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Development of Effective Water Supply Model for Kaduna Metropolis using Unguwar Kanawa as Case Study

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Abstract

The sustainability of water is critical to local, regional, national and global security. It is impossible to think of a resource more essential in the health of human communities or their economy than water. Water runs like a river through our lives, touching everything from our vigor and the fitness of natural ecosystem around us to farmer's fields and the production of goods we consume (Flint 2003).

Goals can be established to begin the in-depth integrated assessment of water shed resources that lead to sustainability. These goals should be formulated to address a number of fundamentals principles that underlay the conservation, protection, remediation, and longevity of water resources such goals might include;

(a) Provide safe, adequate water supplies at time and of the quality needed for domestic municipal, industrial, agricultural and hydropower uses.

(b) Allocate effectively and fairly fresh water among diverse uses and users.

During the process of these research work a questionnaire was provided to the consumers to gather information on water demand, nature of supply, use of metering system or non metering system ,illegal connection and other related information concerning the water supply in Kaduna. Similarly data for Kaduna metropolis population was collected from National population commission. The population of the study area was forecasted using the information collected from population commission. The water bill for different categories of consumers was collected from water board. All the information was gathered and a model equation was used to forecast the water consumption of Unguwan kanawa. In the result of analyses the water demand equation obtained by the regression analyses is:

Qas(Y) = 0.00061 + 520 Pop(X) where Qas(Y) = Actual supply and Pop(X)=population.

Introduction

Background

Nations the world over strive for a studious planning, development and management of Resources in order to meet the basic needs of people over time to live and maintain a Life which is decent healthy and respectable. The regulation and allocation of water resources for use purposes must be based on the river basin planning and actual potential of the water resource and must ensure principle of equality, appropriateness and prioritization order in terms of quantity and quality of domestic water. In case of water shortage, the regulation and allocation of water should be prioritized to domestic supply other water uses will be regulated and allocated in a proportion set (Xuan su, 2005)

When the water source is incapable of meeting the water demand, the branches and localities shall have to readjust their plan for population distribution and socio-economic— plans to make them suitable to the water sources actual capacity. Total domestic water need is at least 115 liters per day in modern households for cooking, drinking, flushing, washings, laundry and personal hygiene (Oyebande, 1990). To determine the water demand of any community it is very necessary to known the population. In Nigeria for example, this vital parameter for estimation of water demand and eventually its rate of growth from time to time is not readily available-for any town or village. However it is generally believe that the rate of growth of population is very high. If this believes is true it means the rate of growth of Water demand will consequently raise. To cope with this growing demand the conventional method for planning and designing water supply scheme should give way to approaches and strategies depending on local comprehensive analysis. Indeed adapting the simple technique of multiplying the population forecast by the average per capital estimated figure has led to overestimate of the future water use with the consequence of poor design of the system. Again the price- demand relationships are in a total mess in most of the developing countries. Non- payment of bill, illegal tapping, and waste in distribution and at head works constitutes serious retarding factors on the performance of water supply schemes (Babatola 1990). Since the demand for water in a community is it urban or rural is a function of it population, life style, industrial and agricultural activities (Jasem, 2002), a strategies is required for the allocation of water. A strategy may be defined in time as "water demand management and/or water conservation as well as the 'increase of water use efficiency'. (Arlosoroff 2003) Good water governance exist where government bodies responsible for water establish to Effective policy legal frame work to allocate and manage water in ways responsive to natural, Social and economic needs, and to the long term sustainability of the resources base.

