



Towards Sustainable Groundwater Management in the South-Western Part of the Chad Basin, Nigeria: A Stakeholder Perspective

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Authors' contributions

This work was carried out by author AB. The author designed the study, performed the content analysis, wrote the first draft of the manuscript and managed literature searches under the supervision of authors JA and CJ. All authors read and approved the final manuscript.

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ABSTRACT

This study evaluates current groundwater management problems in the chad basin and applies the transition management concept that allows stakeholder participation in addressing persistent problems of groundwater management. This has been achieved by carrying out stakeholder analysis; where a total of 5 stakeholder groups consisting of 15 organisations which includes government agencies, water user groups (local residents), civil society organisations, an NGO, and a research institution were identified and engaged via interviews and focus group discussions between April and June 2013. Interview and focus group results showed that most strategic stakeholders interviewed were knowledgeable on the issues related to groundwater contamination, while the focus group participants are having limited knowledge about the issue. Also, concerns about groundwater contamination were high among the interviewees and extremely low among the focus group participants. Presently, none of the stakeholder categories was affected by problems of groundwater contamination. Overall, interviewees and participants proffered options such as provision of adequate legislations, stakeholder inclusion/community participation in water management and the increase in investment in the water and sanitation sector as the most viable options of achieving sustainable

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groundwater management. The outcome of this study will be useful to water managers, policy and decision makers in implementing sustainable groundwater management strategy.

Keywords: Groundwater management; stakeholders; Chad Basin; Nigeria.

1. INTRODUCTION

Groundwater plays a vital role in the socioeconomic development of urban and rural areas in Nigeria. Out of the current population of about 168 million, more than half depend directly on this natural resource for their daily water needs. With a rapid population growth of about 2.5% per annum, the demand for water supply has progressively increased over the last three decades. The provision of safe drinking water has actually deteriorated - access in urban areas fell from 55 million people to 27 million people in 2002 alone [1] largely due to poor management, inadequate technical capabilities, lack of investment and insufficient manpower and their training [2]. Furthermore the institutions responsible for water supply are both ineffective and fragmented; thus a transition is needed to bring about a thorough and holistic change to the current system [3]. This change requires a long period of time to be effective, and into the future it can only be achieved by empowering and engaging the relevant stakeholders in groundwater management issues.

Rapid population growth and uncontrolled urbanisation further aggravates the increasing trend of above ground human activities that potentially affect the quality and quantity of the underlying groundwater by radically changing both recharge and abstraction, thus adversely affecting groundwater quality [4]. Urbanisation, dense population concentrations and human activities all severely affect groundwater quality especially in developing countries of sub-Saharan Africa where the urban expansion is poorly planned [5,6,7,8 and 9].

These problems pose a significant threat to the upper unconfined aquifer system of the Chad Basin around Maiduguri in northern Nigeria (Figs. 1, 2 and 3). This aquifer is the major water supply source for the city and it is hydraulically connected to the Ngadda River which drains the city [10]. This river – groundwater system is threatened by incessant waste disposal in recharge areas by residents and local businesses, uncontrolled pit latrine construction and other non-point sources of contamination across the city.

This negative impact is most significant in some of the areas in Maiduguri where tones of residential and commercial solid wastes are inappropriately dumped into the River Ngadda. The hydraulic connectivity that exists between the river and the upper aquifer serves as a pathway of groundwater contamination. This consequently poses unacceptable health risks to the local population, most especially the urban poor who largely depend on the groundwater without any form of treatment.

