PLANNING AND MANAGEMENT FOR SUSTAINABLE URBAN WATER SUPPLY: A CASE STUDY OF DAMATURU

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AUGUST, 1998.

DECLARATION

I hereby declare that this Thesis: PLANNING AND MANAGEMENT FOR SUSTAINABLE URBAN WATER SUPPLY: A CASE STUDY OF DAMATURU, has been composed by myself and that it is the outcome of my research work. It has never been presented before to any examiner for the award of a higher degree.

Abdu Yaro
March, 1998

CERTIFICATION

The Thesis entitled:PLANNING AND MANAGEMENT FOR SUSTAINABLE URBAN WATER SUPPLY: A CASE STUDY OF DAMATURU by Abdu Yaro meets the regulations governing the Award of the degree of Master of Science, Urban and Regional Planning, Ahmadu Bello University, Zaria, Nigeria and is approved for its contribution to knowledge and literary presentation.



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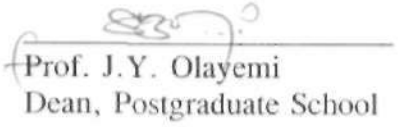
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DEDICATION

This Thesis is dedicated to those people in one way or the other deformed by any water-related infections in the Sudano-Sahehian Zone of Nigeria.

Abdu Yaro,

August, 1998.

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All thanks be to Allah, the most exalted and mercifull for, giving me the knowledge and courage to witness this moment. In fact nothing deserves this but Allah who destined this achievement on me.

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ABSTRACT

The gap between water need and supply has widened in most existing and emerging urban centres in Nigeria. Large number of urban dwellers experience inadequacy of water supply and thus rely on doubtful sources for domestic uses such as shallow wells, harvesting of rain water from roof tops and occasional seasonal streams.

In response to the rapid urban and population growth that has characterized many newly created state capitals, in Nigeria, including Damaturu, water Agencies have evolved policies and programmes for obtaining adequate supply in order to achieve a balanced social and economic urban development.

Although much efforts and financial resources have been invested in water resource development, the net results achieved have been very minimal and unsatisfactory. Thus, in addition to the need to consider principal factors in effective urban water supply and management such as urban population size, distribution, density and overall socio-economic characteristics as well as land and water use pattern, this study has shown that, the water Agencies need to integrate community based organisations who are direct beneficiaries of water projects, the private sector, extra-ministerial bodies such as Petroleum Trust Rind, National Water Rehabilitation Project, the Municipal//Local Governments as well as Non-Governmental Organisations in the Planning, Development and Management of water supply in the Urban areas.

Specific proposals have been given for sustainable water supply in Damaturu.

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CHAPTER ONE
DESIGN OF THE STUDY

1.1.0 INTRODUCTION

The role of water in human activities is quite significant considering the various support activities which are dependent on the availability of water supply. Not only does water remain an indispensable element of life, much of man's efforts to survive and progress physically and socio-economically are dependent on adequate water supply. However, because it is freely available in streams and rivers and through falling precipitation, water has too often been taken for granted and mismanaged. Only in water deficient areas is water accorded its due recognition as a valuable resource.

Recently, more efforts have been directed towards developing water resources for social and economic activities either through the National water Rehabilitation Project, Petroleum Trust fund, Infrastructure Development Fund or both, particularly for urban centres. This development arises owing to the complex problems of effective water supply which still persist threatening the entire fabrics of urban socio-economic development due to:

i) The increasing demand for water as a result of increasing population, urbanization, industrial activities and increase in the standard of living of

the people,

ii) The escalating cost of satisfying this increasing demand for water;

iii) The increasing difficulty of obtaining and developing new sources of water supply within and around urban environments;

iv) The increasing pollution of available water resources as a result of in discriminate dumping of industrial and domestic wastes in water courses.

The overall consequences of these factors have necessitated the need for planning and management of water resources on a sustainable basis for domestic as well as other economic development activities in urban areas.

1.2.0 STATEMENT OF RESEARCH PROBLEM AND JUSTIFICATION

The changing status of Damaturu to a state capital has intensified social, economic and spatial dynamics as reflected by rapid population increase and the establishment of various new institutions, residential areas and administrative offices in different parts of the town. This situation has both increased demand for water supply as well as complicated the process of determining accurate demands resulting into disproportionate supply to different parts of the town. This made water supply not only inadequate but hardly accessible in various parts of the town.

