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Full Length Research Paper

Spatial assessment of fresh water supply in Southwest Nigeria

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Water is an essential commodity with an unparalleled value after air. This paper is designed to assess the spatial pattern and implications of inadequacy of fresh water supply in major cities and towns of Southwest Nigeria. Data were collected with the aid of questionnaires and oral interview from randomly sampled subjects within the study area. The permanent secretaries in the Ministries of Agriculture and Water Resources of the States of the region provide information and data on the facilities, supplies and challenges. The study reveals a significant spatial disparity in the state of infrastructures and availability of fresh water. New layouts have the highest availability and consumption while the rural-urban fringes have the least. The study suggests the need to further strengthen the institutions saddled with water supply provision by adequately financing infrastructure, equipment maintenance and management.

Key words: Spatial variation, fresh water, institutions, Southwest Nigeria.

INTRODUCTION

Water is an essential commodity with an unparalleled value after air. There is virtually no where water is not important, be it in animals and plants (biosphere) kingdoms, in the air (atmosphere) and even in the rock system (lithosphere) (Campbell, 1985; Aderogba, 1994, 2005; Griggs, 1997; Mayers, 2005). In Nigeria, one of the key elements of the Millennium Development Goals is the provision of water in every home by the year 2015. At the global level, the target is to reduce poverty level through adequate provision of potable water. In order to make it a reality, the United Nations (2006) envisioned that "new solution can come in old packages in dry areas". There seem to be multiplicity of challenges associated with supply of fresh water to the cities and towns in the western region of Nigeria, (Aderogba, 1994, 2005).

Many works had been done on the supply situations and it is crisis in the entire country and/or parts of it (Aderogba, 1994, 2005, 2008; Akosile, 2007; Bamijo, 2005; Obafemi and Bakare, 2008). The works are unnecessarily broad and could not address spatial challenges of fresh water supply in Southwestern Nigeria. Also, many of the works are either journalistic or too general and superficial. More importantly, it appears the infrastructures, supplies and challenges of water depict certain pattern which nobody has ever taken note of. Therefore, the objective of this paper is to unravel the spatial variations in the challenges of the supply and demand situations in Western Region of Nigeria. The work adduced some solutions.

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MATERIALS AND METHODS

The study area cuts across 5 major states in Southwest Nigeria, namely, Ogun, Osun, Oyo, Ondo and Ekiti (Figure 1). Fifteen (15) major cities were selected within the states as the area of data collection. All of the cities and towns are noted for one or two of agriculture, administration, commerce or industry. While agriculture may be peculiar to all of the States, the cities and towns are also characterized and known for administrative functions (Table 1). None of them was less than 150,000 people in 2006 head count in Nigeria. Ibadan was 1,021,704, being the largest. The relief is characterised by the Yoruba/Kukuruku highland; and drained southward by Rivers Ogun, Oshun, Oyan, Owena, Osse and their tributaries. These rivers are major sources of water supply to the region. The region falls within the tropics. The vegetation is predominantly ever green High Rain Forest with Guinea Savannah to the north. Mineral and forest resources are plentiful. The proportion of the Muslims and the Christians are about the same;

