PLANNING ANALYSIS OF WATER SUPPLY IN KADUNA METROPOLIS
M.SC (U.R.P) THESIS

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DEDICATION

I hereby affirm that this thesis has been composed by me and that it is a reward of my research work. It has not been presented in my previous application for a high degree. All sources of information are acknowledged by means of references.

Signature

4/8/2000

Date

CERTIFICATION

This thesis entitled planning analysis of water supply in Kaduna Metropolis by Nyam Jim Vitoria meets the regulations governing the award of the degree of M.sc (Urban and Regional Planning) of Ahmadu Bello University and as approved for its contribution to knowledge and literary presentation.

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Thank you and may my God supply all your needs according to His riches in glory in Christ Jesus. Amen.

THESIS ABSTRACT

PLANNING ANALYSIS OF WATER SUPPLY IN KADUNA METROPOLICS

Water is an essential element of living things in general and therefore critical for sustainable development. However with the rapid growth of Urban populace and the consequences of this growth the availability of this resources is becoming less and less. The need to plan the usage of this resources is becoming more paramount nowadays hence the reason for these research.

In the planning of water supply in Kaduna it has been observed that even after the existing problem have been solved there is always a reoccurrence after a period of time. The research has revealed that most of the planning done by the Kaduna state water boards is aimed at meeting present situations. No attempt is made to study the future growth of the city and thus anticipate the future water need of Kaduna and hereby plan towards meeting those future water needs. This will invariably prevent the water inadequacy in Kaduna from reoccurring.

In the research an attempt was made to evaluate the water potential of Kaduna metropolis (both ground and surface water). This was to evaluate

how much water *is* available, which will in turn determine how to plan for the future.

An attempt was also made to determine the water demand of the populace, which was compared with the water supply to the populace. This in turn determined the adequacy of water supply in the metropolis. Also specialized used of water were studied to enable a picture of the total water demand of the metropolis be seen.

In view of the research finding recommendations and proposals were made for sustainable water supply in kaduna metropolis. Proposals like the promotion of private sector participation, commercializing of the state water authority, integrated approach to supply were made. All with the aim of reducing the burden on the Kaduna state water board and making more funds for future development of the water supply system hereby sustaining water supply in the metropolis.

In conclusion the need for observing trend and extent of growth of the metropolis was emphasized in order for better management of growth be made hence making the water supply needed by the populace of Kaduna available.

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CHAPTER ONE

DESIGN OF THE STUDY

1.0 INTRODUCTION

Water is an essential element for the growth of living things in general and therefore critical for sustainable development (Haruna: 1991,1). Due to its importance, the effective supply of water for sustainable urban development has become one area of concern to environmentalists, urban planners and governments.

With the rapid growth of the urban populace, increase in industrial activity and pollution and the change in climatic conditions, the global amount of potable water supply in Nigerian urban centres is reflected by the bad sanitary condition of the cities; detercoration of human health, low level and habhazrad development in the urban areas. This is because the location of industries is greatly influenced by the availability of water supply (Barret 1989:323). Efficiency of sanitation systems are determined by the availability of adequate water supply. This inturn determines the level of human health (Ekanew 1988:18).

As locally available water supplies have gradually been surpassed by local water demand, especially in heavily populated and industrial areas in Nigeria; or as drought occurs and sometimes persist or as quality of water continues to deteriorate, the government of Nigeria has attempted to solve the problems by programmes of water system rehabilitation, construction of Dams and pollution control. However an important observation is that most of these programmes aim at addressing present or existing water problems. This has led to the reoccurrence of the same problems after a period of time. Also these programmes are not based on standard planning procedure, No analysis are made programmes are carried out based on need. (Ekanew 1988:18) with the future water supply problems can not be solved.

Planning for the development of our water resources and the management of water available is important for solving the water supply problems in our urban centres. This can be achieved by estimating present and future needs; estimating the population and spatial growth of the urban area and plan adequately for their water need. This would be a good basis to develop adequately and guide the direction of development in our urban centres.

1.1 STATEMENT OF RESEARCH PROBLEM

Kaduna metropolis like other urban centres in Nigeria is experiencing serious population growth and spatial expansion. In a 30 years span the population has more than doubled, from 233802 people in 1966 to 563400 in 1990 at a growth rate of 2.5%. This has resulted in Kaduna spatial expansion, from a radius of 5kms in 1966 to it's present radius of 40km (ABU:1985).

The population growth and spatial expansion have led to serious water problems in most parts of the city in the early 80's. With less than 50% of the population having access to potable water, (World Bank:1992,41). To address these problem the Kaduna State Government in collaboration with the World Bank, embarking on a programme in 1985. This programme increased the percentage of people having access to portable water to 85% and improved the water distribution network to reach all parts of Kaduna metropolis making the current Kaduna water supply system one of the bast in Nigeria presently (World Bank, 1995,14).

Kaduna metropolis however is expanding rapidly with rapid economic development and the increase of commercial activities. The future population of Kaduna is expected to increase rapidly. Another factor of growth are the new major projects taking place in Kaduna. Some of these are the development of the Eastern sector, the heritage university, the new N.D.A. along Mango road and the new housing estate at Gonin Gora. These projects are expected to boost the population growth and spatial expansion of Kaduna and in turn increase the demand for water.

To avoid a reoccurrence of past water supply problems which is due to the failure of planners to use standard planning procedures to make realistic policies to meet water requirements. These is a need to study the present water potential (both surface and ground water) in Kaduna in relation to the future water requirements which will be influenced by the new major projects in Kaduna and plan towards sustainable water supply in Kaduna metropolis.

1.2 AIM AND OBJECTIVES

The aim of this research is to determine the future growth of Kaduna metropolis and adequately plan for sustainable water supply in the town.

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This aim will be achieved through the following objectives.

1) To review the concepts, determinants and standards for planning for sustainable urban water supply.
2) To analyse the water resource potential in Kaduna and appraise the present state of water supply with reference to the world bank assisted programme.
3) To analyses present and future water requirements with respect to the major land development and projects in Kaduna.
4) To make adequate proposals for sustainable water supply in Kaduna metropolis.

1.3 SCOPE AND LIMITATION

The research covers the urban designated area of Kaduna. The study focuses on the ability to estimate future rate and area of growth of Kaduna metropolis in order to plan adequately for present and future water requirement of the city.

One of the greatest limitation of the study is adequate data. This is because the Kaduna State Water Board became computerised in 1987, thus started storing data adequately with the help of the computer. Data of years before 1987 are in most case incomplete and some lost altogether. Since the new major project is still in the early implementation stages most of the information of their operations are still classified information so were not accessible.

Another limitation was the lack of resent data on industrial development in Kaduna. Due to this limitation past data was used.

The year 2006 was used to evaluate future conditions. This is within the limits recommended for urban plans (seventeen years) and within the proposed time period of the max master plan for Kaduna (1967 - 2017).

1.4 METHODOLOGY

The data on which this study was based was collected by two major sources, viz a viz secondary and primary.

1) From informal interviews with officials of the Kaduna State Water Board and National Institute of Water Resources. This informal interviews provided pertment information on various aspects of the study. Both in a general sense as well as in specific areas.

2) Formal interview in form of questionnaires were conducted. This primary data provided information on the general aggregate of present water demand and supply in Kaduna.

3) The extrapolative method was used to estimate future water requirement and population growth of Kaduna metropolis. This was obtained by the study of past and present situations which are projected and used to estimate future situations.

4) Maps, charts and water distribution layouts were also used and inferences made from them. Secondary data was also collected from journals, newspapers, official gazettes, seminar papers, government files and text books.

1.5 DEFINITION OF CONCEPTS

1.5.1 URBAN AREA

The definition of an urban area differ from country to country and from discipline to discipline. This has resulted in the difficultly in deriving at a single definition used to define an urban area. These are:-

a) Definition based on legal and administrative boundaries: This definition is a reflection of law in any country. Thus urban areas are defined based on legal boundaries delineated by the government in whose jurisdiction the area is located.

b) Definition based on minimal population. This definition is most commonly used. It differs from country to country 250 people minimum in Denmark (Baba:1988). In countries that are heavily populated, population densities are used.

c) Definition based on function of areas: This is regarded as a qualitative definition based on the attributes of settlements. It takes into account not only the number of people living in an area but also the characteristics of population, income, occupa economic activities etc.

In Nigeria the criteria for defining urban areas vary from period to period. During the colonial period, population size was taken into consideration as a criteria for defining urban areas. The urban and rural areas were differentiated by the rank of the traditional ruler (political and cultural state). After independence the size of population was used as the basis for defining urban areas, within a minimum size of 20,000 (Baba : 1988). This criteria is used up to date. The concentration of such group of population could also generate some complicated social and economic activities that would difference the urban from the rural areas.

1.5.2 WATER

The use of water by man, animals and plants is universal. Without it there can be no life (Falkenmark & Winstrand : 1992). According to the Greet Philosopher Pindar of the fifth century BC, water is the best of all things. Another Greek philosopher known as Empedolles of Agrigentus (490-420 BC) stated that water is one of the four elements or roots from which all materials of the world are constituted. The other three elements are air, fire and earth (Falken,at: 1990). This an over statement, but it is obvious to note that water has been responsible for the survival and social development of man from the beginning of his existence, without water life and civilization cannot survive and develop. Wars have been fought in the past over availability of water and even now some countries have strained relationships over some international water bodies disputes.

Water can be said to be a renewable natural resource base on the function of the hydrologic cycle. However, the total amount of water available on the global basis is constant. It's total stock can neither be increased or decreased. About 71% of the earth surface is covered by water (made up of a volume of about 1.4×10^{a} Km^{3}) of this 97.3% is ocean water and the balance of 2.7% is fresh water. At any given time 77.2% of fresh water is frozen in the polar regions and in glaciers in various parts of the world thus not available for human consumption and other uses. The remaining

22.8% of available water is however distributed unevenly around the world. (Wright 1977:2). For example in Africa 50% of its total surface water resources are in eight river basins - Congo, Niger, Ogooue, Zambesi, Nile, Sangam, charilogome and volta. This gives rise to an abundance of water resources in the equatorial region with a sharp contrast with the total lack of it in the desert areas of the north and south (Lehr 1980).

Water is collected and supplied from basically three sources. These are rainfall, surface water and ground water. After the collection, water is transmitted to treatment plants where the water is purified and made conducive for human use. The treated water is then distributed. The distribution of water is the delivery of water through complex pipe networks that serve urban areas. Distribution systems may be generally classified as grid systems, branching systems or a combination of both.

1.5.3. SUSTAINABILITY

Sustainabiliy is defined in this study as the conservation and maintenance of what exist at present. It also refers to meeting the needs of the present without impoverishing future generations and to identity areas of concern.

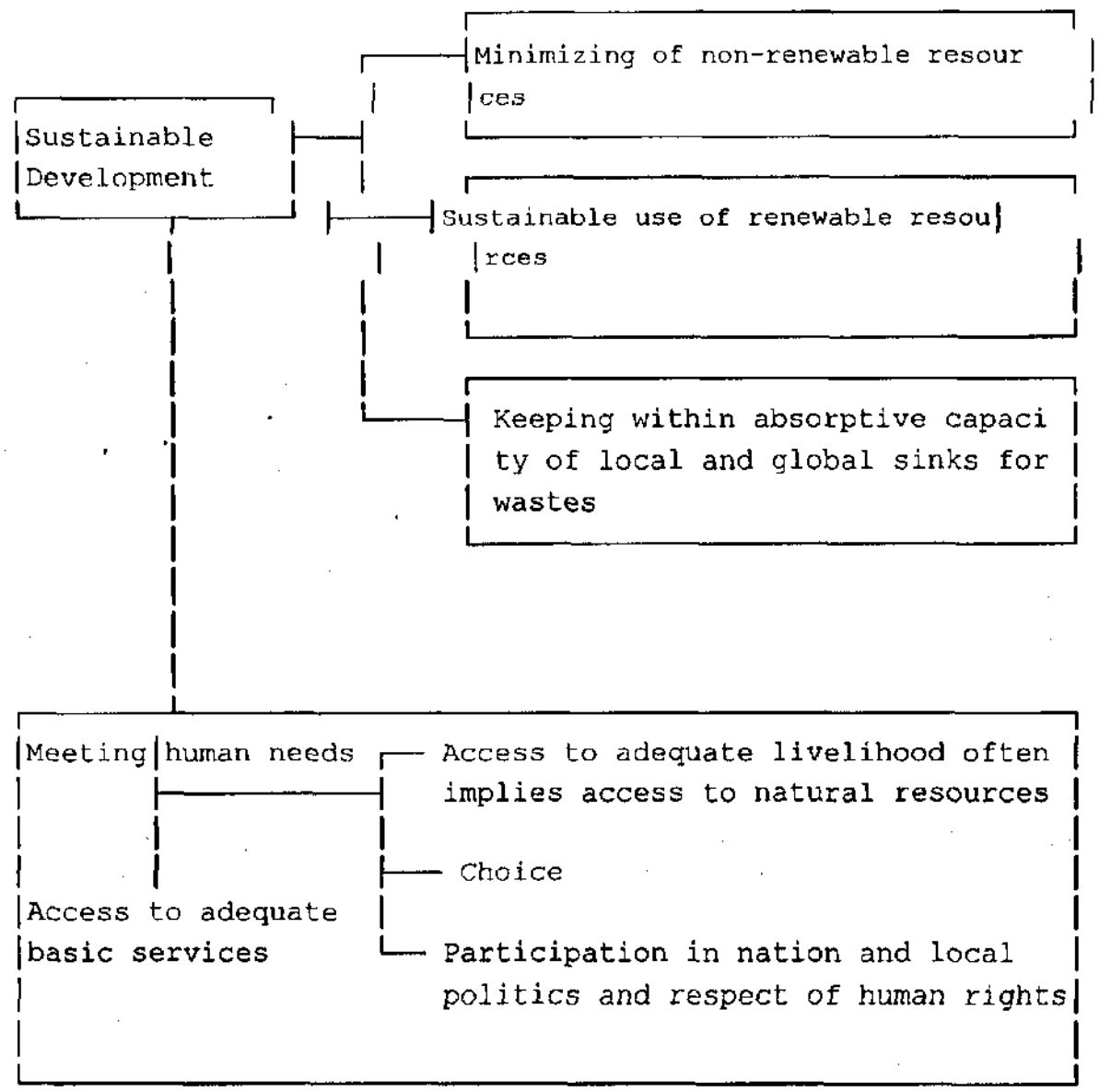
CHAPTER TWO

THE CONCEPT DETERMINANTS AND STANDARDS FOR SUSTAINABLE URBAN WATER SUPPLY AND MANAGMENT SUSTAINABLE DEVELOPMENT

2.10 Sustainable development as a concept is a faily new Idea in development throught. It has however become a fundamental approch to development in cities today. It has it's origin in the report of the club of Rome titled limits to growth published in 1972. This report was the first to analyse the link between global economic growth and natural resources scarcity. In specific terms the report put forward a "world model" looking at the viability of continous growth.