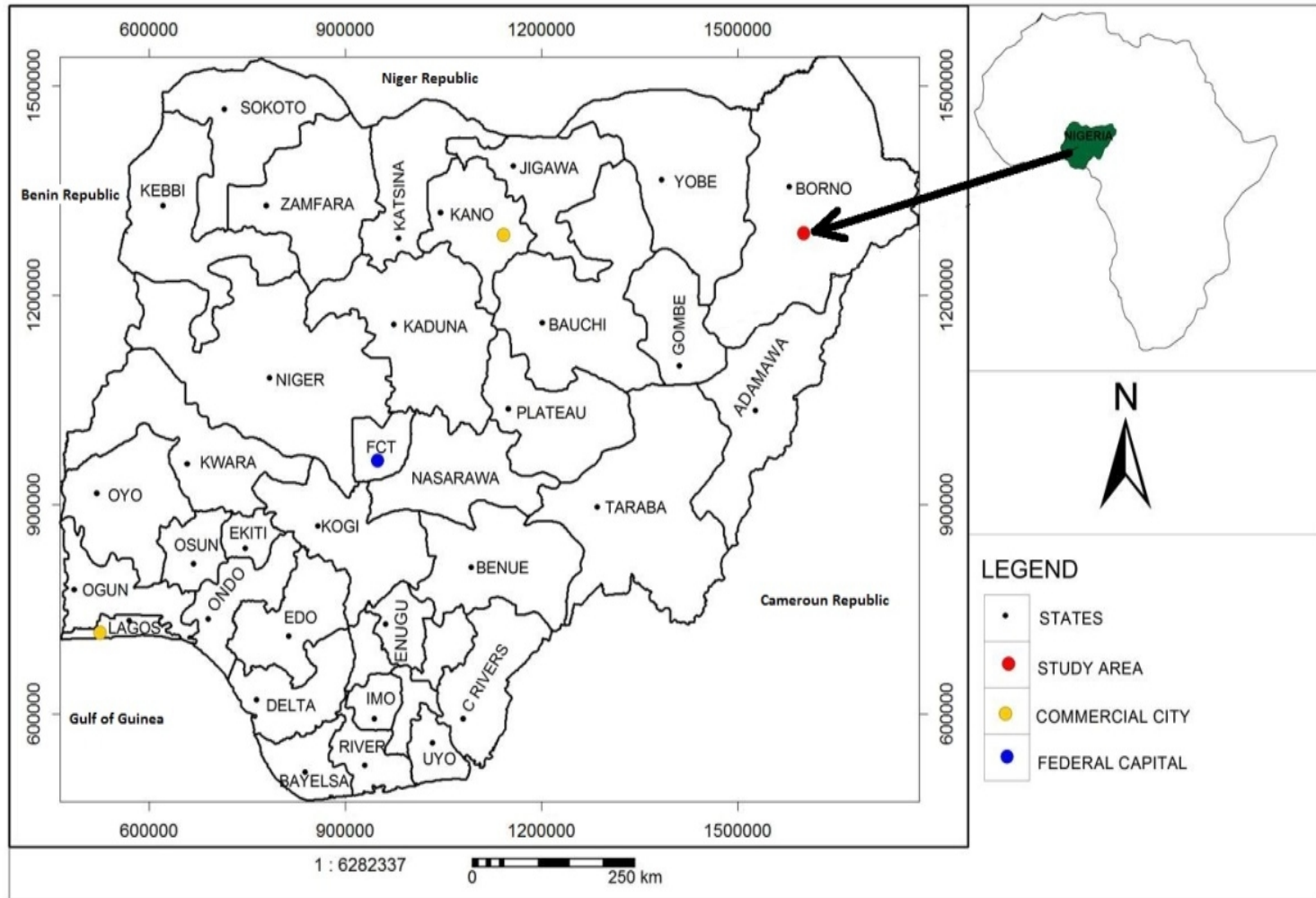


Fig. 1. Map of Nigeria showing study area

