Dissertation By

UZOMA, Emmanuella Chinenye

Departement of : Geography,

University of Nigeria,Nsukka

Rural water supplies in Enugu state: a comparative analysis

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RURAL WATER SUPPLIES IN ENUGU STATE: A COMPARATIVE ANALYSIS

By

Emmanuella Chinenyè UZOMA
B.Sc. (ESUT)
(PG/M.Sc./91/12333)

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Department of Geography, University of Nigeria, Nsukka

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CERTIFICATION

Miss Emmanuella Chinenye Uzoma, a postgraduate student in the Department of Geography, specializing in Hydrology and Water Resources, has satisfactorily completed the requirements for course and research work for the degree of Masters (M.Sc.) in Geography. The work embodied in this thesis is original and has not been submitted in part or full for any other diploma or degree of this or any other University.

DR R.N.C. ANYADIKE
(Supervisor)

PROF. F.S. EBISEMIJU
(External Examiner)

PROF. R.C. BOB-DURU
(Head, Department of Geography)

May, 1996.

DEDICATION

Dedicated to my late father Mr. Joseph U. Uzoma.

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Emmanuella Chinenye Uzoma
Department of Geography
University of Nigeria
Nsukka

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ABSTRACT

This work is aimed at identifying similarities and differences in the water supply situation of six study communities, Obe, Akama Oghe, Adaba, Eka Awoke, and Ndi Offia within Enugu State.

The mean household domestic water demand for the six study communities was found to be 181.0 litres per household per day (lpd), while consumption is 104.3 lpd. This gave a deficiency of 76.7 lpd representing a percentage margin of 42.4%. Analysis of variance revealed that there are no significant differences between the demand for water, while there are significant differences between the supply of water, among the various study communities.

Identification of the various sources of water for the areas showed that Obe, Eka Awoke, Akama Oghe, Ndi Offia and Adaba use the streams as water sources. Adaba and Obe have springs, while ponds are in use in Iheaka, Ndi Offia and Eka Awoke. Raincatch is common to all the communities. Boreholes

are used in Iheaka, Akama Oghe and Eka Awoke. Wells are used in Obe, Ndi Offia and Eka Awoke. Obe, Akama Oghe, and Iheaka are supplied with water by tanker drivers.

Most government aided improvement measures existing in the various study communities were found inefficient. Best applicable alternative improvement measures are then suggested. Among the several alternative improvement measures, massive rainwater harvesting, community participation and training of manpower/educating masses are the ones best recommended for all six study communities.

CHAPTER 1

INTRODUCTION

1.1 Statement of the Research Problem

Numerous research findings indicate that there exists a situation amongst the rural populations of developing countries whereby people are without reasonable access to safe water of adequate quantity (Pacey, 1977; Schultzberg, 1978; and Cembrowicz, 1983).

This situation also exists in the rural areas of Nigeria, where the people often lack safe water as a result of non-developmental and governmental activities in such areas.

Rural water supply is of great importance. The advantages of adequate and safe water supply are immeasurable for in the face of an efficient rural water supply, exists lower medical expenditure, an improved sense of well-being, an increased fitness (hence increased productivity by agricultural workers, leading to an increase in crop production), as well as improved hygiene and more leisure.

A lot of emphasis on urban rather than regional problems has dominated spatial planning in Nigeria. This emphasis has led to the relegation of the rural areas to the background (Ajaegbu, 1972). Since the rural areas harbour the greatest number of people in Nigeria, water provision/availability to these rural areas indirectly means water provision to the bulk of the populace of the nation.

A remarkable feature of our rural communities today is that the rural dwellers' life pattern tends to spun around water supply provision, as the individual families are left to provide this essential service by themselves.

In the rural areas of Enugu State, as in other rural areas in other parts of Nigeria, absence of adequate supply of safewater is a frequent occurrence (Alo - Nwokeocha, 1974; Ugwu, 1979; and Obi, 1984). The rural dwellers require water for their daily activities, and being left to provide their water is common sight

in these rural places. And the consequences include breakdown of the peoples health, time wastage and financial incurrment from buying water.

Common sources of water to the people are, springs, boreholes, shallow wells, runoff from rainwater into stream channels, rainwater stored in containers during rainy season and pond water. These water sources do not follow a pattern of even location, with the resultant effect that the rural people have to trek great distances to collect water.

The borehole sites witness incessant breakdowns of pumping machines, and even when operational, supplies are normally for few hours per day. The rainy season starts mid-march only to end by October, while the five months interval of dry season are without rains. As a result of this, raincatch as a source of water supply to the rural populace is reckoned unreliable.

At the on-set of the dry season most wells within Enugu State start to witness fluctuation

in the level of water. As the dry season heightens towards the month of January, some of them dry up completely. Ponds contain a lot of mud, debris, and some partially decayed materials rendering it totally unhygienic and unfit for most domestic water uses. Ponds too as water sources are highly unreliable because they collect water from rainfalls which are seasonal.

Springs are a good source of water supply but in most cases they occur where their harnessing are usually difficult. The terrain where springs are located are always rugged, slippery, or steepy, and unapproachable by vehicles, motor cars, or even the rural people themselves who trek to them for water collection.

The cost of constructing plastered dug pits privately by individual households or by a group of rural dwellers makes it unpopular as a water source in rural areas. Most villages prefer natural water sources where they collect water at no cost than when they have to buy water from

tanker drivers or water vendors. Except for communities with many natural water sources, other communities without or with few natural water sources are normally left at the mercy of water tanker drivers or vendors.

Some streams found in Enugu State are ephemeral and during the dry season have no water at all within their channels. There are even many more communities with no streams at all passing through them, or even within a 20km radius and as such lack water terribly. Thus, during the dry season there is normally a shortage from nearly all the above sources.

In most of our rural areas, average per capita consumption of water per day is still quite low, often less than 45 litres (Ezeonu, 1983). It is these limitations in the number of water sources per community that render the people unable to attain the minimum of 115 litres of potable water per person per day recommended by the Federal Government of Nigeria (Federal Republic of

Nigeria, 1975).

Most water supply improvement measures used in Enugu State are non-functional and non-productive. Boreholes found in some rural communities are ill-maintained, elevated service reservoirs exist as monuments beautifying the scenery. Hand pumps get broken due to high level of illiteracy among the rural people and lack of technological know-how on using such appliances. Ponds created in the rural areas to capture excess runoff and serve as a water supply source, become water drinking troughs for domestic animals found in those communities. Water tankers provided by the State or Local governments to serve villagers, get diverted by their drivers to other places where they can sell the water and keep the money, instead of serving those the water was meant for.

A considerable number of researches exist, dealing generally with rural water supply problem from the point of view of a single rural area or a group of rural areas discussed as a single unit,

the differences (i.e the spatial inequality) in rural water supply for different communities have not been researched into. As a result, this study intends to identify the differences in water supply, and the varying intensities of rural water supply problem amongst the six study communities. These communities exist within a homogenous socio-cultural group.

1.2 Aim and Objectives of the Study

This study attempts to look at the rural water supply situation existing in some parts of Enugu State, on the basis of a comparative analysis.

The aim of this research work is to identify the similarities or differences between water supply situations existing in all the rural study areas, with the following objectives.

(1) To identify the various sources of water in each of the six study communities.

(2) To examine water demand characteristics of the areas being studied

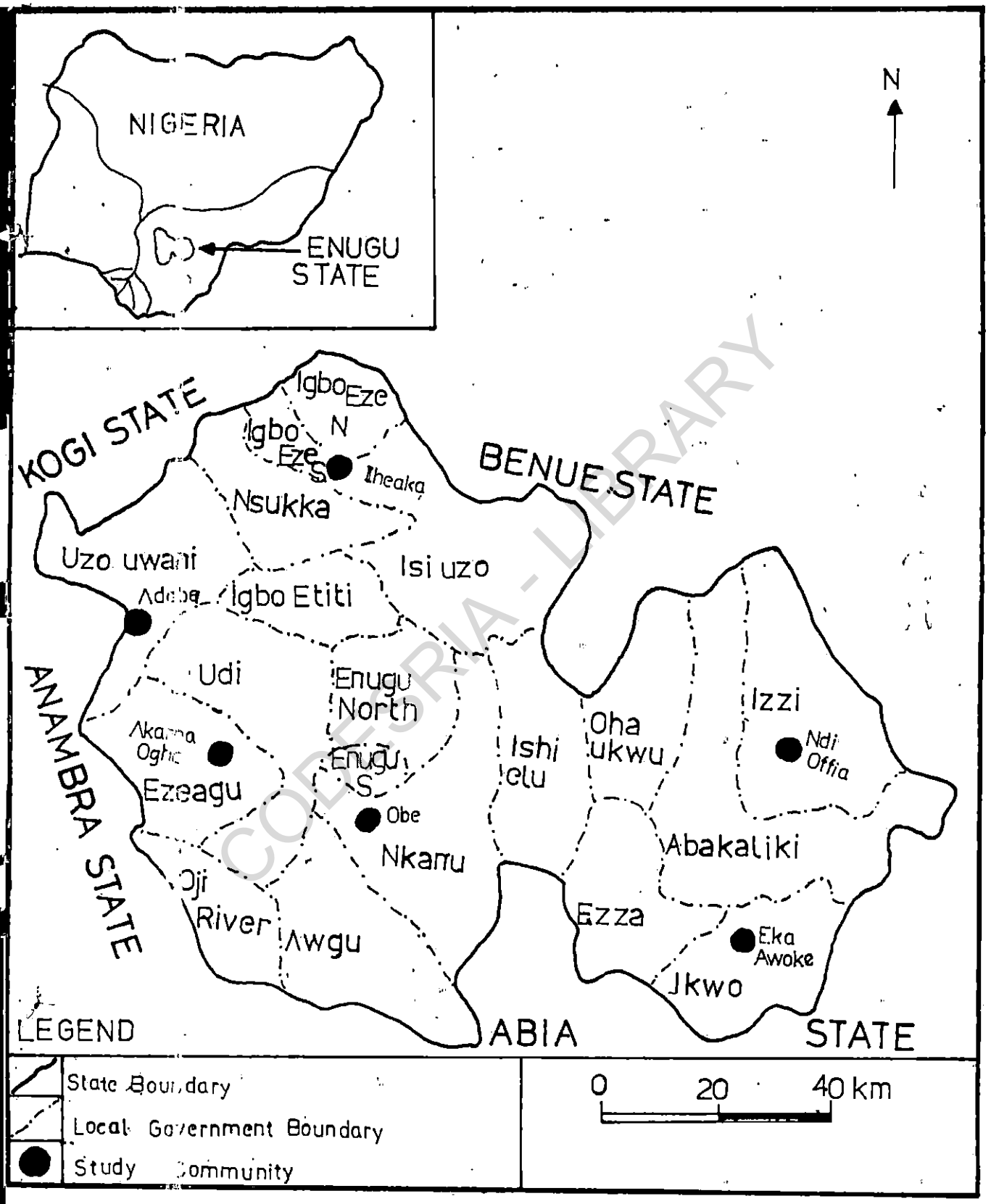
(3) To analyse the water supply strategies already existing in each of the six study communities.

This study is limited to only the geographical analysis of the different modes of rural water supplies, and thus making available all necessary information cum results in their spatial context. Better improvement measures will also be offered, to help resuscitate the water projects that have failed in some communities.

1.3 The Study Area

1.3.1 Location of Study Communities

The six study rural communities to be examined for this project are all within Enugu State. Enugu State is a new state carved out of the former Anambra State in August 27th 1991 by the Federal Government. Adaba, Obe, Iheaka, Akama Oghe, Eka Awoke, and Ndi Offia all constitute the six rural communities (Figure 1)



ENUGU STATE SHOWING SIX STUDY AREAS

(Source: Survey Division MOWLG H, Enugu)

The selection of the study was by the systematic random sampling method. Since the research did not cover the entire Enugu State, it was necessary that a sampling frame be designed from which samples of areas of the state for this research were drawn. The sampling frame for this work was then designed from the list of the local government areas (L.G.As) in Enugu State. Out of the 18 local government areas in the State, 6 were taken by accepting one out of every three L.G.As in the sampling frame. Consequently, each of the six rural communities were drawn by selecting one community randomly from the list of autonomous communities existing in each of the selected 6 local government areas. There are twenty - two autonomous communities in Ezeagu L.G.A, twenty-eight autonomous communities communities in Nkanu L.G.A, fourteen autonomous communities Uzo-Uwani L.G.A, fourteen autonomous communities in Igbo-Eze L.G.A, fourteen in Ikwo L.G.A and eight automomous communities in Izzi L.G.A.

The six study areas are roughly located within longitudes $6^{\circ}55'E$ and $8^{\circ}38'E$ and latitudes $5^{\circ}56'N$ and $7^{\circ}06'N$.

The location of Adaba community is at about longitude $7^{\circ}08'E$ and latitude $6^{\circ}34'N$. While Obe community in Nkanu Local Government Area is located roughly at longitude $7^{\circ}31'E$ and latitude $6^{\circ}18'E$. Iheaka community is located at longitude $7^{\circ}27'E$ and latitude $6^{\circ}54'N$. The location of the other three communities, Ndi-Offia, Eka Awoke, and Akama Oghe are latitude $6^{\circ}24'N$ and longitude $8^{\circ}14'E$, latitude $6^{\circ}07'N$ and longitude $8^{\circ}08'E$, and latitude $6^{\circ}27'N$ and longitude $7^{\circ}19'E$ respectively.

The total population of the six communities studied is 56,038 (Anon, 1992). A breakdown of the population figures for each community is shown in Table 1. Table 1 shows the population of study communities, for 1963 and 1992 years.

Table 1: Population of study communities: 1963 and 1992 (source: Enugu State Ministry of Finance and Economic Planning Statistics Division, Enugu).

Community	Year	Population	Remarks
Obe	1963	4,541	Census
	1992	9,293	Estimate
Akama Oghe	1963	3,488	Census
	1992	7,138	Estimate
Adaba	1963	3,199	Census
	1992	6,546	Estimate
Iheaka	1993	8,294	Census
	1992	16,973	Estimate
Ndi-Offia	1963	3,211	Census
	1992	6,836	Estimate
Eka Awoke	1963	4,521	Census
	1992	9,252	Estimate

1.3.2 Geology and Relief

The geology of Eka Awoke and Ndi-Offia is that of Eze Aku shale formation, and is part of upper cretaceous sediments. They were deposited in the Turonian sea and lie uncomformably on the Albian Asu River group sediments (Orajaka, 1975). Obe is underlain by Enugu shales of the

campanian stage as well as some part of the lower coal measures. The area is typified by dark grey friable shales with occasional thin beds of sand stones and limestones.

The false bedded sandstones also known as Ajalli sandstones are exposed in Iheaka. The body of the sandstone is thick, friable and poorly sorted. It is white in colour sometimes, and there is the presence of iron stains which signify ferruginization (Orajaka, 1975). The Akama community is underlain by the upper coal measures of Nsukka formation.

The rocks of the Adaba community belong to the Imo Shale group. It overlies the upper coal measures formation conformably.

The dominant relief of most of the study communities seems to be the plain, as a result of the nature of the underlying rocks in the area in response to alternating denudational and aggradational activities. Adaba community is situated under 200 metres above sea level.

While Iheaka community exists in a slightly undulating section, and is higher between the heights of 200 metres and 500 metres above see level.

The relief of Akama Oghe is similar to that of Adaba community. Akama Oghe is also situated under 300m above sea level. Obe falls within the heights of 100 metres and 350 metres above sea. And there exists a slight ascent to the west of this community towards the Udi plateau.

An undulating to nearly level plain with low ridges and wide shallow valleys, make up the relief of Eka Ubuagu and Ndi Offia communities. There, it is common place to find heights of less than 100 metres above sea level.

1.3.3 Drainage Features

In the various communities, structure and lithological differences have had a sighificant influence on pattern and orientation of the existing drainage network.

Ndi Offia is an area of impeded drainage in the dry season. The only stream flowing through the area, Iyi Ageze, is a tributary of the Eastern Abonyi river. The Eastern Abonyi river throughout its entire length is 95km (Wigwe, 1975). River Akumitoli is a tributary of the Eastern Abonyi river, this tributary serves as the only stream close to the Eka Awoke community. Thus Ndi Offia and Eka Awoke communities are served with water from tributaries of the Eastern Abonyi river.

Theaka community has an inexistent drainage network, as the location suffers from considerable influence of lithology which has an adverse effect on stream development, pattern and density (Wigwe, 1975). Iheaka is underlain by false-bedded sandstones, hence the paucity of surface drainage owing to high infiltration capacity of the sandstone formations. At Akama Oghe, the main river bordering the area is the

Ajalli river. Actually, its tributary Iyi Oguru river is the stream close to Akama Oghe community.

The rivers of cose proximity to the last two study communities are Adada river and Ogbe river, plus a tributary of Asu river called Orum Mmiri. The first of these, Adada river is close to the Adaba community. For Obe community, the Ogbe river and a tributary of river Asu, Orum Mmiri supply that area and its surrounding areas with water from its stream channel.

The steams within the study areas are characterized by a lot of material in suspension and solution within its steam channel. The reason is that, the streams do flow over areas which have been deeply weathered chemically by the high temperatures and humidities of our study area (Iloeje, 1976).

1.3.4 Climate, Vegetation and Soil

The mean daily maximum temperature within the study communities is usually above 27°c all through the year, being highest between the months of February and April, but never exceeding 35°c (Monanu, 1975). The mean annual maximum temperature is about 33°c, while the mean annual temperature is about 21°c in most cases for the study communities.

The rainfall pattern experienced in the six study areas varies with season. The monthly distribution of rainfall here, shows that there is a long wet season from April to July, interrupted by a short dry season, in August, and then another short wet season from September to October followed by a long dry season from November to March. The mean annual rainfall total for Iheaka and Adaba is generally below 1,750mm. For Obe and Akama Oghe communities, it is between 1,750mm and 2,000mm. Ndi Offia and Eka Awoke communities have a value between 2,000mm and 2,250mm.

All six study communities fall into one broad group of vegetation type which is Rainforest-savanna Ecotone usually referred to as a derived specie of Guinean savanna.

The vegetation of the area is predominantly grass towards Iheaka. As one proceeds southwards towards Eka Awoke, closed or semi-closed forests take up a considerable, proportion of space. Thus the study areas, form the northern fringe of the tropical rain forest zone. Over eighty percent of the plant species of the typical lowland rainforest grow in this forest savanna belt, including few dotted oil palm trees.

The soil classification of the entire study communities is that adapted from D'Hoore (1960), and Ofomata (1975). The Eka Awoke community falls broadly under the Hydromorphic group, the same goes for Ndi Offia as well as Adaba community. These are reddish brown gravelly and pale clayey soils derived from shales, but generally viewed as palecoloured and mottled in the subsoil.

Akama Oghe has the deep porous redsoils of the ferrallitic derived from sandy deposits type, and that of the hydromorphic. The Obe community shares a similar duality of soil type. Only that the reddish brown gravelly and pale clayey soils of Obe exists alongside with red and brown soils derived from sandstones and shales which is a typical ferrallitic soil. For Iheaka, the soil type is the ferrallitic, the deep porous redsoils derived from sandy deposits and rich in free iron, but with a low mineral reserve.

1.3.5 Economy of the Area

Agriculture, particularly farming can be regarded as the mainstay of the economy of the six rural study communities. A minor fraction of the people can equally be seen engaged in trading and craftsmanship.

The availability of a large expanse of flat farmlands noted as "plain relief" has added ease to farming, and has enabled the populace be identified as predominantly an agriculturally rural people.

Yams, cassava, and maize are important products in the subsistence economy of the following communities within the six study areas: Adaba, Ndi Offia and Eka Awoke. Ndi Offia and Eka Awoke cultivate a lot of rice too.

The tendency to water-logging of these areas has discouraged settlements in the area. Soils found in Adaba, Ndi Offia and Eka Awoke are hydromorphic and are liable to water-logging. This has equally resulted in farmers having to construct extra large mounds in an effort to raise the plants roots above the water table.

Iheaka farmers have to rely heavily on fertilizers and animal dung to ensure continuous cropping of their agricultural lands, as their soil type is characterized by low fertility.

1.4 Literature Review

For two-thirds of the world's population, there is no pipeborne water. A study carried out by World Health Organisation (1963), gave a statistics showing the rural community water supply

situation in 91 developing countries at the end of 1970. About 72% of the total population of these countries were sampled, the findings showed that 1.11 billion or 80% were without reasonable access to safe water, in Southeast Asia, it was 91%, while in the Americas it was 76%.

In White's (1977) opinion, the volume of water used by the rural people of tropical developing countries is chiefly a function of income and material wealth, with only the highest income group having access to large amounts of safe water.

According to Obeng (1982) some water programmes in developing countries have yielded satisfaction results, example is the Water Programmes of United Nations Children's Fund (UNICEF) in Bangladesh.

Rural clustered settlements in the developing countries have their sources of water as standpipes, water vendors, surface ponds, steams, underground springs, and shallow wells, deep wells and rain barrels, while those of rural scattered have theirs as surface ponds, steeams, underground springs,

wells and rainbarrels. (Jorgensen, 1982). He believes that generally, water cost (in energy or cash) tends to be low in humid areas and high in arid areas especially in the dry season.

The methods of water supply provision to rural dwellers in other developing countries and Africa are many and vary from locality to locality. The following researchers have in their studies mentioned a few of these (Anis and Cox, 1982; Collin, 1986; Brewster, 1986; Eggers, 1986 and Jong and Hofkes, 1986).