Moreover, the existing practice and research in urban water supply has largely been limited to the problems and requirements for effective management and operational control of water agencies (See Fadumila, 1983, Ammani, 1995 and Isa, 1992). These studies have neither addressed the need to integrate both consumers and producers in the planning, financing implementation and management of water supply scheme nor important variables relating to the problem of water supply such as assessment, management and determination of accurate demand and consumption in relation to critical factors as population distribution and characteristics, landuse pattern, spatial dimension of water distribution problem and participatory approach to supply and management of water as well as the limited water resource potentials in urban centres.

The overall effects of these explain why a large proportion of the people of Damaturu are without adequate water supply despite efforts by the Water Board to construct more boreholes in different parts of the Damaturu urban area. They utilize harvested rainwater from roofs, ponds, streams or buy from water vendors. These practices have resulted into numerous water related health hazards.

Therefore, there is the need to fill this gap in the practice and research by addressing the problem from planning perspective which forms the focus of this study.

1.3.0 AIM AND OBJECTIVES

1.3.1 AIM

The aim of this research is to analyse water demand and supply characteristics in Damaturu with a view to propose planning and management strategies for sustainable water supply in the town.

1.3.2 OBJECTIVES

The following objectives would be pursued to achieve the aim:

i) To review concepts and approaches as well as participatory strategies for planning and management of urban water supply.

ii) To analyse existing water supply and demand characteristics and make projections of future water demand to the target year of 2010.

iii) To analyse water resource potentials within Damaturu and its immediate region.

iv) Make proposal for planning implementation and management of water supply in relation to water resources potentials and projected water demand.

More specifically, attempts shall be made to answer the following questions:

i) Why has the problem of water supply persisted inspite of Government's efforts in this direction?

ii) What planning and management strategies are needed to achieve a sustainable water supply in Damaturu?

iii) What other available source(s) are there around for water supply beside the existing (boreholes) in the area?

iv) How has the existing trend in the population and landuse structure contributed to the problem of water shortage?

1.4.0 SCOPE AND LIMITATIONS

Development of water resources has been dominated by Engineering considerations. This study considers physical planning techniques and management approaches as the basis for effective sustainable urban water supply.

The study, however, is limited to the Damaturu urban area which comprises of about eight neighbouring settlements.

1.5.0 METHODS AND SOURCES OF DATA COLLECTION

1.5.1 HOUSEHOLD SURVEY

Household survey was conducted to obtain data on socio-economic and population characteristics of the inhabitants. It was also used to assess the level and distribution of water supply and demand in different parts of the urban area.

For the purpose of this study, Damaturu urban area was divided into three sectors in view of their socio-economic and water demand disparities, namely; Damaturu old town, Housing Estates, and the Neighbouring Settlements which have been incorporated into the declared urban area of Damaturu.

1.5.2 SAMPLE SELECTION

In order to estimate the present population of Damaturu and other aspects of the research, systematic Random Sampling technique has been used. A total of 232 households representing two percent (2%) of the estimated number of households in Damaturu have been sampled for the purpose of this study. In this way, an average household size of seven persons has been used to arrive at the overall population estimate of Damaturu urban area.

1.5.3 SOURCES OF DATA

(i) Reconnaissance Survey was carried out to identify borcholes, shallow/concrete wells, proposed dam site, the housing estates and the neighbouring settlements in order to assess existing water resource, demand, and supply within the study area.

(ii) Documents and Literature

Available literature on the subject matter was utilized in addition to documents from the various Government parastatals in Damaturu. Among them include documents from the Yobe State Water Board, Ministry of Economic Planning Lands and Survey, National Water Institute, Kaduna, National Water Rehabilitation Project, Damaturu, among others.

(iii) Maps and Diagrams

The Damaturu toporgaphic sheet number eighty (1:100,000) and Damaturu Development Plan (1:20,000) were combined to give detailed physical and landuse characteristics of the entire urban area. other maps include the Chad-Basin Formation, Damaturu Regional Map and rainfall distribution map of Yobe State.

1.5.4 QUESTIONNAIRE AND INTERVIEWS

Two sets of questionnaires were administered according to data required. Questionnaire 'A' was purely technical and was administered at Water Board while

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Questionnaire 'B' was administered on sampled households for information on demand and supply as well as satisfaction or otherwise with the water supply situation in the area. Questionnaire 'A' was to obtain data on the mode of operations, level of inter-agency interaction, problems encountered and general proposals.

Informal interviews with people, staff and professionals on water resource and supply was carried out continuously during the field work.