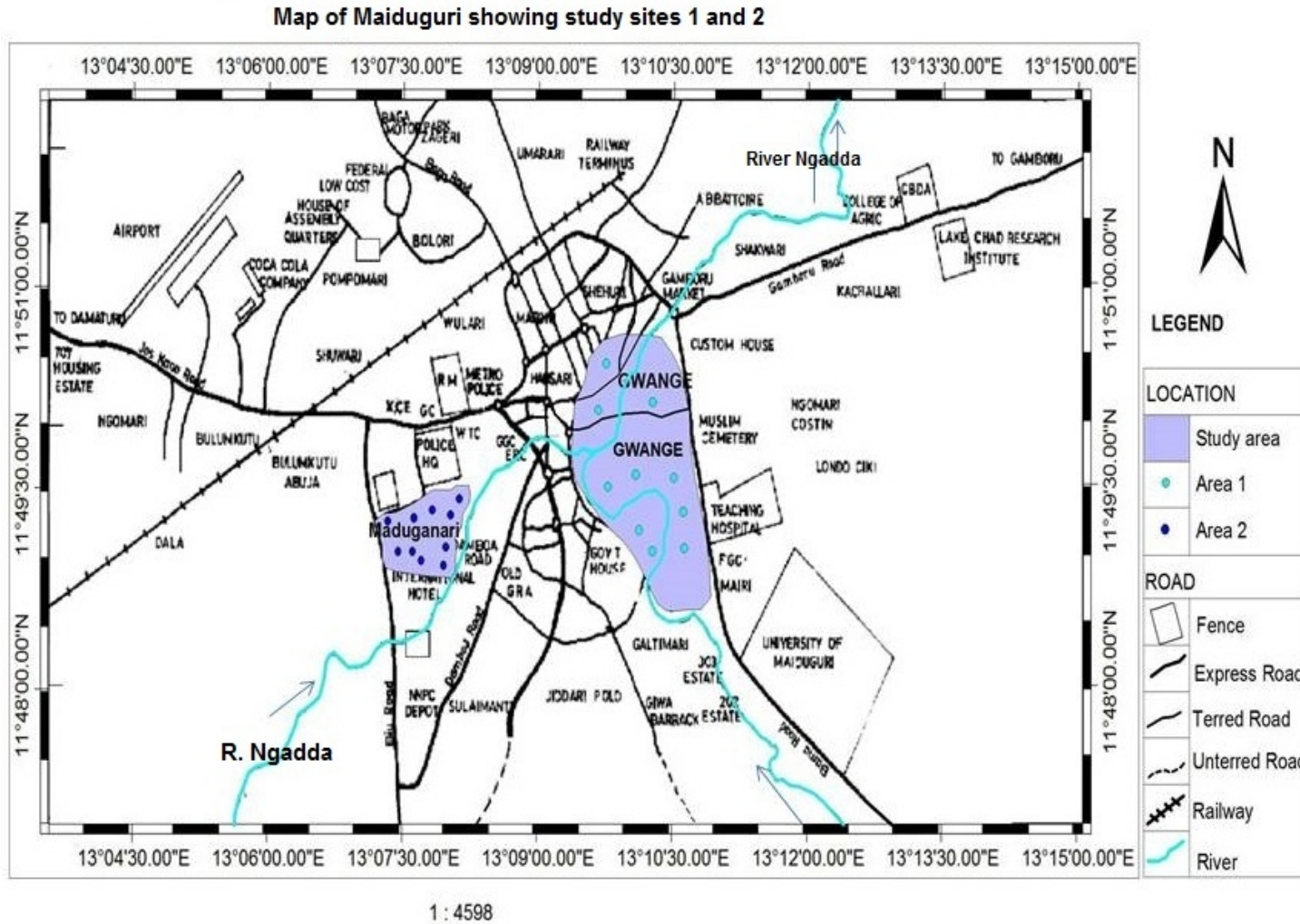


Fig. 2. Map of Maiduguri showing areas with worst impact on groundwater [19]

