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**Spatial patterns of residential water demand
and supply in Nsukka urban area of Enugu
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SPATIAL PATTERNS OF RESIDENTIAL WATER DEMAND
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OF ENUGU STATE, NIGERIA.

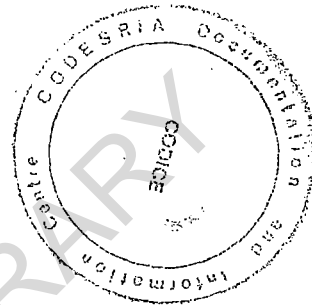
BY

MICHAEL CHUKWUMA OBETA

PG/M.Sc./93/14795
M.Sc. THESIS

DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF NIGERIA,
NSUKKA

AUGUST, 1997



ii.

SPATIAL PATTERNS OF RESIDENTIAL WATER DEMAND
AND SUPPLY IN NSUKKA URBAN AREA
OF ENUGU STATE, NIGERIA

BY

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B.Sc. (Nig.)

PG/M.Sc./93/14795

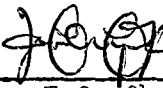
A THESIS SUBMITTED TO THE SCHOOL OF
POSTGRADUATE STUDIES AND THE
DEPARTMENT OF GEOGRAPHY,
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IN PARTIAL FULFILMENT OF THE REQUIREMENTS
FOR THE DEGREE OF MASTER OF SCIENCE (M.Sc.).

AUGUST, 1997

CERTIFICATION

Mr. Obeta Michael Chukwuma, a postgraduate student in the Department of Geography and with the Registration Number PG/M.Sc/93/14795 has satisfactorily completed the requirements for course and research work for the Degree of Master of Science (M.Sc.) in Hydrology and Water Resources. The work embodied in this thesis/project report is original and has not been submitted in part or full for any other Diploma or Degree of this or any other University.

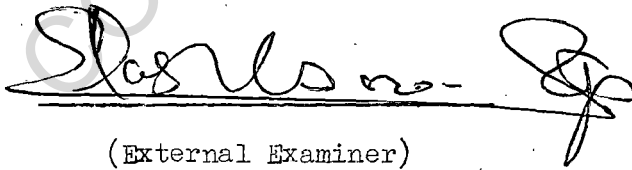
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PROF STOP
USORO
4-2-98

DEDICATION

Dedicated, with joy and gratitude, to my beloved
mother, Mrs M. O. Ugwuanyi; wife and children.

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My most special and profound gratitude go to my supervisor, Dr. R.N.C. Anyadike, who consistently and painstakingly supervised this work. His criticisms, guidance and assistance were of immense benefit to me.

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Obeta Michael Chukwuma

August 1997

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ABSTRACT

This study investigated the spatial patterns of residential water demand and supply in Nsukka urban area of Enugu State.

The result of the analysis established the quantity of water demanded and supplied spatially and in totality and the deficiency in the people's water needs. The mean daily per capita water demand for the entire urban area ^{was} found to be 94.57 litres per person per day (L/P/D), while the mean daily per capita water supply was found to be 51.86 (L/P/D/). This gives a deficiency of 42.71 (L/P/D) which represents a percentage margin of 45%.

Similar analysis in the wards reveal that the ward that is associated with the highest mean per capita water demand is the University ward (159.67 L/P/D). This ward is followed by Onuiyi (119 L/P/D), GRA (106.03), Ihe (86.33 L/P/D). Water is in varying degrees, a scarce commodity in all the wards, however, Nru and Nkpanano wards which attained only 21.8% and 27.2% of the Federal Government recommended minimum of 115 litres per person per day are presently the most water deficient wards.

The supply pattern generally is uneven and irregular. About 42.8% of the sampled population lack piped supply in their residence. The factors which occasion the observed shortfalls in 'target' production quantities are wide and varied and their impacts are not felt, uniformly in Nsukka urban area.

The variables which influence household water demand and consumption patterns were identified and analysed. Multiple regression enabled us to establish the combined and relative contributions of the predictor variables and to assess the interrelationships among the variables. Factor analysis was employed to analyse our data with orthogonal varimax rotation to maximise the variance of the loading on each factor. The 13 predictor variables were reduced to five underlying dimensions that account for 73.6% of the total variance in household water demand and consumption patterns.

The underlying dimensions established for the wards varied from 4 to 6, but generally include the factors determined for the entire urban area.

The existing water development strategies were critically evaluated and found incapable of meeting the people's water needs. Based on these findings, new measures which can improve the supply and management of this resources were advanced.

CHAPTER ONE

INTRODUCTION

1.1 Statement of the Problem

On November 10, 1980, the United Nations General Assembly declared, in a special session, that the third development decade (from 1980 - 1990) was to be the "International Drinking Water Supply and Sanitation Decade". As a consequence of this declaration, Nigeria resolved to adopt the spirit of the United Nation's resolution and subsequently to accept the target to provide, to the best possible extent, all population groups with access to safe and adequate drinking water supply and adequate means of sanitation (Adeyemi, 1986).

Prior to this date, the University town of Nsukka has had a problem in supplying its need for water, a need that has come to assume gigantic proportions since the last three decades. Before 1954, water supply in Nsukka was almost exclusively the responsibility of private agencies (Ugwu, 1964). Based on needs and technological ability and in response to specific factors of the environment, each community in the area had developed and maintained its own water supply system. These systems were temporarily adequate, but they did not guarantee healthy, safe and always sufficient quantities. Natural events such as droughts, as well as the demands of an increasing population were permanent threats

to the community water supply systems (Ugwu, 1964; Eze, 1976).

The above situation which can be considered typical for the years before 1960 started to change with the establishment of the University within this rural area. First, the University, because of its services and prospects for future development, growth and contributions, was a project which the government of the then Eastern Region of Nigeria, never wanted to fail. Therefore, in order to gain the confidence of the highly trained University staff, and in order to establish the University on a solid base, the government considered the provision of adequate water to the inhabitants to be a top development priority (Eze, 1976).

Accordingly, five boreholes with a combined capacity of 3,600,000 litres per day were established within the University community while additional five boreholes, with a combined capacity of 4,800,000 litres per day were established for the rest of the area (Okite, 1976). In addition, individuals were encouraged to own mini reservoirs or tanks of capacity between 1250 to 2500 litres, and of about 2,500 to 7,500 litres for groups and small establishments such as schools and maternity homes (Ugwu, 1964; Eze, 1976).

Despite these measures, a water supply problem still existed in the urban area. The influx of migrants, both local and distant, into the urban area brought its own consequences. It is true that

these migrants brought with them labour, skills and capital which helped in transforming Nsukka from a typical rural community into an emergent urban centre but this rapid expansion also brought with it an increase in water requirements. The Nsukka urban water supply problems has, therefore, more than persisted. All the inhabitants share the concern that water shortages produce major hardships and inhibit development.

The nature and magnitude of shortages is not, however, uniform within the area. While water scarcity is common to the whole of Nsukka urban, the degree of scarcity varies from place to place. For example, the scarcity appears to be more acute in areas surrounding the University. Women and children from these areas are frequently seen along the streets and roads searching for water. Men make use of bicycles and motor-cycles for water haulage. A large number of the urban inhabitants come to the University premises to fetch water. Those University workers that live outside the University premises come to work with plastic containers for fetching water. The selling of water has become a 'normal' (i.e regular and widespread) business in Nsukka urban area. These water vendors make use of motor-cycles, trucks, and tankers. The result is that metal tanks, drums and plastic containers are common features in Nsukka urban area.

The above prevailing situation raises a number of interesting questions, particularly because no other urban area of the same size and history is as unique as Nsukka, where a typical traditional rural savanna community has been, within a generation (35 years), totally transformed by a major institution, an influx of the most educated people in Eastern Nigeria, students from all over Nigeria, as well as service staff - all in one area. What would be the effect of all these on the residential water demand and supply situation? And how does water demand and consumption within the University compare with those of other parts of the urban area? Are the factors which occasion shortages experienced differently among the wards that make up the urban area, and what strategies can bring about improved supply and management of this resources within the whole urban area? Only a detailed and analytical investigation into the general patterns of water demand and supply within the Nsukka urban area can provide accurate answers to questions such as those raised above, and in addition isolate the significant variables which best account for the peoples water use habits. Specifically, these form the focus of this research.

1.2 Aims and Objectives of the Study

Central to this study, is the identification of the more significant variables in the residential water demand and supply situation in an emerging urban centre like Nsukka. This is with a view to enhancing our understanding of the prevailing situations and to enable us proffer effective solutions which will contribute towards a more effective supply and management of this resources in Nsukka urban area.

In order to achieve these aims, certain specific objective investigations will be addressed. These objectives include:

1. To estimate the quantity of water demanded and supplied to inhabitants of the various wards, as a basis for comparison and for determining the deficit in the water needs of the people.
2. To identify and analyse the factors which affect the quantity demanded spatially and in totality as a basis for effective planning.
3. To identify and analyse the factors which best account for the gap between the quantity demanded and supplied within the urban area.
4. To suggest strategies for improved water supply in the urban area.

Studies of this nature provide a better basis for urban water management (Rees, 1982). Per capita water demand, for example, is one of the important variables used in the design and planning of urban water supply systems. It is, therefore, hoped that the result of this study will be of interest to planners in designing the capacity of water work system, adopting a more efficient distribution methods and in predicting future patterns of demand within the study area.

1.3 The Study Area

Nsukka urban area is located in Enugu State of Nigeria, approximately at latitude $6^{\circ} 5' N$ and longitude $7^{\circ} 2' E$ (see Fig. I). The urban area is approximately 64 kilometers north of Enugu, the capital of Enugu State, and is located on a dissected plateau which bears its name. The urban area covers an area of about 13.44 sq. kms, and has a population of 120,064 (Ezema, 1995).

It is currently the administrative headquarters of Nsukka Local Government Area, which is one of the 17 local government areas that make up Enugu State (see Fig. 2)

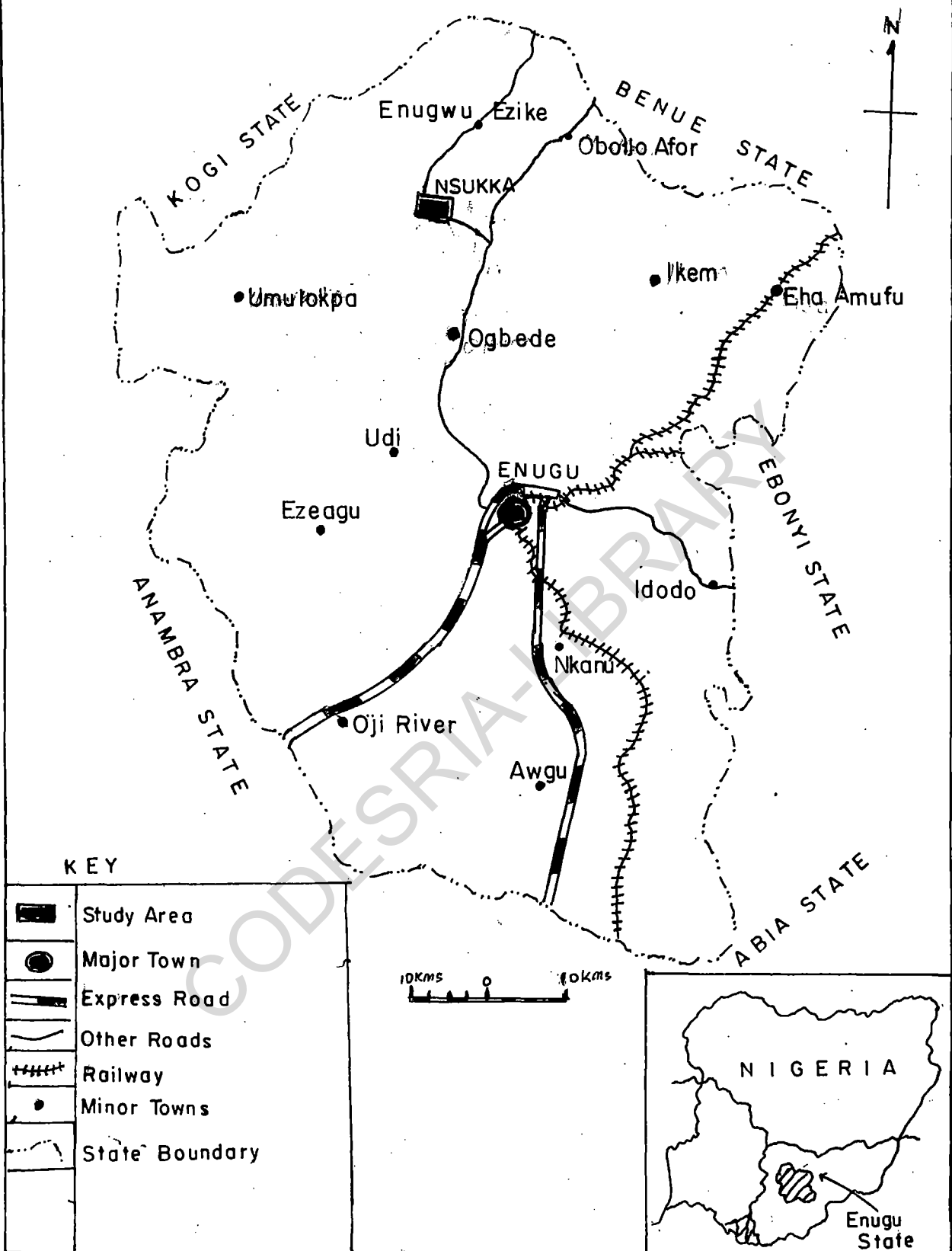
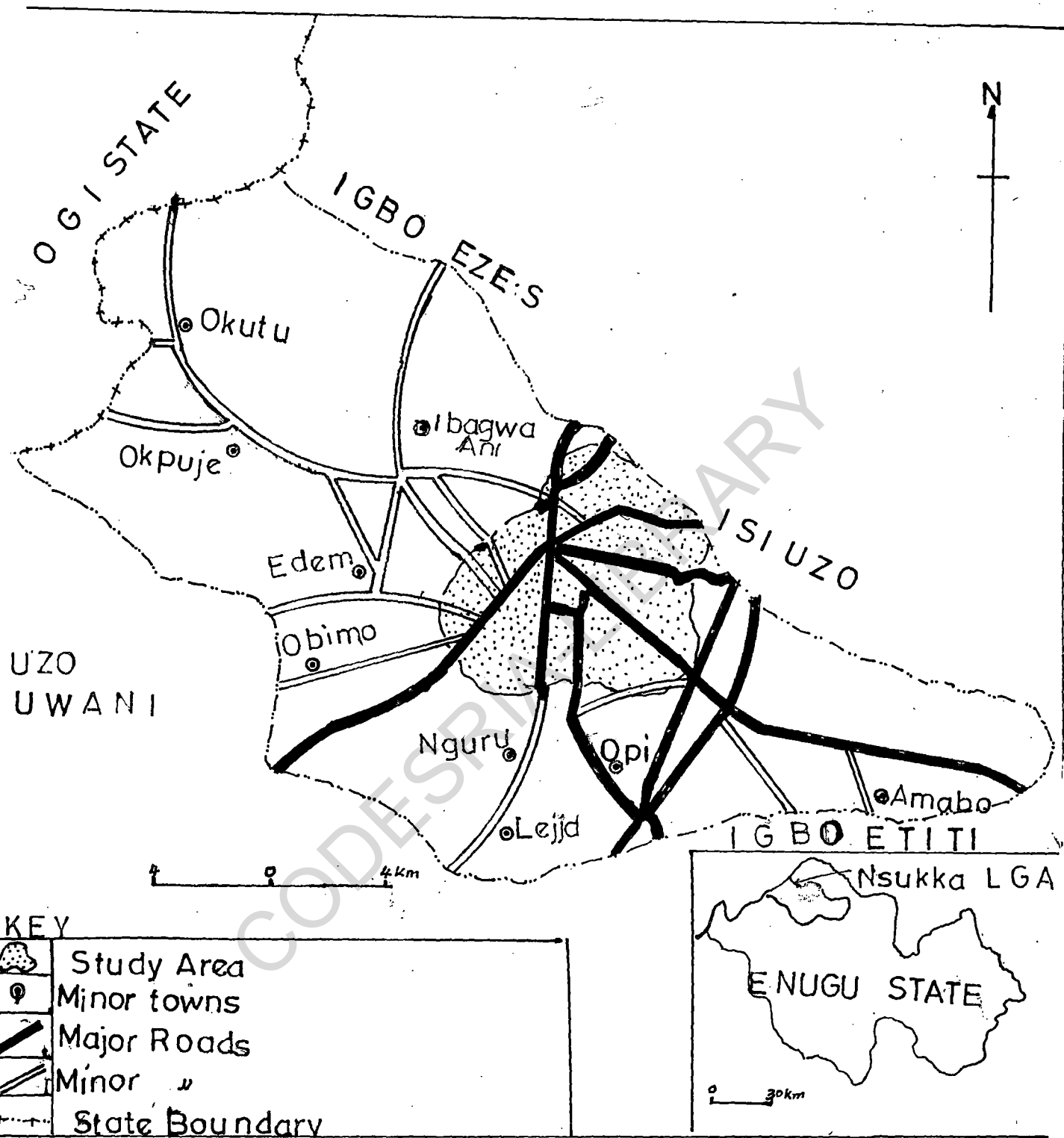


FIG. 1: ENUGU STATE SHOWING THE LOCATION OF NSUKKA



1.3.1 Relief and Drainage

The study area is on a dissected plateau of the late pliocene of the Tertiary period (Ofomata, 1978). The plateau is about 425 meters above sea level, and runs from Udi, with a scarp face on the eastern side and a gentle dip westwards. Two groups of landforms - residual hills and broad dry valleys, dominate the relief of the area, determining, by their east-west axis, the general configuration and shape of the area.

Geologically, the area is underlain by rocks which have been grouped into two, namely: the Ajali sandstone and the Nsukka formation. The Nsukka formation rests on the Ajali sandstone. The rock formation is porous and redish in colour. There is almost a complete absence of surface drainage, owing to the high porosity and consequent high infiltration of the rock formation of the entire urban area.

The Ajali sandstone is, however, a good aquifer and the water table is not far below the surface (mean depth is between 90-120 meters) a situation which favours the sinking of deep wells and boreholes (Eze, , 1995).

1.3.2 Climate

The climate of Nsukka urban may be grouped under the humid tropical, best described as the tropical wet-and-dry or AW climate of the Koppen classification. Its average daily minimum temperature

is about 23.3°C while its average monthly maximum is about 27.7°C . The average daily maximum is about 31.2°C while the annual range is about 13.5° (Okite, 1976).

The rainy season starts in April and ends in November. Average monthly rainfall ranges from 250 mm in April to 380 mm in October, with a mean annual total of 1500 mm (Okite, 1976). This relatively mild climate is one of the major reasons for siting here, the University of Nigeria, Nsukka (Okoye, 1974).

1.3.3 Vegetation

The prevailing type of vegetation in the study area has been designated "the derived savanna" (Eze, 1976). The vegetation comprises of:

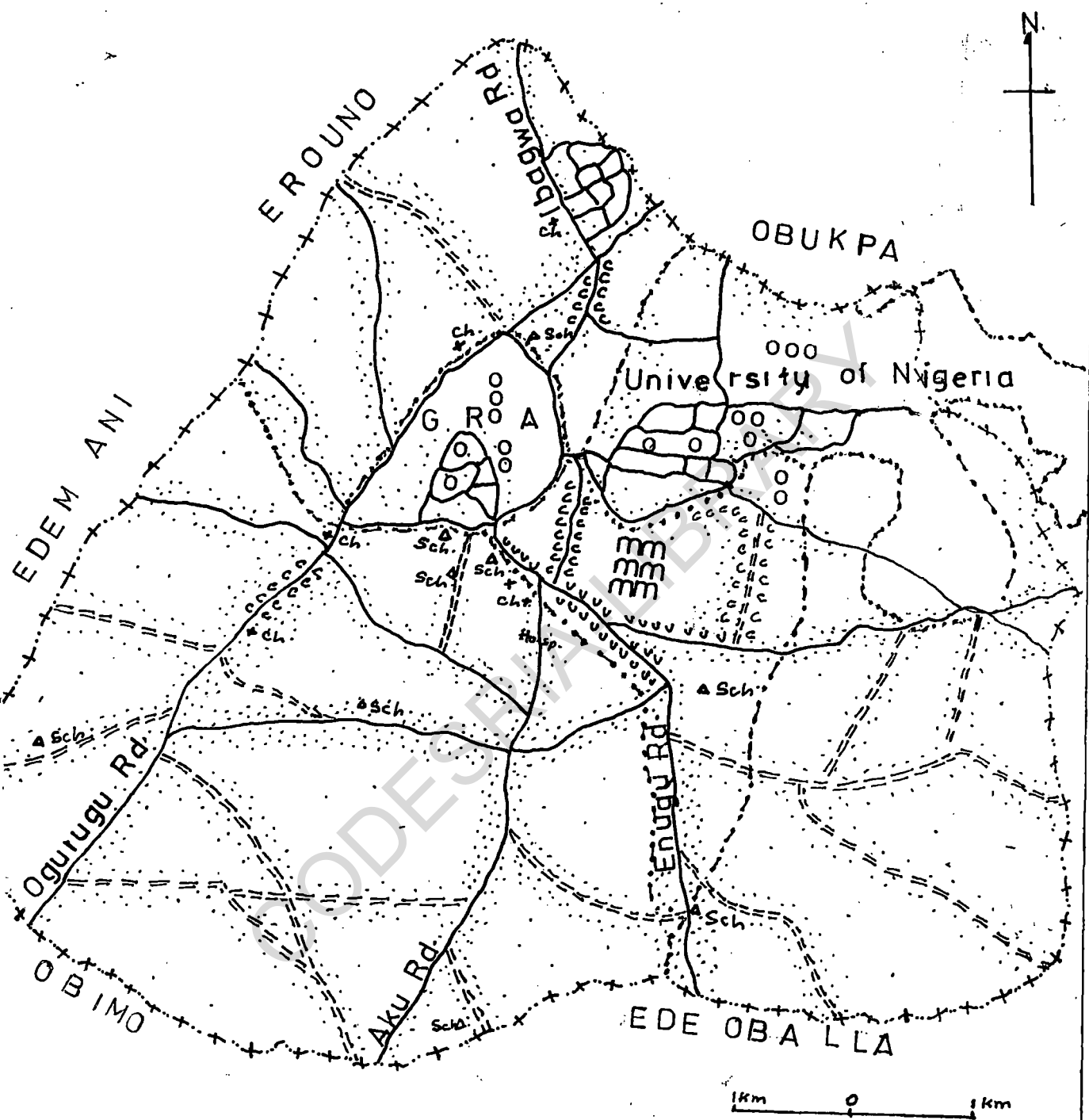
1. Selectively preserved economic and broad leaved trees. These grow mainly on the lowlands.
2. Mixed bushes. These are found mainly on the broad valleys. Most of the trees here are stunted and grow side by side with tall grasses.
3. Shrubs and short grasses. These are found mainly on the tops and sides of the residual hills.

1.3.4 Growth and Development

Before the present century, the area now known as Nsukka urban was an unimportant rural settlement made up of the quarters of Nru, Nkpunano, Ihe and Owerre (Okoye, 1978). These settlements were initially located on hill-tops for protective reasons. With the emergence of colonisation, the area was first administered from Awka (1866), Ekpanga (1909), Obollo-Afor (1918) and lastly, from Nkpologwu in 1920.

Nsukka was raised to the status of a Divisional Headquarters in 1922, to a Headquarter of Igbo-Etiti Rural District Council in 1951 and to a Headquarter of Nsukka County Council in 1954. The colonial administration was attracted to Nsukka urban area because of its centrality and favourable climate induced by its elevation and topography.

The pioneer development projects which helped to stimulate the rapid growth and development of Nsukka urban area include: a native court (1921), a medical centre (1922), a motorable road (1924), a primary school (1926), a postal agency (1929), a maternity home (1935), a health dispensary (1936), a secondary school (1952), a teacher training college (1956), and pipe borne water (1956) (Ugwu, 1964, Eze, 1976; Okoye, 1978; Ezema, 1995). (See figure 3).



KEY

| | | | |
|--|----------------|--|-------------|
| | Urban boundary | | Markets |
| | Major Rds. | | Residential |
| | Minor Rds. | | Shops |
| | Ward boundary | | Offices |

FIG. 3: NSUKKA URBAN STRUCTURE

The establishment and the opening of the University of Nigeria in 1960, is however, one basic event that brought a tremendous increase in the urban infrastructure and population. The non-rural population of Nsukka increased both in total number, in heterogeneity and in sophistication. This unprecedented increase in the urban population is shown in Table I.

Table 1: Population Growth in Nsukka Urban
(Source: Ugwu, 1964; Eze, 1976; Ezema, 1995)

| PERIOD | CATEGORY | | |
|-----------------------------|-----------------------|--------------------|---------|
| | Indigenous Population | Migrant Population | Total |
| Population Census, 1953 | 12,763 | 1,911 | 13,674 |
| Population Census, 1963 | 16,763 | 9,615 | 26,378 |
| Projected Population, 1976 | 33,970 | 37,006 | 70,856 |
| Projected Population, 1980 | 36,283 | 40,741 | 77,024 |
| Projected Population, 1991 | 63,884 | 56,180 | 120,064 |
| Projected Population, 1995* | 69,807 | 61,388 | 124,925 |

*Projection based on 1993 census.

Note that by 1976, the migrant population exceeded the indigenous population.

The construction of motorable roads and houses within the University premises, and in the entire urban area witnessed an unprecedented upsurge. A number of commercial houses such as banks, hotels and fuel stations were established at this period (early 1960s). The Nsukka main market was relocated, widened and modernized (Eze, 1976). The now defunct Electricity Corporation of Eastern Nigeria (ECEN) linked Nsukka urban with her power station at Oji River in 1962. The rate of expansion was so unprecedented that in 1964, the government of the then Eastern Region had to establish a Town Planning Authority to ensure a progressive orderly evolution of the Nsukka urban area. This phenomenal expansion continued unabated until the outbreak of the civil war in 1967 (Okite, 1976).

For most areas in Eastern Nigeria, 1967 - 1970 was a period of intense crisis and destruction. Perhaps no other urban area suffered more, in terms of **physical** destruction, than Nsukka urban. However, the cessation of hostilities and the reopening of the University of Nigeria in 1970, in addition to the oil-boom of the post war era, made the period, 1970 - 1980 another era of rapid growth and development in Nsukka urban. Most of the existing modern establishments, schools, banks, telecommunication, small-scale industries, private hospitals, offices, hotels and other commercial houses which presently dominate the urban landscape were established within this period (Eze, 1995).

The period 1985 - date is witnessing a marked reduction in the rate of infrastructural transformation of Nsukka urban area (perhaps, due to economic reasons). The few remarkable improvements in the urban landscape within this period include the installation of street lights (along Enugu Road), an abandoned attempt at dualisation of Enugu Road, the extension of pipeline network for water distribution and the raising of Nsukka to the status of a Diocesan Headquarters for the Roman Catholics (1992) and the Anglican (1994) churches.

The rate at which improvements and physical transformation of the urban area will occur in future remains to be seen. Nevertheless, one thing is certain. The University of Nigeria, Nsukka will continue to dominate the urban landscape and constitute her main economic base for the foreseeable future.

1.3.5 Residential Structure of Nsukka Urban Area

Politically and administratively (especially for the 1963 census) Nsukka urban area is divided into four main wards. These wards are Nru, Nkpunano, Onuiyi and Ihe and Owerre (see Fig. 4). Each of these wards is made up of a number of villages. To these four, we added the district wards of UNN and GRA which were regarded as separate enumeration units during the 1991 census exercise. These wards are considered relevant to the present study because they:

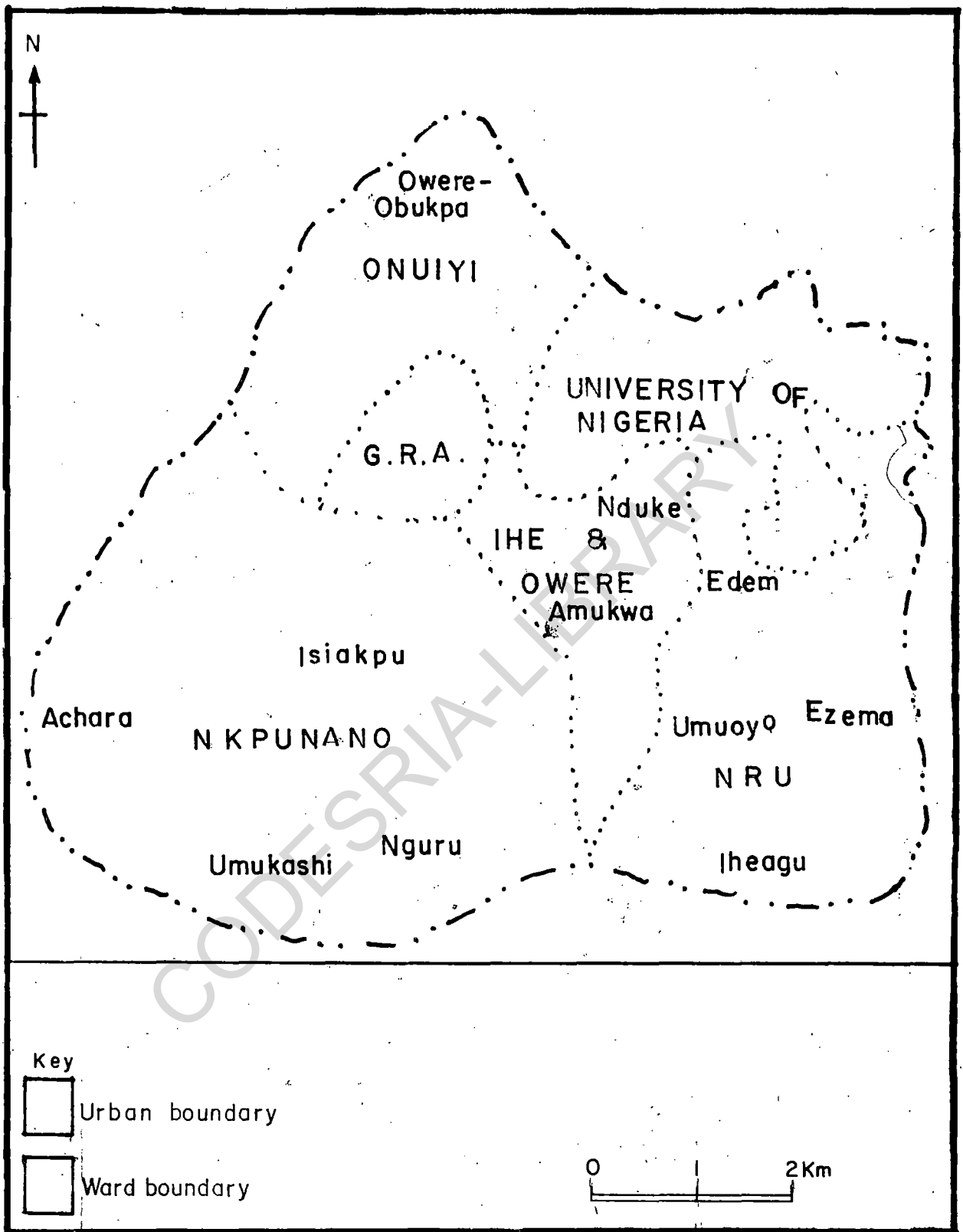


Fig. 4: The six wards of Nsukka

1. Cover the entire urban area.
2. Largely respect physical, political and historical boundaries as far as they are considered important for this study. These wards are further described below:

1.3.5.1 Nru

Nru is an old residential area located in the eastern part of Nsukka urban. It includes the villages of Iheagu, Umuoyo, Ezema and Edem (see Fig. 4). The houses in this area are mostly bungalows, many of which are old. Most of the bungalows have separately detached kitchen and lack modern facilities like taps, water closet system, good roads, and even light. Most of the residents here are of the low income group, being mainly petty traders, artisans, teachers and natives - who are mostly farmers. Nru ward occupies an area of about 3.01 sq. kms.

1.3.5.2 Nkpunano

Nkpunano ward lies in the South Western part of Nsukka urban and includes the villages of Nguru, Umuakashi, Isiakpu and Achara (see Fig. 4). It occupies an area of about 5.02 sq. kms, and is, therefore, the largest ward in Nsukka urban. Many of the houses found here are bungalows but a good number of storied buildings also exist. Some of the houses are self-contained and possess modern amenities like water taps, good roads and light. In general,

this area has a lot of open spaces. Both the low, middle and high income workers reside in this area.

1.3.5.3 Onuiyi

This is a high density residential area which lies closest to the University of Nigeria, Nsukka on the northern and western sides. This residential area occupies an area of about 2.32 sq. kms, and covers parts of Ero Uno, Edem Ani, Obukpa, Onuiyi and Ukwuama villages, (see Fig. 4). Many of the houses here are products of modern architectural designs and possess modern amenities. Modern bungalows and storied buildings co-exist side by side, with a number of old bungalows which usually contain numerous rooms. Middle and low income workers (mostly University staff) reside here.

1.3.5.4 Ihe/Owerre

This ward lies almost at the centre of the urban area. It occupies an area of about 1.16 sq. kms, and is, therefore, the second smallest ward in Nsukka urban area. It covers the villages of Owerre Ani, Ugwuogbodun, Ama Ukwu, and Nbuke. The houses here show a delicate mixture of bungalows and storied buildings, and of modern and old architectural designs. Most of the residents are directly engaged in commerce (trades and artisans), though salaried workers and students also reside at the periphery. The outstanding

character of this zone is the high housing density and lack of open spaces.

1.3.5.5 The GRA

The GRA lies almost at the centre of the urban area and occupies an area of about 0.61 sq. kms. It is, therefore, the smallest ward within the study area. The entire land area belongs to two villages (Ameze and Achara Ani), though the area is now devoted almost exclusively to government offices and staff quarters. The residential houses are mostly bungalows, with archaic colonial architectural designs. A few of the houses are self-contained with modern facilities like taps, and water closet system. The outstanding character of this ward is its openness and low housing density. Low and middle income salaried workers reside here.

1.3.5.6 The University (of Nigeria) Ward

This ward lies in the North Eastern part of Nsukka urban and its land area was carved out of Nru, Ihe/Owerre, Obukpa and Orba communities. It occupies an area of about 1.32 sq. kms. A great variety of buildings exist here. First, we have modern bungalows and storied buildings which house the University staff. Secondly, there are . . . buildings (mostly storied) which house the 10

academic Faculties and Departmental buildings, laboratories, offices, and business centres. The third group are the imposing hostels, which at present have about 15,000 students. Most of the residential houses are self-contained and possess modern amenities like taps, water closet system and 'boys' quarters. The houses here are often set in the midst of large lawns. A large proportion of University staff and students reside within the University.

1.4 Literature Review

Attempts to isolate and critically analyse the variables which influence the quantity of residential water demanded and supplied to urban areas is perhaps as old as recorded history. History informs us that during all the ages, urban areas, especially large ones, have been concerned with their level of water demand and supply (De-Rocy, 1969). Even the ancient 'towns' of Mesopotamia soon found that, as a result of increasing population, the existing local sources of supply (rivers shallow walls, lakes, and rain catchment) were unable to meet the very modest domestic demands of the day. The inhabitants were, as a result, forced to build aqueducts to bring water from distant sources (Ani, 1980).

Similarly, Stell (1960) noted that Roman Provincial cities laboured under severe handicap of limited supply as a result of increased population, low technology and the varied uses of this

resource in their industrial agricultural and municipal life.