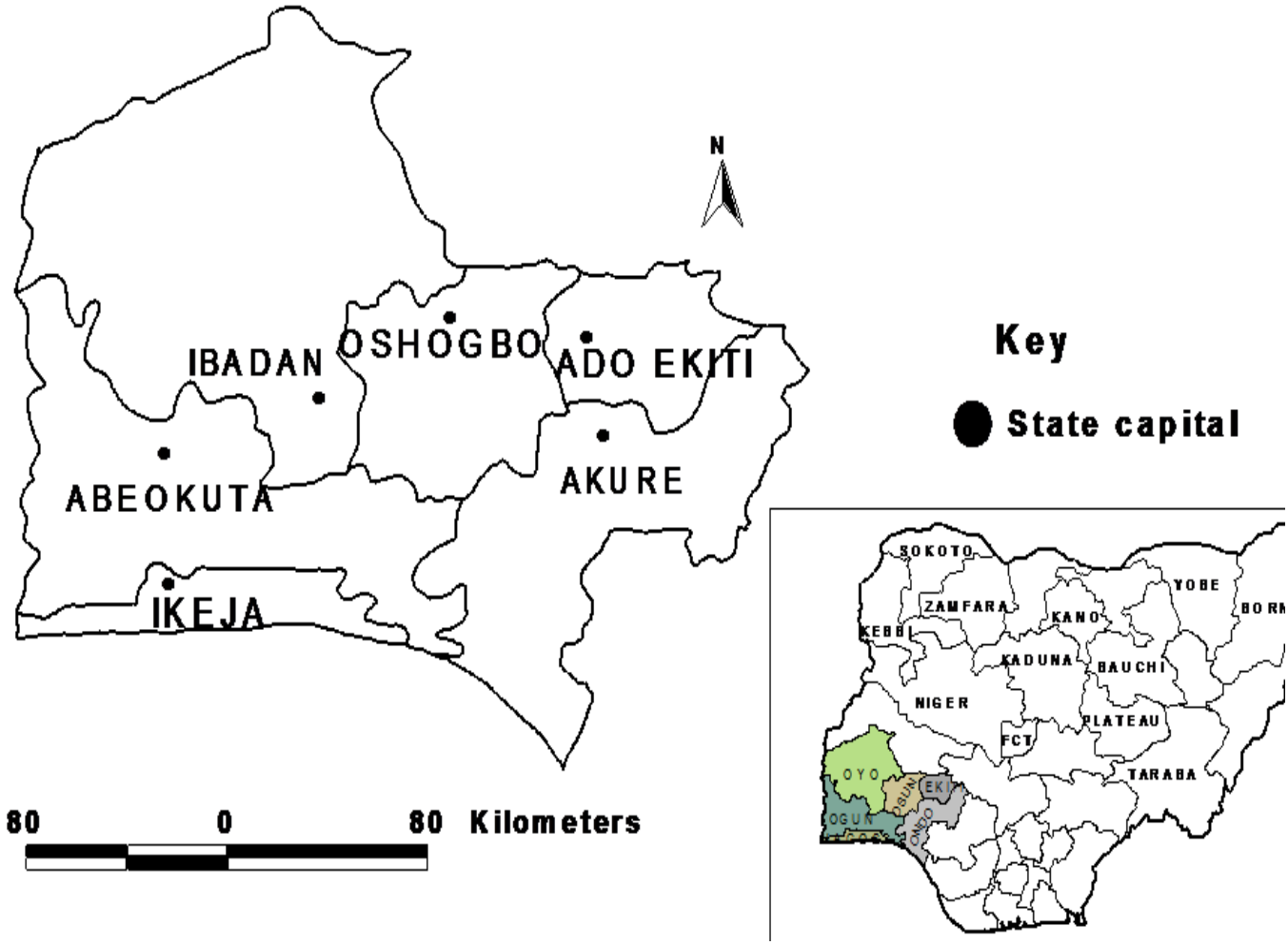

Figure 1. Map of Southwest Nigeria showing capital cities.(inset map of Nigeria).

Table 1. Selected cities and towns of Western Nigeria and their functions.

City /Town	State	Main function	Population
Ibadan*	Oyo	Administration / Commerce/Education	1,021704
Abeokuta*	Ogun	Industry / Commerce	449088
Ile-Ife	Osun	Commerce /Agriculture/Education	643582
Ilesha	Osun	Industry / Commerce / Agriculture	201927
Oyo	Oyo	Commerce / Agriculture	266054
Akure*	Ondo	Commerce / Agriculture	490973
Ondo	Ondo	Commerce / Agriculture	465960
Owo	Ondo	Commerce / Agriculture	222262
Ado-Ekiti*	Ekiti	Commerce / Agriculture	313690
Ogbomosho	Oyo	Commerce / Agriculture	299238
Osogbo*	Osun	Industry /Commerce / Agriculture	155507
Ikere	Ekiti	Commerce / Agriculture	148558
Shagamu	Ogun	Industry / Agriculture	255885
Ijebu-Ode	Ogun	Commerce / Agriculture	157161
Ota	Ogun	Industry / Agriculture	527242

*, State capitals. Source: National Population Commission (2006)

Table 2. Magnitude of uses of water.

Use	No. of respondents	% Proportion
Drinking	2000	100.00
Washing	2000	100.00
Fire fighting	1392	69.60
Waste disposal	1788	89.40
Agriculture	1968	98.40
Horticulture	1370	68.50
Sylviculture	1390	69.5
Bathing	2000	100.00
Education and research	1796	89.80
Spiritual	1762	88.10
Entertainment / Recreation	1756	87.80
Building and construction	2000	100.00
Others (specified)	1324	66.20

Source: Fieldwork (2008).

and the atheists are negligible in number.