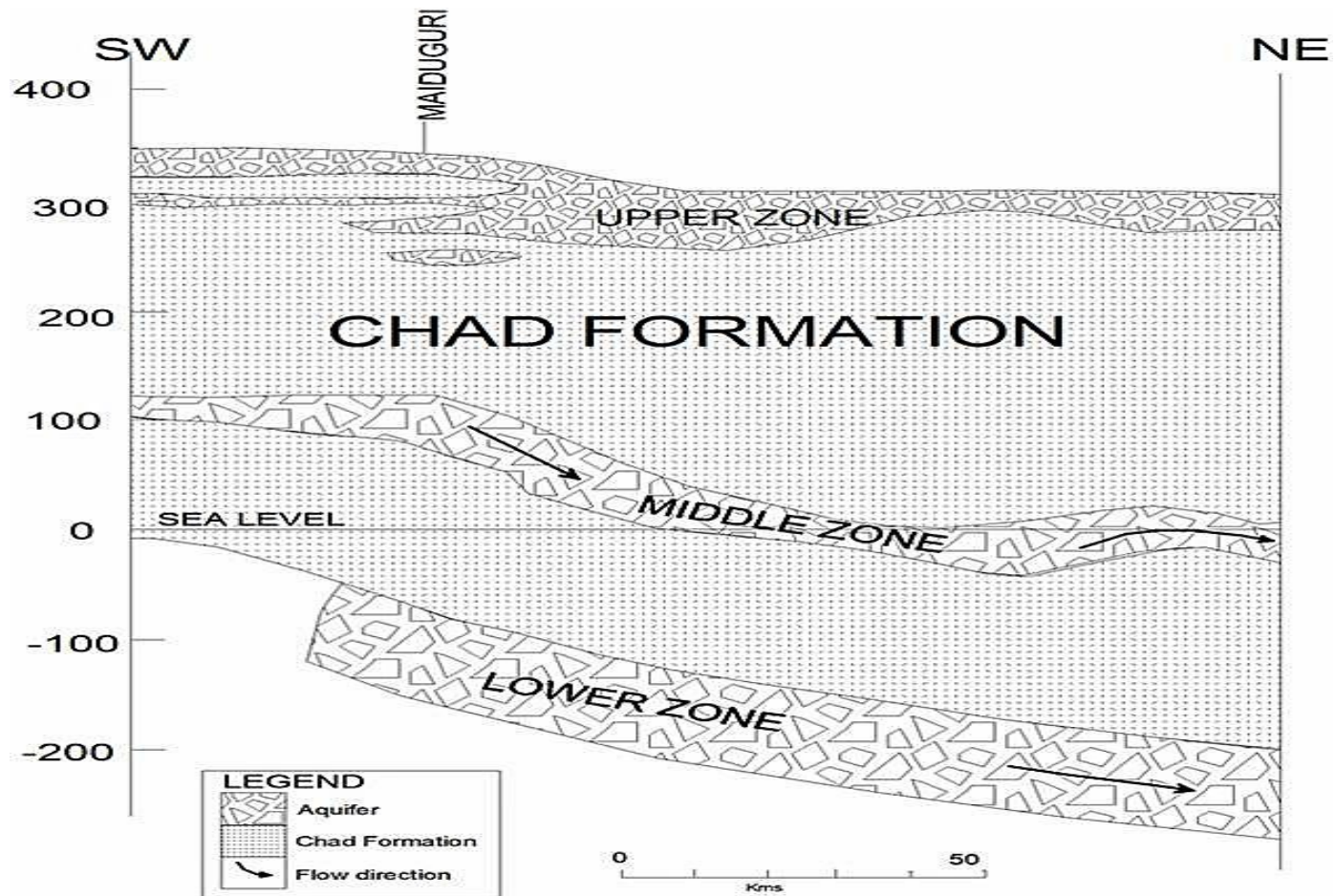


Fig. 3. Cross section of the multilayered aquifer system of the Chad Basin [19]

Thus, a change (or transition) to the management of the groundwater resource is urgently required. Inevitably, this will be a continuous process of radical change in a society which involves co-evolution of economic, cultural, institutional, technological, and ecological developments at different scales and levels [11]. Transition Management (TM) applied to the water sector is an approach where past and current water systems are evaluated to influence the success of a longer term sustainable vision for water management practices in a city [3]. Past and current groundwater management approaches in Maiduguri require to be evaluated to develop a strategy for a sustainable framework which will address the problems associated with the current system. The transition management approach focuses on uncertainty, learning by doing and doing by learning, and the organisation of processes that look at a number of solutions in attaining the goals [3].

The purpose of the study as reported in this paper is to identify transitions that bring change to the current public paradigm of incessant and ineffective waste disposal which in turn affects the integrity of the underlying aquifers. This paper critically examines stakeholder perception and belief towards sustainable groundwater management by addressing above ground scenarios to protect below ground water resources, and seeks to develop a sustainable solution to the current situation by evaluating the existing groundwater management problems using a transition management approach.

2. STUDY AREA

Maiduguri serves as a gateway to the Sahel region of West Africa. The city is the capital of Borno state located in north-eastern Nigeria between 11°50'N and 13°09'E (Fig. 1). It lies on a vast open plain which is flat with gentle undulations at an average elevation of 300m above sea level. Areas such as Lagos Bridge along the river bank, Gwange, Monday Market, Moduganari and Gamboruin Maiduguri (Fig. 2) constitute the worst impacts on the groundwater system with incessant above ground solid waste disposal. Commercial activities have increased over the years leading to significant movement of people who in turn generate such high volumes of wastes that the available waste disposal infrastructure is completely ineffective. According to recent estimates, Maiduguri is estimated to have a population of about 1,197,497 in 2009 [12]. More than 80% of this population depends on groundwater resources, with per capita water consumption of 10-40 litres of water per day [13].