Study Area

Kaduna Metropolis is the study area which is situated at the centre of the northern Nigeria. It was sited on gently sloping ground on the west bank of the Kaduna River, which serves as source of good water supply. It has a population of about 760,084 only for Kaduna North and south local Government. while part of Igabi and chukun local Govt.has a population of about 500,000, making a total sum of about 1.2million according to Census report May, 2007. Kaduna lies in the guinea savannah zone as the rainfall diminishes during the transition for south to northern Nigeria the rain forest gives way to the savannah woodland, which consist mainly of grasses and scared trees. The rainfall is normally within the period of April to October with an average of 1300mm (52.2inch) with 5 month less than 22mm (11inch) and 4 month with relative humidity at noon 20% or less, the average temperature is 32^{o}c. In Nigeria, the southern half of the country is dominated by the River Niger and its tributaries while the interior plateau and its tributaries dominate the north. Kaduna river has its drainage basin originating from the Kujama hills in plateau flowing for 210Km before it enters Kaduna town. The river also lies on Latitude $10\text{-}30^{o}$ north and Longitude $7\text{-}26^{0}$ east. Kaduna River is the main source of water supply for the community of Kaduna metropolitan. The water supply intake is situated at Malali village in Kaduna north where treatment plant was build. The first treatment plant (old plant) was established in 1972 which was commission by the Executive Governor of Kaduna state Alhaji Abba Kiyari, while the second plant (new plant) was established in April 1987 by General Damkat Bali. The second plant was established to supplement the first plant; the old treatment works plant has a capacity of 90million liter per day while the new treatment works has a capacity of 150million liter per day. The total capacity of the treatment works is 240million liter per day. On average a total of about 180 million liter per day is expected to be pumped everyday out of which 85 percent is supply per day. Kangimi dam was also build to supplement the main Kaduna treatment plant which is located at about 30Km away from Kaduna city.

The water treatment works consist of Main five distributions or pumping Station at which water is been pump into various location in the metropolitan, all the five boaster station consist of elevated tank:

(1) Elevated tank in state house: distributed by gravity to various portion within the located areas .

(2) Lugard hall tank along independent way: distributed by gravity to various portion.

(3) Tudun-wada elevated tank: these cover Tudun-wada areas and distributed by gravity to the areas**.**

(4) Kakuri: these cover almost southern part of the city and distributed by gravity to the areas.

(5) Kamazo: these cover Kaduna Refinery and Petrochemical Company and areas a long NNPC.

The above mentioned pumping stations are point where water is distributed within Kaduna metropolis the elevated tank in state house is the one serving in Unguwan Kanawa which is the studied area . The elevated tank has a capacity of $9{,}100m^{3}$, the boaster in the state house distributed water to areas of Unguwan Dosa, Kawo, Part of Badarawa, Unguwar Kanawa, NDA, Unguwar Shanu and Mando. According to the board staff the distribution of water is base on rational method and a maximum of nine hours (9hrs) for the pumping everyday depending upon the power supply, even though the pumping supply is by gravity method.

Aim

The aim of this research work is to use a mathematical linear model to analyze Water allocation strategies used by water works for the distribution of water to various points of use in Kaduna taking Unguwan Kanawa as a case study.

Objectives

The objectives of the study may be stated as follows:

1) To investigate the water supply in Unguwan Kanawa area, if not adequate to suggest a better method of water rationing.
2) To propose a model equation for future water demand in Unguwan Kanawa and else where

Literature

General

Besides air water is the second most important element necessary for the survival of man animals and plants, about 70 to 90 percent of any living cell is made up of water, (Garg, 2005).The importance of water cannot be overemphasized; man needs water for drinking, cooking, bathing, agriculture, cooling, firefighting, and fishing, wild life, and conservation, recreational and navigational purposes. With the increasing scarcity of water resources, degradation of the water environment and climate change, more and more public attention and academic research are being devoted to water resources management and polices, especially water allocation. (Lizhong, 2005).

There are several key problems concerning water allocation and management: They include:

1) Precipitation is geographically and temporally unevenly distributed over different areas of the world. Some places have exceptionally abundant precipitation, exceeding 1500-3000 mm annually, whereas desert regions receive less than 100mm.
2) Water demand is driven by the rapid increase in world population and other stresses. World population reached 5.38 billions in 1996 and will probably increase to around 7.9 billions by the year 2020, 9.9 billion in 2050 and 10.4 billions by 2100 (UN, 1998).
3) Water scarcity is now a common occurrence in many countries, it is been estimated that currently more than 2 billions people are affected by water shortage in over forty countries among which 1.1 billions do not have sufficient drinking water. The situation is particularly serious in many cities located in developing countries. UNWWAP, (2003) report, the major reasons are degraded water quality and pollution of surface and groundwater sources and the loss of potential sources of fresh water supply due to old and unsustainable water management practices.
4) Conflicts often arise when different water users (including the environment) compete for limited water supply.
5) Water allocation is central to the management of water resources. The need to establish appropriate water allocation methodologies and associated management institutions and policies has been recognized by researchers, water planners and governments.