In a water supply study of Burkina Faso by Collin (1986), it was found that small hill dams and lakes were built to supplement other existing local sources of water supply in the area. There is the gravity flow technique of tapping springs currently being practised in Guatemala (Annis and Cox, 1982). Eggers (1986) mentioned the use of boreholes in Yatenga area of Burkina Faso, and that the Mali Aqua Viva has planned to provide its villages with borehole too. According to Brewster (1986), water is provided to rural dwellers in

most developing countries by a village well.

In a study of Alemi in the Lango district of Uganda near the River Nile, for three months of the year the women have to dig holes in the edges of the swamp, or walk to a government bore-hole (Jorgensen, 1982). The Mkuu, a farming community on the slopes of Kilimanjaro highland in Tanzania, have their source of water supply from a high mountain stream. The other sources available are rural standpipes and rainwater from the roof in rainy season (Jorgensen, 1982). In Nandi country in Kenya, spring water is being used (Jorgensen, 1982).

To help lessen the drudgery and physical pain of drawing water manually from hand dug wells, hand pumps are being introduced in different parts of the developing countries. They are, according to Jong and Hofkes (1986), extensively being used in Malawi, Sudan and Zambia.

A case study of rural water supply in rural Togo by Cembrowicz (1983) showed that consumption

from standpipes, under certain conditions, could be as high as 50 to 60 litres per capita per day. in Tanzania, where Warner (1973) made studies before and a year after the installation of improved water supply which reduced the distance from the source for most households, the quantity used increased but not more than a few litres per capita per day. The lower the initial use, the greater the increase with the more readily available suppy.

A recent study in rural Brazil (Briscoe, de Dastro, Griffin North and Olsen, 1990) found that the provision of free water at public standpipes had little impact on peoples willingness to pay for house - connections, and consequently on the total amount of revenue. Yet many low income groups already pay large sums to water vendors (Alo-Nwokeocha, 1974; Ugwu, 1979; and Falkenmark, 1982), not all of whom deliver water to the house. These consumers should gladly pay for a similar level of provision of better quality water (Zaroff and Okun, 1984).

The afore-reviewed literature is on rural water supply sources and situation in the developing nations and Africa. In rural Nigeria, the traditional pattern of water exploitation in Ikwo which falls under the old Abakaliki Division according to Nwafor (1976) has been limited to direct collection of rainwater with pot and extraction from such unhygienic sources, as streams, shallow wells, and shallow ponds. This rainwater, he states, is usually stored for five to six months where it turns slowly into greenish contaminated water.

In a similar study by Onyegbula (1983) on rural water supply in parts of Owerri Local Government area, water sources identified were raincatch, stream sources like Nworie, Otamiri, Oramiriukwa, Ogochie and Imo River. Other sources were open wells, ponds, and boreholes. Emenyonu (1981), Ezeonu (1983), and Ifeabunike (1983) found out that raincatch during rainy season, seems to be the greatest source of water to the rural people.

Other water sources common to these three areas Nnobi, Idemmili and Ikeduru Local Government Areas studied by them are, streams, dugwells, and shallow ponds. In Emenyonu's (1981) study the daily per capita water consumption of the rural dwellers of Ikeduru was between 31-37 litres for some places, or low between 20-30 litres for others.

Udo (1970) and Ugwu (1979) recognise the trade in water as an established occupation in those areas which are still to be served with pipeborne water. A few rural areas in Nigeria enjoy pipe-borne water supply, but the margin is so meagre when compared with those rural areas without it. That is why Ayoade and Oyebande (1978) are right in confirming that most parts of Nigeria especially rural areas lack pipeborne water supply.

Raup (1932), Ugwu (1979), Olofin (1983) and Obi (1984) are of the opinion that water conditions of any one place are directly dependent upon certain factors. In Raup's (1932) and Ugwu's (1979) stance

are the rainfal of the region and the physical characteristics of the basin. Oyebande (1976) and Ifeabunike (1983) even Obi (1984) have equally in their studies maintained that climate is a very important factor affecting water conditions of a place.

Ugwu (1979) and Olofin (1983) have argued that in certain parts of Nigeria, physical constraints of structure, geology and topography pose more serious problems to rural water development than socio-economic and technological ones.

A review of literature on failure of schemes and problems of rural water supply in developing nations and Africa will be discussed herein, for rural water supply is not without its attendant p problems.

Bourne (1982) and Falkenmark (1982) believe that quite often the failure of rural water and sanitation projects in developingcountries can be fraced to a lack of adequate community involvement/.

But in Malawi's gravity fed water system, this singular event of community participation aided its success. Some other success cases are those of Thailand and the Tanzania's country-wide villagization programme which developed the Ujamaa-concept.

Obeng (1982) observes that often, pumps and wells lie unused in most developing countries because no one in the rural community has even the basic knowledge to maintain them in operating order. She noted that in 1969, a WHO/UNICEF team reported that British pumps in India were regularly breaking down after only one week's use.

Falkenmark (1982) feels that the failure of most water schemes in developing countries is getting increasingly high. He stated that Bangla-desh for instance 10% of the wells become choked off annually, partly from corrosion of the tube material. Also in Tanzania 50% of existing Schemes do not operate, while in Liberia 30% of wells were out of order. Dijon (1982) found in a West African

country, that only two handpumps out of fifty were still operating after five years. In another country he found out that, 80% of the installations were out of order.

Overman (1968) in his study highlights yet another problem of rural water supply in the developing countries. According to him, the United Nations Organisation periodically collects evidence which proves that even the barest minimum quantity of water-5 litres, which is the basic necessity for life, is not being attained in less developed countries.

These water problems have taken very wierd dimensions. Evidenced by the United States Department of Agriculture (1955) is the fact that in some places men marry more wives so that they can satisfy the households water needs.

Water scarcity has generally caused untold hardship on the people in rural areas. Studies by Chisholm (1968), Richards (1974), Obeng (1982) and

Balek (1983) have shown that the rural dwellers trek very long distances daily to collect water from different sources. Chrisholm (1968) quoted a West African study which reports that the Ngwa village of South-eastern Nigeria live up to 13 kilometers from permanent water and that in Eastern Nigeria as a whole, half of the rural population live more than 5 kilometres away from perennial streams. However, Balek (1983) in his study of Gwenbe valley community near the Kariba reservoir in Africa found that the women have to travel as much as a distance of 12 kilometers to carry supplies of water for their use. In Ibarapa Division of Western Nigeria the case is not different. Richards (1974) deduced from his study that a housewife may travel as far as 12 kilometres a day fetching water.

Feachem (1973) in his studies relates water supply provision in rural areas to health; for in the New Guinea highlands he found that 90% of the people suffer from skin infections at sometime

each year and the prevalence at one moment, as in Ankole, Uganda was high enough to measure on a village sized sample (Bradley, 1977).

The following scholars have highlighted time wastage as one of the effects of water scarcity in an area (Chisholm, 1968; Ezeonu, 1983; and Chima, 1989). Individuals spend up to 5 hours a day collecting water especially in dry season (Chisholm, 1968). Village women in the region of kilimanjaro highlands spend up to 10 hours a day bringing water to the villages. In EasternAfrica an average time of 46 minutes per day is spent collecting water and in some communities, up to 264 minutes per day are spent (Jorgensen, 1982).

A review of literature on failure of schemes and problems of rural water supply in Nigeria is discussed below.

The average Nigeria village, lacks pipeborne water or any regular and safe source of water for domestic uses (Igbozurike, 1983). Equally Ayoade and Oyebande (1978) in their study assessed that two

thirds of the rural population in Nigeria have no adequate pipeborne water supply for their domestic needs.

Chima in his study found out that the people of Isiala Ngwa have a water supply problem and came out with six factors as those responsible for the water supply problem. There are limitation of available water sources, problem of public water operation and distribution, influence of locational factors. Others are influence of technological/ financial inadequacies, problem of road construction/ road grading, and lastly, the inadequacies.

Different causes of water scarcity have been highlighted in other studies. In Nnobi area of Idemmili Local Government Area, lack of adequate supply of pipeborne water, lack of surface streams in the central parts of the area are major causes of water supply problem there (Ezeonu, 1983). Ifeabunike (1983) affirms that Idemmili Local Government Area is faced with water problems of which the the cause are first, stream sources being fraught

with distance barriers, groundwater difficult to tap and distribute effectively, and the hygiene of the dug wells cannot be guaranteed. While Emezie (1980) in her study of water supply in Nkwerre, attributed causes of water problem to shortages of natural sources of water, imbalance in the distribution of the available sources, financial, technical and management difficulties.

Ifeabunike (1983) and Jeje and Nabegu (1983) have been able to single out pollution of water in their study areas as a major problem of water supply. For the reservoir at Ede, Owo and Iwo, are virtually over silted (Jeje and Nabegu, 1983).

Alo-Nwokeocha (1974), Ugwu (1979), Ezeonu (1983), Obi (1984) and Chima (1989) all seem to agree that health problems such as guineaworm, headache, tiredness, stiff joints, malaria, scabies, diarrhoes, snake/scorpion bites, hynia, result from inadequate rural water supply in any area.

Researchers in Nigeria on rural water supply do show that rural dwellers have to trek several

kilometres daily to water sources (Ezeonu, 1983; Ifeabunike, 1983; and Chima, 1989). Others are Ugwu (1979), and Onyegbula (1983). In the studies by the researchers above, time wastage was equally highlighted as the consequences of long distance trekking as well as queueing at water points.

The list of previous works dealing generally on rural water supply in Nigeria and the developing world at large is quite impressive, but these works have only looked at the problem of rural water supply from the point of view of a single rural area or a group of rural areas discussed as a single unit, the differences in rural water supply for different communities have not been researched into. This is to say that most of the studies existing in this field, deal with single rural or a combination of rural areas as if it were one homogenous unit, without highlighting the spatial inequality that exists within these communities. Thus, the gap this study intends to fill, is to identify the differences in water supply, and the varying intensities of

rural water supply problem amongst the six rural communities (which exist within a homogenous socio-cultural group) being studied.

1.5 Research Methodology

For this research work, questionnaires were designed and utilized (see Appendix A). The data collection was conducted during the fieldwork. A questionnaire survey of 300 households on the whole in the six study communities (Iheaka, Adaba, Obe, Akama Oghe, Ndi Offia and Eka Awoke) of Enugu State was conducted from 5th March to 28th March 1994. A total of 438 questionnaires were distributed, as there were four sets of questionnaires (below is the breakdown). First set of questionnaires were designed for various sectors of the study communities i.e residential, commercial, industrial and service. The second set of questionnaires were for tanker drivers, while the third set of questionnaires were for chiefs, or community heads. The fourth set of questionnaires were designed for heads of the Zonal

Offices of Water Corporation in the study areas. Of the 438 questionnaires administered, 344 questionnaires were returned.

For the survey, the six study communities were picked through systematic random sampling. The system being first to sample or draw out six local government areas from the eighteen local government areas of the state, which served as the sampling frame. And lastly, to sample or draw out one autonomous community from each selected local government area.

Random samples of households, tanker drivers, commercial establishments, industrial establishments, services establishments and zonal offices of Water Board in the six study communities were served the questionnaires. A large number of the respondents were not literate, thus the interviewer had to do most of the filling in after oral interviews with each respondent. However the literate re respondents filled in the questionnaires on their own. Some of the people did not respond due to

suspicion or ignorance on their part, but then on the whole many responded, (see Appendix B).

The researchers definition of household in the context of this study, is a married person with a family or an unmarried person of at least 21 years of age living alone and catering for him or herself.

The distribution of the 300 sampled households among the six communities is presented in Table 2. The 300 sampled households represents a total sampled population of 2,050 for the whole area. When the total sampled population of 2,050 people is compared with the 1992 projected population of 56,038 to find the percentage of sampled population, we get a mean of 24.5%. For research work of this nature, the sampled population is accepted, as well as considered representative of the entire rural communities under study.

Data were collected on the various sources of water to the people, the regularity of water supply by tanker drivers, amount spent in a month per household on water, quantity of water demanded and

TABLE 2: Number of Households sampled in the Six Different Communities and their 1992 Projected Population

COMMUNITIES	Number of sampled households	Mean number of persons per household	Total population sampled	Population of the area (1992) (estimated)	Percentage of sampled population
Obe	50	7	350	9,293	3.8
Akama Oghe	50	6	300	7,138	4.2
Adaba	50	7	350	6,546	5.3
Iheaka	50	7	350	16,973	2.1
Ndi Offia	50	8	400	6,836	5.9
Eka Awoke	50	6	300	9,252	3.2
Total	300	7	2,050	56,038	24.5

the quantity of water consumed daily. Respondents estimated the quantity of water demanded and consumed by their households in units of standard buckets and drums of water per day. These drums and buckets units were then converted to litres by the researcher. A standard bucket has a capacity of 12 litres, while our measure of an average drum is a capacity of 215 litres.

Other information and data for analysis were obtained from fieldwork (through oral interviews) and official records from both published and unpublished sources. Population figures for the six study communities were obtained from the Enugu State Ministry of Finance, Budget and Planning, Statistics Division, Enugu. In the field we also took an inventory of commercial, industrial, and service establishments in each of the six study communities (see Appendix B).

The major technique of analysis include the homogenization of the data. After the homogenization, the data were subjected to Analysis of Variance (ANOVA). The ANOVA was applied to determine significant differences or similarities in the range of responses within the sex communities studied.

Other statistical analysis were deductions of patterns and relationships with the use of totals, means, standard deviations, percentages and maps. All statistical analysis for this research work, were performed with the aid of a casio Fx - 82LB hand-held pocket calculator.

1.6 Plan of the Study

The study is divided into five chapters. The first chapter is the introduction. This chapter is comprised of the following sub-sections, the research problems, aim and objectives of the study, the study area, followed by the literature review, the research methodology and the plan of the study.

In chapter two, sources of water supply in the study areas are exhaustively discussed. This chapter is concluded with a summary of the sources of water supply. The comparism of the various sources as they differ among the six communities is clearly highlighted in the chapter. Chapter three is on the assessment of water demand and consumption in the areas of study. Under this chapter the following sub-headings are treated, domestic water demand and consumption assessment, commercial water demand and consumption assessment, service water demand and consumption assessment, industrial water demand and consumption assessment and lastly summary of water demand characteristics of the study areas. These assessments were compared among the six study communities and ranked.

Water supply improvement measures used in the various study communities, are dealt with in chapter four. This chapter discussed existing water supply improvement measures, analysis of those existing improvement measures and alternative

improvement measures. This chapter is concluded with a discussion on the best applicable improvement measures for each study community.

Chapter five rounds off this research with conclusion and recommendation. Results of the comparative analysis carried out for this research is summarized in this chapter with the actual water supplies situation arrived at, being extensively discussed.

CHAPTER 2

WATER SOURCES IN THE AREAS OF STUDY

There are various sources of water in the six study communities. These sources are raincatch, streams, ponds springs, wells, boreholes, plastered-dug pits, water tankers and water vendors. For this study, the water sources will be discussed under three broad divisions; viz, natural, artificial and commercially procured sources.

2.1 Natural Sources of Water Supply

According to Ayoade (1978), the ultimate sources of water found in nature are rainfall and the resultant springs and streams. From fieldwork, the natural sources of water supply in the six study communities appeared to be only raincatch, streams, springs and ponds.

2.1.1 Streams

Surface water availability in the study areas includes streams, surface water sources generally

form a more accessible source of water, than any other source (Ayoade and Oyebande, 1978). The main streams in the study communities have been noted in section 1.3.3.

People residing in five out of the six study communities employ the use of streams as source of water supply. The communities that possess streams are Obe, Akama Oghe, Adaba, Ndi Offia and Eka Awoke. The names of these streams are listed in Table.

TABLE 3: Names of Streams found in the Study Communities

COMMUNITY	Name of Streams
Obe	(i) Ogbe Stream (ii) Orum Mmiri Stream
Eka Awoke	(i) Akumitoli Stream
Akama Oghe	(i) Iyi Ofuru Stream (ii) Ajalli River
Ndi Offia	(i) Iyi Ageze Stream
Adaba	(i) Adada River (ii) Awoha Stream (iii) Ngene Etiti Stream

(Source: Fieldwork, 1994).

More people in Adaba community use streams as water source than any other community studied for this research. This is largely due to the fact that this particular community has as many as three streams flowing through their land, or in close proximity to them than can be found in any other study community. For in Adaba exists, Adada River, "Awoha" and "Ngene Etiti" Streams as is seen in Table 3. The next community ranking highest in the use of streams is the Akama Oghe community, with two streams, Ajalli and "Iyi Ofuru". Adaba and Akama Oghe community have one thing in common, they both have perennial rivers flowing adjacent to them, because of the relative nearness of these constant flowing rivers; Ajalli River, and Adada River, the people rely on them for water. Its reliability even in the dry season makes it a popular source of water to the people.

The community that ranks as the least user of streams is the Obe community. Though Obe possesses two streams, the streams usually run dry during the

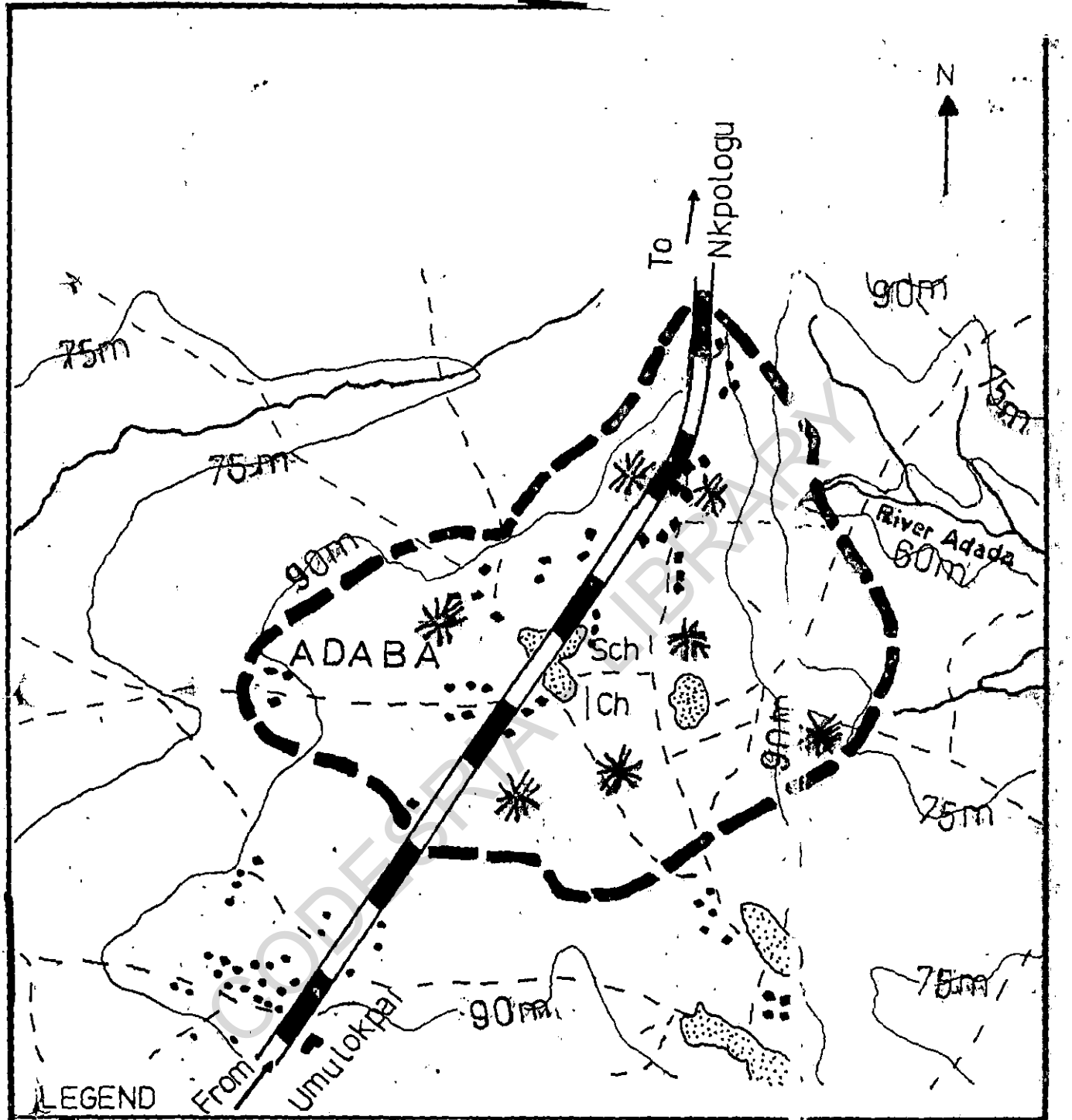
dry season because of their ephemeral nature. The unreliability of the stream as a water source, rendered the people to tend to other water sources where they can get water all year round, e.g wells. Next to Obe as the least user of stream sources, is Eka Awoke community and next to it is the Ndi Offia community. These two above mentioned communities have one stream each, which only flows during the rainy season for a duration of about 8 months, after which its stream channels are left dry. It is the unreliability of these streams as water source, that has made them unpopular to the people of both Ndi Offia and Eka Awoke communities.

Reliability of streams as water source rather than distance, is what is responsible for the low number of people who use streams in the communities of Obe, Ndi Offia and Eka Awoke. In Adaba community, the streams are within trekking distance and most of the people seem to have a stream an average distance of 2 kilometres away for use. None of the streams found in five out of the six study communities had

myths or religious belief surrounding them, that could render them unsafe for use.