Sustainable development can be defined as any activity that raises social welfare with the maximum amount of resource conservation and the minimum amount of environmental degradation, allowable within given economic, social and technical constrainsts (Barrows; 1994) This definition implies an anticipate-and-avoid rather than react and cure defination by the word commission on Environment, pearce et. al (1989) and Drakakis smith (1996), Which term sustainable development as ensuring that development meets the needs of the present without compromising the ability of the future generations to meet their own needs. Other definitions focuses on conservation of the ecology and how it can, he achieved. A common critism of the approach to the definition is that, it is concerned with ecological sustainablity rather than sustainable development. The term sustainable development, brings into interrelated issues in development and thoughts about the management of human activites. While we concentrates on the goals of development, the other focus on the controlling or limiting of harmful impact of human activites on the environment (Hardoy et al: 1992). It is therefore clear that the increasing interest in sustainable development is fueled by the growing popular concern about the environmental impacts of human activities. No where are such impacts manifest than in urban areas.

Fig 2.0 : *Components of sustainable development.*



Source: Hardoy et al : 1992 Pg 181

Figure 2.0 shows that the distinction of sustainable development into it's two components has implications for urban development.

1. Sustainable component: This relates to the impact of each city producer and consumer located within each city on environmental capital such as local and global sinks, renewable and non renewable resources.

2. Development component: Relates to the performance of each city in meeting the needs of it's inhabitants.

For instance with respect to renewable resources, it is well known that natural resources are essential to the existence of any city and for human habitation. Without an adequate supply of these resources most cities would decline and the employment opportunities it offers to its inhabitants greatly reduced. Secondly waste is the consequences of concentration of population in cities and the results of production and consumption activities in the cities. There is a need for adequate provision for the control or removal of waste from cities, other wise it may pose severe ecological damage to the surrounding areas as well as health risks to the inhabitants unsustainable development.

2.20. CONCEPTS, APPROACHES AND STANDARDS FOR SUSTAINABLE WATER SUPPLY

2.21. APPROACHES IN SUSTAINABLE WATER SUPPLY

Water resource development and management has in the past been monopolised by water resource engineers. Due to the technical orientation of their disciple there has been a neglect of the social, economic, demographic determinants of water resources management. Thus has made the development and management of water resources inadequate and policies evolved and adapted unrealistic.

Recently there has been an increasing need to involve other disciples in water resource development and management. This is to enable and overall view of the different determinants of water demand and supply be achieved. To incorporate all these determinants in the development and management of water resources. Hereby proposing realistic policies that will address both present and future water situations in our urban areas. In agreement to this kessler suggested that "architects, city planners, urban managers and other scientist should form partnerships to create economically and viable health efficient and environment friendly policies that would lead to the sustainability of the city".

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Vagale (1969) also observed that "planning of water supply schemes cannot be separated from the socio, economic and physical planning of towns and cities which the scheme is designed to serve". This links water resources development and management to the social, economic and physical characteristics of the area where the development is located.

In Nigeria few planning agencies including the Federal Capital Development Authority (FCDA) have evolved and incorporated concepts which are based on urban physical, social and economic characteristic for effective and sustainable water supply and management.

2.22 CONCEPTS FOR PLANNING URBAN WATER SUPPLY

1) Segregated/catchment concepts: This concept is applicable to urban structure where the centres are weak and have various satellite centres which are characterised by linear or dispersed settlement patterns. Such satellite settlements either in the term of institutions or industrial areas develope independent water supply sources to meet the demands of such catchment centers. This is done mostly through boreholes system.

2) Integrated concept: This concept is applicable to urban structure where the centres are strong with weak satellite centres characterised by centric or cluster pattern. This urban structure is more economical and physically adaptable to a uniform or integrated water supply system using a single and extensive source such as a Dam. This is applicable to water supply system to large residential, commercial and public areas.

Generally the design of a water supply system consists of a sequence of operations - estimation of need, analysis of water available at the source, the design of a reservoir of adequate capacity, the determination of the various pipe sizes and design of distribution network.

Water demand of a city is established as use per capital per day which in turn are highly dependent on the requirement of the population for various activities e.g domestic and industrial uses. The fire hydiant requirement and loss from distribution are also calculated as a percentage of this. It has been established that 200 litres per day is the average demand of cities (Adetayo: 1983). The reservior capacity on the other hand is usually determined by the likely withdrawal demand during a long dry period of usually several weeks depending on local hydrological situation. The various pipe sizes are determined by the total peak demand of the various landuses within the town and to ensure efficient supply of fire hydrant withdrawal at a time of a big fire outbreak.

The common type of water distribution systems used are the branch system and loop network system.

(1) The branch system: can be likened to the tree branch which sprawl out in given directions from the main system to supply the consumers. Apart from the advantage that flow rates in pipes are easily determined and faults easily traced; a breakdown in any of the mains usually results in disrupted supply to consumers. See figure 2.1

(ii) The loop network system. This is a comprehensive effort to ensure efficient supply through out the system even in events when one of the mains goes out of operation. The looped network usually has a ring of mains to which the secondary pipes are connected, which in turn are inter-connected with each other. This is the system used in water provision in Nigeria. See figure 2.2

2.23 Process of water supply planning. The process of water supply planning involve the following:-

(i) The estimation of water demand based on existing and proposed landuses as well as population size distribution and other socio-economic characteristics. They involve the forcast of growth trend and development of demand by their variables.

(ii) Indentification of source of water supply and their protection through standard set backs or developing free zones in the case of borehole sites.

(iii) Planning the development of water sources to various landuses through efficient distribution system with minimum wastage.

(iv) Review and evaluation of strategies as may be require to accomodate changes and innovations.

2.24. **Planning Standards of Sustainable Water Supply Management**

O'Riordan defines water supply management as a process of decision making where by water supply is allocated over space and time according to the need, aspirations of man within the framework of his technological inventiveness, his political and social institutions and legal and administrative arrangements (Ayoade: 1988).

Fig. 2.1 : BRANCH SYSTEM OF WATER DISTRIBUTION NETWORK

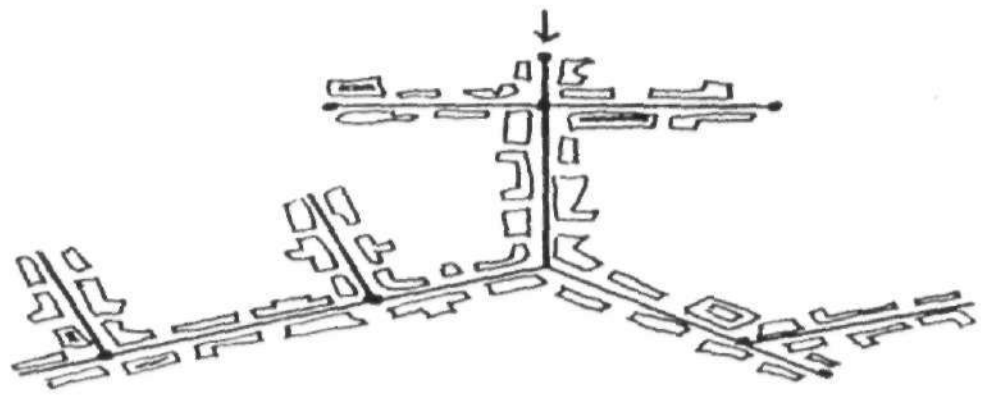
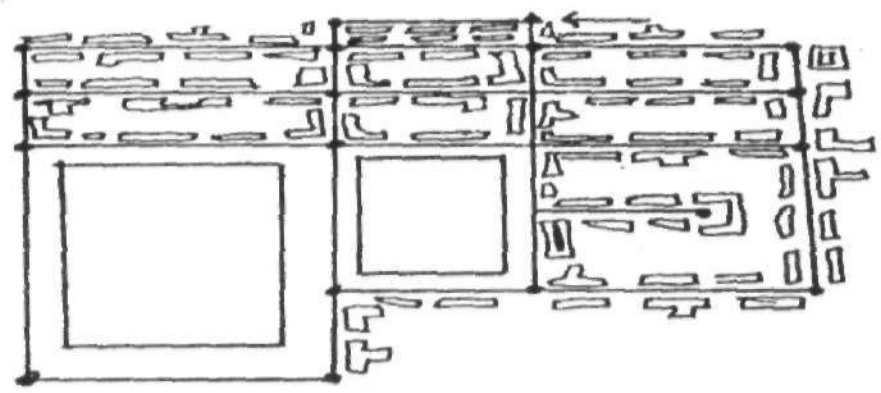


Fig. 2.2 : LOOP SYSTEM OF WATER DISTRIBUTION NETWORK



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Water supply management is basically concerned with the control or direction of water supply. It represents the actual decision concerning policy or practice as to how water is allocated and under what circumstances water may be developed. The management of water supply is made up of other process. These are water resource analysis, water development and planning. The water resource analyst seeks to understand the fundamental characteristics of the resources as well as the process through which the resources is allocated and utilized. (Mitchell :1979). Water resources analysis is the appraisal of the resource process of finding out or deciding the amount or value of a resource for a paticular purpose. Water development represents the actual exploitation of water to satisfy human needs. During the process of development the natural matter is transformed into a useable commodity or service (Ayoade:1988).

Water supply management and planning are closely related. There can be no proper management without planning. Water resource planning in turn depends on proper resource analysis. Thus analysis, planning and management of water resources are interrelated. Water resource management evolves around the estimation of water demand and the valuation of water and utilization. This is the basic consideration in the management and planning of water resources.

2.30. WATER DEMAND ANALYSIS

Appraisal of water resources is not possible without the knowledge of the demands for water, which is controlled by socio economic factors. The major abstractive use of water are for irrigation and water supply for domestic and industrial uses. The water requirement for these purposes now and in the future must be known in other to facilitate natural planning and optimum utilization of the valuable water sources. There are two methods of determining water demand, there are:-

(i) Trend-based or extra-polative method: Here projections of future water consumption are base on past consumption data. This method is easier to use and less demanding in terms of data requirement and input. Its major disadvantage however is that it assumes that the factors influencing demand in the past will remain the same in the future. No attempt is really made to understand why water consumption varies over time.

(ii) Analytical, technique: Here water consumption is disaggregated into major components. Future changes in each component are predicted separately and then aggregated (Ayoade: 1988). This method is move intellectually challenging as an attempt is made to understand the reasons for variation in pattern of water consumption. Factors that affect water demand are indentified and measured and there likely effect on future water demands are then assessed statistically.

Five majors factors have been identified to control water demand. These are population, economic environment, technology, social taste and policy discussions.

2.40 WATER SUPPLY AND USE

Water supply is determined by the different categories of use water is required for. These basic uses are domestic, industrial and agrictural.

(i) **DOMESTIC USE:** This represents about 50% of the water supplied for all categories of use (Ayoade: 1988) This including drinking, cooking, launtry, dish washing, house cleaning, personal washing, flushing of water closet, car washing and watering lawns and flowers. Total amount of domestic water use are however much lower in developing countries than in developed countries; owning to poor water supply and poorer standard of living. See table 2.0. in nigeria cities the average capital water use is 133 litres per day (World Bank; 1995)

Table 2.0 : Total per capital domestic demand for water in various cities and regions

England and Wales	290
Scotland	415
Denmark	340
France	300
U.S.A	250-350
Sweden	210
West Malaysia	164
U.S.S.R. Municipal	164
RSA Johnnesbung poor black housing	118
RSA Black villages where water is hand carried	-15-36
Nigeria	133

Source: Ayoade J.O (1988) P.217 + World Bank (1995) P.78

(ii) **INDUSTRIAL USE:-** Water is need for different purpose in industries. Water is used, to meet the need of staff in the manufacturing process,for energy production for boilers by steam raising, cooling process, cleaning and washing, dissolving and difuting solution and as a raw material (Ayoade:1988). The amount of water consumed by industries in the tropics is much less than in temperature regions because of the lower level of industrialization in the tropics in such cases industries tend to develope their own source of water supply e.g

in Nigeria only 20% of the industries depend on the public supplies for all their water requirement (Ayoade:1988).

Generally water demand for industries depends largely on the number of industries, type of industries and the goods produced. However, 25,000 - 35,000 litres per day is recommended per gross hectare of industrial area. And 45 -70 litres per use in an industry. In other words for every every single use water is required for in any industry 45 - 70 litres must be available for such a use.

iii) Agricultural Use: Agriculture is mainly rainfed in many parts of the tropics. Due to the nature of use of water for agricultural purposes, there is no standard of water requirement for agricultural use. However the quality of water used is very important. Water with a salt content inexcess if 3 - 4g l^{-1} is considered not suitable for irrigation. The degree of mineralization of the water should preferably be less than 500mg l^{-1} conductivity is usually taken as an indicator of the quality of water for irrigation.