Many later studies have focussed attention on individual urban areas, particularly the residential sector. As a result, residential water demand and supply in the residential sector has been more widely studied than in the industrial and commercial sectors (Goltlieb, 1963; Morgan, 1973; Danielson, 1979; Chime, 1984; and Ibeziako, 1985). These scholars have, with varying degrees of success, tried to isolate and analyse the factors which best account for the level of residential water demanded and supplied in their areas of study.

For example, Headley (1963) working in San Francisco - Oakland Metropolitan city (U.S.A.) studied the effect of price and income on residential water demand and noted that quantity of residential water demanded is mostly a function of population size and the type of urban development. He criticised the emphasis on income and price as factors affecting residential water demand in urban areas because of the high inflation being experienced in many nations. He was, however, of the view that price, just as other factors (eg. household size) still play a role in residential water demand.

However, another worker (Goltlieb, 1963) in a more challenging study, re-examined the contributions of price and income in

determining the quantity of residential water demand more critically and concluded that the two are major determinants.

In a similar study, Howe and Linaweaver (1967) studied the effect of household size on residential water demand. They used individual households as units and found that the number of persons per dwelling unit is a significant determinant of the quantity of residential water demanded. In agreeing with Howe and Linaweaver on the effect of household size on residential water demand, Danielson (1979) observed, after a related study, that household size consistently explains more variations in household water demand than any other factor. His calculated correlation coefficient which related water demand and household size was 0.74.

In a related study, Wang (1972) showed that household income was a significant factor affecting residential water demand. He used the cross sectional and temporal model to analyse the effects of income in household water use in Chicago, and his findings were in line with those of Goltlieb (1963) which showed that household income and price are major determinants.

In a related study of the socio-economic factors affecting domestic water demand in Israel, Darr, Feldman and Kamen (1975) discovered that income and its surrogates are important predictors of residential water demand. Variables also identified to be valid

predictors of a residential water demand forecasting model included such factors as the number of persons per family, cultural origin, educational level of the head of the household, and the number of persons per household. In support of Darr, Feldman, and Kamen (1975) and Danielson (1979), Lee (1979) in a study in Bombay (India) found that the factors which affect residential water demand include the level of income, water use habits, housing conditions and household size.

For most urban areas generally, Twort, Heather, and Law (1974) are of the view that the demand for residential water varies according to the standard of living of the country. They concluded that the factors which affect residential water demand include the amount consumers are called upon to pay, the extent of leakage in the network, the type of supply provided and the physical limitations of the distribution system.

In Nigeria, studies in residential water demand include those of Akintola and Areola (1980), Ani (1980), Toro (1980), Ani (1981), Chime (1984), Wanah (1984), Ibeziako (1985) and Ezenwaji (1990).

Chime (1984) in a study of Abakaliki town, discovered that price of water, the educational attainment of the head of the household, and income are the significant variables affecting residential water demand. In a related study, Ibeziako (1985)

using the factor analytic technique identified the six factors which influence residential water demand in Enugu urban areas: as dwelling type, frequency of water supply, the educational level of the head of the household, the density of the public taps, the distance of streams from the household, and the household size,

Presently, studies in residential water demand have been carried out in many Nigerian urban areas, Lagos (Mabogunje, 1961), Ibadan (Akintola and Areola, 1980), Kano (Ahmed, 1984), Abakaliki (Chime, 1984), Enugu (Ibeziako, 1985) and Onitsha (Ezenwaji, (1990)). The findings of these studies, as shown earlier, are not radically different from those in other parts of the world.

Studies in other sectors (industrial) included those of Mabogunje, (1961), Bower (1966), De Rocy (1974), Macuen (1975), Ayoade (1981) and Ezenwaji (1990). A common findings in these studies is that the volume of industrial output and price of water are significant factors affecting industrial water demand. Macuen (1975) in his study, concluded that most factors affecting the residential water demand and consumption, such as assessed value and income, also affect industrial water demand. Similarly, Ayoade (1981) noted that the type, size and location of industry are factors which influence industrial water demand and consumption in Nigeria. The result of this study was very similar to another one which was conducted almost twenty years earlier in Lagos (Mabogunje, 1961). Here, Mabogunje (1961), noted that the type and

size of industrial establishment are some of the factors influencing industrial water demand and consumption.

Water demand and consumption by commercial establishments is an important, yet little understood element in the urban water supply industry. There is a present dearth of literature on commercial water use in urban areas. A few workers, however, have either emphasised the need for, or carried out limited studies on water use by commercial establishments (Headley, 1963; Whiteford, 1972; Morgan, 1974; Macuen, 1975; and Ezenwaji, 1990). Headley (1963) for example noted that water use by commercial establishments require closer study. He criticised the attempt to use factors affecting residential water use to explain that of the commercial sector. The findings of Whiteford (1972), Morgan (1974), Macuen (1975) and Ezenwaji (1990) are similar in essential details. Generally, these workers are of the view that many factors affect commercial water use. Examples of such factors will include, type and size of industry, the number of persons per shift, government regulations, pricing policy, cost and change in technology, availability and regularity of supply and supply cost.

In the present study, attention will be focussed on residential water demand in Nsukka urban area. Nsukka urban area is unique. As noted earlier, no other rural savanna community of the same size/history, has been within a very short time, (35 years) totally

transformed into an emerging urban centre by a major institution, influx of very highly educated people in Eastern Nigeria, students from far and wide and service staff - all in one area. One would like to examine the effects of all these on the residential water demand and supply situation, and assess the water use habits of the University residents and other wards within the urban and other wards within the urban area. Attempts will, indeed, be made to isolate and analyse the significant factors which affect patterns of water supply and demand in order to suggest suitable strategies for meeting the people's water needs. This study will, hopefully, bridge some of these gaps.

1.5 Theoretical Framework

Theories are important in studies involving economic growth, planning, prediction and development in various ways. First, sound theories to a large extent, influence the development of strategies that are usually adopted. Secondly, they help in identifying for the planners and policy makers the crucial variables needed for prediction and development. Most importantly, such theories are crucial to researchers because they help them in formulating hypotheses for investigation and verification (Mabogunje, 1965).

In view of this importance, we shall review some relevant theories of urban water and sectoral water demand and forecasting, and analyse their limitations and implications if adopted for planning purposes.

There are two basic water forecasting theories that are frequently employed in urban water demand analysis (Mitchell, 1979). One is the trend based on extrapolative approach or what is often referred to as the requirement approach. In this approach, projections for future residential water demand are based on past consumption data. The requirement approach is computed by multiplying per capita water consumption by projections in population (Bower, 1966). Some workers in Nigeria have employed this theory (Ani, 1980; Ayode, 1984). But the use of this theory for water demand and as a forecasting tool, has attracted a number of criticisms from researchers. For instance, Foster and Beattie (1979) noted that the assumption that population and per capita water consumption determines the quantity of water demand for the future seems to blanket some other important factors, such as price, consumers income and physical and economic variables which affect water demand and consumption patterns.

In contrast to the above, the second technique which is often referred to as the component approach is more challenging intellectually, but approximate more to reality. Here attempts are made to understand why water consumption fluctuates over time (Ayode, 1984). In this method, factors which are likely to influence water demand are identified and measured, and their likely effect on future changes are assessed. The major assumption here is that future changes in each component are predicted separately and aggregated. This technique has relevance and is often employed (Danielson, 1979; Chime, 1984).

Water, in the words of Saunders and Warford (1976) is both a consumption and an investment good. It is an investment good in that it is part of local infrastructure and can indirectly generate additional future economic activity by attracting and assisting local commerce and industry. This commodity can not, therefore, be replaced by any other substance. Because of this, it is of very high demand by man, and in fact, the demand tend to be perfectly inelastic. Despite this, the quantity which consumers are able to purchase and consume are undoubtedly influenced by certain variables. It is for this reason, that the component/demand and supply technique, graphically explained by Lipsey (1975) and profitably used by Ezenwaji (1990) is examined in details and adopted in this study.

The demand and supply theory is of the form:

$$q_n^d = D(P_n, P_1, \dots, P_{p-1}, Y, T) \dots \dots (1)$$

Where

q_n^d is the quantity which consumers demand of some commodity labelled "P"

D is the functional notation

P_n is the price of the commodity

$P_1 \dots P_{n-1}$ is the short hand notation for price of other commodities.

Y is the consumers income

T is the taste of the consumers.

To accurately measure the influence of the specific variables scholars (Ezenwaji, 1990; Artken, Duncan and McMahon, 1991) often hold the terms on the right hand of equation "1" constant. Then one factor, example price (P_n) is allowed to vary, to enable the researcher measure how the quantity demanded (q_n^d) will vary with such variations, on the assumption that other things remain unchanged (Ezenwaji, 1990). Other factors (eg. income) may be allowed to vary so that its influence on the quantity demanded may be assessed.

This theory is frequently employed by researchers. Howe and Linaweaver (1976) used it to empirically assess how the quantity of water demanded responds to variations in price. The influence of other variables which are assumed to be significant determinants of the quantity of water demanded and consumed in urban areas

(eg. household size, consumers income, etc.) can equally be assessed in line with the above. Warford (1966), Aitken, , Ducan and McMahon (1971) had previously commented on the effectiveness of this theory.

The demand analytic, theory, though appealing has a few shortcomings. The mechanism of holding other things constant is not always in consonance with reality. But there is considerable truth in the proposition of the model. Urban water demand studies Lagos (Mabogunje, 1980), Ibadan (Ayode, 1984), Enugu (Ibeziako, 1985) and Onitsha (Ezenwaji, 1990) have shown that a number of social, economic, physical and environmental factors such as price, income, household size and population increase, etc. Secondly, this theory can easily be applied to any urban area, irrespective of the size and level of development, with producing erroneous results. Errors can only result from application rather than from the conceptual framework. It is for these reasons that we are attracted to it. A basic assumption in our present work is that the quantity of water consumed within the urban area is in accord with the nature of factors affecting the demand for water in the various wards of the study area. For this reason, we have introduced variables which may affect the quantity of water demand in each ward for analysis. The factors which we consider relevant in influencing the demand in the various wards are as follows:

1. the size of the household.
2. the household income
3. the educational attainment of the head of the household.
4. the availability of water taps in the residence.
5. the availability of water taps in the residence.
6. the number of hours tap run in a week.
7. distance to the nearest public water supply source.
8. the number of water using appliances in the home.
9. the number of water consuming appliances in the house.
10. the occupation of the head of the household.
11. quantity of water used for cooking per day.
12. quantity of water used for general house cleaning.
13. availability of water vendors.

1.6 Research Methodology

Central to this study, is the identification of the more significant variables in the residential water demand/supply situation in an emerging urban area, like Nsukka. It will highlight in a spatial context, the scope and intensity of the Nsukka urban water supply problems.

To achieve its stated objectives, we adopted and used the long existing wards (see Fig. 4) which cover the entire urban area, and were delineated based on traditional boundaries and population size

(Eze, 1976; Okite, 1976). Each of these wards is regarded as a sample stratum or unit and sampling was carried out in them.

First, a housing survey was carried out in each of the wards.

Reliable data on the quantity of water demand and consumed, and the factors which influence household water consumption patterns were collected through the use of questionnaire, oral interview and field observations. The questionnaires consist of 17 items, made of brief statements reflecting the various dimensions of water demand and supply. Table 2 shows the housing distribution and patterns of questionnaire returns.

Table 2: Housing Distribution and Patterns of Questionnaire Returns

| S/No. | Wards | Number of Houses | Number of Questionnaire Distributed | Number Returned | Percentage of Return (%) |
|-------|--------------|--------------------|-------------------------------------|-----------------|--------------------------|
| 1 | UNN | 360* ^a | 90 | 75 | 83.3 |
| 2 | Onuiyi | 4004* ^b | 180 | 118 | 65.6 |
| 3 | GRA | 174* ^b | 70 | 50 | 71.4 |
| 4 | Nru | 4104* ^b | 160 | 116 | 72.5 |
| 5 | Nkpunano | 4251* ^b | 230 | 153 | 66.5 |
| 6 | Ihe & Owerre | 4953* ^b | 270 | 168 | 62.2 |
| | | 17,846 | 1,000 | 680 | Mean 68.3% |

Source: (a) Registry Dept. U.N.N. (for *^a)

(b) Town Planning Unit, Nsukka (for *^b)

Two basic sampling techniques were employed. These are, the stratified sampling technique and the simple random sampling method. Stratified sampling was adopted because it permits comparison between different wards (Danielson, 1976; Ree, 1987). Random sampling was used in each ward to ensure that each household has an equal chance of being selected. The effectiveness of these two methods has been highlighted by Saunders and Warford (1976).

The direct delivery technique was used to administer the questionnaire to the respondents in the six wards of Nsukka urban area. This method assures prompt and efficient completion and return of questionnaires (Saunders and Warford, 1976). In each of the houses visited, only the head of the household was selected for interview. Our definition of the head of the household followed Ibeziako (1985) as a married person with a family, or an unmarried person of at least 20 years, living alone and earning an income. The problem of suspicion and hostility to household interviews was overcome through the use of familiar or local residents as assistants. On the whole, 1,000 questionnaires (see table 2) were administered. Some of the households did not return their questionnaire, as a result, it was not possible to recover the 1,000 questionnaires distributed. A total of 680 (or 68%)

questionnaires on residential water demand were returned. This is considered representative of the urban area.

Relevant data concerning the quantity of water actually supplied, the distribution systems, existing supply problems and their relative contributions, . were obtained from the public water works units and distributional centres, through the use of a carefully designed questionnaire (Appendix A²), and oral interview. Oral interview was particularly effective in obtaining relevant and detailed information on the limiting factors to effective delivery of water to the various wards in Nsukka urban area.

Similarly, a third set of questionnaire were designed and administered on water vendors (commercial suppliers) within the study area (Appendix A³). From these, we were able to obtain a reasonable estimate of their relative contribution to the peoples water needs.

Finally, field observations, such as visits to public pump stands, areas within the study area where water scarcity is acute, public water works units, etc. helped to keep us abreast of the actual situation of things in the Nsukka urban water supply industry. Additional information were obtained from secondary sources, such as the consultation of official documents, government reports and records and from library research.

1.7 Plan of the Project

This study is divided into six chapters. The chapters are carefully planned to display a sequential progression of thought and development from the introduction, through the findings, to the conclusion and recommendations.

The first chapter is devoted to the general introduction. This chapter is subdivided into seven sections. The first section deals with the statement of the research problem, while the aims and objectives of the research are spelt out in section two. Section three deals with the study area as it relates to the subject matter. This section is discussed under six sub-headings, namely: location, relief and drainage, climate, vegetation, growth and development and residential structure (of the Nsukka urban area). The remaining sections in this chapter deal with the literature review, theoretical framework, research methodology and the thesis plan.

Chapter two follows suit with a detailed examination of the sources of water supply in Nsukka urban area. The sources of water supply in Nsukka urban area is divided into three, namely: the Nsukka urban water corporation, the University of Nigeria Water Works unit (i.e. Works Department), and lastly from raincatch, springs and commercial suppliers. Coming immediately after this, is an analyses of the capacity of the existing boreholes, the location

and catchments of the present reservoirs, the distribution network and the areal extent of the urban landscape that is fed by gravity flow and by boosting. Lastly, in this chapter, is a summary of the relative contributions of the existing sources of supply to the people's water needs.

The patterns of water demand and supply in Nsukka urban area is discussed in chapter three. This chapter starts with an examination of the temporal trends by both the Nsukka urban water supply corporation and the University of Nigeria water supply unit. The causes of the shortfalls in target production quantities are identified and discussed. Next to be discussed here is the spatial inequalities in piped water supply in Nsukka urban. We started with an examination of the proportion of the people served by piped supplies, the piping system alternatives for households without piped supplies, the limitations of the existing alternatives, and the intensities of piped supplies in Nsukka urban. This is followed by an examination of the water demand and consumption patterns and the relationship between the two. Both the total household and per capita water demand and consumption are found for all the wards within the study area. The demand and consumption patterns are then compared in between wards and then with the federal government of Nigeria standard minimum of 115 litres per capita per day.

Chapter four is on the analyses of the factors which affect water demand in Nsukka urban. The factors which affect household water demand are identified, parametrised and analysed. The results of the analysis are discussed to show existing patterns and relationships.

Chapter five is on the strategies for improved water supply in Nsukka urban. The suitability of otherwise, of the existing strategies for urban water supply are examined and evaluated.

Then, the need for alternative strategies for improved urban water development in Nsukka are advanced. The suggested strategies as well as the on-going programmes for improved water supply in Nsukka urban are also examined in great details.

Finally, the summary of the major findings of this study, the conclusions and recommendations are discussed in chapter six.

CHAPTER TWO

SOURCES OF WATER SUPPLY IN NSUKKA URBAN AREA

Municipal water supply in Europe and America is principally the responsibility of the public works department (Rees, 1982). Consequently, most works on urban water demand in these developed areas usually treat the urban area as a sort of 'closed system' where the only source of water supply is from the municipal water works units (Ibeziakc, 1985).

In developing countries, such an approach may be misleading (Ezenwaji, 1990). This is because public water work departments in developed countries usually operate on 'perfect supply situations' (i.e., adequate and uninterrupted supply), but in developing countries, the situation is generally different. Here the public water works units do not generally supply enough to meet the water needs of the people (Ezenwaji, 1990). In view of this, the consumers are forced not to depend on public water works units entirely.

There is, in Nsukka urban area, a general absence of surface drainage (streams, rivers, lakes and wells). This is due to the fact that the area is underlain by the false-bedded sandstones and the upper coal measures. The false-bedded sandstones are porous, highly permeable and thus greatly facilitate the infiltration of rain water (Ofemata, 1978). In view of this, it is correct to

asset that (though, there are several sources of water in Nsukka) the most reliable source of municipal water (for Nsukka urban) is ground water, i.e. the water occupying the voids within a geological stratum (Nwachukwu, 1978). Ground water possess a number of desirable attributes which make it an attractive and often preferred source of water supply. For example, groundwater is more widely distributed than surface water (Headley, 1963). In addition, it offers a naturally purer, cheaper and more satisfactory source of water than do surface water (Ezema, 1995). It is generally available at the point of use and this reduces the need for incurring large transmission costs (Ezema, 1995). Apart from these, groundwater for Nsukka has other factors recommending it. First, the water table is close to the surface (mean depth is between 90 and 125 meters only and the average yeilds from the water table boreholes is high (2,045 litres per hour). Groundwater occurs widely as underground reservcoirs within Nsukka urban and the application of modern mechnical drilling technology now enables much of it to be drawn from the aquifers, for municipal and other uses.

Presently, most of the water used by the Nsukka urban dwellers is obtained from these underground aquifers. There is almost a total dependence (especially during the dry season) upon mechanically-pumped borehole supplies due to the general absence of reliable

alternative sources, as stated earlier. There are, at present, two borehole systems operating in the Nsukka urban area. These are:

1. The boreholes operated by the Nsukka urban water corporation and
2. The boreholes operated by the Works Department of the University of Nigeria, Nsukka.

2.1 The Nsukka Urban Water Corporation

As noted in chapter 1, section 1, the establishment of the University of Nigeria, Nsukka in 1960, and the general lack of readily alternative sources of supply (streams, rivers, lakes) provided the initial motivation for the establishment and expansion of borehole supplies in Nsukka urban area (Ugwu, 1964; Okite, 1978).

Presently, the Nsukka urban water corporation runs a borehole farm which is located near the University of Nigeria gate. Water supply to all the wards within the urban area, excluding only one (the University community), comes from this borehold farm. Currently, the borehole farm has twelve (only 3 are functional) boreholes numbered 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11 and 12. The earliest set of drilled boreholes (Nos. 1, 2, 3, 4 and 5) have since been out of use (dried up). Boreholes, numbers 1, 2, and 3 were declared 'dead' in March 1973, while borehole numbers 4 and 5 continued to function until the middle of 1979. Currently, two of the existing boreholes, (number 8 and 12) have not functioned since

the middle of June 1993. Borehole number 8 has now (1996) been certified 'dead' (i.e. reactivation is uneconomical) while borehole number 12 does not have a submersible (sumo) pump installed in it.

The average production from the (3) functional boreholes at present is between 140,000 litres and 150,000 litres per hour (Eze, 1995). The yield from these boreholes are emptied into a 275,000 litre ground level concrete service reservoir (located behind pump house, No. 1, Fig.5) which also acts on the suction tank. Presently, there are three pump houses, controlling the various units involved in urban water generation and supply in Nsukka. A breakdown of this is shown in table 3.

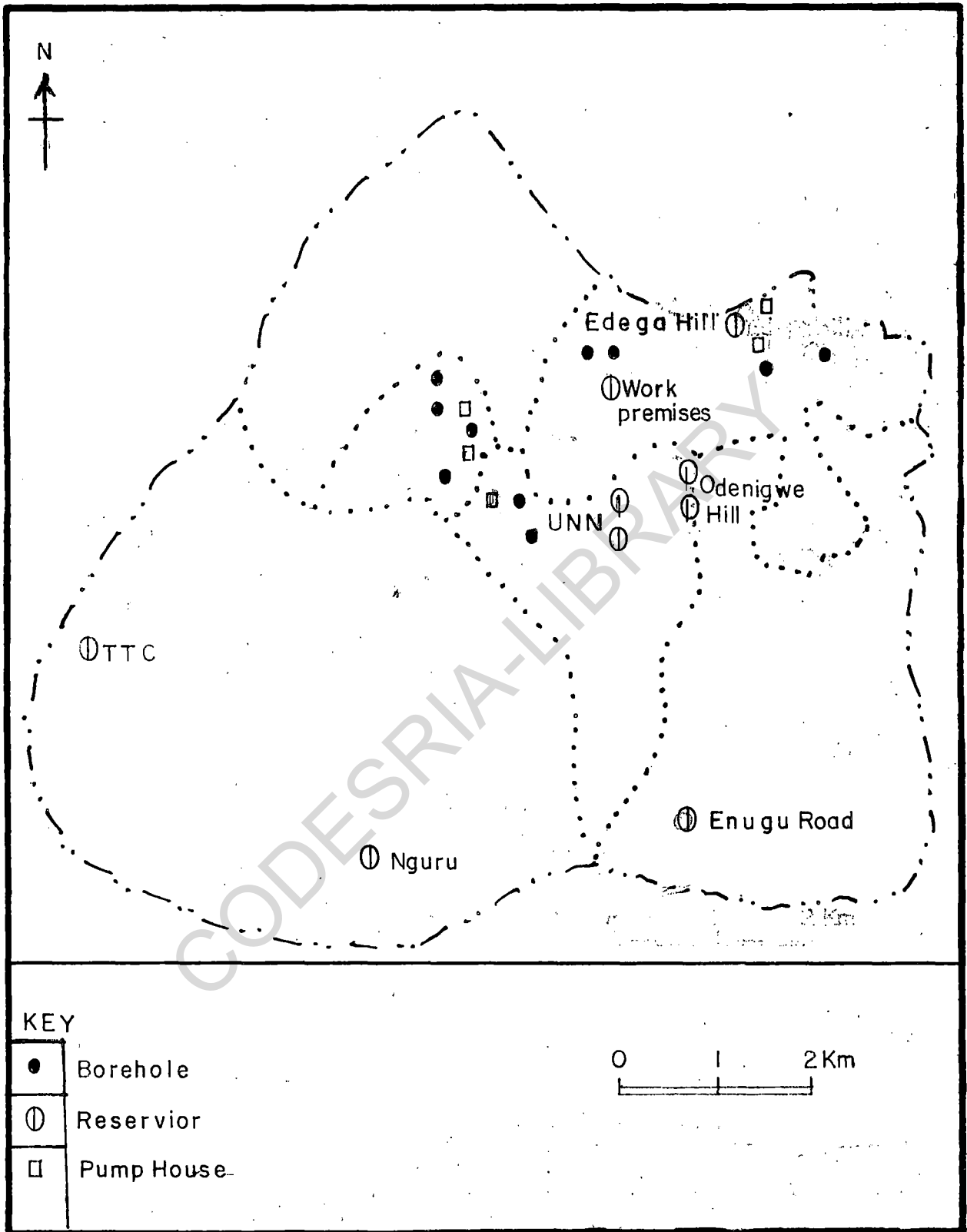


Fig.5 : Nsukka urban major reservoirs

Table 3: Pump Houses and Units of Urban Water Supply Controlled

| S/No. | Pump House Number | Units Controlled | Combined Yield per Hour | Source of Power |
|-------|---------------------|---|-------------------------|---|
| 1 | Pump house Number 1 | Borehole number 7 and 11 and surface booster number 1 & 2 | 76,000 litres per hour | Public power supply through 500 KVA transformer |
| 2 | Pump house Number 2 | Surface booster pump No. 3 and borehole Number 8 | 30,000 litres per hour | Public power supply through 312 KVA transformer |
| 3 | Pump house Number 3 | Boreholes number 9, 10 and 12 | 44,000 litres per hour | Public power supply through 630 KVA transformer |

Source: Nsukka urban Water Corporation.

2.1.1 Capacity of Existing Boreholes

The existing boreholes operated by the Nsukka urban Water Corporation have a combined total capacity of 720,000 litres per hour and an installed capacity of 16,280,000 litres a day.

Unfortunately, only two boreholes (numbers 7 and 9) are presently (fully) functional. Even these two operate only for a few hours daily as a result of financial, technical and social factors which are examined in detail in chapter III. Table 4 shows details of

the location and capacity of the existing boreholes in Nsukka urban area.

Table 4: The Location and Capacities of the Existing Boreholes in Nsukka Urban

| S/No. | | Operating Agency | | Total |
|-------|---|--------------------------------|----------------------------|--------------------------|
| | | Nsukka Urban Water Corporation | Works Department of U.N.N. | |
| 1 | Total number of boreholes | 12 | 6 | 18 |
| 2 | Number of functional boreholes | 3 | 3 | 6 |
| 3 | Daily average number of hours operated | 8 | 12 | 20 |
| 4 | Average Quantity yielded per hour | 60,000 litres | 46,667 litres | 106,667 litres |
| 5 | Average total capacity per day | 4,947,5000 litres | 1,728,000 litres | 6,675,000 litres |
| 6 | Installed capacity per day (litres) | 5,367,500 litres per day | 3,888,000 litres per day | 8,255,500 litres per day |
| 7 | Average daily amount produced in litres | 4,420,000 litres per day | 1,625,000 litres per day | 6,045,500 litres per day |

Source: Field Work 1995/96.

The six functional boreholes (see table 4) are capable of yielding 106,667 litres per hour and 8,255,500 litres per day. Presently, they yield 6,045,500 which is below the combined daily average of 6,675,500 litres per day.

2.1.2 The Urban Reservoirs

The water pumped from the six functional boreholes is held in storage reservoirs for eventual distribution to various parts of Nsukka urban area. At present, the urban area has a total of nine major reservoirs (owned and operated in proportion shown in Table 5). The nine reservoirs have a combined storage capacity of 5.2 million litres. The official catchment area is 13.44 sq. kms, but the dependence of people from surrounding villages (Obukpa, Orba, Ovoko, Edem and Ede Oballa) on the urban water sources will mean that almost 26 sq kms are served by the Nsukka urban water corporation.

Table 5: Major Reservoirs in Nsukka Urban

| S/No. | Location | Capacity (in litres) | Official Catchment Area (Words) | Make | Remarks |
|-------|----------------------------|-------------------------|---------------------------------------|-------|----------------|
| 1 | University Road | 750,000 | Onnuiyi/GRA | RC* | Functional |
| 2 | Nguru | 250,000 | Nru | RC* | " |
| 3 | Amaozara Road | 250,000 | Nkpunano | RC* | Not functional |
| 4 | Enugu Road | 200,000 | Ihe & Owerre | Steel | Functional |
| 5 | T.T.C. Road | 200,000 | Nkpunano | Steel | Not functional |
| 6 | Odenigwe Hill | 688,000 | U.N.N. | RC* | Functional |
| 7 | Odenigwe Hill | 688,000 | U.N.N. | RC* | " |
| 8 | Works Premises (U.N.N.) | 909,000 | U.N.N. | RC* | " |
| 9 | Edega Hill | 1,310,000 | U.N.N. | RC* | Functional |
| Total | | 5,245,000 | | | |

Source: Nsukka Urban Water Corporation.

Works Department, U.N.N.

*RC = Reinforced concrete.

The reservoirs range in capacity from the smallest (200,000 litres) one on Enugu Road, to the largest (1,310,000 litres) one on Edega Hill in the University of Nigeria.

Most of the reservoirs within Nsukka urban area are located on relatively high elevations where they can pump water to consumption areas by gravity through a network of pipelines which will be discussed in the next section. Low level reservoirs have also been established within the Postgraduate hostels and Faculty of Engineering complexes of the University of Nigeria. In addition, mini reservoirs of capacity between 25,000 and 75,000 litres have also been installed for the various undergraduate hostels within the University.

It is important to note (see Table 5) that about 44% of the available reservoirs in Nsukka urban were established to serve the University of Nigeria. In addition, all the reservoirs established by the University are functional (though at varying capacities) two of the reservoirs established by Nsukka urban water corporation (TTC and Amozara Road reservoirs) have been out of use since April 1993. Reasons for this, range from their great distance from the pumping houses, high elevation, insufficient power for pumping water, to constant booster pump breakdowns.

2.1.3 Distribution Network

Water distribution network has been defined by De Mayor and Horwitz (1954) as all the water work components for the distribution of portable water by means of gravity or pumps, through a

distribution piping network to consumers and other users. In their own contribution, Fair and Goryer (1970) described the distribution network as a system of conduits or pipes which range in diameter from a maximum of 250 mm to a minimum of 25mm. Water from the boreholes is first of all pumped to the booster houses from where it is distributed to the various reservoirs. The distribution system is by both boosting and gravity flow. The low lying areas of Nsukka urban, relative to the service reservoirs, are fed by gravity flow. The areas include Onuiyi and the University community wards. This ^{is} made possible by the fact that the service reservoirs that serve these areas are high elevation reservoirs (example, the Odenigwe, Edega and University Road reservoirs, Fig. 5).

The remaining four wards in the urban area are fed by boosting. Booster pump number 1 has the capacity of pumping 110,000 litres of water per hour while booster pumps numbers 2 and 3 have, each the capacity of pumping 675,000 litres of water per hour respectively.

Water distribution to households in Nsukka urban, through pipelines, started in 1957, a year after the urban water corporation was established (Eze, 1995). The connection of pipes in the urban area started in the GRA in 1957 and later spread to other parts of the urban area. All the households within the University ward are

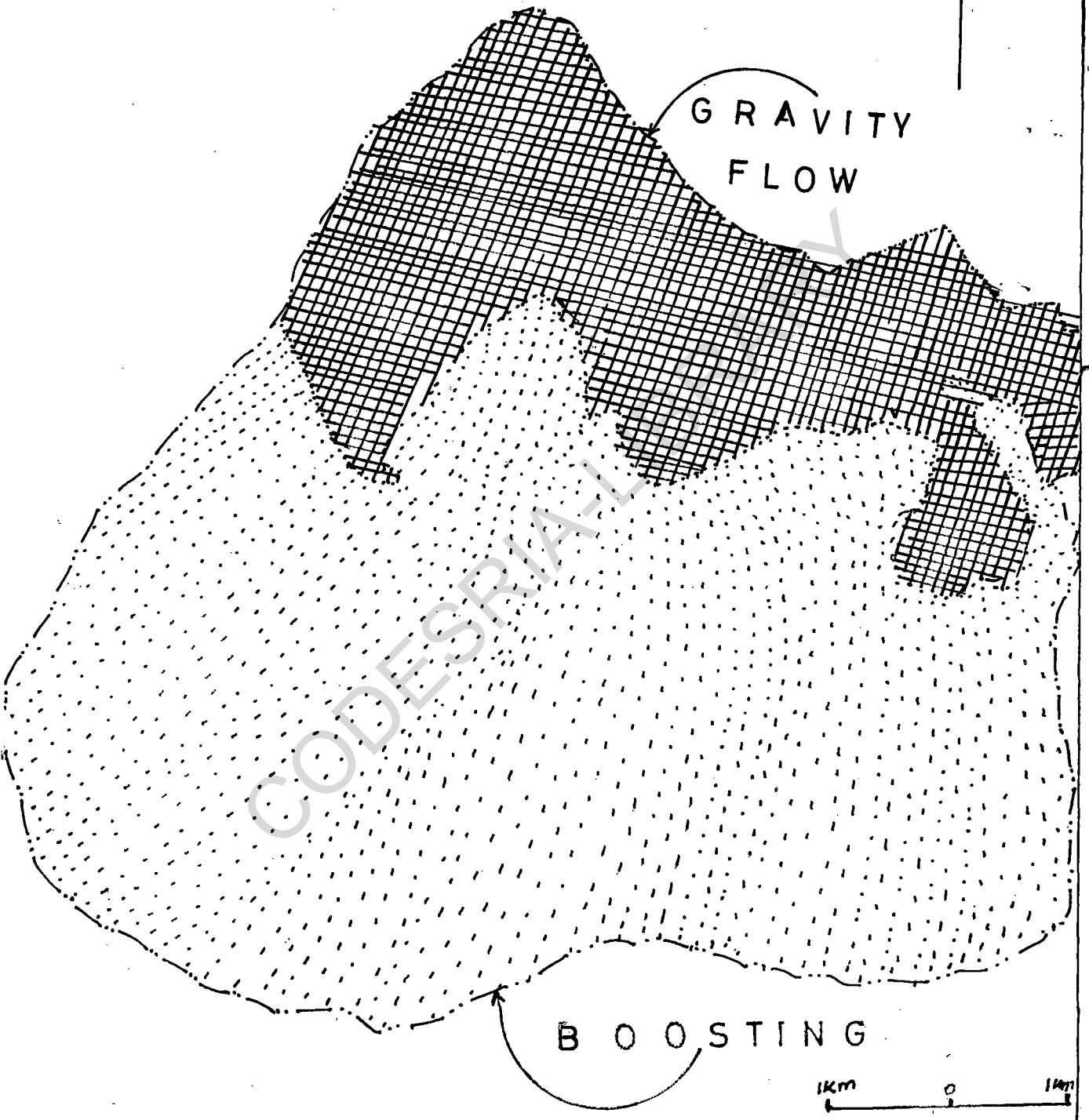


FIG 6: SYSTEM OF SUPPLY AND CATCHMENTS

connected to the network of distribution pipelines criss-crossing the University landscape. Outside the University ward, however, connection is in easy street through public tap system. Households in these remaining wards that wish to be connected make direct representations to the staff of Nsukka urban water corporation. Such households must meet a number of conditions required by the corporation.

2.1.3.1 Pipeline Distribution

Three categories of pipelines are employed by Nsukka urban water corporation. These are:

1. Distribution lines - from the reservoirs to various parts of the urban area. Here pipe diameters range from 200mm to 25mm.
2. Generation lines - from Risers to ground wells. Here, diameters range from 150mm to 100mm.
3. Boosting lines - from boosting pumps to reservoirs. Here diameter range from 250mm to 100 mm.

The distribution lines cover only about 57% of the urban area.