1.6.0 DATA PRESENTATION

1.6.1 GRAPHS AND TABLES

Graphs and tables were used to express the demographic characteristics as well as other aspects of the research findings such as existing demand, deficit and projections in the future.

1.7.0 CONCEPTS AND DEFINITIONS

1.7.1 Concept of Sustainability and Sustainable Development:

Sustainability refers to the desire to maintain the achievements of

development aspirations over time period. It is assumed that the stock of natural resources should not be allowed to decrease over-time, as such, there is need for a balance between development aspirations and appropriate levels of resource development and use.

1.7.2 **Sustainable Water Supply:**

Implies that consequent upon the existing water resource utilization, the natural stock of water resources should not be allowed to pollute or deplete, overtime, as such, there is need for a balance between development aspirations and appropriate level of water resource utilization.

1.7.3 **Conjunctive Water Supply:**

This involves the coordinated and planned development and operations of both surface and sub-surface water resources to meet requirements in a manner whereby water is conserved and optimal beneficial use is obtained. The concept is based on the hydrological linkage between surface and sub-surface water storage, where surface reservoir is used to impound and recharge depleting sub-surface storage. This process helps to moderate the surface water and in the same way minimize the dangers associated with Dam construction (Ayoade, 1988).

1.7.4 Partnership Strategy:

This refers to the process by which people as consumers and producers of utilities and services and as citizens influence the flow and quality of such utilities and services available to them UNCHS (1997).

1.7.5 Water Resource Planning and Management

While water resource management involves the overall planning of the development and utilization of water, water resource planning entails an orderly development and use of water resources to meet present and future demands (Ayoade, 1988).

CHAPTER TWO

REVIEW OF CONCEPTS AND APPROACHES TO PLANNING AND MANAGEMENT OF WATER SUPPLY

2.1 REVIEW OF RELEVANT LITERATURE ON URBAN WATER SUPPLY

The question of adequate quality drinking water supply has probably been one of the main issues in the struggle to achieve better living standard and economic development. That is why several efforts were made at different levels to contribute to understanding and achieving adequate supply of water in the country as well as other places.

Akintola, F. O. and Areola, O.O (1980) noted the incidence of water scarcity in Ibadan City and attributed it to low capital investment by Government to water corporation as well as poor distribution network. This situation created disproportionate and inadequate water supply in the town.

Similarly, Hamidu, I.B. (1988) in a study of Yola metropolis discovered spatial inequalities in domestic water supply, which he attributed to the distribution system, technical disabilities and lack of adequate financial commitment as well as skilled manpower as major management deficiencies.

Faniran, A (1985) in a study carried out in parapa area of Oyo State observed extreme water shortage in the dry season and attributed the problem to inadequate knowledge about available water resources at all levels of planning (ie local, regional or national) as well as lack of appropriate planning development and management strategies.

The above observation appeared similar to that of Ayoade, J.O. and Oyebande, L, (1978). The duo strongly observed that "perhaps the most water resource problem of the Nigerian environment is the control and effective utilisation of surplus seasonal water, both for areas where they fall as rain and for other needy areas. This involves the problem of comprehensive planning and operation of water development projects and adoption of conservation methods aimed at reducing avoidable losses and wastefull usage".

While the duo rightly attributed the problem of water shortage to lack of proper planning, they atttributed the problem of management to inadequate budgetary allocation by State and Federal Governmem to fund water corporations in the Country. Thus, they indicated that while budgetary allocation to water supply sector was increasing, its percentage share when compared to other sectors was reducing.

Table 2.1 **CAPITAL EXPENDITURE ON WATER SUPPLY SECTOR IN NIGERIA**

PLAN PERIOD	CAPITAL EXPENDITURE (=N=. M)	% OF TOTAL CAPITAL EXPENDITURE
1946 - 56	17.124	15.1
1955 - 60	35.000	7.1
1962 - 68	54.500	4.0
1970 - 75	103.400	5.0
1975 - 80	930.038	2.8

Source: Oguntoyinbo (ed) 1978.

Perhaps the study conducted by Aliyu, U.H. (1986) in Maiduguri Metropolis related the problem of inadequate water supply to climatic environment of the area. Thus, he attributed the problem to unreliability of rainfall to provide adequate water for the underground water source as well as the inability of the State to develop and utilise the water resources from Alo river.

In a similar work, Ahmed, H (1991) concluded that "availability of surface water resources in the entire Chad basin area wwas strictly seasonal, thus, currently only few towns have improved water supplies in the form of pipe- borne water or boreholes through Government assistance".

