

An Aspect of Water Distress Level Evaluation in Abakaliki Area and Environs Southeast Nigeria

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ABSTRACT— An improved understanding of physiographic and geologic factors influencing natural water storage and yield, as well as appreciation of the historical and current water sources, availability and use are necessary water management modeling tools for sustainable water resources development. This study aim at identifying the sources and causes of water scarcity, asses level of scarcity and the extent of its effect on the livelihood (healthcare and the environment) and finally proffer ways to either ameliorate or remove effects by integrating existing coping strategies into a standard water management implementation road-map as a panacea for arriving at an improved water supply scheme. In this study, hydrologic and hydrogeologic characteristics were evaluated from analysis of morphometric and lithologic results of both surface and groundwater sources. A questionnaire approach was also used to simulate water availability and use patterns. Empirical method was used in estimating the water distress level. Results indicate an area of high water distress level due to resource scarcity. Geologic factors, lack of abstraction and storage facilities, high cost of water resources facilities development and most pertinently poor management and use of water amongst others are the contributing factors. Analysis of responses from the questionnaire further indicates that the high water distress is associated with health problems, poverty and environmental issues.

availability, distress, geologic, health problems, improved understanding, physiographic, poor management, poverty and environmental issues, water.

BACKGROUND AND RATIONALE.

Water plays a major role in livelihood (healthcare, poverty and environment) hence its shortage is always a severe problem to mankind. Development of water resources is thus a major factor for economic growth as well as human and environmental health, and poverty reduction. Although there is hardly any project without water-related provision attachment, water is still a limiting factor towards achieving the United Nations Millennium Development Goals (MDGs) in terms of agricultural food production, improved health and general water use for environmental sustainability. Millions of people in sub-saharan Africa still live in areas where finding potable water resources is difficult [10]. In Nigeria, problems associated with lack of adequate water supply threaten to place the health of over 40 million people at risk[1]. Access to pipe borne water is becoming increasingly difficult and most households depend on other sources that may be quite contaminated and unreliable. Aina (1996), stated that less than 30% of the Nigerian population has access to safe drinking water and in most cases get only about 25 liters/person/day as compared against the WHO's standard of 120 liters/person/day for domestic use. According to [7] and [9], about 22% of the rural and 65% of urban counterpart of the Nigerian population enjoyed potable water having access to only 25 litres per person per day. This suggests a situation of serious water shortage which has the potential to exacerbate health risks, poverty and natural

ecosystem degradation. The above documented level of water availability however, reflect a national average/scale, and may not be sufficiently useful for planning and management purposes for sub-regions and smaller localities. Abakaliki, a typical smaller locality requires a more site-specific study of water availability for use in developing planning and management framework for achieving water security. The site-specific study includes obtaining of estimates of groundwater and surface water storage potentials, and historical water use pattern in terms of supply and demands. In this study, the level of scarcity of potable water is assessed from data on surface and groundwater storage as well as the demands and usage pattern obtained from answers to questionnaires distributed among stakeholders in Abakaliki area.

1.1 Environmental Setting.

Abakaliki is in Ebonyi State, S/E Nigeria. The area lies between latitudes 06° 05' N and 06° 25' N and longitudes 008° 00' E and 008° 18' E, (fig 1). The area is a gently undulating terrain and lies within Ebonyi River Basin and the Cross river plains; in some isolated sub- areas, however the topography is rugged. The region lies on an elevation ranging from 125m to 245m above mean sea level. Two main seasons dominate the area- rainy (late April-October) and dry (November-April) seasons. Mean annual rainfall is 1000 to 2000mm and mean monthly rainfall vary from 50 to 300mm while August has 180 to 200mm of rain [8]. Records show a mean annual temperature of 31.2°C ranging from 33°C in dry season, to 28°C in wet season. Other minor climatic conditions

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in the area are the short dry season— August break and the harmattan patches of November to February.

1.2 Geology of the Study Area.

The area falls within the Lower Benue Trough and composed of Cretaceous marine sediments in which carbonate rocks abound. The main rock type is shale (Abakaliki shales) with lenses of limestones, sandstones, pyroclasts and evaporites. Generally the shale beds are massive, occasionally laminated and micaceous; they are extensively fractured[12]. There are also emplacement of numerous mafic to intermediate intrusions of lavas and tuffs. Two main soils are found in Abakaliki area— silty clay hydromorphic soil and the grey sandy clay hydromorphic soil. They are moderately to imperfectly drained. The area falls within the rainforest/savannah belts. The lush vegetation is characterized by variety of tree shrubs, grasses and palms. Run-off is high during rainy season courtesy the lithology. Surface water bodies occur during the rainy season and most of them dry up during the dry season. The drainage system is dendritic.

measurement of storage facilities for their operational capabilities (iv) assessment of historical water use data obtained from questionnaire distributed among various stakeholders.