The River Ngadda is used for various domestic activities by the local residents along the river bank including; fishing, bathing, vegetable irrigation, and washing as well as source of drinking by animals [14]. The river flows in a north-easterly direction, originating from a confluence in Sambisa National reserve where the rivers Yedzaram and Gombole meet and stretches across the Maiduguri metropolis, finally emptying into Lake Chad.

3. METHODOLOGY

3.1 Stakeholder Analysis

Stakeholder involvement in water resource management is widely recognised as an important component of the design and implementation of sustainable water management initiatives. The identification of various stakeholders to address persistent issues usually requires some form of stakeholder analysis [15]. The analysis adopted for this study considers the empowerment of grass root individual groups, such as women and groups of youths and those without access to well established social networks, the under privileged, or

the socially disadvantaged [16]. The analytical tools used in categorising the stakeholders are using levels of interest and impact [17] and legitimacy and influence ([18]. A total of 5 stakeholder groups consisting of 15 organisations were identified and engaged via interviews and focus group discussions (Table 1).

Table 1. Stakeholder groups

Organisation type	Number of groups
Government ministries/ agencies	7
Water user groups	5
Civil society organisations	1
NGO	1
Research institution	1

3.2 Interviews

A series of interviews were held with key individuals using open ended questions to explore the current water supply situation in Maiduguri. The principal issues discussed were related to contamination in the study area and the potential for participatory groundwater management. A total of eleven representatives, one each from the seven government ministries/ departments & agencies including the municipal council, one research institution, a non-governmental organisation and two civil society groups were interviewed from April to June 2013 as shown on Table 2.

Table 2. Summary of stakeholders interviewed and their affiliations

Stakeholder	Affiliation
Director groundwater services	Ministry of water resources
Deputy director sanitation	Borno state environment protection agency
Director engineering services	Borno state Urban development board
Senior staff	Ministry of health
Senior staff	Ministry of environment
Council secretary	Maiduguri metropolitan council
Staff member	Borno state house of assembly
Senior lecturer	University of Maiduguri
Coordinator	Friends of the Sahel
Chair woman	Forum of women
Representative	Framers union

3.3 Focus Group Discussions

Three focus group discussions were held across the different communities of the study area. In total there were 52 individuals; 40 males and 12 females drawn from the local residents and water user groups as well as groups of youths. Each focus group comprised 17 to 18 residents from each of these local communities. To increase representativeness, the participants were drawn from different walks of life as summarised on Table 3.

Each of the focus group sessions was chaired by a moderator with two assistants; responsible for audio recording of tapes and note taking respectively. The sessions formed open discussions where questions were thrown to participants for debate. The discussions

focused on groundwater issues such as knowledge about groundwater, pollution and contamination and local groundwater protection strategies. Each of the focus group sessions generated lively debate.

Table 3. Summary of focus group characteristics

Focus group identification	Number of participants	Stakeholders
Focus group 1	17	Local residents, farmers, local business owners, group of youths.
Focus group 2	17	Women group, local residents, and water users
Focus group 3	18	Group of youths, farmers, and local water user groups Women group

4. RESULTS AND DISCUSSION

This section outlines the results from the interview and focus group discussions as shown in Tables 4 and 5 in which stakeholders' proffered solutions to the problem of groundwater contamination in the study area. Both interviewees and focus group participants were engaged in addressing environmental problems, whereas in addressing funding issues, technical/manpower and institutional problems in the water sector, only the interviewees participated.

Table 4. Results from axial coding of stakeholder interviews

Themes	Sub-themes	Properties
Environmental problems	Knowledge about contamination	Yes fully knowledgeable about contamination issues
		Stakeholder is not sure
	Not knowledgeable about contamination issues	
	Concerns about contamination	Stakeholder is extremely concerned about contamination
		Stakeholder is reasonably concerned about contamination
		Stakeholder is totally unconcerned about contamination
Sustainable options for groundwater management	Adequate legislation	Provision of enabling regulatory environment and laws
		Reviewing existing legislations
	Provision of common rules to be applicable in communities	
	Stakeholder inclusion	Stakeholder participation in planning and decision making process
		Stakeholder participation in management of

		water projects
		Stakeholder participation in protection of water resources
	Increased investment & funding	Increased subventions/ funding in the water sector
		Prompt payment of water services by consumers
		Investment in water physical infrastructure
		Investment in human capital
	Institutional integration	Cross-sector coordination among ministries and agencies
		Coordination among local communities and institutions