Questionnaire and oral interviews were employed as instrument for data collection. The questionnaire was designed to elicit information on water supply and demand situations from the public. The respondents were randomly selected across sex, religion, education, profession, income and residential locations/status. Interview sessions were used to obtain data/information from monarchs, Chairmen of Water Boards and supervising permanent secretaries of the arms of the Ministries handling water resources management in each of the states of the region. Data/information on the supply and demand situations, spatial variations and others, and challenges were provided from these sources. Suggestions for sustainable development were adduced. a total of 2000 copies were administered and used for the study. Important issues bothering on water usage, sources, reliability and state of infrastructure were addressed. Simple percentage analysis was employed where necessary to present results of findings.

All the respondents drink water. All the 2,000 respondents (100.00%) also use it for building and construction; bathing and household chores etc, 100.00% (Table 2). In agricultural practices (piggery, planting and harvesting of crops, poultry, fishery, rabbitory etc), water is extensively used by 98.40% of the respondents. Interestingly, as much as 68.50% similarly use it in horticulture. 89.80% use water educationally, particularly in research and development, and for experiment in schools, colleges and in higher institutions. More than 60.00% (66.20%) use it for other (specified) purposes. Muslim faithful and Christians use it for ablution and other spiritual/religious purposes (88.10%). These are aside the proportions that depend on it directly and indirectly in the entertainment and recreation industries (87.80%).

RESULTS

Uses of water

The recreation centers and many of the buildings are designed “to waste water”. Some of the buildings, recreation centres and hotels have swimming pools, fish ponds and gardens; washing cars and other vehicles are regular and daily activities.

Incidentally, unlike it is in so many other cities and towns of Nigeria (Gombawai, 2007; Aderogba, 2005; Yusuf 2007; Bamiyo, 2005), there are special purpose uses in hospitals and maternity homes, entertainment, tourism and hospitality industries. In the hospitality industry, water is extensively used for preparation of foods, drinks and beverages, washing, laundry and dry cleaning, watering plants and flowers, ornamental purposes, cleaning and sewerage disposal among others. However, Table 3 shows main source of fresh water to include bottled and sachet waters (88.40%) pipe borne water (37.60%), boreholes and wells (67.80%), supplies by water tanker drivers (52.30%) and spring, rivers and lakes (38.10%). Surprisingly, supply through human carriage (Mai-ruwa), 27.00% is still recognized; and it is an important source to many. Also, rainfall and dews (53.80%) are still important probably for agricultural and horticultural processes, and local industrial productions.

The supposedly main source of supply of drinking water, the Dams across the rivers of the region are of various capacities and ages. But none of them is less than 40 years old. No expansion, rehabilitation or constructions of new dams have been made by any government, Non-governmental organizations or private bodies in the last 20 years whereas the population and the needs for water is increasing by the day over space. Table 4 shows a typical result of analysis of samples from the treatment plants of one of the dams. Manganese is 0.12. Turbidity is just 8, iron is 0.40 and pH is excellent 7. The Ministry of Health, reviews the treatment operations only at intervals. In every sense, the supplies from the dams meet permissible standards. But, in spite of the global warming (Brian, 2004) and the increasing demand for more of fresh water, (Aderogba, 1994, 2005) the demand and supplies are characterized by unprecedented crisis.

Table 3. Sources of water supply.

Source of water	No. of respondents	% Proportion
Mai-ruwa	540	27.00
Bottled and sachet	1768	88.40
Pipe borne water	752	47.60
Tanker driver	1046	52.30
Boreholes and wells	1356	67.80
Spring, rivers and lakes	762	38.10
Rainfalls and drivers	1076	58.80
Others (Specified)	220	11.00

Sources: Fieldwork (2008).

Table 4. Analysis of typical water supply from a treatment plant.

Chemical parameter	Unit	WHO permissible standard	Observed value
Turbidity	NTV	25	8
Iron	mg/L	1.0	0.40
pH	-	65 to 8.5	7.00
Chloride	mg/L	600	113.00
Sulphate	mg/L	400	119.00
Manganese	mg/L	0.05	0.12

Source: World Health Organization (2005) and Fieldwork (2008).