Prior to 1960 water resources development was an exclusive preserve of the private individuals and groups (Handidu, 1990).The government major intervention came during the first National development plan period (1962 — 1968) through the establishment of the River Niger and lake Chad Basin commissions. The commissions were then mandated to produce hydrological maps of the country's water resources use the map to fashion out a compressive development of agriculture fisheries, animal husbandry and navigation (particularly River Niger). This was followed in 1973 and 1974 with the establishment of Sokoto-Rima and Chad Basin authorities and subsequent increase of the number to eleven River Basins Development Authorities (RBDA) in 1976 to cover the whole country. In 1984, the RBADs were increase to eighteen (18) and redesignated River Basin and Rural development Authorities (RBRDAS) with similar function to the RBDAS. With the change of military administration in 1985, the number (18) was scaled down to eleven and retained the name RBDA and its function limited to purely water resources development.

Some Causes of Water Supply Shortages

The chief reasons for most water shortages can be attributed to greater than anticipation population increases, decreases in well capacity, sediment accumulation in reservoirs, and increased water requirements, both domestic and industrial Both domestic and industrial water requirement have increased greatly since the end of World War II, (Roberts,1956) Considering Kaduna metropolitan communities, high demands of water is now a greater challenge due to the rapid increase in population and Industrials activities, due to these problems Kaduna metropolitan communities are experiencing high demand and consequently these lead to lack of adequate supply in some areas.

Consumption of Water for Various Purposes

The total water supply of a city is usually classified according to its ultimate use or end use. The uses are:-

(a) Domestic: These include water furnished to houses, hotels etc for sanitary culinary, drinking washing bathing and other purposes as mentioned earlier. It varies according to living condition of consumers the range usually being approximated to be 115 liters per day in modern houses (Oyebande, 1990).

(b) Commercial and industrial: Water so classified in these categories is that supplied to industrial and commercial plant. Its importance will depend upon local condition such as the existence of large industrial and whether or not the industries patronize the public water supply. The quantity of water required for a commercial and industrial use to be an average of 12.2m^3 per 100m^2

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of floor area per day (0.3 gal/ft^2) per day (Linsly et al, 1995).

(c) Public use: Public building such as city jails and schools as well as public service flushing street. Fire protection requires much water for which such water consumption varies from 50–75l per capita per day.

(d) Loss and waste: This water is sometimes known as "Unaccounted for "although some of the loss and waste may be accounted for in the sense that its cause and amount are approximately known. Unaccounted for water is due to meter and pump seepage, unauthorized water connections and leaks in main. It is apparent that the unaccounted for water and also waste by customers can be reduced by careful maintenance of the water system, and by universal metering of all water services.

(e) Agricultural water use: Water is used in agriculture for irrigation, as the world population is growing the demand for agricultural raw materials and food is also increasing. It has been noted that on the global level, 13 percent of the available lands are under irrigation using 1-4 million cubic meters of water per annum, (Novetney and Harvey, 1994).

(f) Recreational uses: The World is currently experience a period of rapid recreational development, Public and private agencies are attempting to meet a growing demand for recreation by building new facilities and modifying old ones, (Michael and Clark, 1997).

(g) Fish pond uses: several ponds are made along with reservoir for water supply to serve or allocated for conservative purposes such as fishing purpose. Water can also be used for wild life conservation such as game reserve.

Water Demand Management

In view of increasing cost of providing more water by developing new sources and declining government subvention and grant, most cities and town in the world are trying to attempt to initiate policy measures aimed out managing and controlling demand for water, (Abdu,1998). For effective management of water demand the following measures are proposed.

Water Pricing Measures

The present and method of charging for water is ineffective in bringing about its management. Existing water prices on the basis of either ratable of the property (or some surrogate measures such as the number of water point in the premises, the floor area of the premises or the number of rooms of flats in the premises the amount of water consumed and the cost of providing the service at a particular location). There is no way that the amount of water consumed can be charged arbitrarily. Without mater, there is still no doubt that if water charges are to be fixed on the basis of cost of providing the service.