Streams are non-existent in Iheaka community, this is largely due to the geology of the place. The location suffers from considerable influence of lithology which has an adverse effect on stream development, pattern and density, as well as the high infiltration capacity of the sandstone formation of the area which militates against stream formation. Majority of the inhabitants with streams close to them go to fetch their water in the morning and evening hours.

The "Akumitoli" in Eka Awoke community rises in the south-eastern part of the community and flows in an easterly direction until it joins river Otata, a tributary of the Eastern Abonyi River (Figure 5). Whereas the "Iyi Ageze" stream in Ndi Offia community a tributary of Ewe River, rises in Ndi Offia and flows in a North Westerly direction through the village of Obeagu Ike Enyi until it joins the Ewe River, which finally empties itself into Abonyi



ADABA COMMUNITY (UZO UWANI L.G.A)

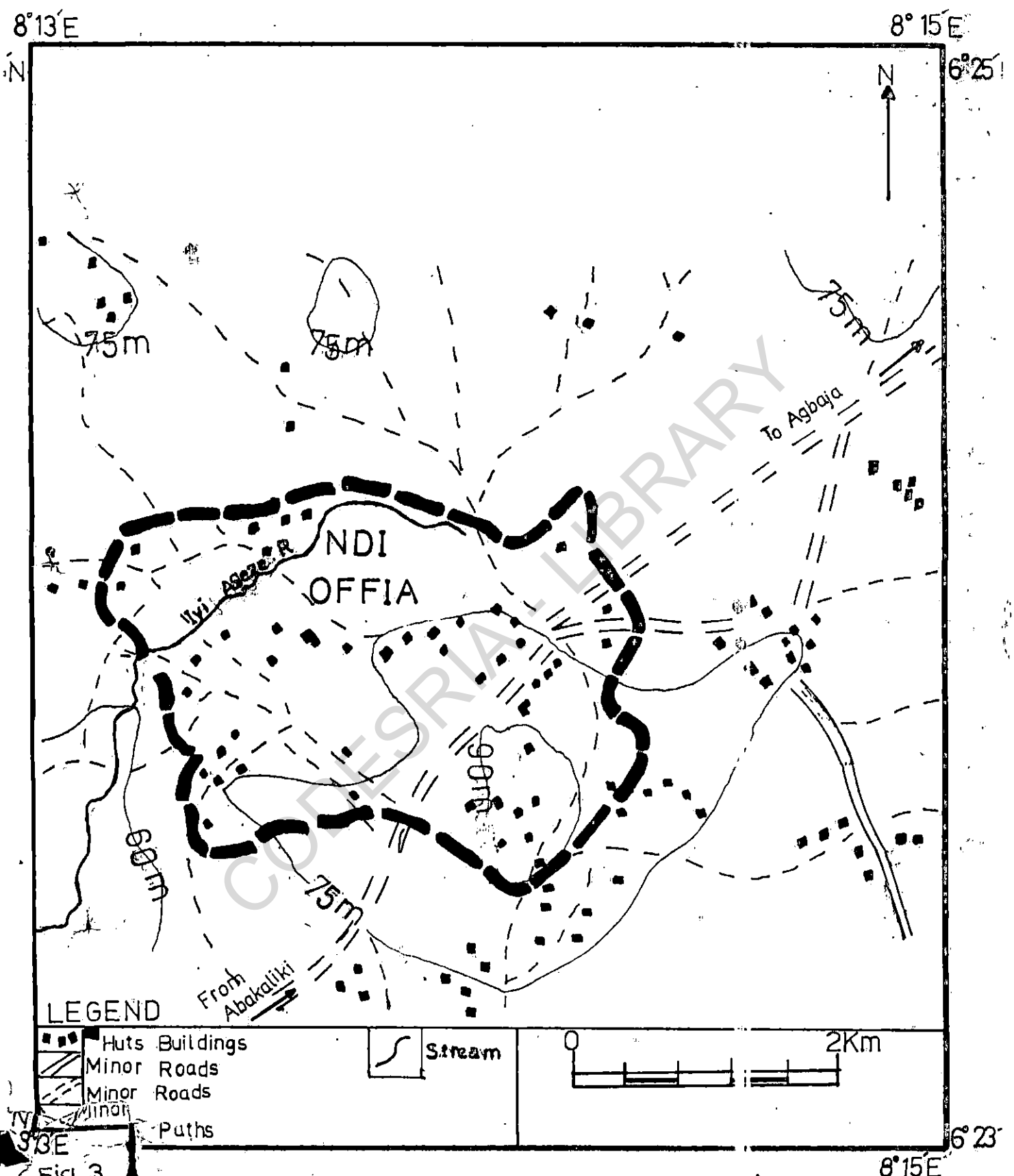


Fig 3

NDI OFFIA COMMUNITY (IZZI L.G.A.)

(Source . Federal Survey Nigeria, 1966)

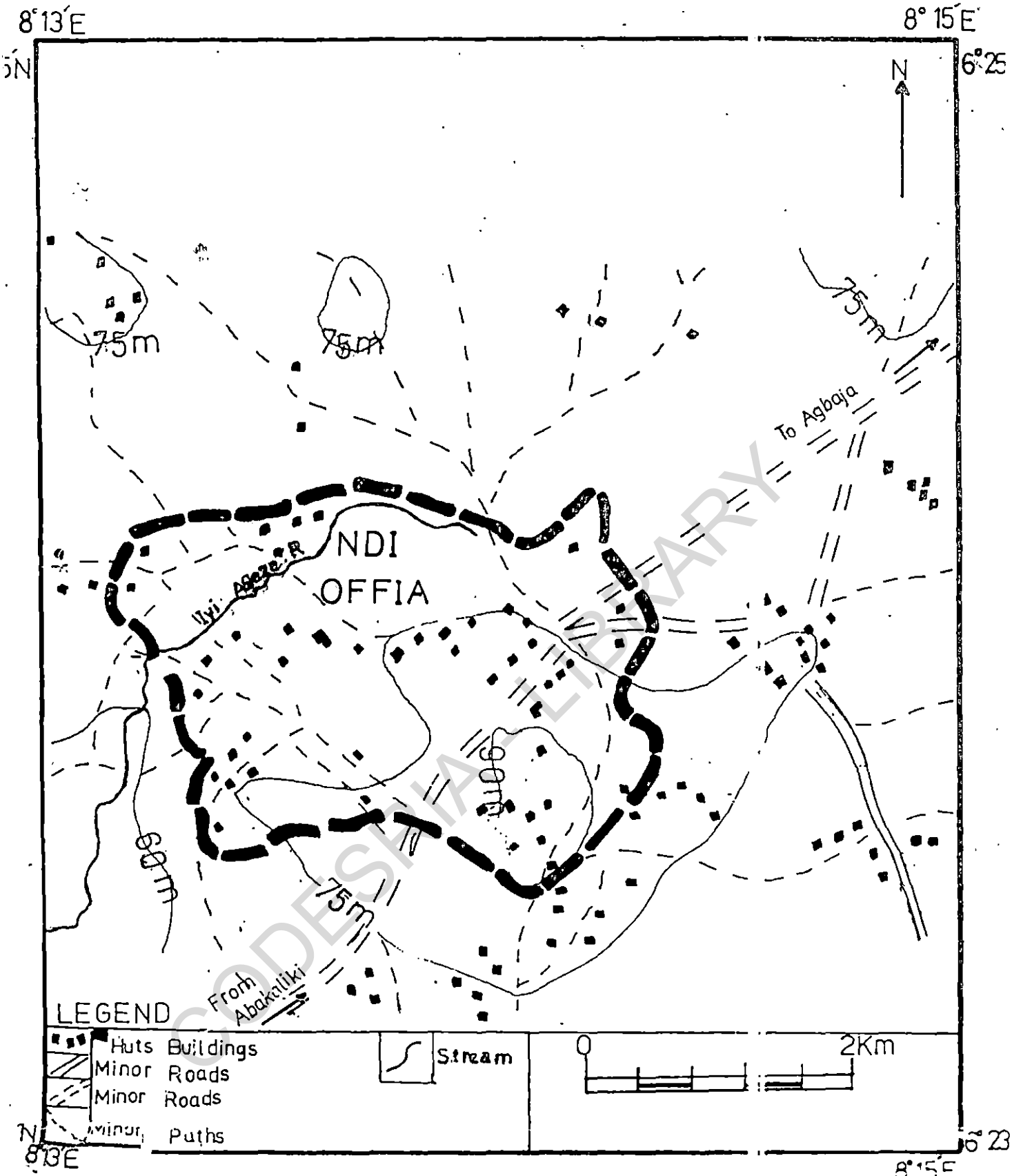


Fig 3 NDI OFFIA COMMUNITY (IZZI L.G.A.)
(source: Federal Survey Nigeria, 1966)

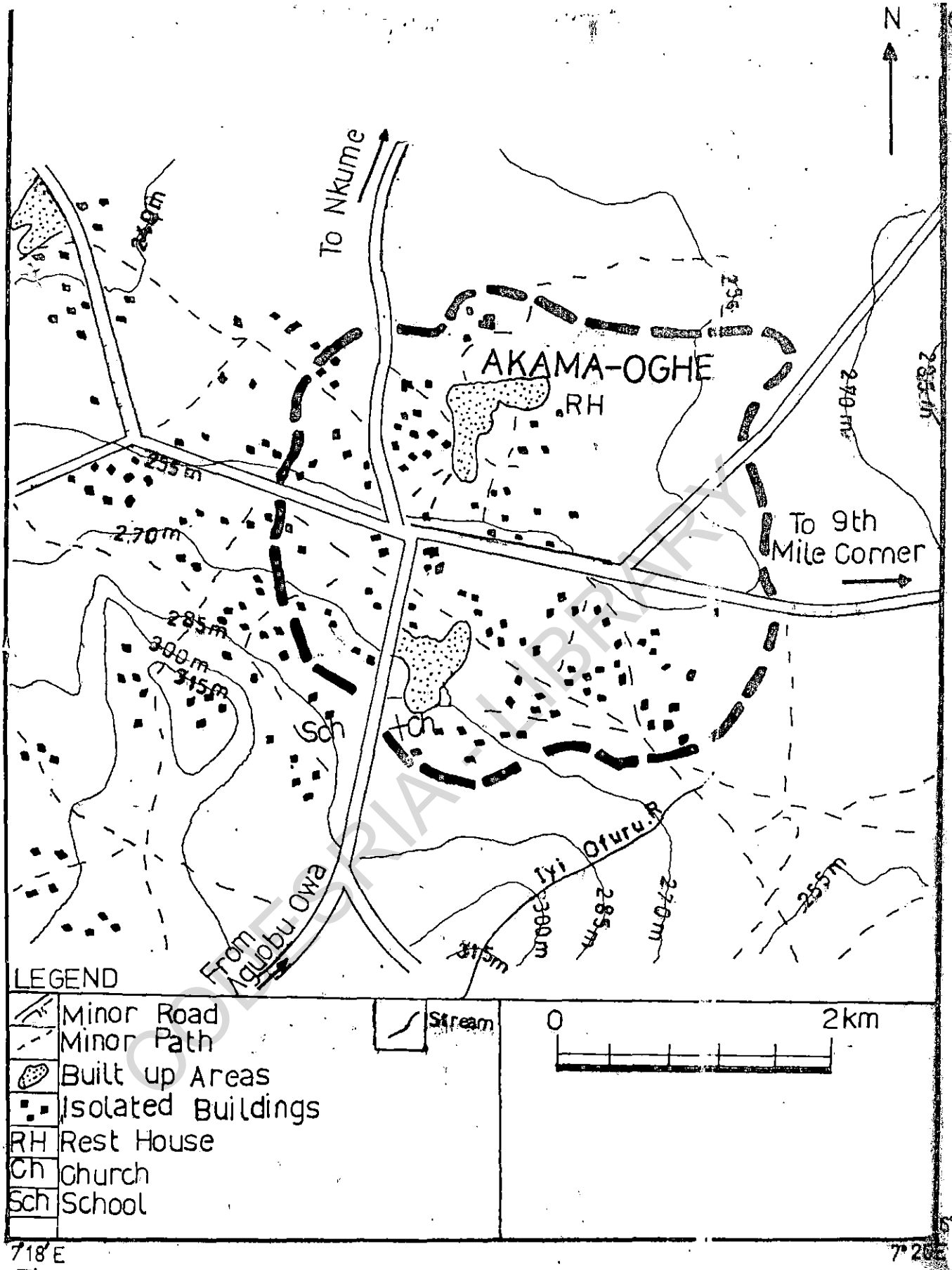


Fig 4 AKAMA-OGHE COMMUNITY (EZE/.GU L.G.A)

(source:Federal Surveys Nigeria, 1966)

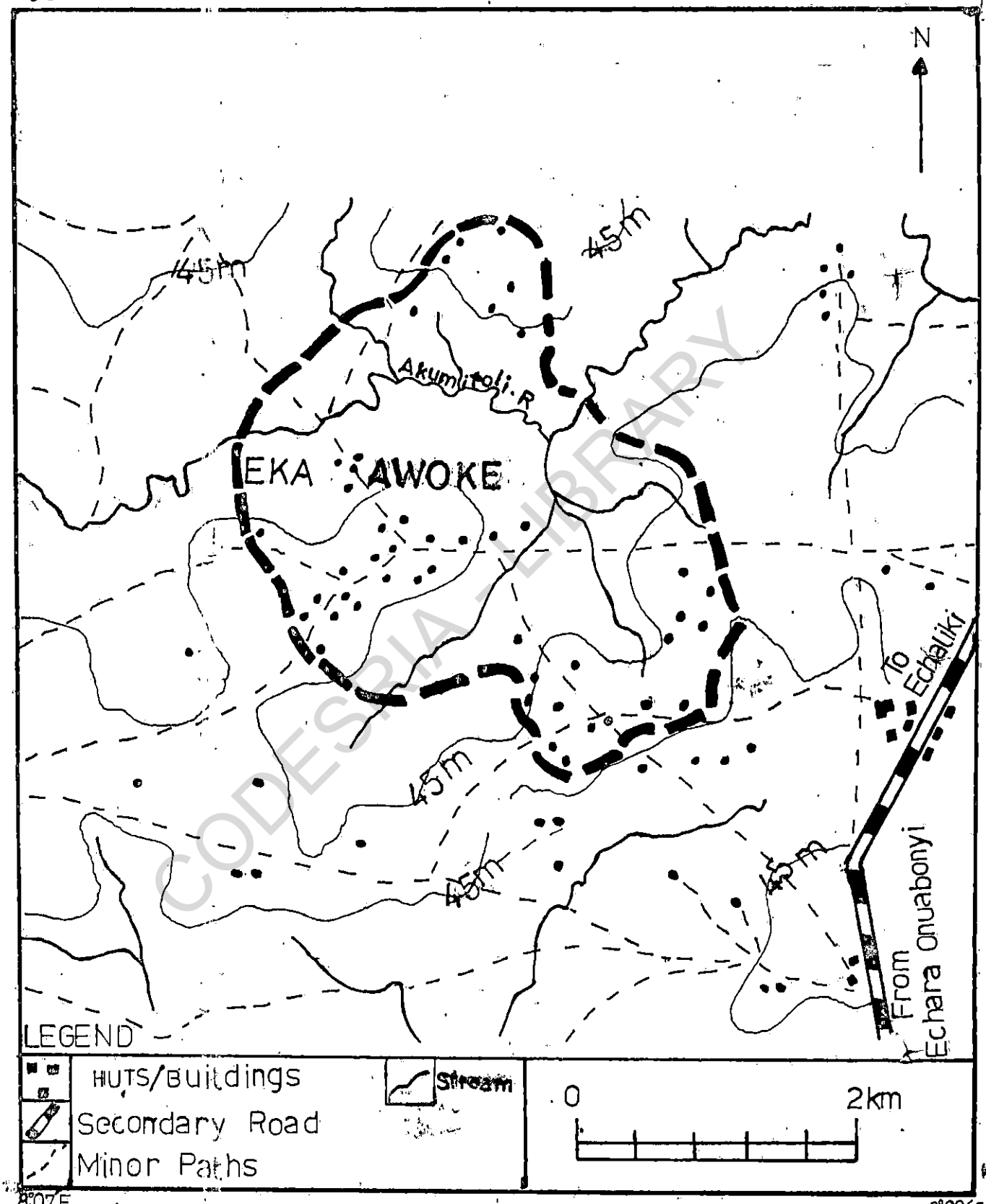


Fig 5 EKA AWOKE COMMUNITY (IKWO L.G.A)
(source: Federal Surveys Nigeria. 1966)

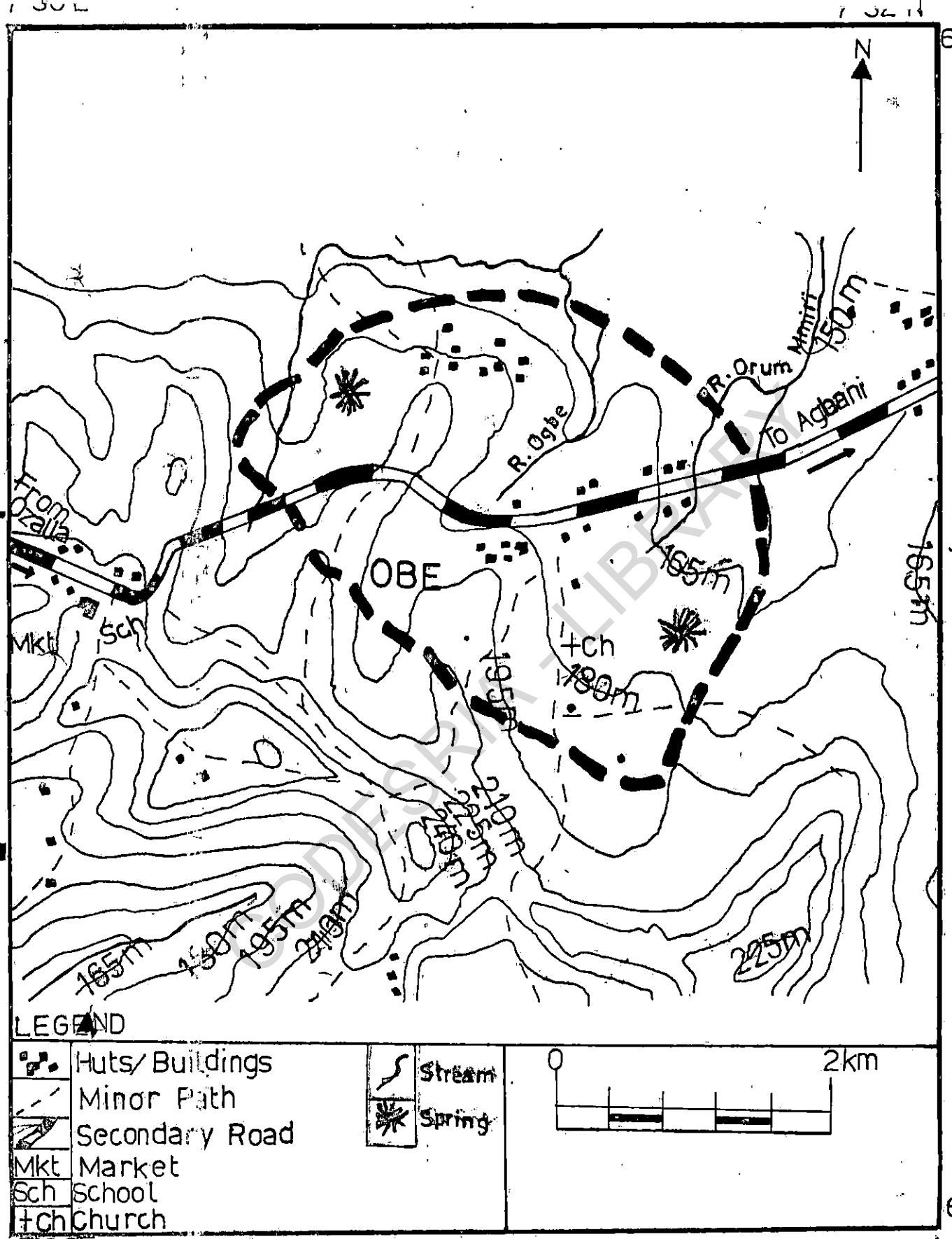


Fig 6 OBI: COMMUNITY (NKANU L.G.A)
(source: Federal Survey Nigeria, 1966)