2.50 STRATEGIES FOR WATER SUPPLY MANAGEMENT

The management of utilities is usually based on two concepts or approaches. These are public corporations with subsidising approach and the free market profit oriented private companies. Water supply management has operated in both approaches depending on the economic environment.

In developed countries the free market profit oriented private companies approach is most in use. Here water is developed, provided, maintained and managed mostly by the private sector. Although the level of services increase because of competition, the price of services also tends to rise. The public sector however has polices in place to control prices for services to enable its affordability by every class of the community. In developing countries like Nigeria, government accepts the provision of water as a service. Management strategies under this approch is through public cooperations with subsidisation approach (corporatisation). Here water supply has been through government agencies or boards which exist as social welfare institutions to provide subsidised water supply service to the people. The problems of the approach is monopoly of the government, hindering competition in the provision and management of services which improves the level of service. Another disadvantage is the lack of adequate funds generating policies for expansion of facilities and sustainable development of water supply.

Another strategy that has been gaining popularity both in the developed and

developing countries is the patrnership strategy. This is a process by which people as consumers of ultilities and services, and as citizens, influences the flow and quality of such ultilities and services available to them. The approach as a management strategy contains a number of general principles that are designed to overcome the limitations of the existing urban administration and management system in the provision of urban ultilities and services in general and water supply services in particular.

There are four basic types of partnership strategy.

There are:-

(i) Community-baased strategy: This is the most elementary form of participatory development. Those involved in the management process are the community members themself. This is achieved through the support of the local management of water supply, enhancing community group capacity to manage water supply and enable these processes through appropriate changes in the legal, technical and policy context. The strength of this strategy derive from creative learning and the community's potential for self organisation. The disadivantages however are:-

(a) It does not always succeed in introducing representative and functionally oriented organisations.

(b) It faces difficulties in linking locally developed water systems to minicipal networks.

(c) Is seldom able to mobilise more than a modest volume of resources.

(ii) Area-based strategies: This is the common form of government directed programmes for participatory water supply upgrading. Rather than a social group, a particular residential area constitutes the frame of reference of development efforts. The principal objective is to improve the efficiency and cost effectiveness of government activities. The strength of the strategy is that it is well suited for channelling large volume of resources and for ensuring more effective linkages between local level of development and municipal systems. The disadvantages however is the loss of community ownership and poor cost recovery systems.

(iii) Functionally - based strategy: It employs the functional structures of the watersupply system as the frame of reference for organising development

inputs. The main objective of this approach is to designate areas of responsibility to each stake holder who may pursue particular interests and exercise capacities, secondly, to establish effective collaboration between these various domains. This strategy has a high level of empowerment of participating community groups. The disadvantage is the difficulties in cordination and linkage between the internal facilities and the government - sponsored external facilities.

(iv) Process-based strategy:This takes the entire process of water resource management as the frame of reference. The main objective is to improve the efficiency, demand responsiveness and accountability of water resource management through a general decentralisation of delivery processes. Privatization is an important decentralization strategy measure. It's advatage is the mobilization of creative capacities at all levels of society and its more productive use of available capacity and potentials.

CHAPTER THREE

ANALYSIS OF WATER RESOURCES POTENTIAL AND THE PRESENT STATE OF WATER SUPPLY IN KADUNA

3.10 BACKGROUND OF STUDY AREA

3.11 HISTORICAL BACKGROUND

Kaduna is located within the Zaria Emirate Council. Before the colonial era, the local settlers around the town were widely scattered and self sufficient, with virtually no outside communication with other towns. In the early 19th century the town along with all the northern areas were conquered by the Fulanis of Sokoto Caliphate under the leadership of Usman Danfodio. This resulted in the slow settling of Hausa farmers and the influence of Islam in the area.

In the year 1912 Kaduna was chosen as the administrative and military headquarters for the protectorate of northern Nigeria by Lord Lugard. This choice was influenced by the availability of water from River Kaduna, the central location of Kaduna with respect to the twelve emirates that made up the then protectorate of Northern Nigeria; the presence of the newly constructed railway line that linked the northern and southern part of the country; and because Kaduna was then free of local political complications. Kaduna became the capital of the northern central states in 1966 when Nigeria was divided into twelve states and still remained the capital of Kaduna State with the creation of 30 states in Nigeria.

3.12 LOCATION

Kaduna is located between latitude $10^{o}28^{1}$N of the equator and longitude $7^{o}20^{1}$E of Greenwich. It has an area of 118Km^2 which was curved out of the former Zaria and Kachia local government areas. It's planned area spans a radius of 40Kms and is linked by a strong communication network with other towns by rail and air. This has enhanced it's developing into an industrial, commercial, military and administrative centre. See Fig. 3.0 and 3.1

The Kaduna urban designated area is made up of seven major districts. These are Afaka, Doka, Gabasawa, Kawo, Makera, Tudun Wada and Sabon Tasha. See Fig. 3.2

