depths of 70 m; and C is artesian with negligible leakage with depths of over 90 m. Most the boreholes sampled exploit units A and B. Very few private boreholes tap unit C (in this pilot study only two boreholes extend to this unit) because of the depth and thus increased cost of drilling.

The State of Play

Sources of water used in communities visited (from Community Interviews)

Across the Maiduguri study area, water for domestic use is primarily sourced from private boreholes. This includes hand pump and motorised boreholes, some with water storage facilities in tanks or reservoirs. The majority of privately drilled boreholes also supply water to neighbouring households, either as a piped supply to individual houses or through a community tap. Bottled/sachet water is sometimes used for drinking, and public (piped) water supply is available in some parts of the city.

Water source preferences (from Community Interviews)

Ten household surveys were carried out across the Maiduguri study area; their water source preferences are summarised in Table A2.1. All households have a privately drilled borehole and three have access to the public (piped) water supply. Of the three households with piped water, only one stated this as the preferred water source, the others preferring to use water from their own boreholes. Two households without access to the public water supply stated that this would be their preference over their own borehole because the water is treated. Three of the households prefer to use sachet water for drinking, instead of water from their boreholes, because of better quality.

Household	Private Borehole Available	Public (piped) Supply Available	Preferred Source (for drinking)
1	YES	YES	PUBLIC
2	YES	YES	PRIVATE BOREHOLE
3	YES	YES	PRIVATE BOREHOLE
4	YES	NO	PUBLIC

5	YES	NO	PUBLIC
6	YES	NO	PRIVATE BOREHOLE
7	YES	NO	PRIVATE BOREHOLE
8	YES	NO	PRIVATE BOREHOLE & SACHET
9	YES	NO	SACHET
10	YES	NO	SACHET

Table A2.1 Water source availability and preferences from Maiduguri Study Area

Boreholes are also the primary source of water for groups in the IDP camps. However, community groups reported issues with the quality (both in terms of taste and illness) and quantity of water provided. In both camps, community members stated a preference for public water supply as this is perceived as being better quality. In one of the camps, the borehole water is not used for drinking and community members choose to buy water, or travel up to 3km to retrieve water from households that are connected to the public (piped) supply.

Trend to development of private domestic boreholes (from Community Interviews)

The household surveys and stakeholder interviews point to a proliferation of private borehole development in Maiduguri since the late 1990s. Of the ten water points surveyed during this study, all were less than 25 years old and half were developed within the last ten years. The main reason given for this is the inefficient, unreliable, and in many cases completely absent public water supply. The general manager of RUWASA estimated that the public water supply only extends to 30-40% of the population of Maiduguri, which has resulted in more than 2000 private boreholes being drilled into the upper aquifer. This situation is being exacerbated by a significant influx of people into this region due to the insurgency, which has seen an increase in the number of boreholes drilled by NGOs for IDP camps – there are an estimated 10-15 boreholes per camp, all exploiting the upper aquifer.

Details of sources tested

The following 29 sources were tested across Maiduguri:

- 22 boreholes with motorised pumps (nine of which were sampled after storage in a tank)
- 7 boreholes with hand pumps

Detailed water point and household surveys were carried out at 14 of these sources, of which ten were privately owned (all motorised boreholes). The remaining four sources (two motorised and two hand pump boreholes) were developed by NGOs for IDP camps. Water quality testing was carried out at the 15 additional sources, but detailed user surveys were not. A summary of the data collected is provided in Table A2.2.

Source Type	Source Depth Measured /Known	Water Level Measured	Vulnerability Assessed	EC Measured	Nitrate Measured	Iron Measured	E. Coli Measured

MB (13)	4	2	8	12	12	0	12
MB* (9)	0	3	4	9	9	0	9
HPB (7)	2	1	2	7	7	0	7

Table A2.2 Summary of data collected for water sources in Maiduguri Pilot Study Area (MB: motorised borehole; MB*: motorised borehole with storage tank; HPB: hand pump borehole)

As shown in Table A2.2, depth and/or water level data was only known or measured for nine of the water points surveyed. The depth of the sources, which include both manually and mechanically drilled boreholes, ranged from 60 to 120m, with the majority between 60 and 70m depth (Figure A2.3). Water levels were predominantly greater than 20m below ground level (bgl), with one shallower level (12mbgl) measured in a borehole close to the Ngadda River.