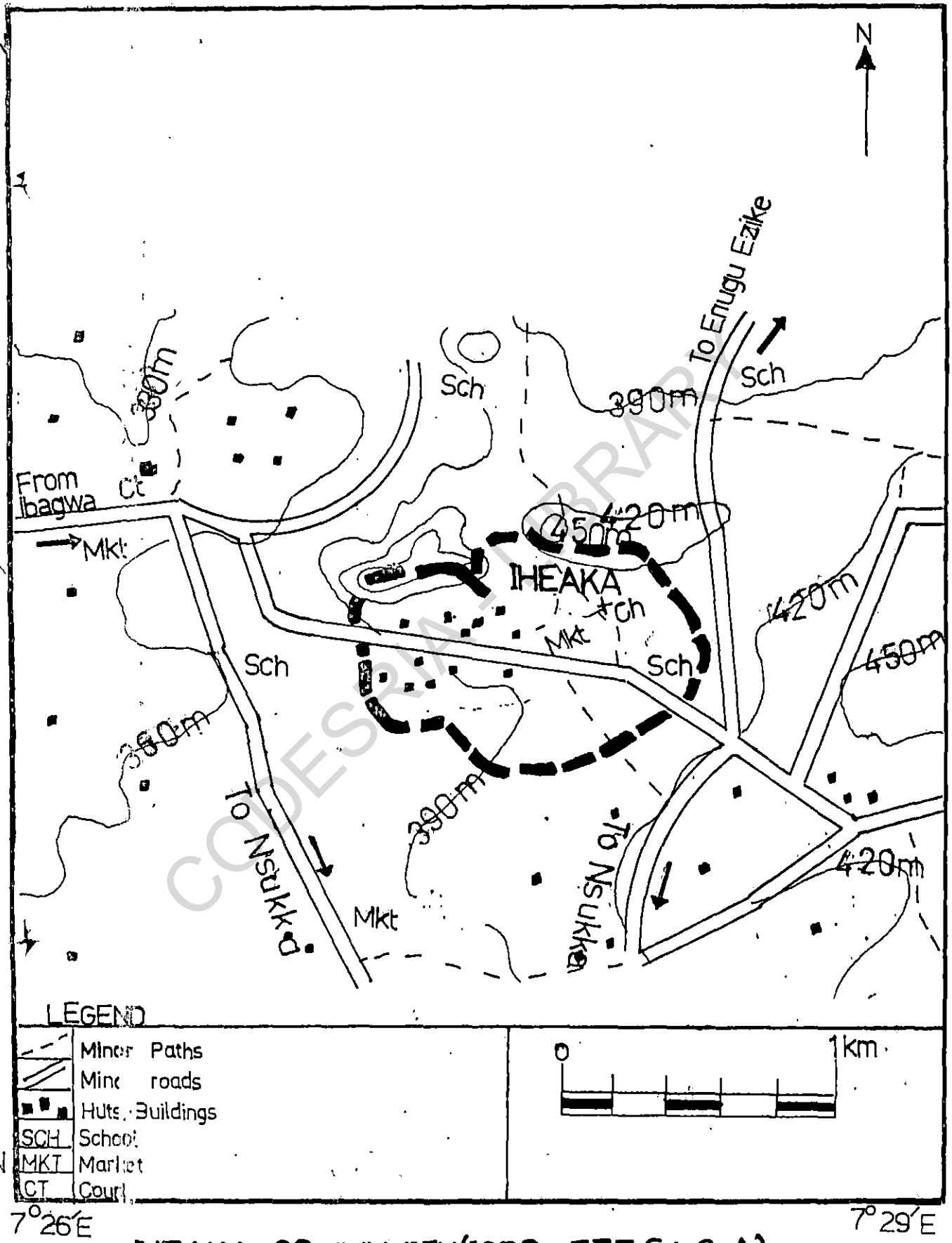


Fig7. IHEAKA COMMUNITY (IGBO-EZE S.L.G.A)

(Source: federal Survey Nigeria, 1966)

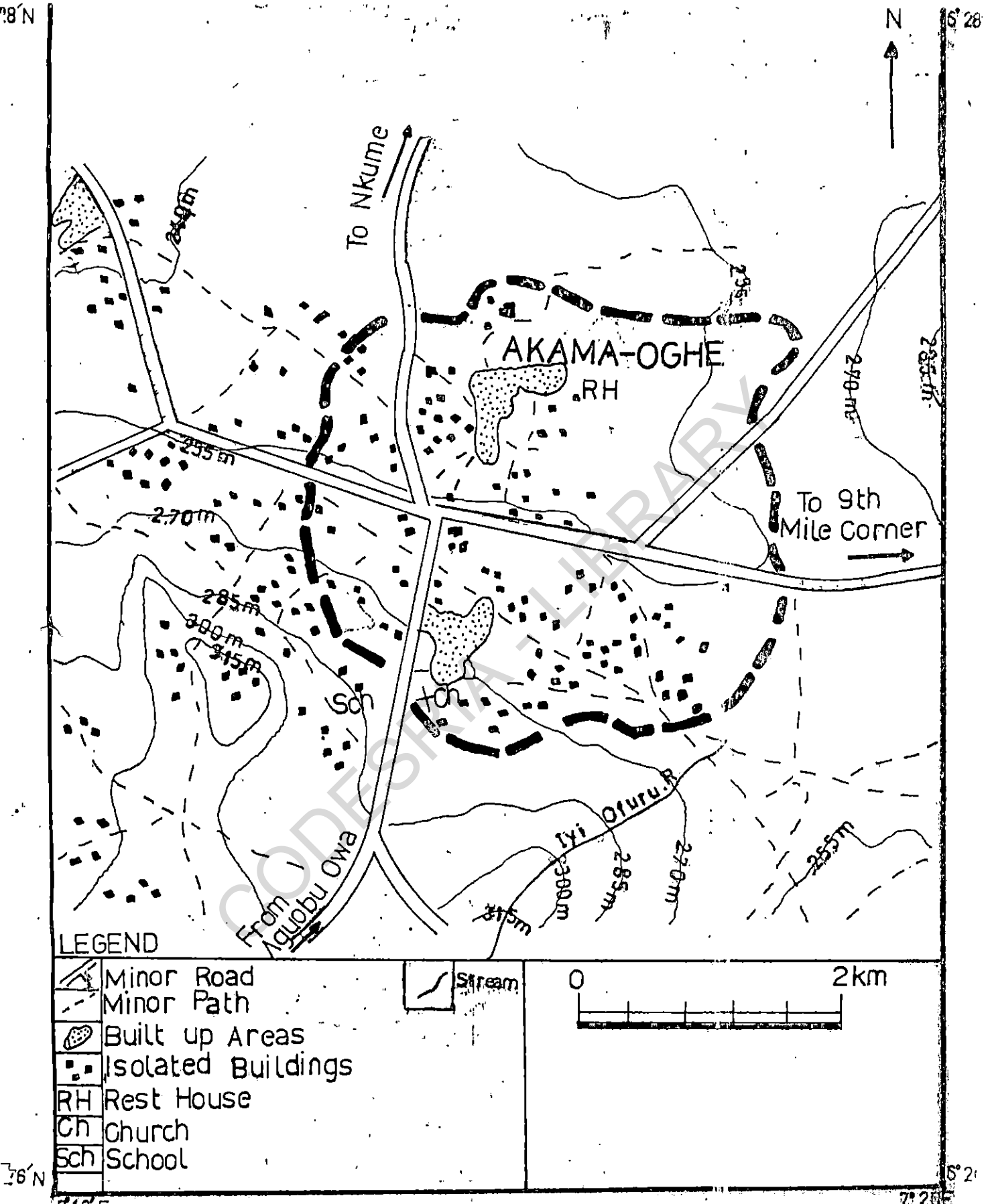


Fig 4 AKAMA-OGHE COMMUNITY (EZEAGU L.G.A.)

(source: Federal Surveys Nigeria, 1966)

River (Figure 3).

River Ajalli which rises east of Akama Oghe community near Ninth Mile Corner Ngwo, flows in a westerly direction, and merely borders the study community Akama Oghe. Its tributary "Iyi Ofuru" which also serves the people of this community flows in north easterly direction till it empties itself into River Ajalli (Figure 4).

Adada River which rises near Igbo Etiti and Akpugo, drains noth-east of Adaba community. Its main tributaries are "Awoha" and "Ngene Etiti". Awoha flows in a north easterly direction and empties itself into Adada River, while Ngene Etiti flows in a north westerly direction through Okpatu village to join Adada River, all of them collectively serve Adaba, community. The "Ogbe" and "Orum Mmiri" streams found in Obe community provide a good drainage system for the people living in the northern parts of Obe community. These streams flow in a northwards direction (Figure 6). Ogbe stream empties into Mvuma River, while "Orum Mmiri" a tributary of

Asu River, later joins Asu River downstream.

The perennial streams, Ajalli and Adada River are at their lowest stage in March, just before the beginning of the rainy season and they rise as the months progress. The peak is however reached in the end of October. A sharp drop in the water level occurs during the end of the rainy season in November and the low water period begins in December.

All the streams found in the study communities, are used in the areas where they are found for domestic and non-domestic water activities. Many water dealers/vendors also go to these streams to pump water from the streams to their water tankers.

2.1.2 Springs

Springs are a source of drinking water for some of the study communities, some of which are located near a river. Springs usually occur where the water table intersects the surface (Monkhouse and Small, 1978).

Springs are found and used as water sources in only two out of the six study communities, Obe and

Adaba. More people in Adaba use springs than people in Obe. The reason for this can be due to the number of springs existing in each community. In Adaba community where most of the water sources are springs, there are seven springs (Table 4) whereas Obe community has only two springs.

TABLE 4: Springs found in the study Communities

COMMUNITY	Name of Springs
Adaba	(i) Ngene Ezeagu
	(ii) Ngene Nvoka
	(iii) Ngene Ituku
	(iv) Ngene Afurugbe
	(v) Iyi Ugwu
	(vi) Awokiyi
	(vii) Okpokoro
Obe	(i) Okpa Mfu
	(ii) Ogba

(Source: Fieldwork, 1994).

Another factor responsible for the popularity of springs as a water source in Adaba is that at least for nearly every area of the community there

exists a spring for the people to use. Whereas for Obe, the "Okpa Mfu" spring is located very far away from the settlements, and the route is a narrow and rugged strip. This very reason has constituted a bottleneck for effective tapping of springs by Obe people for water use.

Most of the springs found in Adaba community, gush out with force from the wall of a steep valley. And from them, pieces of "corrugated iron sheeting" are used to direct water into containers. Whereas in Obe, the springs "Okpa Mfu" and "Ogba", upwell from a very small area (see plate 1), and as such

PLATE 1: Okpa Mfu Spring.

the water has to be scooped into various containers with a bowl. According to Jong and Hofkes (1986), springs are the best of most water sources as it is the purest water source, it emits from the sub-surface and requires little or no treatment.

2.1.3 Ponds

Ponds are usually shallow man-made drpressions or natural depressions on the ground surface, where runoff water collects after rainstorms.

Three communities out of the six study communities depend on ponds as a water source. These communities are Iheaka, Ndi Offia and Eka Awoke. The highest number of people that use ponds can be found in Ndi Offia community, whereas the least numbers is found in Eka Awoke. Here ponds are referred to in their local name "okpuru". Most of the ponds seen in Ndi Offia are natural depressions (see plate 2). Most people in this community use ponds, because boreholes, pipeborne water supply, perennial streams, springs, water vendors are not

PLATE 2: "Okpuru" Oguakpu - A Pond

available to them. These ponds are not centrally located, some rural dwellers have to trek for 30 minutes or more, before they can get to the nearest ponds to collect water.

Ponds found in Ndi Offia are centrally owned by the community and not by individuals. These ponds are characteristically seasonal in nature,

and only rise during the rainy season and later dry out during the dry season. Those of them that do not completely dry out, degenerate into water holes, where muddy water is scooped out (see plate 3a), for use.

PLATE 3a: "Okpuru" Ntam - A Waterhole

Eka Awoke community are least users of ponds as water sources, because the area has a constantly flowing borehole, ponds only help to supplement water gotten from boreholes. It is found that most

of the rural dwellers who use the ponds to supplement, are those of them who live in relatively far distances of about 3 to 7 kilometres from the borehole, and cannot afford to constantly bear the troubles of going to boreholes except when water is needed for drinking and cooking. Ponds found in Eka Awoke community are of two types, the natural depressions and the artificially created ones from dredging a large land mass often by the help of the government to produce a hollow on the ground where runoff water is collected (see plate 3b). The latter ponds, usually are fenced to disallow domestic

PLATE 3D: Artificially Dredged Water Pond.

Ponds are also found in Iheaka, and are used as a water source. Thus the people of Iheaka community are second largest in number, after Ndi Offia to employ the use of ponds as water source. The local name of ponds in Iheaka is "Ogele". The people are constrained to use ponds, since they have only four water sources, which are scarcely adequate. Iheaka lacks streams, springs, wells, and boreholes, thus ponds as a water source seem to them a solution to their biting water needs. Ponds in Iheaka are owned by individual families and never centrally owned by the community. These ponds are man-made depressions created by the people themselves to help store rain water, with a diametre of 4 to 7 metres and a depth of about 5 metres. Ponds in Iheaka are seasonal like those found in Ndi Offia and Eka Awoke. Ponds are non-existent in other study communities such as Obe, Akama Oghe and Adaba, which have many permanent water sources existing for them.

Generally ponds help to supplement rainwater for communities that lack surface water such as streams, or where the distance to streams is long that not enough water can be carried per day to meet their barest requirements. The only factor in most cases that renders ponds unsuitable as water source for the people within the study communities, is the fact that ponds are full of mud and debris and, therefore, cannot be put to much use. Pond water cannot be drank or used for cooking, it is only tolerable for such domestic purposes as extracting oil from palm fruits, washing kitchen utensils, washing agricultural produce from the farm, laundry, cleaning and scrubbing the home.

2.1.4 Raincatch

People in every community, of the six study communities depend on raincatch.

Raincatch is water which falls from the atmosphere (Frank, 1955), it is the most popular

source of water for domestic, industrial and commercial purposes in the six study communities. Normally this water is collected during a rainstorm.

Adaba community is the highest user of this natural water source, whilst the least users is the Eka Awoke community. The next highest user of raincatch is the people of Iheaka community, followed by Obe and Akama Oghe people simultaneously. Whereas, the next least user after Eka Awoke, is the Ndi Offia community.

It is the rainy season period that makes raincatch a major source of water supply to the people, for they prefer to harvest rainwater at their individual homes than trekking to any other water source closeby. The people of Adaba community, who are the highest users of raincatch are able to do so, because most of the houses found in the area are predominantly covered or roofed with galvanized iron sheets. For them, the collecting point is mostly from roofs of houses, where they wait for about

5 - 10 minutes for the rainwater to wash off the dust on the roof top before they start collecting water. For adequate water collection, some houses in Adaba have roof gutters constructed with corrugated iron sheets connected to the roofs, and it is from the roof gutters that water is channelled into their storage containers e.g drums.

The factor most likely to be responsible for the low number of users of raincatch as water source in Eka Awoke and Ndi Offia community, is no other than that many houses here have thatched roofs. Ndi Offia and Eka Awoke communities found near Abakaliki area, are not relatively quite as developed as their counter parts (i.e other study communities) found towards Enugu urban area or Nsukka urban area. Thus most of the houses found in Eka Awoke and Ndi Offia are predominantly thatched roof houses. This house type does not aid proper rain harvest, it is only those few, with corrugated iron sheeting roofs that actually employ

raincatch as a water source, thus the low number of raincatch users.

Since rainfall is seasonal in Enugu State, occurring for only 7 months between April and October (Monanu, 1975), water can only be collected during this period and so rainfall seasonality sets a limit on rainfall utilization.

2.2 Artificial Sources of Water Supply

These sources are man's own effort to obtain water, in order to supplement the natural sources of water supply existing within his domain. Artificial sources of water supply found in the study communities include wells, and boreholes.

2.2.1 Boreholes

Three out of the six study communities have boreholes. These three communities are, Iheaka, Akama Oghe and Eka Awoke. Akama Oghe and Eka

Awoke have functional boreholes, while the borehole in Iheaka is yet to be commissioned (Eze, 1994).

More people use the borehole as a water source in Eka Awoke, than in Akama Oghe community. Other study communities, Obe, Adaba and Nāi Offia do not possess any borehole. More people tend to use the borehole in Eka Awoke because water from the borehole constantly flows, from its handpump. Conversely the borehole at Akama Oghe scarcely yields water. Most times water flows from it about an average of three times in two months. It is the unreliability of the borehole at Akama Oghe that rendered it, an unpopular water source amongst the people of Akama Oghe. Thus the low number of borehole users in Akama Oghe.

The Enugu State Water Corporation is responsible for the borehole water supply system found in the Akama Oghe rural community. Its operations and maintenance are by the staff of the corporation. Whereas the borehole at Eka Awoke was drilled by a

Japanese firm for the Enugu State Ministry of Health, and is presently being run by the WATSAN project (Water and Sanitation project) in Enugu State.

A borehole is a device for the extraction of ground water, for good drinking water supply (Chima, 1989). Borehole water exploitation comprises the drilling and pumping out of ground water with a submersible pump, powered by electricity. This is pumped and stored in an elevated reservoir and from there distributed to the people through the drainage network to the various standpipes (Collin, 1986).

The Eka Awoke borehole has no service reservoir nor a pump house. The borehole has a handpump attached to its head (see plate 4). The ground around the handpump is cemented all round, for a distance of about 5 metres diameter.

This borehole type is usually less costly to construct and maintain when compared to the type seen in Akama Oghe community. For the Akama Oghe community borehole, water was got after drilling at a depth of about 200 metres. The water when pumped

PLATE 4: Borehole with handpump by WATSAN.

is supposed to supply 700,000 litres of water daily. The duration of pumping hours is dependent on availability of fuel (diesel) amongst other factors. The water works of Akama Oghe is equipped with a pumping plant of 139 kilo volt amperes (KVA).

An elevated steel reservoir exists at the premises of the Akama Oghe water works. The pumped water from the borehole is stored in it. Water is

supplied to the public through the distribution network to public standpipes. The standpipes in Akama Oghe community are about twenty in number. Criteria for locating taps where they are presently located, is based on the population concentration of the consumers in the study community rather than any other reason. Most of the taps though functional, hardly run. Occasions when the tap runs it is for one or two hours, and for about three times in two months. In most cases they supply water once a month. This lapse is as a result of inadequate funds with which to buy diesel for the pumping plant, in most cases. In the absence of the above problem, the borehole is actually supposed to supply an average of 700,000 litres of water per day (Ugwu, 1994). There is no metering system in the water works of Akama Oghe or in Eka Awoke community, to record the rate of comsumption in the community by the people.

TABLE 5: Location of boreholes in study communities.

Community	Local Government Area	Number of Borehole
Obe	Nkanu L.G.A	-
Akama Oghe	Ezeagu L.G.A	1
Adaba	Uzo-Uwani L.G.A.	-
Iheaka	Igbo-Eze S. L.G.A.	1 (uncommissioned)
Ndi Offia	Izzi L.G.A.	-
Eka Awoke	Ikwo L.G.A.	1
		Total = 3

(Source: Fieldwork, 1994)

The use of boreholes as a water source is not popular in the six study communities, as can be seen in Table 5. It only exists as a water source, in Akama Oghe and Eka Awoke communities.

2.2.2 Wells

The use of wells as sources of water supply is evident in three of the study communities. The people of Obe employ the use of wells. This

community has no borehole, so the well is their only means of tapping ground water resources. Other communities that use wells are Ndi Offia and Eka Awoke community. More people use wells in Ndi-Offia than any other community that possesses wells. The reason likely to explain this pattern is that Ndi Offia lacks surface streams in the dry season, This thus makes wells one of the more readily available water sources to them. The next largest users of wells as water source, are the people of Obe community. Whilst the least users of wells are Eka Awoke community. Some compounds in Eka Awoke have wells, but because of the presence of the constantly running borehole in that community few people use wells as source of water supply.

Most of the wells in Obe and Ndi Offia community, are seen in the front and sides of buildings inside various compounds. Majority of the wells have top, which is shut after water has been drawn from it. Not all well users own wells. It is mostly the well-off members of the community that

can afford wells, whilebetheir less privileged neighbours come to beg for water from their wells.

Generally, it can be said that wells exist mostly in study communities with relative absence of surface water. These are dug in areas of ground water occurrence. The geology of that area becomes pertinent. Thus, most times the existence of wells in a community marks the scarcity of surface water in that community (Onyegbula, 1983).

Most of the wells found in Obe, Ndi-Offia and Eka Awoke communities are not centrally owned, rather a lot of them are privately owned by individual families or groups of families, and so are found in peoples compounds. It costs as much as ₦4,500 to ₦7,000 to construct a well in ones compound (Ugwu, 1994).

The wells possess varying depths mainly because the rock type of these areas are not similar. Fluctuations in wells are usually through excavation by hand. The diametre of most wells seen, varied from 1.0 metre to 2.5 metres.

In Obe community, most of the wells are lined, this prevents the collapsing of sides of the well. These lined wells usually have clearer water than unlined wells, as was the case in Ndi Offia community. Actually the excavation during the construction of a well never stops until the water table is reached, and water flows in more rapidly from the interstices at the sides of the well, than it can be bailed out. Most rural dwellers extracting water from wells in Obe, Ndi Offia and Eka Awoke communities, do that manually. Water is drawn through the help of buckets or cans tied to ropes. More wells in Ndi Offia community have tops than those without tops, same is the case with Eka Awoke community and Obe community. This indicates the people's awareness of disease free water and environmental pollution (see plate 5).

The obvious handicap of this water source, is the fluctuation that occurs in the water level of most wells during the dry season. These fluctuations

can be attributed to insufficient ground water reserve or superficial depths of wells being constructed by labourers who lack technological know - how.

PLATE 5: Well with top, being fetched by people.

2.3 Commercially Procured Water

As a result of inadequacy of water sources, especially natural sources of water supply in the various study communities, most of those people now resort to buying water. This water is mainly bought from private individuals or groups of individuals

who have undertaken the supply of water on a commercial basis. These are thus the water vendors and the water tanker operators, who cash in on the unfortunate situation of water scarcity in an area (Zaroff and Okun, 1984).