Some major arteries in the distribution networks are:

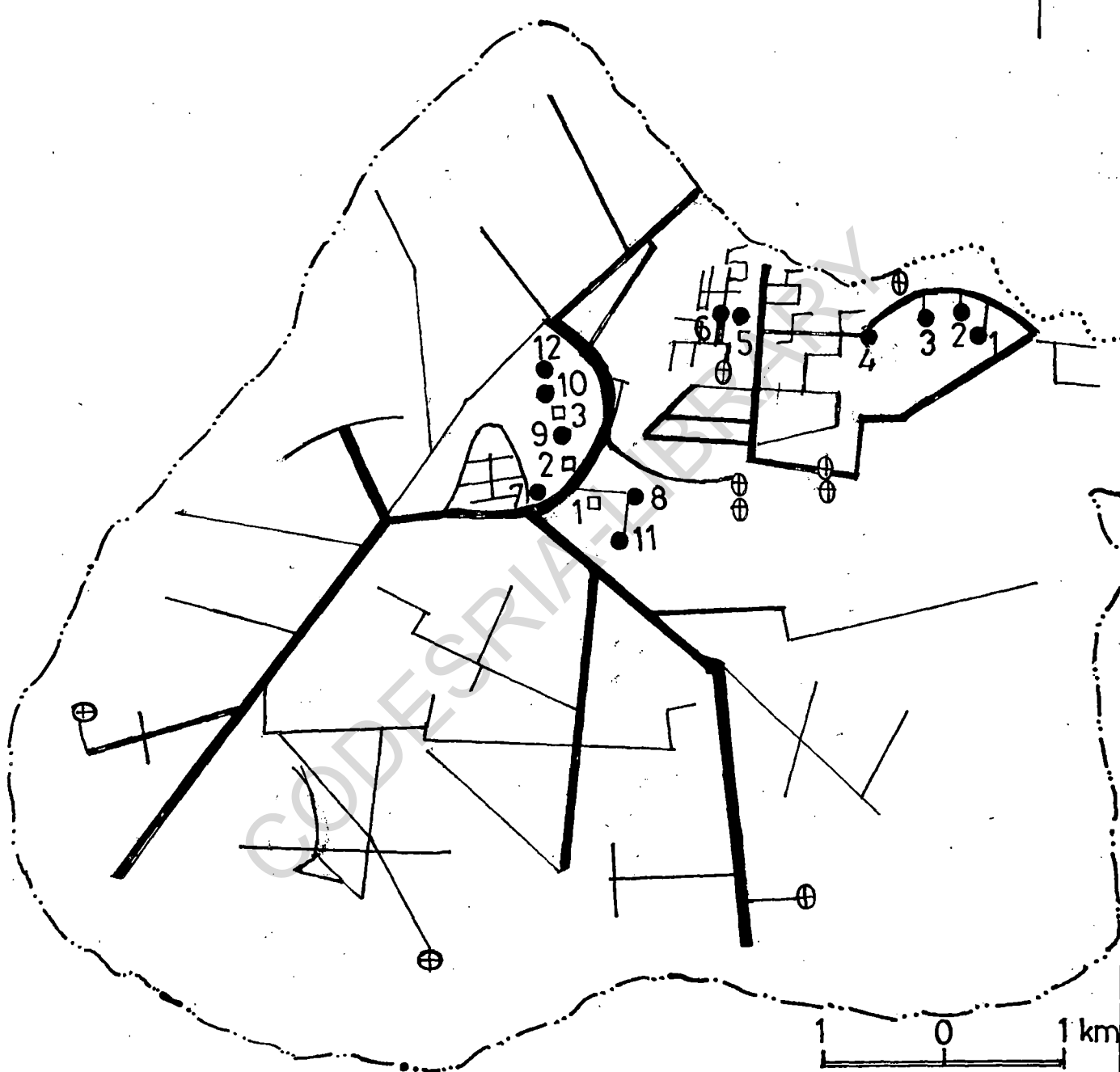
1. A 200mm asbestos pipeline running along the University road and later branching into two at the University road. Round-about - one leading to Odenigbo (terminating at Ikenga Hotel)

and the other to Enugu Road (terminating at Queens Secondary School). Another 200mm pipeline runs from Odenigwe Hill into the University community. About 58% of the water used within the University ward is distributed through these lines.

2. The second is a 150mm asbestos cement pipeline which runs from the boreholes/^{farm} through the fire service station road to Onuiyi, Ibagwa and Obollo roads. This line later branched into two 100mm AC pipes, shortly after the fire service station to various parts of Onyiyi wards.
3. Distribution lines with diameters ranging from 100mm to 25mm are connected to (1) and (2) above from where street and private connections are laid to private homes and other premises. The pipes are either surface or underground systems.

According to field investigations, water distribution through pipeline network in Nsukka urban is hampered by a number of factors such as the:

1. large quantity of water lost through burst pipes and leakages.



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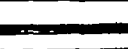



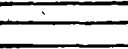

| | | | |
|---|-------------|---|------------|
|  | 200 – 250mm |  | Borehole |
|  | 150mm |  | Pump house |
|  | 100mm |  | Reservoir |

Fig. 7: Pipe-line distribution network

2. absence of properly located service reservoirs from which water can be distributed to the whole urban area by gravity after filling.
3. poor coverage of the urban area by distribution lines.
4. constant breakdowns of booster pumps and borehole faults.
5. inadequate supply of spare parts, especially pipes, valves, detachable joints, etc.
6. low power supply and constant leakages from the public (due to the use of over-aged pipes).

2.1.4 Complementary Distribution

Apart from the pipeline distribution described above, tankers are equally used by both the Nsukka urban water corporation and the Works Department of the University of Nigeria, as additional distributive source, complementing the lack of water pipes in certain parts of Nsukka urban area. Such tankers collect their water from both the urban and the University of Nigeria boreholes. Table 6 shows a summary of the quantities delivered to consumers from the University boreholes in the month of October, 1995.



PLATE: 1: The Odenigwe Hill Reservoirs - established by and to serve the University of Nigeria, Nsukka. The combined storage capacity is 1,376,000 litres.



PLATE II: water tankers are routinely used to distribute water in areas not covered by water pipelines. Note the pump house number II, and some staff of the urban water corporation at the background.

Table 6: Water Distribution by Tankers From the University Boreholes in October 1995

| S/No. | Destination (Wards) | Average No. of time per week | Total Number of times in the month | Total Quantity supplied (litres) | Rank |
|-------|---------------------|------------------------------|------------------------------------|----------------------------------|------|
| 1 | Nru | 5 | 21 | 150,500 | 4th |
| 2 | Onuiyi | 2 | 9 | 67,500 | 7th |
| 3 | Ihe & Owerre | 3 | 13 | 97,500 | 6th |
| 4 | Nkpunano | 7 | 28 | 210,000 | 2nd |
| 5 | Hostel(UNN) | 9 | 36 | 270,000 | 1st |
| 6 | Uni. Farm | 6 | 25 | 187,500 | 3rd |
| 7 | Works Dept. | 4 | 18 | 135,000 | 5th |
| 8 | GRA | 1 | 5 | 37,000 | 8th |
| Total | | 37 | 155 | 1,162,000 | |

Source: Field work, 1995.

2.2 Supplementary Sources of Water Supply in Nsukka Urban

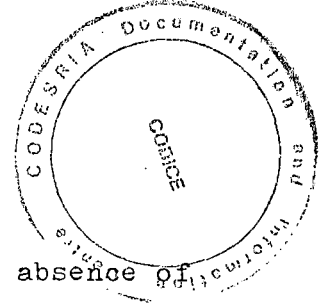
2.2.1 Private Boreholes - the University of Nigeria Water Works Department

Ideally, the University ward, being an integral part of Nsukka urban area should depend on the Nsukka urban water corporation for her normal water requirements and establishing a separate supply agency should not be necessary. But considering the current inadequacies and the frequent breakdowns in

the urban water supply system, such a policy objective would not have aided the growth of the University.

Presently, the University of Nigeria, through her separate supplementary water supply unit (the Works Services Department) plays a significant role in meeting the water needs of even the urban dwellers. The Works Services Department of the University has a total of six (6) boreholes, out of which three (3) are functional. Two of the boreholes pump 65,000 litres of water per hour. The third one pumps 25,000 litres per hour. The boreholes are between 126 and 152 metres deep and are equipped with electrically driven submersible pumping units and one stand-by generator.

Water from the boreholes are first of all pumped to the booster house located at the Agric Farm of the University, from where it is distributed to the various reservoirs. Two of the reservoirs with a capacity of 688,000 litres each are located at Odenigwe Hill. The third and largest reservoir is located at Edega hill (observatory). It has a capacity of 1,310,000 litres. The fourth reservoir is located near the Works Department premises of the University. It has a capacity of 909,000 litres and is, therefore, the second largest reservoir within the University.



2.2.2 Water Vendors

A variety of factors such as the general absence of surface drainage and shortages in supplies from the urban Water Corporation are responsible for the emergence and the continued existence of water vending in Nsukka urban area.

There are, at present, two categories of water vendors in Nsukka urban area. These are the big time water vendors and the small scale ones. The former make use of water tankers and sell mainly to water retailers. They operate mainly in Nru, Nkpunano, Ihe and Owerre wards. The small scale water vendors make use of tanks (metal or plastic) of capacity ranging between 2500 litres to 50,000 litres or drums and sell direct to consumers.

Water vendors usually collect their water from sources that are outside the urban area (- mainly from boreholes at Obollo Afor and Ovoko, and the Adada River) and operate most in times prolonged scarcity - arising, not infrequently, from borehole breakdowns. The vendors hawk their water along streets, remote from the urban supply centres, and price of the water depends on the part of the urban ^{where} the purchase takes place. The average cost of units of water (1995) in the six wards of Nsukka urban is shown in Table 7.

Table 7: Average Cost (in Naira) of Unit Measures of Water in Parts of Nsukka Urban Sept.- Nov. 1995)

| S/No. | Wards | Average Cost of 12 litres ₦ (Standard bucket) | Average Cost of 240 litres ₦ (A drum) | Average Cost of 2500 litres ₦ (small tank) | Average Cost of 50,000 litres ₦ (Big tank) |
|-------|--------------|---|---------------------------------------|--|--|
| 1 | Nru | 4 | 50 | 450 | 700 |
| 2 | Onuiyi | 2 | 25 | 280 | 550 |
| 3 | GRA | 2 | 30 | 300 | 600 |
| 4 | Ihe & Owerre | 4 | 40 | 400 | 700 |
| 5 | Nkpunano | 5 | 60 | 500 | 850 |
| 6 | UNN* | - | - | - | - |

Source: Field work, 1995.

* Commercial supplies are generally lacking.

Buying of water from water vendors is a common practice in Nsukka urban area, especially by commercial houses such as hair dressing saloons, restaurants, and dry cleaners. This is because water vendors are always available and are always willing to penetrate even the remotest parts of the urban area. This source has, however, a number of limitations such as:

1. The high prices which consumers are called upon to pay.
2. The supply of water which is often of doubtful quality - coloured water is often supplied.
3. Periodic vehicle breakdowns - as a result of the long distance between the collection and consumption centres.

2.3 Rainwater Harvesting

One of the most widespread and directly accessible sources of water is rainfall itself. Since the dawn of civilization, humanity has recognised the importance of rainfall as the primary source of water (Headley, 1963). In Nsukka urban rainfall harvesting has been practised for generations (Ugwu, 1964). To date, it is still considered as important source of supply.

Rainwater is collected during a rain storm. Various techniques for rain water collection have been devised and adapted to modern use. A number of micro-catchment systems for collecting rainwater from the roofs of buildings now exist. Paved land surfaces and depressions are often prepared (carefully) to facilitate collection. Tins, buckets, containers drums, etc are used for rainwater collection. In Nsukka urban, the well-to-do often construct channels (with corrugated iron sheets) round the roofs of their buildings to enable them

channel all the rain falling directly on such buildings to large storage tanks. Field investigations revealed that storage tanks (used for rainwater collection and storage) are common in all the wards except the University ward. Table 7 shows a summary of the availability of such large storage tanks.

Table 8: The Use of Storage Tanks for Rainwater Collection in Nsukka Urban

| S/No. | Wards | No. of Storage Tanks | Estimated Capacity (Litres) | Remarks |
|-------|--------------|----------------------|-----------------------------|-----------|
| 1 | Nru | 73 | 260,500 | High |
| 2 | GRA | 17 | 85,000 | Medium |
| 3 | Onuiyi | 34 | 135,000 | Medium |
| 4 | Ihe & Owerre | 138 | 535,000 | Very high |
| 5 | Nkpunano | 104 | 394,000 | Very high |
| 6 | U.N.N. | NA | NA | - |
| | Total | 466 | 1,412,000 | |

Source: Fieldwork, 1995.

The principal limitation of this source of water is the seasonality of rainfall. In Nsukka, rainfall starts in April and ends in November. Again, the water collected (from dirty roof-tops) may be coloured, turbid and impure - making it unfit for human consumption.

In spite of the above limitations, one can still assert that the widespread presence of iron-roofed buildings and the use of storage tanks has created a greater potential for the use of roof catchment as a supplementary source of supply in Nsukka urban area. The rainfall seasonality means that large catchment areas and storage capacities will be required if reasonable rainwater is to be collected for prolonged use.

2.2.4 Surface Drainage (Spring and River Water)

As noted earlier, there is a general absence of surface drainage in Nsukka urban, due to the high porosity and consequent high infiltration of the false-bedded sandstones on which the urban area rests. There are, however, some seasonal springs which lie within and outside the urban boundary. These south-flowing springs issue from perched aquifers (Eze, 1995) on the slopes of the upper coal measures. Most of these springs (variously known locally as "Iyi Mpi", "Iyi Edem", "Iyi Ajah", "Iyi Adoka" and "Iyi Asho") on which some of the people depend for their domestic water supply are seasonal and hardly yield any water during much of the dry season months (November to March).

Apart from the above springs, the Adada River - which cross the Nsukka Plateau is located near (about 12.5 kms) (Eze, 1995) to the Nsukka urban boundary. Adada is a perennial, south flowing river. It has its source at the upper coal measures formation (at about 365 meters contour lines (Eze, 1995)) and flows in a southwards direction until it entered Anambra river through Do and Adani Rivers. Adada and the other springs mentioned earlier are not important sources of water to Nsukka urban dwellers because of their distance from the urban area, the seasonality of some, their rough roads, and the difficult topography. Patronage of these sources is highest in periods of prolonged shortages arising from breakdowns in the urban supply systems.

2.3 Relative Contribution of the Various Sources of Water Supply in Nsukka Urban

The various sources identified and described above have their limitations. Rainfall in Nsukka is both seasonal and unevenly distributed. Although, the annual distribution of rainfall is clearly defined, with 90% of rain falling between April and October, variations from year to year can be considerable (Eze, 1976). Some urban dwellers have a clear vision of the severe limitations of this source and have devised bold

measures (use large surface and subsurface tank) to secure from this source maximum water which often lasts long into the dry season.

Similarly, surface supplies from springs and streams are quite limited, though occasional breakdown in the urban water supply system and draughts, have forced people to continue patronising these sources.

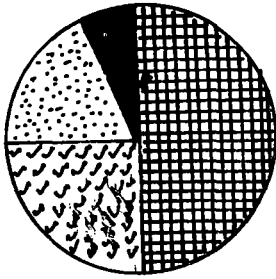
Supplies from vendors have now been sufficiently developed and water tankers, apart from hawking water along the major streets, now penetrate remote areas. Field investigation revealed that many people now patronise this source, through the quality of the supplies is often doubtful.

Borehole supplies is now dominant/popular and all the functional boreholes have a combined capacity to deliver 8.2 million litres of water to the urban dwellers daily. The limitation of this source is the frequent and often prolonged breakdowns in the supply system. Such breakdowns often force the urban water corporation to operate at below 10% capacity. In addition about 46% of the entire urban area is not covered by pipeline distribution network.

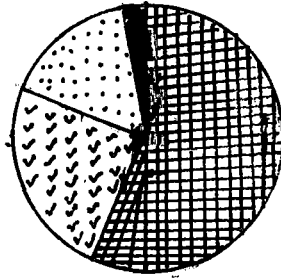
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Table 9 and figure/show the relative contributions of the various sources to the peoples water needs (between August and November 1995). To arrive at the figures, we summed up, and

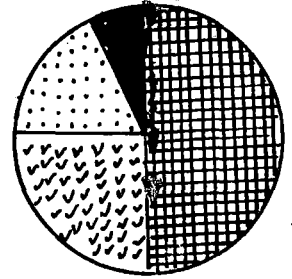
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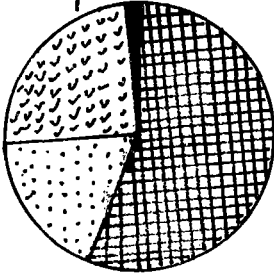
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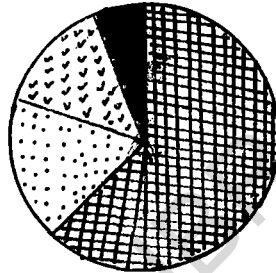
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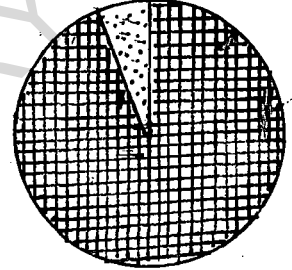
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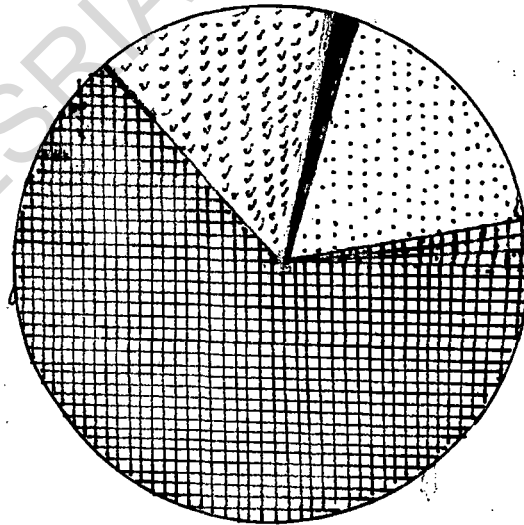
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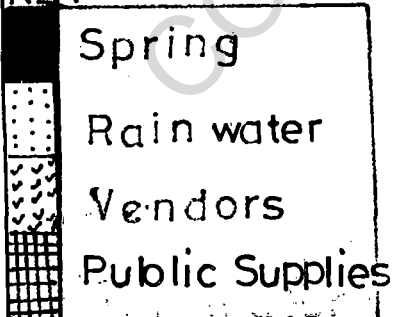


FIG. 8: RELATIVE CONTRIBUTIONS OF THE EXISTING SOURCES OF WATER IN NSUKKA

converted to percentages of the overall totals, the number of households in such ward which identified any of the sources as her "primary source of her water supply."

Table 9: The Relative Contribution of the Various Sources of Supply to the People's Water Needs

| Wards | Type of Source Available | Primary Source (%) | Remarks |
|--------------|--------------------------|--------------------|-----------|
| Nru | Urban Water Corporation | 51 | High |
| | Water Vendors | 24.6 | Medium |
| | Spring and Stream | 0.4 | Very low |
| | Rainwater harvesting | 20.4 | Medium |
| Total | | 100% | |
| GRA | Urban Water Corporation | 58 | Very high |
| | Water Vendors | 11.7 | Low |
| | Spring and Streams | 0.2 | Very low |
| | Rainwater harvesting | 22.3 | Medium |
| Total | | 100% | |
| Nkpunano | Urban Water Corporation | 50.4 | High |
| | Water Vendors | 24.0 | Medium |
| | Spring and Streams | 04.6 | Low |
| | Rainwater Harvesting | 21.0 | Medium |
| Total | | 100% | |
| Ihe & Owerre | Urban Water Corporation | 52.1 | High |
| | Water Vendors | 26.1 | Medium |
| | Spring and Streams | 02. | Very low |
| | Rainwater harvesting | 19 | Medium |
| Total | | 100% | |

| | | | |
|--------|-------------------------|------|-----------|
| Onuiyi | Urban Water Corporation | 62.8 | Very high |
| | Water Vendors | 12.2 | Low |
| | Spring and Streams | 05.1 | Very low |
| | Rain water harvesting | 19.9 | Medium |
| Total | | 100% | |
| U.N.N. | Piped Supplies | 96.3 | Very high |
| | Water Vendors | 0.0 | None |
| | Spring and Streams | 0.0 | None |
| | Rainwater harvesting | 03.7 | Very low |
| Total | | 100% | |

Source: Field Work, 1995.

The result of our analysis show that 62.4 % of the respondents in the entire urban area identified piped supplies as their primary source, 20.6% identified rainwater, 16% identified water vendors while only 01% described springs and streams as their primary source of supply.

CHAPTER THREE

WATER SUPPLY AND CONSUMPTION PATTERNS IN NSUKKA URBAN AREA

Our aim in this chapter is to carefully examine, in great details, the spatial patterns of water supply and demand in Nsukka urban, with a view to identifying and analysing significant patterns and features in the urban water supply system and in the people's consumption of piped water.

3.1 Temporal Trends in Nsukka Urban Water Supply

Monthly supply reports, in the Progress Report File of the Nsukka Urban Water Corporation, usually starts, as a matter of tradition, by stating the proportion of the 'target' or 'expected' quantity attained (within the month), and thereafter proceeds to explain why there was a shortfall between the 'target' or 'expected' quantity and the actual quantity supplied. The target or expected quantity, according to the Zonal Water Engineer, refers to the maximum quantity supplyable (i.e. the installed capacity). The installed capacity is in turn, based on urban water demand surveys first conducted in Nsukka by the former East Central State Government in 1971 and later repeated by the former Anambra State Water Corporation in 1981/82 through the use of trend base technique or the requirement approach. This technique involves

multiplying the per capita water consumption by projections in the population (Rees, 1982). The urban water corporation has not been able to achieve such target production quantities since 1970. This is illustrated in tables 10 and 11; and in figure 9.

Table 10: Water Supply in Nsukka Urban
(1970 to 1980)

| Year | Target/ Expected Quantity | | | Actual Quantity (litres) | | | Shortfall (litres) | | | Average Daily Quantity Supply | |
|------|------------------------------|-----|-----|--------------------------------|-----|-----|-----------------------|-----|-----|-------------------------------------|-----|
| 1970 | 1 502 | 132 | 547 | 506 | 710 | 849 | 1 013 | 421 | 689 | 1 388 | 248 |
| 1971 | 1 613 | 098 | 815 | 537 | 699 | 605 | 1 075 | 399 | 210 | 1 473 | 150 |
| 1972 | 1 621 | 879 | 938 | 540 | 626 | 646 | 1 081 | 253 | 292 | 1 481 | 162 |
| 1973 | 1 729 | 700 | 000 | 540 | 626 | 652 | 1 189 | 073 | 348 | 1 481 | 160 |
| 1974 | 1 529 | 554 | 498 | 575 | 472 | 140 | 954 | 082 | 358 | 1 56 | 636 |
| 1975 | 1 486 | 288 | 760 | 420 | 165 | 370 | 1 066 | 123 | 390 | 1 151 | 138 |
| 1976 | 1 726 | 416 | 420 | 764 | 777 | 200 | 961 | 939 | 220 | 2 095 | 280 |
| 1977 | 1 680 | 661 | 480 | 743 | 144 | 380 | 1 260 | 496 | 110 | 2 036 | 012 |
| 1978 | 2 205 | 734 | 085 | 735 | 244 | 685 | 1 470 | 489 | 400 | 2 014 | 369 |
| 1979 | 2 306 | 376 | 660 | 768 | 792 | 200 | 1 537 | 584 | 460 | 2 106 | 280 |
| 1980 | 2 320 | 571 | 115 | 765 | 885 | 705 | 1 554 | 685 | 410 | 2 098 | 317 |

Source: Enugu State Water Corporation (Monthly Report File for Nsukka Urban Area).

The problem of enormous shortfall in water production quantities (in Nsukka urban) which developed in early 1970s and continued throughout the 1980s is even worsening. The prevailing situation (currently) is illustrated in Table 11.

Table 11: Monthly Supply of water to Nsukka Urban From 1993 to 1995

| Month | Target or Expected Quantity (M ³) | Actual Quantity (M ³) | Shortfall (M ³) |
|------------|---|-----------------------------------|-----------------------------|
| Jan. 1993 | 446 400 | 152 050 | 294 350 |
| Feb. 1993 | 446 400 | 156 401 | 289 999 |
| March 1993 | 446 400 | 134 134 | 312 266 |
| April 1993 | 432 000 | 132 134 | 299 866 |
| May 1993 | 432 000 | 131 767 | 300 233 |
| June " | 432 000 | 127 358 | 304 642 |
| July " | 432 000 | 132 940 | 299 060 |
| August " | 446 400 | 98 746 | 347 654 |
| Sept. " | 446 400 | 128 775 | 317 625 |
| Oct. " | 446 400 | 132 781 | 313 619 |
| Nov. " | 446 400 | 134 727 | 311 673 |
| Dec. " | 482 000 | 136 658 | 345 342 |
| Jan. 1994 | 446 400 | 138 406 | 307 994 |
| Feb. " | 432 000 | 134 282 | 297 718 |
| March " | 446 400 | 916 35 | 304 765 |

| Months | Target or Expected Quantity (M ³) | Actual Quantity (M ³) | Shortfall (M ³) |
|------------|---|-----------------------------------|-----------------------------|
| April 1994 | 446 400 | 134 135 | 312 265 |
| May " | 334 800 | 171 767 | 163 124 |
| June " | 334 800 | 137 940 | 196 860 |
| July " | 334 800 | 128 746 | 206 054 |
| August " | 446 400 | 19 977 | 426 423 |
| Sept. " | 334 800 | 172 981 | 161 819 |
| Oct. " | 446 400 | 160 727 | 285 673 |
| Nov. " | 446 480 | 174 315 | 272 085 |
| Dec. " | 446 480 | 152 658 | 293 822 |
| Jan. 1995 | 446 480 | 154 794 | 291 686 |
| Feb. " | 446 400 | 172 525 | 273 875 |
| March " | 446 400 | 178 897 | 267 503 |
| April " | 446 400 | 187 435 | 258 965 |
| May " | 446 400 | 164 790 | 281 610 |
| June " | 334 800 | 152 693 | 182 107 |
| July " | 334 800 | 152 658 | 182 020 |
| August " | 446 400 | 104 780 | 141 620 |
| Sept. " | 334 800 | 102 431 | 221 369 |
| Oct. " | 446 400 | 162 604 | 283 796 |
| Nov. " | 446 400 | 194 606 | 251 794 |
| Dec. " | 446 400 | 202 263 | 244 137 |

Source: Nsukka Urban Water Corporation Monthly Progress Report File (1995).

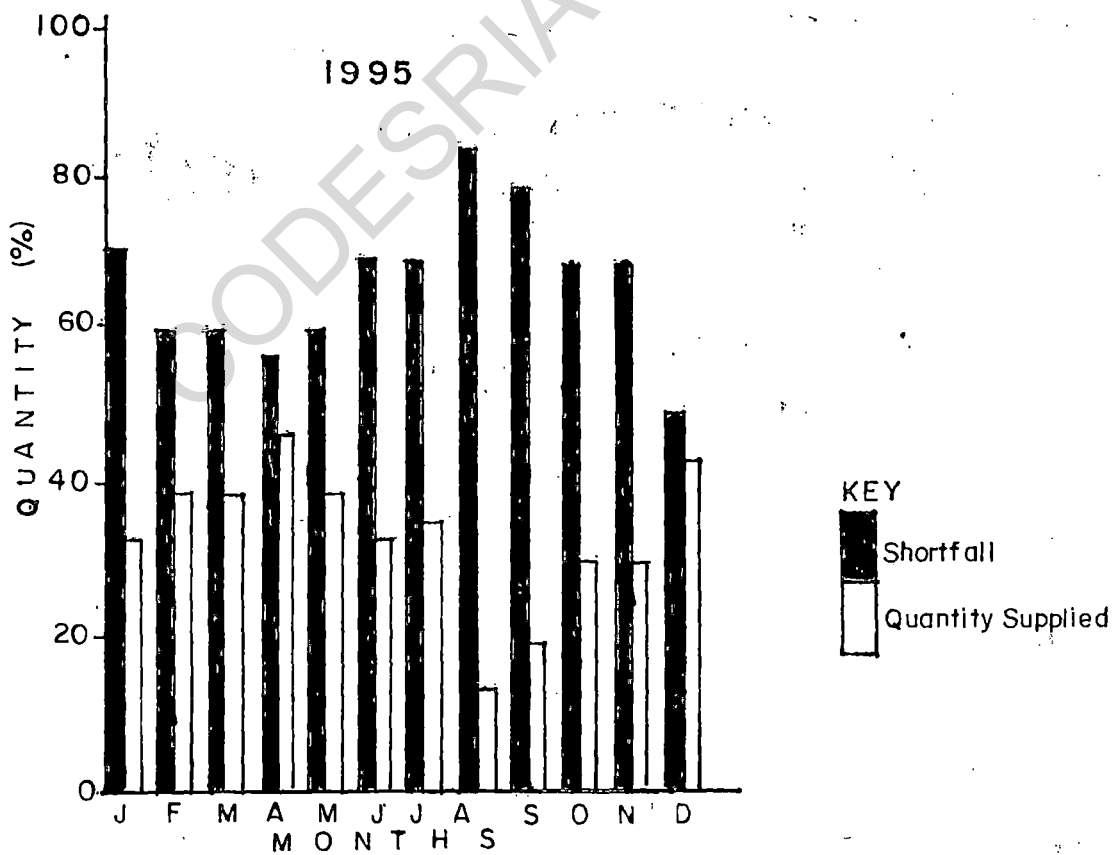
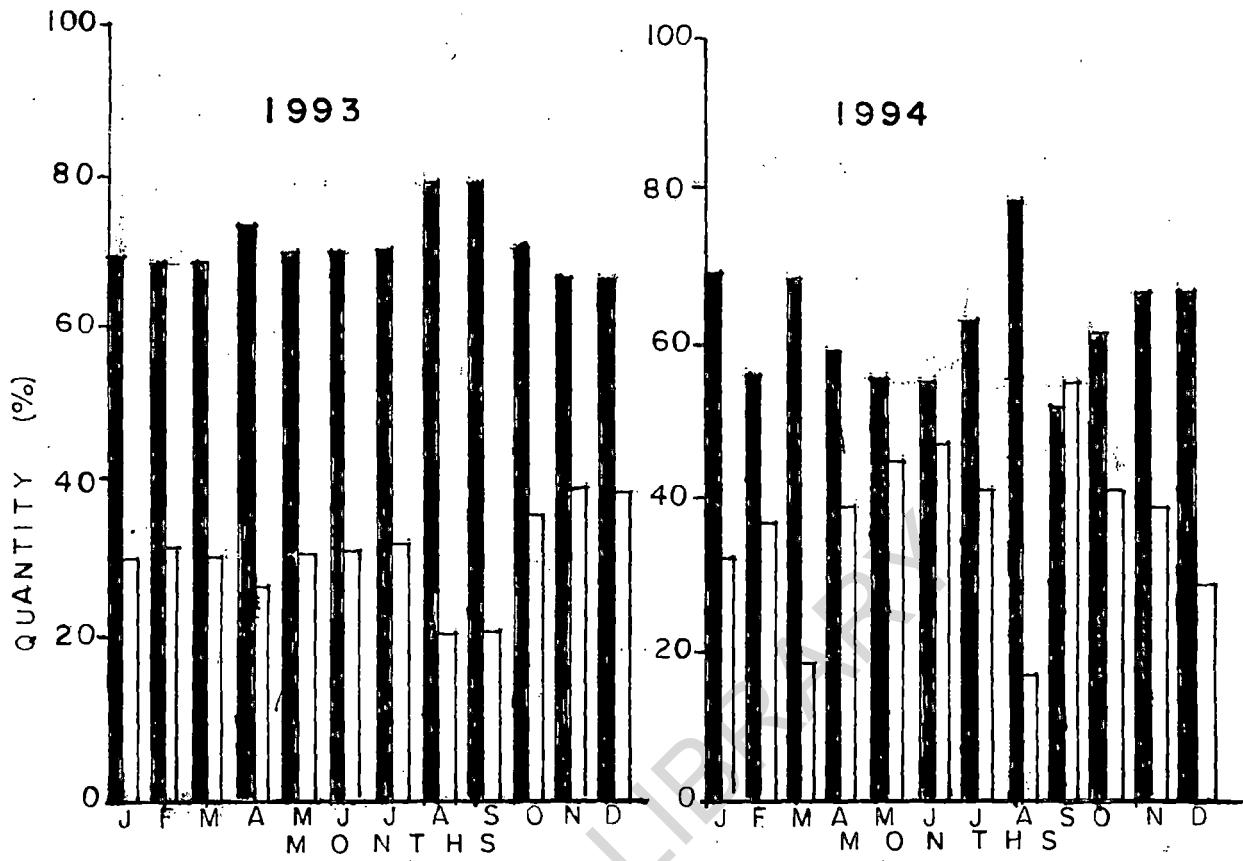


Fig.9: Trends in Nsukka urban water supply

Notice that the target production quantities and even shortfalls for the various months are relatively uniform. This is probably due to the slow rate of expansion and elimination of supply 'constraints'.

Field investigations equally revealed that the largest private supplier of water in Nsukka urban, that is, the University of Nigeria Water Works Department, equally experience enormous and persistent shortfalls in target production quantities. This is illustrated in Table 12.

Table 12: Daily Supply of Water by Works Department of the University of Nigeria, Nsukka (Nov. 1995)

| Dates | Target Quantity (M ³) | Actual quantity Supplied (M ³) | Shortfall (M ³) | Quantity Distributed (M ³) | Quantity Reserved (M ³) |
|---------|-----------------------------------|--|-----------------------------|--|-------------------------------------|
| 1-11-95 | 3420 | 1160 | 2260 | 1156 | 4 |
| 2-11-95 | 3420 | 1164 | 2256 | 1158 | 6 |
| 3-11-95 | 3420 | 1164 | 2256 | 1154 | 10 |
| 4-11-95 | 3444 | 1158 | 2286 | 1154 | 4 |
| 5-11-95 | 3444 | 1156 | 2288 | 1154 | 2 |
| 6-11-95 | 3448 | 1158 | 2286 | 1154 | 4 |
| 7-11-95 | 3420 | 1164 | 2256 | 1156 | 8 |
| 8-11-95 | 3420 | 1162 | 2258 | 1154 | 8 |
| 9-11-95 | 3420 | 1160 | 2260 | 1154 | 4 |

| Dates | Target Quantity (M ³) | Actual Quantity Supplied (M ³) | Shortfall (M ³) | Quantity Distributed (M ³) | Quantity Reserved (M ³) |
|----------|-----------------------------------|--|-----------------------------|--|-------------------------------------|
| 10-11-95 | 3444 | 1166 | 2278 | 1156 | 10 |
| 11-11-95 | 3420 | 1163 | 2257 | 1156 | 7 |
| 12-11-95 | 3420 | 1158 | 2262 | 1154 | 4 |
| 13-11-95 | 3444 | 1156 | 2288 | 1154 | 2 |
| 14-11-95 | 3444 | 1166 | 2278 | 1158 | 2 |
| 15-11-95 | 3420 | 1154 | 2266 | 1158 | 4 |
| 16-11-95 | 3420 | 1164 | 2256 | 1156 | 8 |
| 17-11-95 | 3444 | 1162 | 2282 | 1154 | 6 |
| 18-11-95 | 3444 | 1160 | 2284 | 1154 | 4 |
| 19-11-95 | 3420 | 1164 | 2256 | 1154 | 10 |
| 20-11-95 | 3420 | 1158 | 2262 | 1156 | 2 |
| 21-11-95 | 3420 | 1158 | 2262 | 1156 | 2 |
| 22-11-95 | 3420 | 1164 | 2256 | 1154 | 10 |
| 23-11-95 | 3444 | 1164 | 2280 | 1154 | 10 |
| 24-11-95 | 3444 | 1164 | 2280 | 1154 | 10 |
| 25-11-95 | 3444 | 1160 | 2284 | 1154 | 6 |
| 26-11-95 | 3444 | 1160 | 2284 | 1154 | 6 |
| 27-11-95 | 3420 | 1162 | 2258 | 1154 | 6 |
| 28-11-95 | 3420 | 1164 | 2256 | 1156 | 8 |
| 29-11-95 | 3420 | 1162 | 2258 | 1156 | 6 |
| 30-11-95 | 3420 | 1164 | 2256 | 1156 | 8 |

Source: Water Works Unit of the Works Department, University of Nigeria, Nsukka. Note that the Water Works unit always/a quantity which is never below 2 cubic meters /have in reserve.