Demand and supply crisis

The demand and supply situations in all the sampled cities and towns have exhibited a number of certain common crises on the economy, social and developmental growth of the region, viz:

(1) Dirty and unhygienic living habits and environment;
(2) Frequent sourcing for alternatives and too much man-hours spent to fetch enough for daily household use;
(3) Large sums of money earmarked and expended at every sector and level;
(4) Frequent and negative news on the print and electronic media;
(5) Self reliance strategies developed by individuals, and governments, and government parastatals, non-governmental organizations and firms;
(6) Evidence of presence of water-borne diseases;
(7) Absence of public pumps for pipe borne water;
(8) Overstretched facilities;
(9) Failure to meet the standard permissible parameters;
(10) Broken water pipes and leakages all over;
(11) Dirty and unhygienic supplies;
(12) Empty cans and sachets of water and non-degradable substances;
(13) Challenges of boiling and treatment of pipe borne water to meet portability;
(14) Vandalized water pipes and other facilities in the cities, towns, and at water works;
(15) Intermittent running of taps for few hours or few days of the week or for certain period of the day at some localities only;
(16) Low pressure in public pipe borne supply system, that is, where there is any network at all;
(17) Inadequate Water Treatment Plants;
18) Inadequate Storage Tanks and Distribution Network;
(19) Unconnected new suburbs and neglected rural-urban fringes;
(20) Inadequate supplies for recreational, entertainment, and religious purposes and for horticulture, and sylviculture and agriculture;
(21) Inability to have all year round planting of crops;
(22) Lack of attention to damaged pipelines leading to leakages and wastes;
(23) Need to strengthen security around the dams, the Treatment Plants and Pump Stations;
(24) Visible particles and debris in the so-called potable water;
(25) High rush for rain water harvesting at its seasons;
(26) Complete absence of potable water at some locations;
(27) Prominent roles of Mai-ruwa carrying water about; and
(28) High preference and high demand for sachet and Specifically, Table 5 shows general inadequacies in bottled water.

Table 5. Reasons for inadequacy of pipe borne source.

Reason	No. of respondents	% Proportion
Outdated technology	1554	77.70
Inadequate machines and materials	1034	51.70
Inadequate and inefficient pipeline network	1982	99.10
Inefficient and unskilled work force	988	49.40
Unhygienic/Contaminated water	1020	51.00
Inadequate water in dam	1020	89.90
Leakages of pipelines	1798	86.20
Public misuse of water	322644	32.20
Low level of treated water	974	48.70
Ill-treated water	102	30.10
Low level of head water	1732	86.60
Others (Specified)	446	22.30

Source: Fieldwork (2008).

Table 6. Average composition of circulating water.

Chemical parameter	WHO permissible standards	Observable values in mg/L
pH	6.5 to 8.5	7.4
Conductivity		180
Calcium (as Ca^{2+})	-	20
Magnesium (as Mg^{2+})	50	2
Sodium		9
Potassium		2
Chloride (Cl_2)	600	7
Nitrate (as NO_3)	50.10	0
Sulphate (as SO^{2-})	150	5
Bicarbonate		52
Phosphate		0
Total minerals		124

Source: WHO (2005) and Aderogba (2005) fieldwork.

supplies especially of pipe borne source. Pipe borne source is no longer popular (Aderogba, 1994, 2005). Rather, individual families, communities, groups, organizations and institutions have to fend for themselves through self provided and self maintained boreholes and wells, and harvested rain, rivers, streams, ponds, lakes and dews (Aderogba, 2008, 2005).

However, as a supplement and/or alternative, majority of the respondents (88.40%) identified sachet and bottled water as the most readily alternative and/or supplement to borehole and/or well and pipe borne sources. Table 6 shows the average composition of water that circulates in the region. The providers, brands and trade names are numerous: SWAN, Eva, CIL, SPARWASSER, GOSSY, FARO, Voltic, Safari, AQUADANA, Ragolis, Zemax, Ultra cool, Nestle and others. The readings of some of the compositions are at variance with the World Health Organization (WHO, 2005) permissible standards. Apart from the bottled water, there is also sachet water. It is popularly referred to as “Pure Water”. All the brands have National Agency for Food and Drug Administration Control (NAFDAC) registration. However, the following depicts spatial variations in the infrastructures, uses, availability and challenges.