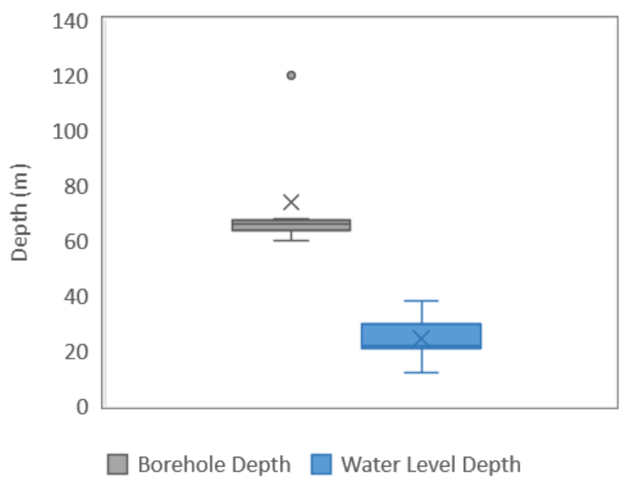


Figure A2.3 Known or measured source and water level depth

Vulnerability assessments were carried out at 14 water points, providing a vulnerability score between zero (low vulnerability) and seven (high vulnerability). The factors considered in this score are summarised in Table A2.3. The results (Figure A2.4) show that the majority of sources in Maiduguri were classed as low to medium vulnerability, with one highly vulnerable hand pump borehole located in an IDP camp.

Factor contributing to vulnerability	**Vulnerability Score**
Presence of a pollution source within 10m of the water point: No / Yes (at a lower elevation) / Yes (at a higher elevation)	0 / 1 / 2
Poor drainage around the water point causing ponding within 2m: No / Yes	0 / 1
Concrete apron of radius > 1m: Yes / Yes but damaged / No	0 / 1 / 2
Cover over the water point: Yes / No	0 / 1
Fencing around the source: Yes / No	0 / 1
TOTAL SCORE (sum of all scores above)	0 to 7