3.2 Determinants of the Shortfall in Supply

The expansion and modernization programme (which include the establishment of additional boreholes and reservoirs (between 1970 and 1982) of the Nsukka urban water supply industry, initiated in the early 1970s and continued in moderate form until 1985 (when it was temporarily abandoned due to financial constraints) had the attainment of the "sufficiency potential" such as the 115 litres per head per day proposed by the federal government of Nigeria in the third National Development Plan as its primary objective.

Since 1970, however, the Nsukka urban water supply has been irregular and insufficient to fulfil the above objective. A variety of determinants have been identified as being responsible for the situation. These determinants are varied and are caused by a multiplicity of environmental, technical, economic and human factors which are often closely related to each other and are responsible for failures to achieve target production quantities by Nsukka urban water corporation (Ezema, 1995, Eze, 1995). The names and impacts of such determinants ^{which} are described in great details in the monthly Progress Report File of the Urban Water Corporation include the inability of the urban water corporation to

promptly effect repairs, abstract enough water from source, and/or the inability to eliminate losses from the distribution network. The frequency of determinants interference in the supply system is not uniform in Nsukka urban. Consequently, water supply relative to demand is also experienced differently among the six wards of Nsukka urban area. We shall, in this section, analyse the factors which occasion the observed shortfall in production. The data, ~~were~~ as noted earlier, extracted from the monthly Progress Report File of Nsukka Urban Water Corporation. The staff of the Water Corporation were equally interviewed to obtain necessary details. The observed determinants which occasion the observed shortfall in target production quantities and other failures related to the attainment of the corporation objectives are shown in Table 13

Table 13: Determinants of Shortfalls in Water Supply in Nsukka Urban Between 1993 and 1995

| Period | Shortfall (M ³) | Major Determinant of Shortfall | No. of Determinants |
|-----------|-----------------------------|--|---------------------|
| Jan. 1993 | 294 350 | Borehole fault, Booster Pump fault, leakages | 3 |
| Feb. " | 289 999 | B/H fault, burst pipes, leakages, Gen. set fault | 4 |
| March " | 312 266 | Gen. set fault, B/H fault, faulty sumo leakages | 4 |
| April " | 299 866 | Burst pipes, B/H breakdown, sumo fault | 3 |
| May " | 300 233 | Submersible sumo fault, B/H breakdown | 2 |
| June " | 304 642 | NEPA failure, burst pipes, B/H fault | 3 |
| July " | 299 060 | Lack of valve tetatchable joints B/H fault | 3 |
| August " | 317 654 | Dropping of valve, NEPA failure, B/H fault | 3 |
| Sept. " | 317 625 | Lack of valve, pipe burst, B/H fault | 3 |
| Oct. " | 313 619 | B/H fault | 1 |
| Nov. " | 311 673 | B/H fault, burst pipes, faulty sumo | 3 |
| Dec. " | 345 342 | B/H fault, and burst pipes | 2 |
| Jan. 1994 | 307 994 | B/H fault, faulty sumo | 2 |
| Feb. " | 297 718 | B/H fault, booster pump breakdown | 2 |

| Period | Shortfall (M ³) | Major Determinant of Shortfall | No. of Determinants |
|------------|-----------------------------|--|---------------------|
| March 1994 | 354 765 | B/H fault, Gen. set fault, burst pipes | 3 |
| April " | 312 265 | B/H fault, lack of joints | 2 |
| May " | 163 124 | B/H fault, lack of joints, valves | 2 |
| June " | 196 860 | Low power, B/H fault | 2 |
| July " | 206 064 | Low demand, B/H breakdown, NEPA failure | 3 |
| August " | 426 423 | Low demand B/H fault, Gen. set fault | 3 |
| Sept. " | 161 819 | Low demand, B/H fault, NEPA fault | 3 |
| Oct. " | 285 673 | Low demand, B/H fault, lack of detachable joints | 3 |
| Nov. " | 272 085 | Burst pipes, B/H fault Booster fault | 3 |
| Dec. " | 293 822 | Borehole fault, leakages, Boaster fault | 3 |
| Jan. 1995 | 291 686 | Borehole breakdown Gen. set fault, leakages | 3 |
| Feb. " | 273 875 | Borehole breakdown, leakages | 2 |
| March " | 267 503 | Faulty Gen-set, heavy leakages | 2 |
| April " | 258 965 | Borehole fault, and faulty sumo | 2 |
| May " | 281 610 | Borehole fault, burst pipes, boaster fault | 3 |
| June " | 182 107 | Low demand, dropping of valve, B/H fault | 3 |

| Period | Shortfall (M ³) | Major Determinant of Shortfall | No. of Determinants |
|-----------|-----------------------------|---|---------------------|
| July 1995 | 182 020 | Low demand, B/H fault, Gen-set fault | 3 |
| August " | 170 020 | Low demand, burst pipes | 2 |
| Sept. " | 221 369 | Low demand, faulty sumo | 2 |
| Oct. " | 283 796 | Borehole fault, burst pipe, Gen-set fault | 3 |
| Nov. " | 251 294 | Borehole breakdown, heavy leakages | 2 |
| Dec. " | 244 137 | Faulty sumo, B/H fault, booster fault | 3 |

Source: Compiled from the "Monthly Progress Report File" for Nsukka Urban (Enugu State Water Board).

Table 13 indicates and summarises the frequency of occurrence of the salient factors which account for the inability of the Nsukka urban water corporation to attain target production quantities. These factors are not mutually exclusive, rather interactions and reinforcement among them in the rule. As table 14 clearly indicates, shortfalls in Nsukka urban water supply are largely due to technical and economic factors. The most frequent and persistent defect of the borehole supplies is the frequent tendency for the boreholes to be out of working order. Of the twelve boreholes drilled by Nsukka urban water

corporation only three are working (some at 30% below installed capacity) and supplying water to the urban inhabitants.

The dependence upon a mechanically pumped borehole has also led to frequent and often serious setbacks as a result of frequent breakdowns of machinery and the slow rate/high cost of repairs. The relative contributions of all the determinants are summarised in Fig. 10. According to the zonal water engineer, all plans and programmes (that are) aimed at improving the supply situation must be backed with adequate supply of funds. Adequate funding is necessary in order to effect the needed repairs, to replace aging machines and to implement expansion and modernization programmes. This according to our respondents explains why the water corporation approved the policy of commercializing her public stand pipes, imposing charges on clients wishing to be connected to the mainlines, raising water bills and embarking on massive disconnection exercise for bill defaulters.

Although, all these problems are real and jointly interact to occasion the prevailing shortfalls in supply, the frequency of their interference and consequent relative contributions are not equal. The table below shows the relative strengths of the determinants. (See Fig. 10 also)

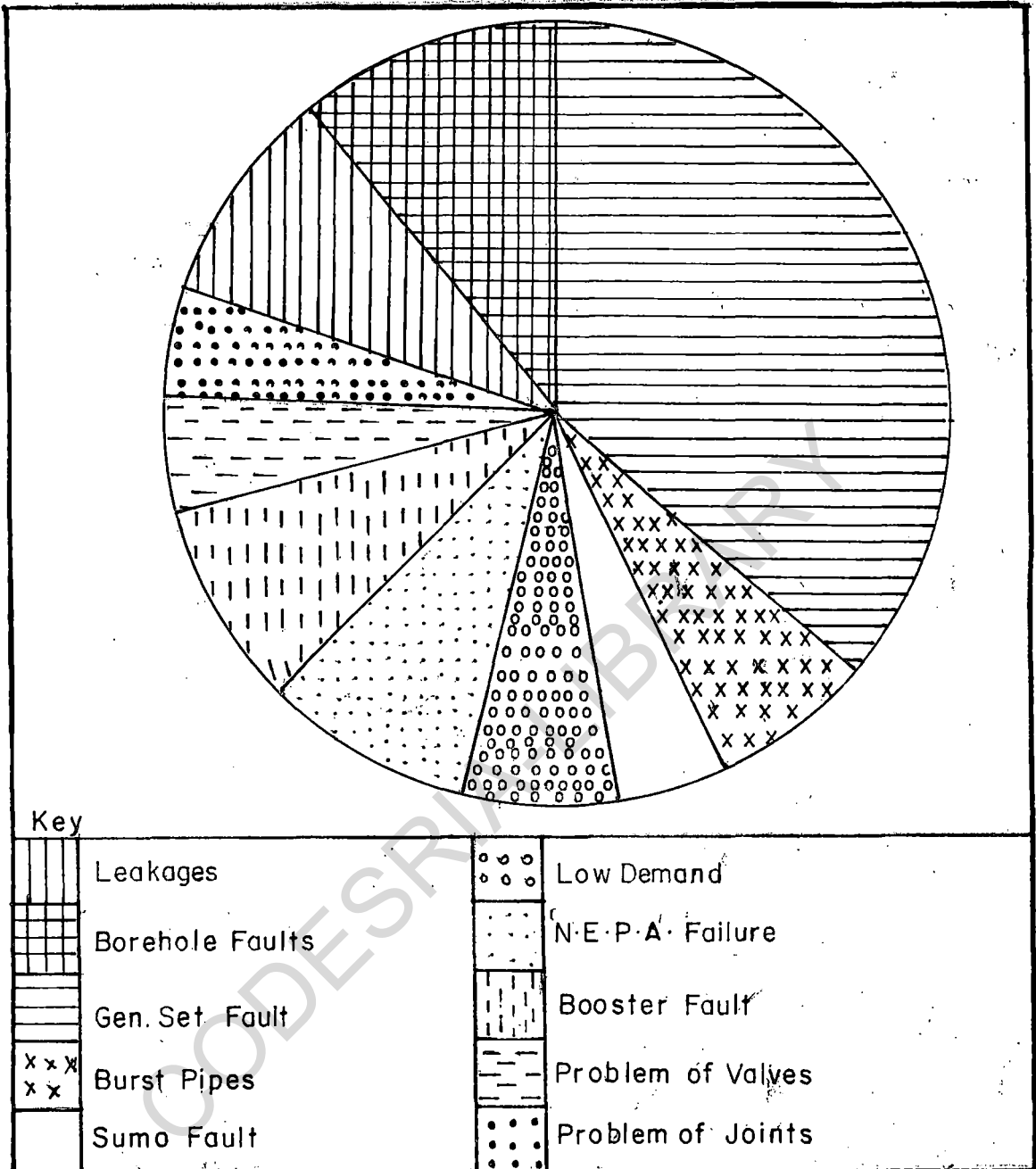


Fig. 10 : Determinants of shortfall in quantity supplied

Table 14: The Relative Contributions of the Major Determinants of Shortfalls in Water Supply in Nsukka (1993 - 1996)

| Determinant | Frequency | Percentage | Rank | Mean No. of Day Taken to Rectify |
|-------------------|-----------|------------|------|----------------------------------|
| Borehole fault | 33 | 37.1 | 1st | - |
| Boaster fault | 6 | 6.7 | 6th | 8 |
| Burst pipes | 10 | 11.2 | 2nd | 4 |
| Leakages | 8 | 9 | 3rd | 4 |
| Generator's fault | 4 | 4.5 | 8th | 6 |
| Faulty sumo | 7 | 7.7 | 5th | 4 |
| NEPA failure | 6 | 6.7 | 6th | - |
| Low demand | 8 | 9 | 3rd | - |
| Problem of valve | 4 | 4.5 | 8th | 6 |
| Problem of joints | 3 | 3.4 | 10th | 6 |
| Total | 89 | 100 | | |

Source: Fieldwork, 1995.

The above result clearly support earlier findings by Katzman (1979) and Hauke and De Mare (1982). The findings of these workers indicated that water shortages in urban areas of most developing countries are as the result of both shortages of natural sources of water and imbalance in the distribution of available quantities. The later result mainly from technical, financial and management difficulties, as well as from policy

inadequacies. Water shortages cause real hardships to the urban inhabitants. An emerging urban center (like Nsukka) which is experiencing increased population growth, rapid industrial expansion and gradually improved housing is bound to require an ever increasing quantities of this resources. The enormous shortfalls in target production quantities is therefore, a source of concern, especially to the urban water corporation.

3.3 Spatial Inequalities in Nsukka Urban Water Supply Patterns

Our aim in this section is to carefully highlight the spatial inequalities in the patterns of water supply to the six wards which make up the study area. In the advanced countries of Europe and America, water supply in urban areas is principally the responsibility of the public works departments and 'perfect supply situations' (that is, every household obtains steady and regular supply) are often attained (Rees, 1982). In developing countries, the situation is, however, different (Ezenwaji, 1991). Here - (1) the public water works do not generally supply enough to meet the water needs of the people (Ibeziako, 1985), (ii) the supply pattern is highly variable both spatially and temporally.

In Nsukka urban, the only reliable source of urban water in the ground water (see chapter II, section 1). The application of modern mechanical drilling technology now enables much water to be drawn from the aquifers. However, the quantities currently abstracted and distributed is in comparism to demand, abysimally low. The distribution system is also uneven. So that, whereas water has remained, in varying degrees, a scarce commodity to each of the six wards of Nsukka urban; some wards experience more severe shortages than others. Water shortages is, therefore, noticed more in some areas than in others, especially when the easily accessible, low cost alternative source (rainfall) is exhuasted.

We examined, in this section the general spatial inequalities in the supply system such as the proportion of the people served by piped supplies, the delivery (piping) systems, alternative sources for people without piped supplies, the intensity of piped supplies and the varying quantities delivered to the various wards.

3.3.1 The Proportion of the People Served by Piped Supplies

The conventional and easy manner of judging the equity of the urban water supply system is to identify and summarise the proportion of the population which is served by piped supplies. Table 16 summarizes the proportion of the sampled population that is served by piped supplies in the various wards within the Nsukka urban area.

Table 15: The Proportion of the (Sampled) Population Served by Piped Supplies

| S/No. | Wards | No. of Respondents | No. Served by Piped Supplies | Percentage | Remark |
|-------|--------------|--------------------|------------------------------|------------|-----------------|
| 1 | U.N.N. | 75 | 75 | 100 | Very high |
| 2 | GRA | 50 | 30 | 60 | Relatively high |
| 3 | Onuiyi | 118 | 59 | 70 | High |
| 4 | Nru | 116 | 45 | 38.8 | Low |
| 5 | Ihe & Owerre | 168 | 107 | 64 | Relatively high |
| 6 | Nkpunano | 153 | 83 | 54.2 | Moderate |
| Total | | 680 | 399 | 58.71 | |

Source: Fieldwork (1995).

As shown in table 15, the University community has the highest percentage (coverage) of households served by piped supplies in Nsukka urban. She is followed (not very closely) by Onuiyi, Ihe and Owerre and Gra. The Nru ward has the lowest percentage of households that are served by piped supplies in Nsukka urban area.

3.3.3.1.1 The Piping System to Individual Households

The enumeration of the proportion of households served with piped supplies often obscure a very important element in household water delivery - the piping system to homes. Water may be delivered to individual homes through a single outlet which may be in or near the house or through the (often preferred) multiple-tap system which minimises the need to carry water around the premises. In Nsukka urban area, the system of household water delivery is shown in table 16.

Table 16: Water Delivery to Households in Nsukka
Urban: Tap-Types

| Wards | No. of Respondents | Household with Multiple-Tap System | Household with one Central Supply | Household with Broken Down (Pipes Taps | Household Without Taps in Residence |
|--------------|--------------------|------------------------------------|-----------------------------------|--|-------------------------------------|
| UNN | 75 | 70 | 5 | 0 | 0 |
| Onuiyi | 118 | 18 | 41 | 12 | 47 |
| GRA | 50 | 8 | 22 | 5 | 15 |
| Nru | 116 | 12 | 33 | 18 | 53 |
| Nkpunano | 153 | 23 | 60 | 24 | 46 |
| Ihe & Owerre | 168 | 28 | 79 | 21 | 40 |
| Total | 680 | 159 | 240 | 80 | 201 |

Source: Fieldwork (1995).

As shown in table 16, 240 households or 34.5% of the sampled households in Nsukka urban obtain their piped water through one central supply in their place of residence, 201 households or 29.5% of the sampled households have no taps in their residence while 159 or 24% have the preferred multiple tap system. Presently, 80 households or 11.8% of the sampled households have non-functional taps in their residence.

3.2 Alternative Sources for Households Without Piped Supplies

Before assessing the level of deficiencies arising from the current water demand and supply patterns in Nsukka urban area, it may be necessary to briefly describe in a spatial context, the alternative sources for households without piped supplies in their residence. This is summarised in Table 17 and in figure 11.

Table 17: Alternative Sources for Households Without Piped Supplies

| Wards | No. of Respondents | No. Without Piped Supplies | Alternative Sources | | | | Depending on Stored Rain Catch (in Tanks) |
|--------------|--------------------|----------------------------|---------------------------|--------------------------|------------------------|--------------------------------------|---|
| | | | Buying from Water Vendors | Fetch- ing from Borehole | Fetch- ing from U.N.N. | Fetch- ing from Neigh- bouring Yards | |
| UNN | 75 | 0 | 0 | 0 | 0 | 0 | 0 |
| Onuiyi | 118 | 59 | 5 | 6 | 28 | 18 | 2 |
| Nru | 116 | 71 | 7 | 6 | 33 | 21 | 4 |
| GRA | 50 | 20 | 2 | 11 | 0 | 7 | 0 |
| Nkpunano | 153 | 70 | 6 | 28 | 18 | 13 | 5 |
| Ihe & Owerre | 168 | 71 | 13 | 27 | 17 | 14 | 0 |
| Total | 680 | 291 | 33 | 78 | 96 | 73 | 11 |

Source: Fieldwork (1995).

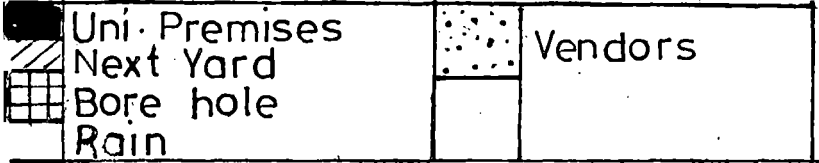
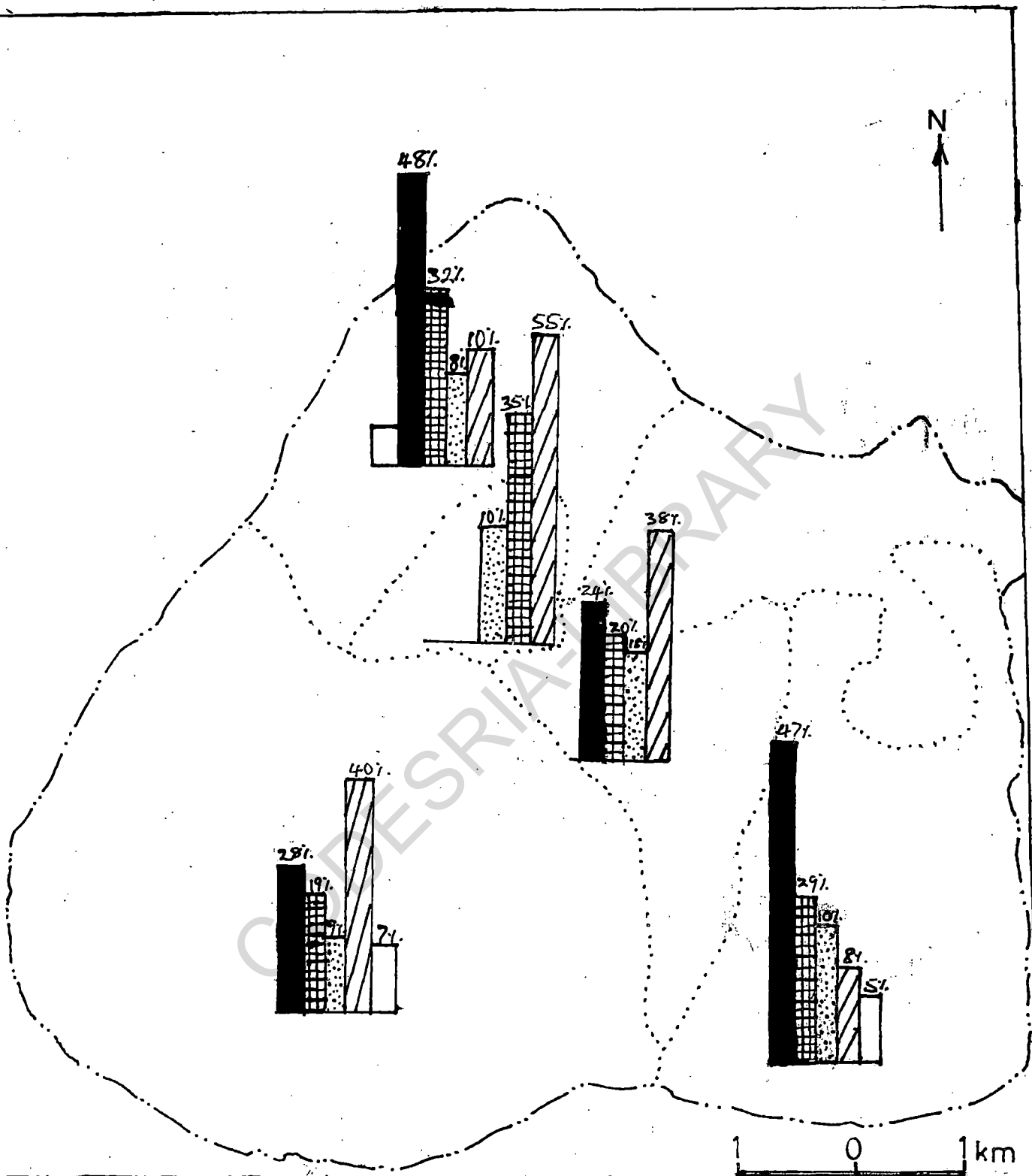


Fig. 11: Alternative sources for households without piped supplies

Table 16 shows that 28 households (made up of columns 5 and 6 in table 16) or 42.8% of the sampled households lack piped supplies in their residence, 96 or 33% of these households obtain their water from the University premises, while 78 or 26.8% get their water from the borehole, 73 or 25% of these households depend on their neighbouring 'yards' for domestic water supply while 33 households or 11.3% of the sampled households depend on vendors, only 11 or 3.7% depend on stored rain catch.

3.3.2.1 The Limitations of the Observed Alternative Sources

Field investigations and oral interview revealed that fetching water from distance sources (eg. from the urban borehole farm, from the University premises or even from springs), which is a common practice in Nsukka urban area, has a number of disadvantages, for example, it was established during field work that people often carry insufficient amount of water to their homes for batching, washing and for good hygiene. Furthermore, carried water is frequently and easily contaminated. In addition, thousands of man-hours are lost and the carriers (mainly children and women) are exposed to environmental hazards. Long queues at peak hours sometimes lead to querrels and even fighting among the carriers resulting in water wastes and occasional injuries.

The delivery of water to households through pipelines is undoubtedly a preferred option. The simplest and cheapest being a single outlet in or near the house. This eliminates water carrying outside the premises, encourages cleanliness and ensures adequate use of water for health and hygiene. This desired option however, has been hampered in Nsukka urban area by a variety of factors such as:

1. high cost of connection fee.
2. clients inability to purchase the needed materials (pipes, valves, joints, etc.)
3. the availability and supplementary supplies from supplementary sources (rain catch, springs, water vendors
4. insufficient supply of fund and materials to embark on expansion and modernization programmes.

3.3.2.2 Inequalities in the Amount of Water Piped to Wards

At present, the functional boreholes (see table 4) in Nsukka urban are capable of yielding a combined total of 6,675,500 litres per day (often much less is yielded) for delivery to the six wards of Nsukka urban. There is, however a considerable variation in the amount delivered to wards.

Table 19 shows clearly the annual and mean monthly and daily quantities of piped water supplied to the various wards in 1995.

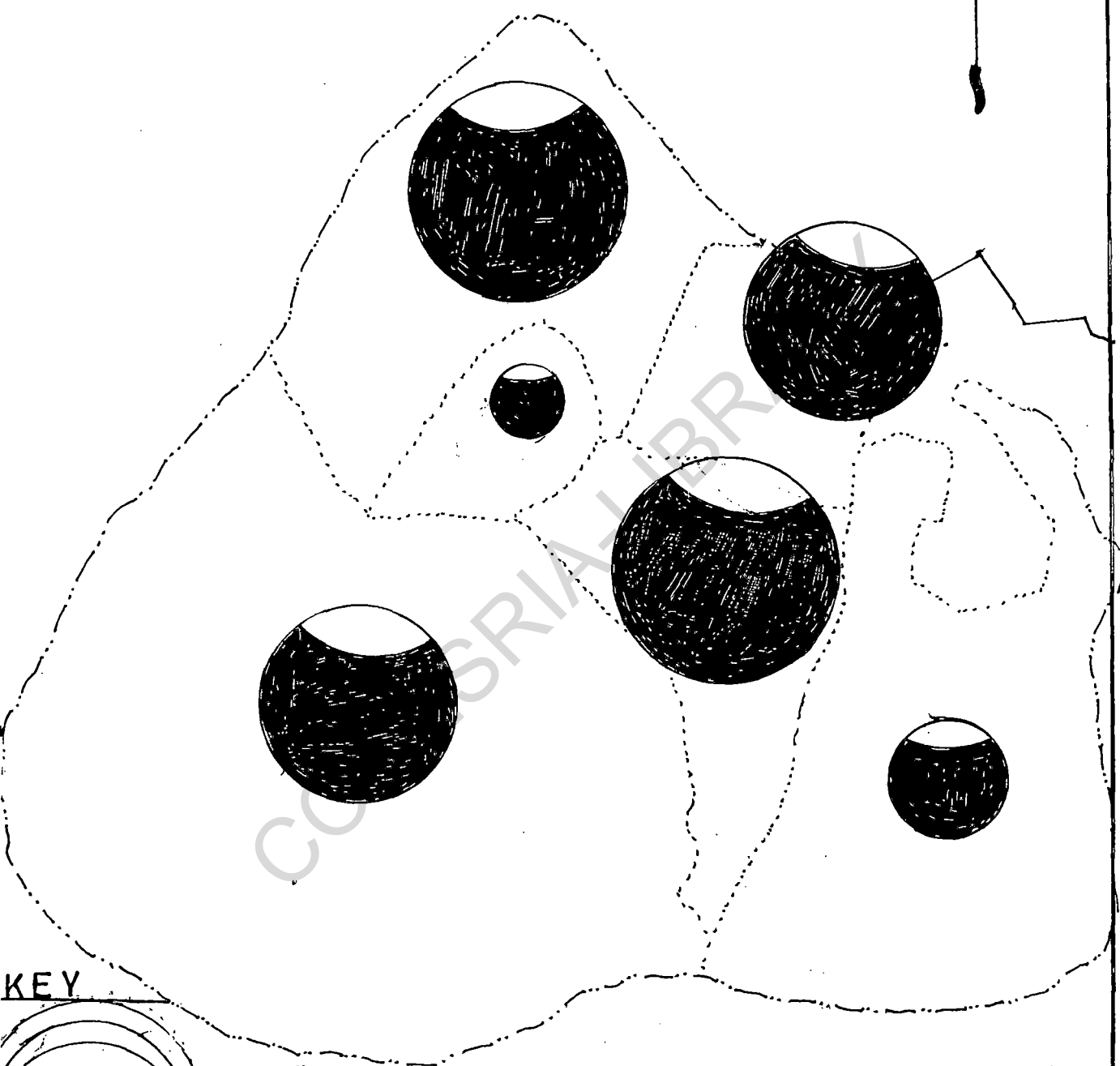
Table 18: Variations in Quality of Water Supplied to Wards in Nsukka Urban (1995)

| S/No. | Wards | Annual Amount M ³ | Mean Monthly Amount M ³ | Mean Daily Amount (litres) | Supplier |
|-------|--------------|------------------------------|------------------------------------|----------------------------|-------------------------|
| 1 | UNN | 401,738 | 33,478.2 | 1,115,940 | Works Dept., UNN |
| 2 | Onuiyi | 514,789.6 | 42,899.1 | 1,429,967 | Urban Water Corporation |
| 3 | GRA | 103,741.5 | 8,645.1 | 288,170 | " " |
| 4 | Ihe & Owerre | 586,138.3 | 48,844.9 | 1,628,163 | " " . : |
| 5 | Nkpunano | 431,142.3 | 35,928.5 | 1,197,617 | " " . : |
| 6 | Nru | 231,655.3 | 19,304.6 | 643,487 | " " |

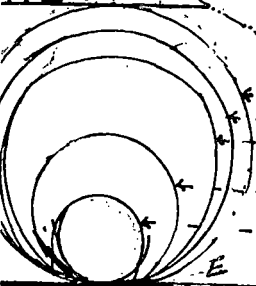
Source: (a) "Water allocation file" (pumping Unit), Nsukka Urban Water Corporation.

(b) Water Supply Unit, Works Dept. UNN.

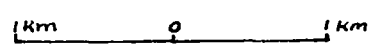
Table 18 shows that the University ward does not, as expected enjoys the highest mean monthly and daily supplies. According to the zonal water engineer, no single ward is supplied with an amount which will satisfy all legitimate uses. None enjoys regular and uninterrupted supply. As a result of the increasing expense of water supply facilities and urban population, drought



KEY



- - - 50 000 m³
- - - 40 000 m³
- - - 25 000 m³
- - - 18 000 m³
- - - 9 000 m³



G.12: INEQUALITIES IN AMOUNT OF WATER SUPPLIED TO WARDS

management (i.e. supplying less than normal demand) has become an attractive, alternative to maintaining full level supplies in Nsukka urban.

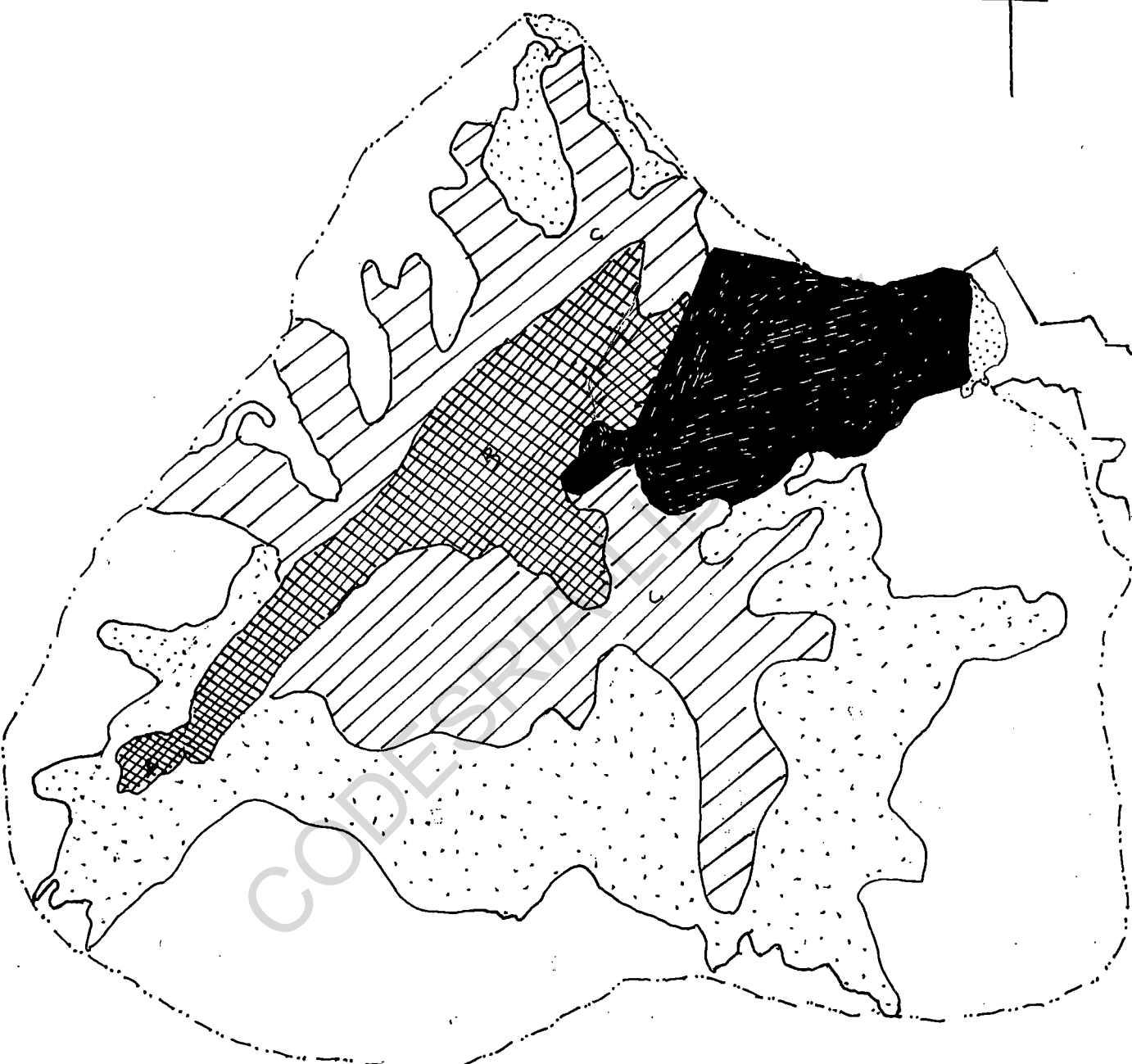
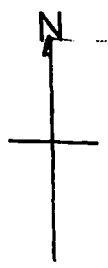
3.3.3 The Varying Intensity of Piped Supplies

According to Rees (1982) a conventional method of assessing the effectiveness of piped supply is to examine the intensities of supplies. Table 19 and figure 13 below summarises the average number of days and hours (per week) of piped supplies to the six wards within the study area.

Table 19: The Intensity of Piped Supplies (Water) in Nsukka Urban Area

| Wards | Average No. of Days Taps Run Per Week | Average No. of Hours Taps Run Per Day | Average No. of Hours Taps Run Per Week | Remarks % Hours of a Week |
|--------------|---------------------------------------|---------------------------------------|--|---------------------------|
| UNN | 6 | 8 | 48 | 21.36 |
| Onuiyi | 4 | 6 | 24 | 1.07 |
| GRA | 3 | 6 | 18 | 10.71 |
| Nru | 2 | 4 | 12 | 1.07 |
| Nkpunano | 3 | 6 | 18 | 1.07 |
| Ihe & Owerre | 3 | 6 | 18 | 1.07 |

Source: Fieldwork (1995).



KEY







| | | | |
|--|--------------------|---|------------------|
|  | 72 Hours (Average) |  | 24 Hours Average |
|  | 48 " " " |  | LACK PIPE SUPPLY |
|  | 36 " " " |  | |



FIG.13: INTENSITIES OF PIPED WATER SUPPLY IN NSUKKA

The above table suggests that the most acute problem of domestic water supply in Nsukka urban area is experienced in Nru ward. Field investigation revealed that this is the ward where the least rapid urban growth is taking place, where Municipal Organisation and public services are least adequate and where modern means of excreta disposal (water closet system) is generally lacking. Majority of the population are 'natives' who are generally poor. However, a number of modern houses, served with modern amenities now exist within the Nru ward of Nsukka urban.

3.4 Patterns of Residential Water Demand in Nsukka Urban Area

The terms water demand and water consumption have often been used interchangeably by several workers. For example Frankel and Shourvauavirukal (1978) Rees (1978), Akintola and Areola (1980), Obeng (1980) and Hanke and De Mare (1982), used the two terms interchangeably in their different studies on patterns of water demand and consumption (see chapter I, section 4). These workers based their interchangeable use of these two key terms on two major premises, viz:

1. the patterns of water consumption in any area often determines the patterns of water demand and

2. the factors that affect water demand also affect water consumption patterns. Based on these arguments, some of these workers, particularly Frankel and Shourvanavirukal (1978), Rees (1978), Katzman (1977) and Hanke and De Mare (1982) used present water consumption patterns to predict and forecast future water demands for domestic and other uses.