Metering

Water meters along with appropriate rates and efficient billing and collection system are effective way for reducing water waste, promoting savings and detecting loses. Although the installation maintenance and reading meters is an expensive exercise, they must be introduced to allow authorities to manage demand closely and this conserve water. Metering all supplies as is done for electricity will necessitate the need to manage and change the people's attitude towards water waste. (Abdu, 1998)

Water Restriction

Water use restriction may be voluntary or enforced by law; Care must be taken to ensure that the consumption of water is not restricted below the desirable minimum (per capita) compatible with the rising standard of living of the people. Consumers are entreated to report promptly, cases of burst pipe: and leakages around there premises or anywhere else that such occur. If this fails the bye – laws have to be enacted by the (Kaduna State Water Board) to ensure that water is not wasted or squandered. The penalty for damaging water pipes by individuals or construction firms should be made stiffer and enforced more diligently.

Model

A model is a system whose operation can be used to predict the characteristic of a similar system or prototype, usually more complex or built to a much larger scale. (Ibrahim, 2006). Acknowledgement of the laws governing the phenomena under investigation is necessary if the model study is to yield accurate quantitative result.

Mathematical Model

A mathematical model is simply a quantitative expression of the process or phenomenon one is observing, analyzing or predicting. (Mustafa and Yusuf 1997) Since no process can be completely observed, any mathematical expression of a process will involve some element of stochastic, i.e. uncertainly.

Research Methodology

This research work required population data, which was collected from National Population commission, the data collected from population commission only captured Unguwan Kanawa in 1991 and a projection of 2000 and 2001 while that of 2007 did not capture Unguwan kanawa but captured Kaduna north in which Unguwan kanawa is inclusive. The consumption rate was obtained by the use of structured questioner, Verbal interview in which the result will be analyze by the used of computer software.

Research Methods

Two sets of structured questionnaires were employed to gather all necessary information. One set was addressed to consumers (users) and one set was addressed to agencies responsible for planning, production and distribution of potable water. Similarly road interview was conducted to vendors of water, tankers etc. The purpose of the above is to gather information on the actual Supply situation, problems and prospects of water supply within the study area. It is believed that a balanced view of the level of water service as well as water problems and their solution will be obtained if these were properly merged. There are problems with subjective questionnaire surveys, particularly in societies where many of the respondents either do not have adequate perception of the resources problem, or are unwilling to match their unceasing complaints and demand for improved welfare with commitment of (responding to) challenges which may provide solution to their problems.

In the research methodology the followings parameters were also investigated:

1. The distribution pipe system.

The essence of this investigation is to find out the distribution pipe for leakage problem, because leakage in pipe can caused short of water supply in sufficient quantity. Control of pipe leakage is also part of the strategy for allocating water in sufficient quantity to consumers.

2. Illegal connection from consumers.

In some cases public developed the attitude of connecting water pipe for their consumption without the permission of water board authority, such illegal connection result to short of water supply. It is therefore important as part of strategy to investigate and look for a solution as to eliminate such illegal behavior.

3. Water tight joint and pressure distribution.

The above can also be investigate to check up water leakage .Due to high pressure in pipe can also lead to higher leakage losses Water tight joints in the water mains and pipes generally leak due to bad plumbing leading to high wastage of water.As pointed out earlier, enormous amount of water is lost in leakages, wastes, thefts, etc, in every water supply scheme. In order to control these loses and to reduce them to minimum, it is desirable to thoroughly inspect these factors which causes losses and wastages in the study area as follows:

1) In the distribution system, there are some burst and roast pipe which leaks water before it reach the consumers. These will involve carefully inspecting the pipe network of all the pipe connection system in the study area so that new pipe should be replaced for any inadequate pipe that is incapable supplying water in order to reduce losses.
2) Illegal or unauthorized connection which must be detected and check through verbal interview to the consumer/Questionnaire interview and with the assistance from ward head. Similarly through the inspection of burst pipe can also indicate the sign of illegal connection by consumers. As strategy, law enforcement should be applied through the aid of ward head and water agencies any unauthorized connection should be heavily punished by the law enforcement.
3) Water tight joint and pressure distribution should also be monitored, because the joints in the water mains and pipes generally leak due to bad plumbing, leading to high wastage of water. The leakage of water can be reduced by careful and checking the plumbing system in the study area, so that a regular maintenance and keeping the joint water tight so as reduced water loss. Pressure in the distribution system should be monitor so that no high pressure should be operated during distribution of water, because high pressure in the distribution pipes lead to high leakage loses. So much so that an increase in pressure from 20m head of water to 30m head of water may increase the leakage by about 20 to30 percent (S K Garg, 2005)The study area was divided into four (4) zones.