Table A2.3 Factors considered in the water point vulnerability assessment score

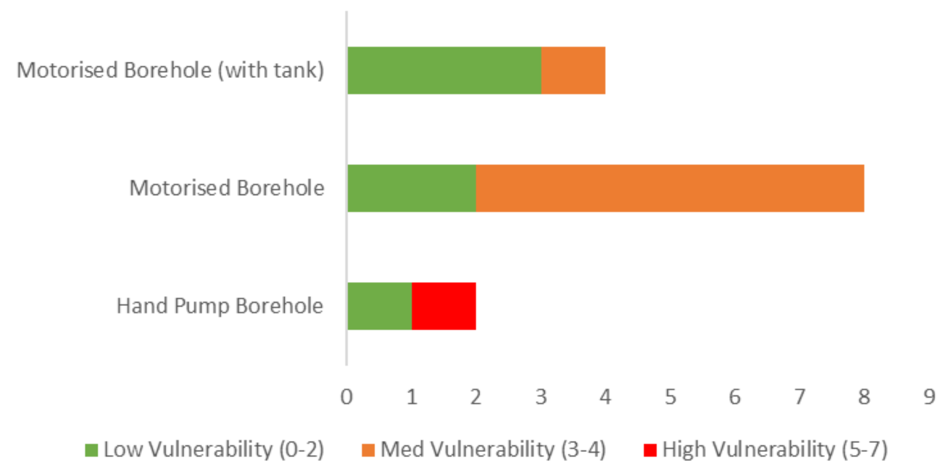


Figure A2.4 Number of sources classed as low, medium and high vulnerability

Water Quality of Sources Tested

Several water quality parameters were collected to determine the quality of groundwater from different source types across the Maiduguri Pilot Study Area: E. Coli concentration, nitrate, and specific electrical conductance (SEC). SEC gives a measure of the dissolved material in groundwater and can be elevated by natural or anthropogenic processes. SEC is often used in combination with other water quality indicators, such as nitrate and microbiological parameters, to indicate anthropogenic contamination. E. Coli is a coliform bacteria indicative of faecal contamination in groundwater, which is a known contributor to the diarrhoeal disease burden (Pruss-Ustun et al, 2014). The main source of faecal contamination in urban groundwater is municipal and domestic waste (e.g. pit latrines, septic tanks, sewer leakage, sewage effluent and sewage sludge), particularly where there is high population density and inadequate sanitation and sewage treatment facilities. The ability of these microorganisms to survive in the environment is determined by the characteristics of the organism and the properties of the soil, unsaturated zone, and aquifer (Pedley et al, 2006). Concentrations in groundwater are dependent on the pathway from source to receptor, and may be attenuated in deeper and/or lower permeability aquifers. Elevated nitrate is frequently associated with high counts of faecal indicator bacteria, although the evidence surrounding the disease burden associated with nitrate in drinking water is complex (Lapworth et al, 2017). Sources of nitrate in drinking water include municipal and domestic waste, as well as agricultural use of fertilisers and pesticides. Denitrification (the reduction of nitrate) can occur in the environment under low oxygen conditions.

Figures A2.5 to A2.7 show the results of the nitrate, SEC and E. Coli sampling for groundwater sources across the Maiduguri Pilot Study Area. It is difficult to infer any meaningful relationships between source type or depth and water quality from these results. All sources are exploiting the upper unconfined aquifer, which may be vulnerable to contamination from surface activities. A slightly higher percentage of hand pump boreholes show elevated nitrate concentrations compared to the motorised boreholes (Figure A2.5), a trend that is generally reflected in the SEC results (Figure A2.6), while a higher percentage of motorised boreholes show unsafe levels of E. Coli compared to the hand pump boreholes (Figure A2.7).

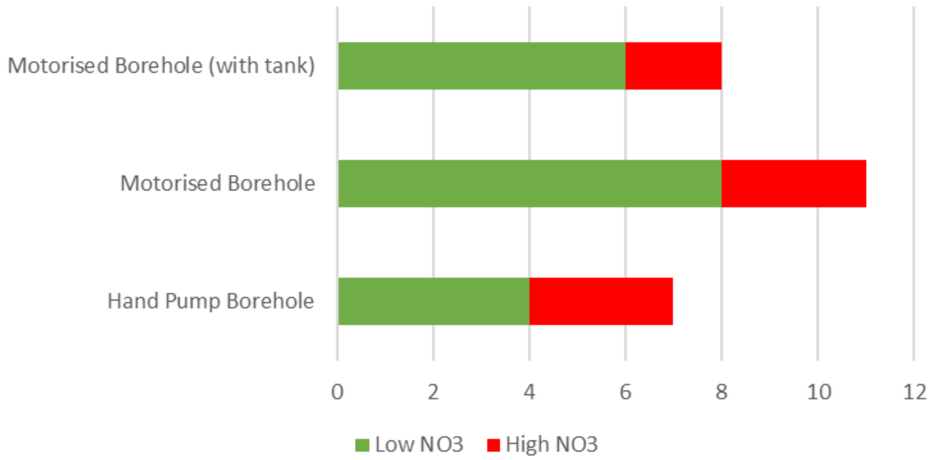


Figure A2.5 Source risk as indicated by nitrate concentrations and World Health Organisation classification from their Guidelines for Drinking Water Quality (low NO_3: <50mg/l; high NO3: >50mg/l)