In developing countries, however, it has been discovered that the quantity supplied by the public works departments is never enough to meet the people's water needs (Akintola and Areola, 1980, Ibeziako 1985, Chima, 1989). In view of this water consumption hardly equals water demand. Water consumption is usually less than water demand. In our present study, household water demand is defined after Chima (1989); Ezenwaji (1990); and Ezema (1995), as the anticipated amount of water required by the household for all their domestic uses. Household water demand is, therefore, considered synonymous with household water need. Household water consumption on the other hand is taken to mean the actual amount (that is the real quantity supplied) of water fetched or piped to the household and consumed by the members of the household.

The mean household water demand for Nsukka urban area was obtained from the questionnaire samples which were administered on the respondents. The respondents estimated their household water needs in standard buckets (Standard Organisation of Nigeria (SON), size 30) which has a capacity of 12 litres. The household water demand for each of the household was obtained from the sample questionnaire return which was completed by the head of the household earlier defined after Ibeziako (1985) as a married person with a family or an unmarried person of at least 20 years, living alone and earning an income (see chapter 1 section 6). The mean household water demand for each ward was obtained by dividing the summed total of the various household demands in each ward by the number of households therein. The mean household water demand for the entire urban area was then computed by dividing the summed means of all the wards by the number of wards in Nsukka urban area. The result is presented in table 20.

Table 20: Household Water Demand and Supply
in Nsukka Urban Area in 1995

| Wards | Mean Water Demand Per H/H Per Day (Litres) | Mean Per Capita Water Demand Per Day (Litres) | Mean Household Water Supply (Litres) | Mean Per Capita Supply | % Demand Satisfied by Supply |
|--------------|--|---|--------------------------------------|------------------------|------------------------------|
| UNN | 958 | 159.67 | 659 | 109.8 | 68.75 |
| GRA | 742 | 106 | 443 | 63.29 | 59.7 |
| Onuiyi | 714 | 119 | 415 | 69.17 | 58.13 |
| Nru | 499 | 62.38 | 201 | 25.13 | 40.27 |
| Ihe & Owerre | 518 | 86.33 | 241 | 40.17 | 46.55 |
| Nkpunano | 540 | 77.14 | 219 | 31.29 | 40.56 |
| Mean | 662 | 94.57 | 363 | 51.86 | |

Source: Fieldwork (1995).

Table 20 shows that the mean household water demand for Nsukka urban area was found to be 662 litres. Among the wards, the University community has the highest mean household water demand of 958 litres per household per day (L/HH/O. The University community is followed by GRA with a mean household water demand of 742 litres per household per day. Onuiyi (714 litres) and the GRA wards have relatively similar mean household water demand. These two wards lie

closest to the borehole farm managed by the Nsukka Zonal Water Board, and have similar water use habits. As shown in table 21, Nru with a mean household water demand of 499 litres per household per day (L/HH/D) is the least.

The fifth column in table 21 above is the daily per capita water demand. The figures were obtained by dividing the mean water demand per household by the mean number of persons per household (see table 22). From this table, the University community has the highest relative mean daily per capita water demand of 159.8 litres per person per day (L/P/D). She is followed by Onuiyi 119 litres, GRA, 106 litres, Ihe and Owerre 86.33 litres and Nkpunano 77.14 litres. Nru has the lowest with only 62.35 litres per capita per day (L/P/D). As shown in table 21, the per capita water demand for Nru and Nkpunano are generally, similar. These two wards suffer more from prolonged water shortages and this tends to lower the quantity demanded by the people. Similarly, two other wards (GRA and Onuiyi) have relatively similar per capita water demands. These two wards as noted earlier live closest to the borehole farm (a foremost supply centre) of the urban water corporation and enjoy a relatively more regular supply, and this tends to increase the quantity demanded by the people. As noted earlier, the ward that is associated with the highest per capita water demand is the University community

while Nru recorded the least per capita water demand. This pattern is not surprising since UNN is a relatively high class residential area while Nru is generally inhabited by the low income group. In addition, UNN enjoys a more regular and steady supply of piped water than Nru where supply is generally erratic (hence are low per capita water demand recorded for the ward). Members of the University community generally believe that there is 'enough' water. They, therefore, demand more for domestic uses than others who are constantly faced with shortages.

3.4.1 Variations in Residential Water Demand in Nsukka

According to Ezema (1995) Nsukka urban area is not made up of homogeneous people and housing structures. There are variations in personalities and socio-economic status as evidenced in occupation, educational attainment, income, and standards of living of the inhabitants. As a result of these variations, there exist a lot of differences and similarities amongst the inhabitants which make it necessary for their patterns of water demand to vary (see tables 20 and 21).

A major area where such variation is evidenced is on household size. The result of our investigations and questionnaire responses show that the average number of persons per

households varies from ward to ward. Table 22 shows, among other things, the variations in the household size among the wards of Nsukka urban. The mean size of households was found to be 7 persons. Some wards (GRA & Mkpunano) have the same mean household size of 7 persons each while Nru has the highest mean household size of 8 persons. As shown in table 22 the range in mean household size in Nsukka urban is generally low.

The variations in mean household size (ie. the mean number of persons per household) may have contributed significantly to the observed variations in mean daily household water demand in Nsukka urban. For example, the household with the highest daily demand was found to be 1024 litres while the household that recorded the lowest daily demand was found to be 18 litres. The difference was found to be 1006 litres. For the various wards, the difference between the household with the highest daily demand and the household with the lowest is as follows: UNN 48, GRA 58, Nru 72 litres, Onuiyi 64 litres and Ihe & Owerre 86 litres. The average quantity of daily household water demand is shown in table 21. UNN has the highest mean daily household water demand of 958 litres per day. She is followed by GRA (742 litres), Onuiyi (714 litres), Ihe & Owerre (518 litres) and Mkpunano (540 litres).

The average per capita water demand (ie. mean quantity demanded per person per day) in each of the six wards of Nsukka urban is equally shown in table 20. As noted earlier, the ward that is associated with highest per capita water demand is the University community with 159 litres per capita per day. She is followed by Onuiyi 119 litres, while Nru recorded the least per capita water demand of only 62.38 litres per person per day (L/P/D). The average per capita water demand for the entire urban area is 94.57 litres per person per day (L/P/D).

As shown in table 22, the mean per capita water demand for all the wards in Nsukka urban except the University community is generally very low, with some (Nru and Nkpunano) being far below the minimum of 115 litres per person for day, recommended by the Federal Government of Nigeria in the Third National Development Plan. Nsukka plateau is a water deficient area. The people are generally of low socio-economic status and some wards suffer from persistent and prolonged water shortages arising from the frequent tendency of the boreholes to be out of working order (see table 14). As a result, the people do not generally demand much water. The percentage of the Federal Government recommended minimum attained by the six wards in areas of supply (see table 21) are UNN (95.48%), Onuiyi 60.15%), GRA (55.03%),

The & Owerre (34.9%, Nkpunano (27.2%) and Nru (21.8%). This generally low level of water demand is bound to improve with gradually improved housing, industrial developments, and improvements in the people's living standards. The information analysed above are summarised in tables 20 and 21.

Table 21: Household Size and per Capita Water Supply in Nsukka Urban

| Wards | Mean Size of Households (ie. mean No. of Persons (H/H) | Mean Daily Household Water Supply in (Litres) | Mean Daily per Capita Water Supply in (Litres) | % of the Federal Government Recommended Minimum of 115 Attained |
|--------------|--|---|--|---|
| UNN | 6 | 659 | 109.8 | 95.48 |
| Onuiyi | 6 | 415 | 69.17 | 60.15 |
| GRA | 7 | 443 | 43.29 | 55.03 |
| The & Owerre | 6 | 241 | 40.17 | 34.93 |
| Nkpunano | 7 | 219 | 31.29 | 27.20 |
| Nru | 8 | 201 | 25.13 | 21.85 |
| Mean | 7 | 353 | 51.86 | |

Source: Fieldwork (1995)

Significant (from the above table) however, is the relative high water demand for the University community and, to some extent, in the Onuiyi ward. This is probably due to the fact that

the supply system in these wards is relatively stable and often adequate. As a result, the people generally demand more water than others.

3.5 Variations in Water Demand and Supply in Nsukka Urban Area (see tables 21 and 23)

The total amount of water supplied to the household equals that which is either fetched by members of the household and or piped to the household by the water works departments (Ibeziako, 1985, Chima, 1989). As stated in section 3: of this chapter, fetching of water (from boreholes and the University premises, is a common practice in Nsukka urban area. The practice is also energy and time consuming. As a result, those involved, often fetch only the quantity required to meet the most basic needs of the family. In addition, water, as noted earlier is, in vary degrees, a scarce commodity to the six wards of Nsukka urban. Even where pipe water is supplied to compounds by the Urban Water Works Department, the supply system is often so irregular and infrequent. The result is that the overall amount supplied is limited, whatever the supplied is, therefore, consumed.

In establishing the variations between the demand and supply of water in Nsukka urban, we first established the actual quantity available to households. This we did by obtaining

figures of actual quantities supplied by the Urban Water Works Department and figures of the quantities supplied by the largest private supplier in Nsukka urban.- the Works Department of the University of Nigeria. No realistic estimate of the quantity of piped water supplied in Nsukka urban can ignore supplies from the University Water Works Unit, on which a whole ward (ie UNN) and 33% of households without piped supply in Nsukka urban (see section 4.3.2 of this chapter) depend almost exclusively for their household water needs. Table 22 shows clearly the average monthly and daily quantities of water supplied to Nsukka urban area by the two suppliers mentioned above.

Table 22: Monthly Quantities of Water Supplied to Nsukka Urban Area in 1995

| Month | Quantity Supplied by Urban Water Corporation (M ³) *a | Quantity Supplied by Works Dept. UNN (M ³) *b | Total Quantity Supplied (M ³) | Mean Daily Supplied by Urban Water Corporation (Litres)*b | Mean Daily Supplied by Works Dept. UNN (Litres *b) | Total Mean Daily Supplied in (Litres) |
|-------|---|---|---|---|--|---------------------------------------|
| Jan. | 154,794 | 34,266 | 189,060 | 4,993,355 | 1,105,355 | 6,098,710 |
| Feb. | 172,525 | 34,824 | 207,349 | 6,161,602 | 1,243,714 | 7,405,321 |
| March | 178,897 | 32,690 | 211,587 | 5,770,871 | 1,054,516 | 6,825,387 |
| April | 187,435 | 28,236 | 215,671 | 6,247,833 | 941,200 | 6,957,129 |
| May | 164,790 | 30,855 | 195,645 | 5,315,806 | 995,323 | 6,311,129 |
| June | 152,693 | 32,845 | 185,538 | 5,089,767 | 1,059,516 | 5,985,097 |
| July | 152,658 | 32,780 | 185,438 | 4,924,452 | 1,057,419 | 5,981,871 |
| Aug. | 104,780 | 34,794 | 139,574 | 3,380,000 | 1,122,387 | 4,502,387 |
| Sept. | 102,431 | 32,826 | 135,257 | 3,414,367 | 1,094,200 | 4,508,567 |
| Oct. | 162,604 | 26,614 | 189,218 | 5,245,290 | 858,516 | 6,103,806 |
| Nov. | 194,606 | 38,764 | 233,270 | 6,486,867 | 1,292,133 | 7,775,667 |
| Dec. | 202,263 | 42,244 | 244,507 | 6,524,613 | 1,362,710 | 7,887,323 |
| Total | 1,930,476 | 401,738 | 2,332,214 | | | |
| Mean | 160,873 | 33,478.2 | 194,351.25 | 25,362,433 | 1,115,940 | 6,478,373 |

Source: (a) Nsukka Urban Water Corporation (1995) (for *a)

(b) Works Department, U.N.N. (1995) for "b)

Three outstanding features of the supply system are apparent in table 22. The first is the fluctuation in the monthly and daily quantities supplied while the second is the significant decrease in quantity supplied during the rain season particularly in September when demand is at its lowest level. The Zonal Water engineer noted that demand is generally low between June and September and that the reduction in demand is traceable to the fact that people supplement their supply from rain catch. The third feature is the significant relative increase in quantities supplied in December and January. Those are the 'peak periods in demand'. In stable periods (i.e. devoid periods) of frequent and prolonged interruptions due to breakdown in the supply system, water production and supply remain relatively uniform for the other months.

The total amount of water supplied to Nsukka Urban in 1995 was 2,332,214 M³ (i.e. combined totals of the quantities supplied by Nsukka urban water Corporation and that of the University Water Works Unit). The mean monthly supplied was 194,351.2 M³ while the mean daily supply was 6,478,373 litres per day. To get the monthly supply, we divided the total quantity supplied in 1995 by 12. This gave us a mean daily supply of 6,478,373 litres. To obtain the mean daily per capita water supply, we

divided the mean daily supply with the projected population of Nsukka urban for 1995 (which is 124,926 (see table 1)). This gave us a per capita daily supply of 51.861 litres per person per day (L/P/D). Table 21 shows that the mean per capita water demand in Nsukka urban is 94.57 litres while field investigations and questionnaire responses show that the mean per capita water supply is 51.86 litres. This gives in an **average** gap deficiency of 42.71 litres. There is, on the average, therefore, no considerable gap in water demand and supply in the urban area.

3.6 Deficits in the Patterns of Water Demanded and Supplied in Nsukka Urban Area

Table 21/23 shows the quantities of household water demand and supply in Nsukka urban area. On the overall household basis, field investigations and questionnaire responses indicate that the mean per capita water need (demand) for Nsukka urban is 94.57 litres per capita per day (L/P/D), while the mean per capita water supply is 51.86 litres per capita per day. There is, therefore, a big gap between water demand and supply in the urban area. As table 19 shows, water supply to some wards (eg. Nru) is generally low. (The reasons for this low quantities of supply have been identified and analysed as the beginning of this chapter).

There is however, a considerable variation in the deficits among the six wards of Nsukka urban area. Table 21 shows the average per capita water demand and consumption as well as the percentage of demand satisfied by supply in the six wards within Nsukka urban. From the table, UNN was seen to be the least water deficient ward. She has a mean per capita water demand of 159.7 litres and of mean per capita water supply of 109.8 litres. The percentage of demand satisfied by supply is 68.75%. This closely approximates the required 115 litres per head per day which is recommended by the Federal Government of Nigeria in her Third National Development Plan. The University community is followed (not closely) by Onuiyi ward which attains a mean per capita water supply over demand of 58.13%. In GRA and Ihe & Owerre wards, the per capita water supply over demand is 59% and 46% respectively. Nkpunano and Nru wards have per capita water demand over supply of only 41% and 40%. These two wards are therefore the most water deficient wards in Nsukka urban area.

From the above, it is clear that the highest performance achieved of water supply over demand is seen in UNN with 68.8%. This figure translates to a percentage deficiency of 31.25% (daily) implying that the ward still need about 31.25% of its current levels of water supply to satisfy the total water demand for the ward, which is 1,464,671 litres per day. Another ward

where water supply achieves a high percentage of performance over demand is Onuiyi ward where water supply satisfies 58.13% of demand. The percentage of performance achieved by other wards are GRA 59.7%, Ihe & Owerre 46.55%, Nkpunano 40.56%, and Nru 40%. Nru ward, therefore, experiences the lowest relative amount of water supply in Nsukka urban area. This ward is poorly covered by pipeline distribution networks, very far from the urban borehole farm (a foremost supply point) far from the surrounding springs and the University premises. In terms of household water demand, the lowest amount of 499 litres per household per day (L/HM/D) was also recorded at Nru. Apart from the factors mentioned earlier, the relative poverty of the inhabitants of this ward equally contribute to this situation.

One very essential features of the domestic water demand and supply that has been portrayed in our examination of the patterns of residential water demand and supply in Nsukka urban is that the demand for most of the wards was below the Federal Government recommended minimum of 115 litres per head per day. While UNN closely approximate this minimum, the remaining five wards are far from attaining the recommended minimum. On the whole, the percentage of water demand satisfied by supply for the various wards has already been indicated.

3.7 Public Perception of the Water Supply Situation in Nsukka Urban

Our aim in this section is to evaluate how the Nsukka urban dwellers see the water supply situation on which all their domestic and many other activities depend. The people's perception of the water situation is an important aspect of environmental perception. This is due to the fact that water, a being/natural phenomenon, is one of the most important elements of the natural environment. The area of environmental perception deals with man's understanding of the systematic relationship between the physical world and the elements therein (Robinson, 1995). There are individual and class differences in perceptual functioning. These differences are often attributable to individual present and past experiences, value system, needs and location (Robinson, 1995).

The above attributes are clearly reflected in the perception of the Nsukka urban dwellers on the water supply situation. Generally the people readily acknowledge the 'prime necessity' of piped water supplies and easily regret that the supply system is often irregular and inadequate. Some are already apprehensive of the future. It is not difficult to imagine that a few years from now, the urban area may face a major water supply crisis because of the combined effects of rapid population

growth, industrial expansion and inadequate facilities, the problems of fund, irregular power supply, frequent breakdown, and poor maintenance," noted a respondent at Nru ward.

Another area in which the opinions of the urban dwellers were sort was on (their view on) the enormous time spent on fetching water from boreholes and University premises. Surprisingly, majority of those interviewed do not regard time spent on fetching water as "wasted" time. One respondent noted that securing drinking water for family/^{use} is so essential, and "I don't feel any other assignment should take precedent. We are even lucky to have places we can collect water from."

On the issue of irregular and limited piped supplies, majority of the people feel that the situation now constitute a major problem which the urban water supply corporation must address. They are however, pleased that alternative sources often exist.

Associated with irregular and limited piped supplies is the issue of perennial/prclonged water supply shortages in some parts of Nsukka urban. Field investigation revealed that while some of the residents of such areas deeply regret the situation and seek alternative accommodation because of it, others do not see the situation as problematic. "Are you asking me how we (is.Nru people) are coping with the situation? It is

already a 'way of life' for us. It is not our duty to dig boreholes," noted one Mr Ezeugwu. The degree of water scarcity varies almost directly as one moves away from the major supply centres. Against this background, it is rather surprising that the expected heightened sensitivity of the urban dwellers to the apparent lack, by most people of the water deficient wards, of access to adequate and regular water supply is lacking. When asked what the concerned Nru dwellers are doing to minimise water shortages in their ward, one of the respondents replied "we hope that those whose duty it is (ie. the government) will act". Most of the residents of the water deficient wards (Nru, Nkpunano, Ihe & Owerre) only restated their 'believe' that the government and the University are 'aware' of the situation and 'hoped' that they will not allow the situation degenerate to a major crisis. Only a few saw the need to initiate individual and community action to supplement supplies from the urban water corporation. It can therefore, be said that the awareness of the need for individual and community involvement in water resource development which has been described as a 'prime force' (Robinson, 1995) in stirring new developments is generally lacking, especially among the 'natives' within the study area.

Finally it is also a surprise to us that majority of the urban dwellers do not appreciate the serious problems posed to the continued urban growth and expansion by the current supply situation. The normal thing is that water taps should be in every household, and that one can get water just by turning the taps on whenever one so wishes. In such a situation, water storage in containers/tanks, water fetching (from boreholes, University) by women and children, and buying of water from commercial supplies will not be necessary. In addition, the recommended minimum domestic consumption rate of 115 litres per head per day will be obtained by everybody. But all these are 'ideals' or 'dreams' for the Nsukka urban dwellers, where average per capita water supply is just 51.86 litres per person per day. The current supply situation is therefore, insufficient for meaningful urban growth and industrial expansion. Regretably, majority of the urban dwellers do not perceive the situation as bad as it is in reality. Many believe that as soon as they can obtain enough water for their most basic needs, then the water supply situation is not problematic.

CHAPTER FOUR

ANALYSIS OF THE FACTORS AFFECTING WATER DEMAND
PATTERNS IN NSUKKA URBAN

Our aim in this chapter is to isolate and analyse the dominant and significant factors affecting water demand and consumption patterns in Nsukka urban area. This is achieved through the application of the multivariate statistical techniques of multiple regression and factor analysis to the variables which we consider relevant in influencing water demand and consumption patterns earlier established and described in Chapter Three. The variables which we consider relevant in influencing water demand and consumption patterns have been identified and parameterized in the manner described below.

4.1 Outline of the Variables Affecting Water
Demand and Consumption in Nsukka Urban Area

As stated in chapter 1, section 5, the factors which we consider relevant in influencing water demand and consumption patterns in Nsukka urban area are numerous. These variables are extracted from the questionnaire returns administered on the respondents. They are mainly physical, social and economic factors. In this section, we shall describe some of them in details. We shall in

parametise
addition / them in order to them in numerical terms.

They include:

1. The Size of the Household

It is obvious that households with large sizes will likely consume more water than those with small sizes. The number of persons in a household is recorded as indicated by the respondents.

2. The Household Income

We assume in this study that household income influence the availability of water consuming gardets and consequently, the overall quantity of water used in the house. In other wards, household with higher income tend to consume more water than those with little income. We recorded the income as provided by the respondents or estimated from their salary grade levels.

3. The Educational Attainment of the Head of the Household

The level of education attained by the head of the household invariably affects the socio-economic status of the household and consequently the amount of water consumed (Ezenwaji, 1990). In the present study, the level of educational attainment is considered after Chima (1989) on the

number of years respondents spent in getting the formal education. This is shown in the table below.

| S/No. | Level of Education | No. of Years in School |
|-------|--|------------------------|
| 1 | No formal education | 0 |
| 2 | Primary school education | 6 |
| 3 | Secondary school education | 11 |
| 4 | NCE and OND | 14 |
| 5 | University Degree (B.Sc., H.N.D., B.A., B.Ed.) | 16 |
| 6 | Higher Degree (M.Sc, M.A. Ph.D. | 20 |

4. Availability of Water-taps in Residence

It is often assumed that households with water system in the house tend to consume more water than those without water system (Ibeziako, 1985; Ezenwaji, 1990). In the present study, if water system exist in the house, then a value of 1 (one) is recorded, and if there is none, a value of 0 (zero) is recorded.

5. The Number of Hours taps Run in a Week

In a 'perfect supply situation' water taps run for twenty-four (24) hours a day, and households use water as preferred because of the unlimited supply. But where taps

run only for a few hours a day and few days a week, then amount available is limited and consumption tend to be less. In our present study, we recorded the number of hours as provided by the respondents.

6. Distance to the Nearest Public Water Supply Source

The frequency, regularity and quantity of water which household are able to secure from public water supply sources often influence the quantity used (Chima, 1989). Our respondents estimated the distance to the nearest public water supply sources in kilometers, and such estimated figures were recorded.

7. The Number of Water Using Appliances in the Home

The greater the number of water consuming appliances in the house, the greater is the likelihood of consuming greater quantities of water. The value of 1 (one) is assigned to each of these appliances. Where none exist, the lowest value of 0 (zero) is recorded.

8. The Quantity of Water Used for Cooking Per Day

This was estimated by the respondents in units of standard buckets (standard Organisation of Nigeria SOS Size 30) and converted to litres (12litres).

9. The Number of Rooms Occupied by a Household

Our assumption is that the greater the number of rooms occupied by the household, the greater the likelihood of consuming more water for household activities. The number of rooms occupied by a household was recorded as provided by the respondent.

10. The Quantity of Water Used for Cleaning the House

This is often related to the availability of space and the level of dirtiness. The quantity of water used for general household cleaning was estimated in units of standard bucket (SOS size 30) and converted to litres.

11. Availability of Water Vendors

Our assumption is that areas where commercial supplies is totally lacking may likely suffer more, especially in time prolonged shortages and as such may tend to consume less water. In this study, we assign a value of 1 (one) if commercial suppliers are available, and a value of 0 (zero) if commercial suppliers are lacking.

12. Cost of Water Supplies

Consumer economists often assert that increase in price is often followed by a decrease in demand. The expectation here is that the higher the cost of water, the lesser the quantity which households are able to purchase and use. The cost of water per month is indicated by the respondents and recorded in naira.

13. Occupation of the Head of the Household

The occupation and rank of the respondents are extracted from the questionnaire. A system of categorization and ranking of occupational groups employed by Ibeziako (1985) was considered relevant for this study because it is very comprehensive and includes all the necessary groups. This system of categorization and ranking is as shown in table 23.

Table 23: Occupational Groups

| S/No. | Occupational Group | Scale | Example |
|-------|---------------------------|-------|-----------------------------------|
| 1 | Unskilled workers | 1 | Labourers, Messengers, etc. |
| 2 | Traders | 2 | Retail traders, etc. |
| 3 | Artisans | 3 | Mechanics carpenters, etc. |
| 4 | Clerical & sales Officers | 4 | Typists, Clerical Assistant, etc. |
| 5 | Semi-Professional | 5 | Draughtsmen, Superintendent, etc. |
| 6 | Professionals | 6 | Lawyers, Professors, etc. |
| 7 | Others | 7 | Industrialists, Employers |

Variable Abbreviation

The (physical, social and economic) variables listed and described above, are, for the purpose of this analysis abbreviated as shown in table 24.

Table 24: Variables Used in Factor Analysis and Multiple Regression Studies of Water Demand and Consumption Patterns in Nsukka Urban Area

| S/No. | Variable Description | Variable Abbreviation |
|-------|--|-----------------------|
| 1 | The size of the household | SIZE |
| 2 | The income of the head of the household | XNCON |
| 3 | Educational qualification of the household head | EDU |
| 4 | Availability of water-taps in residence | TAP |
| 5 | Number of hours taps run per week | HOUR |
| 6 | Distance to the nearest public water supply source | DIST |
| 7 | Number of water consuming appliances | WCA |
| 8 | Number of rooms occupied by the household | ROOM |
| 9 | Quantity of water used for cooking | COOK |
| 10 | Quantity of water used for household cleaning | HOUSE |
| 11 | Availability of water vendors | WC |
| 12 | Cost of water supplied in a month | COST |
| 13 | Occupation of the head of the household | OCUPA |

The total amount of water demanded/consumed (AMT) will be regressed against the 13 variables described above.

4.2 Analysis of Causal Relationships

Basically, a powerful statistical technique which is often used (Kirby, 1976) (Goddard & / for analysing causal relationship among dependent and independent variables is the multiple regression model. This statistical technique is further described below.

4.2.1 The Multiple Regression Model

Multiple regression analysis is a general statistical technique by which one can accurately analyse the relationship between the dependent or criterion variable and a set of independent or prediction variables (Nie, Hall, Jenkins Streinbrenner and Bent, 1975). The technique may be viewed as a descriptive toll by which the linear dependence of a variable on the other can be summarised and decomposed (Goddard and Kirby, 1976). It is also an inferential tool which enables one to evaluate the relationships in a given population through the examination of sample data (Muther and Doornkamp, 1978). The general expression of the multiple linear regression as given by Hullman and Boyef (1975) is as shown below:

$$Y = a + b_1 x_1 + b_2 x_2 + b_3 x_3 + \dots + b_n x_n \text{ te } \dots (2)$$

Where Y is the dependent variable; $x_1, x_2, x_3 \dots x_n$ are

the regression coefficients; n is the base constant, and e is the error term or the proportion of the variance not explained by the regression.

Many geographers have employed this statistical analysis in their investigations. For instance, Hagget (1964) utilized this statistical technique to study regional and local components in the distribution of forest areas in South East of Brazil. He was able to arrive at the conclusion that forest density index and terrain index are particularly important factors in determining forest patterns. Similarly, Abumere (1979) applied this technique in the study of diffusion of secondary schools in Bendel State of Nigeria. Anyadike (1981) used the model to determine the relative importance of atmospheric variables contributing to the rainfall of West Africa. Other geographers who have successfully applied this statistical technique in their own studies include Regens (1967), Kings (1969), Willis (1975), Turvey (1976), Ibeziako (1985), Chima (1989), Ezenwaji (1990) and Ezema (1995). We will employ this technique in this study to reveal the relevant factors influencing the amount of water demanded and consumed in Nsukka urban area. The variables which we consider relevant in influencing the amount of water demanded in Nsukka urban are defined, described and parametrized in section 4.1 of chapter 4.

4.2.2 The Combined Influence of the Predictor Variables on the Amount of Water Demanded in Nsukka

4.2.2.1 The Entire Urban

The combined strength of the relationship between the 13 predictor variables and the amount of water demanded and consumed in Nsukka urban is assessed by the multiple correlation coefficient (R). The result of the computer analysis reveal that the multiple correlation coefficient is of 0.807, with a coefficient of multiple determination (R^2) of 0.652. That is, the combined effect of the 13 predictor variables accounts for or explains 65.2% of the variations in the amount of water demanded/consumed per household in Nsukka urban. This leaves 34.8% which the multiple regression model is unable to explain - meaning that other variables other than those utilized for this study also account for water demand and consumption in Nsukka urban area.

The standard error of estimate for this regression analysis is +149.8 litres per household. This means that the average over or under estimation of household water demand is in Nsukka urban using these 13 predictor variables is 149.8 litres. The apparently high figure/value returned by our analysis should not be a surprise. When we consider the wide range in household water demand (arising from say variations in household size)

and that our interest is in estimating the water demanded by households, we realise that the above figure, though apparently large, is not unexpected.

4.2.2.2 The Combined effects of the Predictor Variables on Household Water Demand in the Wards

The result of our multiple regression analysis of the effects of the 13 predictor variables on the amount of water demanded/consumed in the six wards of Nsukka urban is shown in table 24.

Table 24: Relationship Between Water Demand and the Predictor Variables for the Wards in Nsukka Urban

| S/No. | Wards | Contribution of Variables (R ²) | Contribution of Variables (R ² %) | % Unexplained |
|-------|--------------|--|---|---------------|
| 1 | GRA | 0.872 | 87.2 | 12.8 |
| 2 | Onuiyi | 0.637 | 63.7 | 36.3 |
| 33 | Ihe & Owerre | 0.727 | 72.7 | 27.3 |
| 4 | Nru | 0.763 | 76.3 | 23.7 |
| 5 | UNN | 0.778 | 77.8 | 22.2 |
| 6 | Mkpunano | 0.608 | 60.8 | 39.2 |

Column 4 of table 24 shows the percentage of the variations in household water demand which the predictor variables were able to account for, while column 5 shows the percentage the 13 predictor variables were unable to explain. As shown in table 24, the ward with the highest explanation based on the 13 predictor variables is the GRA (87.2%). This shows that the 13 predictor variables employed in our analysis are most successful in the explanation of water demand and consumption in GRA. In contrast, Nkpunano ward recorded the least explanation (60.8%) based on the 13 predictor variables. This shows that the 13 predictor variables employed in our analysis are least successful in explaining household water demand in this ward. This may be because Nkpunano has a very high concentration of low income dwellers (especially natives) whose pattern of water usage is unclear or unique. It may equally be that the information collected from this ward were (perhaps deliberately) falsified by the respondents. Generally, however, the 13 predictor variables explained high percentages in the variations in household water demand and consumption in the remaining wards - UNN (77.8%), Nru (76.3%), Ibe (72.7%) and Onuiyi (63.7%). Onuiyi ward with a value of 0.637 (63.7%) most closely approximate the value of the entire urban area which is 0.652 (65.2%).

The result of the computer analysis reveal the standard error of estimate for the various wards are: GAA (± 109.7 litres), Onuiyi (± 120.0 litres), UNN (125.5 litres, (Nkpunano (± 120.9 litres) and Nru (± 104.4 litres). As noted earlier, when we consider the wide range in household water demand and consumption patterns, these figures, though apparently high may not be unexpected.

4.3 Analysis of the Individual Contributions of the Predictor Variables to the Observed Variations in the Amount of Water Demanded in Nsukka Urban

4.3.1 The Entire Urban

The individual contributions of the 13 predictor variables to the observed variations in the amount of water demanded (X_1 , AMT) was also calculated with the aid of the multiple regression model. The result is shown in table 25.

Table 25: Individual Contributions of the Independent Variables to the Variations in the Total Amount of Water Demanded by Households in the Entire Nsukka Urban

| Independent Variables | Standard Error | R ² | R ² (%) | Signs | F. Ratio |
|-----------------------|----------------|----------------|--------------------|-------|----------|
| X2 XNCON | 0.006 | 0.127 | 12.7 | + | 40.600 |
| X3 COST | 0.058 | 0.009 | 0.9 | - | 5.215 |
| X4 COOK | 0.148 | 0.150 | 15.0 | + | 2.653 |
| X5 HOUSE | 0.096 | 0.059 | 5.9 | + | 37.631 |
| X6 EDU | 1.336 | 0.110 | 1.1 | + | 5.109 |
| X7 HOUR | 2.931 | 0.010 | 1.0 | + | 5.270 |
| X8 SIZE | 2.729 | 0.145 | 15.5 | + | 74.128 |
| X9 WC | 19.386 | 0.004 | 0.4 | - | 0.138 |
| X10 COUPA | 4.051 | 0.010 | 1.0 | + | 0.029 |
| X11 DIST | 4.414 | 0.001 | 0.1 | - | 2.715 |
| X12 TAP | 5.455 | 0.001 | 0.1 | + | 15.843 |
| X13 WCA | 5.810 | 0.000 | 0.0 | + | 8.049 |
| X14 ROOM | 6.157 | 0.117 | 11.7 | + | 0.552 |
| Total | | 0.652 | 65.2 | | |

Four variables contributed significantly to the variation in household water demand and consumption patterns in Nsukka urban area. A total of 53.9% of the variations in household water demand and consumption is explained by the variables. The

variables are COOK (the quantity of water used for cooking (15%)), SIZE (household size (14.5%)), XCON (the income of the household head (12.7%)), and ROOM (the number of rooms occupied by the household (11.7)). Only one other variable HOUSE (quantity of water used for household cleaning (5.9%)) is significant at 0.05 level of significance. Other variables are not significant at 0.05 level of confidence. Variable X13 (the number of water consuming appliances (WAC)) make no measurable contributions to the variations in household water demand and consumption patterns in Nsukka urban area. The fact that the other seven variables (see table 25) make no significant contributions to the variations in household water demand seems to suggest that they are not important in explaining the household water consumption patterns in Nsukka urban area. We shall, therefore, conclude that the factors affecting the total amount of household water demand and consumption in the Nsukka urban area are the quantity of water used for cooking (COOK), the size of the household (SIZE), the income of the head of the household (XCON), and the number of rooms occupied by the household (ROOM).

Additional information on the behaviour of the predictor variables can be obtained from the signs carried by the regression coefficients. These signs (see column 5 of table 25) indicate the direction of the relationship between the dependent

variable and the 13 predictor variables. As shown in table 25, ten of these variables have positive signs showing that there is a direct relationship between these predictor variables and household water demand. In other words, a unit increase in any of these variables (X2, X4, X5, X6, X7, X8, X9, X10, X12 and X14) will also lead to a unit increase in the amount of water demanded by households. The remaining three variables (X3, X7 and X11) have negative signs showing that there is an inverse relationship between these predictor variables and the amount of water demanded by households. This simply means that any unit increase in any of these predictor variables will lead to a unit decrease in the amount of water demanded by household in Nsukka urban.

The standard error of estimate of the multiple regression is again shown in column two. The variables with the highest standard errors of estimates are X9 (availability of water vendors (19.386), X13 (availability of water consuming appliances (5.810) and X12 (availability of taps in residence (4.455)). This shows that these predictor variables are not good indicators of the amount of water consumed by households in Nsukka urban. In contrast, variables X2 (household income), X3 (cost of water supplied in a month) X5 (quantity used for household cleaning) X8 (household size), etc. generally have low standard errors of estimates. This shows the importance of these variables

are as fairly accurate estimators of the amount of water demanded and consumed in Nsukka urban.