Findings (1996) highlighted on the imminence of water shortage in the entire Sub-Saharan African region and attributed the situation to water resource variability and demand, infrastructure and costs as well as dependency and subsidy.

One peculiar omission from the above submissions has been the failure to analyse and address squarely the important issue of demand for water in different sectors of urban areas particularly in almost all the above case studies; a position which forms part of this study. Moreover, inadequate funding has almost alwalys been observed as a bane to most water corporations. However, very little options have proved to provide lasting solution to the problem, most especially on a longterm sustainable basis.

2.2 REVIEW OF THEORETICAL APPROACHES AND STANDARDS

Planning, development and management of water resources has traditionally been the monopoly of water Resources Engineers who determine and adopt concepts, standards and criteria in urban water development schemes. This approach seems to be in appropriate as important factors like the spatial distribution and characteristics of population and landuse are ignored as vital inputs. In other words, the proposals of physical planners in detailing out the spatial distribution of landuses and population characteristics which are the primary determinants of water supply and demand are rarely given due analysis in favour of over all population

figures.

Recently, few master plans particularly the Federal Capital Development Authority (F.C.D.A) have evolved and incorporated some concepts which are based and relied on urban physical, social and economic characteristics for effective and sustainable water supply planning and management.

As Vagale (1969) observed that "planning of water supply scheme cannot be separated from the socio-economic and physical planning of towns and cities which the scheme is designed to serve. Thus, existing landuse pattern, network of roads and streets, density of households, household size and income, type and condition of buildings as well as form and structure of the urban area are the typical physical planning determinants of urban system on which planning of water supply depends upon".

2.2.0 CONCEPTS FOR PLANNING WATER SUPPLY IN URBAN AREAS

2.2.1 SEGREGATED/CATCHMENT CONCEPT

This applies to urban form characterized by weak centre with various satellite centres which conform to either linear or dispersed settlement patterns. Most such urban forms attract and adopt segregated/catchment water supply pattern. In other words, such satellite settlements either in the form of institutions or

industrial areas develop independent water supply sources to meet the demands of such catchment centres mostly through borcholes system.

2.2.2 INTEGRATED CONCEPT

This applies to urban form characterized by strong centre with weak satellite centres forming a concentric/cluster pattern. Such urban forms appear more economical and physically adaptable to a uniform or integrated water supply system using a single and extensive source such as dam. This applies to water supply system to large residential, commercial and public areas.

However, recently, the two concepts have been tackled through a comprehensive water supply scheme which integrates both surface and sub-surface sources.

2.3.0 TECHNIQUES OF FORECASTING WATER DEMAND

2.3.1 EXTRAPOLATIVE/TREND-BASED TECHNIQUE

This refers to projection of future water demand based on previous consumption data. This is easier to use and less demanding in terms of data requirements and inputs. Itsmajor short-coming is that it assumes that the factors

influencing demand in the past will remain the same in the future (Ayoade, 1984).

2.3.2 ANALYTICAL TECHNIQUE

This refers to where water consumption is disaggregated into major sectors/components of urban area. Future changes in each sector are predicted separately and then aggregated. (Parker and Penning-Rowsell 1980). In this technique, attempt is made to understand the reasons that may influence changes in water consumption in the future.

2.4.0 STAGES IN WATER SUPPLY PLANNING AND MANAGEMENT

The stages involve the estimation of water demand based on existing and proposed landuses as well as population size, distribution and other socio-economic characteristics. They include the forecast of growth trend and development of demand by these variables. This is followed by the identification of sources of water supply and their protection through standard setbacks or development free zones in case of borehole sites. After this stage, the next is planning the development of water from source to various landuses through efficient distribution system with minimum wastage.

The last two stages are the implementation and management of water project

followed by review and evaluation of strategies as may be required to accommodate changes and innovations.

