



## Evaluation of Dutse Metropolis Water Supply System Scheme

<sup>1</sup>Muhammad, I. A, Abubakar, M; <sup>3</sup>Saleh, I. U., <sup>4</sup>Ugwu, S.J., <sup>5</sup>Shariff, F.U., <sup>6</sup>Adedokun, A. A

<sup>1</sup>Hydrology and Water Resources Management Department National Water Resources Institute

<sup>2</sup>Agric and Bio-environmental Engineering Technology Department National Water Resources Institute,

<sup>3&4</sup>Research and Technical services Department, National Water Resources Institute,

<sup>5</sup>Training Department, National Water Resources Institute,

<sup>6</sup>Department of Water Resources and Environmental Management National Water Resources Institute, Kaduna State

### ABSTRACT

Water supply is the provision of water by public utilities, commercial organizations, community endeavours or by individuals, usually via a system of pumps and pipes. This research work was aimed at assessing the current water demand and to forecast for the future water demand of Dutse metropolis Jigawa state, and to estimate the population covered by the supply. The study utilized the administration of questionnaires and personal interview of individuals, both private and government workers. The water demand of the metropolis was found to be 180466.24 m<sup>3</sup>/day in 2021 20232.42 m<sup>3</sup>/day in 2025 22683.49 m<sup>3</sup>/day in 2029 24018.23 m<sup>3</sup>/day in 2031 whereas water supply to the metropolis was found to be 6497.3 m<sup>3</sup>/day. The metropolis would experience supply deficit of 17520.95m<sup>3</sup>/day in next ten years owing to the projected population growth of the metropolis. It is recommended that water supply from surface water source to the metropolis and reliable and sustained electricity to operate the boreholes. Alternative source of energy (preferably renewable energy source) should be giving priority.

### ARTICLE INFO

Article History

Received: September, 2023

Received in revised form: November, 2023

Accepted: January, 2024

Published online: February, 2024

### KEYWORDS

Water Supply, Water Demand, Dutse Metropolis, Population Estimate, Future Water Demand, Supply Deficit

### INTRODUCTION

Planning, developing, allocating, and managing the best use of water resources are all included in the activity of managing water resources (Zahoor, et al., 2019). In order to accomplish successful sustainable water management, it is necessary to control water resource systems, which are a combination of environmental factors and water resource created structures (Dewulf, Craps, Bouwen, Taillieu, Pahlostl, 2005). In a perfect world, water resource management planning would take into account all competing demands for water and aim to distribute it fairly in order to fully meet human needs (Daene, 1993).

In order to improve water supply and public health, there is an urgent need for good theory and practise integration, notably in planning water resource management (Nicol, 2000; UNICEF, 1999), A severe water deficit that can

support future population increase will prevail unless the management of the world's water resources is successfully improved, as evidenced by the mounting demand on them (Biswan, 1978). This is because poor management, pollution, and conservation will lead the world's water supply to run out.

Nigeria has two large rivers that run through it on both sides, as well as several branches of other tributaries, but the country still struggles with a lack of water. Stakeholders have recently become aware of the necessity for good planning of Nigeria's water resources due to recent droughts, floods, urban water shortages, and water contamination across the globe and in Nigeria. The minimal standard amount per capita for underdeveloped nations is 120 litres per day, according to the World Health Organisation (WHO) (World Health Organization, 1999).

Corresponding author: MUHAMMAD, I.A.

✉ [ebukush3@gmail.com](mailto:ebukush3@gmail.com)

Hydrology and Water Resources Management Department National Water Resources Institute Kaduna State

© 2023. Faculty of Technology Education. ATBU Bauchi. All rights reserved



In Africa, the water supply system is unreliable (Nepad, 2006; Rached, Rathgber, Brooks, 1996). Due to climate variables, high human water use as a result of rapid population increase and industrialisation, and especially in dry places, water resources are continuously becoming scarce for future generations. It is essential to conserve water resources, avoid pollution, and manage demand and supply well since water shortages would have severe effects on both people and the environment (Arendal, 2009).

