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Assessment of Water Supply Potential of the River Ethiope

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ABSTRACT

Although water is an abundant natural resource, available in the rivers, streams, and wells to meet the needs of people, water of adequate quantity and acceptable quality is not always available to the consumers. This is the problem facing Abraka and its environs. River Ethiope with a catchment area of 493.50km^2 at Abraka is naturally drained with stable and well defined slopes, firm bank and bed and very clear water. If the water is properly harnessed and utilized, it can be a boom and of immense value and no small measure enhance the economic, social and industrial well being of the people of this region. Four years of daily water stage and 20 years simulated river Ethiope watershed run-off coupled with two (2) years stream flow and head measurements were used for the assessment. The result shows a yield of $966.50 \times 10^6 m^3$, which can be generated from the river per annum. The combined water requirement of Abraka is $28.359 \times 10^6 m^3/year$. The current water demand and forecasted water demand up to year 2033 can be met by resources in the basin. This paper also revealed that the water requirement of the towns through which the river transverse can be met.

Keywords: Assessment, Water, Supply, Potential, River, Resources, Abundance, Catchment.

INTRODUCTION

Nations the world over, strive for studious planning, development and management of resources in order to meet the basic needs of people, overtime, to live and maintain a life which is descent, healthy and respectable[1]. Water is the basic necessity of life. It is required for human and animal consumption, growth of agricultural produce and it also serves various other purposes. The assessment of water resources potential of river and its development are important and integral for sustainable healthy society[2]. The economy of a nation depends to a large extent on the development and conservation of water resources[3]. The United Nations has defined the minimum levels of the basic requirements, which express descent, healthy and respectable life.

There is the need to develop the data set necessary to model and forecast the potential of water resources available in various parts of Nigeria upon which sustainable dry season agriculture could be built to fight poverty and increase income for farmers in the region whose greater percentage of her population are peasant farmers. The importance of dependable and safe water supply for domestic, municipal and industrial purposes cannot be over emphasized[4]. Water uses also vary from recreational as in boating and swimming, to commercial and tourism in canals and waterways as has been planned for River Niger from Lokoja to Onitcha and as practised from Marina Lagos by ferry to Apapa[5].

Water resources development of the River Ethiope can be fully carried out through utilizing available river discharge, rainfall and variability data and catchment area over some period, and it is imperative that the water resource engineer knows the relationship between these data. It is against this background that the researcher wishes to assess the water resources potential of the River Ethiope in terms of capacity to support water supply, hydropower, irrigation, navigation, tourism and recreation. Figure 1 shows the use of water globally which include water supply, hydropower, agriculture, navigation and tourism, recreational and environmental activities.