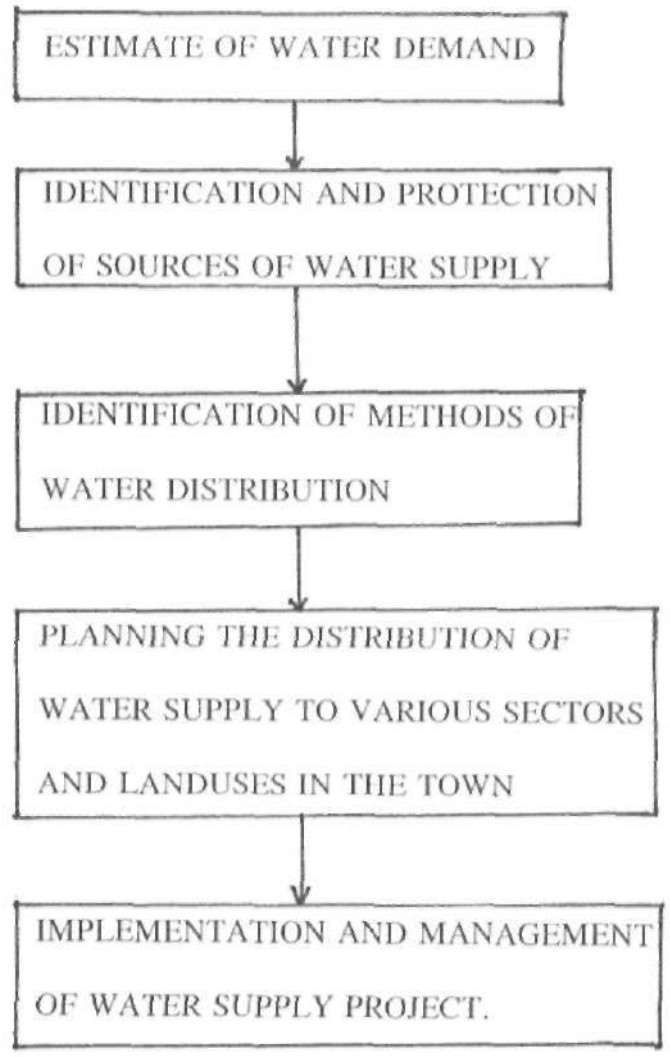
2.4.1 MANAGEMENT APPROACHES/STRATEGIES FOR WATER SUPPLY

Utility management strategies are generally based "either on free market profit oriented private companies, public corporations with subsidisation approach or public commercial corporation operating on cost recovery but without emphasis on profit making" (Isa, 1992).

Unlike other utilities, water supply management approaches have operated according to different economic policy approach. In Nigeria, Government accepts the 'provision of water as a service which is obligated to perform to the citizens'. National Development Plan (1970-1975).

Some water supply management strategies under this policy approach have been through public corporations with subsidization approach (Corporatisation). Water supply has been through Government agencies/boards which exist as social welfare institutions to provide subsidized water supply services to the people (Isa, 1992).

DIAGRAM SHOWING THE STAGES OF WATER SUPPLY PLANNING AND MANAGEMENT



Source: Ayoade, J.O (1980)

2.4.2 PARTNERSHIP STRATEGY FOR WATER SUPPLY MANAGEMENT

This has been defined as a process by which people - as consumers and producers of utilities and services, and as citizens, influence the flow and quality of such utilities services available to them UNCHS (1997). The approach as a management strategy embodies 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 utilities and services in general and water supply services in particular.

2.4.3 PARTNERSHIP APPROACHES

(a) Community-Based-Strategy: Relies on Community initiatives and the existing community-based organisations.

(b) Area-Based-Strategy: Activities are managed in this strategy by Government as Structured with regards to a particular area.

(c) Functionally-Based-Strategy: Activities are organised based on clearly designated areas of responsibility for each stakeholder/partner.

(d) Process-Based-Strategy: Activities are governed by government but the entire process of infrastructural services are on a city-wide scale (UNCHS, 1997).

2.4.4 CONSERVATION MEASURES OF WATER SUPPLY MANAGEMENT

This involves a whole host of different adjustments through: Control of evaporation loss from reservoirs, improved efficiency of distribution system, the elimination or reduction of wasteful use of water and under precarious conditions, the recycling of waste water.

2.5.0 WATER DISTRIBUTION PATTERNS

2.5.1 RADIAL/BRANCHED PATTERN

This is likened to the tree-branch which sprawl out in a 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, breakdown in any of the mains usually result in disrupting the whole supply to consumers over a large area. This pattern fits into segregated/dispersed urban form.

2.5.2 GRID/LOOPED PATTERN

This is a comprehensive effort to ensure efficient supply throughout the system even in events when one of the mains goes out of operations. The looped

system usually has a ring of mains to which the secondary mains are connected. The system is expensive to implement and requires considerable manpower for its operations. It is suitable in cluster/integrated urban form.

ASPECTS OF EXISTING WATER SUPPLY IN DAMATURU

3.1.0 ANALYSIS OF EXISTING POPULATION AND WATER SUPPLY IN DAMATURU

The size, distribution, density as well as socio-economic characteristics of population of Damaturu town as a rapidly urbanising state capital appear to be the dominant factors in determining existing and perhaps future water supply situation.