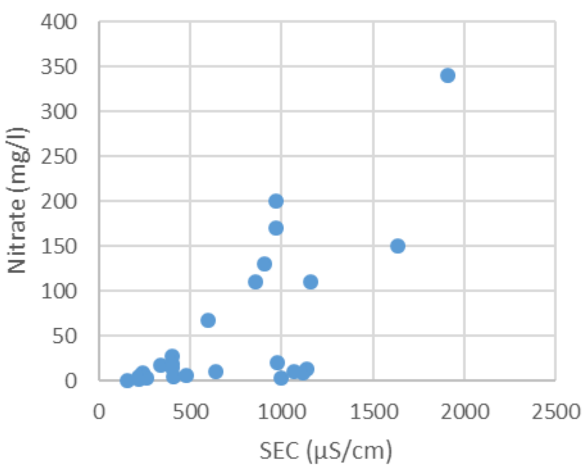


Figure A2.6 Positive relationship between SEC and nitrate concentrations for groundwater sources across Maiduguri study area

Of the 28 sources tested for E. Coli contamination:

- 15 sources were considered safe: 6 hand pump boreholes, 6 motorised boreholes, and 3 motorised boreholes with tanks
- 5 sources were considered intermediate risk: 1 hand pump borehole, 2 motorised boreholes, and 2 motorised boreholes with tanks;
- 8 sources were considered high or very high risk: 4 motorised boreholes, and 4 motorised boreholes with tanks.

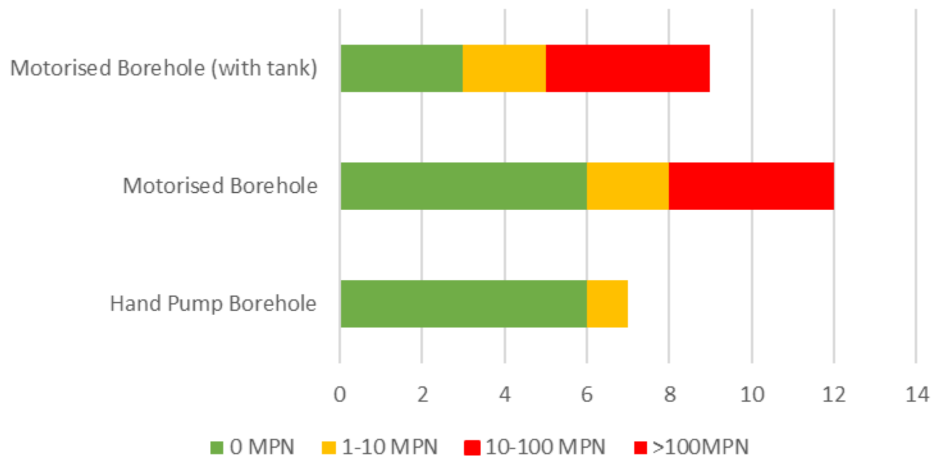
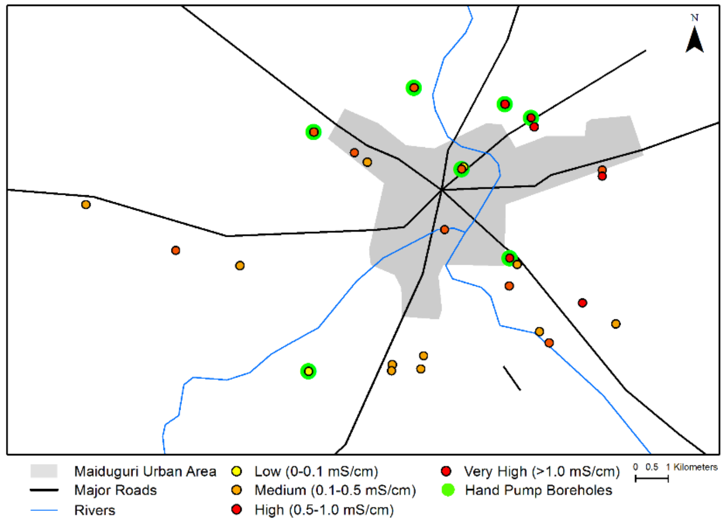


Figure A2.7 Source risk as indicated by E. Coli MPN method and World Health Organisation classification from their Guidelines for Drinking Water Quality

A vulnerability assessment was undertaken for six of the eight high or very high risk sources in Maiduguri. Five of these sources had a pollution source (soakaways) within 5-10m of the borehole, three had a concrete apron with a radius greater than 1m, five were covered, and all were fenced. The overall vulnerability of these sources was classed as low to medium (as were the majority of sources in this area).