2.3.1 Water Tankers

Obe, Akama Oghe, and Iheaka communities, are the three communities supplied with water by water tanker drivers. Akama Oghe community is the largest user of this water source, followed by Iheaka. Whereas Obe community is the least user of this water source. This water source seems to be favoured by the people of Akama Oghe, because the tanker drivers find the road most motorable at the same time close to the water borehole hydrant at Ninth Mile Corner, Ngwo. In Obe's case, the road is motorable as wells, but no water hydrant is hear enough to it, except tanker driver comes into Enugu urban to refill his tanker, thus the fewness of water tankers to this community, which has inturn given rise to the low number found

in Table 6, for Obe community.

Most water tanker drivers who supply Obe community with water to go to fill up their tankers at the Enugu State Water Corporation, New Market Water Works borehole hydrant. This is one of the two closest water hydrants for water tanker driver in this area. The second closest water hydrant is the Artesan, Enugu State Water Corporation hydrant, which is pipeborne water from the Ajalli Water Works. Another source of water for those tanker drivers who supply Obe community is the Nvene spring water, though it is far.

The two major sources where tanker drivers that supply Akama Oghe community with water go to refill are, Kalawa stream at Oghe village (untreated) and the Ninth Mile Corner Ngwo, Enugu State Water Corporation borehole hydrant (see plate 6). While the Nsukka, Enugu State Water Corporation borehole hydrant and the Obollo Afor, Enugu State Water Corporation hydrant are water sources for tanker drivers that sell water to people of the Iheaka community.

PLATE 6: Borehole Hydrant at Ninth Mile Corner, Ngwo.

According to the responses from interviews with water tanker drivers during the fieldwork, the cost of refilling at various hydrants or water points differ. At the various state owned Water Corporation hydrants, cost of refilling water tankers is between N100 - N200 (source: Fieldwork, March 1994), as all water tankers do not possess the same capacity. This price does not differ during the rainy season. At the Nvene spring water in Udi L.G.A, N40 is paid (Source: Fieldwork,

1994), if plant/pump and hose are brought along for water collection. Some group of water tanker drivers avoid buying water from such hydrants in order to maximize profit. They go to the nearby streams to refill their tankers, this case was seen in Akama Ohe, with contaminated river Kalawa serving such tanker drivers.

The water tanker drivers carry their water from one community to the other with their lorries to sell to their customers. Evidence of this is seen in Akama Oghe community, where the streets are normally lined with buckets, cans, and drums in readiness for water tankers. These water tanker drivers make as many as three trips in a day, on the average most of them make two trips per day. They all belong to a Water Tanker Union, that does not determine nor influence the prices at which water is sold.

The cost of a drum full (i.e 215 litres) of water varies from one study community to another. This cost is usually influenced by the distance of a community

to a water hydrant where the tanker drivers go to refill. In Obe, a drum of water costs ₦40 during the dry season, a 500 gallon tank (i.e 2,250 litres) cost as much as ₦350 to fill within the same period, and within the same dry season a 1000 gallon tank (i.e 4,500 litres) cost ₦500 to fill up. For Akama Oghe community, a drum (i.e 215 litres) of water cost ₦25 during the dry season. A drumfull of water during the dry season at Iheaka community costs ₦30 to fill up, while a 500 gallon (i.e 2,250 litres) tank cost ₦250 within the same period.

The demand on water tankers is usually highest during the dryseasons. At times, water tanker drivers do suffer the problem of water purchase, and this is when there is a major pipeburst at the water hydrants due to high hydraulic pressures on pipes or breakdown of pumping machines. Other major set backs experienced by these water tanker drivers is glut in the market or sales during the rainy season, breakdown of water tanker lorry, burst tyres, high cost of fuel and oil. For water tanker drivers that refill at Nvene Spring, Udi, when the

rains descend during rainy season and renders the only access road slippery (as it is on a slope), they turn to other water sources for water collection.

2.3.2 Water Vendors

Water vendors are those who sell water especially in small units, smaller than what is obtainable from water tanker drivers. The chain is such that, water tanker drivers sell water to water vendors who inturn sell to consumers.

Of the six communities for this study, water from vendors as a source of water supply is common only to the people of Iheaka community. This is largely because there exists no surface stream in the community, such that during dry seasons when there is no raincatch, the people resort to buying water. Most of the rural dwellers of Iheaka community are low income earners, who cannot afford to purchase water in drumfulls, and need to buy in bucketfulls which they can afford, this results in some members of the community water vending to satisfy this lot.

Not all water vendors buy water from water tankers, some possess private boreholes from which they sell water to those who want to buy. There are some water vendors who neither buy water from water tankers to resell, nor do they possess a private borehole, they own storage tanks or plastered dug pits from which they sell water to the people. A bucket of water sold by some water vendors in Iheaka community costs as much as ₦2.50 as at March, 1994, while a drum costs as much as ₦30 at the same period. Half drums (107.5 litres) are sold at ₦15 each, while a gallon (4.5 litres) of water is ₦1 (march, 1994). Cost of water in the rainy seasons differs from the cost in the dry season.

An obvious problem associated with water vending is the high prices at which water is usually sold, and the fact that the purity of the water cannot be guaranteed.

2.4 Summary of Sources of Water Supply

The major source of water supply in the study communities comes from rainfall, while the least used water source to them is that from water vendors.

TABLE 6: The Pattern of Patronage of Sources of Water Supply

Community	Water Tanker	Water Vendor	Bore-hole	Well	Rain-catch	Stream	Pond	Spring
Obe	14	0	0	25	35	9	0	23
Akama Oghe	42	0	25	0	35	21	0	0
Adaba	0	0	0	0	41	24	0	45
Iheaka	24	16	0	0	38	0	22	0
Ndi Offia	0	0	0	32	27	14	33	0
Eka Awoke	0	0	45	12	25	12	9	0
Total	80	16	70	69	201	80	64	68
Percentage	12.4	2.5	10.8	10.6	31.0	12.3	9.9	10.5

(Source: Fieldwork, 1994)

From table 6, the most commonly used water source is raincatch, followed by stream and water tanker, closely followed by water from borehole. From Table 6, it is equally evident that everyone of the study communities makes use of water from raincatch. No other water source is common to all six study communities.

Only three communities use ponds these are Iheaka, Ndi Offia and Eka Awoke, while two communities only, Obe and Adaba use spring as water sources. Streams are used by Obe, Akama Oghe, Adaba, Ndi Offia and Eka Awoke, whereas wells are used in Obe, Ndi Offia and Eka Awoke. Boreholes exist in only two communities Akama Oghe and Eka Awoke, while water vendor as a water source is in only Iheaka community. Obe, Akama Oghe and Iheaka employ the use of water tankers. This is clearly indicated in Table 6.

Two of the six study communities can boast of five water sources. These communities are Obe and Eka Awoke. As can be seen in Table 6, the five water sources for Obe are stream, spring, raincatch, well and water tankers, whereas those for Eka Awoke are stream, raincatch, bofe-hole, wells and ponds. Other study communities have less

number of water sources. Ndi Offia, Iheaka and Akama Oghe have four, while Adaba community has the least, three.

Adaba community with the least number of water sources seems to be the only community with nearly one natural water source in each ward within the community. That is basically why rural dwellers of this community do not bother with buying water, even though the access road to Adaba is bad and dusty, and not one to encourage tanker drivers to come and sell water in such an area.

Obe community has its water sources as stream, spring, raincatch, well, and water tanker, no other study community has exactly the same water sources. It only has spring as a source of water supply, in common with Adaba community, while it has well in common with Ndi Offia community and Eka Awoke community. Obe people have relatively enough natural water sources available to them, that they do not have to use ponds, however they lack borehole.

Adaba community possesses springs and streams as water sources whereas Iheaka does not (Table 6). Iheaka people use water from ponds and Adaba people do not. Ndi

Offia and Eka Awoke communities possess wells, which are non-existent in Iheaka and Adaba Communities probably due to the geology of these two areas.

For Enugu State this research reveals that, on the average every community within Enugu State uses raincatch as a water supply source. And that wells exist for most communities which are not underlained by the false bedded sanstones, for such areas have high infiltration and also a water table too far to strike by well diggers.

Generally, it can be assumed also that communities t that exist within the Abakaliki area employ the use of ponds as a water source, as areas adjacent to most influent streams of the Abonyi River have ephemeral stream. Other conclusions drawn are, commercially procured water as a source of water supply generally seem to be embraced by people in some rural communities of Enugu State, especially those around the Enugu and Nsukka areas. This is because the roads here are fairly motorable unlike the roads found in the Abakaliki area.

Many rural communities within Enugu State are without pipeborne water supply, from results of these field studies.

CHAPTER 3

ASSESSMENT OF WATER DEMAND IN THE AREA

In this chapter, we examine the quantities of water demanded by the various sectors of the six study communities, as well as the quantities consumed.

The terms "water demand" and "consumption" used in this study are defined in section 3.1.

3.1: The Demand for Water In Rural Areas.

There is a correlation between the demand for water in rural areas and the level of development of the country/region in which the rural areas are located. The demand for water in the rural areas of the developed nations is high, nearly equalling that of their urban areas. Whereas the demand for water in the rural areas of developing countries is very low.

According to white (1977), the volume of water used in the developing nation ranges from a daily mean consumption per persom of a little over a litre to about 25 litres for rural consumers without tap connections and standpipes. Many investigators have suggested that the absolute minimum water consumption

when water is supplied by public standpipes set in streets is 23 litres per head per day (Katzmann, 1977). Cembrowicz (1982), In his study of rural Togo, came up with findings which showed that consumption from standpipes could be as high as 50 - 60 litres per person per day.

The following researchers, Teller (1963), white, Bradley, and white (1972), Feachem (1973), Frankel and shouvana-virakul (1973), Warner (1973) and white (1977) found that, for village dwellers who use public standpipes, the consumption is about 10 - 50 litres per person daily, and 15 - 90 litres for those with only a single tap in the household. The larger the household, the smaller the per capita water use daily (Teller, 1963; Lee, 1969; and white et. al, 1972).

Frankel and shouvanavirakul (1973) found the range of consumptive figures used for design purposes to be 50 - 80 litres per capita daily. Actual use he found to vary from 9.6 - 36.8 lpcd at standpipes, and 24.4 - 65.2 lpcd for house connections. This led him to believe that design figures of 25 lpcd for standpipes and 50 lpcd for house connections would be more rea-

listic.

In the rural areas of Nigeria (Uzuakoli Village; Bende L.G.A., Igbo - Eze L.G.A., Ikwo L.G.A., Isiala - Ngwa L.G.A., Ikeduru District, Nnobi Village; Idemili L.G.A.), the volume of water used ranges from a mean per capita water consumption per person per day of 20 lpcd (lites per capita per day) to 42 lpcd (litres per capita per day) (Ugwu, 1989; Emenyonu, 1981; Ezeonu 1983; Ifeabunike, 1983; Kanu, 1983; Onyegbula, 1983; and Obi 1984).

Water demand depends on a number of factors. These factors are, size and nature of the population, level of education, social and religious philosophy, income, climate, water use habits, number of public standpipes, accessibility of the supply, household size and level of economic development (Shipman, 1967; Twort, Hoather, and Law, 1974; Danielson, 1979; Akintola and Areola, 1980; and Ayoade, 1984). Factors that affect water demand also affect the consumption pattern, thus their interchangeable use (Chima, 1989).

For this research, water demand is the actual amount of water needed by the people for their activities (domestic, industrial or commercial). Whereas consumption is actual amount of water supplied, since all the water supplied is in one way or the other consumed.

3.2: Domestic Water Demand and Consumption:

3.2.1: The Domestic Water Demand:

For the various household activities, the mean household domestic water demand for the six study communities is found to be 181 litres per household per day (lpd), this figure is obtained from questionnaire samples. The mean daily domestic per capita demand of water was found to be 26.5 litres per person per day (lpd) with a standard deviation of 12.1 lpd. To enable us know the quantity of water demanded by the people for this research, the respondents had to estimate their household domestic water demand in standard buckets (standard organisation of Nigeria (SON) size 30). And one standard bucket (SON) size 30) has a capacity of 12 litres. And standard drums

(SON) medium size), with a capacity of 115 litres for medium size drum. Results of the conversion is presented in table 7.

From Table 7, the mean domestic water demand for Obe was seen to be the highest with 350 litres per household per day (lpd), whereas that of Eka Awoke with a mean per household water demand of 117 lhd is the least. Thus, the range of the mean domestic water demand for the study communities is 233 litres, and the standard deviation is 85.8 lhd.

The mean domestic demand per household is similar from one community to another except for Obe community which is relatively too high and Eka Awoke community which is relatively too low (Table 7). The study communities have people with one culture and tradition, similar habits and similar water needs for residential purposes, this explains the reason why the mean domestic water demand per household in Akama Ogbe, Adaba, Iheaka and Ndi Offia are similar.

The mean daily domestic per capita water demand to the nearest litre in each of the six study communities (column three of Table 7), were obtained by dividing the mean number of persons per household.

TABLE 7: The Mean Household Domestic Water Demand In Study Communities

Community	Mean Demand per Household per Day (litres)	Mean per Capita Demand per Day (litres)
Obe	350	50.0
Akama Ogbe	161	26.8
Adaban	144	20.6
Iheakafia	180	25.7
Ndi Offia	132	16.5
Eka Awoke	117	19.5
Median	152.5	23.2
Mean	181	26.5
Standard Deviation	85.8	12.1

(Source: Fieldwork, 1994)

From this column, the highest mean daily domestic per capita water demand of 50 lpd was found in Obe community. Ndi Offia community had the lowest with 16.5 lpd.

From Table 7, it can be seen that low figures exist for the per capita water demand, found in all

the six study communities, except for Obe community which has a relatively higher figure when compared to the others.

This low per capita water demand amount found in the following communities, Adaba, Iheaka, Akama Ogbe, Ndi Offia and Eka Awoke may be due to no other reason than these factors: relative poverty of people living in the area, water supply shortages (from fewness in the number of water sources available), and absence of water consuming appliances by the households. Usually it is the norm in the face of a acute water supply shortages, for the people to lower their quantity of water demand, generally because they have got accostumed to low water use, and cannot imagine themselves demanding any quantity more than twice or at the most thrice of what they consume daily even in the face of adequate water supply. And what explains the relatively big difference or rather gap between Obe community per capita domestic water demand and other study communities' domestic water demand (Table 7) is the slightly higher socio-economic status of the people, their closeness to Enugu Urban area, the presence of more intense commercial activities, and

the presence of more infrastructures (in comparison with other study communities). It is these above listed factors that are responsible for the slightly higher per capita domestic water demand figure we have for Obe (Table 7) during the fieldwork.

3.2.2: The Domestic Water Consumption:

Our fieldwork and questionnaire responses revealed thatt the average number of persons perhousehold differs from community to community from Table 8 for instance, while Ndi Offia has an average size of households of 8 persons, the Akama Ogbe community has an average household size of 6 persons. Mean number of persons in a household is found by dividing the sum of the average number of people in a household in each sampled community by the total number of communities sampled for this research, this value is 7 (Table 8).

Generally, the average size of households for the study communities was found to be 7 persons, as stated above. The average household per capita water consumption in the study communities was found to be 15.3 lhd (litres per head per day), while the mean consumption per household per day is 104.3 litres (Table 8).

The amount of domestic water consumed per household per day is dependent upon, the total amount of water fetched for that day by members of the household, the adequacy of water storage facilities as well as the long distance to the various water sources. The mean household domestic water consumption figures (Table 8) for the various household activities for the study communities were obtained from the questionnaire samples. The mean consumption per household 104.3 litres, was found by dividing the actual mean amount of water consumed in a household in each sampled community by the member of communities sampled for the entire researtch.

The estimation of their domestic water consumptions in standard buckets (SON, size 30), as was the case in sub-section 3.2.1, the buckets of water consumed were converted to litres as presented in Table 8.

From Table 8, the mean per household water consumption for Obe (163 litres). Adaba (114 litres) and Iheaka (101 litres) are the highest, while Ndi Offia

(80 litres), Eka Awoke (84 litres) and Akama Ogbe (84 litres) are the lowest. To get figures of the mean daily domestic per capita consumption of water to the

TABLE 8: The Mean Daily Domestic Household water Consumption Pattern in the Study Communities.

Community	Mean Number of Persons in a Household.	Mean Consumption per Household per day (litres)	Mean per Capita Consumption per day (litres)
Ogbe	7	163	23.3
Akama Ogbe	6	84	14.0
Adaba	7	114	16.3
Iheaka	7	101	14.4
Ndi Offia	8	80	10.0
Eka Awoke	6	84	14.0
Median	7	92.5	14.2
Mean	7	104.3	15.3
Standard Deviation	0.75	31.5	4.4

(Source: Fieldwork, 1994)

nearest litre in each community of the six study communities, we had to divide the mean consumption per

household by the mean number of persons per household. These figures can be seen in the fourth column of Table 8. From this column, the mean daily domestic per capita consumption of water appear to be generally very low in all the communities. The highest consumption is 23.3 litres per person per day (lpd) in Obe, the smallest mean daily domestic per capita consumption of 10.0 lpd is recorded in Ndi Offia.

Areas with relatively high mean per capita consumption, Obe and Adaba correspond with areas having or lying near surface streams and springs. In the case of Obe community, the relatively high mean per capita consumption is also due to the influence of the Enugu Urban centre's closeness to it (sub section 3.2.1 for the other causative factors). This actually accounts for the relative high mean per capita consumption of 23.3 lpd (Table 8). In the case of Ndi Offia with the least mean per capita consumption of 10.0 lpd, the area does not have a permanent stream, it lacks springs and does not possess a borehole. These discrepancies in the mean per capita consumption of water in the study communities result to high range of 13.3 lpd (that

is the highest lpd minus the lowest) with a standard deviation of 4.4 lpd as shown in Table 8.

In summary, the average household per capita water demand in the six study communities was found to be 26.5 litres per head per day (lhd), while the average water consumption (supply) was found to be 15.3 lhd. This leaves an average total deficiency of 11.2 i.e 26.5 minus 15.3 between per capita amount of waterd emand and per capita amount of water supply.

From Table 9, Adaba is seen to be the least water deficient community, with a mean per capita water supply over demand of 79.1%. It is closely followed by Eka Awoke, with 71.8%. In Obe, the mean per capita water supply over demand is only 46.6%. The position of the other communities is Akama Oghe (52.2%), Iheaka (56.0% and Ndi Offia (60.6%).

Water consumption by the residential sector of the study communities is not only a function of the total number of households as well as the adequacy of water supply sources. The high percentage figures that exist as the adequacy of water

TABLE 9: A summary of average per capita water need (demand) and consumption (supply), for the six study communities.

Community	Average per capita water demand per day (litres)	Average per capita water consumption per day (litres)	% Demand satisfied by supply
Obe	50.0	23.3	46.6
Akama Oghe	26.8	14.0	52.2
Adaba	20.6	16.3	79.1
Iheaka	25.7	14.4	56.0
Ndi Offia	16.5	10.0	60.6
Eka Awoke	19.5	14.0	71.8

supply sources. The high percentage figures that exist for Adaba community and Eka Awoke community (in column four of Table 9) is as a result of the abundant natural water supply sources found in Adaba which are permanent in nature and the presence of a constant flowing borehole found in Eka Awoke, which is in use all year round. These have gone a long way in helping the people to meet their water demands. Thus the low margin of water deficiency seen in the above two communities.

One remarkable feature of the residential/

domestic water consumption that has been portrayed by our examination of the per capita water consumption is that the water consumption of the six communities, Obe, Akama Oghe, Iheaka, Adaba, Ndi Offia and Eka Awoke were extremely below the Federal Government recommended minimum standard of 115 litres per head. The above observation is remarkable, in that it reveals that these study areas suffer from a certain measure of water inadequacy. And thus need more water supply else they will perpetually be prone to health hazards and other negative socio-economic effects of water inadequacy (see page 1, paragraph 3).

3.3 Commercial, Services, and Industrial ~~trial~~ water demand and consumption.

3.3.1 Commercial Water demand and consumption.

The commercial sector in the study communities include commercial ventures such as restaurants, bars/beer palours, hair dressing salons, chemists, barbing salons and grinding mills. Most of these operate at very small scale.

A commercial venture for the purpose of this

study, is regarded as a lock-up store or business premises where buying and selling is engaged in, or where services are rendered for some amount of money. For example, a restaurant is defined as a place which has provision for eating, while beer palours or bars have provision for drinking. The total number of commercial ventures for each community in this research, were put at 16 for Obe, 21 for Akama Oghe, 22 for Adaba, 23 for Iheaka, Eka Awoke (fieldwork, 1994). See Appendix B for details of these commercial ventures, and their total number for all the six study communities.

Of the 91 commercial centres in the six study communities, a total of 2 commercial centres per community were randomly selected. Table 10 shows that Iheaka had the highest number of commercial establishments (23), followed by Adaba (22), while Ndi Offia community has the least number of 2. The size of the commercial establishment is defined in terms of the number of people who come to pay for commodity/services in that place daily.

Table 10 shows the total water demand and supply in commercial establishments in study

TABLE 10: Distribution of Commercial water demand and consumption in study communities (litres per day).