Spatial variations

There are no clear distinctions between one zone and the other; one graduates into the other perceptually. The zones are similar to what Mabogunje (1980) identified for the Nigerian (Yoruba) settlements: Innermost is the core followed by new suburbs, the new layout and the outskirt (rural-urban fringe) that is, the outermost, in that order

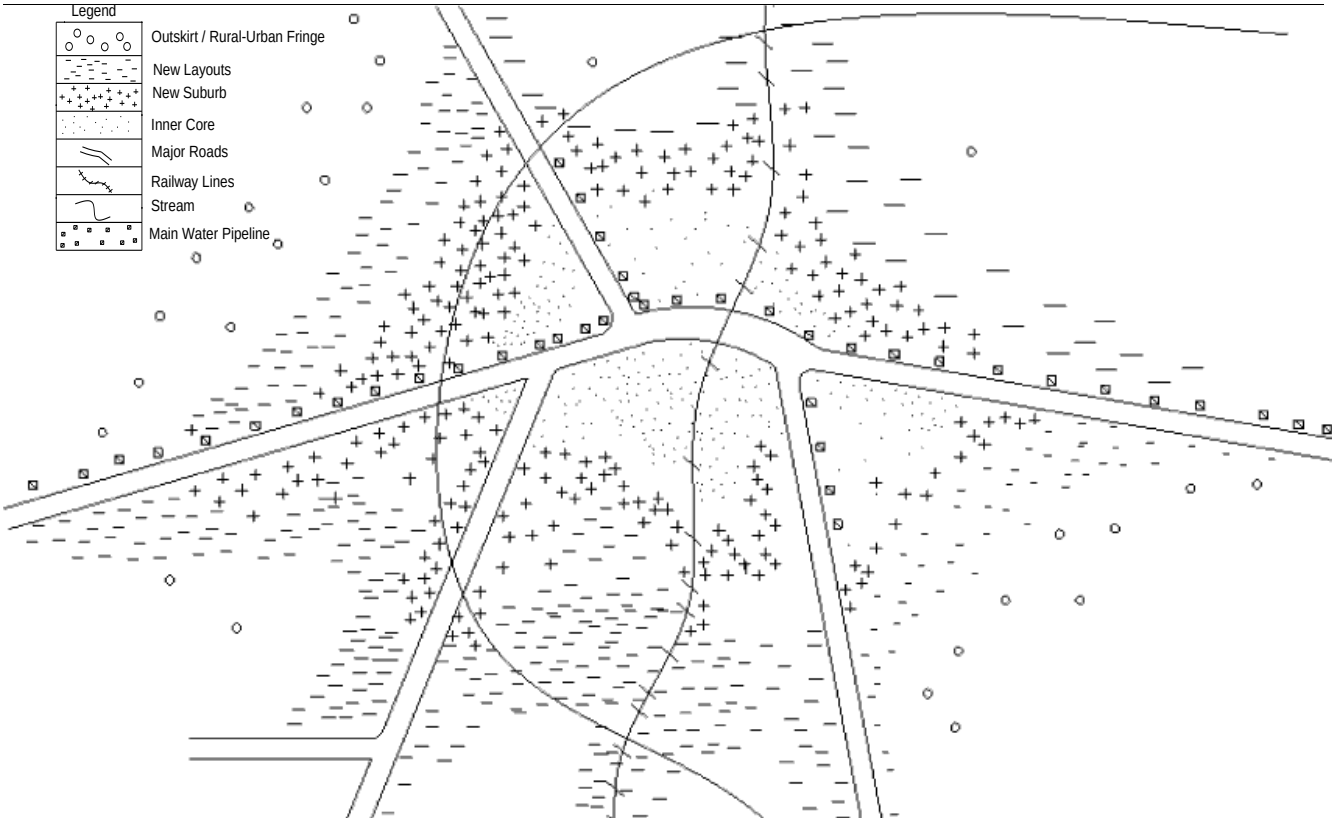

Figure 2. Typical spatial outline of the cities and towns. Source: Aderogba, K. A. Field Work.

(Figure 2). Each of the zones tends to extend outward along the roads, railways and streams that pass through the settlement. The Main pipeline from the dam run parallel with the main roads and it also branches with smaller pipes with the feeder (secondary) roads until it gets to the public taps and homes.