Figure A2.6 shows that SEC and nitrate are generally well correlated, however there are some notable sources which show very elevated conductivities without high nitrate concentrations. These sources are all located in the north-eastern part of the study area (Figure A2.8). As in the Lagos Study Area, nitrate and SEC are not always indicators of faecal contamination, with several sources showing elevated nitrate (>50 mg/l) but no E. Coli contamination. These sources include both hand pump and motorised boreholes, and predominantly occur along the main road that runs from the northwest to the southeast through Maiduguri (Figure A2.8). It should be noted that microbiological indicators tend to show more temporal variation than nitrate and SEC. Repeat water quality sampling of these sources would be useful to determine variations in faecal contamination indicators over time.

Figure A2.8 shows some broad spatial trends in water quality, with those sources showing low nitrate and E. Coli concentrations generally located in more recently-settled areas with low population density and sources with higher concentrations located in older and more densely populated areas.



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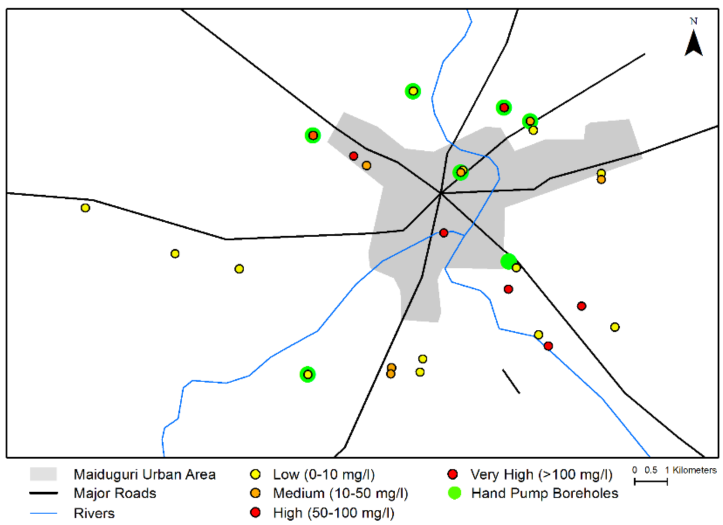

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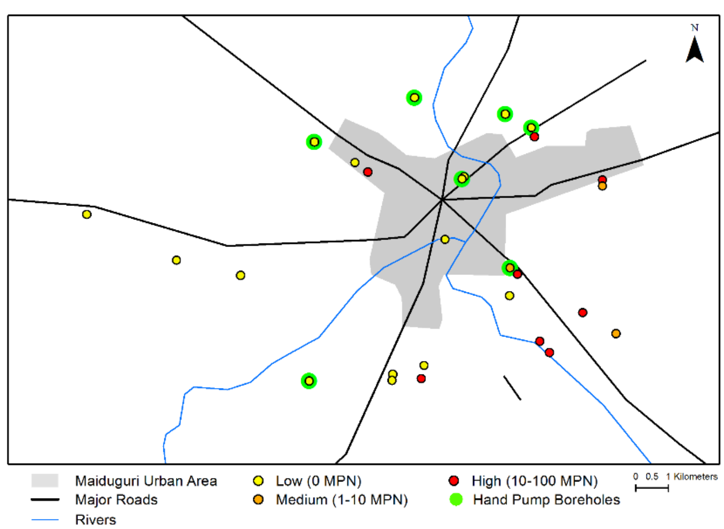
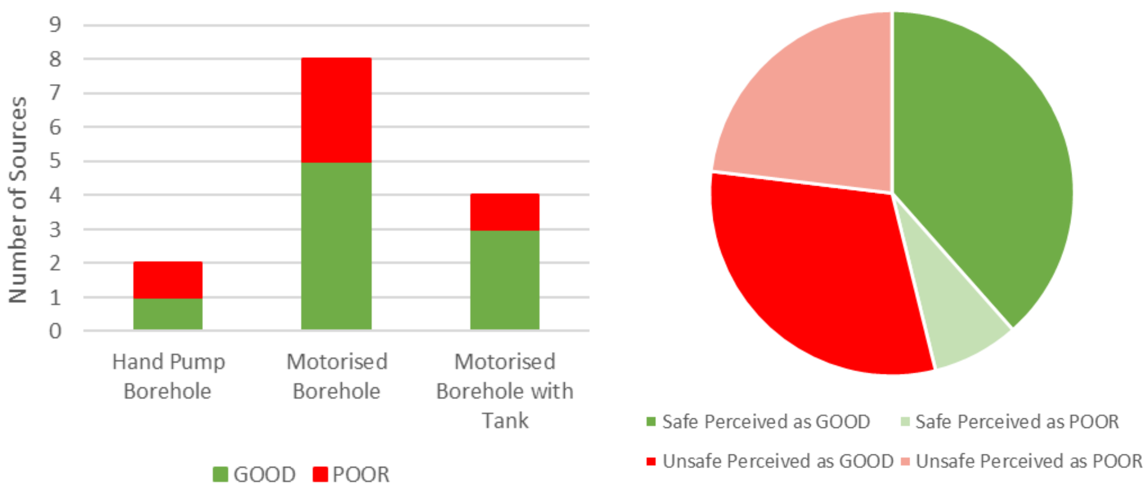