The existing water supply to Dutse town is mainly from two well fields located at Shuwarin village, some 12 kilometres northeast of Dutse. Although Shuwarin is underlain by the Chad sediments, it lies in the basement foreland, where the Chad sediments are rather thin. The boreholes at Shuwarin terminate in and screen the weathered Basement Complex rocks underlying the Chad sediments. The average yield of the boreholes in the well field is about 350 m<sup>3</sup>/day, which is higher than the average yield from a typical borehole in the basement complex. This is due to the storage provided by the overlying Chad sediments. The unweathered crystalline rocks in the immediate surroundings of Dutse, comprising granites, granodiorites, and rhyolites, from which the town derived its name, do not have any porosity and do not yield water.

However, secondary porosity with some aquifer potentials develops where the crust is weathered or fractured. Several boreholes have been drilled into this type of aquifer around Dutse over the years, but the yield of the boreholes is low, at 2.3 l/s (Jigawa State water cooperation, 2007). Dutse metropolis in Jigawa state, Nigeria, is facing a water shortage challenge due to an increase in population. The growing population of humans and animals in the last three decades and the higher standard of living have jointly resulted in higher urban water demand at a time when the supply is diminishing. The situation has been aggravated by a lack of planning due to insufficient specialized staff to carry out instructions, keep records, and maintain structures (Jigawa State water cooperation, 2007).

This problem of water shortage may be due to changes in the factors governing water consumption. Residents subjected to water shortages usually source water from commercial hawkers, and some, especially women and children, carry it over long distances. Inadequate supply has often led people to use sources that are contaminated and thus dangerous to human health. However, in an attempt to assess the water supply scheme of the Dutse metropolis, this study focused on assessing the water utilization of the metropolis, estimating the current water demand and supply, and forecasting the future water demand and supply deficit of the metropolis. Therefore, the evaluation of the water supply system will provide important information for the development of future water supply projects.

## MATERIALS AND METHODS

### Study Area

Dutse is a city located in north – Western part of Nigeria, it is the capital city of Jigawa state with an estimated population of 75,341 (National Population Commission, 2006). Dutse city is bounded by latitude 11°N to 13°N and longitude 8°E to 15°E. The climate is semi-arid and characterized by a long dry season and a short rainy season. There are two air masses which with them bring rain bearing of south western winds and the cold dry dusty wind locally known as “Harmattan” at different times of the year. Either one of the winds prevails and the area experiences rainfall or the dry Harmattan depending on the advancement or retreat of the one another (Jigawa State water cooperation, 2007). Yearly extreme in temperature range from 22°C during Harmattan period to about 36°C during the hot season. The rainy season lasts from April – October with annual rainfall in the range of 600mm – 1000mm in the north and southern part respectively (Jigawa State water cooperation, 2007). Figure 1.0 present map of the study area.

---

Corresponding author: MUHAMMAD, I.A.

✉ [ebukush3@gmail.com](mailto:ebukush3@gmail.com)

Hydrology and Water Resources Management Department National Water Resources Institute Kaduna State  
© 2023. Faculty of Technology Education. ATBU Bauchi. All rights reserved

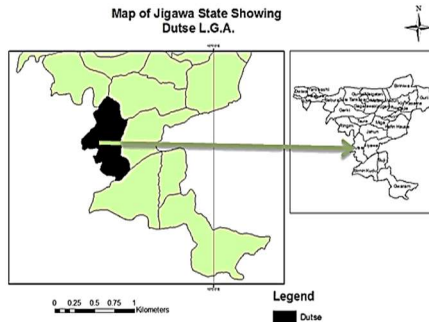


Figure 1.0 map of Jigawa state showing the study area.

**Sources of information**

The sources of information for this work are from primary and secondary sources.

**Primary source**

These are information obtained from administration of questionnaire and personal interview of individuals, both private and government workers.

**Secondary source**

Information obtained from journals, textbooks, term papers and data from government organization newspapers are the secondary source of information.