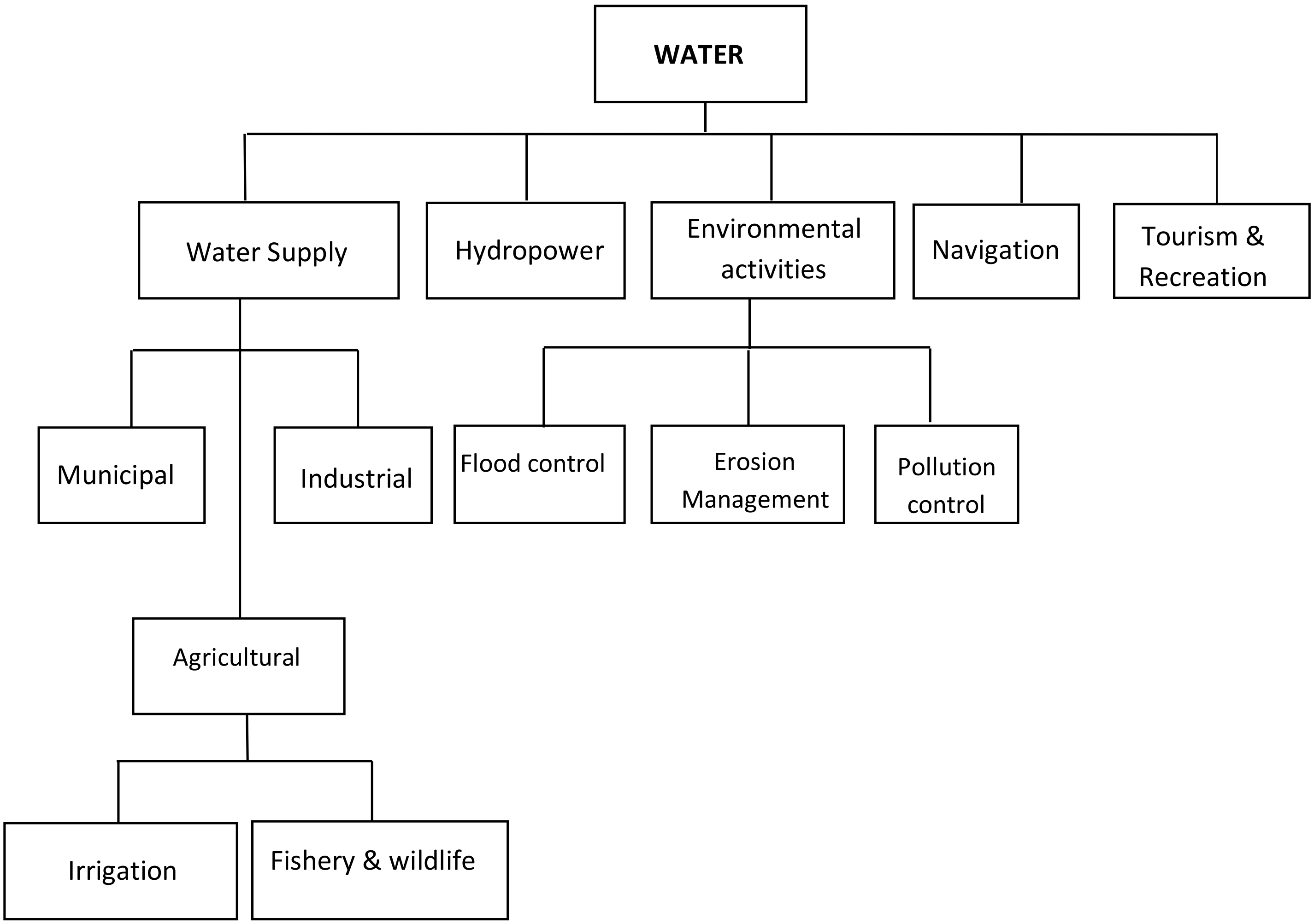

Figure 1: Global Use of Water

STUDY AREA

The study area of this research work is River Ethiope basin which is located in South-West zone of Delta State. River Ethiope originates from a small community of Umuaja in Ukwani local government area and transverses through several towns and communities including Abraka which host the main campus of the Delta State University, the academic capital/head quarters of Delta State, then meandering to Sapele before emptying into the Atlantic Ocean as shown in figure 2. River Ethiope is known for its natural clean/ deep water source (figure 3). At most points along the water course, one could visibly see the river bed. River Ethiope is located in the South-West of Delta

State (figure 2) between latitude 5º 44ˡ N to latitude 6º 4ˡ N and longitude 5º 12ˡ E to longitude 6º 12ˡ E. It transverses parts of Ukwuani, Ethiope-East, Okpe, Sapele local government areas e.t.c. the combine population of Umuaja, Umutu, Ebedi, Obinomba, Obiaruku, Abraka, is estimated to be 166,897 people (NPC, 1991, 1996 and 2006). The economy of these communities is based mainly on trading and agricultural practices with the main campus of the Delta State University as an educational institution.