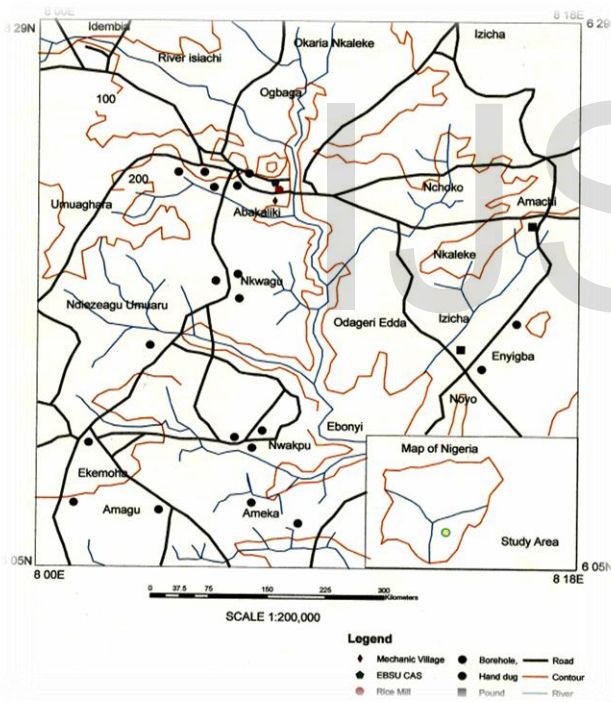
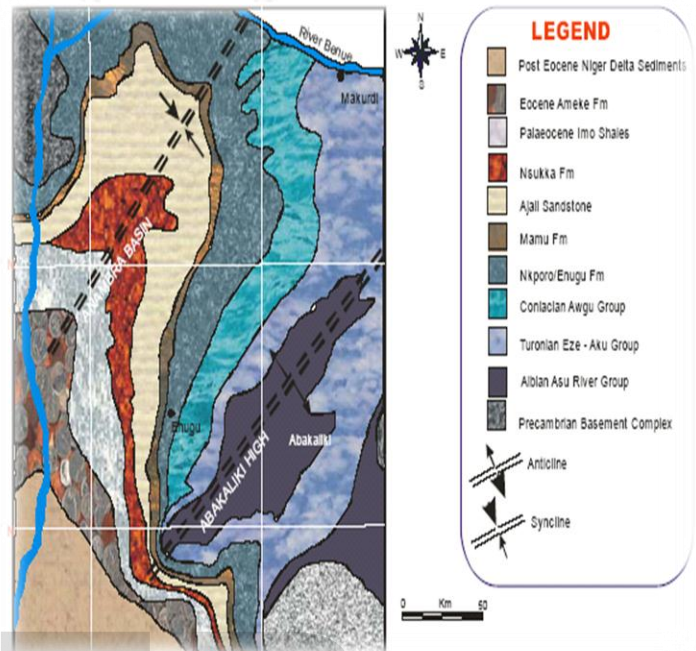


Figure 1: Map of Abakaliki area and environs.

2.0 METHOD OF STUDY

Groundwater availability was studied by using (i) empirical method of MacDonald et al, which associates water yield with rock type, fractures and extent of weathering, (ii) conventional analysis of aquifer parameters of transmissivity and storativity, (iii) surface water storage estimation from



Geological map of South-eastern Nigeria showing the Southern Benue Trough and Anambra Basin, (Modified after [3].

Table 1 shows the [10] empirical model for determining groundwater yield for the various hydrogeological environments. According to the model, highly weathered and/or fractured crystalline basement rock is associated with groundwater yield of 0.1 - 1.0 l/s (moderate) while a low yield of 0.0 - 0.5 l/s is associated with poorly weathered and/or fractured shale. The hydrogeological environment were evaluated from existing geological literature including those of [12], [6], as well as borehole lithologs sourced from the Geological Survey Agency of Nigeria and Ebonyi State Rural and Urban Water Supply and Sanitation Agency.