Table 5. Results from axial coding of the 3 focus groups workshops

Themes	Sub-themes	Focus group 1	Focus group 2	Focus group 3
Environmental problems	Knowledge about contamination	Participants are knowledgeable	Participants felt they are affected	Participants are familiar
		Participants are not knowledgeable	Participants felt they are not affected	Participants are not familiar
	Concerns about contamination	Participants are concerned	Participants are worried about it	Participants are concerned
		Participants are not concerned	Participants are not worried	Participants are not worried about it
Sustainable options for groundwater management	Community participation	Empower and involve local communities	Involve the local community leaders	Provide support for local communities
	Strict laws	Introduce communal laws	Control waste dumping	People should safe guard water points
		Prohibit unnecessary impact	Prohibit excessive wastage of water	

4.1 Environmental Problems

These are problems inherent in the case study area and where identified as vital for the development of sustainable framework that will ensure groundwater quality protection. As

indicated in Tables 4 and 5 above, the environmental problem falls into two sub-themes; knowledge about contamination and concerns about contamination.

4.1.1 Stakeholder's knowledge about groundwater contamination

The officials from the ministries of water, environment, and health, and those from the academia were more knowledgeable about issues related to groundwater contamination. This acquaintance was due to their professional experience or the relevance of their respective ministries in relation to the management of water resources:

"I have been working here for nearly 20 years now, let me assure you that most of the boreholes owned by the state government within the metropolis are free from contamination and they have good water quality. This means the groundwater is safe for domestic consumption" [Director, Ministry of water res.]".

Also, some interviewees from other agencies and organisations such as the urban development board, the metropolitan council, women forum, and an NGO the Sahel green belt were fairly knowledgeable about the current state of groundwater contamination.

The participants of the three focus groups show similarity in their opinion, except on a few instances. Majority of the participants are not familiar with issues attributed to groundwater contamination. Whilst it is acknowledged that awareness creation is needed for the primary stakeholders, few issues might be pointed out; participants are knowledgeable about surface water contamination, the non-visible nature of groundwater is a critical factor in participants' decisions, and participants especially local farmers failed to recognise the impact of their activities on groundwater resources, and they could not identify well water as groundwater. Thus, specific awareness creation programmes will go a long way in increasing the capacities of the focus group participants in relation to groundwater contamination issues.

From the foregoing, it can be claimed that knowledge about groundwater contamination is good among the strategic stakeholders interviewed. Accordingly, this can be attributed to their high level of education and awareness, and due to their professional experiences.

4.1.2 Stakeholders concerns about groundwater contamination

Despite the disparity of knowledge amid the stakeholders interviewed, concerns about groundwater contamination were very high. Majority of the interviewees were worried that contaminated water can be harmful to human life, and they attest that they are willing to be involved in addressing the situation. Interviewees from the academia and the ministries responsible for water supply and healthcare service delivery were the extremely concerned; while those representing individual groups were the least concerned about the issue.

Contrastingly, concerns about groundwater contamination were extremely low among the participants of the focus group. This can be attributed to their low level of environmental awareness as they are mostly less affluent individuals with little education - farmers, local business owners and traders who constitute the bulk of the urban poor populace. The general trend of little understanding about groundwater contamination can also be ascribed to incomplete information on water quality for public dissemination by the state water ministry and other sister ministries or agencies. Noteworthy at present, none of the interviewees and focus group participants was affected by the problems of contamination.

Most concerns on groundwater contamination centred on the booming population and their associated above ground anthropogenic activities; this is a major environmental problem affecting groundwater resources in Nigeria. Foster [4] has shown that urbanisation affects the quantity and quality of the underlying groundwater by adversely affecting its quality. In this regard, [4] cited that population and uncontrolled urban growth as the major factors of groundwater contamination in developing countries. Also [8] carried out a study of the Indonesian city of Yogyakarta, and concluded that urbanisation and population pressure are the two main challenges to water resource management, especially in cities of third world countries. Furthermore, in the study area [19] has carried out an assessment of the groundwater quality and confirmed that the water is safe for domestic consumption.