To allocate water for any community it is necessary to know the followings factors:

1) Actual supply from the source.
2) The water demand per capita per day for the community to be serving.
3) The total population of the community.
4) Losses due leakages during distribution.

In the research work a liner regression model equation was used for the allocation of water distribution in the study area.

<u>The Model Equation for Allocation</u>

It is stated earlier that the allocation of water is depend upon the available water, and that the demand also depend on the population in the community, its follows that there is linear Relationship between demand and supply. If that is true .then; $Q_{as} = dxp + I_d$ (3.1.2)

Where; Qas= Actual supply

d = Demand per capita per day (usually 100-1501/c/d)

p = Population

I_d= Distribution loses

The equation above appear to be like a regression equation in linear form which one variable depend on the other variable, i.e. actual supply is depended on Population In the research work the variables will be investigated and observe if they arc correlated. The population will be obtaining from population census and data obtain from questionnaire. And the method of arithmetic or geometric progression would be use to forecast the future Population. Aluko method would also be applied in the research work. The followings formulas were applied in the analysis respectively:

$Q_n = P_n xq$… 2.1.3

Where Q_n = recorded average daily consumption at year n; P_n= population at year n; qn = computed per capita daily demand at year n

$Q_{as}=dxp+I_d$ .... (3.1.4)

Where; Qas= Actual supply

d = Demand per capita per day (usually 100-1501/c/d p = Population and I_d= Distribution loses

Method of Population Forecast

Population growth: In order to predict the future population, as correctly as possible, it is necessary to know the factors affecting population growth. There are three main factors responsible for changes in populations. They are :(i) births (ii) deaths (iii) migrations. All these varying influences make the task of predicting future population, very difficult and highly unexact, as it is very difficult and time consuming especially for the engineers to evaluate all these economic and social factors. It is therefore, more common to rely upon mathematical formulae and graphical solutions based upon previous population records(S K Garg, 2005).The method of population is obtain by the following formulae

Arithmetic increase method: This method is based upon the assumption that the population increases at a constant rate i.e. the rate of change of population with time i,e **(dp/dt)** is constant . Thus **(dp/dt) =k** or $\int_{p1}^{p2} dp = k\int_{t1}^{t2} dt$………………equation (1) by integration of equation 1 then it becomes:

P_2-P_1=k (t_2-t_1)…………………(2) where suffixes 1 and 2 represent the last and the first decade or census, respectively. Thus t_2-t_1 = no. of decade. The general form of Arithmetic increase is given by: **p_n={p_o+n.μ}…………………..(3)** where **p_n**=prospective or forecasted population after n decades from the present (i.e. last known census), **p_o**=population at present(i.e. last known census),**n**=no, of decade between now and future. **μ=** average (arithmetic mean) of population increase in the known decade. **Geometric increase method:** In this method, the per decade percentage increase or percentage growth rate (r) is assumed to be constant, and the increase is compounded over the existing population every decade. This method is therefore also known as **Uniform increase method.** The difference between arithmetic and geometric method is that in geometric there is compounding in every decade while in arithmetic there is no compounding. Hence geometric increase is given by: **p_n= p_o+r/100p_o ...…… (4)** thus eqution (4) can simplify as: **p_n= p_o (1+r/100) ………………………(5) ,** where r is in percentage similarly **p_n=** population after 2 decade for successive decade, equation (5) can be simply to give : **p_n= p_o $(1+r/100)^n$** …………….(6), where **p_o** = Initial population, ie the population at the end of last known census, **p_n** =future population after a decades, **r** = assume geometric rate(%). This assumes growth rate (r) can be computed from the past known population data in 3 ways:

(1) **r=** $\sqrt[t]{\frac{p2}{p1}} - 1$ where p1= initial known population,p2=final known population ,t= no. of decade (period) between p_2 and p_2.