**Water utilization**

A structural questionnaire is used in ascertaining water utilization in the study area. 100 questionnaires were purposively distributed evenly in the study area. 85 questionnaires were returned making 85% of the total questionnaire administered. The sample of the questionnaire is presented in appendix A.

**Population forecasting**

Geometric increase method is used in forecasting population growth in this work. It is chosen because the growth rate is nearly constant every year. In this method a constant percentage of growth is expected for equal periods of time. The population at the end of 'n' years or decades, given as, the rate of increase is proportional to population as presented by Eqn. (1)

$$Pf = P (1 + r/100) n \quad \dots\dots\dots (1)$$

Where Pf = future Population

P = present population

r = Growth rate

n = Number of years (10)

The National population commission of Nigeria employs growth rates for Jigawa States as (2.90%). For Dutse city the same value is adopted.

**Water requirement**

Water supply systems are provided to satisfy the present and future demand of its consumers. The consumption estimate used by the (FMWR/JICA, 2014) is 120 L/c/d is adopted and 30% of the domestic requirement for non-domestic needs, Eqns. (1), (2), (3), & (4)

$$\text{Domestic requirement} = \text{population} \times 120\text{L/c/d} \quad \dots\dots\dots (2)$$

In L/day

$$\text{Non domestic requirement} = 30/100 \times \text{domestic requirement} \quad \dots\dots\dots (3)$$

In L/day

$$\text{Total quantity of water required} = \text{Domestic requirement} + \text{Non domestic requirement in L/day} \quad \dots\dots\dots (4)$$

**Supply estimates**

The average yield of the boreholes and their operational hour per day were obtained from Shuwarin main water works. The total supply per day was obtained by multiplying the yield of each borehole by the operational hours.

The summation of the supply per day of all the boreholes gives the total volume of water supplied in a day for the consumers.

If the total supply is less than the quantity required, deficit is calculated using Eqn.(5) and additional supply required using Eqn.(6) and the required boreholes needed to match the deficit is calculated using Eqn.(6)

$$\text{Total water demand (deficit)} = \text{Quantity required} - \text{Quantity supplied} \quad \dots\dots\dots (5)$$

$$\text{Number of boreholes to be provided} = \text{Deficit/Average yield of boreholes} \quad \dots\dots\dots (6)$$

Average yield = required yield for the design.

Corresponding author: MUHAMMAD, I.A.

[ebukush3@gmail.com](mailto:ebukush3@gmail.com)

Hydrology and Water Resources Management Department National Water Resources Institute Kaduna State  
 © 2023. Faculty of Technology Education. ATBU Bauchi. All rights reserved

## RESULTS AND DISCUSSION

### Water utilization

#### Water utilization by level of educational

The research assessed by the water supply within the metropolis. It was found that 5% of the respondents are primary school certificate holders, 20% are secondary certificate holders, 15% tertiary certificate holders and 60% do not have formal education. The respondents mostly used the water for drinking, bathing, washing and cooking. Fig 4.1 presents the water utilization by educational level.

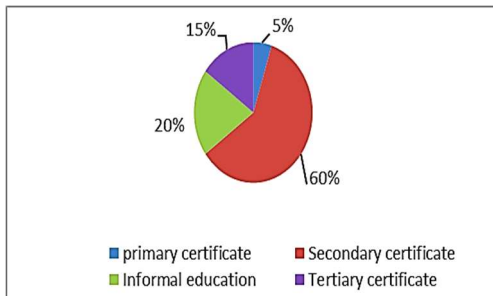


Fig 3.1.1: Educational Level

#### Water utilization by age group

The research assessed by the water supply within the metropolis. It was found that 30% of the respondents are of 18 – 25, 40% of 26 – 45 category, and 30% are above 45 years. The respondents mostly used the water for drinking, bathing, washing and cooking. Fig 4.1.2 presents the water utilization of the study area by age group