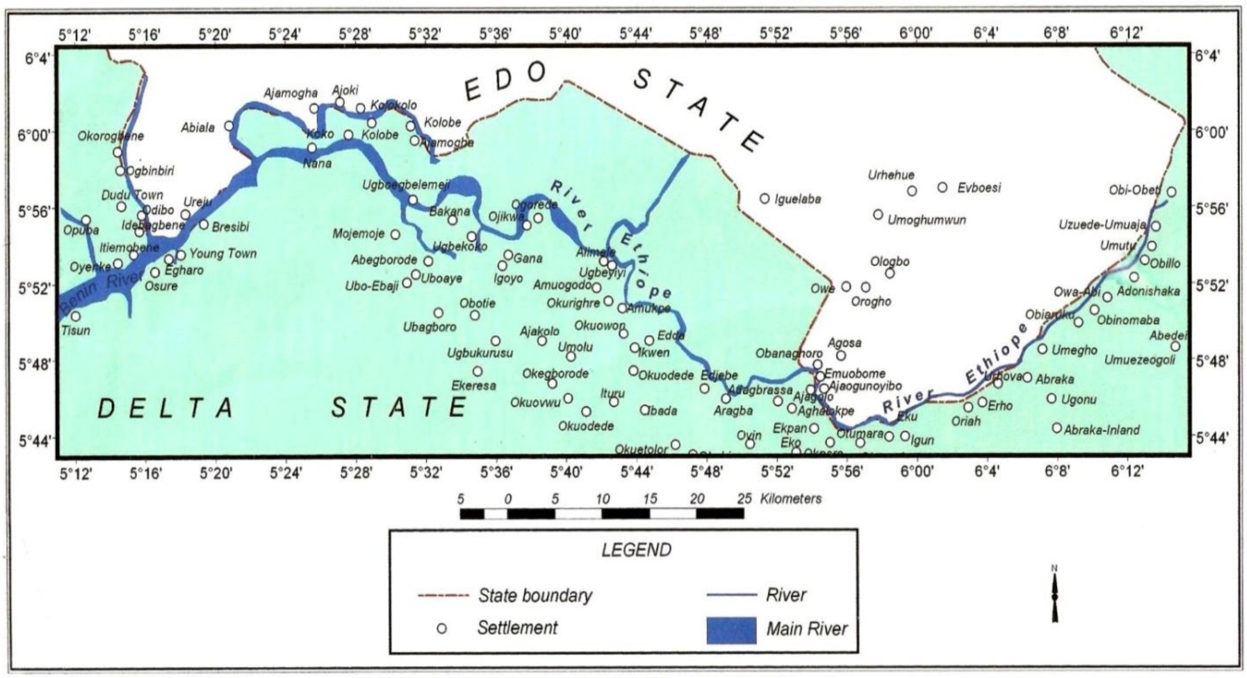

Figure 2: Location of River Ethiope in Delta State

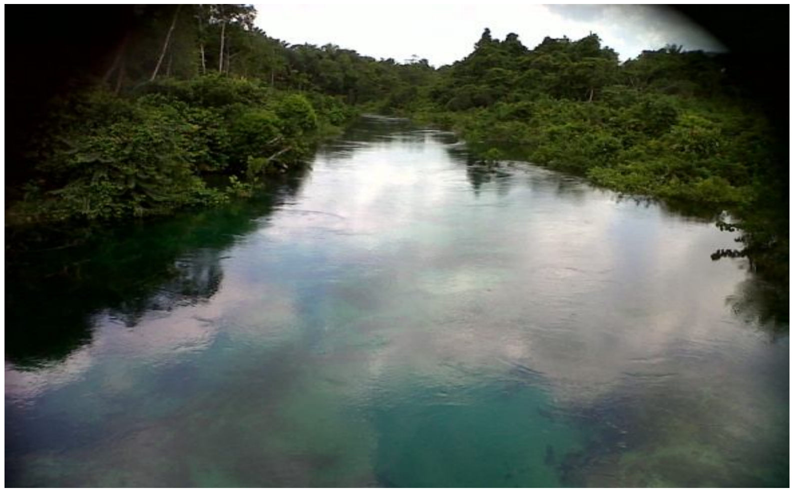

Figure 3: River Ethiope Natural Clarity

WATER SUPPLY

Water demand already exceeds supply across the various towns and communities the river Ethiope transverses, due to the increase in population, urbanisation and development of small and medium scale industries. The first water scheme in Obiaruku which served Obiaruku, Abraka, Obinomba etc has long collapsed and abandoned in the early 80s. Figure 4 shows the head works of the scheme with a maximum supply of 21,600 gal/day (86,400 litres/day) [6]. Several bore-hole schemes have also emerged in the campuses of the University and Obiaruku market as “interventive” projects with several of such schemes presently abandoned (figure 5). Presently majority of the communities rely on self-drilled shallow well bore-holes while others still fetch directly from the river with containers as shown in figure 6.