(2) r=$\frac{increase\ in\ population}{original\ population}$x100 values, are computed for each known decade, and their average may be taken as the assumed constant per decade increase (r)

(3) The average may again be either the arithmetic average i.e. $\frac{r1+r2+r3+\cdots\cdots rt}{t}$ or the geometric average ie $\sqrt[t]{r1xr2xr3\ldots\ldots rt}$

Method of varying increment or incremental increase: I n this method, the per decade growth rate is not assume to be constant as in the arithmetic or geometric progression methods: but is progressively increasing or decreasing, depending upon whether the average of the incremental increases. The population for a future decade is worked out by adding the mean arithmetic increase (say **μ)** to the last known population as in "arithmetic increase method" and to this is added the average of the incremental increases **ỷ,** once for the first decade, twice for the second decade, thrice for the third decade, and so on. Incremental increase is given by:

p_n=p_o +nμ) +n$\frac{(n+1)\acute{y}}{2}$

Where pn=population after n decade from present (i.e. last known decade),µ=average increase of population of known decade=average of incremental increase of the known decade.

From the method of population forecast described above one of the method will be used in order to forecast the population of Unguwan kanawa which is the study area. In this case I applied **Geometric increase method.** The values of census figure for Unguwan kanawa in 1991 and the projected figure for 2001 is shown in table below and the result for the forecast was analyzed by using excel.

Analysis of Result

Considering the data for the census of 1991 and projected values of 2000 and 2001, the following result was obtained by Geometric increased method using excel as shown in table below. The result was calculated from 1991 to 2031 that is for successive 4 decade. A decade was defined as every 10years. The formula obtained from Geometric increase method is given as: $\mathbf{p_n = p_o (1+r/100)^n}$ where $\mathbf{p_o}$ = Initial population, ie the population at the end of last known census, $\mathbf{p_n}$ =future population after a decades, **r** = assume geometric rate(%).

Table 1: Analysis of Population Forecast Result (Unguwan Kanawa)

Year	Population	Increase in population in each decade	Percentage increase i.e. growth rate
1991	9732		
2000	12922		
2001	13336	3604	0.370325
2011	18274.65		
2021	50084.41		
2031	100168.8		

Table 2: Table For Old and New Water Rate Charges in Kaduna (Extracted from Kaduna water board)

Categories	Current rate(₦/m3)	New Rate(₦)
Domestic customers	21	32
Commercial/Industrial Customers	70	210
Public Institutions	30	60
Raw water charges	7.25	100
3 Bedroom flats and above in low density areas	2,310 monthly	5,775 monthly
3 Bedroom flats and above in high density areas	714 monthly	1,428 monthly
1 or 2 Bedroom House anywhere	609 monthly	914 monthly
Single Tap anywhere	420 monthly	630 monthly
Tankers Supply.	100	200

Considering the data collected for different classes of household connection in Unguwan kanawa area, the following result was obtained for the daily water consumption per category of house connection using both old and new rate of water charges. The water consumption is charge monthly per 21 m^3 and $32m^3$ for domestic consumption for old and new rate respectively in each class of connection the consumption was calculated using excel. The consumption of water is not measured by flow meter but rather charge as per unit rate of 21 m^3 and $32m^3$ for domestic consumption, here in the analysis of result the consumption was calculated for domestic consumption according to the type of building which was described below.