2.1 Groundwater and Surface Water Storage.

The VES data and Lithologs of boreholes (locations as shown in Figure 1) were used to identify and correlate the hydrostratigraphic units. Transmissivity values were estimated using hydraulic conductivity values typical of fractured and unfractured clays as provided by [6] and thickness estimation range of 22.60m. Using Transmissivity, (T) relation [6],

$$T = K_{f,n} b \dots\dots\dots (1)$$

where *K* is the hydraulic conductivity, the subscripts *f, n* refer to fractured and unfractured conditions respectively and *b* is the bed thickness.

Table 1: Model For Evaluation Of Groundwater Potential of The Main Hydrogeological Environments after Allan Macdonald et al, 2005.

Hydrogeological sub-environment		Descriptions	Groundwater Potential and av. yield (in l/s)
Crystalline basement rocks	Highly weathered and or fractured	Crystalline and metamorphic rocks can be fractured, decompose due to weathering	Moderate 0.1-1
	Poorly weathered or fractured	Crystalline and metamorphic rocks may not be weathered or fractured	Low: 0.1-1
Consolidated sedimentary rocks	Mudstones and shales	Consolidated silt and clay. Often interbedded with sandstone and or limestone layers. Mudstone may be fractured.	Low 0.0-0.5
	Limestones	Fossils deposited in seas cemented to form rocks. Slightly soluble in rainwater, develops conduits and fracture (karst features).	Moderate-high: 1-100
Volcanic rocks	Extensive volcanic terrains	Terrain made up of volcanic lava and pyroclastic rocks	Pyroclastic rocks: 0.5.-5

Typical **K** values and the clay thickness are:

$$K_f = 10^{-8} \text{m/s}$$

$$K_n = 10^{-10} \text{m/s}$$

$$b = 22.60 \text{m}$$

Substituting in (1), Transmissivity values = $2.26 \cdot 10^{-6} \text{m}^2/\text{s}$ and $2.26 \cdot 10^{-8} \text{m}^2/\text{s}$ for fractured and unfractured scenarios respectively.

Channel geometry (depth, width and mean flow velocity) were estimated at five locations along the water courses, fig. 1 to enable the determination of stream discharge. Flow velocities were measured at some locations using a float. The surface velocities so obtained were converted to mean flow velocity. Stream discharge (**Q**) was calculated as the product of mean flow velocity (**V**) and cross-sectional area (**A**), using the relation, $Q = VA$. The discharge for Ebonyi River and three of its tributaries (Iyiokwu, Iyiachi and Akpara) were estimated. Surface water storage facilities including Ezillo Regional Water Scheme, rivers, streams and some ponds were evaluated. Their locations are shown in figure 1. Data on their operational capacities including installed and operational capacity as well were obtained from the relevant water agencies.

2.2 Interviews and Questionnaires.

Interviews and structured questionnaire method were adopted in this study as a means of obtaining data on historical water use. The questionnaire was designed to get information on source, quantity, availability, safety, use of water and community management approaches. The stakeholders include adult men and women, housewives, civil servants, traders, water vendors and contractors.

3 . RESULTS and DISCUSSION.

3.1 Results.

The borehole lithologies indicate that the area is underlain predominantly by shale with thin beds of micaceous sandstones, mudstones and limestone lenses with scattered granitic intrusives. Borehole yield data from Eb-RUWASSA range from 3.3 l/s to 5.8 l/s. This falls within the low to moderate yield potential of [10]. The transmissivity values compare reasonably well with the low to moderate yield potential for fractured clays of [10], and are according to [6] poor- yield aquifers. Stream discharges vary from $5.8 \text{ m}^3\text{s}^{-1}$ (5,800 l/s) in the upper reaches of the tributaries to $29.6 \text{ m}^3\text{s}^{-1}$ (59,600 l/s) in the main Ebonyi river at the southern part. This (59,600 l/s) serves as estimated total run off or total discharge across the entire area during the rainy season. This is high and consistent with [11] which states that high runoff coupled with high evapotranspiration in the area due to climatic condition considerably reduces the amount of water available for infiltration and aquifer recharge. The shally terrain further contributes to the high run-off. The Ezillo Water Scheme installed at the capacity of $33,840 \text{ m}^3/\text{day}$ is presently operating at about 50% installed capacity. Average storage capacity of ponds ranges from $18,000 \text{ m}^3$ to $22,113 \text{ m}^3$. Oral discussion with indigenes and operators confirm that both ponds, hand dug wells, boreholes as well as streams flood in the rainy seasons and depreciates to poor yield with on-set of dry season; and some go completely dry during the dry season. A major observation on these water facilities is the lack of maintenance resulting to frequent breakdown and consequent interruption of water supply to the community. Over 80% of those interviewed stakeholders observed that lack of maintenance constitutes a major factor militating against improved water supply.