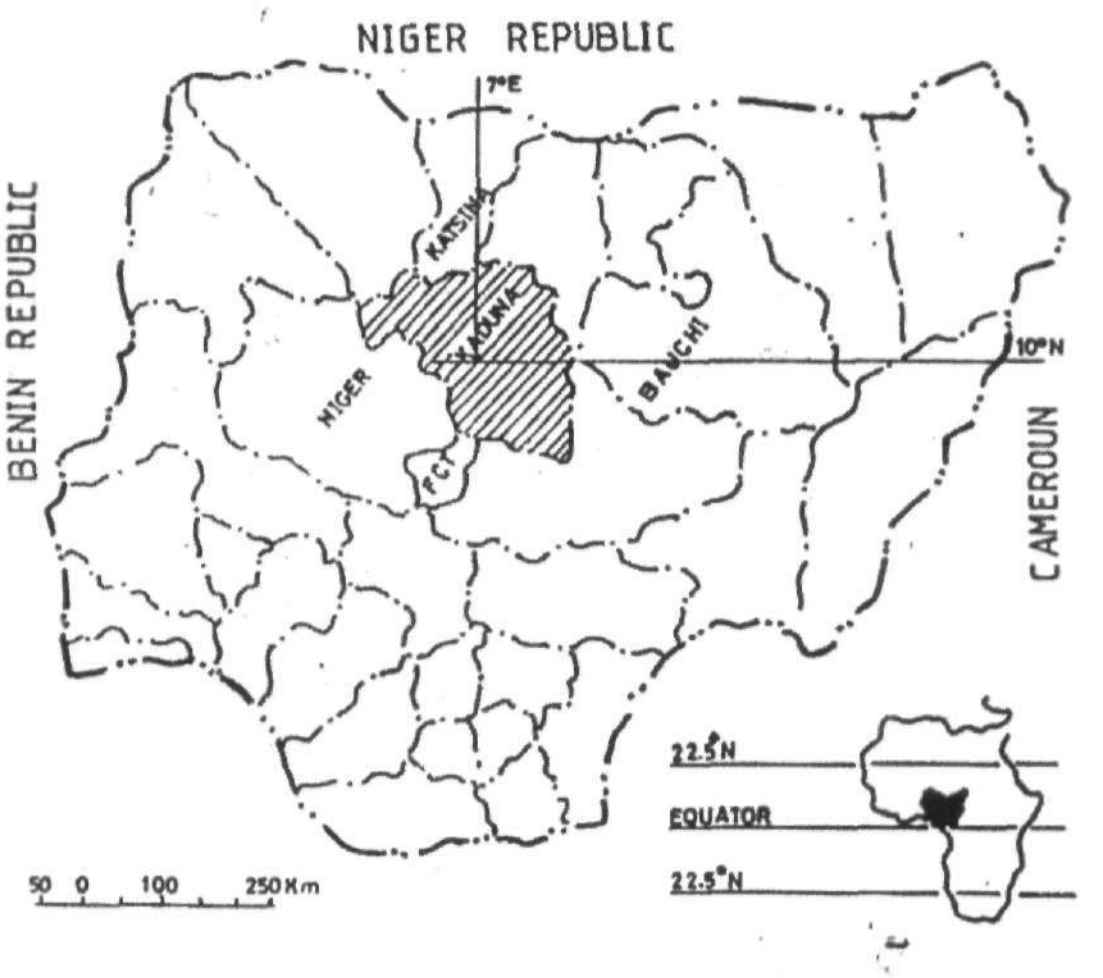


Fig 3.0 : KADUNA METROPOLIS WITHIN THE CONTEXT OF THE CONTINENT, NATION AND STATE

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Source: URP Dept Library

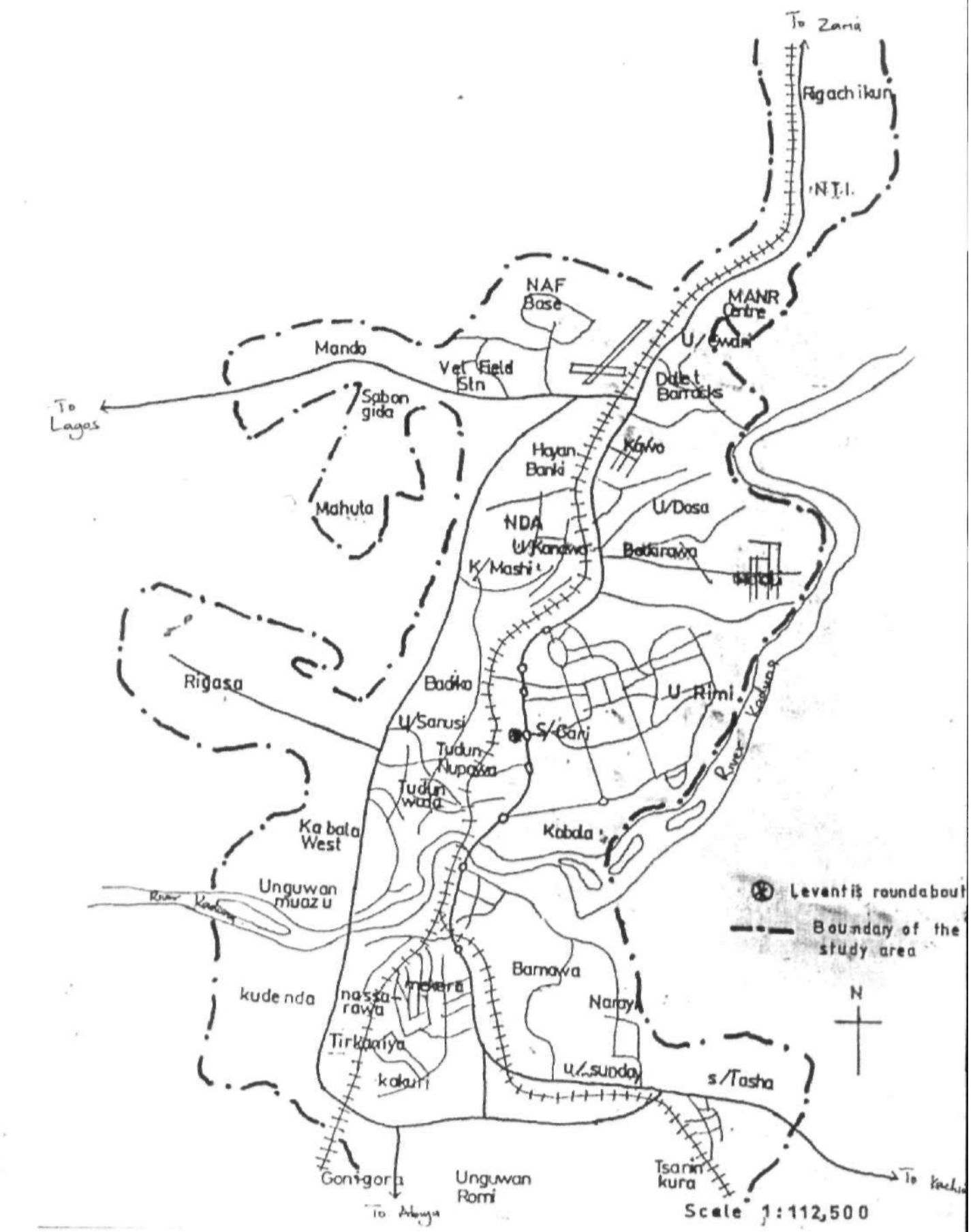


Fig. 3.1 : THE STUDY AREA

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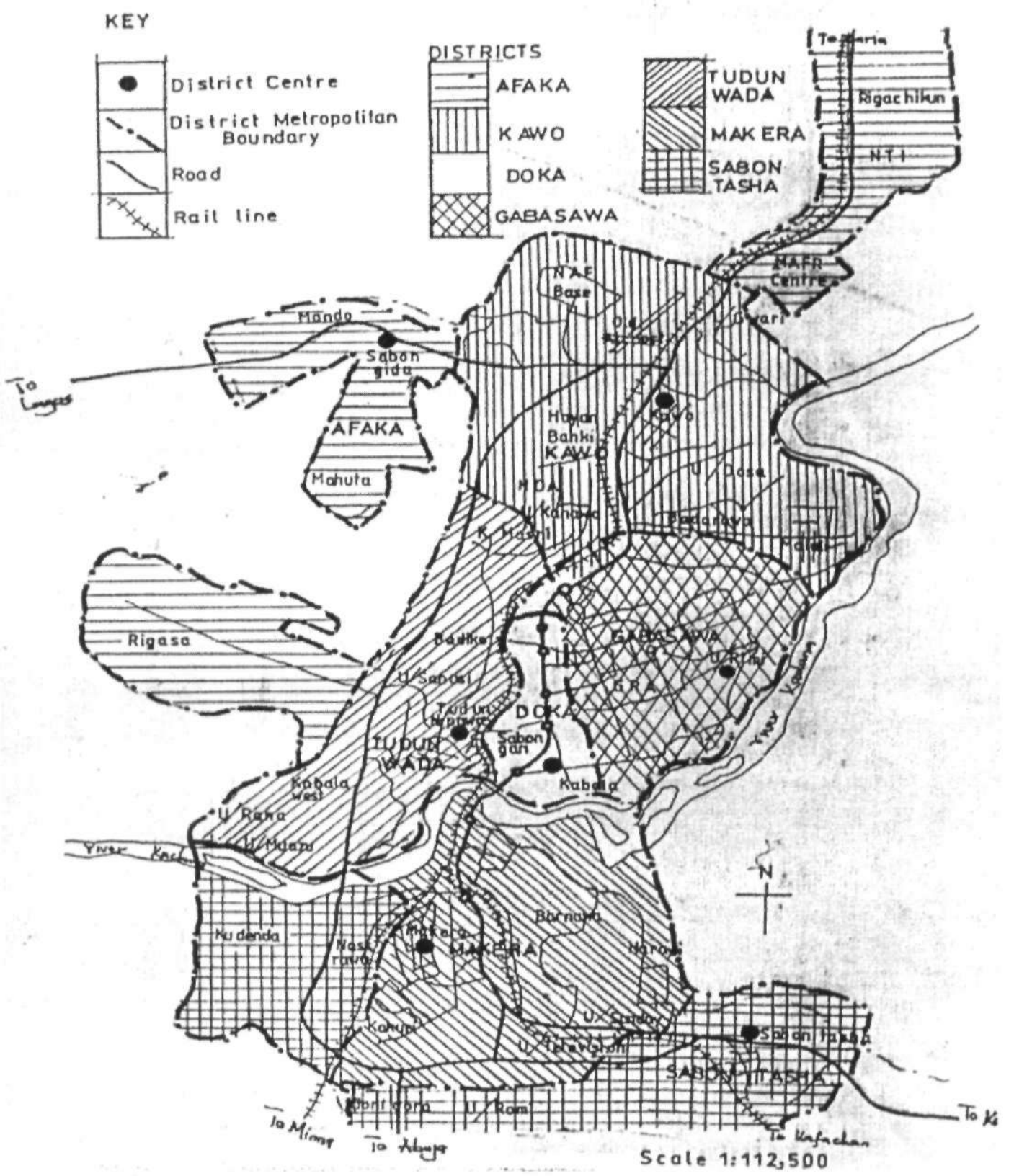


Fig. 3.2 : ADMINISTRATIVE DISTRICTS OF KADUNA

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3.13 CLIMATE

Kaduna experiences two main climatic seasons in a year. These are the dry season from November to March - characterised by dust laden harmattan wind and the wet season from April to October - characterise by the prevailing wind from the south-west to the hinterland bringing rain. The annual rainfall figure is 164mm with only a single rainfall peak which comes in August or September.

The highest temperature is experienced in April and they range from 25°F to 105°F, while the lowest are recorded in January between 45°F and 55°F. There is considerable changes in humidity which in the dry season may well be below 10% in the afternoon and 30% at dawn. August however is a relatively cooler month because of the rain, the humidity at mid-day can be over 70% and at dawn 95%.

3.14 TOPOGRAPHY, GEOLOGY AND DRAINAGE

Kaduna's regional topography consist of a rolling part like terrain with little relief situated about 100ft above the 2000ft contour line.

The formation of Kaduna is of basement complex which constitutes the largest single geological and hydrogeological unit in the area. The main types of rock of this unit are the granites, gneisses and magmatites. Rock out crops within the area are frequent. There is a great fluctuation in the bedrock level hence it is difficult to predict the depth of the rocks below the surface. In some location the bedrock is relatively shallow. The surface in most areas however have decomposed to laterite.

Kaduna is predominantly drained by River Kaduna which slopes gently from the north to the south west and its tributaries which flows from the Jos Plateau dividing the town into two.

3.15 TOWN PLAN AND LANDUSES

Kaduna town is divided into different zones taking into consideration the likely future development. In the south, the area is dominated by heavy industrial activities, in the northern part of the town is the light industrial growth centre which is located at Kawo layout. The presence of these industries has greatly influenced the presence of squatter settlers who move in to seek employment.

The residential neighbourhood are of different densities - low, medium and high density. The low density residential areas are also known as the government reserved areas located at Malali, Anguwan Rimi and Barnawa.

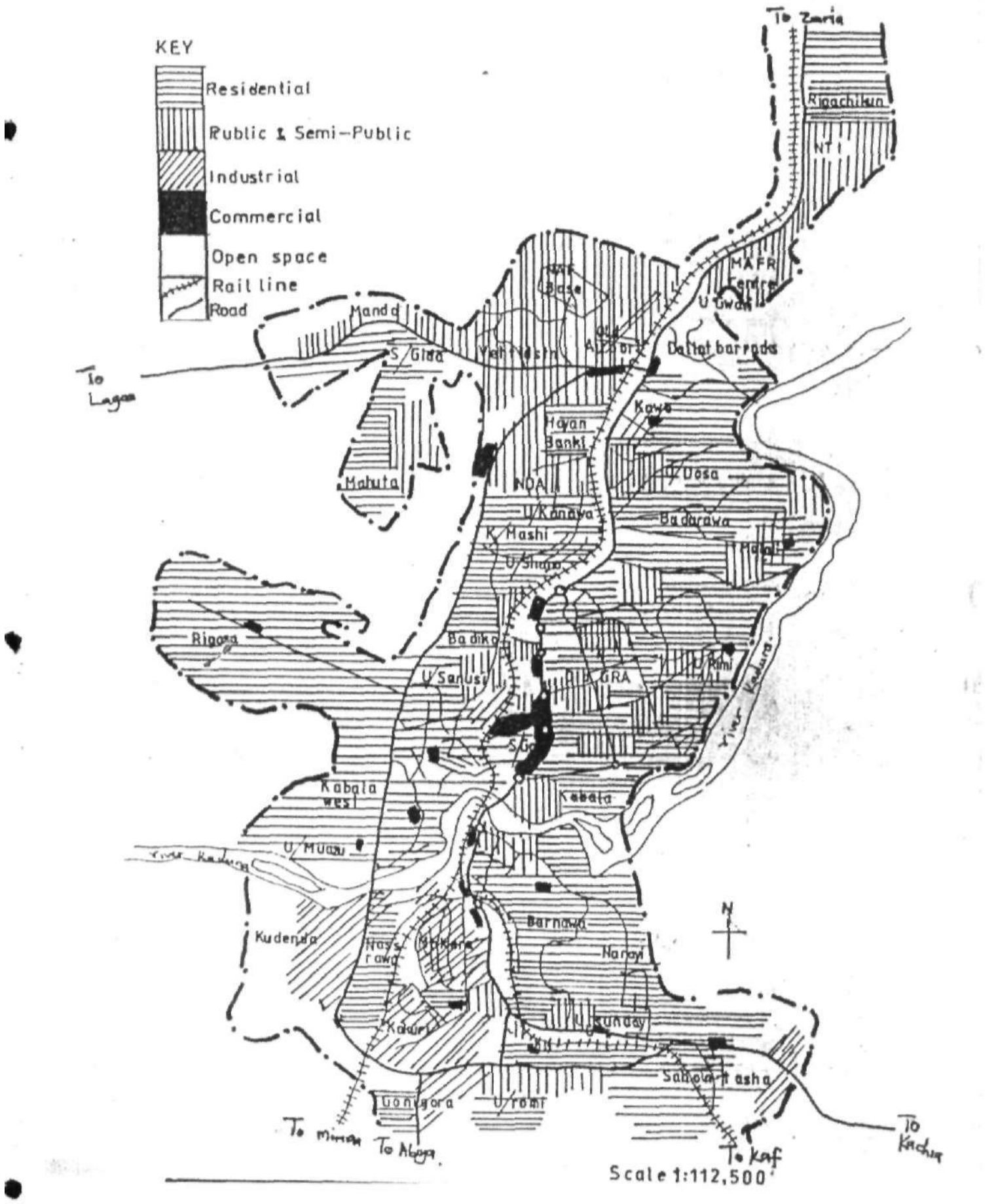


Fig. 3.3 : THE EXISTING LANDUSE STRUCTURE

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The commercial and institution landuses are located within the central part of the town. The development of the town follows a linear pattern, along both sides of the major road passing through it. The linear pattern allows a gradual growth and expansion programme around the town with minimum interference. On the outskirts of the town land is allocated for small scale farming although this is likely to be discontinued in the event of any major expansion programme. See fig. 3.3

3.16 POPULATION

In terms of it's population, Kaduna metropolis in 1952 had a population of 40,000. This figure rose to 149,910 in 1963 with a growth rate of 2.5% showing a fourfold increase in eleven years. This figure also increased to 260,000 in 1985 with a growth rate of 3.9%. By 1991 the population of Kaduna metropolis was reported to have increased to 931521 (by the 1991 population census). Presently the population of Kaduna is estimated to be about 1032521 with a growth rate of 5.0% per annum.

Over the years, the population growth of the town has been greatly influenced by the construction of Kaduna refinery and its associated petrochemical industries, the relocation of the Federal Capital at Abuja which is only 150km from Kaduna town, and the administrative and military importance of the town. Bulk of the population is concentrated in Sabon Tasha, Tudun Wada and Kawo district. Each contributing 29.5%, 23.7% and 23.1% respectively to the total population of the town. The average population density is estimated at 80 person per hectare.

3.20 WATER RESOURCES POTENTIAL OF KADUNA METROPOLIS
3.21 SURFACE WATER RESOURCE OF KADUNA METROPOLIS

Kaduna is located north of the confluence of the Niger and Benue Rivers. The principal river draining the town is the River Kaduna which rises on the Jos, Plateau at he south-east boundary of Kaduna State. The river flows westward in a northerly arc through Kaduna town to join the Niger River about 150km upstream of the confluence with the Benue River. The Galma Catchment is one of the tributaries of River Kaduna from the north that is also used for water supply in Kaduna.

The volume of flow of River Kaduna can be estimated by the following formula:

Average runoff of River Kaduna at Kaduna South Station divided by 1000 multiply by catchment area x $10^6 M^3$

Average runoff - 523.06cfs to change to m^3
- $(0.3048)^3$ x 523.06
- $281.6m^3$

Area (catchment) - $18410km^2$ at station recorded
Volume of flow - $\frac{281.6}{1000} \times 18410 \times 10^6 m^3$

- $5184.3 \times 10^6 m^3$

The annual waterflow in River Kaduna is estimated to be 5184 billion litres per year and about 14.2 billion litres per day. In other words it can be said that in a day Kaduna metropolis has about 14.2 billion litres of surface water available for production and supply for the various uses of water in Kaduna metropolis.

3.22 GROUND WATER RESOURCE OF KADUNA METROPOLIS

Kaduna and environs is underlain by the crystalline basement complex. The complex consist entirely of magmatites, gneisses, granite and quartzites. The oldest rocks of the area are the gneisses and the older matasediments believed to be Birrimian in age (Oyawoye, 1970 & Mc Curry, 1976).

Despite the mixed review made on the ground water prospects of the basement complex areas of Nigeria especially as reported by (Ajayi and Adegoke, Anthony, 1988), the ground water potential of Kaduna can be considered to be adequate. In the basement complex, the permeability and storativity of the ground water system are dependent on secondary structural features such as the extent, and volume of fractures together with the thickness of weathering (clark, 1988). It has also been discovered that below the veneer of regolith, the fresh basement rocks are highly fractured at shallow and even at great depths.

Thus making the basement complex rocks and their weathered derivatives constituting large reservours of underground water.

However high annual rainfall and temperature is the study area results in the formation of deep weathered zone in addition to high density of fractures, have contributed tremendously to good aquifers and high yields of borehole in Kaduna. The recorded yield of borehole for Kaduna range from 17,280 litres/day to 207,360 litres/day with an average yield of all borehole at approximately 90,650 litres per day. Presently 37 borehole have been dug in Kaduna, estimating ground water supply at 3.33 million litres per day.

3.30 APPRAISAL OF THE PRESENT STATE OF WATER SUPPLY IN KADUNA

Kaduna had it's first water works constructed in all (water news, 1987), in 1929, the site was moved for expansion as the demand for water increased. The expansion of the water works was aimed at serving both Kaduna north and Kaduna south. Due to the high rate of industrial growth and subsequent population increase, there was a need to expand or build a larger water works. In 1964 conclusions were reached to construct the present water works - Kaduna North and Kaduna South water works. With the construction of the water works the Kaduna State Water Board was created in 1971 to manage and operate the water works and was responsible for the supply of pipe borne water to the principal towns of Kaduna State.

In the 80's the installed capacity of both water works was 90mld, although an improvement from the capacity in 1978 which was 72mld it was not adequate for the increasing demand for water at that period with distribution limited to 50% of the town. With the rehabilitation of both water works the installed capacity of both water works increased to 267mld.

Kaduna North Old Water Works	-	90mld
Kaduna North New Water Works	-	150mld
Kaduna South Water Works	-	27mld

The Kaduna north old water works was rehabilitated in 1994 and completed in 1996. The rehabilitation restored the water works back to it's former installed capacity of 90mld after dropping to 40mld. The Kaduna south water works is currently undergoing rehabilitation. This increased the percentage of people in the town having access to pipe borne water to 80%. See fig 3.4, 3.5, 3.6

Presently the water works produces below installed capacity. The Kaduna south water works produces 20mld at 74% performance. The Kaduna North old and new water works produces at 70mld and 135mld respectively at 85% performance. In the light of the national objective with respect to urban water supply, stated in the NIgerian third National Development Plan (1975 - 80) and the deteriorating economy in the 1980's, the world bank water supply projects were commissioned in various parts of the country. The Kaduna water supply project is one of such projects. The project was prepared and implemented during the oil boom period, but was adversely affected during it's implementation by the deterioration of the Nigerian economy, when oil prices fell in the 1980's. The focus of the project was in acgumenting the water supply situation in its respective service areas and developing the necessary management capacity. The project was completed in 1989.