3.1.1 POPULATION SIZE

The fact that the 1991 Census nearly coincided with the time when Damaturu became a state capital has made it difficult to have an accurate population figure for that year, which will serve as a base for future population projections. This accounts for the need for other sources of information on the population of the town.

Preliminary stage report on urban water supply by consulint Nigeria limited (1972) projected the population of Damaturu town to 1991 as 52,033 with average annual increase of 5.29%.

Musa (1994) projected the population of Damaturu to 1997 as 80,579 with an annual growth rate of 5.5%.

The common observation about these studies inspite of being based on 1963 census was characterized by high rate of annual growth which could hardly be observed on the ground.

However, the 1991 census put the population of Damaturu urban area as 46,953 with an estimated annual growth rate of 2.83%. When projected to 1997, the population stands at about 55,512. This does not seem to be accurate either as annual increase rate of 2.83% might not be able to give accurate high rate of population increase owing to the rapid influx of public servants and service workers as a result of state creation and subsequent change of status of the town.

TABLE 3.1: 1963 AND 1991 CENSUS FIGURES FOR DAMATURU AS COMPARED TO 1997 HOUSEHOLD SURVEY

YEAR	1963 CENSUS	1991 CENSUS	HOUSEHOLD SURVEY (1997)
1991	57,373	46,953	-
1997	80,579	55,512	78,728
2000	94,620	60,360	91,138
2005	123,664	69,398	113,577
2010	161,625	79,791	138,184

Source ; National Population Commisision (1991)
Federal Office of Statistics (1989)
Field Survey (1997)

One major cause for the difference in figures between 1963 and 1991 Census periods has been the rate of growth. Rate of population growth being a factor of natural increase and migration has constituted a difficult position to estimate in most developing countries, thereby making population figures a socio-political issue. While information on natural increase is rarely obtained, rate of migration is totally hardly measured. Therefore population census figures are never agreed upon among communities, States and /or regions.

The contradiction between 5% and 2.83% rates of growth for 1963 and 1991 census periods respectively was based on the expectation of differnt socio-economic growth indices at two different times. While the former was conducted when expectation for socio-economic growth was high, the latter was conducted at a time when both factors of migration and natural increase were moderate. This has made it necessary to apply some research technique that will provide an estimate for the year of research by household survey, since both 1963 and 1991 census figures for 1997 were based on estimated projections on different expected rates of growth.

Therefore, the study resolved to acquire and estimate the population of Damaturu urban area through a field survey using a systematic Random - sampling technique. The sample frames are categorised into three: Damaturu old town, Neighbouring settlements and groups of housing estates which are further broken

down into wards. A total of 232 households representing (2%) of the estimated number of households in Damaturu have been sampled with an average household size of seven persons in the Damaturu old town and neighbouring settlements while an average of six persons for the Housing Estates.

TABLE 3.2: **ESTIMATED POPULATION OF DAMATURU URBAN AREA**

Sectors	Estimated Number of Households	Estimated Household Size	2% of Whole	Estimated Population
Damaturu Old Town	7392	7	148	51,744
Housing Estates	2024	6	41	12,144
N. Settlements	2120	7	43	14,840
Total	11530		232	78,728

Source: Field Survey (1997)

3.1.2 POPULATION DISTRIBUTION IN DAMATURU URBAN AREA

Population distribution among the three sectors of the Damaturu urban area is given in more detail in Tables 3.3 and 3.4