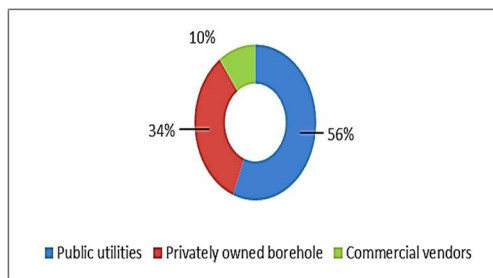


Fig 3.2: Water Source of the study area

#### Water supply of the study area

The research assessed by the water supply within the metropolis. The supply assessed

is from public scheme. It was found that 80% of the respondents received water thrice a day cumulating to 12 hours of supply, 18% receive water twice a day cumulating to 8 hours of supply and 2% receive water once in a day cumulating to 4 hours of supply. Fig 3.3 presents the current water situation of the study area.

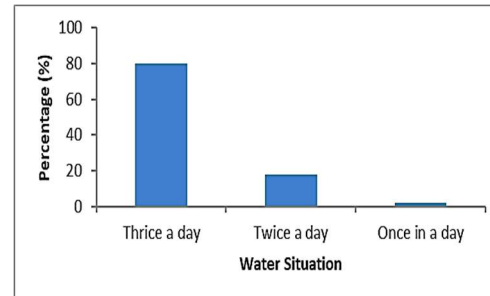


Fig 3.3: Current Water Situation

#### Assessments of monthly income and willingness to pay for water

The research assessed by the water supply within the metropolis. It was found that 65% of the respondent's monthly income ranges from 18000-50000 naira and 35% of those earning between 18000-50000 are willing to pay 1000 naira/month for portable water supply. For those earning between 50000-150000 naira, the respondents are willing to pay 2000 naira/month while the respondents earning 150000 naira and above are willing to pay 2500 naira/month. Thus fig 3.4 present the willingness of respondents to pay by monthly income. It can be concluded that people that are earning higher are willing to pay more.

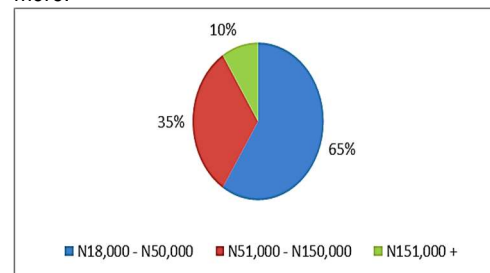


Figure 3.4: Monthly Income of the respondents

#### Population forecasting

Corresponding author: MUHAMMAD, I.A.

[ebukush3@gmail.com](mailto:ebukush3@gmail.com)

Hydrology and Water Resources Management Department National Water Resources Institute Kaduna State  
 © 2023. Faculty of Technology Education. ATBU Bauchi. All rights reserved

The population of Dutse city based on 2006 Census was 75341. Taking the 2006 as the base year and applying a growth rate of 2.9%, the projection populations are calculated below and the projected population is presented in figure 3.5

$$P_f = p (1 + r/100)^n$$

$$P_{2021} = 75341(1+0.029)^15 = 115681$$

$$P_{2025} = 115681(1+0.029)^4 = 129695$$

$$P_{2029} = 129695(1+0.029)^4 = 145407$$

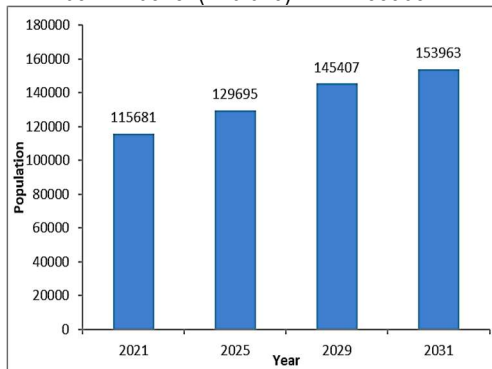
$$P_{2031} = 103181(1+0.029)^2 = 153963$$


Figure 3.5: Population forecasting of the study area

Design Population for the next ten (10) years (2021 – 2031) is 153963. The projected population in 2031 shows an increase of about 104% from 2021.