4.3.2 Individual Contributions of the Predictor Variables to Variations in Water Demand in the Wards

The contributions of the individual variables to the observed variations in household water demand in the various wards was also calculated with the aid of the multiple regression model. The result is shown in table 26.

Table 26: Individual Contributions of the Independent Variables to the Variations in the Total Amount of Water Demanded and Their Standard Errors of Estimate (Nkpunano Ward)

| Independent Variable | Standard Error | R ² | R ² (%) | Signs | F. Ratio |
|----------------------|----------------|----------------|--------------------|-------|----------|
| X2 XNCON | 0.014 | 0.024 | 2.4 | + | 3.951 |
| X3 COST | 0.102 | 0.025 | 2.5 | - | 2.739 |
| X4 COOK | 0.342 | 0.247 | 24.7 | + | 4.281 |
| X5 HOUSE | 0.250 | 0.023 | 2.3 | + | 1.792 |
| X6 EDU | 1.475 | 0.000 | 0.0 | + | 0.112 |
| X7 HOUR | 5.613 | 0.000 | 0.0 | + | 0.146 |
| X8 SIZE | 4.946 | 0.170 | 17.0 | + | 56.334 |
| X9 WC | 30.730 | 0.007 | 0.7 | + | 2.154 |
| X10 COUPA | 6.557 | 0.015 | 1.5 | + | 4.756 |
| X11 DIST | 6.656 | 0.003 | 0.3 | - | 0.911 |
| X12 TAP | 7.752 | 0.001 | 0.1 | + | 0.464 |
| X13 WCA | 9.935 | 0.001 | 0.1 | + | 0.235 |
| X14 ROOM | 10.666 | 0.102 | 10.2 | + | 0.058 |
| | Total | 0.608 | 60.8 | | |

In Nkpunano ward (table 26) three variables make significant contributions to the variations in household water demand and consumption patterns. A total of 51.9% of the variations in household water demand is explained by these three variables. The three variables are X4 (the quantity of water used for cooking - COOK (24.7%), X8, SIZE (household size = 17%), and X14, ROOM (the number of rooms occupied by the household = 10.2%). Four additional variables XNCON (household income = 2.4%) COST (the cost of water supplied in the month = 2.5%), HOUSE (quantity used for household cleaning = 2.3%) and OCUPA (the occupation of the household head = 1.5%) make minimal contributions. Note that variable X4 (quantity used for cooking alone contributed the largest (24.7%) to the explained variance.

In the University ward (table 27), the situation is different.

Table 27: Individual Contributions of the Independent Variables to the Variations in the Amount of Water Demanded and Their Standard Errors of Estimate (UNN Ward)

| Independent Variable | Standard Error | R ² | R ² (%) | Signs | F. Ratio |
|----------------------|----------------|----------------|--------------------|-------|----------|
| X2 XNCON | 0.012 | 0.119 | 11.9 | + | 0.925 |
| X3 COST | 0.003 | 0.000 | 0.0 | - | 0.108 |
| X4 COOK | 0.392 | 0.101 | 10.1 | + | 0.078 |
| X5 HOUSE | 0.221 | 0.000 | 0.1 | + | 0.685 |
| X6 EDU | 9.675 | 0.022 | 2.2 | + | 0.078 |
| X7 HOUR | 9.564 | 0.019 | 1.9 | ++ | 0.608 |
| X8 SIZE | 8.669 | 0.283 | 28.3 | + | 24.514 |
| X9 WC | 0.001 | 0.000 | 0.0 | - | 0.102 |
| X10 COUPA | 30.454 | 0.004 | 0.4 | + | 9.886 |
| X11 DIST | 0.003 | 0.000 | 0.0 | - | 0.098 |
| X12 TAP | 9.872 | 0.051 | 5.1 | + | 0.108 |
| X13 WCA | 23.738 | 0.021 | 2.1 | + | 9.806 |
| X14 ROOM | 24.423 | 0.158 | 15.8 | + | 5.914 |
| Total | | 0.778 | 77.8 | | |

Four variables made the greatest contributions to the variations in household water demand. These variables which collectively contributed 66.1% to the explained variance include variable X14 (the number of rooms occupied by the household -

ROOM = 28.3%), X8 (household size - SIZE = 15.8%), X2 (household income - XNCON = 11.9%) and X4 (the quantity used for cooking - COOK = 10.1%), three variables make no measurable contributions to the variations in household water demand and consumption patterns. These are COST (the cost of water supplied in a month), DIST (the distance to the nearest source of public supply) and WC (the availability of water vendors.

In the ward (table 28), the situation is also unique.

Table 28: Individual Contributions of the Independent Variables to the Variations in the Total Amount of Water Demanded and the Standard Errors of Estimate (The Ward)

| Independent Variable | Standard Error | Contribution of Variables (R^2) | Contributions of Variables R^2 (%) | Signs | F. Tation |
|----------------------|----------------|-------------------------------------|--------------------------------------|-------|-----------|
| X2 XNCON | 0.012 | 0.023 | 2.3 | + | 0.173 |
| X3 COST | 0.091 | 0.006 | 0.6 | - | 9.059 |
| X4 COOK | 0.518 | 0.473 | 47.3 | + | 5.312 |
| X5 HOUSE | 0.242 | 0.009 | 0.9 | + | 0.025 |
| X6 EDU | 2.700 | 0.029 | 2.9 | + | 23.790 |
| X7 HOUR | 5.647 | 0.000 | 0.0 | + | 0.939 |
| X8 SIZE | 5.813 | 0.095 | 9.5 | + | 56.909 |
| X9 WC | 32.247 | 0.006 | 0.6 | + | 2.744 |
| X10 COUPA | 7.290 | 0.009 | 0.9 | + | 6.265 |
| X11 DIST | 8.507 | 0.004 | 0.4 | - | 2.776 |
| X12 TAP | 15.178 | 0.002 | 0.2 | + | 10.427 |
| X13 WCA | 10.600 | 0.007 | 0.7 | + | 3.826 |
| X14 ROOM | 10.464 | 0.066 | 6.6 | + | 0.127 |
| | Total | 0.727 | 72.7 | | |

Two variables, namely COCK (the quantity used for cooking (47.3%) and SIZE (the household size (9.5%)) accounted for 56.8% of the observed variations in household water demand. The contribution of one other variable, that is ROOM (the number of rooms occupied by the household = 6.6%) is significant at 0.05 level. Other variables generally make very low contributions to the observed variance. The ward is a high density, mixed income residential area, with a high concentration of large family sizes (squeezed into a few rooms) - hence the remarkable influence of household size on the water demand patterns in the ward.

Nru ward (table 29) compares favourably with the entire Nsukka urban (table 25).

Table 29: Individual Contributions of the Independent Variables to the Variations in the Total Amount of Water Demanded and Their Standard Errors of Estimate (Nru Ward)

| Independent Variable | Standard Error | Contribution of Variables (R^2) | Contribution of Variables R^2 (%) | Signs | F. Ratio |
|----------------------|----------------|-------------------------------------|-------------------------------------|-------|----------|
| X2 XNCON | 0.016 | 0.028 | 2.8 | + | 7.743 |
| X3 COST | 0.12 | 0.000 | 0.0 | - | 0.086 |
| X4 COOK | 0.326 | 0.083 | 8.3 | + | 0.072 |
| X5 HOUSE | 0.291 | 0.135 | 13.5 | + | 12.527 |
| X6 EDU | 2.884 | 0.038 | 3.8 | + | 1.299 |
| X7 HOUR | 8.734 | 0.003 | 0.3 | + | 2.254 |
| X8 SIZE | 4.850 | 0.251 | 25.1 | + | 64.922 |
| X9 WC | 66.907 | 0.003 | 0.3 | + | 2.007 |
| X10 COUPA | 7.803 | 0.003 | 0.3 | + | 0.920 |
| X11 DIST | 6.199 | 0.000 | 0.0 | - | 0.061 |
| X12 TAP | 17.854 | 0.001 | 0.1 | + | 0.631 |
| X13 WCA | 9.704 | 0.004 | 0.4 | + | 1.544 |
| X14 ROOM | 9.050 | 0.214 | 21.4 | + | 0.753 |
| | Total | 0.763 | 76.3 | | |

Here four variables contributed significantly to the variations in household water demand and consumption patterns. A total of 68.3% of the variations in household water demand is explained by these four variables. The variables are SIZE (household size =

25.1%), ROOM (the number of rooms occupied by the household = 21.4%), HOUSE (the quantity used for household cleaning = 13.5%), and COOK (quantity used for cooking = 8.3%). Other variables make minimal or no measurable contributions to the observed variations in household water demand and consumption patterns in the ward. Table 30 shows the individual contributions of the 13 predictor variables to the observed variations in water demand in Onuiyi ward.

Table 30: Individual Contributions of the Independent Variables to the Variations in the Total Amount of Water Demanded and Their Standard Errors of Estimate (Onuiyi Ward)

| Independent Variables | Standard Error | Contributions of Variables (R^2) | Contributions of Variables R^2 (%) | Signs | F. Ratio |
|-----------------------|----------------|--------------------------------------|--------------------------------------|-------|----------|
| X2 XNCON | 0.020 | 0.141 | 14.1 | + | 6.714 |
| X3 COST | 0.220 | 0.010 | 1.0 | - | 0.001 |
| X4 COOK | 0.216 | 0.003 | 0.3 | + | 2.653 |
| X5 HOUSE | 0.160 | 0.004 | 0.4 | + | 3.394 |
| X6 EDU | 5.586 | 0.070 | 7.0 | + | 17.735 |
| X7 HOUR | 5.594 | 0.054 | 5.4 | + | 16.770 |
| X8 SIZE | 6.290 | 0.140 | 14.0 | + | 41.478 |
| X9 WC | 44.584 | 0.029 | 2.9 | + | 4.584 |
| X10 COUPA | 16.483 | 0.006 | 0.6 | + | 0.001 |
| X11 DIST | 36.250 | 0.003 | 0.6 | - | 1.133 |
| X12 TAP | 7.788 | 0.000 | 0.3 | + | 0.040 |
| X13 WCA | 12.098 | 0.002 | 0.0 | + | 0.670 |
| X14 ROOM | 21.846 | 0.173 | 0. | + | 2.782 |
| Total | | 0.636 | 63.6 | | |

Like in Nru, four variables namely: ROOM (the number of rooms occupied by the household = 17.3%), XNCON (income of household size = 14.0%) and HOUR (the number of hours taps run in a week = 5.4%) make the largest contribution of 52.4% to the variations in household water demand. The number of hours taps run per a week (ie. variable X7 (HOUR) contributed 5.4% to the explained variance. The contributions of the remaining variables are not significant at 0.05 confidence level.

Table\$ 31 shows that two variables (X14 and X4) make the greatest contributions in the GRA ward.

Table 31: Individual Contributions of the Independent Variables to the Variations in the Total Amount of Water Demanded and Their Standard Errors of Estimate (G.A. Ward)

| Independent Variables | Standard Error | Contributions of Variables of Variables (R^2) | Contributions of Variables of Variables R^2 (%) | Signs | F. Ratio |
|-----------------------|----------------|---|---|-------|----------|
| X2 XNCON | 0.033 | 0.027 | 2.7 | + | 3.300 |
| X3 COST | 0.355 | 0.010 | 1.0 | - | 7.405 |
| X4 COOK | 0.686 | 0.364 | 36.4 | + | 18.444 |
| X5 HOUSE | 0.354 | 0.066 | 6.6 | + | 5.293 |
| X6 EDU | 13.917 | 0.001 | 0.1 | + | 1.663 |
| X7 HOUR | 10.856 | 0.000 | 0.0 | + | 3.120 |
| X8 SIZE | 10.726 | 0.064 | 6.4 | + | 13.507 |
| X9 WC | 46.844 | 0.032 | 3.2 | + | 7.974 |
| X10 COUPA | 22.885 | 0.004 | 0.4 | + | 1.525 |
| X11 DIST | 14.617 | 0.002 | 0.2 | - | 0.271 |
| XX12 TAP | 21.758 | 0.001 | 0.1 | + | 0.190 |
| X13 WCA | 29.448 | 0.001 | 0.1 | + | 0.494 |
| X14 ROOM | 22.407 | 0.298 | 29.8 | + | 0.203 |
| | Total | 0.872 | 87.2 | | |

A summary of the individual contributions of the 13 predictor variables to variations in household water demand and consumption in the six wards of Nsukka urban area is shown in table 32.

Table 32: The Contributions of the Individual Variables to Variations in Household Water Demand in the Six Wards of Nsukka

| VARIABLES WARDS | XNCON | COST | COOK | HOUSE | EDU | HOUR | SIZE | WC | OCUPA | DIST | WCA | ROOM | TOTAL | |
|-----------------|-------|------|-------|-------|------|------|-------|-----|-------|------|------|------|-------|------|
| RA | 2.7 | 1.0 | 36.4* | 6.6* | 0.1 | 0.0 | 6.4 | 3.2 | 0.4 | 0.2 | 0.1 | 0.1 | 29.8 | 37.2 |
| WUIYI | 4.1* | 1.0 | 0.3 | 0.4 | 7.0* | 5.4* | 14.0* | 2.9 | 0.6 | 0.1 | 0.0 | 0.2 | 17.3* | 63.6 |
| HE | 2.3 | 0.6 | 47.3* | 0.9 | 2.9 | 0.0 | 9.5* | 0.6 | 0.9 | 0.4 | 0.2 | 0.7 | 6.6* | 72.7 |
| RU | 2.8 | 0.0 | 8.3* | 13.5* | 3.8 | 0.3 | 25.1* | 0.3 | 0.3 | 0.0 | 0.1 | 0.4 | 21.4* | 76.3 |
| NN | 1.9* | 0.0 | 10.1* | 0.1 | 2.2 | 1.9 | 28.3* | 0.0 | 0.4 | 0.0 | 5.1* | 2.1 | 15.8* | 77.8 |
| IPU* | 2.4 | 2.5 | 24.7* | 2.3 | 0.0 | 0.0 | 17.0* | 0.7 | 1.5 | 0.3 | 0.1 | 0.1 | 10.2* | 60.8 |

* Significant at 0.05 level.

As shown in table 32, three variables, ROOM (the number of rooms occupied by the household), SIZE (the size of the household) and COOK (the quantity of water used for household cooking) make significant contribution in all the wards. This clearly shows that these variables are very important in explaining the people's water demand and consumption patterns. Four variables, namely WCA (the number of water consuming appliances), DIST (distance to the nearest source of public supply source), OCUPA (the occupation of the household head) WC (availability of water vendors) and COST (the cost of water supplied in a month) generally make no appreciable contributions to the water demand and consumption patterns in any of the wards. These variables

4.4 Analysis of the Interrelationship Among
the Variables Influencing Water Demand and
Consumption in Nsukka Urban

The interrelationships among the independent variables used in our analysis are found by correlation analysis. The result is presented in a 14 x 14 matrix of inter correlations for the whole urban area and for each of the wards (tables 34 to 41). These tables show that some of the independent variables are highly correlated with themselves, for instance, table 34.

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are, therefore, not important in explaining the water demand and consumption patterns in Nsukka urban.

To further clarify our analysis, we isolate the variable which made the highest contributions to the explained variance in each of the wards. This is shown in table 33.

Table 33: Percentages of the Variations Explained by the Leading Variables in the Wards of Nsukka Urban

| S/No. | Wards | The Most Important Variable | % Explained by the Most Important Variable |
|-------|----------|-----------------------------|--|
| 1 | GRA | COOK | 36.4% |
| 2 | ONUIYI | ROOM | 17.3% |
| 3 | IHE | COOK | 47.3% |
| 4 | NRU | SIZE | 25.1% |
| 5 | UNN | SIZE | 28.3% |
| 6 | Nkpunano | COOK | 24.7% |

From table 33, it can be seen that the quantity of water used for household cooking (COOK) appear to be the major determinant in three wards (GRA, Ihe and Nkpunano) while the number of rooms occupied by the household (ROOM) is the most important variable explaining water demand and consumption patterns in Onuiyi ward. Household size is the most important determinant of water demand patterns in Nru and UNN wards.

It is important to note that the ward is the only ward where the percentage of the variations in water demand explained by the most important variable contributed up to 47.3%

As noted earlier, signs carried by the regression coefficients (column 5) show the direction of the relationship between the dependent variable and the 13 predictor variables (tables 25-31). As shown in the above tables, ten variables (X2, X4, X5, X6, X7, X8, X9, X10, X12 and X14) generally have positive signs showing that there is a direct relationship between these variables and the amount of water demanded. The remaining variables with negative signs show that there is an inverse relationship between these variables and the amount of water demanded by households. The positive sign between variable X7 (the number of hours taps ran per week) and the amount of water demanded in GRA, Ihe, Nru and Mpunano wards should not be a surprise. In these wards, where drought management (ie. rationing) has been adopted as a guiding policy by the urban water corporation, the tendency for demand to increase on the number hours taps run increases should be expected. But in UNN and Onuiyi wards where supply is more regular and stable, the relationship between variable X7 and the amount of water demand is negative - indicating that the tendency to store water in these wards is lacking.

Table 34: Correlation Matrix of the Variables Constituting the Multiple Regression Model for the Entire Nsukka Urban

| | | X 1 AMT | X 2 XNCON | X 3 COST | X 4 COOK | X 5 HOUSE | X 6 EDU | X 7 HOUR | X 8 SIZE | X 9 WC | X 10 COUPA | X 11 DIST | X 12 TAP | X 13 WCA | X 14 ROOM |
|-----|-------|---------------|-----------------|----------------|----------------|-----------------|---------------|----------------|----------------|--------------|------------------|-----------------|----------------|----------------|-----------------|
| X1 | AMT | 1.00 | | | | | | | | | | | | | |
| X2 | XNCON | 0.431* | 1.00 | | | | | | | | | | | | |
| X3 | COST | -0.099 | -0.324 | 1.00 | | | | | | | | | | | |
| X4 | COOK | 0.531 | 0.261 | -0.134 | 1.00 | | | | | | | | | | |
| X5 | HOUSE | 0.522 | 0.253 | -0.121 | 0.423 | 1.00 | | | | | | | | | |
| X6 | EDU | 0.372 | 0.670* | -0.178 | 0.276 | 0.194 | 1.00 | | | | | | | | |
| X7 | HOUR | 0.375 | 0.218 | -0.453 | 0.377 | 0.321 | 0.296 | 1.00 | | | | | | | |
| X8 | SIZE | 0.656* | 0.128 | 0.112 | 0.696* | 0.380 | 0.180 | 0.161 | 1.00 | | | | | | |
| X9 | WC | 0.358 | 0.276 | -0.502 | 0.373 | 0.351 | 0.302 | 0.435 | 0.145 | 1.00 | | | | | |
| X10 | COUPA | 0.343 | 0.416 | -0.225 | 0.301 | 0.208 | 0.676* | 0.354 | 0.167 | 0.406 | 1.00 | | | | |
| X11 | DIST | -0.235 | -0.212 | 0.450 | -0.240 | -0.250 | -0.226 | -0.643* | -0.079 | -0.684* | -0.262 | 1.00 | | | |
| X12 | TAP | 0.440 | 0.478 | -0.504 | 0.362 | 0.353 | 0.351 | 0.616* | 0.121 | 0.422 | 0.458 | -0.518* | 1.00 | | |
| X13 | WCA | 0.434 | 0.384 | -0.363 | 0.343 | 0.260 | 0.340 | 0.536 | 0.201 | 0.523 | 0.394 | -0.451 | 0.568 | 1.00 | |
| X14 | ROOM | 0.342 | 0.649* | 0.104 | 0.344 | 0.677* | 0.205 | 0.054 | 0.356 | 0.063 | 0.137 | -0.019 | 0.097 | 0.132 | 1.00 |

* Significant Coefficients, + /- 0.50

Correlation matrix of the variables constituting the multiple regression model for Nsukka urban shows that variable X4 (amount used for household cooking) is strongly correlated with variable X8 (household size). Similarly, variables X2 (household income) is strongly correlated with variable X14 (the number of rooms occupied by the household), while variable X6 and X10 are highly intercorrelated. The high level of interrelatedness among some of the independent variables should not be a surprise. For instance, one would expect the quantity of water used for household cleaning to be related to the number of rooms occupied or the quantity used for household cooking to be related to the number of persons in a household.

The situation in the six wards are shown in tables 35 to 40. In the ward (table 35) the result of the correlation analysis show that variable X4 (quantity used for cooking) is strongly correlated with X5, X7 and X8. That is, the amount of water used for cooking is strongly related to the size of the household the number of hours taps run and the amount used for household cleaning, (table 35). Similarly, variable X6 (educational qualification of the household head) is strongly related to variable X10 (occupation of the household head).

In Onuiyi ward, the situation is not entirely different.

Table 35: Correlation Matrix of the Variables Constituting the Multiple Regression Model for the Ward

| | | X 1 AMP | X 2 XNCON | X 3 COST | X 4 COOK | X 5 HOUSE | X 6 EDU | X 7 HOUR | X 8 SIZE | X 9 WC | X 10 COUPA | X 11 DIST | X 12 TAP | X 13 WCA | X 14 ROOM |
|-----|-------|---------------|-----------------|----------------|----------------|-----------------|---------------|----------------|----------------|--------------|------------------|-----------------|----------------|----------------|-----------------|
| X1 | AMP | 1.00 | | | | | | | | | | | | | |
| X2 | XNCON | 0.179 | 1.00 | | | | | | | | | | | | |
| X3 | COST | 0.123 | 0.103 | 1.00 | | | | | | | | | | | |
| X4 | COOK | 0.716* | 0.107 | -0.133 | 1.00 | | | | | | | | | | |
| X5 | HOUSE | 0.560* | 0.055 | -0.078 | 0.689* | 1.00 | | | | | | | | | |
| X6 | EDU | 0.479 | 0.334 | 0.068 | 0.379 | 0.360 | 1.00 | | | | | | | | |
| X7 | HOUR | 0.400 | 0.071 | -0.428 | 0.614* | 0.507* | 0.295 | 1.00 | | | | | | | |
| X8 | SIZE | 0.729* | 0.161 | 0.168 | 0.657* | 0.495 | 0.272 | 0.164 | 1.00 | | | | | | |
| X9 | WC | 0.389 | 0.073 | -0.367 | 0.590* | 0.552* | 0.262 | 0.534* | 0.138 | 1.00 | | | | | |
| X10 | COUPA | 0.241 | 0.207 | -0.004 | 0.300 | 0.297 | 0.677* | 0.203 | 0.231 | 0.273 | 1.00 | | | | |
| X11 | DIST | -0.210 | -0.017 | 0.327 | 0.387 | -0.321 | -0.187 | -0.622* | -0.076 | -0.567* | -0.130 | 1.00 | | | |
| X12 | TAP | 0.350 | 0.029 | -0.363 | 0.587* | 0.520* | 0.238 | 0.794* | 0.097 | 0.504* | 0.243 | -0.603* | 1.00 | | |
| X13 | WCA | 0.370 | 0.059 | -0.283 | 0.488 | 0.349 | 0.163 | 0.537* | 0.215 | 0.507* | 0.218 | -0.404 | -0.544* | 1.00 | |
| X14 | ROOM | 0.258 | 0.103 | 0.125 | 0.264 | 0.210 | 0.180 | 0.023 | 0.327 | 0.023 | 0.111 | -0.024 | 0.005 | 0.034 | 1.00 |

* Significant Coefficients, + /- 0.50

Table 36: Correlation Matrix of the Variables Constituting the Multiple Regression Model for Onuiyi Ward

| | | X 1 AMT | X 2 XNCON | X 3 COST | X 4 COCK | X 5 HOUSE | X 6 EDU | X 7 HOUR | X 8 SIZE | X 9 WC | X 10 COUPA | X 11 DIST | X 12 TAP | X 13 WCA | X 14 ROOM |
|-----|-------|---------------|-----------------|----------------|----------------|-----------------|---------------|----------------|----------------|--------------|------------------|-----------------|----------------|----------------|-----------------|
| X1 | AMT | 1.00 | | | | | | | | | | | | | |
| X2 | XNCON | 0.500* | 1.00 | | | | | | | | | | | | |
| X3 | COST | 0.247 | 0.199 | 1.00 | | | | | | | | | | | |
| X4 | COCK | 0.200 | 0.334 | 0.072 | 1.00 | | | | | | | | | | |
| X5 | HOUSE | 0.195 | 0.187 | 0.122 | 0.172 | 1.00 | | | | | | | | | |
| X6 | EDU | 0.474 | 0.694* | 0.247 | 0.218 | 0.047 | 1.00 | | | | | | | | |
| X7 | HOUR | 0.314 | 0.072 | 0.187 | 0.149 | 0.035 | 0.197 | 1.00 | | | | | | | |
| X8 | SIZE | 0.622* | 0.405 | 0.120 | 0.646* | 0.168 | 0.203 | 0.137 | 1.00 | | | | | | |
| X9 | WC | 0.171 | 0.159 | 0.035 | 0.214 | 0.192 | 0.168 | 0.580* | 0.245 | 1.00 | | | | | |
| X10 | COUPA | 0.317 | 0.261 | 0.081 | 0.205 | -0.068 | 0.385 | 0.394 | 0.367 | 0.560* | 1.00 | | | | |
| X11 | DIST | -0.179 | -0.132 | -0.027 | -0.172 | -0.177 | -0.131 | -0.562 | -0.226 | -0.831* | -0.501* | 1.00 | | | |
| X12 | TAP | 0.075 | 0.017 | -0.185 | 0.090 | 0.135 | 0.040 | 0.411 | 0.067 | 0.499 | 0.309 | -0.487 | 1.00 | | |
| X13 | WCA | 0.286 | 0.283 | 0.094 | 0.175 | 0.034 | 0.328 | 0.360 | 0.293 | 0.386 | 0.408 | -0.386 | 0.283 | 1.00 | |
| X14 | ROOM | 0.416 | 0.360 | 0.053 | 0.048 | 0.673* | 0.216 | -0.018 | 0.414 | 0.123 | 0.203 | -0.101 | -0.067 | 0.209 | 1.00 |

* Significant Coefficients, + /- 0.50

Table 36 shows the matrix of inter correlation among the independent variables in this ward. As shown in the table, variable X4 (quantity used for cooking) is strongly correlated with variable X8 (household size). Similarly variables X2 (household income) is strongly related to variable X6 (educational qualification of the household head) while variables X5 (quantity used for household cleaning) is strongly related to variable X14 (the number of rooms occupied by the household).

Table 37 shows the matrix of inter correlation among the independent variables in Nru ward.

Table 37: Correlation Matrix of the Variables Constituting the Multiple Regression Model for Nru Ward

| | X 1 AMT | X 2 XNCON | X 3 COST | X 4 COOK | X 5 HOUSE | X 6 EDU | X 7 HOUR | X 8 SIZE | X 9 WC | X 10 COUPA | X 11 DIST | X 12 TAP | X 13 WCA | X 14 ROOM | |
|-----|---------------|-----------------|----------------|----------------|-----------------|---------------|----------------|----------------|--------------|------------------|-----------------|----------------|----------------|-----------------|------|
| X1 | AMT | 1.00 | | | | | | | | | | | | | |
| X2 | XNCON | 0.190 | 1.00 | | | | | | | | | | | | |
| X3 | COST | 0.143 | 0.064 | 1.00 | | | | | | | | | | | |
| X4 | COOK | 0.405 | -0.046 | 0.065 | 1.00 | | | | | | | | | | |
| X5 | HOUSE | 0.629* | 0.084 | 0.212 | 0.442 | 1.00 | | | | | | | | | |
| X6 | EDU | 0.334 | 0.092 | 0.030 | 0.086 | 0.193 | 1.00 | | | | | | | | |
| X7 | HOUR | 0.233 | 0.109 | -0.564 | 0.180 | 0.225 | 0.195 | 1.00 | | | | | | | |
| X8 | SIZE | 0.796* | -0.035 | 0.180 | 0.456 | 0.519* | 0.241 | 0.091 | 1.00 | | | | | | |
| X9 | WC | 0.168 | 0.043 | -0.612* | 0.152 | 0.173 | 0.210 | 0.614 | 0.066 | 1.00 | | | | | |
| X10 | COUPA | 0.142 | 0.294 | -0.014 | -0.027 | -0.012 | 0.524* | 0.108 | -0.005 | 0.169 | 1.00 | | | | |
| X11 | DIST | -0.124 | -0.172 | 0.404 | -0.038 | -0.158 | -0.133 | -0.673* | -0.020 | -0.739* | -0.053 | 1.00 | | | |
| X12 | TAP | 0.159 | 0.062 | -0.528* | 0.204 | 0.575* | 0.145 | 0.883* | 0.091 | 0.064 | 0.564* | -0.539* | 1.00 | | |
| X13 | WCA | 0.176 | 0.020 | -0.291 | -0.015 | 0.104 | 0.184 | 0.494 | 0.070 | 0.523* | 0.154 | -0.417 | 0.403 | 1.00 | |
| X14 | ROOM | 0.463 | 0.047 | 0.302 | 0.304 | 0.612 | 0.162 | 0.019 | 0.441 | 0.012 | -0.011 | -0.051 | 0.010 | 0.034 | 1.00 |

* Significant Coefficients, + /- 0.50

In this ward (table 37) variables X5 (quantity used for household cleaning) is strongly correlated with variable X14 (the number of rooms occupied), while variable X10 (the occupation of the household head) is strongly correlated with X12 (availability of water taps in residence).

Tables 38 and 39 show the matrix of inter correlation among the independent variables in GRA and Nkpunano wards. In GRA variables X2 (household income) is strongly correlated with variables X6 (educational qualification of the household head), X10 (occupation), X12 (availability of taps in residence) and X14 (number of rooms occupied). Variable X4 (quantity used for cooking) is strongly correlated with variable X8 (household size), while variable X6 (educational qualification) and X10 (occupation) returned the highest value of the multiple correlation coefficient of 0.904. Very strong inter correlations among the independent variables are few in Nkpunano ward, (see table 39). In this ward, variables X4 (quantity used for cooking) is strongly correlated with variable X8 (household size) while X5 (quantity used for cleaning) is strongly related to variables X14 (the number of rooms occupied).

Table 38: Correlation Matrix of the Variables Constituting the Multiple Regression Model for the GRA Ward

| | | 1 X AMP | 2 X XNCON | 3 X COST | 4 X COOK | 5 X HOUSE | 6 X EDU | 7 X HOUR | 8 X SIZE | 9 X WC | 10 X COUFA | 11 X DIST | 12 X TAP | 13 X WCA | 14 X ROOM |
|-----|-------|---------------|-----------------|----------------|----------------|-----------------|---------------|----------------|----------------|--------------|------------------|-----------------|----------------|----------------|-----------------|
| X1 | AMP | 1.00 | | | | | | | | | | | | | |
| X2 | XNCON | 0.279 | 1.00 | | | | | | | | | | | | |
| X3 | COST | -0.095 | -0.113 | 1.00 | | | | | | | | | | | |
| X4 | COOK | 0.735* | -0.027 | -0.157 | 1.00 | | | | | | | | | | |
| X5 | HOUSE | 0.793 | 0.254 | 0.055 | 0.587 | 1.00 | | | | | | | | | |
| X6 | EDU | 0.025 | 0.711* | 0.176 | -0.147 | -0.010 | 1.00 | | | | | | | | |
| X7 | HOUR | 0.380 | 0.075 | -0.206 | 0.420 | 0.309 | -0.104 | 1.00 | | | | | | | |
| X8 | SIZE | 0.807* | 0.129 | 0.038 | 0.628* | 0.685* | -0.086 | 0.364 | 1.00 | | | | | | |
| X9 | WC | 0.238 | 0.194 | -0.524* | 0.471 | 0.192 | -0.060 | 0.433 | 0.245 | 1.00 | | | | | |
| X10 | COUFA | 0.042 | 0.706* | 0.030 | -0.137 | -0.009 | 0.904* | -0.096 | 0.390 | 0.360 | 1.00 | | | | |
| X11 | DIST | -0.183 | 0.010 | 0.492 | -0.360 | -0.124 | 0.060 | -0.426 | -0.184 | -0.683* | 0.026 | 1.00 | | | |
| X12 | TAP | 0.259 | 0.794* | -0.501* | 0.497 | 0.182 | -0.168 | 0.690* | 0.214 | 0.650* | -0.146 | -0.632 | 1.00 | | |
| X13 | WCA | 0.290 | -0.110 | -0.271 | 0.452 | 0.196 | -0.147 | 0.577* | 0.196 | 0.412 | -0.123 | -0.313 | 0.699* | 1.00 | |
| X14 | ROOM | 0.546* | 0.618* | 0.047 | 0.313 | 0.698* | 0.022 | 0.246 | 0.491 | 0.129 | 0.035 | -0.108 | 0.402 | 0.207 | 1.00 |

* Significant Coefficients, +/- 0.50

Table 39: Correlation Matrix of the Variables Constituting the Multiple Regression Model for Nkpunano Ward

| | | X 1 AMT | X 2 XNCON | X 3 COST | X 4 COOK | X 5 HOUSE | X 6 EDU | X 7 HOUR | X 8 SIZE | X 9 WC | X 10 COUPA | X 11 DIST | X 12 TAP | X 13 WCA | X 14 ROOM |
|-----|-------|---------------|-----------------|----------------|----------------|-----------------|---------------|----------------|----------------|--------------|------------------|-----------------|----------------|----------------|-----------------|
| X1 | AMT | 1.00 | | | | | | | | | | | | | |
| X2 | XNCON | 0.194 | 1.00 | | | | | | | | | | | | |
| X3 | COST | 0.152 | 0.032 | 1.00 | | | | | | | | | | | |
| X4 | COOK | 0.577* | 0.272 | -0.083 | 1.00 | | | | | | | | | | |
| X5 | HOUSE | 0.486 | 0.065 | 0.113 | 0.600 | 1.00 | | | | | | | | | |
| X6 | EDU | 0.159 | 0.183 | -0.042 | 0.287 | 0.190 | 1.00 | | | | | | | | |
| X7 | HOUR | 0.077 | 0.090 | -0.561* | 0.289 | 0.257 | 0.191 | 1.00 | | | | | | | |
| X8 | SIZE | 0.722* | 0.072 | 0.165 | 0.689* | 0.272 | 0.116 | 0.014 | 1.00 | | | | | | |
| X9 | WC | 0.173 | -0.056 | 0.445 | 0.286 | 0.488 | 0.195 | 0.229 | 0.084 | 1.00 | | | | | |
| X10 | COUPA | 0.023 | 0.188 | -0.199 | 0.321 | 0.296 | 0.152 | 0.439 | 0.072 | 0.343 | 1.00 | | | | |
| X11 | DIST | 0.088 | 0.014 | 0.528* | -0.208 | 0.319 | -0.136 | -0.369 | 0.002 | -0.630* | 0.226 | 1.00 | | | |
| X12 | TAP | -0.042 | 0.030 | -0.342 | 0.126 | -0.218 | 0.106 | 0.491 | -0.055 | 0.389 | 0.230 | -0.351 | 1.00 | | |
| X13 | WCA | 0.107 | 0.075 | -0.192 | 0.180 | 0.123 | 0.151 | 0.401 | 0.041 | 0.382 | 0.147 | -0.362 | 0.205 | 1.00 | |
| X14 | ROOM | 0.319 | 0.129 | 0.139 | 0.324 | 0.687* | 0.084 | -0.043 | 0.344 | 0.068 | 0.086 | -0.054 | 0.087 | 0.052 | 1.00 |

* Significant Coefficients, +/- 0.50

In the University ward, the situation is relatively unique. Limited interrelatedness among the independent variables exist but strong interrelatedness are few.

As shown in table ^{40,} / only two independent variables X^4 (quantity used for cooking) and X^8 (household size) are very strongly inter-correlated.