(c)

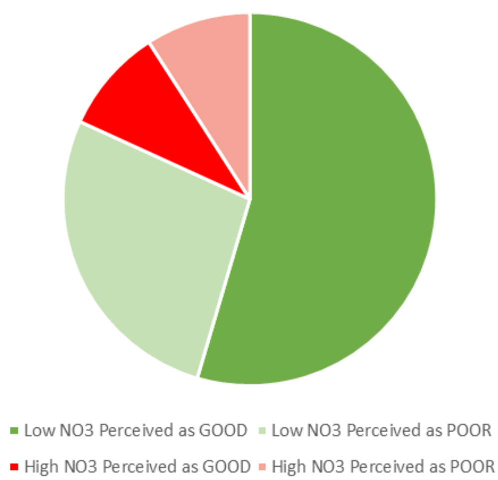
Figure A2.8 Spatial variations in (a) SEC, (b) nitrate, and (c) E. Coli

Perceptions of Sources Tested

The household surveys and community discussions provide information on peoples' perceptions of different source types in terms of the quality of water they provide. At 14 of the 29 sources tested, users were asked whether they perceived the quality of water as good or poor. The results show that 50% of hand pump boreholes, 63% of motorised boreholes, and 75% of motorised boreholes with tanks are perceived as good quality (Figure A2.9a). However, Figure A2.9 indicates that people's perceptions of water quality from a source do not necessarily reflect the safety of water for drinking.



(a) **(b)**



(c)

Figure A2.9 (a) Number of sources perceived as good and poor quality by users; (b) perceptions of safe (MPN: 0/100ml) and unsafe (MPN: >0/100ml) sources according to the E. Coli results; (c) perceptions of sources with low (<50mg/l) and high (>50mg/l) nitrate concentrations.

Of the nine sources perceived as good quality, four are classed as unsafe for drinking, according to the measured levels of E. Coli. These include two motorised boreholes and two motorised boreholes with tanks. In the case of nitrate, incorrect perceptions of water quality apply equally to hand pump and motorised boreholes. Of those perceived as poor quality, a salty taste was the main reason given, with one report of water causing sickness.

Information on the functionality of sources was collected for 14 water points in Maiduguri, of which 12 are reported to provide water all year round. The two sources that do not provide adequate water all year are motorised boreholes with storage tanks, one of which is situated in an IDP camp with a population too large to be supported by the available water supply. Depth information was not available for the boreholes supplying these systems however they were manually drilled, indicating a likely maximum depth of around 50m and certainly not deeper than 70m. Five of the 14 water points were reported to have broken down in the last year, all of which are motorised boreholes. The private sources were all reported to be fixed within days. The source that typically takes longer than one month to be repaired uses a solar powered pump and the solar panels were damaged by wind.