3.2 Questionnaire Response Analysis. The analysis shows that the main source of water is precipitation

particularly in the rural areas. Water supply is however augmented to a very limited extent by government piped water, communal efforts and private vendors. The result further revealed that water collectors are mainly children and women. Water points are far averaging about 2000m. Victims of water related problems are the poor, children and women. Water situation contributes 36% to poverty level, 32% to health problems and 28% to poor environmental health. Over 65% respondents indicate that water is very scarce in the area.

3.3 Assessment of Water Distress Level. Result from the questionnaire reveal that residents obtain an average of 50 liters/person/day of fair quality water in the urban area and about 25 liters/person/day in the rural area compared to WHO recommendation of 120 liters/person/day. Water Distress, Wd can be expressed as:

$$Wd = \frac{(1 - Wa) \times 100}{Wr} \dots\dots (2)$$

where, Wa is water available i.e. 50 liters/person/day in urban area and 25 liters/person/day in the rural area and Wr is water required, i.e. WHO requirement of 120 liters/person/day. Substituting values into equation (2), provides for Wd values of 62% for urban and 80% for the rural areas respectively.

3.4 Discussion

The water bearing units are the shales which are however fractured; they are associated with low transmissivity values hence have poor water potentials. Another source of water supply is rainfall. This is collected and stored in surface storage facilities (streams, artificial impoundments and containers) and underground in the fractured aquitards.

Water availability is season dependent. In the dry season, rain water source is not available. Most of the surface sources dry up leaving pockets of water at points along the channels. More so, water table drops much below exploitable depths in boreholes/hand dug wells. During this period, surface water impoundments with its attendant contamination problems remain the only available source. This heightens the water distress.

The calculated high water distress level of 62% and 80% in the urban and rural areas respectively indicates a severe shortfall in potable supply where about 62% of the urban population faces water starvation and 80% in the rural areas. The distress level is however ameliorated and its effect reduced by as much as up to 10% to 12% in the rainy season through rainwater harvesting in both urban and rural areas. In the rural and semi-urban areas, this is further augmented by pond and stream water sources by as much as 12% to 15%. This augmentation however comes from ephemeral and potentially contaminated streams and impoundments. This creates a false impression of water availability at the instance of health and associated problems.

4.0 IMPLICATIONS OF THE WATER DISTRESS LEVEL ON LIVELIHOOD.

Analysis of the questionnaire response pattern indicates that health, poverty and environmental issues are related to the high water distress level in the area. From the questionnaire, 36% of the sampled respondents ascribed lack of water to poverty, 28% associated environmental degradation to lack of water while 32% associated health problems to water distress. There is high incidence of gastro-intestinal diseases including diarrhea etc. Infections are definitely associated with the severe water shortages.

An important consequence of the high water distress level is that women and children undertake the responsibility of scouting and collecting water for household use. This potentially exposes these vulnerable classes to risks of abuses such as kidnapping and rape which probably contracting HIV/AIDs. Poverty is associated with water distress. Time, finance and other resources which should have been directed to other economic productive use are diverted towards scouting and purchasing water. This, consequently further reduces the purchasing power of the local residents thereby aggravating poverty. Poverty in itself militates against the water security. Scarcity of water in different ways results in land degradation and in turn to problems of food production. In the context of water distress - human health - poverty - environmental health cycle, the adverse effects of water distress on human health and poverty exerts cumulative negative effects on the total environmental health. For example, an index of poverty and inability (financially) to adopt the current but costlier cooking technology and process (gas, kerosene etc) leads to tree felling for firewood. Tree felling for firewood and as income earning is common in the area. In the long-term, the present level of environmental degradation (such as tree felling and desertification, as well as over-exploitation of associated resources) may worsen. This in turn places other resources at risk.

5.0 SUMMARY AND CONCLUSION

The low to medium groundwater yield potential and the seasonal nature of surface water bodies in combination result to severe water distress estimated to be about 62% for urban areas and 80% for rural communities. Geologic factors, lack of abstraction and storage facilities, poor management and use of water, high cost of water resources facilities are some of the technical factors thought to be responsible for the water distress. The shortfall in water availability has very adverse consequences on health, environmental hazards and poverty level. The measures adopted by the community to cope with the water distress include rainwater and flood water harvesting, reduction in the consumption and use of water with its attendant exacerbates the already poor sanitation as well as frequent family migration and settlement near water courses and potential groundwater discharge areas. These coping measures can be more effective if they are streamlined and integrated into standard water management strategy.

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