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Table 40: Correlation Matrix of the Variables Constituting the Multiple Regression Model for the University Ward

| | X 1 AMT | X 2 XNCON | X 3 COST | X 4 COOK | X 5 HOUSE | X 6 EDU | X 7 HOUR | X 8 SIZE | X 9 WC | X 10 COUPA | X 11 DIST | X 12 TAP | X 13 WCA | X 14 ROOM | |
|-----|---------------|-----------------|----------------|----------------|-----------------|---------------|----------------|----------------|--------------|------------------|-----------------|----------------|----------------|-----------------|------|
| X1 | AMT | 1.00 | | | | | | | | | | | | | |
| X2 | XNCON | 0.554* | 1.00 | | | | | | | | | | | | |
| X3 | COST | 0.000 | 0.000 | 1.00 | | | | | | | | | | | |
| X4 | COOK | 0.575* | 0.338 | 0.000 | 1.00 | | | | | | | | | | |
| X5 | HOUSE | 0.348 | 0.217 | 0.000 | 0.530* | 1.00 | | | | | | | | | |
| X6 | EDU | 0.483 | 0.472 | 0.000 | 0.367 | 0.258 | 1.00 | | | | | | | | |
| X7 | HOUR | 0.553* | 0.407 | 0.000 | 0.439 | 0.368 | 0.516* | 1.00 | | | | | | | |
| X8 | SIZE | 0.776* | 0.467 | 0.000 | 0.667* | 0.335 | 0.380 | 0.447 | 1.00 | | | | | | |
| X9 | WC | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 1.00 | | | | | |
| X10 | COUPA | 0.503* | 0.334 | 0.000 | 0.292 | 0.241 | 0.358 | 0.439 | 0.480 | 0.000 | 1.00 | | | | |
| X11 | DIST | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 1.00 | | | |
| X12 | TAP | 0.693* | 0.475 | 0.000 | 0.380 | 0.225 | 0.405 | 0.514* | 0.507* | 0.000 | 0.464 | 0.000 | 1.00 | | |
| X13 | WCA | 0.719* | 0.457 | 0.000 | 0.552* | 0.362 | 0.417 | 0.546* | 0.584* | 0.000 | 0.547* | 0.000 | 0.590* | 1.00 | |
| X14 | ROOM | 0.524* | 0.465 | 0.000 | 0.480 | 0.451 | 0.317 | 0.566* | 0.432 | 0.000 | 0.446 | 0.000 | 0.501* | 0.513* | 1.00 |

* Significant Coefficients, + /- 0.50

A close examination of tables 34 to 40, however, will reveal that there exist so many redundancies in the correlation matrix. That is, there exist several variables that appear to make no contributions to the observed variance in household water demand amounts in Nsukka urban area. There is in view of this, the need for a technique that is capable of removing spurious correlations so as to concentrate only on those that are orthogonal or according to Davis (1971), offers an 'economy of description,' i.e. simplifies the difficulties of explanation as a result of so many significant correlation coefficients existing side by side with a lot of redundancies. To achieve this, we transform our variables into orthogonal values through factor analysis.

4.5 Factor Analytic Model

Factor analysis is a robust statistical technique that is used to simply and organise large amounts of data (Mather and Doonkamp, 1978). Attempts are made, through the application of factor analysis (FA), to clarify relationships between measured characteristics, to eliminate redundant variables, to determine the nature and order of importance of the basic 'dimensions' of the data matrix and reduce quantitative observations into distinct patterns

of occurrence (Rummel, 1967; Mather and Doornkamp, 1978; Chima, 1989 and Ezenwaji, 1991). The concepts underlying factor analysis can be presented in geometrical context. If variables are considered as vectors, that is, as lines having directions and magnitude, then the angle between any two vectors reflects the degree of similarity between the variables concerned (Mather and Doornkamp, 1978). Thus, two completely dissimilar variables (with a correlation coefficient of -1) would be represented by two vectors pointing in opposite directions. Identical variables, on the other hand, would be represented by two vectors superimposed on one another.

An important assumption of factor analysis is that each variable (strictly, its variation) can be sub-divided into several independent parts in terms of its association with other variables. In addition, correlation coefficients are determined for each of the different segments of the system under study. According to the general assumption, these segments are entirely independent of each other so that we can identify the groups or variables between which the correlation are high and segment and relevant variables where the correlations are near zero. These segments are

not observable in reality and can not be directly measured. They are referred to as factors. The actual model for the working of factor analysis (FA) is as follows:

$$Y = X_1 F_1 + X_2 F_2 + X_3 F_3 \dots X_m F_m \dots \quad (6)$$
 where Y is a known variable with \angle data, X represents loadings, and F is the factor. In this calculation of factors, we may find that some of the F-functions are common and generate variables. These are called group factors and their delineation is one of the major goals of factor analysis.

The patterns shown by the result of factor analysis can be viewed from two perspectives (Gattle, 1952) one can look at the pattern of variations of individuals across characteristic groups shown by their profile and this type of analysis is called Q factor analysis (QFA). The other perspective is to look at the pattern from the point of variations of characteristics. This is called 'R' factor analysis (PFA). The 'R' factor analysis is mostly used in geographical studies (Chima, 1989; Ezenwaji, 1990). Ideally, if the application of factor analysis is successful, then a small number of factors should explain a substantial portion of the variation in the original data, and secondly, these factor scores should be meaningful in a statistical sense.

The number of geographical studies that have used this technique (FA) of multivariate analysis has grown rapidly. For example, Maboḡunge (1968), Ayoni (1976), Ebisemiju (1978), Ibeziako (1985), Anyadike and Ibeziako (1987), Chima (1989), and Ezenwaji (1990) are a few examples of geographers who have utilized factor analysis in various geographical studies in Nigeria alone. We have used this technique in the present study in order to remove the battery of redundancies in factors explaining water demand and consumption patterns in Nsukka urban area.

4.5.1 Extraction of the Factors

Factor analysis, for reasons elucidated in section 4.4 of this chapter, was employed to collapse the redundant variables into groups of closely related variables and reduce them to few orthogonal factors. The initial step in factor analysis (Yeates, 1974) is to determine the significant factor loadings. Each factor consists of (14, in this analysis) numerical values called factor loadings. The factor loadings are the correlations between each variable and that particular factor. In this study, significant loadings are considered from the threshold value of 0.60. This cut-off value of 0.60 is an arbitrary decision

rule (Johnson, 1991) based on the size of the factor loadings and to ease interpretation.

The next step in the analysis is the algebraic solution of the eigen values and eigen vectors or factors of the covariance matrix. The sum of these squared factor loadings is known as the eigen values. The eigen values show the total variance explained by each factor. In other words, the eigenvalues of the covariance matrix determine the percentage of the total variance explained by each of the factors.

The third step in the factor analysis procedure is to determine estimates of communality in the data. Communality is the proportion of the variance for each variable explained by all the significant factors. Determination of the estimates of communality in the data being analysed is outside the scope of our present study.

The next and rather an important step in the factor analysis procedure is the question of the number of factors to be extracted. The rule is that only those factors that account for more than their proportionate share of the original variance should be extracted (Berry, 1961; Simmon, 1964). This, for Goddard and Kirkby (1978) include all those eigen vectors with eigenvalues greater than 1.00, and this is

the most frequently used. King (1969), is however, of the view that the most important eigenvalues are those that explain over 5 percent of the total variance. Some scholars, such as Ibeziako (1985) have used this approach. It is equally used here (ie. in the present study).

The next step in factor analysis is the process called factor rotation. The varimax orthogonal rotation is often (Ezenwaji, 1990) performed to rotate the factors about their axis so as to maximise the covariance of the loadings on each factor in order to achieve as many high and as many low loadings as possible while maintaining the orthogonality of the original factors. The purpose of factor rotation is to redistribute the factor loadings from among many to far fewer variables so as to obtain distinct clusters of variables and at the same time to preserve the patterns of variations found in the unrotated factors. Problems of interpretation are reduced substantially by factor rotation. For instance, a comparison of the unrotated and rotated factor matrixes (tables 41 and 42) show marked differences both in the number of significant factor loadings and the percentage of the total variance explained by each. For example, while the unrotated factor matrix (table 41) has three significant factors components that explain 90.6% of the total variance, the rotated factor matrix has five significant factor components explaining 73.6% of the total variance.

Table 41: UNROTATED FACTOR LOADINGS
(NSUKKA URBAN)

| Variables | Factor I | Factor II | Factor III |
|-----------------|----------|-----------|------------|
| x1 | 0.680* | 0.498 | -0.033 |
| x2 | 0.577 | 0.087 | 0.614* |
| x3 | -0.484 | 0.464 | -0.042 |
| x4 | 0.573 | 0.320 | -0.145 |
| x5 | 0.541 | 0.330 | -0.205 |
| x6 | 0.515 | 0.093 | 0.362 |
| x7 | 0.742* | -0.290 | -0.253 |
| x8 | -0.463 | 0.694* | -0.264 |
| x9 | 0.772* | -0.414 | -0.217 |
| x10 | 0.566 | 0.002 | 0.293 |
| x11 | -0.642* | 0.379 | 0.446 |
| x12 | 0.774* | -0.520 | 0.084 |
| x13 | 0.668* | -0.203 | 0.201 |
| x14 | 0.252 | 0.401 | 0.068 |
| Eigen Values | 5.071 | 1.741 | 0.915 |
| Percentage Exp. | 59.5 | 20.4 | 10.7 |
| Cum Percentage | 59.5 | 79.9 | 90.6 |

* Loadings exceeding + /- 0.60

Table 42: Varimax Rotated Factor Matrix
(Nsukka Urban)

| Variables | Factor I | Factor II | Factor III | Factor IV | Factor V |
|-----------------|----------|-----------|------------|-----------|----------|
| X1 | 0.221 | 0.534 | 0.233 | 0.204 | 0.174 |
| X2 | 0.180 | 0.172 | 0.502 | 0.153 | 0.82 |
| X3 | -0.419 | 0.143 | -0.056 | -0.270 | -0.016 |
| X4 | 0.262 | 0.530 | 0.120 | 0.021 | 0.252 |
| X5 | 0.226 | 0.441 | 0.053 | 0.090 | 0.632* |
| X6 | 0.182 | 0.192 | 0.695* | 0.217 | 0.027 |
| X7 | 0.785* | 0.174 | 0.208 | -0.057 | 0.108 |
| X8 | 0.015 | 0.887* | 0.042 | -0.053 | -0.010 |
| X9 | 0.816* | 0.138 | 0.229 | -0.007 | 0.152 |
| X10 | 0.273 | 0.145 | 0.629* | 0.111 | 0.056 |
| X11 | -0.807* | -0.068 | -0.063 | -0.043 | -0.037 |
| X12 | 0.642* | 0.138 | 0.303 | 0.277 | 0.169 |
| X13 | 0.530 | 0.231 | 0.302 | 0.170 | 0.026 |
| X14 | -0.065 | 0.405 | 0.157 | 0.743* | 0.143 |
| Eigen Value | 5.431 | 2.112 | 1.252 | 0.771 | 0.720 |
| Percentage Exp. | 38.8 | 15.1 | 8.9 | 5.5 | 5.1 |
| Cum. Percentage | 38.8 | 53.9 | 62.8 | 68.3 | 73.6 |

* Loadings exceeding + /- 0.60

increased
Rotation / the number of significant factors from 3 to 5 and reduced the percentage of explained variance by the unrotated factor matrix. For this reason, our interpretation is based on the varimax rotated factor matrix.

4.5.2 Interpretation of Derived Factor

Factor I

As shown in table 42 (matrix of factor loading for Nsukka urban area), factor 1, which explains 38.8% of the total variance, is the color factor, and at the same time, one that is relatively difficult to interpret because it comprises a large number of highly intercorrelated variables. Three variables, X7 (the number of hours taps run per week), X9 (the availability of water vendors), and X12 (availability of tap water in residence) have high positive loadings on this factor. One variable X11 (the distance to the nearest public water supply source) has a high negative loading (-0.807) on this factor. The positive signs on variables X7, X9 and X12 show that there is positive relationship between the three variables and the factor. In contrast, the negative sign on variable X11 shows

that there is a negative relationship between the factor and the variable. Generally, this factor describes the impact which the presence of water supply facilities have on household water demand. Factor I is therefore, identified as the availability of water supply in residence.

Factor II

Factor II has an eigenvalue of 2.112 and explains 15.1% of the total variance. It has high positive loading (+0.887) on only one variable X8 (the size of the household). The positive sign indicates that there is a positive relationship between this factor and the variable. We shall label this factor the number of person per household.

Factor III

Factor III has an eigen value of 1.252 and accounts for 8.9 percent of the total variance. It has high positive loading (+0.629) on variable X10 (the occupation of the head of the household) and variable X6 (educational qualification of the head of the household). It is necessary to note that factor II has a relatively high positive loading (+0.502) on variable X2 (the income of the head of the household). Educational qualification, income level and occupation are variables which are generally used to describe the socio-economic status of an individual. Factor III can, therefore, be denominated the socio-economic status of the head of the household.

Factor IV

Factor IV has an eigen value of 0.771 and accounts for 5.5 percent of the total variance. The strongest positive loading (+0.743) is found on variable X14 (the number of rooms occupied by the household). What this positive sign is indicating is that there exist a positive relationship between the number of rooms household occupied and the quantity of water demanded. When the entire loadings are carefully examined, it is easy to notice that factor IV has no loading value of over 0.300 on the other variables. It is, therefore, easy to identify this factor as the availability of space in residence.

Factor V

Table 42 shows that factor V has an eigen value of 0.720 and accounts for only 5.1 percent of the total variance. This factor has only one high positive loading (+0.632) on variable X5 (the quantity of water used for household cleaning). The positive sign shows that a positive correlation exist between the variable and the factor. Thus, as the quantity required for household cleaning increases, the demand also increases. Variable X5 is therefore, describing the impact which domestic uses has on household water demand, hence factor V can be identified as the frequency of requirements for domestic duties.

We have, from our factor analytic model, been able to identify the five unique factors which can be used to explain or account for the variations in the amount of water demanded/ consumed in Nsukka urban area. Thus the model has successfully transformed our 13 predictor variables to 5 underlying dimensions, which, in order of importance are as stated below.

1. The availability of water supply in residence.
2. The number of persons per household.
3. The socio-economic status of the head of the household.
4. The availability of space in residence.
5. The frequency of requirements for domestic duties.

4.5.3 Analysis of the Results for the Wards

1. GRA Ward

Table 43 shows the matrix of factor loadings for the GRA ward.

Table 43: Varimax Rotated Factor Matrix
(GRA Ward)

| Variables | Factor I | Factor II | Factor III | Factor IV | Factor V |
|-------------|----------|-----------|------------|-----------|----------|
| X1 | 0.127 | 0.558 | 0.099 | -0.084 | 0.118 |
| X2 | 0.017 | 0.165 | 0.789* | -0.113 | 0.160 |
| X3 | -0.386 | 0.039 | -0.028 | 0.350 | 0.040 |
| X4 | 0.434 | 0.740* | -0.104 | -0.037 | -0.104 |
| X5 | 0.097 | 0.778* | 0.049 | 0.044 | 0.441 |
| X6 | -0.079 | -0.053 | 0.977* | 0.022 | -0.022 |
| X7 | 0.804* | 0.257 | -0.021 | 0.098 | 0.094 |
| X8 | 0.157 | 0.199 | -0.017 | 0.873* | 0.123 |
| X9 | 0.745* | 0.168 | 0.086 | -0.269 | -0.041 |
| X10 | -0.039 | -0.034 | 0.917* | 0.036 | -0.031 |
| X11 | -0.798* | -0.048 | -0.006 | 0.220 | -0.031 |
| X12 | 0.827* | 0.148 | -0.109 | -0.221 | -0.030 |
| X13 | 0.446 | 0.157 | -0.111 | -0.033 | 0.100 |
| X14 | 0.090 | 0.481 | 0.068 | 0.043 | 0.680* |
| Eigen Value | 4.985 | 2.835 | 2.352 | 0.811 | 0.694 |
| % Explained | 35.6 | 20.3 | 16.8 | 5.8 | 5.0 |
| Cum % Exp. | 35.6 | 55.9 | 72.7 | 78.5 | 83.4 |

* Loadings exceeding + /- 0.60

From table 43, it is seen that factor I with eigen value 4.985 accounts for the highest percentage of the observed variance (35.6%) while factor V, with eigen value of 0.694 accounts for the least (only 5.0%). Factor I has high positive loadings on variables X7 (the number of hours taps run per week), X9 (the availability of water vendors) and X12 (the availability of water taps in residence). Variable X11 (distance to the nearest source of public water supply) has a high negative loading of -0.789, indicating that an inverse relationship exist between this variable and Factor I. These variables as noted earlier generally describe the impact which availability of water supply facilities have on household water demand. It can, therefore, be labelled the availability of water supply in residence.

Two variables X4 (quantity used for cooking) and X5 (quantity used for household cleaning) load positively high (+0.740, and +0.778) on factor II. Increased use of water for household cooking and cleaning will result in higher household water demands. Factor II can therefore, be regarded as the level of water need for domestic duties.

Factor III has an eigen value of 2.352 and accounts for 16.8% of the total variance. It has high positive loadings on variables X2 (household income), X6 (educational qualification of the head of the household) and X10 (occupation of the head of the household). Factor III obviously refers to the socio-economic status of the head of the household. Factor IV has an eigen value of 0.811 and accounts for only 5.8% of the total variance. Its highest positive loading (+0.873) is on variable X8 (the size of the household). It can be denominated the number of persons per household.

Finally, factor V has an eigen value of 0.694 and accounts for 5.0% of the total variance. It has one strong positive loading (+0.680) on variable X14 (the number of rooms occupied by the household). Factor V can, therefore, be identified as the availability of space in residence.

Onuiyi Ward

The matrix of factor loadings for Onuiyi ward is shown in table 44.

Table 44: Varimax Rotated Factor Matrix
(Onuiyi Ward)

| Variables | Factor I | Factor II | Factor III | Factor IV | Factor V | Factor VI |
|-------------|----------|-----------|------------|-----------|----------|-----------|
| X1 | 0.597 | 0.538 | 0.081 | 0.135 | -0.039 | 0.412 |
| X2 | 0.060 | 0.541 | 0.367 | 0.158 | -0.003 | -0.634 |
| X3 | 0.013 | 0.172 | 0.039 | 0.108 | -0.048 | 0.037 |
| X4 | 0.128 | 0.166 | 0.654* | 0.015 | -0.091 | 0.028 |
| X5 | 0.100 | 0.392 | 0.134 | 0.074 | -0.636* | 0.001 |
| X6 | 0.137 | 0.032 | 0.255 | 0.271 | 0.356 | 0.110 |
| X7 | 0.649* | 0.567 | 0.043 | 0.215 | 0.056 | 0.465 |
| X8 | 0.154 | 0.699* | 0.229 | -0.034 | -0.099 | 0.005 |
| X9 | 0.945* | 0.346 | 0.010 | 0.050 | -0.120 | 0.098 |
| X10 | 0.567 | -0.093 | 0.158 | 0.031 | 0.354 | -0.045 |
| X11 | -0.908* | 0.012 | -0.047 | -0.030 | 0.131 | 0.048 |
| X12 | 0.566 | -0.012 | 0.051 | -0.228 | -0.050 | 0.176 |
| X13 | 0.417 | -0.304 | 0.153 | 0.071 | 0.173 | 0.053 |
| X14 | 0.368 | 0.512 | -0.075 | 0.646* | 0.094 | -0.024 |
| Eigen Value | 4.330 | 2.262 | 1.230 | 1.053 | 0.946 | 0.754 |
| % Explained | 30.9 | 16.2 | 8.8 | 7.5 | 6.8 | 5.4 |
| Cum. % Exp. | 30.9 | 47.1 | 55.9 | 63.4 | 70.1 | 75.5 |

* Loadings exceeding + /- 0.60

As shown in table 44 factor I with an eigen value of 4.330, accounts for 30.9 percent of the total variance (highest) while factor V, with eigen value of 0.754 accounts for the least percentage of the total variance (only 5.4%). Two variables, X7 (the number of hours taps run per week), X9 (the presence of water vendors) are loaded highly and positively (+0.649 and +0.945) while one variable X11 (the distance to the nearest source of public water supply) is loaded highly but negatively (-0.908). Only one variable X8 (the size of the household) is loaded highly (+0.699) on Factor II which has an eigen value of 2.262 and accounts for 16.2% of the total variance. Similarly Factor III which accounts for 8.8 percent of the total variance (eigen value - 1.230) has only one positive loading on variable X4 (quantity used for cooking). Factor IV has an eigen value of 1.053 and accounts for 7.5 percent of the total variance. It has only one high positive loading on variable X14 (the number of rooms occupied). Factor IV has only one relatively high positive loading on variable X2 (income of the head of the household).

Factor I appears to describe the influence of readily available source of water on household water demand. It can therefore, be regarded as the availability of regular water supply in residence. Factor II refers to the number of persons per household, while Factor III can be identified as the frequency of requirements of water for domestic duties. Factor IV refers to the availability of space in residence, while Factor V can be regarded as the socio-economic status of the head of the household.

The Ward

Table 45 shows the varimax rotated factor matrix for the ward.

Table 45: Varimax Rotated Factor Matrix
(IHe Ward)

| Variables | Factor I | Factor II | Factor III | Factor IV | Factor V |
|-------------|----------|-----------|------------|-----------|----------|
| X1 | 0.279 | 0.554 | 0.316 | -0.127 | 0.364 |
| X2 | -0.009 | 0.093 | 0.888* | 0.032 | 0.023 |
| X3 | -0.520 | 0.191 | 0.131 | -0.015 | 0.250 |
| X4 | 0.550 | 0.692* | 0.139 | 0.91 | 0.036 |
| X5 | 0.463 | 0.663* | 0.111 | 0.164 | 0.072 |
| X6 | 0.166 | 0.223 | 0.331 | 0.013 | 0.021 |
| X7 | 0.884* | 0.157 | 0.145 | -0.090 | -0.066 |
| X8 | -0.023 | 0.584 | 0.128 | 0.655* | -0.004 |
| X9 | 0.825* | 0.136 | 0.099 | 0.145 | 0.129 |
| X10 | 0.164 | 0.149 | 0.485 | 0.475 | -0.020 |
| X11 | -0.669* | -0.041 | -0.070 | 0.033 | 0.051 |
| X12 | 0.889* | -0.071 | 0.069 | 0.115 | 0.187 |
| X13 | 0.595 | 0.194 | 0.067 | 0.126 | 0.055 |
| X14 | 0.062 | 0.364 | 0.121 | 0.035 | 0.630* |
| Eigen Value | 5.409 | 2.328 | 1.230 | 0.817 | 0.801 |
| % Explained | 38.6 | 16.6 | 8.9 | 5.7 | 5.6 |
| Cum. % Exp. | 38.6 | 55.3 | 64.1 | 69.8 | 75.4 |

* Loadings exceeding + /- 0.60

As can be seen from table 45, factor I accounts for 38.6% of the total variance while factor five accounts for only 5.7%. Three variables load highly and positively on Factor I. These are variables X7 (the number of hours taps run per week), X9 (the presence of water vendors) and X12 (the availability of taps in residence. Variable X11 (distance to the nearest source of public water supply) has a high negative loading (-0.669). What this factor is highlighting is the interaction between water availability and use. It is, therefore, identified here as the availability of regular water supply in residence.

Factor II has an eigen value of 2.328 and accounts for 16.6% of the total variance. It has two positive loadings on variables X4 (quantity used for cooking) and X5 (quantity used for household cleaning). The loadings are +0.692 and +0.663 respectively. Factor two appears to be highlighting the interactions between the amount demanded and quantity used for domestic purposes. It is therefore, identified as the frequency of requirements for domestic services.

Factor III has an eigen value of 1.230 and amounts for 8.9% of the total variance. One variable (X , the level of income of the head of the household) loads very highly and

positively (+0.831) on this factor. It refers to the socio-economic status of the head of the household.

Factor IV has an eigen value of 0.817 and accounts for 5.7% of the total variable. Only variable X8 (the household size) loads highly (+0.655) on this factor. It refers to the number of persons per household.

Factor V has an eigen value of 0.801 and accounts for only 5.6% of the total variance. Variable X14 (the number of rooms occupied) loads highly (+0.630) on this factor. It can therefore, be identified as the availability of space in residence.

Nru Ward

Table 46 shows matrix of factor loading for Nru ward.

Table 46: Varimax Rotated Factor Matrix
(Nru Ward)

| Variables | Factor I | Factor II | Factor III | Factor IV | Factor V |
|-------------|----------|-----------|------------|-----------|----------|
| X1 | 0.112 | 0.561 | 0.164 | 0.068 | 0.173 |
| X2 | 0.050 | 0.031 | 0.141 | 0.035 | 0.129 |
| X3 | -0.633* | 0.171 | 0.052 | 0.400 | 0.093 |
| X4 | 0.086 | 0.439 | -0.014 | 0.154 | 0.675* |
| X5 | 0.130 | 0.577 | 0.016 | 0.476 | 0.070 |
| X6 | 0.132 | 0.221 | 0.626* | 0.106 | -0.015 |
| X7 | 0.919* | 0.117 | 0.056 | -0.010 | 0.064 |
| X8 | -0.000 | 0.828* | 0.071 | 0.105 | -0.101 |
| X9 | 0.981* | 0.048 | 0.123 | 0.110 | -0.031 |
| X10 | 0.067 | -0.043 | 0.856* | -0.070 | 0.231 |
| X11 | -0.755* | -0.017 | 0.005 | -0.139 | -0.156 |
| X12 | 0.652* | 0.084 | 0.085 | -0.049 | 0.038 |
| X13 | 0.525 | 0.091 | 0.133 | 0.042 | -0.041 |
| X14 | -0.032 | 0.446 | 0.040 | 0.605* | 0.018 |
| Eigen Value | 4.362 | 3.064 | 1.569 | 0.994 | 0.825 |
| % Explained | 31.2 | 21.9 | 11.2 | 7.1 | 5.9 |
| Cum % Exp. | 31.2 | 53.0 | 64.2 | 71.3 | 77.2 |

* Loadings exceeding +/- 0.60

Factor I, which has an eigen value of 4.362, accounting for 31.2% of the total variance, comprises a large number of highly intercorrelated variables. Variables X7 (the number of hours taps run per week) X9 (the presence of water vendors and X12 (the availability of taps in residence) have high positive loadings with this factor. The loadings are +0.919, +0.981 and 0.652 respectively. Two variables, variables X3 (the cost of water supplied in a month) and X11 (distance to the nearest source of public water supply) have high negative loadings of -0.633 and -0.755 respectively. Generally, this factor is highlighting the interactions between frequency of supply and quantity demanded by households. This factor is, therefore, identified as the frequency of supply.

Factor II which has an eigen value of 3.064, and accounting for 2.9% of the total variance, has only one high positive loading. Variable X8 (household size) loads highly (+0.828) on this factor. The factor, therefore, refers to household size.

Factor III has an eigen value of 1.569 and accounts for 11.2% of the total variance. It has high positive loadings on variables X6 (educational qualification of the the household) and X10 (occupation of the household head.

Generally, this factor, as in the previous ones, is describing the socio-economic status of the head of the household and is, therefore, identified as such.

Factor IV has an eigen value of 0.994 and explains 7.1 percent of the total variance. It has only one high positive loading on variable X_{14} (the number of rooms occupied), the loading is +0.605. This factor can, therefore, be identified as the availability of space in residence.

Finally, factor V has an eigen value of 0.825 and accounts for only 5.9 percent of the total variance. It has only one high positive loading (+0.675) on variable X_4 (the quantity used for cooking). It can therefore be denominated as the frequency of requirement for cooking.

Nkpunano Ward

Table 47 shows the varimax rotated factor matrix for Nkpunano ward.

Table 47: Varimax Rotated Factor Matrix
(Nkpunano Ward)

| Variables | Factor I | Factor II | Factor III | Factor IV | Factor V | Factor VI |
|-------------|----------|-----------|------------|-----------|----------|-----------|
| X1 | 0.054 | 0.851 | 0.171 | 0.096 | 0.084 | -0.219 |
| X2 | -0.007 | 0.079 | 0.522 | 0.001 | 0.047 | 0.011 |
| X3 | -0.562 | 0.129 | 0.034 | -0.614* | 0.076 | -0.044 |
| X4 | 0.168 | 0.682* | 0.416 | -0.037 | 0.123 | 0.280 |
| X5 | 0.177 | 0.630* | -0.006 | 0.044 | 0.152 | 0.398 |
| X6 | 0.172 | 0.111 | 0.339 | 0.036 | 0.024 | -0.009 |
| X7 | 0.867* | 0.067 | 0.127 | -0.108 | -0.073 | 0.169 |
| X8 | -0.044 | 0.502 | 0.679* | 0.039 | 0.128 | -0.012 |
| X9 | 0.802* | 0.126 | 0.120 | -0.021 | 0.091 | 0.081 |
| X10 | 0.293 | 0.033 | 0.342 | -0.007 | 0.072 | 0.586 |
| X11 | -0.775* | -0.054 | 0.015 | 0.181 | -0.146 | 0.045 |
| X12 | 0.480 | -0.034 | 0.079 | -0.083 | -0.120 | 0.191 |
| X13 | 0.461 | 0.061 | 0.178 | 0.063 | -0.097 | -0.107 |
| X14 | 0.053 | 0.307 | 0.129 | 0.036 | 0.570* | 0.040 |
| Eigen Value | 3.952 | 2.794 | 1.170 | 0.951 | 0.813 | 0.800 |
| % Explained | 28.2 | 20.0 | 8.4 | 6.8 | 5.8 | 5.7 |
| Cum. % Exp. | 28.2 | 48.2 | 56.5 | 63.3 | 69.1 | 74.9 |

* Loadings exceeding + /- 0.60

As can be seen from the table 47, Factor I which has an eigen value of 3.952, explained the highest percentage of the total variance (28.2%), while Factor IV which has an eigen value of 0.800 explained the least (5.7%). Among the variable correlated highly with this factor are those pertaining to the impact or the influence of readily available water to household water demand patterns. The variables include X7 (the number of hours taps run per week), X9 (the availability of water vendors) and X11 (distance to the nearest public water supply source). This factor has high positive loadings on variables X7 (+0.867) and X9 (+0.802). On the other hand, it has a negative loading (-0.775) on variable X11. Thus there is a positive association between variables X7 and X9 and this factor, and a negative association between the factor and variable X11. What this variable appears to be highlighting is the influence of regular availability of water on household demand patterns. It is therefore identified here as the frequency of household water supply.

Factor II has an eigenvalue of 2.794. It explains 20.0% of the total variance, and is positively correlated with variables referring to the level of water requirement for household services. The variables include X4 (quantity required

for household cleaning). The loadings for X_4 is +0.682 and X_5 is +0.630. We can, therefore, label this factor as the magnitude/frequency of requirements for services in households.

Factor III has an eigen value of 1.170. It accounts for 8.4 percent of the common variance and is positively correlated with the size for the household (ie. variable X_8). It can, therefore be denominated the 'household size'.

Factor IV has an eigen value of 0.951 and accounts for 6.8% of the total variance. It has high negative loading (-0.614) on only one variable X_3 (the cost of water supplied in a month). We can, therefore, identify this factor as the influence of price on water.

Factor V, with an eigen value of 0.813, accounts for 5.8% of the common variance. It is positively correlated with the number of rooms occupied by the household. It, therefore, refers to the availability of space in residence. Factor VI, has no loading values of up to 0.600. When we take the variable with the highest loading into account (X_{10} , household income). We can identify this factor as the socio-economic status of the head of the household.

The University Ward

The matrix of factor loadings for the University ward is shown in table 48.

Table 48: Varimax Rotated Factor Matrix
(University Ward)

| Variables | Factor I | Factor II | Factor III | Factor IV |
|-------------|----------|-----------|------------|-----------|
| X1 | 0.089 | 0.564 | 0.083 | 0.114 |
| X2 | 0.063 | 0.544 | 0.267 | 0.129 |
| X3 | -0.003 | 0.102 | 0.003 | 0.001 |
| X4 | 0.137 | 0.164 | 0.689* | 0.016 |
| X5 | 0.101 | 0.184 | 0.533 | 0.074 |
| X6 | 0.145 | -0.311 | 0.258 | 0.227 |
| X7 | 0.645* | 0.032 | 0.044 | 0.216 |
| X8 | 0.158 | 0.685* | 0.323 | -0.034 |
| X9 | 0.002 | -0.000 | 0.001 | 0.001 |
| X10 | -0.566 | 0.085 | 0.168 | 0.033 |
| X11 | -0.002 | 0.001 | -0.002 | -0.001 |
| X12 | 0.541 | -0.029 | 0.048 | -0.219 |
| X13 | 0.447 | -0.019 | 0.513 | 0.074 |
| X14 | 0.038 | 0.534 | -0.074 | 0.616* |
| Eigen Value | 5.630 | 2.312 | 1.452 | 0.971 |
| % Explained | 39.8 | 18.1 | 10.9 | 7.5 |
| Cum. % Exp. | 39.8 | 57.9 | 68.8 | 76.3 |

* Loadings exceeding + / - 0.60

Three variables, X3 (cost of water supplied in the month), X9 (the presence of water vendors) and X11 (distance to the nearest source of public water supply) have no measurable impact on domestic water demand and consumption patterns.

Factor I which has an eigen value of 5.630 accounts for 39.8%. It is positively correlated with variable X7 (the number of hours taps run per week). We can, therefore, label this factor the frequency of water supply.

Factor II has an eigen value of 2.312 and accounts for 18.1% of the common variance. It is positively correlated with variable X8 (the number of persons per household) we can therefore, identify this factor as the household size.

Factor III has high positive correlations with variables which relate to the impact which frequent requirements for household services have on domestic water demand. The two variables with relative high positive loadings are X4 (quantity needed for cooking) and X5 (quantity needed for household cleaning). Their loadings are +0.689 and +0.533 respectively. We can, when the above is taken into account, label this factor the magnitude/frequency of requirements for household services.

Finally, Factor IV has generally low loadings. It has an eigen value of 0.971 and accounts for 7.5% of the common variance. It is positively correlated with variable X14 (the number of rooms occupied by the household). In view of this, this factor is identified as the availability of space in residence.

Summary of Results for the wards

For purposes and ease of comparison, we present in table 49, a brief summary of the general indicators of water demand structure and their relative strengths in the 6 wards under study.