The world bank water supply project provided Kaduna with a good water distribution network with new pipes layed in all parts of the town. In particular the network was adequately provided in the peripheral areas of Kaduna where prior to the project were not laid with pipes and therefore had no access to pipe borne water. These areas are Afaka, Sabon Tasha, Anguwan Television, Rigasa, Anguwan Romi etc. There was also the rehabilitation of old pipes especially those in Sabon Gari area. This increased the service coverage in Kaduna to 87% and about 898,273 people are presently being supplied with safe piped water; thus increasing the specific consumption to about 120lcd as planned. See fig. 3.7

The supply is however intermittent due to erratic power supply. The water supply in Kaduna presently can be said to be adequate when it is compared with the requirement of 160lcd by A.I.D and W.H.O. standards and the requirement of 180lcd by the United Nations (Okpala:1986). It also meets the Nigerian governments target for 1980 (third national development plan 1979-1980) being 115cld.

In terms of distribution of water supply, Kaduna is divided into zones known as pressure zones. These zones are fed by either a ground level or an elevated reserviour. Certain reserviours are supplied by booster pumping stations located within the town. From these reserviours connections are made to other parts of the city (by pipes through gravity flow) to streets and eventually to the consumer. The size of the pipes used differ from 7.6cm to 20.3cm and sometimes 30.4cm. Some industrial pipes or main pipes as large as 61cm.

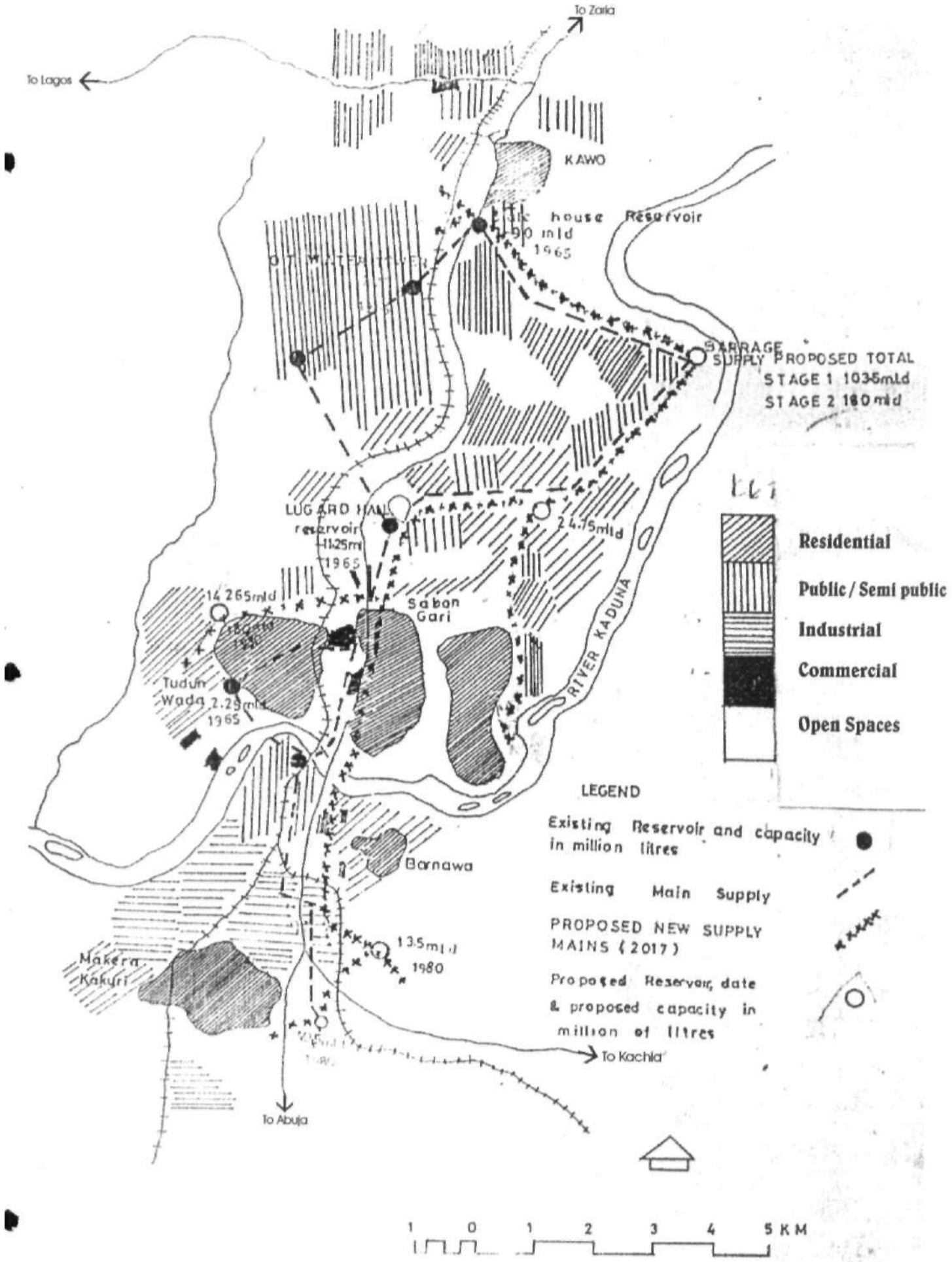


Fig. 3.4

KADUNA MASTER PLAN PROPOSAL FOR WATER DISTRIBUTION (1967 - 2017)

SOURCE: Kaduna MasterPlan Review (1983)

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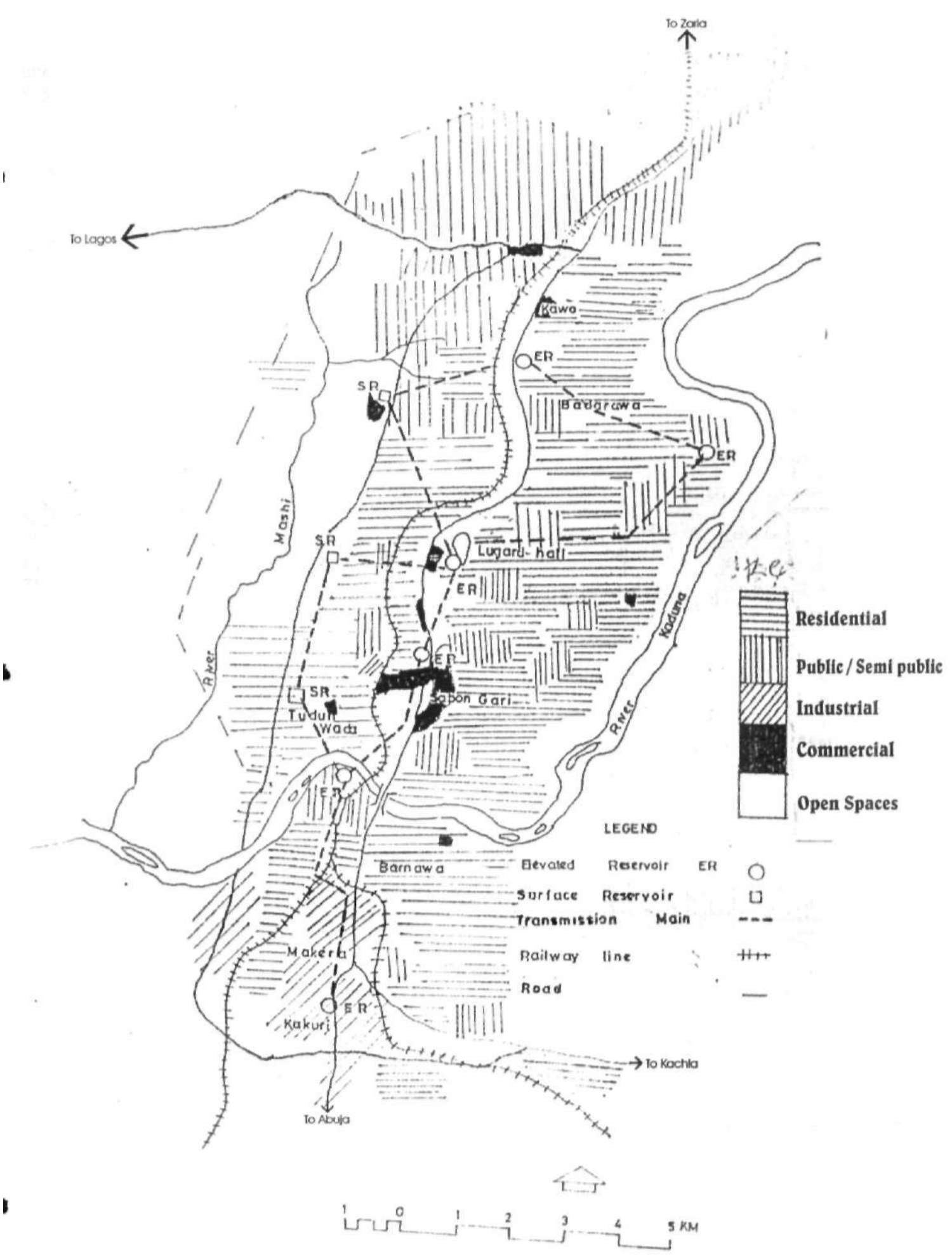


Fig. 3.5

EXISTING WATER SUPPLY SYSTEM IN KADUNA (1983)

SOURCE: Kaduna MasterPlan Review (1983)

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TABLE 3.0

SERVICE WATER RESERVIOUR IN KADUNA METROPOLIS

S/No.	Location	Capacity	Type	Construction
1.	State house	9.09	Ground Level	Reinforced Concrete
2.	Lugard Hall	13.6	Ground Level	Reinforced Concrete
3.	Tudun Wada	2.27	Ground Level	Reinforced Concrete
4.	Lugard Hall	4.54	Elevated	Steel
5.	Kamaza	30.0	Ground Level	Reinforced Concrete
6.	Kakuri	24.0	Ground Level	Reinforced Concrete
7.	Rigasa	7.0	Ground Level	Reinforced Concrete
8.	N.D.A.	2.27	Elevated	Steel
9.	Airport Road	2.50	Elevated	Steel
10.	Old Airport/Air Force	2.27	Elevated	Steel

Source: *Kaduna State Water Board (1997) State Wide Water Resource Master Plan. Parkman Nigerian Limited, Lagos. Pg. 198*

TABLE 3.1

BOOSTER PUMPING STATION IN KADUNA METROPOLIS

Location	Pumps	Rating L/Hr
State House to Old Airport		475,000
State House to Airport Road	Weirs (2 Nos)	500,000
State House to N.D.A		550,000
Lugard Hall	Weirs (2 Nos)	378,000
Polytechnic Road	Weirs (2 Nos)	500,000

Source: *Kaduna State Water Board (1997) State-Wide Water Resource Master Plan. Parkman Nigerian Limited, Lagos. Pg. 198.*

The capacity of all the reserviours sums up to 97.5 million litres per day. According to the Kaduna State Water Board, the reserviours work at full capacity and pumping is stopped only when the reserviours are full.
This means that although the two water works produces 225mld which is 84.5% of it's installed capacity, only 97.5mld is being distributed to the consumers. This can be attributed to the capacity of reserviours not adequate to store the whole 225mld produced by the Kaduna North and South Water Works. Some industries are however supplied water directly from the water works. This is because of the high water demand of these industries. These industries collectively account for 761,763 litres per day from the total amount of water supplied.

Every day 5% (6.75mld) of the water supplied is used to deslug the treatment plant and 10% (22.5mld) loss is experienced in the system through busted pipes and illegal connections.

The implication of this is that everyday 97.47mld from the amount of water produced is not utilized. It is left in the reserviours at the Kaduna North and South water works.

In terms of ground water supply, boreholes are used mostly by industries while hand dug wells are owned by individuals. Presently there are 37 boreholes in Kaduna metropolis with a total capacity yield of 3.33mld.

CHAPTER FOUR

ANALYSIS OF PRESENT AND FUTURE WATER REQUIREMENT WITH RESPECT TO THE MAJOR LAND DEVELOPMENT AND PROJECT IN KADUNA

4.10 ANALYSIS OF PRESENT WATER DEMAND IN KADUNA

Kaduna metropolis has been witnessing a rapid growth over the years. This can be attributed to the importance of Kaduna as a commercial, industrial and administrative center. With the changes in the economic fortunes of the country especially from the mid seventies to the early eighties, the importance of Kaduna also magnified. The oil boom of the early seventies also led to the increase in commercial activities in the city. Many new opportunities were created in Kaduna in the social, cultural and economic sector of the city. This in turn attracted an inflow of people into Kaduna from surrounding rural areas and from other urban areas to avail themselves to the new opportunities created in the city.

With the increase in economic activities in Kaduna and the influx of people into the town came the rapid increase in water demand. The water demand however differs from one land use to the other and from one distinct to another depending on the distribution of conduce in the various districts.

For effective analysis of the water demand in Kaduna (both present and future) each district represented a unit, where data was collected and analysed. The landuse percentages in each district was analysed, and the water demand for each landuse in each district was determined. These districts were Afaka, Gabasawa, Doka, Kawo, Sabon Tasha, Tudun Wada and Makera.

4.11 RESIDENTIAL LANDUSES

Presently, the density of residential development stands at approximately 85pplha. This is categorised into high, medium and low density area. The high density areas takes up approximately 52% of the total residential landarea and is distributed largely within Doka, Makera and Sabon tasha districts. The medium and low density residential areas accounts for about 25% and 13% of the total residential area respectively. These are located mainly in Tudun Wada, Makera, Gabasawa and Kawo districts.

The total land area presently under residential development is estimated at 8550Ha representing 41.8% of the total development land area of Kaduna. The percentage of residential development however differs from one district to the other. This has a direct relationship with the population of the different districts and thus the domestic water demand in the district. The domestic water demand can be determined by multiplying the population of each district and the present per capita consumption rate which is 120 litres per person per day. See table 4.0. The present total domestic water demand in Kaduna metropolis is estimated at 123.9 million litre per day. This shows a 68% increase from the domestic water demand in 1983 which was approximately 38.9mld.