### Consumption estimates

Using the [12] Standard of consumption estimates, 120L/C/D for domestic requirement and 30% of the domestic need as non-domestic requirement and 4% as loses, the following Calculation are made.

### Current water demand (2021)

$$\text{Domestic requirement} = 115681 \times 120 \text{ L/C/d}$$

$$= 13881720 \text{ L/day}$$

$$\text{Non-domestic requirement} = 13881720 \times 0.30$$

$$\text{L/C/d}$$

$$= 4164516 \text{ L/day}$$

$$\text{Total requirement} = 13881720 + 4164516$$

$$= 18046236 \text{ L/day}$$

### Future water demand (2025)

$$\text{Domestic requirement} = 129695 \times 120 \text{ L/C/d}$$

$$= 15563400 \text{ L/day}$$

$$\text{Non-domestic requirement} = 15563400 \times 0.30$$

$$\text{L/C/d}$$

$$= 4669020 \text{ L/day}$$

$$\text{Total requirement} = 15563400 + 4669020$$

$$= 20232420 \text{ L/day}$$

### Future water demand (2029)

$$\text{Domestic requirement} = 145407 \times 120 \text{ L/C/d}$$

$$= 17448840 \text{ L/day}$$

$$\text{Non-domestic requirement} = 17448840 \times 0.30$$

$$\text{L/C/d}$$

$$= 5234652 \text{ L/day}$$

$$\text{Total requirement} = 17448840 + 5234652$$

$$= 22683492 \text{ L/day}$$

### Future water demand (2031)

$$\text{Domestic requirement} = 153963 \times 120 \text{ L/C/d}$$

$$= 18475560 \text{ L/day}$$

$$\text{Non-domestic requirement} = 18475560 \times 0.30$$

$$\text{L/C/d}$$

$$= 5542668 \text{ L/day}$$

$$\text{Total requirement} = 18475560 + 5542668$$

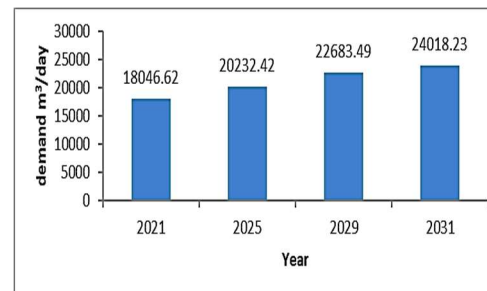
$$= 24018228 \text{ L/day}$$


Figure 3.6: Water Demand

### Supply estimates

The current water supply to Dutse city from 94 functional boreholes with varying capacities is presented in the Table 1



**Table 1:** Present water supply from boreholes in Dutse City

S/N	Name of Pump Station	Number of Boreholes	Average Yield L/S	Operational Hour/day	Total Water Supply
1	Takur	8	1.2	16	552960
2	Dan Masara 744	5	1.2	16	345600
3	Burtulan	10	1.2	16	691200
4	I.D.H.E	5	1.2	16	345600
5	Model	15	1.2	16	1036800
6	Garu	5	1.2	16	345600
7	Fanisau	3	1.2	16	207360
8	Yankatako	1	1.2	16	69120
9	Mechanic Village	2	1.2	16	138240
10	Main water Works	20	1.2	16	1382400
11	Gidan lhu	20	1.2	16	1382400
					Net Supply = 6497.3 (m <sup>3</sup> /day)

Source: Dutse main water works

**Water supply deficit (2021)**

The water supply deficit of the study area was calculated. The calculation was done for the current period (2021) and for the projected period (2025, 2029, 2031). The entire deficit was calculated based on current supply.

$$180466.2 \text{ m}^3/\text{day} - 6497.3 \text{ m}^3/\text{day} = 11548.936 \text{ m}^3/\text{day}$$