Table 49: A Summary of the Indicators of Water Demand Structure and Their Relative Strength in the Wards on Nsukka

| GRA Ward | % | Onuiyi Ward | % | Ihe Ward | % |
|---|--------|---|--------|---|--------|
| Indicators | % Exp. | Indicators | % Exp. | Indicators | % Exp. |
| 1. Availability of regular water supply in residence | 35.6 | Availability of regular supply in residence | 30.9 | Availability of regular supply in residence | 38.6 |
| 2. Frequency of water requirement for domestic duties | 20.3 | Household size | 16.2 | Frequency of requirements for domestic duties | 16.6 |

| GRA Ward | | Onuiyi Ward | | The Ward | |
|---|--------|---|--------|---|--------|
| Indicators | % Exp. | Indicators | % Exp. | Indicators | % Exp. |
| 3. Socio-economic status of the head of the household | 16.8 | The frequency of requirements for domestic services | 8.8 | Socio-economic status of household head | 8.9 |
| 4. Household size | 5.8 | Availability of space in residence | 7.5 | Household size | 5.7 |
| 5. Availability of space in residence | 5.0 | Socio-economic status of the household head | 6.8 | Availability of space in residence | 5.6 |
| 6. Other factors | 16.6 | Other factors | 24.5 | Other factors | 24.4 |
| Total | 100 | Total | 100 | Total | 100 |
| Nru Ward | | Nkpunano Ward | | University Ward | |
| 1. The frequency of water supply in residence | 31.2 | The frequency of supply to residence | 28.2 | The frequency of supply in residence | 39.8 |
| 2. Household size | 21.9 | The frequency of requirements for domestic services | 20.0 | Household size | 18.1 |
| 3. Socio-economic status of the household head | 11.2 | Household size | 6.8 | Frequency of requirements for domestic duties | 10.9 |
| 4. Availability of space in residence | 7.1 | The influence of price on water | 5.8 | Availability of space in residence | 7.5 |

| Nru Ward | | Nkpunano Ward | | University Ward | |
|--|--------|------------------------------------|--------|-----------------|--------|
| Indicator | % Exp. | Indicator | % Exp. | Indicator | % Exp. |
| 5. The frequency of requirements for cooking | 5.9 | Availability of space in residence | 5.7 | | |
| 6. Other factors | 22.8 | Other factors | 25.1 | Other factors | 23.7 |
| Total | 100 | Total | 100 | Total | 100 |

We have been able, through the use of the factor analytic model, ~~been able~~ to collapse our water demand variables to a maximum of 5 underlying dimensions for each ward under study. Furthermore, this model has enabled us to establish the relative strenght of the factors. Of the five dimensions, the availability and regularity of supply in residence accounted for the highest contributions in all the wards. Other factors such as household size, space available and socio-economic status of the head of the household, make remarkable contributions in most of the wards. No two wards exhibited exactly the same pattern of the general indicators employed in our analysis but Nkpunano ward can be described as relatively unique because the remarkable contributions made by cost of water supplied made on the water demand pattern in the ward. This general indicator equally

had a substantial high loading in Nru ward (-0.637). These are wards where supply is most irregular and 'drought management' (ie. rationing) is a standing policy. In view of this, households turn, not infrequently, to water vendors for most of their water needs.

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CHAPTER FIVE

STRATEGIES FOR IMPROVED WATER SUPPLY IN
NSUKKA URBAN

5.1 The Concept of Strategy

Strategy is a term that now enjoys universal respect and admiration (Dandy, 1987). No corporate executive would fail to affirm that the application of effective strategy is important and that his firm attempts to do so on a continuous basis. Generally, the term strategy refers to "approaches" or "methods" of achieving desired objectives (James, 1979). Developing improved strategies which can work within a system/and or community to meet the needs of the community is often described as a universal goal (James, 1979). Any existing strategy is often viewed as a consequence of innovation diffusion (Dandy, 1987) in which the attributes of functionality and applicability formed the basis for the adoption.

Given the necessity of obtaining and securing sufficient quantities of water for the population, an important consideration in the choice of a strategy is often the 'sufficiency potential' of the strategy (Ayoade, 1981). The choice of a strategy is not, of course, always limited

by the sufficiency potential alone. Questions relating to the technical/resource requirements of the strategy, the physical attributes of the area, the beneficiaries (their needs, capabilities, background, etc) also need to be considered.

The scheme for the present chapter is, therefore, as follows: first, a brief evaluation of the existing strategies for securing household water in Nsukka urban is given. A consideration of all the programmes (public and private) which are aimed at achieving the sufficiency potential and mitigating disparity in household water supply in Nsukka urban is considered. This is followed by an examination of the strategies/policies which have been adopted to achieve 'target' production quantities and improve supply urbanwide. This formed the basis of our discussion on the need for alternative strategies for improved water supply in Nsukka urban. Finally, a framework for developing improved strategies for water supply in Nsukka urban is advanced.

5.2 Strategies for Securing Household Water in Nsukka

The sources of domestic water supply in Nsukka urban area, as discussed in chapter II, are many and varied. The urban dwellers have adopted and used (over the years) a

number of strategies to secure water for domestic purposes. These strategies are, for the purpose of this discussion, separated into two - traditional and modern.

5.2.4 Traditional Strategies

The traditional strategies for securing domestic water in Nsukka urban is based essentially on the various methods of harvesting rain water. Modernization has not significantly altered the various methods of rain water collection and conservation in Nsukka urban. However, this strategy has a great limitation- limitations arising from rainfall seasonality and variability as well as from the problems of collection and storage. The various methods of rain water harvesting in the study area is as shown below:

- Collection and conservation of rain water from roofs of buildings (this is the most common).
- Collection and conservation of rain-off from shallow ponds/catchpits - now on the decline.
- Collection of rain water running down the stem of certain trees (coconut trees).

Prior to 1950 (Ugwu, 1964) the second method (that is collection from catchpits) was widespread. However, the introduction and spread of metal and concrete underground storage tanks have diminished the importance of catchpits and significantly improved the traditional rain water harvestation from roofs in Nsukka urban. Generally, however these strategies have several structural and functional deficiencies that distinguish them from modern strategies as well as severely limit them from attaining the 'sufficiency potential' with regards to the people's water needs. For instance, apart from seasonality, annual rainfall amounts vary significantly in Nsukka from year to year and the high cost/limited capacities of storages tanks limits them in the area of sufficiency and long-term/period dependence.

5.2.2 Modern Strategies

The traditional strategies were largely dominant until the establishment of the University of Nigeria (in the sixties) which brought substantial changes in all 'dimensions of life' in Nsukka urban area. Perhaps, one of the most significant development measures which helped to transform the rural communities of Nsukka urban was the

establishment of a modern water supply system. The Eastern Nigeria government (in 1957) decided to implement a 'sustainable water supply system' (Eze, 1978), that will satisfy the water needs of the Nsukka urban population (Eze, 1978; Okite, 1978). Fortunately, the urban bed rock is a good aquifer and the mean depth of ground water was not far the surface (Nwachukwu, 1978). Thus, the drilling technology which was put in place to exploit the ground water resources not only grew and developed rapidly, but became the most vivid and concrete expression of the impact of modernization on the life of the population. Piped supplies, from the urban water corporation is undoubtedly the most important strategy for securing water resources for household use. Although, 'extensive piped water distribution program' were started in the early 1970s (Okite, 1978) their coverage is still limited. Various parts of Nsukka urban are still without piped supplies. The traditional water collection strategies still flourish in many parts - partly because of the low socio-economic status of most of the people and the inability of the urban water corporation to embark on aggressive expansion and modernization programs.

Finally, the 'importation' of drinking water for distribution through vendors is regarded as a modern strategy for

securing water for household needs (Zimmermann, 1986). Majority of the inhabitants of Nru and Nkpunano wards spend a high percentage of their income in buying water from tankers and vendors. Households in these and other wards spend a lot of money in buying water containers and storage devices such as jerry cans, tins, drums, tanks of varying capacity, etc. This practice is a limiting factor (especially in households of low socio-economic status) on the household water availability and use. The level of dependency on the various strategies outlined above is shown in table 8 and discussed in chapter II.

5.3 Evaluating the Strategies for Household Water Supply in Nsukka Urban

5.5.1 Rainwater Harvestation

It is true that one of the most widespread and directly accessible source of water in Nsukka currently is rainfall itself. But as shown in figure 8 (chapter II) this strategy do not make appreciable contribution to the water needs of the people in all the wards. Some of the many problems of rainwater collection is that rainfall in Nsukka is seasonal, unevenly distributed, and that to be successful, better collection techniques have to be developed and adapted to modern use. Majority of the people are of the low and middle income earners who lack the means to construct large catchment area

and tanks of high storage capacities required, if a reasonable rain water supply is to be provided with any reliability. The availability of modern buildings and tanks has, however, created a greater potential for the use of roof-catchment as a supplementary source of water supply at the point of consumption.

5.3.2 Commercial Supplies

Although commercial supply of water to households has existed in Nsukka for several decades now (Eze, 1978) it is not given much attention until there is a major breakdown in the public water supply system. In view of this, this strategy makes very little impacts (see figure 8, Chapter II) in the people's water needs. Generally, supplies from vendors has a number of limitations, viz - cost constraints.

- availability is uncertain and
- supply of water of doubtful quality.

Water is too essential a resource to be left to the impersonal forces of (demand & supply) free markets especially during shortages. Water vendors, in an attempt to maximise profits, often make some household supplies insufficient to satisfy demand at prevailing prices.

5.3.3 Piped/Public Water Supply

Figure 8 (chapter II) shows that piped supply makes the highest contribution (62%) to the household water needs in Nsukka urban. But a close observation of table II (chapter III) will show that the Nsukka urban water corporation operated at 25 - 35% capacity in 1993, 1994 and 1995. The corporation has not been able to meet her "target production quantities" since 1970. The reasons for this situation is due to what the zonal water engineer described "as operational constraints". The constraints are many and varied. They are discussed in details in chapter III and summarised under the sub-headings shown below.

5.3.3.1 Financial Constraints

The zonal water engineer and his staff regard financial constraints as underiably the most important constraint facing the Nsukka urban water corporation. Before discussing the magnitude of this constraint, it is useful to consider its nature. Capital (ie. cash) is primarily the means of acquiring more and better facilities, additional labour, and embarking on expansion and modernization programmes. But since 1984, the Nsukka urban water corporation has been receiving what the zonal water engineer described as "subsistence fund" or just the amount needed to provide minimum services. Financial constraints is at the root of all the urban water corporation

problems - particularly the limited or non-repair/replacement of facilities, delayed expansion and modernization programs, poor pipeline network coverage.

5.3.3.2 Technical Constraints

The technical constraints embrace all the problems relating to or arising from the installation of facilities and processes that are needed to ensure that the distribution system are in the best of conditions. The technology that is currently in use by the urban water corporation is over-aged and repairs as well as replacement of parts are slow and often uncertain. Generally, problems such as borehole breakdowns, burst pipes, leakages, sumo-pump fault, generators' fault, etc. which are common with the urban water supply corporation areas due to technical constraints and limited resources. The combined effect of these problems bring about low yield and this in turn compel the urban water corporation to embark on drought management' (ie. rationing).

5.3.3.3 Socio-Economic Constraints

Apart from the nature of or insufficient equipment available for use, other important socio-economic constraints such as poor attitudes to work (potentially usable technology can be applied only by people), non/irregular payment of salary,

vandalism and conservatism are example of socio-economic constraints which often account for the inability of the corporation to operate at desired capacities.

5.3.3.4 Administrative Constraints

Efficient administrative technical and skilled personnel are needed to plan and implement planned urban water programs. This is severely lacking in Nsukka urban.

In summary, the greater limitation of the public water supply industry in Nsukka is the frequent and persistent breakdown in the supply system and the slow rate of repairs and replacements of relevant parts. Available records at the zonal headquarters of the water corporation reveal that the organisation has had problems of securing relevant spare parts, maintaining machinery, and securing adequate funds since 1984. These problems compel the corporation to resort to rationing and rationing limits water availability and use. Meaningful economic development and urbanization can not take place in Nsukka urban, if water supply is erratic, uncertain and insufficient.

5.4 The Impact of the Constraints on the Urban Water Supply Situation

Field investigations revealed that the effects of the numerous constraints on the various strategies for securing household water supply can broadly be summarised under three sub-headings viz:

- Quantity Problems
- Distribution Problems
- Quality Problems

5.4.1 Quantity Problems

The resultant effects of the above constraints include among other things; the inability of the urban water supply units to attain the 'sufficiency potential' in the residential sector (ie. meet total household water demand) as well as the 'target production quantity (ie. installed capacity). For instance, the mean daily per capita water demand for Nsukka (see chapter III) is 94.57 (L/P/D), which for a population of 124,926 (Nsukka urban area, in 1995) will amount to a daily average of 11,814,251 litres. Regretably, the mean daily per capita water supply is only 51.86 (L/P/D) which for a population of 124,925 translates to only 6,478,373 litres. This leaves us with a daily deficiency of 5,335,878 litres. Similarly, the installed capacity (1995) is designed

to yield a daily average of 16,400,000 litres (60% - 72% of this is for residential needs while 40 - 28% for industrial and commercial needs) while the entire supply system at present yields only 6,478,373 litres, leaving a daily shortfall of 9,921,627 litres.

The silent implications of the above situation is that the existing strategies are not meeting the people's water needs. And this is largely due to the continued deterioration in the quantity supplied. To break this vicious circle according to our respondents requires a determined long term effort both to installed modern machinery, maintain/expand existing facilities, and to provide the urban water corporation with a 'solid resource base'. This is examined in details in section 5.5.

5.4.2 Distribution Problems

The water distribution network of Nsukka urban, according to field investigations is uneven and in 'bad' condition. Every month, thousands of gallons of water are lost through wastes and leakages or even losses, arising from the carelessness of consumers with ready access to water supplies. Wastage is defined here as misuse or excessive legitimate use (Morgan, 1973). Water leakages and waste are common

in Nsukka urban area. Often the 'where' and 'to what extent' is unknown. Wastage in the urban water distribution arise from a variety of causes, viz:

- delays between locating and repairing leaks
- poor control systems including overflow of service reservoirs.
- taps and standpipes (now few) left running
- ineffective mains cleaning and clearness.

The measures already put in place by the urban water corporation to reduce wastage and leakages,

include:

- educating the public on the need to conserve water and report leakages promptly.
- imposition of controls, securities and penalties.

There is an absence of control measures (particularly metering) to regulate the consumption behaviours of the population. Private water connections with water meters are non-existent, while a significant part of the urban landscape are not covered by pipeline network. The urban water corporation believes that an extension of the system beyond the capacity of the existing supply is not advisable. Even in areas covered by the pipeline network, supply is

often erratic and prolonged shortages are not uncommon. All these, are in varying degrees attributable to the operational constraints, facing the urban water corporation.

5.4.3 Quality Problems

One of the unfortunate consequences of leakages is the deterioration in quality supplied. Leaks in the pipelines often lead to additional pollution - inducing polluted ground water into the mains through the leak openings. The situation if unchecked (through repairs and removal of contaminants) lead to tremendous high disease rates, particularly infectious intestinal diseases. The solution to this problems lies in constant surveillance and prompt repairs of leaks. Field investigations, however, revealed that even the very obvious leaks in the main lines are not repaired promptly, talkless of the smaller leaks at the street or private household connections which may remain unattained for many weeks. The zonal water engineer is, however, of the view that the only area of concern with regards to raw water quality for Nsukka urban is the iron content - which is now treated efficiently.

5.5 Suggested Strategies for Improved Water Supply in Nsukka Urban Area

We have, in the proceeding sections, discussed the limitations of the existing strategies for securing sufficient water for household use in Nsukka urban. A key issue through out our discussions so far is 'sufficiency'. To be sufficient, the urban water corporation must deliver quantities which can gurantee improved standard of living, rapid population growth and meaningful economic development. This situation is far from being realised in Nsukka urban. Ingermittent supply and rationing have long been accepted as 'management policies' in Nsukka urban.

In view of this, we sought and obtained the views of the staff of the Nsukka urban water supply units on how the present supply situation can be improved. We summarise in table 50, the measures/strategies identified and, thereafter, described each in detail. Our respondents firmly believe that the suggested measures/strategies are capable of achieving two related objectives, namely:

- ensure maximum satisfaction for the entire urban dwellers through the redistribution and better management of available water resources.
- overcome the Nsukka urban water supply problems by significantly improving the existing strategies.

Table 50: Suggested Measures to Improve Piped Water Supply in Nsukka Urban Area

| S/No. | Measures (Preferred Strategy) | UNN Water Supply Staff (Frequency) | Urban Water Supply Staff (Frequency) | Total | % of Cum. Total |
|-------|--|------------------------------------|--------------------------------------|-------|-----------------|
| 1 | Speedy completion of the Government water development programme for Nsukka Urban | 10 | 28 | 38 | 13.7 |
| 2 | Improved distribution network | 09 | 26 | 35 | 12.6 |
| 3 | Reactivation of public water taps | 04 | 29 | 33 | 12.0 |
| 4 | Elimination of existing constraints on piped supply | 11 | 22 | 33 | 12.0 |
| 5 | Private sector participation | 01 | 31 | 32 | 11.6 |
| 6 | Prompt maintenance of machinery/replacement of over-aged pipes | 14 | 14 | 28 | 10.0 |
| 7 | Adequate investments in water development | 12 | 14 | 26 | 9.4 |
| 8 | Higher water tariff | 00 | 22 | 22 | 8.0 |
| 9 | Prompt repair of leaks | 06 | 12 | 18 | 6.5 |
| 10 | Others | 04 | 07 | 11 | 4.2 |
| Total | | 71 | 205 | 276 | 100% |

Source: Fieldwork (1995)

Some of the above measures are briefly described sections below.

The current government's water-development programmes for Nsukka Urban (ie. No. 1, table 50) include:

- (a) The Greater Nsukka Urban Water Scheme and
- (b) The National Water Rehabilitation Project (NWRP) for Nsukka Urban.

5.5.1 Current Government Water Development Programmes for Nsukka Urban

Theoretically, all levels of governments share the responsibility of ensuring the availability of adequate and qualitative water supplies to meet the people's water needs in Nsukka urban and rural areas. In practice, however, the task of providing municipal water for Nsukka urban has always been left in the hands of regional/state governments and private agencies. Currently, the Enugu State Government is responsible for providing portable water to the Nsukka urban dwellers. The Enugu State Water Corporation sinks and maintains boreholes and oversees the urban water distribution network. According to the State Director General for Public Utilities (Mr. Albert Edoga) the State Government, in collaboration with the Federal and other relevant institutions, have two ambitious water development programmes for Nsukka urban area. These programmes are:

- The Greater Nsukka Urban Water Scheme
- The National Water Rehabilitation Project (NWRP) - the Nsukka Scheme.

5.5.1.1 The Greater Nsukka Urban Water Scheme

The most elaborate and expensive water resource development and supply programme for Nsukka urban is the Greater Nsukka Water Scheme, which was conceived simultaneously with the Greater Enugu and Abakaliki Water Schemes in the early 1980s. The Greater Nsukka Water Scheme is an ambitious water development programme which is based on a design to impound the Adada River and deliver from it an average of 50,000 cubic meters of portable water per day through a 12 kilometer pipeline to the Nsukka urban dwellers (Edeoga 1996, Eze, 1995). It is ironic that whereas the Abakaliki and Enugu Schemes, with capacities of 75,000 and 77,000 cubic meters per day respectively were commissioned in 1985 (Edeoga, 1996), the Greater Nsukka Water Scheme, started simultaneously with them has been abandoned due to financial constraints and political reasons (Eze, 1995). The Director General of Public Utilities, however, has described the abandonment as 'temporary'. He observed the current down-turn in the economy has caused many state governments to experience, in differing degree, stagnation if not declining government revenues and serious balance of payment and debt servicing difficulties. This has led to drastic cut backs in investments in public utilities. Despite these problems however, the state

government is determined to revive the Greater Nsukka Water Scheme as soon as her finances improves

5.5.1.2 The National Water Rehabilitation Project
(NWRP) - The Nsukka Scheme

As the name implies, the National Water Rehabilitation project (NWRP) is a scheme aimed at increasing the supply of portable water throughout the Federation by rehabilitating existing water supply schemes and to restore them to the designed capacity. The scheme is also aimed at sustaining the increased water supply through institutional strengthening of the State Water Agencies.

Enugu state is in Zone "F" of the scheme which comprises states such as Enugu, Anambra, Benue and Cross-River. The state has in addition met all the stipulated conditions necessary for the take off the scheme (Edeoga, 1996). In view of this, the scheme has selected 3 urban and 11 rural communities which are to benefit from that rehabilitation programme. Nsukka urban area is one of the beneficiaries and the project implementation within the urban stated in February 1995. Our respondents believe that NWRP will boast supply in Nsukka urban.

The Nsukka Project of the scheme is based near the borehole farm at the University gate. The project managers are charged with the responsibility of rehabilitating the

existing boreholes and even pipeline extension when completed the level of water supply from the boreholes is expected to increase from the current 1,500 cubic meters a day to about 9,000 cubic meters per day (Eze, 1995). Apart from modification of the priority borehole field and expansion of the rising mains and distribution system, the NWRP Nsukka urban project, is also expected to embark on the energization of two of the boreholes by NEPA.

5.5.1.3 Public Standtaps

There are at present 72 public standtaps in Nsukka urban out of which only 18 are functional and connected to the mains.

All the functional public standtaps have also been commercialised (ie. users are required to pay). The public standtaps are located haphazardly over the area. For instance, there is no fixed distance for establishing a public standtap, no number of households to be served and no regularity of flow. There are over concentration of public taps in Onuiyi and Ihe wards - Nru and Nkpunano are very poorly served. To our respondents believe that improve the supply situation, the existing public standtaps should be revived and systematically located - using for example a target of 500 - 1000 households as a yardstick.

5.5.1.4 Individual Participation

At present, individual participation in water resource development in Nsukka urban is limited to the construction of underground concrete and metal tanks. Water is then directed to these tanks for storage by channelisation mainly during rainfall. This level of participation can be improved if well-to-do individuals and private associations becomes involved in the drilling of boreholes for private use. In Kenya and Tanzania (Roth, 1985) such private boreholes are among the most reliable in the country. The urban water supply staff strongly recommend this measure.

5.5.1.5 Maintenance of Machinery

Our respondents believe that renewed interest in the maintenance of existing machinery is necessary to achieve target production quantities (see chapter III) and reduce the frequent water loss through leakages and pipe bursts.

5.5.1.6 Elimination of Existing Constraints

The next strategy, which is rather considered important by our respondents, is the elimination of the current operational constraints facing the urban water supply units. This programme is necessary in order to ensure that the huge government investments in the water sector is not wasted, and that the difficulties often experienced in importing

essential parts and operating the system is reduced to the barest minimum. The "maintenance culture" of the Enugu State Government is indeed considered **relevant** / especially now that here. enough funds can not be generated to replace broken down parts or expand existing systems.

5.5.1.7 Improved Water Tariff

The low water tariff now charged by Nsukka urban water corporation no doubt constitute a constraint to higher performance. For instance, the present estimated cost of producing one cubic meter of portable water, including pumping and treatment is about ₦20.00 while water charge for residential use is estimated to be as low as ₦2.50/M³. This low internally generated revenue is one major reason why the corporation experiences difficulty in operating and maintaining its system.

5.5.1.8 Effective Planning

Planning provides new and useful insights of crucial importance of how goals can be met or how existential problems can be solved (Ayode, 1981). Planning is not an end in itself, but a means, an unavoidable means for better use of what we have, or getting what we desire. No task is of greater importance in improving supply than the development of strategic plans.

5.5.1.9 Manpower Development

The use of effective training to enhance capability and competence has, of course, long been recognised (Dandy, 1987). Yet its use by institutions in developing countries remain limited (Ayoade, 1981) and its advocacy has, in practice, been less than enthusiastic (Ezema, 1995), yet no requirement is of greater importance in the development of effective urban water supply than the "brainpower" of technical 'experts' hence its recommendation.

5.5.1.10 Adequate Investments

Fund is primarily the major means of acquiring new facilities or more often the required skilled labour. Significant developments in the water supply industry such as the drilling of additional boreholes, the building of additional reservoirs and even the maintaining of the distribution system, etc. can not occur in the absence of fund. The 'small scale nature of water resource development projects in Nsukka urban has been attributed to the "subsistence fund" provided to the urban water corporation.

5.5.1.11 Research and Development

Mismatches between what users really need and what planners supply often lead to users' dissatisfaction and waste of a nation's resources - materials, labour, time and foreign

exchange needed for other purposes (Duncan, 1987). Objective research helps to solve the problems of over or under designed systems (Roth, 1985). Objective research provide appropriate guidelines for effective maintenance and management and helps to free more resources which could be devoted either to extending services into underserved areas or to accelerating developments through other sectors - hence the need for such researches in the water supply sector in Nsukka urban.

5.5.1.12 Surveillance and Prompt Repair of Leaks

Surveillance and repairs of leaks promptly is extremely ~~necessary~~ necessary to reduce the high water loss and wastage which can result in the distribution system due to leakages. Although, the question of exactly how much water was lost through leakages in Nsukka urban in 1995 remained unanswered, it was discovered that the case of leakages/burst pipes are frequent and widespread in Nsukka urban area.

CHAPTER SIX

CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

The overall objective of this study is to analyse the spatial residential patterns of water demand and supply in Nsukka urban area, and advance suggestions which can lead to improved supply and management of these resources within the area of study. The results of this study clearly extend our understanding of the spatial patterns of water demand and supply in Nsukka urban where a delicate mixture of urban and rural features are strongly interlocked with one another. Specifically, we have been able to establish the underlying dimensions of water demand and supply for the entire urban area and for the wards within the urban. We also established (spatially and for the entire urban) the other essential features of demand and consumption features (such as mean daily per capita water demand and supply, mean daily household water demand and supply, total household water demand, etc.) and the gap in the people's water needs. This enabled us to compare demand and consumption patterns among the six wards. The University ward for instance has both the highest mean daily household water demand and supply as well as the highest mean daily per capita water demand and supply. Supply within this (UNN) ward is more stable and regular and in addition, the fact that

consumers outside this ward generally pay from 50 - 350% more than their counterparts in the University ward is also an important factor in the relative water use rates.

The underlying factors identified as being largely responsible for variations in household water demand and consumption patterns in the entire urban and in the wards include:

- i) The availability of water supply in residence.
- ii) The socio-economic status of the household head.
- iii) The household size.
- iv) The availability of space in residence.
- v) The frequency of requirements for domestic and
- vi) The influence of price (Nru and Nkpunano wards only).

These underlying dimensions could form the platform upon which meaningful management practices in the distribution system can be carried out.

Another important finding of this study is the existence of spatial inequalities in the distribution system. The supply system is inadequate and unevenly distributed. An equitable supply system is one which promotes greater equality of conditions (Aithen & Duncan, 1991). Services are fairly/equitably distributed when everyone gets the same services at a uniform cost (Roth, 1986). Presently, the principle of equity in the Nsukka urban water supply is lacking.

Nine essential measures (based on the informed opinion of the water works units) which are capable of improving current levels of supply and management of the urban water resources were advanced. These measures ought to be implemented because, as the urban becomes more populated, and therefore, more service oriented, her future economic vitality will expectedly depend on the extent to which the urban water supply problems are identified and tackled. The long term solution to the urban water supply problems, however, requires ideas and visions in water resource planning, development and management.

Finally, the findings of this study relate remarkably with those of Chime (1984), in Abakaliki Urban, Ibeziako (1985) in Enugu Urban, Ani, (1986), in Jos and Ezenwaji (1990), in Onitsha Urban. The findings of this and the above investigators, for instance revealed that:

1. the profound inadequacy of this resource in the concerned urban areas is a longstanding phenomena and that calls for improved supply have been load and recurrent.
2. the quantity of water demanded and consumed by households is a function of varied variables whose contributions vary from one urban area to another. However, certain variables such as income level of the household head, size of household, regularity of supply, educational attainment of the

household head and the quantity needed for household cooking were found to significant determinants in all the (urban) areas studied.

3. Similar factors (when the variables are statistically reduced to a few factors explaining significant variations in household water demand and consumption) generally influence the residential water use habits in the areas studied. For instance, Ibeziako (1985) using the factor analytic technique determined that the six factors which influence residential water demand in Enugu Urban are:

1. dwelling type.
2. frequency of water supply.
3. the educational attainment of the household head.
4. the density of public taps
5. the distance from the streams from the households and
6. household size.

Similarly, Ezenwaji (1990) in Onitsha identified the five factors explaining 84.1% of the variations in household water demand and consumption as the:

1. level of household sanitation.
2. Socio-economic status of the household head.
3. level of kitchen demand for water.
4. level of household infrastructure and
5. the general level of water rates in residence.

Comparatively however, there are profound variations in the daily per capita water demand and supply; in mean daily household water demand and supply; and in the level of deficiency in the people's water needs. Onitsha for instance has both the highest mean daily household water demand and supply as well as the highest mean daily per capita water demand and supply. Nsukka recorded the least. This variations is largely due to various factors such as variations in the socio-economic status of the inhabitants of various urban areas.

6.2 Recommendations

On the basis of the findings of this study, we recommend the immediate implementation of the suggested measures (table 50) in order to improve piped supply urbanwide. The result of our analysis has already established a gap in the people's water needs. We are of the opinion that the measure will bridge the gap by tremendously increasing current supply levels, mitigating the current spatial inequalities in supply and by addressing the determinants of the shortfalls in target production quantities.

Secondly, we recommend an increase in the budgetary allocation to the urban water corporation and the University water works unit. This is necessary to enable these units expand and modernise the supply system, to purchase and maintain essential machinery, to

reactivate public water taps, to drill new boreholes, to recruit skilled staff, and to improve household connections.

Also, recommended is the establishment of modern and improved techniques for rain water collection and storage. The presence of many modern buildings has created a greater potential for the use of roof-catchment as a major supplementary source of supply.

There is in addition, a need for effective training of the supply staff (- no other requirement is of greater importance in the development of urban water supply than the 'brain power' of technical "experts" (Roth, 1985) and metering to reduce wastage.

It is our firm hope that the result of this study will be useful to policy makers, planners, and all the agencies involved in water resource delivery in Nsukka urban. In this regard, we believe that the adoption of the findings will go a long way to ensuring that the people's water needs are met.

6.3 Areas for Further Study

This study concentrated on the spatial patterns of residential water demand and supply in Nsukka urban. The residential sector is just one out of many other sectors that make up an urban environment. Therefore, we recommended that more efforts should be directed to exploring the patterns of

demand and supply in other sectors, such as industrial, commercial and agricultural sectors, etc. in order to get a 'complete' picture of the 'total' patterns of water demand and supply in Nsukka urban.

There is, in addition, the need for examining the influence of additional variables such as attitudinal, behavioural, climatic factors, etc. on water demand and consumption patterns in order in order to achieve a greater explanatory power.

Finally, it may be necessary to examine, in details, the suitability or otherwise of the various (existing) water allocation options currently developed and variously supplied in urban water allocation in various countries (Rees, 1982). Every option has its strenghts as well as weakness, and effective selection can only be made when the impact of several options have been objectively analysed (Aitken, Duncan, and McMahon, 1991).

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APPENDIX A : SPSS COMPUTER PROGRAMME APPLIED FOR FACTOR ANALYSIS.

RUN NAME : Nsukka Urban Water Supply

FILE NAME : M.C. Obeta

VARIABLE LIST : AMT, XNCON, COST, COOK, HOUSE, EDU, HOUR, SIZE, WC, OCUPA, DIST, TAP, ROOM

INPUT MEDIUM : CARD

SUBFILE LIST : UNN(75), GRA (50), ONULYI (118), Nru (116) NKPUNANO (153), IHE (168).

INPUT FORMAT : FIXED (2F7.0,3F6.0, 3F5.0, 6F4.0).

RUN SUBFILES : EACH

REGRESSION : VARIABLES = AMT TO ROOM/REGRESSION = AMT WITH XNCON TO ROOM (2) /

STATISTICS : 1

RUN SUBFILES : ALL

REGRESSION : VARIABLES = AMT TO ROOM
: REGRESSION = AMT WITH XNCON TO ROOM (2)/

STATISTICS : 1

RUN SUBFILES : EACH

FACTOR : VARIABLES = AMT TO ROOM TYPE = PA2/
: NFACTORS = 6/
: ROTATE = VARIMAX/

STATISTICS : 4, 5, 6

RUN SUBFILES : ALL
: NIFACTOR = 6/
: ROTATE = VARIMAX/

STATISTICS : 4, 5, 6

FINISH.

APPENDIX A1

QUESTIONNAIRE FOR RESIDENTIAL AREA

INSTRUCTION: Please use (✓) where appropriate.

1. In which part of Nsukka urban do you reside? _____
(e.g. Ugwuoye, Onuiyi, etc.).
2. What is your level of education attainment?
None Primary WASC NCE
HND/Degree (Please tick as appropriate).
3. Salary grade level: 01 - 03 ; 04 - 06
07 - 09 ; 10 - 12 ; 13 and above
4. If you are not a salaried worker, about how much do you
earn per month? _____ (please specify).
5. Do you have tap water in your place of residence?
Yes No
6. If NO, where do you get your water? _____
(eg. fetching from the campus, buying from water vendors,
collecting from storage tanks).
7. If YES, how often do water run in your residence per week?
eg. Everyday Twice per week, Thrice per week
8. If your water tap runs daily, about how many hours does
it last per day?
1 hour ; 6 hours ; 12 hours ; 24 hours
9. If water tap is not in your compound, how far is the source
from where you get an alternative supply from your house _____
10. Do you have a pipe-borne water system in your house?
Yes No

11. What water consuming facilities do you have? _____
(eg. flush toilets, showers and baths, etc., please specify).
12. How many people are there in your household? _____
13. How many rooms are occupied by your household? _____
14. Please, estimate the quantity of water (in bucketfuls)
used daily in your house for the following:
- (a) Cooking _____ (b) washing cloths _____
- (c) General house cleaning _____ (d) others _____
(Please specify).
15. If you buy water from vendor, what is the cost of water per:
- (a) a bucket _____ (b) a drum _____
16. About how much do you spend on water per:
- (a) Day _____ (b) Month _____
17. About how much do you pay per month as your water rate? _____
(Please specify).

APPENDIX A2

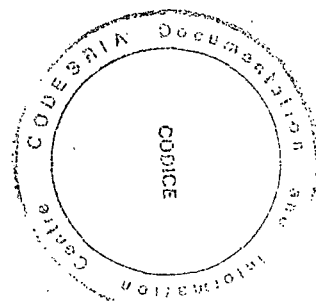
QUESTIONNAIRE FOR WATER WORKS

INSTRUCTION: Please use (✓) where appropriate.

1. Name of the water works unit _____
2. Location of the water works unit _____
3. Name of the supply area(s) for the water work unit _____
4. What is the total amount (in litres) of water which you serve to your supply area(s) daily? _____
5. Do you emphasize the supply of water to any particular area?
 Yes No
6. If Yes, please what is the name of the area? _____
7. Why do you have to emphasize the supply to that particular area? _____
8. Do you experience constant breakdowns in your supply system?
 Yes No
9. If Yes, then please mention the factors and the extent to which they contribute to such breakdowns.

| Factors | Extent of Contribution | | | | |
|------------------------------|------------------------|----------|-----------|----------------|-----------|
| | Very Strongly | Strongly | Minimally | Very Minimally | No Effect |
| eg. (a) Erratic Power supply | | | | | |
| | | | | | |

10. How can the current level of supply be increased?
(a) _____ (b) _____
(c) _____ (d) _____
11. How adequate is the revenue generated from the consumers for the maintenance of the water works?
(a) Very adequate (b) adequate
(c) Not adequate
12. If the revenue generated from consumers is inadequate how do you get the money needed for the maintenance of the water works? _____ (please specify).
13. How many reservoirs do you have? _____
14. What are the capacities of the various reservoirs? _____
15. Where are the reservoirs located? _____
16. Do you have any reason(s) for locating the reservoirs in the manner in which they are located? _____
17. Are all the reservoirs presently in use? _____
18. If No, please indicate the ones presently in use _____
19. What are the reasons why the rest are out of use? _____
20. How many functional public pump stands do you have? _____
21. How are the functional public pumps distributed within the town? _____
22. How many broken down public stand pipes do you have within the urban? _____
23. How are the broken down public stand pipes distributed within the urban? _____



APPENDIX A3

QUESTIONNAIRE FOR WATER VENDORS

1. The medium used for selling water _____
(eg. drums, trunks, storage tanks, tankers, etc.)
2. Sources of the water sold _____
3. Part(s) of the urban area where such water is sold _____
4. Estimate the quantity of water sold daily _____
Weekly _____
5. What is the cost of your water in:
(a) buckets _____ (b) drums _____
6. Is the water supplied daily enough for the people in the
area(s) you are serving?
(a) Yes (b) No
7. If No, how do they make up for the deficit? _____
8. What season (or months) of the year is water sold mostly
in Nsukka urban? _____
9. What are the reason(s)? _____
10. Please, estimate the quantity of water you collect per
trip for distribution _____
11. Do you pay for the water you collect for distributions?
Yes No
12. If yes, about how much do you pay for the quantity you
collect per trip for distribution? _____
(Please specify).