Table 4.0: Residential landuse percentage and domestic water demand of the various districts in Kaduna metropolis.

District	POP				Cpcd				Water Demand			
	1965	1984	1990	1997	1965	1984	1990	1997	1965	1984	1990	1997
Afaka		50225	6587	30,000	85	115	120	120		577,875	7904440	3,600,000
Gabasawa	15,361	33601	44044	95451	85	115	120	120	1305685	3,864,115	5285280	11,454,120
Doka	44,311	96930	127058	275343	85	115	120	120	3,766,435	11,146,950	15246720	33,041,160
Kawo	34,530	70509	99010	214565	85	115	120	120	2,935,050	8,108,535	11881200	25,747,800
Sabon Tasha		10050	40000	71000	85	115	120	120		1,155,750	4800000	8,520,000
Makera	20214	44218	57961	125607	85	115	120	120	1,718,190	5,085,070	6955320	15,072,840
Tudun Wada	35495	77644	101779	220550	85	115	120	120	3,017,075	8,929,060	12213480	26,466,600
Total	**149911**	**337977**	**476,439**	**932581**					**12,742,435**	**38,867,355**	**57172440**	**123,902,520**

L.P.d = Litres per person per day.
Cpcd = consumption per capital per day

Source: *Filed Survey; Max lock (1967), URP dept. ABU Zaria (1983); Kaduna State Government (1995)*

4.12 INDUSTRIAL LANDUSE

The growth of industrial activities has been gradual over the years. The pattern of landuse distribution between 1965 and 1995 indicates a gradual increase in industrial land area coverage. From 1965 to 1983 there had been a 263% increase in industrial activities, however from 1983 to 1995 the growth of industrial activities has reduced to 93.1%. This can be attributed to the high recession in the economy since the mid eighties to date. Since 1990 there has not been any substantial industrial development and about 39.1% of the heavy industries that were operational in the eighties have been shut down.

Industrial activities at the moment is accommodated on a land area of approximately 1980 Ha representing 7.8% of total developed land area.

The industrial water demand has increased with the increase of industrial activities especially from 1965 to 1983 (representing both heavy and light industrial activities). During this period the water demand experienced a 33% increase. The present industrial water demand is estimated at 58.5mld showing a 43.3% increase from the demand of 25.3mld in 1983. The sharp reduction in the growth of water demand during this period can be attributed to the reduction in industrial development and the closure of 39.1% of the heavy industries that were operational in the eighties. The present growth is mainly attributed to the increase of light industries in Kaduna. See Table 4.1

Table 4.1 - Industrial landuse percentage and water demand of the various districts in Kaduna metropolis (1983-1995).

District	**Industrial Area (Ha)**			**Water Demand (mld)**		
	1965	**1983**	**1995**	**1965**	**1983**	**1995**
Afaka		21.3			0.53 - 0.75	
Gabasawa	126.4			3.15 - 0.75		
Doka						
Kawo			190.32			4.76 - 6.66
Sabon Tasha		314.1	663.4		7.85 - 10.99	16.6 - 23.2
Makera	148.99	408.7	908.7	3.7 - 5.2	10.2 - 14.3	22.7 - 31.8
Tudun Wada	3.60	100.7	187.2	0.09 - 0.13	2.52 - 352	4.68 - 6.55
Total	279	1010	1950	6.97 - 9.76	21.1 - 29.6	49.7 - 68.2
Average				8.37	25.34	58.5

Ha - Hectares
Mld - Million litres per day
Standard - 25,000 - 35,000 litres per gross Ha

Source: *Field Survey; Max lock (1967); Urp dept (1983). ABU Zaria, Kaduna State Government (1995)*

4.13 COMMERCIAL LANDUSES

The total land area that covers commercial uses is estimated at 900 hectares, representing 4.4% of total developed land area. This represent a 400% increase over the max lock proposal of 197 hectares in 1965. Current distribution of commercial activities cover designated market centres and some commercial retail centres scattered along major roads of the metropolis. Presently commercial activities have increased, with district like Doka, Gabasawa, Kawo and Sabon Tasha experiencing increase of activities by 215.6% between 1988 and 1995. The commercial land area as a proportion of total developed land area has however remained relatively constant at 3 - 4%. This situtation is also effected the water demand for commercial activities. However the commercial water demand is not too high, averaging about 40 litres per day per full time employee. This is low compared to water requirements of other landuses like domestic (residential) and industrial uses. Due to inadequate date only employee data of 1965 to date was used. Thus was data that was available in the state ministry of commerce and tourism.

Table 4.2: Number of commercial employees and commercial water demand of the various districts in Kaduna metropolis (1965, 1989, 1997)

District	No. of Commercial Workers			Commercial Water Demand Lpd		
	1965	1985	1997	1965	1985	1997
Afaka	24	621	275	960	24,840	11,000
Gabasawa	229	2324	2815	9160	92,960	112,600
Doka	240	6715	6365	9600	268600	254,600
Kawo	144	1687	1995	5760	67480	79,800
Sabon Tasha	163	1402	1750	6520	56080	7000
Makera	180	4649	5290	7200	185960	211,600
Tudun Wada	146	4389	4770	5840	175560	190,800
Total				45,040	871,480	867,400

Source: *Field Survey, Max Lock (1967); URP dept. ABU Zaria (1983). Kaduna State Government (1995). Federal Ministry of Labour and Productivity (1997).*

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The total commercial water demand for Kaduna in 1985 was estimated at 0.87 million litres per day. This has however remained constant to date.

4.14 PUBLIC LANDUSES

The uses covered under this category include administration, health, law enforcement, education, financial institutions and the military. Current estimate within the metropolis suggest that over 29.3% of the developed land area of the town is under this use. This compares with a figure of 35.4% in 1983 and 28.8% in 1966.

The water demand for public landuse like in commercial landuses is not as high as the demand for domestic and industrial landuses. Averaging about 40 litres per day per full time employee. The demand for water for public uses like that of commercial uses is low compared to other landuses. See table 4.3

Table 4.3: Number of public workers and public landuse water demand of the various districts in Kaduna metropolis (1965, 1983, 1997).

District	No. of Public Workers			Public Water Demand		
	1965	1983	1997	1965	1983	1997
Afaka	556	683	1929	22240	27,320	77160
Gabasawa	14832	4251	51516	593480	729480	2,060,640
Doka	3456	18237	12009	138360	170040	480,360
Kawo	1436	1763	4986	57440	70600	199440
Sabon Tasha	32	40	112	1280	1600	4480
Makera	840	1032	2915	33600	41280	116600
Tudun Wada	3893	4785	13516	155720	191400	540640
Total				100mld	1.23mld	3.48mld

Source: *Field Survey, Federal Ministry of Labour and Productivity (1997), Civil Service Commission (1997).*

Water for public landuses has a 35% increase from the early 80s to the present demand. This can be attributed to the increase in educational, military and administrative institutes. Data on the number of employees in the public sector are for establishments that registered with the Ministry of Labour and Productivity.

SUMMARY

The present total water demand of Kaduna metropolis reflecting the water demand of all landuses in the various districts in Kaduna is estimated at 186.7mld. This shows that the water produced everyday by the two water works which is 267mld is adequate for all the landuses in Kaduna metropolis. Although 10% of water produced is lost through busted pipes and illegal connection and 5% is used to deslug the treatment plants the water available for use which is 195.75mld is still adequate for present demand for all landuses of Kaduna metropolis.

4.20 ANALYSIS OF FUTURE WATER DEMAND IN KADUNA

Distribution of future landuse pattern and water demand in Kaduna can not be easily determined by studying only past trends. This is because the growth of activities for the past seven years does not tally with what has been happening since the mid seventies. This can be attributed to the recession in the economic low standard of living and instability in the political sector of the country. For example in residential landuses and development, the rural-urban drift of people seeking employment in the city have been replaced by an urban-rural drift, reducing the rate of residential development in Kaduna. This is because of the high cost of living in the town. This has caused people to move back to the rural areas where cost of living is lower. The improvement of infrastructure in the rural areas is another factor. Water projects like the world bank water supply scheme of Zonkwa and Egabi and projects on rural electrification in areas like Kachia have made these areas more conducive for living than Kaduna.

In the past seven years there has not been any substantial growth in industrial activities (especially heavy industrial activities). During this period about 39.1% of heavy industries in Kaduna have been shut down, due to the lack of funds to carry operations and the lack of raw materials. This is unlike in the late seventies to early eighties when he growth of industrial activities was high because of the oil boom.

However, due to the lack of adequate data on landuse distribution of the various districts in Kaduna and the difficulty in determining past landuse patterns adequately, the trend or extrapolative method was used to forecast future water demand of various districts in Kaduna metropolis. Comparism of past water demand (165 and 1983) and present water demand (1997) was made. This was used to establish the growth of the water demand of the various landuses in each district in Kaduna. This rate was used to determine future water demand for the year 2005 see table 4.4

Water demand for all landuses in Kaduna for the year 2005, (litres).

District	Domestic	Industrial (mld)	Commercial	Public
Afaka	5278440		16120	113120
Gabasawa	16791720		165080	3020880
Doka	48438336		373240	704200
Kawo	37746275	4.76 - 6.66	117000	292360
Sabon Tasha	12490320	16.6 - 23.2	102640	6560
Makera	22096788	22.7 - 31.8	310200	170960
Tudun Wada	38799156	4.68 - 6.55	279720	7925660
Total	181641035	48.74 - 68.21	1,364,000	5,000,640

Source: *Field Survey, Max Lock (1967); URP dept. ABU Zaria (1983). Kaduna State Government (1995). Federal Ministry of Labour and Productivity.*

Assumption: Due to the state of the economy it is assumed that no industrial development will occur from now to the year 2005. Thus the present industrial development is estimated for Kaduna for the year 2005.

This implies that the present industrial water demand will remain the same by the year 2005.

The total water demand of Kaduna metropolis for the year 2005 is estimated at 236.7 - 256.2 mld. This estimate however does not reflect the projects and land developments that are presently going on in Kaduna. These projects at completion

would require water and thereby effect the total water demand of the city. These projects are:-

1. The Eastern Sector: The fast purpose of the eastern sector development project is to open up Kaduna metropolis to growth and development, out of this initial purpose other benefits follow. These include; the decongestion of the built up areas of the city, the reduction of the dimensions of its physical development problems, and the creation within the sector of ample opportunities for living, work and recreation. The eastern sector is estimate to have a population of 440000 and an area of 8000ha having 47% of residential landuse, 10% of commercial landuse, 2% of industrial land, 10% of public landuse, 15% of roads, 7% of organised open spaces and 9% of green space.

   The estimates of the water requirement of the new sector was made on the basis of per capital water consumption rate of 140Lpd (litres per day). This is to create room for increased water consumption that may arise in future as economic prospectors increases and standard of living increase. Total per capital water requirement is estimated at 61.6mld.

2. Heritage University: This consist predominantly of public landuse or activities. It has an area of 150ha with an estimated population of both students and staff of 26,394 people. By 1990 which is when phase one is estimated to be completed is estimated to have a demand of 3.8mlpd. By the completion, of the university by the year 2023 the water demand is estimated to be 19.5mld.

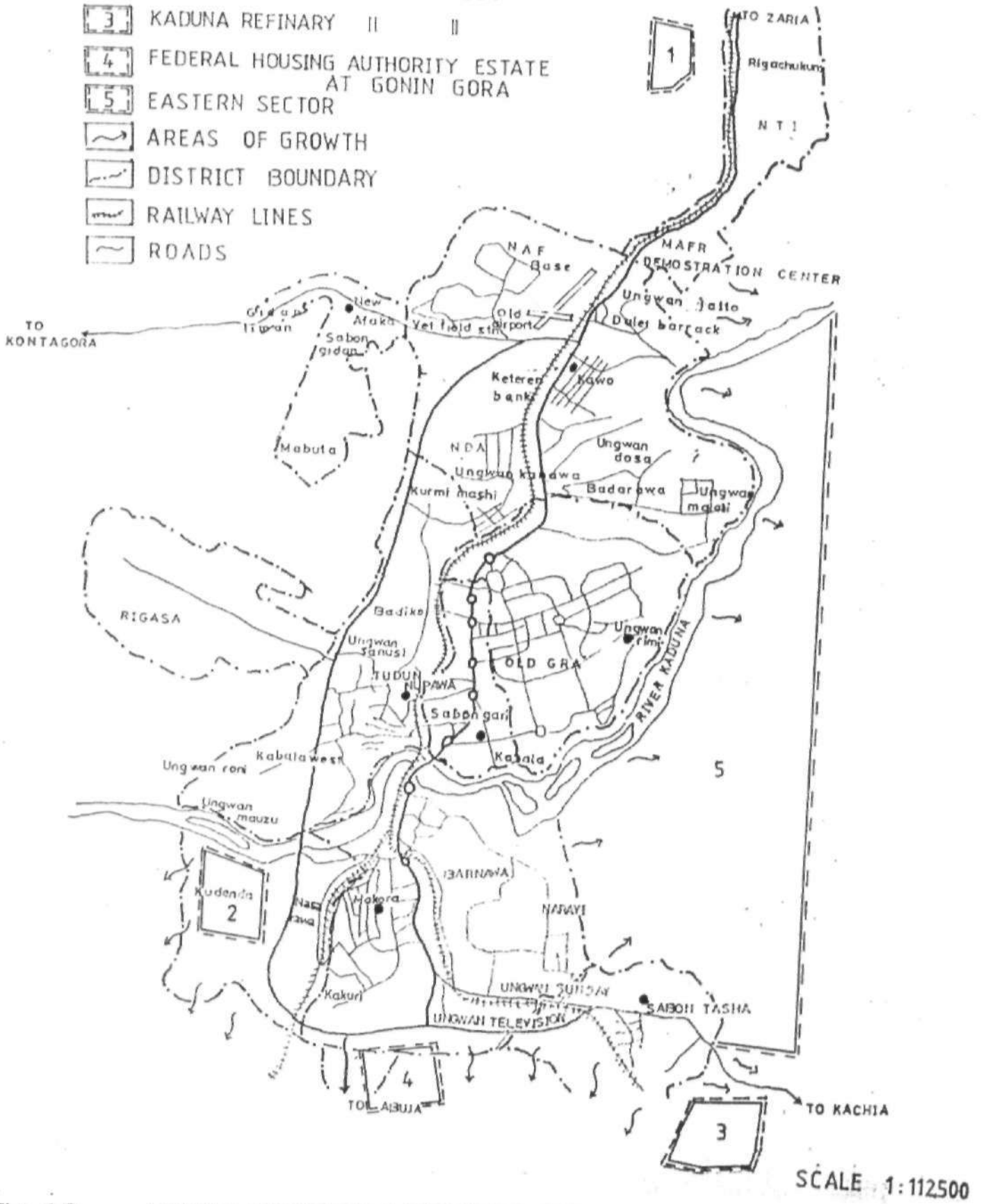
3. Housing Estate at Goni-Gora Kaduna: This project consist of residential landuses only with 176 housing units, made up of 120 three bedroom flats and 56 four bedroom flats with an average family size of seven persons per household. The population of the housing estimate is at 21120 people. The water requirement of the estate is estimated at 2.53mld.