Figure 4: Headwork of Obiaruku Water Scheme

Figure 5: Self Drilled Bore Holes at Delsu Campus 2 & Obiaruku Market

Figure 6: Women and Children Fetching Water Directly from the Ethiope River

MATERIALS AND METHODS

The materials required for the study include;

- Daily water stage and discharge record (4years) and annual discharge at Abraka gauge station.
- Rainfall record (1991- 1994).
- Topographical sheets
- Population census results
- Stage-discharge rating curve of river Ethiope at Abraka.
- Stream flow measurement
- Head measurement

HYDROLOGCAL ANALYSIS

- **Catchment Delineation**

In delineating catchment area of the river Ethiope, the following steps were taken;

1. The bridge at Abraka along Sakponba road was identified as outlet point to the catchment. This is the lowest elevation in the basin referred to gauge station and flow measurement points at Umutu (figure 7a &b).

Figure 7a: Gauge Station

Figure 7b: Stream flow & Depth Measurements

2. The slope and distance area extent of the drainage was also obtained through a rigorous survey work carried out (figure 8).

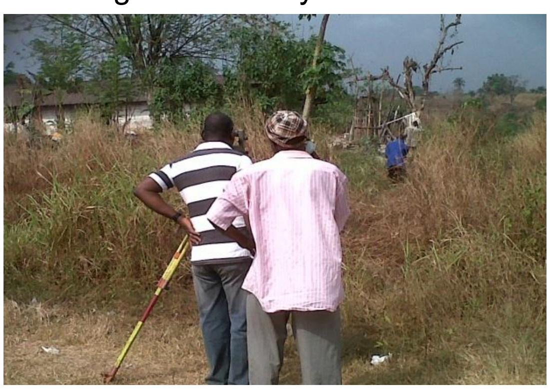

Figure 8: Survey for slope measurement

DETERMINATION OF CATCHMENT CHARACTERISTICS

- **Catchment Area**

Pick polyline from tool bar and digitize the area in question such that the shape drawn is completely joined to form one entity. Highlight the shape digitized and right click. This will automatically display some numbers of parameters which include the area and length.

- **Main Stream Length (L)**

The main stream length is determined by highlighting on the major stream (River Ethiope). Ensure that the river is properly joined right clicking on the highlighted river, a dialogue box will open and length is displayed.

- **Catchment Slope (S)**

The catchment slope is the division of the maximum elevation by the main stream length.

Catchment Characteristics of River Ethiope at Abraka

The catchment area of river Ethiope at Abraka was delineated and some major features within the catchment are digitised. The results obtained are as shown below.

Table 1: Catchment characteristics of River Ethiope at Abraka

Area (km^2)	493.50km^2
Length of main stream (km)	119km
Length of main stream from catchment's centroid to outlet of the river (km)	33km
Maximum elevation of the river	23.28m

MEASURED STREAM FLOW AND HEAD

Direct measurements of the river flow and head were also carried out with the following results.