Old rt--------old rate, new rt-------new rate, unit rt---unit rate, c/u.r old----consumption per unit rate old price,

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c/u.r new---consumption per unit rate current price, no. of h.hl---number of household Connected, con/h.h.o-----consumption per household connected in cubic meter at old rate, con/h.h.n-----consumption per household connected in cubic meter at new rate

DO1………………………….Denoted a single tap connection anywhere

DO2………………………….Denoted 1 or 2 bedroom flat connection anywhere

DO3………………………….Denoted 3 bedroom flat connection anywhere

DO4.,……………………….Denoted 4 bedroom flat connection anywhere

Analysis of Result

Table 3: Table for the Computation of Water Consumption in Unguwan Kanawa Area

category	old rt (₦)	new rt(₦)	unit rt(m^3)	unit rt(m^3)	c/u.r old	c/u.r new	no. of h.hl	con/h.h.o(m3	con/h.h.n(m3)
DO1	420	630	21	32	20	19.6875	587	11740	11556.56
DO2	609	914	21	32	29	28.5625	53	1537	1513.813
DO3	714	1428	21	32	34	44.625	24	816	1071
DO4	2310	5775	21	32	110	180.4688	8	880	1443.75
							672	14973	15585.13

By using Aluko model which is stated below:

$Q_n = P_n x q_{d...}$ 2.13.4.

Where Q_n = recorded average daily consumption at year n; P_n= population at year n; qn = computed per capita daily demand at year n.

If r = population growth rate which is calculated to be equal to 0.370325 then by using geometric increased method given by: $\mathbf{p_n = p_o (1+r/100)}$. Using excel for the period of 1991 to 2031 that is for the period of four decade. The water consumption is charge monthly per 21 m^3 and $32m^3$ for domestic consumption for old and new rate respectively in each class of connection the consumption was calculated using excel on daily consumption by dividing the monthly consumption by 30days An assumption was made in two different conditions, First condition, on the assumption that the total populations forecast over each decade were connected with water board while the second assumption which is the actual connection with the water board in each decade was forecasted using growth rate of 0.370325 respectively as shown in the result of analyses the result is obtained as follows:

Analysis of Result

Table 4: Table for Water Consumption for Population Forecast Over Four Decade

year	$p_{n(Population)}$	$q_{d(daily\ demand\ in\ m3\ for\ old\ rate)}$	$q_{d\ (daily\ demand\ in\ m3\ for\ new\ rate)}$	$Q_{n=record\ avr\ d.\ con\ at\ yr\ n\ (new\ rate)}$	$Q_{n=record\ avr\ d.con\ at\ yr\ n\ (old\ at\ rate)}$
1991	9732	499.1	519.5	5055774	4857241.2
2001	13336	499.1	519.5	6928052	6655997.6
2011	18274.65	499.1	519.5	9493680.675	9120877.815
2021	50084.41	499.1	519.5	26018851	24997129.03
2031	100168.8	499.1	519.5	52037691.6	49994248.08

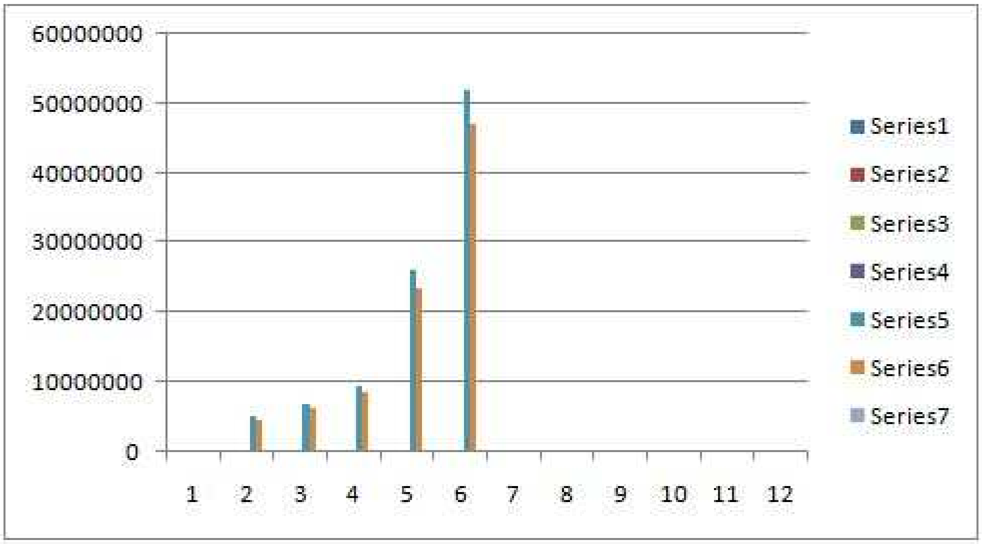

Figure 1: Graph Of Recorded Average Daily Consumption For Both New And Old Rate

Analysis of Result

Table 5: Table for Water Consumption for Population Forecast With Assumed House Connection Over Four Decade