The Inner Core is not planned. It is characterized by ancient buildings occupied by old and contended indigenes. Government establishments are not common except probably old colonial buildings that have been renovated and converted to post offices, police stations, maternity Homes, dispensaries libraries or town halls. The palace of the king and the main (Traditional) market are located here. Old protestant churches and mosques are located here too. House to house connection of water pipes is not common but only public taps that are not less than 200 to 300 m apart. Even then, most of the pipes are corroded. In the course of road construction, reconstruction and rehabilitation, most of the pipes are damaged; and substantial quantity of water got lost through these sources. Also, where there are any at all, pressure in the pipes are very low and water can only drip at the taps. Thus, the supply is never sufficient; and rain water, at its season, is always harvested, stored and used to meet every need. These are supplemented by Mai-ruwa and tanker drivers hawking fresh water. Sachet water is considered to be the most pure. Water pipes are made of galvanized pipes that are connected to the main of larger diameter but made of bristle iron cast.

The main that runs from the dam terminates within the New Layouts. Immediately after the Inner Core is the New Suburb. Few modern residential buildings are here. There are also a few hospitals, maternity homes, schools and colleges with laboratories that require water in large quantity and quality. There are no public water taps at all. Rather, there are house to house connection to the bath-rooms, kitchens, laundry, and sometimes for watering gardens and lawns. Some schools and public buildings do have self procured and maintained standing pumps within the premises for purpose of washing cars, watering flowers and grasses. The pipes are both galvanized and polyvinyl chloride (PVC) made.

Generally, the demand for water is relatively greater than in the Inner Core. But again, supply from the Main is never sufficient. The taps run only occasionally; and not in every nook and cranny. Plastic overhead tanks ranging between 500 to 5,000 litres capacities are mostly used to store water whenever the supply comes. Those that can afford it also have underground tanks. Supplies are also supplemented by water tankers, hawkers and Mai-ruwa; and a few depend solely on boreholes and wells.

Harvesting of rain water is not common. The residents

do use sachet and bottled water.

The New Layout is the most planned. The residences are planned along with roads and streets. The zone is occupied mostly by the affluent. The houses are connected to the main with PVC pipes. This is where most government establishments, most modern residential buildings, public places, recreation centres, hotels, brothels, restaurants and eateries, bars and institutions of higher learning and others are concentrated. Water is most extensively used here for sanitation, recreation and entertainment, hospitals and schools, hotels, restaurants and bars, markets and large scale and small scale industrial productions and services. Because the pipe borne source is not always available, dependence on it is not significant. Most homes, communities, public places, businesses, institutions etc depend on boreholes, wells and water tanker driver for supply. The only water pipes are made of PVC. The population density is lowest compared to the Inner and New Suburb but water is most plentifully consumed. Most sophisticated and most affluent homes drink more of bottled water.

The outskirt rural-urban fringe (outermost) is some kilometers away from the Inner Core (Figure 2). There are more vacant, undeveloped pieces of land. There are lots of land speculations. Very many Pentecostal churches are springing up. One can rarely find any public primary or secondary schools. Schools are mostly privately owned. Life here is rural and urban. Residential buildings are found scattered all over. The streets, lanes and whatever will be crescents are not very distinct yet. Though there are some industries located in the zone, majority of the inhabitants depend on water hawked around by Mai-ruwa, water tanker drivers, boreholes and wells (for the affluent) and rain water and dews for the less privileged. Water for drinking is fetched in jerry-cans and bottles from the New Suburbs and New Layout where residents daily commute to work. Sachet and bottled water are also used sparingly.

DISCUSSION

Potable fresh water is a must for every home and community. The demand for fresh water in quantity and quality is increasing by the day and over space just as the cities and towns are expanding and increasing in population size, area extent and human activities. The supply and demand situations in the southwestern Nigeria are parlous. The resultant crises are taking the resemblance of adamant Third World cities where essential infrastructures are lacking. In its various forms and in quantity and quality, water is becoming scarce commodity in the region. The available quantity depicts adverse spatial variations and cannot meet the demand. The prospect for higher demand for quality fresh water is increasing and it will continue to increase as there are declining capacities of public water supply, in particular, to cope with the situation.

There is a common spatial variation in the pattern depicted in the cities and towns. It is just imperative that these parlous situations are nipped at the buds With the large amount of mineral deposits and forest resources awaiting industrial exploitation, and improved seedlings of crops, the processing of all of which will require large quantity of fresh water, supply situations must drastically improve over space and time. It is not unlikely if the global warming will not further compound the situations. The nation at large intends to make water readily available in every home before 2015; and also it will be required to make the vision of the United Nation realizable. If the region will continue to worth its being what it commands, the supply situations have to change drastically. There must be elaborate and deliberate planning and forecasting for provision of water and other infrastructures for every zone of each city and town in particular, the generality of the region and the nation at large.