4.2 Sustainable Options for Groundwater Management

These are the options proffered by the stakeholders in ensuring sustainable management of groundwater resources; the interviewees and focus group participants suggest multiple options such as the provision of adequate legislations, stakeholder inclusion, increased investment & funding, and institutional integration as discussed below.

4.2.1 Provision of adequate legislations

The interviewees from the water resources ministry and the university strongly emphasised that current legislations are inadequate and requires more robust laws that will ensure sustainability of water resources. Some interviewees are of the opinion that even if the current legislations are adequate, their enforcement will be a daunting task for the authorities concerned; as this will require the cooperation of the citizens.

In this regard, others suggest that the adoption and imposition of common rules at the community level will be the best way to start the process of enforcement. However, this was vetoed by the focus group participants; this unwillingness by the participants can be linked to their low level of confidence on the tolerability of the common rules at the community level. Disputably, adherences to common rules by the people as practiced by traditional rulers in the past have been weakened at the societal level, and most participants are not familiar with existing legislations governing the control and protection of water resources.

4.2.2 Stakeholder inclusion

Presently stakeholder exclusion is a key feature of the current system, majority of the strategic stakeholders interviewed are of this opinion. Also, majority of the participants are of the view that involving local communities in water projects will address many problems from the onset. The exclusion of stakeholders in water management was evidenced by the unsustainability of most water projects under the auspices of the rural water supply programme and host of other previous water projects initiated by various past governments across the state.

Arguably, the exclusion of stakeholders was due to the dominance of the top-down approach in the current system, and the tolerance of excessive bureaucracy in governance. Stakeholder exclusion is especially evident in the planning and decision making stages. Also, community participation in protection of water resources is very limited; with few exceptions in rural areas where water supply wells are protected by the local communities.

Presently, stakeholder exclusion is a key feature of the current system in Nigeria. Local stakeholder participation such as demonstrated in this study is vital if sustainable groundwater management is to be achieved, especially in developing countries. This approach is in line with the opinions of [20,21,22, and 23].

4.2.3 Increased investment and funding in the water sector

Interviewees suggest that most water projects especially at the state level are failing because of the inadequacy of subventions/funding. Also, interview participants stressed that adequate investments in physical infrastructure and human capital are lacking.

Accordingly, this has affected the training of members of staff and has led to the hindrance of human capacity development in the state water agency. Also, the non-payment of water services by consumers is another major issue; this has led to the decline in revenue profile of the state water agency as people see the provision of water supply as the responsibility of the government.

4.2.4 Institutional integration

At present, institutional coordination in addressing groundwater issues is non-existent in the current management system. Interview participants uttered that most institutions have different programmes and are independent of one another in tackling a particular societal issue.

Contrastingly, coordination among the local communities is moderate to strong depending on a particular community. This is because of the traditional alignment of addressing vital issues among key members of the community.

5. CONCLUSIONS

In conclusion, the shallow (10-25 meters) groundwater system in the study area faces significant threats from uncontrolled above ground anthropogenic activities. Safe, affordable and clean groundwater is vital for socioeconomic development and access to clean water is a human right and indispensable to human well-being. Transitions are required to ensure sustainable management of groundwater in such a way that reflects its environmental, economic, social and cultural values, in all its uses. The study has shown that stakeholder's knowledge about groundwater contamination issues is good among the strategic stakeholders and limited in the focus group category, concerns about groundwater protection were high in both interview and focus group categories. Most strategic stakeholders interviewed and the focus group participants were of the opinion that existing legislations are inadequate, stakeholder exclusion is a key feature of the current system, governments should increase investments in the water sector, and institutional coordination and integration is poor in the water sector. Thus, a participatory approach involving all relevant stakeholders and sundry should be encouraged to ensure sustainable management of groundwater resource. Public awareness and enlightenment campaigns are essential in educating the citizenry for a change to occur.

The study has also highlighted environmental problems responsible for groundwater contamination. Hence, the capacities to deal with pollution threats are completely inadequate and need to be strengthened. This can be ensured by training members of staff on water quality issues and the implementation of groundwater monitoring networks. On the other

hand, sensitisation of the general public about pollution threats, identification of potential threats to groundwater systems will enhance their capacities.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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