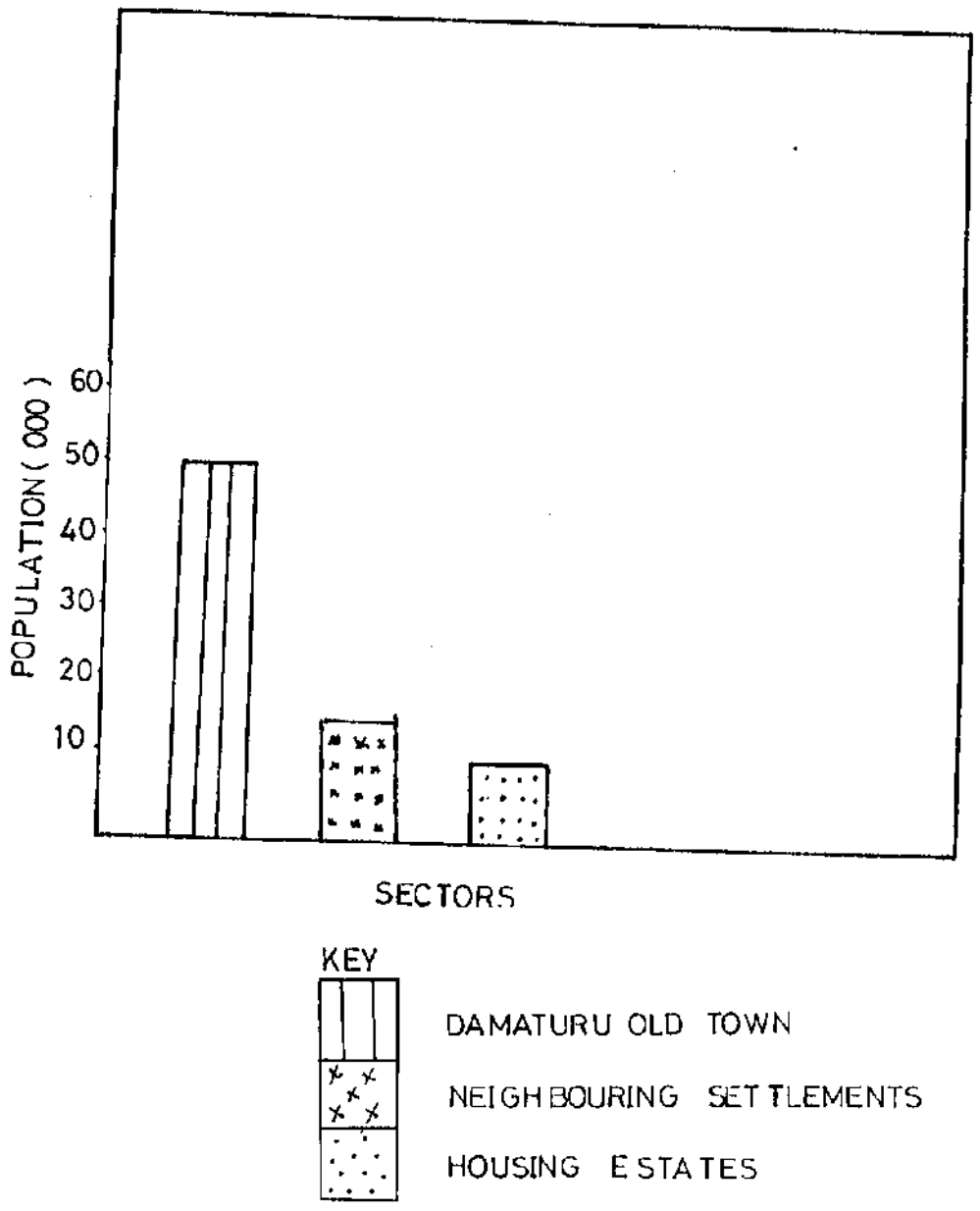


FIG. 3.1 POPULATION DISTRIBUTION IN DAMATURU URBAN AREA

ABDU Y
M. Sc. II (1996)

SOURCE: FIELD SURVEY (1997)

TABLE 3.3: ESTIMATED POPULATION BY WARDS IN DAMATURU OLD TOWN

WARDS	HOUSEHOLDS	HOUSEHOLD SIZE	2% OF WHOLE	POPULATION
ABASHA	1223	7	24	8561
GWANGE	1189	"	24	8323
BINDIGARI	1074	"	21	7518
HAUSARI	986	"	20	6902
NJIWAJI	1086	"	22	7602
AJARI	995	"	20	6965
NAYI-NAWA	839	7	17	5873
TOTAL	7392	7	148	51744

Source: Field Survey (1997)

The Survey included those neighbouring settlements within 15 kilometres radius from Maiduguri Junction in Damaturu town.