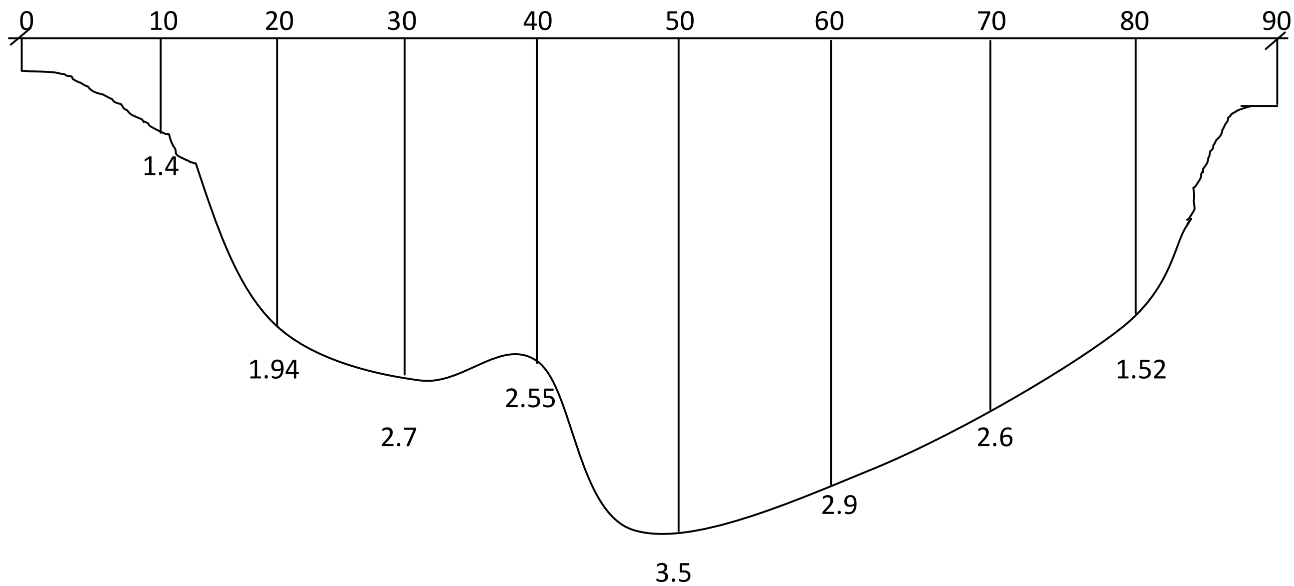

Figure 9: Measured Stream Flow and Head

Average Depth = $\frac{sum\ of\ measured\ depths}{number\ of\ intervals\ measured}$

$$= \frac{1.4+1.94+2.7+2.55+3.5+2.9+2.6+1.52}{9} = \frac{19.11}{9}$$

$$= 2.12m$$

FLOW RATE

The flow rate is calculated by the formula:

$$Q = 0.83\left(\frac{bd}{144}\right)\left(\frac{100}{t}\right) \quad [NRAES, 1978]$$

Where;

Q = flow rate in m^3/sec

b = stream width in m

d = average stream depth in m

t = time for float to drift in seconds

From research/study,

$b = 83.1m = 3{,}272"$
$d = 2.12m = 83.46"$
$t = 180\ seconds$

Substituting values

$$Q = 0.83 \left(\frac{3{,}272\text{x}93.46}{44}\right)\left(\frac{100}{180}\right)$$

$$= 0.83[1896.4][0.556] = 874.45\text{ft}^3/\text{sec}$$

$$\therefore Q = 24.79\text{m}^3/\text{s}$$

RIVER ETHIOPE RATING CURVE

This is a graph showing the water level elevation or a stage of a stream channel at a point of interest to their corresponding discharge. Figure 10 represents the River Ethiope rating curve (Benin-Owena river basin). Raghunath, (1985, determined the rating curve of a river as follows;

$$Q = K(h - h_0)^n$$

Taking log of both sides and relating it to straight line equation, it becomes

$$\underbrace{\log Q}_{y} = \underbrace{\log K}_{c} + \underbrace{n\log(h - h_0)}_{mx}$$

Hence the plot of Q vs $(h-h_0)$ on a log-log paper gives a straight line whose slope is n and Q = K when $(h-h_0) = 0$ where K and n are constants for any stream gauge stage.
In this case, the value of h_0 is 0.70m as obtained from the graph