Community	Number of Commercial ventures in the study community	Mean Commercial water demand per commercial venture per day (litres)	Mean commercial water consumption per commercial venture per day (litres)	Difference	% of demand satisfied By supply
Obe	16	149.5	83.8	65.7	56.0
Akama Oghe	21	251.0	125.5	125.5	50.0
Adaba	22	113.8	84.0	29.8	73.8
Iheaka	23	352.5	167.3	185.2	47.5
Ndi Offia	2	18.0	6.0	12.0	33.3
Eka Awoke	7	108.0	72.0	36.0	66.7
Median	18.5	131.7	83.9	47.6	53.0
Mean	15.2	165.5	89.8	75.7	54.6
Total	91	19,066.1	10,188.2	8,877.9	53.4

communities. From the table it, could be seen that Ndi Offia, with (33.3%), recorded the least percentage of water demand satisfied by supply.

In terms of the mean water demand per commercial establishment, the Iheaka community ranks the highest with 352.5 litres per commercial venture per day (lcvpd), while Ndi Offia community has the lowest water demand at 18 lcvpd. This shows a demand range of 334.5 litres among the communities. The reason for this obvious high demand range could be as a result of the differences in sizes and number of commercial establishments which require that they demand water differently.

Generally, the total commercial water demand for the study communities is 19,066.1 litres as against the total water consumption 10,188.2 (lcvpd). This shows a total water deficiency of 8,877.9 (lcvpd) representing a percentage deficiency of 46.6%, and showing that the percentage of water demand satisfied by water supply is 53.4%.

The community with the least percentage of demand satisfied by supply was Ndi Offia (33.3%). Table 10 shows that Iheaka had the highest water deficiency of 185.2 ld, while Ndi Offia had the least with 12.0 ld.

This shows a deficiency of about 173.21d among the study communities. This high deficiency range shows the degree of differences or spatial variation that is found among the study communities.

3.3.2 Service Water demand and Consumption.

Service water demand and consumption includes all water used or needed by the service sector which within the study communities. Within the six study communities, the services sector include hospitals, maternity homes, primary schools, and secondary schools as well as health centres.

The total number of service establishments for each community are shown in Table 11. While details of these service establishments, and their total number for all the six study communities are presented in Appendix 2.

From Table 11, it can be seen that Iheaka has the highest number of service establishments (8), while Ndi Offia had the least (1).

The total services water demand for the various services activities for the study communities obtained from the questionnaire samples was found to be 25,491.0 ld. While the mean services water demand

for the six study areas was found to be 620.8 (lpsed). As in section 3.2, the respondents estimated their services water demand in standard buckets (SON, size 30) and in drums (SON medium size). The capacities of the water containers, for size 30 bucket is 12 litres, and for the medium size drum it is 115 litres. It is with these known capacities, therefore, that we did the conversion as presented in Table 11.

From Table II, it can be seen that Iheaka has the highest mean services water demand with 2,150.0 litres per services establishments. The smallest, 54 litres is found in Ndi Offia. The range of mean services water demand is thus 2,096 litres. This high range indicates variations in the amount of water required for services activities in the different communities of the study area and the number of services establishments.

Table II also shows the mean services water consumption for the six study communities, this value i.e. the sum total is 8.047.0 litres. From the table, Obe and Iheaka have the highest mean services water consumption with 567.5 lpsed and

TABLE II: Distribution of services water demand and consumption in study communities (litres per day)

Community	Number of service establishments	Mean services water demand per services per day (litres)	Mean services water consumption per services per day (litres	Difference	% of demand satisfied by supply
Obe	6	1,107.5	567.5	540.0	51.2
Akama Oghe	2	30.0	12.0	18.0	40.0
Adaba	4	275.0	173.0	102.0	62.9
Iheaka	8	2,150.0	472.0	1,678.0	22.0
Ndi Offia	1	54.0	30.0	24.0	55.6
Eka Awoke	4	108.0	30.0	78.0	27.8
Median	4	191.5	101.5	90.0	45.6
Mean	4.2	620.8	214.1	406.7	43.3
Total	25	25,491.0	8,047.0	17,444.0	31.6

472.0 lpsed respectively. While Akama Oghe has the smallest with 12.0 lpsed, followed by Ndi Offia and Eka Awoke, each with 30 lpsed. The range of mean services water consumption for the entire study communities was found to be 555.5 litres. This high range does mark the amount of variation in mean services water consumption activities. This trend is explained by the fact that Obe and Iheaka communities have proximity with two major urban centres Enugu and Nsukka towns, and the socio economic levels of the two towns seem to be rubbing off on these communities. Thus, the large number of services establishment found there, which has in turn increased the quantity of water demanded or consumed by the services establishments. While Ndi Offia and Akama Oghe have one or two services establishments which invariably requires lesser amount of water.

3.3.3. Industrial Water demand and consumption.

The total number of small scale industries in the six study communities are 22. Akama Oghe has the largest number of industries, while Iheaka and Eka Awoke have the least number, 1 (Table 12). In terms of the mean industrial water demand in the study communities, Obe has the largest amount 20,215.0 (lpivd),

TABLE 12: Distribution of Industrial Water demand and consumption in study communities (litres per day).

Community	Number of Industrials concerns in the study areas	Mean industrial water demand per industry per day (litres)	Mean industrial water consumption per industry per day (litres)	Difference	% of demand satisfied by supply
Obe	4	20,215.0	2,107.5	18,107.5	10.4
Akama Oghe	8	3,332.5	2,418.8	913.7	72.6
Adaba	6	322.5	107.5	215.0	33.3
Iheaka	1	430.0	215.0	215.0	50.0
Ndi Offia	2	42.0	42.0	0.0	100.0
Eka Awoke	1	54.0	30.0	24.0	55.6
Median	3	376.3	161.3	215.0	52.8
Mean	3.7	4,066.0	820.1	3,245.9	53.7
Total	22	110,023.0	28,754.4	81,268.6	26.1

while Ndi Offia had the least amount 42.0 lpivd.

One observation is that the amount of water consumed by the communities' industrial water supply are not close to each other because of the variations that exist in the number of industries for each community. For example, while Akama Oghe consumed the highest amount 2418.8 lpivd, the lowest amount 30.0 lpivd is consumed in Eka Awoke community. The difference between the two communities is 2,388.8 litres, this large range indicates that the consumption patterns of these industries in the study communities are not the same.

From Table 12, the total number of industrial water demand was 110,023.0 litres per day, as against the total water consumption of 28,754.4 ld. On the demand and consumption for the communities, Ndi Offia had the highest percentage of demand satisfied by supply (100%), while Obe had the least, which was 10.4%.

3.4: Total Water demand and Consumption from all the sectors in the study communities.

An analysis of water demand and supply was done for all the sectors in the six study communities of Enugu State.

From the analysis it was seen that some communities

demanded and consumed more water than others. Table 13, showed that the estimated total water demand for the study communities is 1,674,790.2 ld as against the estimated total water supply of 912,487.5 ld. This quantity of water supply represents 54.5% of demand in all sectors of the study communities.

Obe xx had the highest water demand of 554,547.0 ld and equally consumed the highest amount of water 229,742.7 ld. Conversely, Eka Awoke (181,656.0 ld) and Ndi Offia (112968.0 ld) demand the least amounts of water daily (Table 13). Obe demanded the highest amount of water mainly because of the block industries that exist in the community which require a lot of water. Eka Awoke and Ndi Offia demanded least quantities of water, because very few industries and commercial establishments exist in these communities.

The poorest performance of water supply over demand was observed in Obe (41.4%). This suggests that the present water supply be stepped up about two and half times to match it's water demand. Following Obe closely, is Iheaka and Akama Oghe with 54.6% meaning also that supply of water had to be increased by two times the present supply to satisfy the present demand needs.

Adaba has its water demands nearly being met by its supply. Adaba with 78.3% of its demand being satisfied by supply just needs a little bit of water supply increase, so also does Eka Awoke with 71.7%. Generally, this study reveals that total demand met by supply is 54.5% This implies that a near equal percentage of demand is not being met by supply, at least by 45.5%. This therefore concludes that the study communities are hampered by water supply shortages. Worst hit communities being Obe, Iheaka and Akama Oghe. All the same there exists no state of emergency in water supply provision for Akama Oghe and Iheaka, which have an average water supply situation of supply balancing demand halfway. The Obe community really has to be handled by a worst - first strategy as the situation of 41.4% of demand being met by supply is low.

From Table 13, it can also be seen that the residential sector has the highest water demand 1,520,210.1 ld, while commercial water demand has the least, 19.066.1 ld. The pattern is not much different in the sectoral water supply. The residential sector has the highest water supply 865,457.9 ld, closely followed by industrial with 28,754.4 ld, while services water supply had the

TABLE 13: Demand and supply of water in all sectors of the study communities.

Community	SECTORAL WATER DEMAND					SECTORAL WAT		
	Residential	Services	Commercial	Industrial	Total	Residential	Services	Commerci
Obe	464,656.0	6,645.0	2,392.0	80,860.0	1,674,790.2	216,526.9	3,405.0	1,380.
Akama Oghe	191,298.4	60.0	5,271.0	26,660.0	223,289.4	99,932.0	24.0	2,635.
Adaba	134,847.6	1,100.0	2,503.6	1,935.0	140,386.2	106,699.8	692.0	1,848.
Iheaka	436,206.1	17,200.0	8,107.5	430.0	461,943.6	244,411.2	3,776.0	3,847.
Ndi Offia	112,794.0	54.0	36.0	84.0	112,968.0	68,360.0	30.0	12.
Eka Awoke	180,414.0	432.0	756.0	54.0	181,656.0	129,528.0	120.0	504.
Mean	253,368.4	4,248.5	3,177.7	18,337.2	279,131.7	144,243.0	1,341.2	1,704.
Total	1,520,210.1	25,491.0	19,066.1	110,023.0	1,674,790.2	865,457.9	8,047.0	10,228.

least, 8,047.0 ld. This signifies spatial variation of water demand and consumption amongst sectors of the study communities, as amongst the study communities too.

3.5 Summary of the demand characteristics of the study communities.

The summary on these, demand and consumption of water by the study communities will be discussed using the Analysis of variance tables (ANOVA tables) below.

Analysis of variance (ANOVA) technique was first discovered by Sir Ronald Fisher in 1923 and it is based on F - distribution. According to Nwabuoke, (1986) the procedure for testing the equality of three or more means, is provided by a statistical technique known as Analysis of variance (ANOVA). Analysis of variance (ANOVA), studies inter-relationships among factors (strivastava and Gnanadesikan, 1971). This analytical tool is used for detailed comparisons and pairwise comparisms. It is also used in the testing of hypotheses concerning population means, it is also used to test differences between variations. Often times it is used to compare and draw conclusions.

Oyeka (1990) defines Analysis of variance as a

technique of partitioning the total variation of data into useful components which provide means of measuring different sources of variation. For the two-way analysis of variance employed in this section, the total variation in the data is split into three, with the following assumptions, equal variances, normality and independence. Analysis of variance (ANOVA) operates under three models, the fixed effect model, the random effect model and the mixed model. The results of the ANOVA technique are usually presented in an ANOVA table.

For this section, an analysis of variance test was performed to find out if there is no significant difference in the water demanded by the people of the six study communities. Table 14 is a summary of the results of the analysis (see Appendix C).

TABLE 14: Analysis of variance of the water demand in the six communities

Source of variation		Degree of Freedom (df)	Sum of squares (SS)	Mean squares (MS)	F-ratio
Between groups	Sectors	3	45325864.63	15108621.54	0.99
	Demand	5	116574774.60	23314954.92	1.53
Within groups		15	228677837.50	15245189.17	-
Total		24	-	-	-

Since the table value 2.90 of the theoretical F5,15 at 95% confidence level is greater than calculated F-value of 1.53, the afore assumption is accepted. Therefore, there are no significant differences between the demand for water among the various study communities. Hence the observed differences among the six means are due to chance variations. This implies that the demand for water in the different study communities are similar. This is likely due to the fact that, the communities have almost the same level of socio-economic rating, poverty, absence of government influence, and they all exist within the same homogenous socio-cultural group. Hence all areas end up demanding nearly the same quantity of water for all their sectors (residential, commercial, service and industrial).

Another analysis of variance test was equally performed, this time to test if there exists no significant differences in the water supplied to the people of the six various study communities. Table 15 is a summary table, showing the results of the second analysis.

Since the table value 2.90 of the theoretical F5,15 at 95% confidence level is less than the calculated F - value of 3.58, we then reject the afore assumption. Therefore there are significant differences between

the supply of water among the various study communities. Hence, the indication is that the supply of water in the different study communities are not similar. Reasons likely to be responsible for these differences are, unequal distribution of sources of water supply. Adaba for instance has seven springs as well as streams, whereas Iheaka neither has a stream nor a spring. Meanwhile the entire population of Iheaka is larger.

TABLE 15: Analysis of Variance of the Water Supply in the six communities.

Source of Variation		Degrees of Freedom (df)	Sum of Squares (SS)	Mean Squares (MS)	F-ratio
Between groups	Sectors	3	598808.12	199601.70	0.77
	Supply	5	4599628.01	918725.60	3.58
Within groups		15	3854354.29	256956.95	-
Total		24	-	-	-

Other factors could be the number of people in each household for each study community, seasonality of rainfall/ephemeral streams, non-functional boreholes in some communities, literacy/awareness level of the rural dwellers in the different communities, accessibility of the various sources of water supply, level of development, geology of the area, distance to water sources and adequacy of water storage facilities per

community. These afore-mentioned causal factors, are reasons responsible for the variation seen, by all study communities not consuming the same or nearly the same quantity of water. For instance Obe consumes the highest with 2,782.1 litres mean figure, while the next highest is by Akama Oghe, and this is 2,570.3 litres mean figure and then the lowest consumption is 88 litres mean figure by Ndi Offia.

CHAPTER 4

WATER SUPPLY IMPROVEMENT MEASURES USED IN THE AREA

4.1 Water Supply Improvement Measures Used In Rural Areas:

There exists in rural areas of the world and developing countries in particular, simple water development improvement measures for improving water supplies. These strategies are highly successful in the face of ensured efficiency.

Presently for most rural communities in developing and developed nations according to (Wolman,1969), the demand for water often times does exceed the supply thus creating a situation of perpetual water deficiency. It is only with the adoption of a good strategy on water resource management for rural water supply that water problem can come to an end.

According to Obeng (1982), some water programmes in developing countries have yielded satisfactory results. There are the water programmes of UNICEF in Bangladesh and the effort of the Malawi government,

where handpumps are attached to boreholes and water wells, to reduce the energy expended by the people in drawing water. Jong and Hoekes (1986) also found that handpumps were being extensively used in Malawi, Sudan and Zambia.

Rural Bangladesh, uses locally made handpumps (Aziz, Hoque, Huttly, Minnatullah, Hasan, Patwary, Rahaman and cairncross; 1990). The type of handpump commonly used in Bangladesh is capable of drawing water from a depth greater than 8 metres, it is known as the Tara pump. According to Aziz et al (1990), these are installed on tubewells sunk using the ingenious "sludger" method. This method employs no sophisticated equipment or machinery. In rural Bangladesh, one public handpump is available for every 125 rural inhabitants.

The Mark Yand the Madzi is used by rural Malawi, white Blair and Nsimbi handpumps are commonly used in Zimbabwe, Ethiopia uses the Ethiopia EP50 handpump (Morgan, 1990). Other handpumps extensively used by the rural communities of

developing countries is India Mark II in India, Afridev in Kenya and Abi Vergnet in Cote D'Voire.

The handpump strategy for rural Zimbabwe seems to be more popular, for it is cheapest and simplest to repair and maintain. As a matter of fact the Blair and Nsimbi handpumps have been adapted for the range of conditions normally found in the communal lands (Morgan, 1990). The handpump strategy however has its disadvantage, in that villagers upon fighting at water points for water damage these handpumps. However, without maintenance the pumps can fail too, and remain out of order for months. It is therefore the maintenance system, rather than the pump itself which determines whether a handpump programme will be successful in the long term.

In rural Guatemala, the dominant strategy for water supply is by gravity flow. The water source, a spring exists on a higher elevation than the town, steelpipes are used to transport this water from that height to a distribution tank. From the tank, the distribution network carries this water to the public taps (Annis and Cox, 1982).

It is an inexpensive technology, quite ideal for the developing nations. In Manica - land District of Zimbabwe, for instance, many hundreds of small springs have been protected in the hills, the water collected being piped to communal standposts within a village (Morgan, 1990).
Gravity system of supplying water should be used, it is the most reliable means of providing water to the people in the long term.

Large storage tanks/reservoirs centrally located is a good strategy, which if protected from evaporation losses would reduce the water problems in rural communities. This is being practised in Australian rural areas (Glennie, 1983). There monomolecular film, floating covers and gloating granular materials are measures being employed to suppress evaporation from the storage tanks. For our rural areas in Nigeria, this method is far too expensive.

Some schemes are achieved through community participation, and most of them have recorded huge successes (Schultzberg, 1978; Falkenmeark, 1982). For in Malawi's gravity fed water system, this

singular event of community partcipation has aided its success. Other success cases are those of Thailand and the Tanzania's country - wide villagization programme which developed the Ujamaa - concept (Bourne, 1982; and Falkenmark, 1982).

The use of boreholes and tubewells is a good water supply improvement measure, this involves the tapping of groundwater resources. The use of this strategy in Yatenga area of Burkina Faso was mentioned by Eggers (1986) in his study, also mentioned in his study is the Mali Aqua Viva's plan to provide its villages with boreholes. Success ratios of boreholes however are interlinked with geology of the area (Azeez, 1972).

At the local level, Bangladesh has one of the most ambitious and successful rural water supply programs in the World. More than half a million public tubewells are installed and functioning (Aziz, Hoque, Huttly, Minnatullah, Hasan, Patwary, Rahaman and Cairncross, 1990). Shallow wells too are in use, Morgan (1990) maintained in his study that shallow wells are used by more people than any

other single source of water in rural Zimbabwe, these wells are usually not more than 15 metres deep.

Collin (1986), in a water supply study of rural Burkina Faso was able to identify a supply strategy. For the rural communities small hill dams and lakes were being built to supplement other exixting local sources of supply present in the area. This strategy involves effective tapping of surface water sources, especially for areas with rivers that possess dam sites. There are examples of where small mountain streams have been dammed in rural Zimbabwe, and the water collected in this way has been piped to supply the rural dwellers (Morgan, 1990).

For some rural areas, long term policies/cum planning strategies are employed. In rural Tanzania, the "growth point" strategy is a common strategy being adapted by the government to resolve water problems (Falken-mark, 1982). This involves supplying areas where economic activities are densest, first before spreading to other areas. In rural Brazil, the government has incorporated the manpower training strategy into the policies of their water

resource management. According to Falkenmark (1982), five years ago Brazil set the training of 60,000 people in six years as a national priority in order to bring water supply service to 60% of its rural population.

Another technique of water supply development, is that of recycling of renovated sewage effluent from households and farmlands, this strategy has gained popularity in all parts of Isreal and Namibia (Johnston, 1971). It is actually one technique though, that has not gained popularity yet in most parts of the world.

4.2 Existing Water Supply Improvement Measures For Water Development In The Study Communities.

Information on existing water supply improvement measures for the six study communities were obtained from using questionnaires, interviews and field observations, our respondents being community leaders (who are knowledgeable in rural water supply development in their communities), the rural dwellers and zonal managers of the Enugu State water board.

From the previous chapters, it is obvious that the six study communities have inadequate water supply. In a bid to solve this problem, various improvement measures or strategies have been made available by the government and the people to provide water. In this context, for this research, water supply improvement measures imply the various methods or strategies employed or to be employed in the different study communities to alleviate the problem of water supply shortages. Already existing in the study communities are three strategies (fieldwork), and a discussion of these can be seen below.

4.2.1 Government Participation

Government Participation is felt in only three out of the six study communities. There are only three rural water works in the entire study communities. The only one being controlled by the Enugu State Water Board, is the Akama Oghe borehole Scheme. The hand pump operated scheme in Eka Aweke, though funded by the former Anambra State government, is

presently being controlled by WATSAN, a governmental agency under the Enugu State Ministry of Health. WATSAN is, water and Sanitation Programmes.

Iheaka borehole is being funded jointly by the people and the African Development Bank (ADB), though uncommissioned as of March, 1994. After its commissioning all its activities would be handed over to the Enugu State Water Board. They would inturn oversee the activities of this borehole. Thus, these rural water works get their water from their respective boreholes. The underlying improvement measure here, is that based on the exploitation of groundwater resources in the development of the various communities water sypplies.

This strategy does not involve the treatment of water from the boreholes, before they are distributed to the consumers. Distribution network exists only in Akama Oghe community. The borehole in Eka Awoke lacks distribution network, it is a hand pump-operated borehole so the people trek from various corners of the community to the borehole site to fetch water.

The laying of pipelines for the distribution network of Iheaka borehole is still currently being carried out (fieldwork, 1994).

Most of these government aided improvement measures existing in the study communities, are most or less redundant. Iheaka people cannot experience relief from their water supply problems until the borehole yet to be commissioned starts functioning. While the borehole at Akama Oghe is hardly functional, its high level service reservoir stands as a monumental white elephant structure. All the same, the WATSAN (water and sanitation programmes) operated handpump borehole in Eka Awoke community has helped to minimise (though to a little extent) the problem of rural water supply in this community.

4.2.2 Community Participation

Some communities have on their own made great efforts towards their water development and maintenance. Akama Oghe and Iheaka are two of such communities.