4. The Kaduna Refinery and Kudenda Industrial Layouts: This layout are two of the six industrial layouts that exist in Kaduna metropolis. The four other industrial layouts have been developed with the Kaduna South industrial layout having a 100% development record. Others have been substantially developed although not up to 100%. However infrastructure and services have been adequately provided. The Kaduna Refinery and the Kudenda industrial layouts however is undergoing development with the Kaduna Refinery having a development record of 5%. The two layouts have a collection area of 400ha with 390ha yet to be developed. By the time the area is fully developed the water requirement of the area is estimated between 7.73mld - 13.65mld. The time the area will be fully developed can not be estimated since the layout is

developed predominantly by the private sector.
The total water demand of Kaduna metropolis reflecting all new projects and land development going on in Kaduna for the year 2005 can be estimated as 328.13mld - 353.55mld. This is by far more than the projections made by the water board to be same period. This can be attributed to the following reasons:-

1. The projections of the water board which is 270.8mld is not realistic. It does not take into consideration the rate of change of landuses overtime in the various districts in Kaduna. The percentages of landuse used to project the water demand for the future are too generalised and does not reflect present situation in Kaduna.

2. The water board projected figures does not reflect specialised areas of uses. This include the new projects and land developments that are coming up Kaduna and their water demand.



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Fig. 4.0 **NEW LAND DEVELOPMENT AND PROJECTS IN KADUNA METROPOLIS**

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SOURCE: Field Survey, Kaduna polytechnic (1996)
NUC (1990), EH.A (1984), Kaduna State Government.

5.00 PROPOSAL FOR SUSTAINABLE WATER SUPPLY IN KADUNA METROPOLIS

5.10 INFERENCES FROM SURVEY

The survey conducted in the study shows that the present water produced by the Kaduna North and South water works is adequated for the present demand for water by the different landuses in Kaduna metropolis. The amount of water produced by the two water works is estimated at 267mld, however due to the water works working at 84.5 % of its installed capacity the actual amount of water produced by the water work is 225mld. From the amount produced, 10% is lost daily through leakages and vandalisation and 5% is used daily to desluge the treatment plant. This brings the amount available to 195.8mld.

From the survey the present total water demand in Kaduna was estimated at 186.7mld. This includes demand from the different land uses in the different districts in Kaduna. However at the district level the situation is different. The districts are supplied water via the numerous water reservours located in Kaduna. The total capacity of the reservours amounts to 97.54ml. Although some industries are supplied water straight from the water works the total amount of water distributed to the different districts does not meet or is not adequate for the water demand in some districts. This explains why water is adequate in some parts of Kaduna and not adequate in other parts of Kaduna. This situation can be attributed to the following problems.

RAPID RATE OF UNPLANNED AND UNCONTROLLED URBANISATION

Kaduna metropolis with a present growth rate of 5.0% is experiencing rapid population and spatial growth with these growth, areas in Kaduna are undergoing uncontrolled development. Areas like Goni-Gora, Kudenda,

Rigasa which use to be satellite settlement have merge with the city forcing the government to derive ways to providing social services to such areas. Due to the fact that the reached those areas before they were planned for what is evident in such areas is habhazad urbanization which makes it difficult to plan and provide such areas with basis amenities like pipe borne water. Thus such areas are experiencing problems of adequate water supply. In most case the residents of such area supplement with well water.

WEAK INSTITUTIONAL ARRANGEMENT OF KADUNA STATE WATER AUTHORITY

The Kaduna State water board from it's inception in 1971 has the sole responsibility of providing water for the populace of Kaduna metropolis. The responsibility of maintenance the after system and the collection of revenue from its serves was that of the board.

In the seventies and early eighties the board functional adequately because there was less need for water and the funds to maintain the systems were available. However by the late eighties the need for water increased at a fast rate and the funds to maintain adequate water production and manage the water supply system was not available. This is because KSWB was established to provide essential services, thus was not originally established with a commercial orientation. This is evident from their lack of commercial policies and their failure to establish a commercial arm of their operation unit that could enable them to efficiently collect revenue from their water sales.

WEAK OPERATIONAL AND MANAGEMENT ARRANGEMENT

The operations and management of the water systems is done solely by the staff of the Kaduna State water Board. This is faced with serious problems.

Firstly, the lack of funds to train personnels to enable them meet the rapid increase of water demand and secondly the funds to adequately maintain existing system.

With the lack of funds and able personal the water system is left in a deterioraly state. This has led to water loss of 10% (22.5mld) every day.

Lack of funds also means the lack of capital to invest more in the expansion of the existing water system, to meet the growing need. Due to the fact that water supply is capital intensive the private sector is to encourage to invest into this area of the economy.

HIGH LEVEL OF POLLUTION

The rapid rate of urbanisation invincibly implies the rapid increase of population growth especially in the high population density areas and satellite towns which are now merged with the metropolis. These area are characterised by poor environmental condition from the pattern of urban production and consumption.

From the late eighties to date Kaduna metropolis has experienced an increase in commercial activities and a decline in industrial activities. About 35% of residential landuses are being converted to mixed landuses especially in high density areas. This has lead to the increase in the deterioraly condition of such areas. This area are consequently characterised by bad sanitary conditions leading to the pollution of available water supply.

LARGE POLITICAL INTERFERENCE IN TARIFF SETTING AND COLLECTION

The public sector in Kaduna has been characterised by stagnancy. This is because of the lack of adequate capital to fund its operation. This means that the government is left with the power to choose areas of priority to invest available capitable.

However, politics has played a huge role in determing areas or projects that yet the funds available. This also depends on the person incharge.

In the running of the water board politics has played a major role. In the bid of impressing the populace the government have made unrealistic tariffs and collection policies that are not aimed at meeting cost of water production. With the inability of government to subsidise the cost of production for the populace the Kaduna State Water Board is left to function inadequately and unable to invest in increasing production to meet the water need by the year 2005.

See figure 5.0

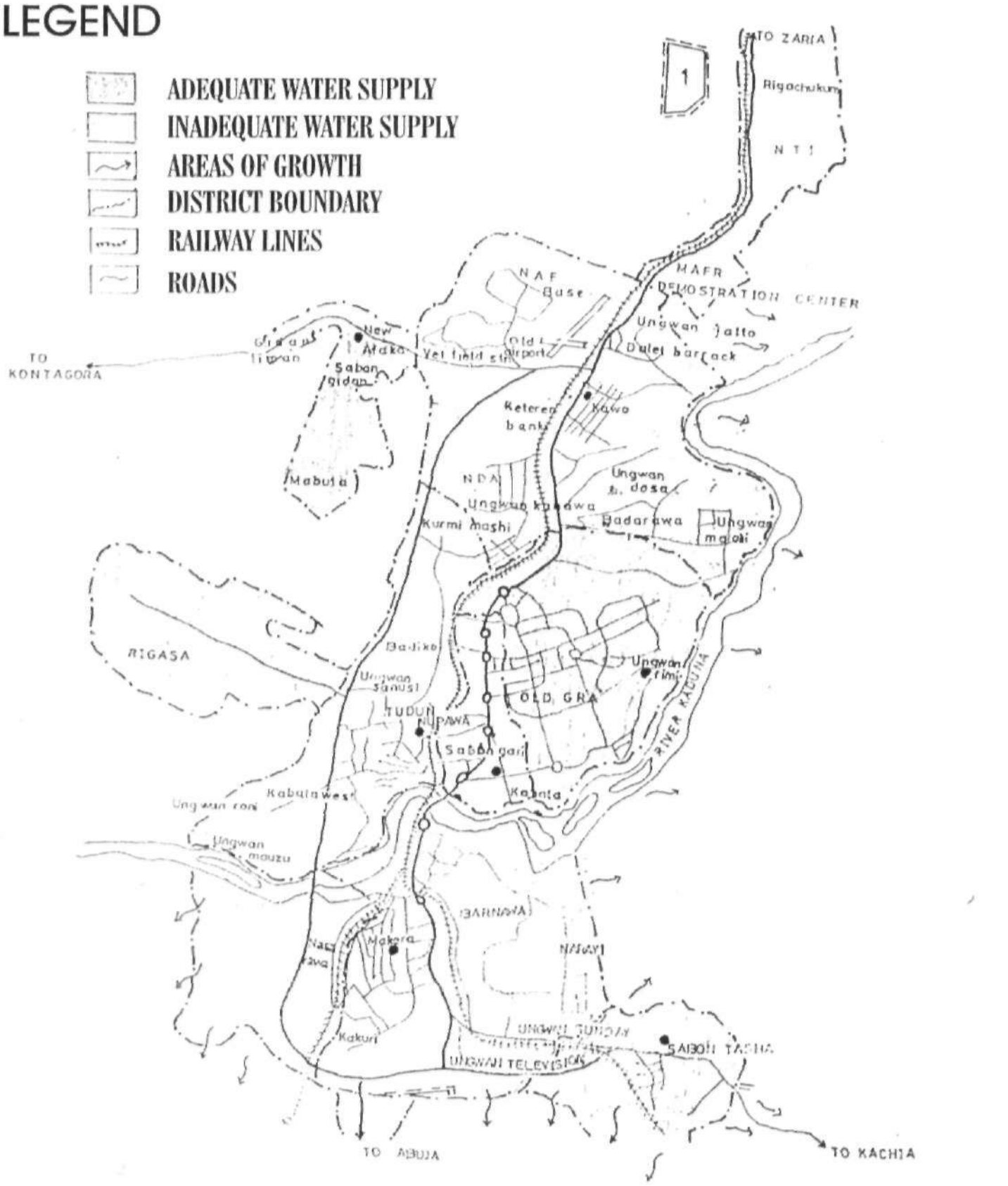


Fig. 5.0 **ANALYSIS OF WATER DISTRIBUTION IN THE VARIOUS DISTRICTS IN KADUNA METROPOLIS**

SOURCE: Field Survey, Kaduna Master Plan Review(1983)

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Table 5.0 Analysis of Water Demand/Supply in the Districts in Kaduna.

District	Water Demand (mld)	Water Supply (mld)	Comment
Afaka	0.67	9.50	Adequate
Gabasawa	13.6	13.6	Adequate
Doka	33.78	4.56	Inadequate
Kawo	33.67	13.63	Inadequate
Sabon	31.73	30.0	Adequate
Makera	47.20	24.7	Indequate
Tudun Wada	33.75	2.27	Inadequate

Source: 1. Field Survey (1997)
2. Kaduna State Board (1997)

These problems are caused by: -

1. The intensification of landuses in the areas
The inability of the reservours serving these areas in meeting the growing water demand, which is a consequence of the growth of landuses in the areas.

Further analysis of the data collected for the survey reveals that the water presently produced by the Kaduna North and South water works (267mld) will not be adequate for the future water needs of the Kaduna populace. (320.4mld - 339.9mld). This amount includes the water requirement of new projects currently going on in Kaduna, and which will be responsible for future growth in areas where these projects are located. The areas where growth is envisaged are Afaka, Sabon Tasha, Gabasawa and Kawo districts.

To adequately meet the present and future water demand in Kaduna metropolis there is a need to:-

1. Increase the reservour capacity in districts where the reservours serving them are not adequate e.g. Tudun Wada, Makera., Doka and Kawo.

2. Increase the amount of water produced by the Kaduna North and South water works to meet future demand by the year 2005 which is 320.4 - 339.9mld. Anticipate the areas of growth in Kaduna and provide new reservours or increase the capacity of already existing reservours to meet the increase demand that is anticipated in these areas.

5.20 PROPOSAL FOR SUSTAINABLE WATER SUPPLY IN KADUNA METROPOLIS

The sustainable development approach involves meeting the needs of the present populace of Kaduna without compromising the ability of the future generation to meet their water need. This can only be achieved when the Kaduna State Water Board is self sustaining, in other words the operations of the board should be sustained by the revenue collected from the sales of water produced by the board. This would mean removing subsides, commercialising the Kaduna State Water Board or commercialising certain aspects of their operation e.g billing and revenue collection and the involving the private sector in the operations of the water board. There must however be a check by the government to ensure that the poor are ensured equitable access to services.

5.21 PROMOTING PRIVATE SECTOR PARTICIPATION

This participation may range from service contracts - by which the private sector provides specific technical services such as pipe repairs or meter reading; to management of contracts and leases - under which the private sector takes on responsibility for the overall operation and maintenance of the water system; to concessions - through which in addition to operation and maintenance, the private sector takes on overall investment responsibilities for the improvement and expansion of water services. These options differ in their allocation of risks and responsibilities between the public and private sectors, their complexity and their duration.