Issues with annual water availability and drought were only reported for one of the sources, while users of the remainder of the water points reported no experience of drought.

Developing boreholes (Underlying Drivers of Disaster Risk)

Reasons for sinking boreholes

The primary reason for the proliferation of private boreholes in Maiduguri, as highlighted by the household, community and stakeholder interviews is the absence of a government-provided public water supply. This was not available to 11 (80%) of the 14 households/communities interviewed, four of which were located in IDP camps. The remaining three households drilled private boreholes due to the poor quality and unreliability of the public water supply. Control, convenience, low cost of drilling, and water security were also stated as reasons for developing private boreholes. Other reasons include the status that a borehole can confer, as well as the lower cost of accessing water once a borehole is in place. For the NGOs drilling boreholes in the IDP camps the primary consideration was to be able to provide water quickly to as many people as possible.

Perceptions of public supply

The general perception of the public supply is that it is unavailable, inefficient and unreliable. In terms of water quality, perceptions of the public water supply were variable. Of the three households with access to the public supply, two of these viewed the water as poorer quality than that from their own boreholes. One household suggested that the public supply brought illness as it was not always treated properly. Set against this, one household felt the quality of the public supply they received was better than that of their borehole. More than half of households without access to the public supply perceived it to be better quality than water from boreholes.

Risk perceptions/problems identified of borehole development

When asked about perceived changes in the environment or weather over the past few years, more than 90% of households/communities (13 out of 14) reported one or more of the following: later onset of the rainy season, lower rainfall (in terms of intensity and/or duration), greater fluctuation in rainfall, and higher temperatures. Despite these observations, only 56% of households/ communities (9 out of 14) reported concerns about the impact this might have on the water table, and only 14% (2 out of 14) reported concerns about the amount of groundwater that might be available in the future. Two respondents stated a concern that the cost of accessing water may increase if the water table falls significantly, but the majority of households/communities believed that they would always be able to access sufficient water. Commonly repeated phrases included: “water is abundant”, “water is inexhaustible”, and “there will always be enough water”.

The General Manager of RUWASA stated that the majority of people are not aware of the risks or consequences of widespread private borehole development, a view also held by one of the manual drilling companies interviewed. This was particularly the case in terms of knowledge of good siting practice and the risk of drilling boreholes in too-close proximity to each other. The main risk identified by the wider population was of falling water tables. However, the population regards over-abstraction as a necessity and unlikely to constitute a problem, the response given to interviewers was that boreholes will simply need to be deeper.

Choice of contractors

The General Manager of RUWASA expressed concern that the majority of drilling of private boreholes is undertaken by inexperienced or unqualified drillers. The main factors influencing individuals’ choice of drilling contractor were word of mouth, quality of previous jobs, and the equipment a driller has available.

Treatment practices

The majority of private borehole owners do not treat their water. Users of boreholes in the IDP camps report treatment using tablets provided by NGOs, but most believe these are ineffective and choose not to drink the water from these boreholes. One private household reported the use of chlorine powder, which had been provided by UNICEF.

Differential (dis)incentives for action

What influences choice of water source

The over-riding influence on the choice of water supply is what is available. In the absence of the provision of a public water supply, (described as the failure of government to provide a reliable water supply) households are pushed into drilling their own borehole (or accessing the borehole of a neighbouring family. This is facilitated by the availability of shallow aquifer and the low cost of manual drilling, which make it affordable for a number of individuals in the region. All of the groundwater sources surveyed around Maiduguri are exploiting the upper unconfined aquifer. The low cost and suitability of manual drilling in this area make private boreholes an affordable option for many individuals and households.

An individual borehole also gives a sense of water security and control, which can be important where public provision is unreliable even where it is present. Some households choose to drink sachet water and use borehole water for other domestic uses. This tends to be due to preferences of taste and perceptions of quality. Cost can also play a role, with one household operating a shallow borehole and a deeper borehole utilising a high-capacity pump which is more expensive to operate.