Iheaka has twice undertaken annual fund raising ceremonies for water supply improvement. Here, the rural dwellers, with their sons and daughters that are non-residents of the community contribute what they can. Thus, it is not the levy type of contribution, rather it is giving out of ones free will no mateer the amount. However, in Akama Ogbe the fundraising was different. The people of Akama Ogbe quanterly (in every year) pay levies towards funding their water scheme, every taxable male adult or female adult, married men and women are levied a fixed sum of money on a proprotional basis. For instance, in Akama Ogbe community, the men paid ₦50 while the women paid ₦40 in 1993. Members of the community whether resident or non-resident in the community usually pay the levy.

Generally, large sums of money are realised by both methods of community projects fund-raising. For instance Iheaka realized ₦300,000 in 1993, while Akama Ogbe community realized between ₦50,000 and ₦100,000 in the same year.

By both communities the main choice of water supply improvement measure advocated for has been to exploit ground-water using borehole and then piping the water to different parts of the community as well as increasing the number of standpipes as many as possible so as to serve all.

None of the study communities had its members contributing labour for a water project except for Akama Oghe. In the course of laying the pipelines for their water scheme, their adult males were compelled by the community head to volunteer themselves to supply labour for digging trenches.

An observation worthy of mentioning, is the fact that most attempts by the rural dwellers to improve their water supply have remained in the planning stage, this can be said of Adaba, Obe and Ndi Offia communities. In Obe, an attempt at a water supply project was aborted, as the already contrubuted money was embezzled by some members of the planning committee.

Another community contributory effort, are the central ponds dug by the Ndi Offia community in three

strategic locations within the community. These ponds are quite large, about seven metres deep. Periodically, these ponds are cleaned and re-dug in readiness for another year's rainy season.

4.2.3 Individual Participation.

Individual efforts at harvesting rainwater for storage abound, and this can be termed individual participation, and is part of the existing water improvement measures for this study. Some individuals possess underground concrete tanks, plastered dug pits, metal tanks and drums, which is filled up during rainfall for storage through the method of channelisation from corrugated zinc roofs (section 2.1.4). This collected rainwater is used for domestic and non-domestic activities.

It is common place in Obe and Ndi Offia for well-to-do members of the community to construct wells for private use. Some neighbours of these well owners benefit too, by going to fetch water in those compounds with wells. This has aided the reduction of water supply shortages in some communities.

4.3: Analysis Of Those Water Supply Improvement Measures Existing For Each Study Community.

The most important thing about a rural water supply scheme or improvement measure is its reliability. An analysis of existing water supply improvement measures will enable us adequately assess those improvement measures currently available in the study communities, to find out if they are actually arresting the water needs of the people.

In some communities that can boast of rural water works, there is no fixed distance for the installation of public stamdpipes. The standpipes are located in a scattered manner, over the entire community. The resultant effect is that a considerable number of the rural dwellers will still be trekking daily for distances up to 3 kilometres in order to fetch water from the nearest public standpipe. In Akama Oghe, public standpipes are located in their present sites using the population concentration approach, where the densest locations within the community are given a standpipe or two as against the low density-areas (Eze, 1994).

4.3.1 The number of Communities served with boreholes:

Out of our six study communities three possess boreholes while the other three do not. Out of these three communities only one can boast of an efficient delivery of water to the people. One is hardly functional, while the third one is yet to be commissioned This indicates a lag of functional schemes over non-functional ones.

The Akama Oghe rural water works distributes water through 20 public stand pipes situated in various parts of the community. This scheme when functional should supply water to the people five to six hours daily and for six days a week. These rural dwellers in Akama Oghe therefore face serious water shortages presently as the scheme is hardly functional now.

Eka Awoke hand pump operated borehole does not have a distribution network, hence no stand pipes. The people of this community usually trek an average distance of 6 km daily to this community borehole water source to fetch water. Though with constant flow, a lot of energy is expended in trekking to the source and back.

4.3.2 Problems associated with the boreholes:

The number of existing boreholes within the study communities is highly insufficient. This is only in two out of the six study communities. Boreholes being non-functional or faulty for several months is indeed a problem. The high level service reservoirs now exist as monumental structures beautifying the scenery.

The Akama Oghe borehole suffers from lack of trained personnel to operate and maintain the scheme. Quarterly, money is contributed by the rural dwellers of this community to purchase fuel for the operation of the borehole. Most often this money is inadequate, thus the issue of inadequate fuelling of pumping plants, which leaves the people with the water scarcity situation unchanged. At times, the pumping plant experiences breakdown and canibalising of its parts by thieves.

The public standpipes in Akama Oghe, 20 in number are insufficient for a community that has a population of 7,138 (1992 Population Estimate). As a result of administrative bureaucracy and inefficiency of the workers/personnel of the State Water Board, the people of Akama Oghe are left to fund the operation and

maintenance of their water scheme themselves, which should not be.

Corruption is a factor that has rendered the borehole scheme at Akama Oghe barely functional. Series of cases are pointers to the fact that water tanker operators and vendors bribe borehole operators to abscond from their duty posts, and not pump-water, to enable their water businesses thrive (Eze, 1994).

Eka Awoke borehole lacks distribution network and storage tanks. Due to the absence of distribution system/standpipes in this community the people trek long distances daily to the handpump operated borehole located east of the community. The fear of damage to this particular handpump serving the entire Eka Awoke with 9,252 people (1992 Population Estimate), will be reduced if enough standposts or handpump operated boreholes are provided. Distance and time spent at the handpump borehole will be reduced greatly.

If ever Eka Awoke community decides to embark on the provision of a distribution network, they would be frustrated by unfavourable topography. The relief of the area is too level, that gravity cannot be employed to aid water distribution. While the reason for the absence of borehole and government wells in Adaba, Obe

and Ndi Offia, is that the people have no governmental support that would enable them develop their supplies. And since they lack adequate community participation to develop and maintain a water supply scheme, they are left with none. Obe community which made an attempt at providing a scheme for itself, could not succeed as a result of misappropriation of community funds meant for the water supply project.

4.3.3 Problems associated with the other existing improvement measures:

Communities with individuals who participate towards water development improvement measures by harvesting rain water are usually faced with a problem of rainfall seasonality. Most of these rural dwellers, because they are often riddled with poverty, can only afford small unit containers such as pots with which to store water, and the number of these pots are usually inadequate. Since they cannot store large quantities of water, by the time the dry season advances into its second month, all they have stored would have finished. This exposes the futility of rain water harvesting by the rural dwellers in the study communities.

The central ponds found in Ndi Offia are also beset with the problem of rainfall seasonality. By the time it is the month of December or January, the water

levels of the ponds drop considerably. Often times algae and some aquatic weeds can be seen growing by the sides of the ponds. The people usually have to compete for these water sources with some of the domestic animals such as goats in the community, because they are not fenced. Certain considerations were not even made before the siting of these ponds, for instance taking into account the sanitary conditions of the areas surrounding the ponds, which form the ponds catchment area. These central ponds were not sited on elevated grounds, or away from areas where waste water accumulates, or away from latrines, cattle sheds, and hollows in the ground. Ponds are ditches where runoff water accumulates, the fact that they are highly unsafe for drinking and cooking cannot be overemphasized.

Houses with thatched roofs are prevalent in the following communities, Ndi Offia, Eka Awoke and Adaba. These thatched-roofs are not effective for rainwater harvesting, thus the rural dwellers have their pots set under banana trees or coconut trees for water collection. Others set up their basins and earthen pots in an open field, and the villagers stay in the rains catching as much as they can.

Wells constructed by the individuals for private use, equally suffer from seasonality of rainfall. By the time the dry season sets in the water level of most of the wells fall. Some of the wells even dry up, those that possess shallow depths often do. There are cases where children are seen throwing objects into these wells for the fun of it, while drawing water from them for use.

4.3.4 Results of the Analysis:

From the analysis so far, it is conclusive and acceptable to say that for Akama Oghe Water Supply Scheme, there exists an absence of effective supervision of this scheme by the Water Board. Other conclusions to be drawn as a result of the use of the existing water development improvement measures are, the lack of trained personnel for operation and maintenance of schemes. The absence of storage tanks in some communities, or high tower reservoirs. And for some (high level service tanks) that exist alongside non-functional boreholes, they exist as monumental structures. Lack of spare parts for repairs when pumping plants breakdown at Akama Oghe Rural Water Works and absence of installed fuel tanks for periods of fuel scarcity.

On the part of the rural dwellers themselves, there exists a lukewarm community participation among the members of the community to develop and maintain water supply system. Also witnessed is the misappropriation of community fund meant for operation and maintenance of water schemes. Generally, the paucity of the population of most of the study communities are not favourable to the generation of fund for water project execution and operation, this is true of Ndi Offia, Obe and Adaba communities.

With a per capita water consumption of 14.olpd for Eka Awoke, and 14.olpd for Akama Oghe communities with borehole (see Table II), these figures are too low. In relation to the Federal Government of Nigeria's recommended standard of 115 lpd, it is deficient by about 87.8%. Which shows that the supply from these boreholes hardly even meet water demands of the study communities half way.

The average water collection distance in Akama Oghe is about 2.5 kilometres, while in Eka Awoke it is 6 kilometres, these distances are quite high. For any water development strategy to be effectively felt in any geographical area, water distance must be at its minimal.

For two study communities out of the six study communities for this study to be with boreholes, it signifies a degree of inefficiency in the supply improvement measure being used for rural water development. And of these two communities, only one can boast of a constant flowing borehole, as the other one is hardly functional.

The results of the analysis goes to show that the existing supply improvement measures being used by the government in the areas of study and by the people themselves is highly inefficient as their demands are rarely being met by the supply. Water supply shortages still persist in these communities. This therefore calls for an immediate reappraisal of the existing water development improvement measures in order to meet the present water needs of the people of the study communities.

4.4 The need for alternative water development improvement measures:

Most attempts made by the people and the government to solve the water supply problem appear to be without much success as water supply shortages persist in these areas. Thus the water supply development improvement measures adopted by the people and the government are

failing to meet their expected goals. It becomes pertinent that alternative improvement measures be adopted to improve the prevailing situation.

According to Cairncross (1992), water supply programmes have discovered the need for locally appropriate technology. In her study of Rural Guatemala, for example, the communities were unable to operate and maintain complicated systems with unfamiliar hardware. While for many countries, it has taken several years of experimentation to develop a handpump suitable for local conditions and village level maintenance. Thus it is true that from the experiences of other parts of the world (as in section 4.1), one or more improvement measure options will begin to emerge; construction of a prototype or two, for the use of willing communities, will refine some ideas and eliminate others. An example from the rural water sector is the south coast Handpumps project in Kenya which evolved and grew over several years into the district-wide Kwale projedt (Morgan, 1990).

Certain considerations need be made before the adoption of a strategy that has been used in one or two of the localities with a similar rural water supply problem. These are, the local environmental conditions

of the study area, and the people's actual water needs. They will enable us achieve a balance. Rural water supply has taught us that systems planned without user participation are likely to be inappropriate to users' needs, but this important lesson is yet to be learned by many. It then becomes pertinent that these two parties play their roles, the people themselves and the government of that particular geographical area.

The major strategies highlighted in section 4.1 for the development of rural water supply are, the exploitation of groundwater resources, effective use of surface water sources and the efficient participation of members of the community in water projects. Other strategies are, construction of central storage tanks/ reservoirs, manpower training, recycling of renovated sewage effluent and the "growth point" strategy.

In some of the study communities, the borehole water supply improvement measure is currently in use to tap groundwater resources by the government and the people. Assessing this strategy, it is obvious that it has the advantage of good water quality, thus saves cost. Neither the government nor the people of the six study communities for this research, has made an attempt at

developing their surface water supply. It is surprising that gravity schemes have not played an important role in any of the six study communities especially for communities such as Obe and Adaba that have springs.

The differences that exist in the strategies seen in the study communities and those operative in other rural areas of the developing world, is the lack of effective use of surface water sources development strategy, the absence of the construction of central tanks/reservoirs strategy. Even the community participation strategy is at its minimal in the study communities. There exists several success cases of community participation in the rural areas of other developing countries, as is the case in Malawi, Tanzania and Thailand.

In Eka Awoke community, the decision and implementation of their borehole scheme is by the State Government, while the members of the communities themselves are on-lookers. An area like Akama Oghe community, the problem of community participation is the inability to gather sufficient fund to maintain and operate their water scheme due to the low population figures of this community. And Obe community, where the people have mobilized themselves to provide water

for their community through community effort, failed due to misappropriation of funds.

It is these imbalances found in the already existing water supply improvement measures in some of the study communities, that have necessitated the need for a more appropriate and efficient water supply improvement measure. New alternative improvement measures that will incorporate the people's opinions/ suggestions into that of the government need be mentioned, to arrest the water supply problems of the study communities.

However, it should be noted that any water supply improvement measures chosen and the method by which it is chosen must be suited to the environmental and social conditions in which it is placed. It is the absence of this, that many projects fall short of their stated objectives, without contributing to the improved well-being of the people.

4.5 Alternative Improvement Measures:

In this section, the water development improvement measures considered suitable for the development of water supply in the study communities, will be discussed. Taking into consideration, the environmental conditions of the study communities as well as the water resources available in those areas. Thus, the best water development measure in our opinion, is that which will increase the total volume of water supplied daily and reduce water collection journeys.

Alternative improvement measures to be suggested will be classed under two broad groups. Those that are high valued and those that are low valued. High valued, in the sense that they are of a higher priority need in application. While low valued improvement measures are those that can be remotely applied now or in the near future. Thus, low valued improvement measures are not urgent or immediate water inadequacy arresting strategies, they most likely will span over a long time before actualization.

4.5.1 High Valued Improvement Measures:

These are, the development of surface sources of water supply, the construction and use of deep standard wells and boreholes/handpumps, large scale rain water

harvesting and community participation.

The most elegant method or water development improvement measure is not by pumping or even exploitation of underground water reserves, but by making springs and other surface sources flow under the influence of gravity to the people. The raw water from the available surface water source (rivers, lakes or springs) could be treated and circulated to the community through pipes, this can be applied by any of the five study communities that possess surface water. Hence pipe-borne water might be guaranteed to supplement other sources. This improvement measure is presently the only solution to the problem of water supply in Akama Oghe and Adaba communities, because of surface streams like Ajalli and Adada River which have high water discharge rates and have been of use by the people of the above communities.

The intensive large scale harvesting of rain water should be encouraged in all the study communities. With sufficient storage facilities, especially large cemented wells (to store water during the rainy season), water will cease to be a problem. Households should endeavour to buy large metallic tanks and dig underground tank/well. Thus rainwater harvesting, for the study communities that experience a minimum of 7 months rainfall duration, is

indeed a worthwhile strategy. Storage tanks could be built either below or above the ground, those below the ground should be fitted with a handpump.

These tanks should be fully closed to prevent evaporation, while all apertures should be screened to prevent the access of mosquitoes, insects and rodents. It is necessary too, to pass the water through a sand filter before it is consumed so as to safeguard against water contamination from the roofs. The most practical method of using rainwater is through guttering and piping to a tank or series of tanks. If they are built well in concrete or cement mortared brickwork, they can be considered a worthwhile investment. Ideally tanks should be covered, this prevents the growth of algae, reduces evaporation and helps to prevent contamination. Water collected in reservoirs built below ground level must either be pumped out or siphoned out through piping to lower lying areas.

There should be a combination of efforts of the people and the state government. Villagers should be involved in both the financing and the execution of the rural water scheme as well as provision of the unskilled labour needed during construction work. For it is in the face of this community participation, that communities

can generate the commitment for maintenance because they are involved. In community participation, rural dwellers are involved in the siting, excavation, installation and maintenance of their own protected water supply. A general meeting should be organized for each ward where future water development is planned. They will discuss the objectives of the programme, and what role they will play in it.

In community participation, community members should organize labour for drilling/digging and in fitting the pump itself, as well as subsequent maintenance of the pump. They should equally contribute to the planning, operation and maintenance of the handpumps. In summary, the success of community participation requires that the villagers be motivated and involved in the selection and planning of the scheme.

Exploitation of underground water sources by the digging of deep standard wells, and the construction and use of deep standard boreholes, is quite popular and acceptable for most rural communities. The success of this improvement measure depends on the experience of the practising water engineer/contractor. This is because inadequate feasibility studies of the nature of the groundwork occurrence, wrong site selection, and inappropriate exploitation methods are

among the factors that will affect the lifespan of these water supply schemes. Since most contractors are only interested in the gains they will make from the construction of water projects, countless handpumps are likely to lie non-functional. There should be this conscious effort to blend this strategy when adopted, with other strategies such as rainwater harvesting and the development of surface streams.

While constructing wells for use, efforts should be made to dig the well when water table is at its lowest. The months of October and November are appropriate. Proper siting of wells, should be taken into consideration, they should be far from latrines and areas where waste-water collects. Fitting a well top on wells are advantageous, for this reduces the chances of well contamination to its barest minimum. Adequate knowledge of the nature and distribution of the aquifer through well planned ground water exploration, need be known by well contractors, often times it helps prevent the collapse of well lining due to weakening of the ground around the well.

Installation of handpumps are encouraged, as an efficient water development improvement measure. Break-down of handpumps will be reduced if enough handpumps are provided and evenly distributed. Enough handpumps will

reduce the number of people one handpump serves, it will make the people depend more on underground water than the untreated water from the rivers.

4.5.2 Low Valued Improvement Measures:

These are, the "growth point" strategy, joint funding of water projects by the people and the government, training of manpower, construction of link roads to all stream sources and educating the people on water problem.

Joint financing of water projects by the community and the government is viable, as provision of adequate and good quality water involves a huge sum of money. That way the villagers would not shoulder most of the financial burden, nor the government, there will be a blending of the two. This approach has been used in some communities in Nigeria, where the people through the water development committees organise and raise funds for water supplies. This strategy is dependent on the amount of financial resources available in the community.

Educating the people on the effects of water scarcity in their community is an improvement measure. They should be made to realise that water scarcity will continue as long as no improved condition is supplied. That way, they will be able to participate in the

"war against water scarcity" in their community (both financially and in planning). Such education should not limit itself at stressing the scarcity of water, but also go further to mention the need for water supply conservation and storage.

Construction of roads to link all the sections of the river or stream in an area/community is an improvement measure, for accessibility to a water source means an efficient use of the source to arrest the problem of water shortage.

Another strategy is the "growth point" strategy. This improvement measure advocates that, for the selection of the communities to be supplied with water first, emphasis should be placed on supplying water to areas where economic activities is densest, before spreading to other areas. As is practiced in rural Tanzania (Fal-Kenmark, 1982). The application of this strategy in our study communities will enable areas near the village market/major road be supplied with water first.

The training of adequate and skilled personnel to run borehole stations, treatment plants and maintain open wells will help reduce cases of breakdown of machines. The training could be done within the State, the Nation or in other countries where the training facilities are

available. The presence of National and International assistance in the training of manpower and implementation of water schemes should be encouraged.

The success of rural water projects might therefore be a function of, among other things, the extent to which it might be possible for the project to adapt itself to prevailing socio-economic and environmental conditions and for the local community to absorb the changes resulting from the strategy.

4.6 Best Applicable Improvement Measures to Each Study Community:

Already some communities out of the six study communities have started using the exploitation of groundwater reserves strategy. The use of boreholes can be seen in Akama Oghe community and Eka Awoke community. Since there is an inefficient maintenance and management of the borehole scheme at Akama Oghe due to lack of funds and the non-chalant attitude of the staff of the Enugu State Water Board at the schemes, if introduced to other communities there is still the likelihood of water problems persisting in such areas.

From our analysis of the number of communities served with boreholes discussed in sub-section 4.3.1, we are convinced that the use of a borehole scheme without distribution network to the consumers (the rural dwellers), can hardly ease the problem of water shortages. For water trekking distances to water sources need be bridged, the people can never collect an adequate supply, enough to meet their demand having to trek constantly, coupled with the weight of the water. That is why there is still the presence of

water supply shortages in Eka Awoke even though the area has a handpump operated borehole. There is just one borehole water point serving the entire community of 9,252 people (1992 population estimate).

To successfully combat water shortage problem, it is best to combine the use of boreholes/wells and the development of surface streams and springs. So, far Akama Oghe that already has a borehole, it should develop its permanent stream source, Ajalli River. Eka Awoke equally has a borehole, but then lacks a permanent stream source. In the absence of developing surface streams, the people of Eka Awoke should intensify their rainwater harvesting on a large scale. Adaba Community should equally develop its numerous surface streams and springs. The Adada river found in Adaba, has a high water discharge rate and could be developed.

Effective rain water harvesting with adequate storage facilities should be encouraged in all the six study communities. For instance, Iheaka that has no streams or springs should concentrate on their deep standard borehole (yet to be commissioned) and the use of large storage reservoirs (such as drums

and tanks; under-ground or surface) to harvest rain water.

The following communities should use the strategy of groundwater exploitation, both boreholes and wells as the case may be, Ndi Offia, Obe and Eka Awoke communities.

Community participation should be embarked on by all the six study communities. Water supply projects should be built free by the government and the people asked to pay for the operation and maintenance costs or be jointly funded and maintained by both parties. Other community contribution could be in the form of labour.

The method of selecting communities to be supplied with water should be based on the "growth point" strategy. In this strategy the communities are ranked according to the density of their economic activities, and those communities with the densest economic activities are given highest priorities. Its application in our study communities will enable areas without water but with very dense economic activities, such as Obe, Iheaka, Adaba and Akama Oghe communities to be supplied with water first, in that

order. The major disadvantage of this strategy is that most of the worst communities in terms of the worst communities in terms of rural water supply, for instance Ndi Offia, are neglected.