category	No of H.h con.(P_n)	r=g.rate	Year(n)	q_d=daily con.	q_d=daily con.	$Q_{d=rec.con\ at\ n.yr}$	Q_d=daily con.
DO1	587	0.370325	10	499.1	519.5	4014664.448	4178758.126
DO2	53	0.370325	20	499.1	519.5	724964.96	754596.8678
DO3	24	0.370325	30	499.1	519.5	492429.0294	512556.363
DO4	8	0.370325	40	499.1	519.5	218857.3464	227802.828
						5450915.784	5673714.185

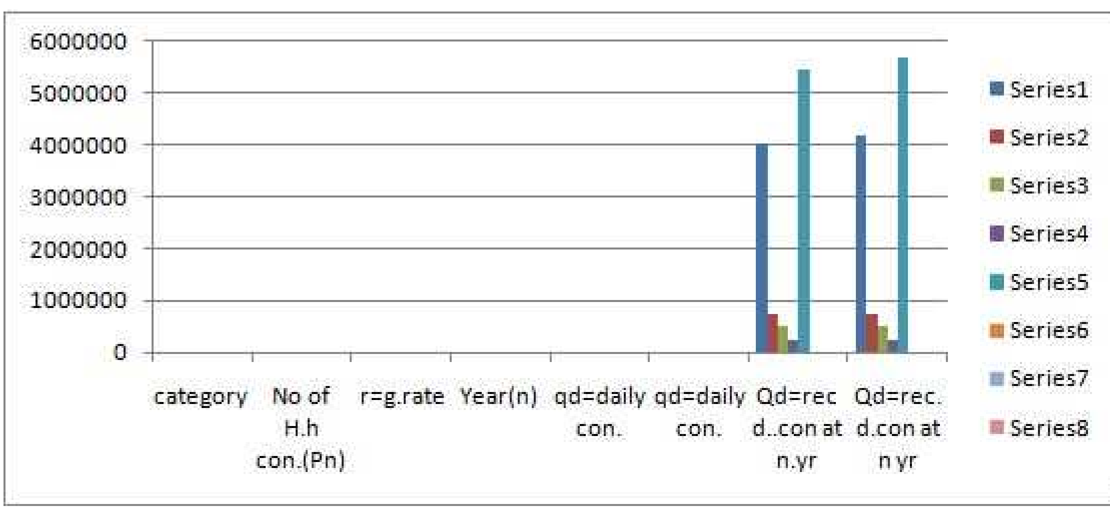

Figure 2: Graph Of Recorded Average Daily Consumption With Assumed House Connection For Both New And Old Rate

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By using the data for population forecast above, the daily water demand, the proposed future model equation can be obtained using Mini Tab R14 Package. The equation to be use for the analysis is given as:

Q_{as}=dxp+I_d .... (3.2)

Where; Qas= Actual supply

d = Demand per capita per day (usually 100-1501/c/d),

p = Population I_d= Distribution loses

ANALYSIS OF RESULT

Regression Analysis: Qas(Y) versus Pop(X)

Obs	Pop(X)	Qas(Y)	Fit	SE Fit	Residual	St Resid
1	9732	5055774	5055774	0	-0	-0.34
2	13336	6928052	6928052	0	-0	-0.35
3	18275	9493681	9493681	0	-0	-0.37
4	50084	26018851	26018851	0	0	1.73
5	100169	52037692	52037692	0	-0	-1.70

The regression equation is
Qas(Y) = 0.00061 + 520 Pop(X)

Predictor	Coef	SE Coef	T	P
Constant	**0.000612**	**0.001711**	**0.36**	**0.744**
Pop(X)	**519.500**	**0.000**	**1.5566E+10**	**0.000**

S = 0.002543 R-Sq = 100.0% R-Sq(adj) = 100.0%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	**1**	**1.56719E+15**	**1.56719E+15**	**2.423E+20**	**0.000**
Residual Error	**3**	**0**	**0**		
Total	**4**	**1.56719E+15**			

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