Dutse city has a current (2021) water shortage of 173968900 L/day. Future water supply deficit (2025) 20232420 L/day – 6497280 L/day =13735140 L/day Future water shortage (2025) of Dutse City is 13735140 L/day. Future water supply deficit (2029) 22683492 L/day – 6497280 L/day =16186212 L/day. Future water shortage (2029) of Dutse City is 16186212 L/day. Future water supply deficit (2031) 24018228 L/day – 6497280 L/day = 17520948 L/day. Future water shortage (2031) of Dutse City is 17520948 L/day. The supply deficits for the period under review is presented in figure 3.7

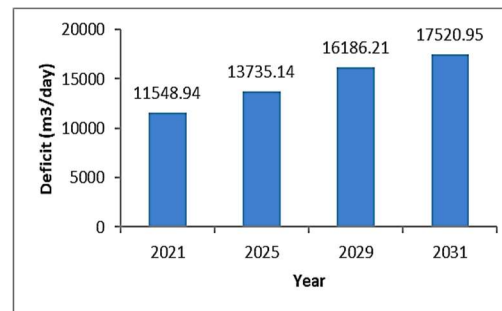


Figure 3.7: Supply Deficit

**Matching Deficit with Supply**

To match the current and projected deficit with adequate supply, considering a supply from ground water source only(as it is in the current practice), number of boreholes required are calculated. The boreholes are assumed to give a yield of 1.2 l/s.

**Number required 2021**

$$\text{Number of required} = (11548.936) / (1.2 \times 60 \times 24 \text{ L/day}) = 111$$

One hundred and eleven (111) boreholes are required to meet the current demand with average yield of 103680 L/day

Corresponding author: MUHAMMAD, I.A.

[ebukush3@gmail.com](mailto:ebukush3@gmail.com)

Hydrology and Water Resources Management Department National Water Resources Institute Kaduna State

© 2023. Faculty of Technology Education. ATBU Bauchi. All rights reserved

**Number required 2025**

Number of required= $(13735140)/(1.2 \times 60 \times 60 \times 24 \text{ L/day}) = 132$

One hundred and thirty two (132) boreholes are required to meet the future demand (2025) with average yield of 103680 L/day.

**Number required 2029**

Number of required= $(16186212)/(1.2 \times 60 \times 60 \times 24 \text{ L/day}) = 156$

One hundred and fifty-six (156) boreholes are required to meet the future (2029) demand with average yield of 103680 L/day.

**Number required 2031**

Number of required= $(17520.95)/(1.2 \times 60 \times 60 \times 24 \text{ L/day}) = 169$

The number of boreholes required for the period under review is presented in figure 4.8

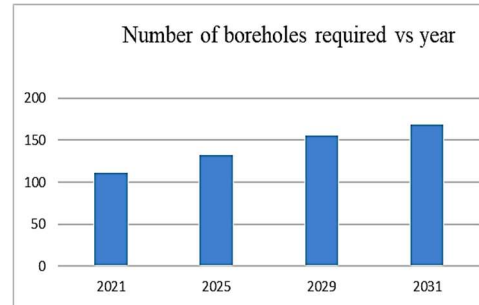


Figure 3.8: Number of required boreholes

The supply shortfall for the period under review could be met by the addition of at least 169 boreholes with an average yield of 1.2 L/day

Summary of current and projected population, supply, demand, deficit and number of required boreholes is presented in Table 2.

**Table 2:** present summary of current and projected population, supply, demand, deficit and number of required boreholes.

Year	2021	2025	2029	2031
Demand (m3/day)	18046.62	20232.42	22683.49	24018.23
Supply (m3/day)	6497.3	6497.3	6497.3	6497.3
Deficit (m3/day)	11548.94	13735.14	16186.21	17520.95
Population	115681	129695	145407	153963
Number of required boreholes	111	132	156	169

**SUMMARY**

Evaluation of water supply systems in Dutse metropolis is aimed at assessing the current water demand and supply situation of the metropolis water works. Based on the available information, the current as well as future demand of the metropolis was estimated taking into consideration are growth of future population growth.