In rain water harvesting it is pertinent that the rural dwellers provide more water storage facilities in their homes to store adequate water during the rainy season. Traditional methods of rain water harvesting, under coconut trees and banana trees or in the open field, ought to be modernized. Actually all the six study communities should be encouraged to build large storage facilities to store harvested rain water during the dry season.

The development of surface streams cannot be practised in communities such as Ndi Offia and Eka Awoke even though they have streams, because their streams are ephemeral, drying out at the onset of the dry season.

Training of manpower and educating the people on water conservation techniques are the strategies best applicable to all six study communities, others are the construction of link roads to stream sources for communities such as Ndi Offia, Eka Awoke, Obe, Adaba

and Akama Oghe, that have stream sources. Below is a table that best summarises the various best applicable improvement measures to each study community.

TABLE 16: The various best applicable improvement Measures to each study Community:

COMMUNITIES STRATEGIES	AKAMA OGHE	EKA AWOKE	NDI OFFIA	IHEAKA	ADABA	OBE
Develop Permanent Streams	1	0	0	0	1	0
Rainwater Harvesting	1	1	1	1	1	1
Develop Springs	0	0	0	0	1	1
Boreholes/ Wells	1	0	1	1	0	1
Community Participation	1	1	1	1	1	1
Growth Point	1	0	0	1	1	1
Training of Manpower and Educating Masses	1	1	1	1	1	1
Construction Of Link Roads	1	1	1	0	1	1

LEGEND

1	Yes
0	No

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 SUMMARY OF FINDINGS:

The following are the summaries of the major findings of the study.

i. Obe, Eka Awoke, Akama Oghe, Ndi Offia and Adaba are communities that have streams as sources of water supply. Streams are non-existent in Iheaka. Adaba and Obe have springs as water source. Ponds are used in the following communities, Iheaka, Ndi Offia and Eka Awoke as water source. Generally people in every community of the six study communities depend on rain catch. These three communities have boreholes, Iheaka, Akama Oghe and Eka Awoke. The people of Ndi Offia, Eka Awoke, and Obe use wells. Obe and Akama Oghe and Iheaka, are the three communities supplied with water by tanker drivers. Water vendors are common place as water source in Iheaka community.

ii. Many rural communities within Enugu State are without pipe borne water supply from results of the six study communities.

iii. An analysis of existing water supply improvement measures carried out, revealed the following, that Government participation is felt in only three out of the six study communities, Eka Awoke, Akama Oghe and Iheaka. The underlying improvement measure here is that based on the exploitation of ground water resources. Thus there is a borehole with distribution network in Akama Oghe. This borehole is hardly functional, water is distributed here through 20 public standpipes situated in various parts of the community. Eka Awoke borehole which can boast of an efficient delivery of water to the people, lacks distribution network since it is handpump operated. While Iheaka borehole scheme that is yet to be commissioned, is currently having its pipelines being laid. Most of these government aided improvement measures existing in the study communities were more or less redundant.

iv. Akama Oghe and Iheaka are two communities that enjoy community participation. Iheaka has twice undertaken annual fund raising

ceremonies for water supply improvement, whereas the people of Akama Oghe quarterly pay levies towards funding their water scheme. Akama Oghe people also contributed labour in the course of laying the pipelines for their water scheme. Individual efforts at harvesting rainwater for storage abound, under individual participation.

v. Evidence from the study reveals that there exists an absence of effective supervision of water schemes by the Enugu State Water Board. This goes to show that the existing supply improvement measures being used by the government and the people in the areas of study, is highly inefficient as their demands are rarely being met by their supply. Water supply shortages still persist in most communities. This calls for the need to suggest alternative improvement measures.

vi. The people of Eka Awoke, usually trek an average distance of 6km daily to this community borehole water source to fetch water. For Akama Oghe people, theirs is 2.5 km.

vii. The mean household domestic water demand for the six study communities is 181.0 litres per household per day (lpd). The mean daily domestic per capita demand of water was found to be 26.5 litres per person per day (lpd). The mean domestic demand per household is similar from one community to another except for Obe community which is relatively too high 350.01 and Eka Awoke community which is relatively too low 117.0 l.

viii. The average household per capita water consumption in the study communities was found to be 15.3 lhd (litres per head per day) whole the mean consumption per household per day is 104.3 litres. In summary, the average household per capita water demand the six study communities was found to be 26.5 litres per head per day (lhd), while the average water consumption was found to be 15.3 lhd. This leaves an average total deficiency of 11.2 lhd. It is remarkable to note that the water consumption of the six communities Obe, Akama Oghe, Iheaka, Adaba, Ndi Offia and Eka Awoke were extremely below the Federal Government recommended minimum standard of 115 litres per head.

ix. In terms of the mean water demand per commercial establishment, the Iheaka community ranks the highest with 352.5 litres per commercial venture per day (lcvpd), while Ndi Offia community has the lowest water demand at 18 lcvpd. This shows a demand range of 334.5 litres among the communities. Generally, the total commercial water demand for the study communities is 19,066.1 litres as against the total water consumption 10,188.2 (lcvpd). This shows a total water deficiency of 8,877.9 (lcvpd) representing a percentage deficiency of 46.6%, and showing that the percentage of water demand satisfied by water supply is 53.4%.

x. The total services water demand for the various services activities for the study communities is 25,491.0 ld. While the mean services water demand for the six study areas was found to be 620.8 (lpsed0. Iheaka has the highest mean services water demand with 2,1500 litres per services establishments. The smallest, 54 litres is found in Ndi Offia. The range of mean services water demand is thus 2,096 litres. The sum total of the mean services water consumption is

8,047.0 litres. The range of mean services water consumption for the entire study communities was found to be 555.5 litres.

xi. The total number of industrial water demand is 110,023.0 litres per day, as against the total water consumption of 28,754.4 ld. Obe has the largest amount of mean industrial water demand 20,215.0 (lpivd), while Ndi Offia has the least amount 42.0 lpivd. While Akama Oghe consumed the highest amount 2,418.8 lpivd, the lowest amount 30.0 lpivd, is consumed in Eka Awoke community. The difference between the two communities is 2,388.8 litres, this large range indicates that the consumption pattern of these industries are not the same. Gross industrial water inadequacy is responsible for the slow take off of rural industrialisation within Enugu State.

xii. Results of the analysis of variance test performed to find out if there is no significant difference in the total (residential, commercial, service and industrial) water demand by the people of the six study communities showed that there are no significant differences between the demand for water

among the various study communities. This implies that the demand for water in the different study communities are similar, for these communities have almost the same level of socio-economic rating, poverty, absence of government influence and they all exist within the same homogenous socio-cultural group. Hence all areas end up demanding nearly the same quantity of water for all their sectors (residential, commercial, service and industrial).

xiii. Results of another analysis of variance test performed to find out if there exists no significant difference in the water supplied to the people of the six various study communities, showed that there are significant differences between the supply of water among the various study communities. Hence the indication is that the supply of water in the different study communities are not similar due to reasons like, unequal distribution of sources of water supply, number of people in each household for each study community, seasonality of rainfall/ ephemeral streams, non-functional boreholes in some communities, literacy/awareness level of the rural dwellers in the different communities,

accessibility of the various sources of water supply, level of development, geology of the area, distance to water sources, adequacy of water storage facilities per community.

This study does not, however, regard its findings as final.

5.2 SUMMARY OF RECOMMENDATION:

These are as follows:

i. The number of functional handpump operated boreholes should be stepped up, at least to a minimum of about five for each community. This will reduce to a large extent the long distances people trek to get to water points to collect water.

ii. The government themselves should introduce water vending to areas lacking surface streams/water schemes, at a reduced cost. They should be able to penetrate even the interiors of villages that suffer unmotorable roads, because they are the worst hit when it comes to water shortage.

iii. Springs in communities such as Adaba and Obe should be tapped and the water stored in reservoirs from where the people can come and fetch it, if the government and the people are unable to fix distribution network from the reservoirs to the people.

iv. Communities such as Akama Oghe that have a borehole scheme with distribution network, adequate information need be passed to the

people, letting them know the time and days of the week the taps will run. This way the people will know how to schedule their activities to fit their water collection periods.

vi Extensive groundwater investigation studies need be carried out in order to know the hydrogeologic dynamics of the area, before the actual groundwater exploration starts off. This will militate against abandoned boreholes from wildcatting, or drying up of water schemes immediately they are commissioned for use. Experienced and qualified water engineers should be awarded water contracts over and above the recruitment of laymen that comes most times with political considerations rather than expertize.

vi. We advise that each rural community should have at least one rural water development committee under the auspices of the village head. This committee will be the one to actualize any form of community participation to be embarked upon. It would also be designated with the duty of finding the best suitable water improvement measure to adopt. This committee will police and monitor the efficiency of their water schemes, and make

report to the government on any failure and need for a rectification.

vii. The following methods of water exploitation should be employed. The tapping of surface streams should be recommended for communities that have a perennial river with a high discharge rate. Areas without stream, could exploit their groundwater resources by digging wells and constructing boreholes for use. Some communities can even combine the above methods of both surface and groundwater exploitation. These two would complement each other, generate enough supply of water to the people.

viii. People should be encouraged to tap rain water by buying plastic or metal tanks for water storage. For those who have the means, the best is the construction of underground concrete storage tank with a motor attached to it capable of pumping water into the house for use.

xi. The people should be educated on the need for adequate water supply provision as well as the health dangers of polluting the few existing water sources.

5.3 CONCLUSION:

In this project attention has been focused on rural water supply and a comparative analysis of the situation present in the six study communities, Obe, Akama, Oghe, Adaba, Iheaka, Ndi Offia and Eka Awoke in Enugu State, Nigeria. This work has fulfilled what it has set out to achieve in the statement of problem, and in the aims and objectives of the study. This research has revealed the similarities and differences that exist in rural water supply of the study communities. Various sources of water supply in the areas have been studied and identified. Inequality in the occurrence of water sources, the presence of water supply improvement measures and various water needs of the difference study communities were duly exposed.

The water demand and consumption within the study communities have also been assessed. Water supply improvement measures used in the study areas have been analyzed. Where we think loopholes might exist we have emphasized the need for alternative water development improvement measures. And have gone ahead to render some suggestions, by introducing alternative improvement measures, i.e. those suitable for each community of the six study communities.

Hence the study has fulfilled its objectives which include the identification of the various sources of water in each of the study communities, an examination of the

water demand characteristics of the areas being studied and an analysis of the water supply strategies already existing in each of the six study communities. A summary of findings and recommendations have also been made to aid water resource planners.

It is important to mention that during the course of the fieldwork some problems were encountered. These are some of those major problems:

i. The first is that of language barrier and illiteracy. Ninety-eight percent of the respondents could neither read nor write, this therefore made the questionnaires an interview schedule. The filling of responses, had to be done by us. For communities such as Ndi Offia and Eka Awoke, the assistance of a paid interpreter had to be employed to enable us get our data, as we could not understand their own dialect of the Igbo language.

ii. We encountered some social problems during the course of the fieldwork. We were regarded with suspicion and scorn by most of our respondents. Majority of them were indifferent to the question being asked, they felt more

or less bothered by the whole exercise, claiming that this is not the first time students visit their communities only for their problems to still remain with them, unsolved. Most of those who regarded us with suspicion refused to be part of the data collection exercise. This was also the case with some of the tanker drivers selling water.

iii. Reaching most of the Ezes or Chiefs of the communities for study was indeed a problem, as most of the Ezes or Chiefs do not reside in the villages/communities where they were supposed to be Chiefs. We had to obtain addresses of such Chiefs only to reach them after several visits, in the urban centres close to their communities where they have decided to reside in.

iv. Another of the problems encountered during the field work was that of lack of transportation. Getting a vehicle to take us down to our various study communities and back to our station from motor-parks most times took as long as three to four hours. What is largely responsible for this trend seen, especially in the case of Adaba motor park and the motor park of these two communities within Abakaliki area; Eka Awoke and Ndi Offia is the breakdown of many of the mass transit buses and most other

commercial vehicles plying such routes. Generally most of the link roads to these rural communities are bad and untarred with lots of pot-holes capable of damaging vehicles over the years.

Despite these limitations, it is hoped that future researchers who might be interested in the same area of research would find in this study a wider ground to start off other productive researches. We suggest that future researches be carried out on the underlisted topics in the field of rural water supply.

i. Identification of the factors which are responsible for the failure of most rural water supply development projects in Enugu State.

ii. An analytical study of the economics of water vending in some communities of Enugu State.

iii. Evaluation of industrial water demand as it affects economic development and growth in some communities within Enugu State.

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APPENDIX A1

UNIVERSITY OF NIGERIA NSUKKA
DEPARTMENT OF GEOGRAPHY

QUESTIONNAIRE (M.Sc. FIELD WORK)

Sectors: Residential/Service/Commercial/Industrial/ Agricultural.

Sir/Madam,

I am carrying out an M.Sc. research in Rural Water Supplies in parts of Enugu State. Please supply the information below, it will however be treated with the strictest confidence. The data required are for research. Thank you.

Yours faithfully,

UZOMA, E. C.

1. How many persons are in your household?
   How many people are employed in your establishments?
   How many students/staff are in your school?
   How many bedspaces/patients are in your Clinic?
2. Where do you get water from?
   (a) Stream (b) Ponds (c) Spring (d) Raincatch
   (e) Well (f) Borehole (g) Tanks (h) Plastered dry pits
   (i) Pipe borne water (j) Water tanker (k) Water vendors
   (l) Others (specify)

3. What is the name of this source?
4. If you have piperborne water in your premises, do you pay water rate? Yes/No. If yes, how much?
5. How often does the tap run?
   And for how many hours each day?
   How many standpipes are in your premises?
6. If you buy water, whom do you buy water from?
7. If by water tanker how regular is the supply?
8. What quantity do you normally purchase?
   (Estimate in bucket-fulls or drum-fulls).
9. How much do you pay for this?
10. About how much is spent in a month on water?
11. Do you include money for buying water in your daily/weekly/monthly budgets? Yes/No.
12. What quantity of water do you use per day?
13. What period of the day do you use water most?
14. What quantity of water would you like to use per day, in the face of adequate water?

APPENDIX A2

UNIVERSITY OF NIGERIA, NSUKKA
DEPARTMENT OF GEOGRAPHY

INTERVIEW SCHEDULE FOR TANKER DRIVERS

1. From what source(s) do you get the water you sell to the people?
2. What is the name of this source?
3. Do you make efforts to get treated water to the people?
4. How much is paid to fill a tanker lorry from the source of water? .. .. ..
5. If this price differs in the rainy season, how much is paid then? ..
6. How many trips do you make in a day from water source to the buyers? .. ..
7. Do you belong to a water union? Yes/No ..
8. Are prices at which water is sold, influenced by the Union? .. .. ..
9. What season of the year is the demand made on you by people (i.e members of the community) greatest?
10. Do you have problem of water purchase at this period too?
11. (a) Are the number of trips you make in a day to consumers satisfactory by you? Yes/No

    (b) How many trips do you make?

    How many would you have wanted to make? ..
12. Do you consider this venture lucrative or a thankless task?

APPENDIX A3

UNIVERSITY OF NIGERIA, NSUKKA
DEPARTMENT OF GEOGRAPHY

INTERVIEW SCHEDULE FOR COMMUNITY HEAD, CHIEFS OR MEMBERS OF COMMITTEE IN-CHARGE OF WELFARE/WATER SUPPLY IN THE COMMUNITY

1. What water scheme exists in your community?
2. How is this water distributed from the source to the members of the community?
3. Was this water scheme made available to you by the government? Or by your own self efforts? Or by philanthropic organisations/individuals?
4. If governmental, which of these bodies is involved?
   (a) Federal Ministry of Agriculture and Water Resources
   (b) Better Life for Rural Women
   (c) State Water Board
   (d) World Bank Project
   (e) UNICEF Assisted Project
   (f) W.H.O. Assisted Project
   (g) DFFRI
   (i) ADB
5. Is the water scheme a blend between your efforts and that of the government?
6. If so what aspects did your contribution come under? Is it in joint funding of water scheme or labour provision only?

7. If all efforts are entirely those of the community's, then is it co-operative/thrift society contributory effort?

8. If a philanthropic organisation assisted in the provision of a water scheme, what is the name of this organisation?

9. If it is an individuals' effort only, who is this individual?

10. Was the water scheme funding by -
    (a) Community levy
    (b) Government funding
    (c) UNICEF funding but labour for construction of scheme being community dependent.
    (d) World Bank funding
    (e) Others (specify)

11. If labour was provided, what type of labour actually?

12. About how much in all was realized from members of the community, if funding of water scheme was by community levy?

13. How much was paid by each household?

14. Was this levy payment by equal participation? or by stratification? i.e were certain age groups alone involved in the payments, or was a particular sex i.e females alone levied for payment of water schemes, or

were the educated members of the community with employment outside the community alone levied?

15. How co-operative were members of the community towards contributing funds for the scheme being used?
16. If reluctance was evidenced what reasons could be responsible for this attitude?
17. Is your present supply scheme, a success story?
18. If No, why?
19. What method of water provision would you have preferred that the community had, other than what you presently possess?

APPENDIX A4

UNIVERSITY OF NIGERIA, NSUKKA
DEPARTMENT OF GEOGRAPHY

QUESTIONNAIRE FOR PUBLIC WATER BOARD

1. What is the source of pipeborne water supply to these six communities understudy?
2. How much water is pumped daily?
3. What quantity do you distribute to the public daily?
4. For how many hours a day, and for how many days a week is water pumped?
5. How do you distribute the water from source to the people?
6. What is the number of public taps in each study community?
7. What are the criteria for locating these taps where they are presently located?
8. What is the maximum amount of water delivered to the community weekly?
9. What is the reason for inadequacy in the maximum amount of water delivered?
10. What is the depth and rate of flow of each of the boreholes within the study communities?
11. How is this water distributed from source to the people?
12. What is the depth and rate of flow of each of the hand-dug water wells with handpump within each of the six study communities.
13. How is this water distributed from source to the people?
14. How much does it cost to set up a village water supply scheme (by estimation)?

APPENDIX B: AN INVENTORY OF COMMERCIAL, INDUSTRIAL AND SERVICES ESTABLISHMENTS IN EACH OF THE SIX STUDY COMMUNITIES.

INDUSTRIAL TYPE	AKAMA OGHE	NDI OFFIA	EKA AWOKE	ADABA	IHEAKA	OBE
Garri Processing	6	2	1	4	1	3
Oil Mill "	0	0	0	1	0	0
Cashew Processing	1	0	0	0	0	0
Pottery"	1	0	0	1	0	0
Block Industry	0	0	0	0	0	1
TOTAL	8	2	1	6	1	4

COMMERCIAL VENTURE TYPE	AKAMA OGHE	NDI OFFIA	EKA AWOKE	ADABA	IHEAKA	OBE
Hair Salon	6	0	2	6	6	3
Restaurant/Bar	8	0	3	8	8	8
Chemist	4	1	2	8	7	2
Hotel "	0	0	0	0	0	1
Grinding Mill	3	1	0	0	2	2
TOTAL	21	2	7	22	23	16

SERVICES ESTABLISHMENTS	AKAMA OGHE	NDI OFFIA	EKA AWOKE	ADABA	IHEAKA	OBE
Schools "	1	0	3	3	5	5
Health Centres/ Clinic	1	1	1	1	3	1
TOTAL	2	1	4	4	8	6

APPENDIX C: A WORKED EXAMPLE OF AN ANALYSIS OF VARIANCE TEST OF THE WATER DEMAND IN THE SIX STUDY COMMUNITIES.

Procedure

Step 1: The researcher built a contingency table with columns representing Demand for the six different study communities and rows representing the various sectors of the community. From the observed values, the expected values, were calculated using the formula:

$$xij = u + ti + bj + Eij$$

Where u is the general mean
And ti is the mean effort of the ith village Demand
bj is the mean effort of the jth village Demand
Eij is the random error associated with the observed xij.

Step 2:

$$SSU = \frac{T^2}{ab} = \frac{29248.4^2}{24} = 35644437.61 = C$$

$$SSt = Ci - c; \text{ where } Ci = \frac{Ti^2}{6}$$

$$Ci = \frac{2958.2^2 + 130.5^2 + ... + 731.9^2}{6}$$

$$= \frac{485822413.4}{6} = 80970402.24$$

$$SSt = 80970402.24 - 35644537.61$$

$$= 45325864.63$$

$$SSb = Cj - c \text{ where } Cj = \frac{T^2_{.j}}{9}$$

$$Cj = \frac{159.2^2 + ... + 24372^2}{4} =$$

$$= \frac{608877248.9}{4} = 152219312.2$$

$$SSb = 152219312.2 - 35644537.61$$

$$= 116574774.6$$

$$SSc = Cij - Ci - Cj + C$$

$$\text{where } Cij = Ex^2_{ij}$$

$$Ex^2_{ij} = 426223014.3$$

$$SSc = 426223014.3 - 80970402.24$$

$$- 152219312.2 + 35644537.61$$

$$= 228677837.5$$

Step 3:

SV	df	SS	MS	F-ratio
Between (Sectors	3	45325864.63	15108621.54	0.99
Groups (Demand	5	116574774.60	23314954.92	1.53
Within Groups	15	228677857.50	15245189.17	--
TOTAL	24	---	---	--

DECISION: Since the table value 2.90 of the theoretical F5,15 at 95% confidence level is greater than the calculated F - value of 1.53, we conclude that the demand for water among the various study communities are not significantly different.

CONCLUSION: Based on the analysis the researcher concluded that, there are no significant differences between the demand for water among the various study communities.