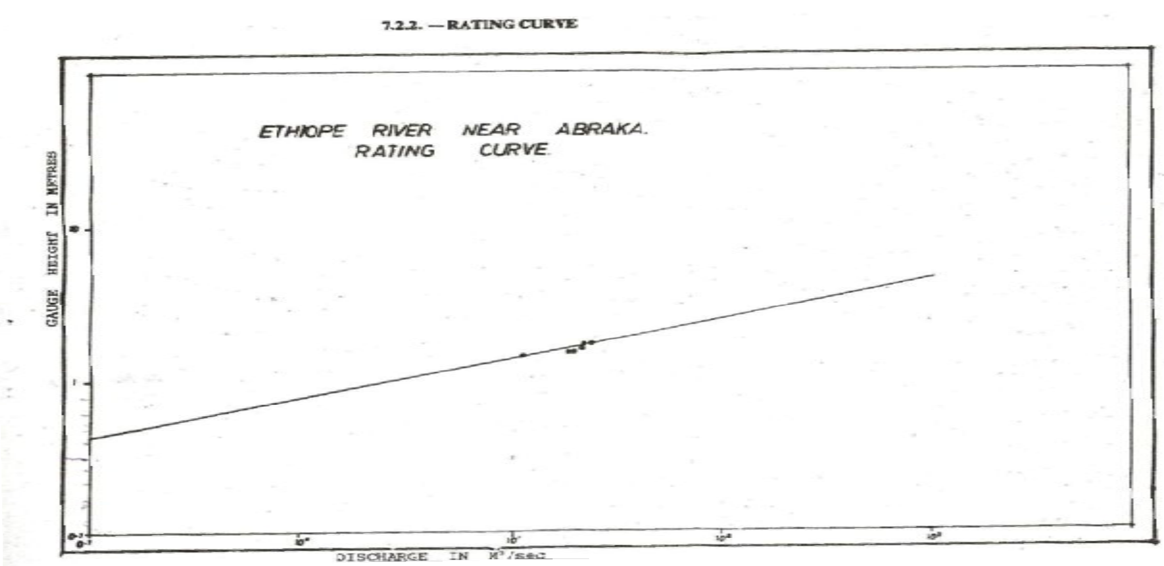

Figure 10: River Ethiope Rating Curve

YIELD ASSESSMENT OF RIVER ETHIOPE AT ABRAKA

Yield in this will mean the catchment yield from the river. This is defined as the total annual run-off volume of water that can be expected from the stream (2). The catchment yield of the river is $966.5 \times 10^6 m^3/year$

POPULATION ESTIMATE FOR ABRAKA AND ENVIRON

According to 2006 Census from the National Population Commission, the combine population figure of Abraka, Obiaruku, Umutu etc. is 166,897. Taking an annual growth rate of 3.1% and design period of 27 years,

From the formula:

$$\ln P_t = \ln P_o + k_g(t - t_o)$$

Where

- $\ln$ = natural log
- P_t = Population estimate at year t (2033)
- t = Year population is being estimated
- P_o = base population at reference year t_o ($P_o = 166{,}897$ in 2006)
- k_g = Geometric growth rate constant = 3.1%
- t_o = reference or base year ($t_o = 2006$)

$$\therefore \ \ln P_{2033} = \ln P_{2006} + k_g(t_{2033} + t_{2006})$$

$$\ln P_{2033} = \ln 166{,}897 + 0.031(27)$$

$$= \ln 166{,}897 + 0.837$$

$$= 12.862$$

$$\therefore \ P_{2033} = e^{12.862} = 385{,}385.73 \cong 385{,}386$$

ESTIMATED WATER DEMAND

Adopting per capita demand of 160liters/c/day (http://nptel.iitm.a.c.in/courses/webcoursecontent/IIT-KANPUR/wastewater/lecture.%202htm,2010)

Unit water demand (UWD) = 160 litres/c/day

Let

Q_{AV} = Total average domestic water demand

$= P_t \times UWD\ (m^3/day)$

Q_{ICI} = Industrial commercial water demand = 20% of Q_{AV}

Q_L = Un-accounted water (due to loses) = 5% of Q_{AV} in m^3/day

Q_T = Total water demand = $Q_{AV} + Q_{ICI} + Q_L = 1.25\ Q_{AV}$ in m^3/day

Q_{DES} = Target design peak water demand = 1.2 Q_T in m^3/day

Adopted design peaking factor $Pf = 20\%\ or\ 0.2$

Q_{PH} = Peak Hourly demand (Demand intensity) = $\frac{18\ (Q_{AV} + Q_L)}{24}$ m³/hour