The current demand of the metropolis was found to be 180466.24m3/day. In trying to meet the demand, a total of 6497.3 m3/day was supplied from 94 out of the 112 boreholes provided within the metropolis. This would translate into an 11548.94 m3/day supply deficit. A situation that would need 111 additional boreholes with an average yield of 103.68m3/day to match the demand.

The study also found the demand of water to increase with increase in population. The water demand in 2025, 2029, and 2031 is estimated to be 20232.42m3/day, 22683.49m3/day, and 24018.23m3/day respectively. If nothing is done between now and the forecast period, the metropolis would experience supply deficit of 13735.14m3/day, 16186.21m3/day, 17520.95m3/day in 2025, 2029, 2031 respectively. This would require 169 boreholes with average yield of 103.68 m3/day to match the demand.

**CONCLUSIONS**

Based on the study carried out, the following conclusions are drawn;

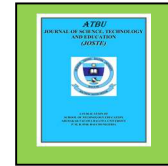
1. The current water demand of Dutse metropolis is 180466.24 m3/day. The current supply

Corresponding author: MUHAMMAD, I.A.

[ebukush3@gmail.com](mailto:ebukush3@gmail.com)

Hydrology and Water Resources Management Department National Water Resources Institute Kaduna State

© 2023. Faculty of Technology Education. ATBU Bauchi. All rights reserved



capacity by the authority is 6497.3 m<sup>3</sup>/day. This is achieved by the ninety four (94) active boreholes of the available one hundred and twelve (112) boreholes.

2. The future (2031) water demand of 24018.23m<sup>3</sup>/day.

### RECOMMENDATIONS

Based on the study, the following recommendation are made to improve the supply to the area.

1. The authorities should as a matter of priority look into supplying water from surface water source to the metropolis

### REFERENCES

- Arendal, U. (2009). Increases global water stress. <http://maps.grida.no/go/graphic/increase-sd-global-water-stress>
- Biswan, A.K. (1978). Resources and Needs, assessment of the world water situation in asit, water demand and management proceeding. The united nation water conference part I and II. Pergaman press.
- Daene, C. M. (1993). Journal of Water Resources Planning and Development. American society for civil engineer (united states), ISSN: 0733-9496.
- Dewulf, A., Craps, M., Bouwen, R., Taillieu, T, Pahlostl, C. (2005). Integrated management of natural resources, dealing with ambiguous issues, multiple actors and diverging frames. Water Science and Technology. vol. 52(6), pp, 115-124.
- FMWR/JICA,(2014); The project for review and update of nigeria national water resources master plan. Summary report, vol(2):Federal ministry of water resources Nigeria/Japan international cooperation agency (2014)
- Jigawa State water cooperation (2007), National water rehabilitation project technical consultancy development. Draft final report.
- Nepad, H. (2006). Water in Africa, management option to enhance survival and growth. Economic Commission for Africa
- Nicol, A.L. (2000). Adopting a sustainable livelihoods approach to a water projects: Implications for policy and practice. Working Paper 133, Overseas Development Institute, London. Available at <http://www.odi.org.uk/publications>.
- Rached, E., Rathgeber, E., Brooks, D.B. (1996). Water Management in Africa and Middle East: Challenges and Opportunities. IDRC Books, Ottawa, Canada.
- UNICEF. (1999). Towards better programming: A water handbook. Water, Environment and Sanitation Technical Guidelines Series No 2, United Nations Children's Fund, New York. Available at <http://www.unicef.org/wes>.
- World Health Organization (1999). Operation and maintenance of urban water supply and sanitation systems. Geneva.
- Zahoor, S.A.,Ahmad, S.,Ahmad, A., Wajid, A., Khaliq, T., Mubeen, M.,... & Nasim, W. (2019). Improving water use efficiency in agronomic crop production. Agronomic crops: volume 2: Management practices, 13-29.

---

Corresponding author: MUHAMMAD, I.A.

✉ [ebukush3@gmail.com](mailto:ebukush3@gmail.com)

Hydrology and Water Resources Management Department National Water Resources Institute Kaduna State

© 2023. Faculty of Technology Education. ATBU Bauchi. All rights reserved