The ease of installing a private borehole is increased by limited governance oversight. Government in the region does not restrict private borehole development, as there is no license or permit required.

Patterns of water use

Only three of the ten households surveyed had access to both a private borehole and public water supply, two of which stated a preference for the borehole water. Three of the households with access only to a private borehole use this conjunctively with sachet water for drinking. Users of the four boreholes surveyed within the IDP camps stated a preference for buying water or walking to neighbouring houses to collect water from the public supply for drinking purposes, using this conjunctively with the borehole for other domestic purposes.

Effects on adaptability

Households with a private borehole generally viewed this as a more reliable and abundant source than the public water supply, providing greater water security for their families. This has the following positive impacts on daily life: households worry less about the future, they save time through not having to collect water, and they save money by not having to purchase water from private vendors. Those that provide water to their neighbours also reported general benefits to the wider community, highlighting the significance of both individual and community effects.

Attitudes to water resource

As discussed above, the predominant attitude to (ground) water resources is that they are unlimited and inexhaustible. Those that recognised potential threats to the long-term supply related to climate change or over-abstraction, stated that they have no choice but to continue to abstract from private boreholes because they have no other option. Whilst there is a recognition that water tables will fluctuate, with a general perception that groundwater levels are falling (along with the drying of Lake Chad) this does not appear to influence overall perspectives on the long-term availability of the groundwater resource. Indeed, respondents suggested that as populations and water demands increase so the significance of the groundwater resource will also increase. No conservation practices are reported amongst households, which reflects the perception of an unlimited supply of water modulated only by the cost of access.

Role of governance

As in Lagos, groundwater governance in Maiduguri is limited with no clear policies from central or local government related to the development, management, or monitoring of groundwater. At present, government does not take responsibility for monitoring or regulating drilling and there is no data on the number of private boreholes being drilled or the volumes of water being abstracted.

As in all three of the pilot regions, the formal governance structures are notable by their absence. Proposed Federal legislation promulgated in 1993 and now referred to as Water Resources Act 100, remains under review and awaiting enactment. In this vacuum, policy actors state explicitly that in the absence of adequate public provision, households have little choice but to commission their own boreholes.

There is also only limited monitoring of the groundwater resource. Within Borno State there are only three monitoring stations commissioned by the Nigeria Hydrological Services Agency (NIHSA) and data has not been available since 2010. NIHSA is also responsible for water quality monitoring, but as yet a full programme is not in place due to lack of equipment.

Role of communication

Interviews with two radio stations in Maiduguri revealed that water is a major issue that is reported on, but with a focus on national issues, such as water in the national development plans, failure of government to provide adequate public water supply, children not attending school to collect water, the commercialisation of water, and the impact of the insurgency on water resources. The stations were not aware of the issues and potential risks surrounding the proliferation of private borehole development, but were positive that the media could play a critical role in educating communities and putting pressure on government to act.

Conclusions

- Poor public water supply provision and increased demand related to the insurgency has led to a proliferation of private boreholes in Maiduguri
- This is aided by ease of access to the shallow unconfined aquifer, the suitability and low-cost of manual drilling, and a lack of groundwater governance
- Where the public supply is available most prefer private boreholes
- Borehole and sachet water are the preferred sources for drinking
- There are broad spatial trends in groundwater quality with poorer quality generally seen in older, more densely populated areas

- Issues were reported with the availability and quality of water from boreholes in the IDP camps – this may suggest poor siting and construction where boreholes are installed quickly
- Households with a private borehole feel more secure, in terms of water security and financial security, and report worrying less about the future
- Despite widespread observations of reducing rainfall, only 14% reported concerns about the amount of groundwater that might be available in future

Future Research Questions

- How does chemical and microbiological contamination vary over space and time?
- Is the perception of abundant groundwater availability justified – how sustainable are rates of abstraction relative to recharge?
- What are the most effective ways to communicate the potential risks associated with uncontrolled borehole development to communities and local/national government?
- How can governance structures be improved/streamlined to control or manage private groundwater source development?

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