S/N	YEAR	Projected population $r = 3.1\%$	Average domestic demand $Q_{AV}\ in\ m^3/day$ $160L/c/day$	Industrial commercial Institutional water $Q_{ICI} = 0.2Q_{AV}$ $in\ m^3/day$	Unaccounted for losses $Q_L = 0.05Q_{AV}$ $in\ m^3/day$	Total water demand $Q_T = Q_{AV} + Q_{ICI} + Q_L$ Or $Q_T = 1.25Q_{AV}$	Target design peak water demand $Q_{DES} = 1.2Q_T$ $in\ m^3/day$	Peak Hourly Demand (Demand Intensity) 0.75 $(Q_{AV} + Q_L)$ Or $\frac{18(Q_{AV}+Q_L)}{24}$ in m^3/hr
1.	2006	166,897	26,704	5,341	1,335	33,380	40,056	21,029
2.	2007	172,146	27,543	5,509	1,377	34,429	41,315	21,690
3.	2008	177,549	28,408	5,682	1,420	35,510	42,612	22,371
4.	2009	183,139	29,302	5,860	1,465	36,628	43,954	23,075
5.	2010	188,905	30,225	6,045	1,511	37,781	45,337	23,802
6.	2011	194,853	31176	6,235	1,559	38,970	46,764	24,551
7.	2012	200,988	32,158	6,432	1,608	40,198	48,238	25,325
8.	2013	207,316	33,171	6,634	1,659	41,464	49,757	26,123
9.	2014	213,843	34,215	6,843	1,711	42,769	51,323	26,945
10.	2015	220,576	36,252	7,250	1,813	45,315	54,378	28,549
11.	2016	227,521	36,403	7,281	1,820	45,504	54,605	28,667
12.	2017	234,685	38,000	7,600	1,900	47,500	57,000	29,925
13.	2018	242,074	38,732	7,746	1,937	48,415	58,098	30,502
14.	2019	249,696	39,951	7,990	1,998	49,939	59,927	31,462
15.	2020	257,558	41,209	8,242	2,060	51,511	61,813	32,452
16.	2021	265,667	42,507	8,501	2,125	53,134	63,761	33,474
17.	2022	274,032	43,845	8,769	2,192	54,806	65,767	34,528
18.	2023	282,660	45,226	9,045	2,261	56,533	67,840	35,615
19.	2024	292,000	46,720	9,344	2,336	58,400	70,080	36,792
20.	2025	301,194	48,191	9,638	2,410	60,239	72,287	37,951
21.	2026	310,677	49,708	9,942	2,485	62,135	74,562	39,145
22.	2027	320,459	51,273	10,255	2,564	64,091	76,909	40,378
23.	2028	330,549	52,888	10,578	2,644	66,110	79,332	41,649
24.	2029	340,951	54,553	10,911	2,728	68,191	81,829	42,961
25.	2030	351,686	56,300	11,260	2,815	70,375	84,450	44,336
26.	2031	362,759	58,041	11,608	2,902	72,551	87,061	45,707
27.	2032	377,000	60,320	12,064	3,016	75,400	90,480	47,502
28.	2033	388,481	62,157	12,431	3,108	77,696	93,235	48,949

CONCLUSION

This paper has shown that there is available water resource potential from the basin (River Ethiope Basin) which can be harnessed to solve the problem of water supply in Abraka, Obiaruku, Umutu, Umuaja, and all other communities the river Ethiope transverse and their environs. The stream flow is $996.50 \times 10^6 m^3$ per year. The combined water requirement of Abraka and associated communities along the Ethiope is $28.359 \times 10^6 m^3$ per year. This requirement can be met with the available water in the basin even without a reservoir.

RECOMMENDATIONS

1. This paper has justified that there is available water resources for harnessing within the catchment, therefore the responsible agency should endeavour to develop the available water resources for economic development.
2. Effort should be made to establish more and new hydrological stations and also revive the non operational existing ones as inadequate and inconsistent data characterised the major challenges of this research.
3. Water available could be harnessed for other development like power, navigation and agriculture.

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