The motivation of the government of Kaduna State for seeking private sector participation in water services would be to secure sustainable improvements in the efficiency with which services are delivered. The government might also be looking for new sources of finance for needed investments in network rehabilitation and expansion, or for new water and sewage treatment facilities or they may be looking for ways to make services provide more sensitive to customers needs and preferences.

The only disadvantage to this proposal is that the involvement of the private sector would lead to the increase in the cost of the water produced. This is because the private sector operates strictly by the free market principles. Under this principle the main objective of the private sector is to maximise profit.

Profit orientation is advantageous in that it leads to better services and enable the funds necessary for more investments in water services available. However, this would unavailable mean the service would be less available to most of the people in the metropolis because of the cost of the water. There is a need for the Kaduna State government through the Kaduna State Water Board to pay the cost for water, and continue to subsidise for the cost of water used by the people living in the metropolis, hereby making it accessible to all the populace of Kaduna metropolis.

5.22 COMMERCIALIZING STATE WATER AUTHORITY

The Kaduna State Water Board from its inception in 1971 has the sole responsibility of providing water for the populace of Kaduna metropolis and the maintenance of the water supply systems. It was established to provide essential services thus was not originally established with a commercial orientation. This is evident from their of commercial policies and their failure to establish a commercial arm of their operation unit that would enable them to effectively collect revenue from their water sales. Presently, revenue is collected for only 27% of water produced. Due to this condition, the Kaduna State Water Board does not generate enough funds from its revenue to improve on the provision of its services.

In view of the state of the Kaduna State Water Board the is a need for the board to commercialize its services. This can be achieved by adopting commercial principles in its operations. Some of the principles that can work in Kaduna are:-

COMPETITION

Monopoly on public services has been observed to be detrimental to sustainable development in the provision of such services. Especially with the rapid urban growth occurring in all cities in the world. The burden of the responsibility of providing such services by the body incharge is becoming unbearable. This has led to the deterioration of the services and its resulting consequences.

Competition promotes efficiency and provides users with options that in turn make infrastructure providers more accountable. As technology imps

with time more areas of competition are created in the provision of water.

Technological changes are creating a variety of new opportunities for changing the way water is provided.

CO-OPERATION

Co-operation means working or acting together for a common purpose. This involves the coming together of the Kaduna State Water Board and other stakeholders in the development of water provision. These stakeholders could include the consumers, the communities and the private sector. In many infrastructure activities, market signals can not be relied on the provide information about demand or to gauge performance. Where users are locked into a delivery network, they cannot express their preferences or dissatisfaction through choice. In such circumstances, other means of making suppliers accountable to users are needed. Through various mechanisms designed to broaden participation in decision making and to provide wide access to information on infrastructure provide, users and other key stakeholders can be represented in (and sometimes take responsibility for) the planning, financing and delwery of services.

There are many such partnership that have been used in such situation as stated in chapter two. However, for the situation Kaduna the functional - based collaboration partnership is the best adoption. The main objective of this approach is to designate areas of responsibility to each stakeholder. In this case the partnership consist of the State Water Board, the private sector and lastly the consumer.

Function of the Kaduna state water board in the partnership: The function of the board should be mainly in the development of the water sources and the formulation of policies. They can be termed as the governing body in the partnership. They are to control the activities of the other members of the partnership and planning of the water supply system. This is to ensure that the consumers are educated about their functions and how to carry them out (informative) and also to prevent the private sector from making services unaffordable to the consumer (since they are profit oriented). Their control and monitoring should also prevent the monopoly of certain private enterprises in the provision of services. They are also to serve as an advisory body to the private investors.

Function of the private sector in the partnership: The function of the private sector is mainly in investing in the provision and maintenance of the services. In developed countries the supply of water is done mainly by private firms. However nowadays it is becoming rampant in developing countries however the growth of the private sector

involvement in infrastructure like water supply development has been show. This is because water supply projects are capital intensive. In developing countries the private sector or most private establishment do not have the kind of capital to invest in these area. The profit also are long term profit, which is a factor that prevents most private establishment from investing in infrastructure since these establishments prefer short term profit oriented projects. In order to make water supply development appealing to the private sector; the public sector must make incentives available.

Some of these incentives can be: -

1. Providing loans for development at fairly low interest rates.
2. Make land for development readily available to the private developer.

Function of the consumer in the partnership: The consumer function should be mainly that of management. The consumers should be able to look after the infrastructure in their different districts. This they can do by informing the board when there is a bursted pipe, vandalization and to report when there is a problem in their area.

The consumer can also be involved in the planning of the provision and distribution of water supply. This is to make it easier for them to accept the plans and enable the water boards have an accurate knowledge of the needs of the consumer thus making plans adequate.

5.23 INTEGRATED APPROACH TO SUPPLY

To sustain present water demand and meet future water demand, the Kaduna State Water Board needs to develop alternative sources of water to compliment pipe born water. The state is blessed with abundant water resources - ground water and surface water, which can be harnessed. This is the fastest and cheapest way to improve the water supply in Kaduna metropolis.

The ground water resources estimated at an average yield of 3.33mld can serve as an alternative source, which the board can develop to complement pipe borne water. The Kaduna State Water Board can encourage individuals to dig borcholes for their various domestic uses. This is to compliment pipe borne water hereby reducing total dependency on it and cost incurred by its use.

Competition promotes efficiency and provides users with options that in turn make infrastructure providers more accountable. As technology imps with time more areas of competition are created in the provision of water.

Technological changes are creating a variety of new opportunities for changing the way water is provided.

5.30 CONCLUSION

The rapid growth of Kaduna metropolis and it consequences on water supply can be monitored and managed with adequate planning. Planning for the present and future taking into consideration specialised uses.

Growth is dynamic thus our planning for this growth must also be dynamic. There is a need to be abreast with growth of Kaduna and adopt new and better ways to manage this growth here by making the water supply needed by its populace available.

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APPENDIX I

DEPARTMENT OF URBAN & REGIONAL PLANNING
FACULTY OF ENVIRONMENTAL DESIGN
AHMADU BELLO BELLO UNIVERSITY ZARIA

Introduction:
This survey is being conducted on the planning analysis of water supply in Kaduna Metropolis. With the aim of identifying the lapses and proposing appropriate remedies. This is in pursuit of a post graduate degree in Ahmadu Bello University Zaria.

It would be appreciate if you would kindly answer the following questions. All information provided shall be treated confidentially and used purely for academic purposes.

-Victoria Nyam Jim

Note: Please tick the appropriate answers.

GENERAL INFORMATION

1. Occupation of respondent.
   a) Civil Servant ☐ (b) Industrialist ☐ (c) Business ☐ (d) Farmer ☐
   e) Others (Specify).....

2. Sex of respondent.
   a) Male ☐ (b) Female ☐

3. Marital Status?
   a) Single ☐ b) Married ☐

4. If married, what is the size of your family?
   a) Less than 3 persons ☐ b) 3 - 5 persons ☐ c) 6 - 10 persons ☐ d) More than 10 persons specify.....

5. Level of education?
   a) Primary ☐ b) Secondary ☐ c) Post Secondary ☐ d) University ☐ e) Others (specify).....

6. How much do you earn monthly?
   a) Less than₦ 1000 ☐ b)₦ 1000 -₦ 2500 ☐ c)₦ 2500 -₦ 5000 ☐ d) More than₦ 5000 (specify).....

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RESIDENTIAL CHARACTERISTICS

7. What district do you live in?
   a) Afaka ☐ b) Gabasawa ☐ c) Doka ☐ d) Makera ☐ e) Tudun Wada ☐
   f) Sabon Tasha ☐ g) Kawo ☐

8. How can you describe the sanitary condition in your area?
   a) Bad ☐ b) Fair ☐ c) Good ☐ d) Very Good ☐

9. Describe the state of utilities, facilities and infrastructure in your area?
   a) Adequate ☐ b) Fair ☐ c) Inadequate ☐

WATER SUPPLY CHARACTERISTICS

10. Do you have pipe borne water in your area?
    a) Yes ☐ b) No ☐

11. If yes what is the level of supply?
    a) Regular ☐ b) Periodic ☐ c) No supply at all ☐

12. How much water do you use a day (estimate by number of buckets)
    a) 2-5 buckets ☐ b) 5-10 bucket ☐ c) 10-15 buckets ☐ d) Others specify.....

13. What is the landuse characteristics of your premises
    a) Residential ☐ b) Commercial ☐ c) Industrial ☐ d) Public/Semi-Public ☐

14. Is the water supplied adequate for your needs?
    a) Yes ☐ b) No ☐

15. Can you then say there is water problem in your area?
    a) Yes ☐ b) No ☐

16. If yes what can you say is the cause of the problem?
    a) Distribution ☐ b) Breakdown of System ☐ c) Lack of adequate maintenance ☐ d) Area not yet under laid with pipe borne water pipes ☐ e) Constant vandalization of water supply system ☐ f) Others (specify).....

17. What alternative water source is available to you?
    a) Well ☐ b) Borehole ☐ c) Personal water tanks ☐ d) Rivers and Streams ☐ e) No alternative source ☐ f) Others specify.....

18. Is there any attempt made by the community to solve the water problem in your area?

a) Yes □ b) No □

19. Has Kaduna State water board made any attempt to solve the water problem?

a) Yes □ b) No □

20. Would you like to be involved in the management of water supply in your area?

a) Yes □ b) No □

21. If yes what are your reasons?

a) You want to improve the water condition of your area □
b) No particular reason □ c) Others (specify).....

APPENDIX II

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FACULTY OF ENVIRONMENTAL DESIGN
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- Victoria Nyam Jim

Note: Please tick the appropriate answers.

1. Which department of the water board is responsible for water distribution in Kaduna.
   a) Project and planning ☐ (b) Engineering ☐ (c) Maintenance ☐ (d) Others (Specify).....

2. How many staff does the department have?
   a) 1 - 5 ☐ (b) 6 - 10 ☐ (c) 11 - 15 ☐ (d) 16 - 20 ☐
   (e) Others (specify).....

3. Are the number of staff adequate for the responsibility of the department?
   a) Yes ☐ (b) No ☐

4. What is the quality of water produced by the Kaduna State Water Board?
   a) 90 - 100% pure ☐ (b) 75 - 90% pure ☐ (c) 50% pure ☐
   (d) Below 50% pure ☐

WATER SUPPLY AND DISTRIBUTION

5. What criteria is used in the distribution of water in the different districts in Kaduna?

   a) Population size ☐ (b) Demand for water ☐ (c) Landuse in the area ☐

d) No particular criteria [ ] (e) Others (specify).....

6. To what capacity are the reservoir operated?
a) Full capacity [] (b) [] capacity [] (c) Half capacity [ ] (d) [] capacity []
(e) Others (specify).....

7. Does the water distributed meets the demand for water in each district?
a) Yes [] (b) No []

8. If no, what are the reasons for the inadequacy?
a) Fast growth of population [] (b) Lack of funds [] (c) Break down of existing systems [ ] (d) Inability to enlarge distribution system to meet expanded area [] (e) Others (specify).....

9. What is the quality of supply of water to each district

DISTRICT	QUANTITY
Kawo	
Doka	
Tudun Wada	
Gabasawa	
Sabon Tasha	
Makera	
Afaka	

MAINTENANCE

10. How is the water distribution system maintained?
a) Routine checkup by the water board [] (b) Using contractors [] (c) Systems are not maintenance [] (d) Others (Specify).....

11. Do you experience problems in maintaining the system?
a) Yes [] (b) No []

12. If yes what problems are encountered in the maintenance of the water distribution system?
a) Lack of funds [] (b) Lack of adequate manpower [] (c) Lack of committed personnel [] (d) Diversion of funds to other uses [] (e) Others (specify).....

13. How frequent do pipe get damaged in each district?

DISTRICT	FREQ OF DAMAGE OF PIPE
Kawo	
Gabasawa	
Doka	
Makera	
Tudun Wada	

14. How does the department get to know about damaged pipes?
a) The public informs the board □ (b) The board has gadgets for detecting damage of pipes □ (c) Through routine checkup done by board □ (d) Others (specify).....

15. How fast are the damages repaired?
a) Immediately □ (b) Delayed □ (c) Not repaired □

16. What problems are associated with delayed repairs?
a) Lack of funds □ (b) Lack of skilled manpower □ (c) Lack of committed manpower □ d) Diversion of funds to other uses □ (e) Others (specify).....

17. Through what method does the Kaduna State water board meet the increasing demand for water supply in the metropolis?
a) Improving the existing water works □ (b) Managing the available water by rationing □ (c) Developing other water sources □ (d) Do nothing □ (e) Others (specify).....

MANAGEMENT

18. In management of water what strategies are employed by the board?
a) Involving the private sector □ (b) Involving the community □ (c) Educating the public about water use □ (d) Involving the local government in water management □ (e) Others (specify).....

19. What is the degree of success of strategies?
a) Very successful □ (b) Successful □ (c) Not Successful □

20. If not successful what are the reasons for the failure?
a) Lack of funds □ b) Lack of interest by the public □ (c) Inability to get the private sector interested in water supply □ (d) Lack of qualified manpower □ (e) Others (specify)

21. What is the distance between the storage tanks/reservoirs and their area of reach?

a) Less than 1km □ (b) 1km □ (c) 2 - 5km □ (d) More than 5km □ (e) Others (specify).....

PRODUCTION

22. What is the cost of water production per day?

23. Is there any tariff?
a) Yes □ (b) No □

24. Do the tariff on water supply meet the cost of water production?
a) Yes □ (b) No □

25. If No what are the reasons?
a) The people do not pay regularly □ (b) Illegal connections □ (c) Water supply is high subsidized by government □ (d) Others (specify).....

26. How much would each consumer need to pay each month for the cost of production to be met?.....