Recommendation towards sustainable growth and development

Water for sustainable growth and development is imperative: A great return on investment will be in areas of improved health and reduction in drudgery in these among women and children, (United Nations, 2007; Akosile, 2007); and agglomerative advantage for industrial growth and development. The government should take over supply facilities. The development departments in each local government area should be charged with the responsibility of massively and consistently rehabilitating broken-down points. In order to ensure adequate supply to every community and zone, measures that must be taken, among others, should include, at the interim, extension and rehabilitation of hand-pump operated boreholes provided by the defunct Directorate for Food and Rural Infrastructure (DFRRI).

Feasibility studies for the provision of motorized mini-water schemes to adjacent large rural communities must be carried out with a view to making provisions for the communities. If the adjacent rural communities and the rural- urban fringes are not developed and equipped, it will only take a few years before the rural-urban fringe will become urbanized and start experiencing the same problem. All existing Dams across the region must be rehabilitated, equipped and manned; and new ones at strategic locations that will attract agglomerative advantages must be built. The new and the old dams and the treatment plants must be equipped with facilities that will allow for maximum aeration, coagulation, flocculation, rapid filtration and neutralization. The Dams and the accompanied treatment plants must also be complemented with service buildings: laboratories, control rooms (and general offices), chemical buildings for chemical storage,

generator buildings (and electric generators) and workshops that will house spare parts and tools that will be frequently required at the water works.

There must be extension of pipeline networks to serve the suburbs that lack pipe borne supplies. Samples must be adequately and regularly collected and analyzed to ensure quality. The Ministries of Health should continue to periodically review all operating and monitoring data for compliance and independently include inorganic and organic chemicals, pesticides and herbicides and radioactive and microbiological contaminants to ensure non-violation in the entire network.

The Water Boards must install and operate digital video surveillance network (DVSN) for the dams and distribution networks to ensure security. The system will be able to utilize digital video recording system with multi-user system of monitoring and control. The video should also be installed at the treatment plants and pumping stations to deter any criminal activities within vicinities

The DVSN may have to be centralized video-monitoring for one common centre for each complete network of a dam and its pipeline network and pump stations. This will provide a cost effective electronic security solution for visual verification of remote alarms resulting in more expedient emergency response to citizens, threats and deterrence of vandalism and theft.

Government policies and programmes should be realistic and focused: the governments and governances should be futuristic and be aware of the fast growing cities and towns in the Third World and of course the threat of global warming. Site and service approach should be adopted for the new suburbs and estates that are springing up per day.

In the interim, the rural-urban fringes and adjacent rural communities that are served with neither bore holes nor pipe borne water should be provided with bore holes or wells. These should be equipped with motorized pumping machines and overhead tanks for purpose of storage. The water from such tanks can be distributed to members of the community through 2 to $1^{1/2}$ inches diameter pipes using gravitational force. Otherwise, the rural communities will fend for water in the New Layout and the rural-urban fringes thereby aggravating the problems. Again, quality assurance is very important, and the department of health at the local government levels may work out the modality to further ensure quality.

Conclusion

The cities and towns are fast growing with multiplicity of functions but not with facilities and amenities that should go along with them for sustainable development. Global warming is another very serious threat. It may be too early to start experiencing water shortage and or epileptic supply of it. And, very soon, factories and industries will start springing up in numbers to exploit the mineral, forest and agricultural resources that are plentiful within the region. Also, the effect of the global warming may be setting in more seriously and soon.

The water sector can take a clue from telecommunication (in Nigeria). In the last 8 years, Nigeria's telecommunication industry has witnessed tremendous growth and development through private sector participations. This sector could be similarly grown and developed for sustainable economic growth and development. Every hand must be on deck to ensure availability of quality and quantity for every use. The poor status of infrastructures, facilities and amenities in other political units of the nation should not be made to be replicated in this region. The challenges of global warming must be challenged.

The Nigerian Standard for Drinking Water Quality (NSDWQ) is desirable to ensure access to quality; and it should be enforced by Standard Organization of Nigeria (SON) and/or National Agency for Food and Drug Administration Control (NAFDAC) or whichever agency the regional governments choose to.

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