TABLE 3.4 **ESTIMATED POPULATION OF NEIGHBOURING SETTLEMENTS WITHIN DAMATURU URBAN AREA.**

SETTLEMENTS	HOUSEHOLDS	HOUSE SIZE	2 % OF WHOLE	POPULATION
MALAMATARI	346	7	7	2422
DAMAKASO	288	"	6	2016
MAISANDARI	327	"	7	2289
PAMPAMARI	159	"	3	1113
SABON-KASA	217	"	4	1519
DIKUMARU	245	"	5	2184
SINDIRI	226	"	5	1582
KASESA	312	7	6	1715
TOTAL	2120	7	42	14,840

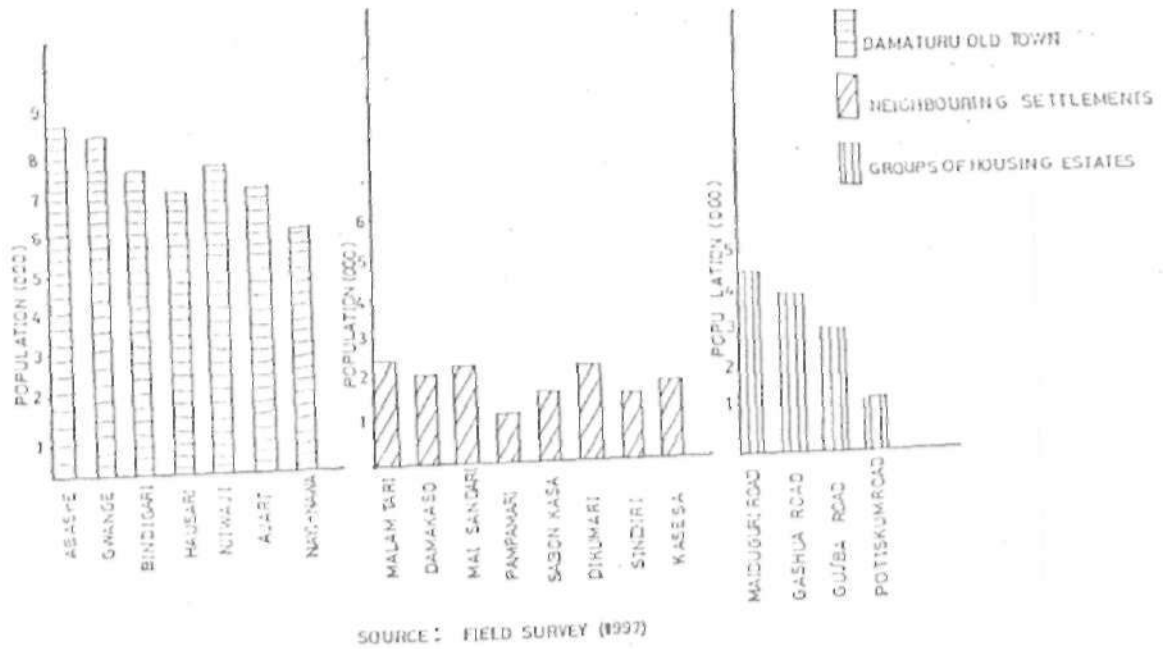
Source: Field Survey (1997)

The survey categorized the housing estates into groups along the four major roads in Damaturu town.

TABLE 3.5 ESTIMATED POPULATION OF HOUSING ESTATES

ESTATES	HOUSEHOLDS	HOUSEHOLD SIZE	2 % OF WHOLE	POPULATION
MAIDUGURI ROAD	720	6	14	4320
GASINA ROAD	620	"	13	3720
GUJBA ROAD	484	"	10	2904
POTISKUM ROAD	200	6	4	1200
TOTAL	2024	6	41	12,144

Source: Field Survey (1997)



SOURCE: FIELD SURVEY (1997)

FIG. 3.2 POPULATION DISTRIBUTION IN DAMATURU URBAN AREA

ABDU Y.
M. Sc. II(1998)

3.2.0 EXISTING WATER SUPPLY IN DAMATURU

The existing water supply was analysed on the basis of the three major population groups/sectors that have now formed the Damaturu urban area as described above. This was in view of their differing water demands due to their socio-economic disparities.

In line with this, the survey discovered three major sources of water in the area as: Boreholes, Shallow/Concrete Wells and Seasonal Streams/Ponds. Besides the boreholes, both shallow/concrete open wells and ponds appeared to be seasonal water sources, and people who depend on these sources have to trek long distances or get supply from water vendors or tankers for their domestic uses.

However, there were about 22 boreholes and 31 shallow/concrete wells in the declared urban area of Damaturu. Based on the average of 216,000 liters per boreholes per day, the boreholes were estimated to supply about 4,752,000 liters per day (YSWB 1997), while the shallow/concrete wells were estimated to supply about 15,500 liters per day giving an overall estimated 496,000 liters per day. Thus, the overall water supply from these two sources stood at 5,248,000 liters per day.

The distribution of both boreholes and wells differed among the three population groups giving rise to a disproportionate supply. Thus, table 3.5 gives the distribution of boreholes and wells within Damaturu urban area.

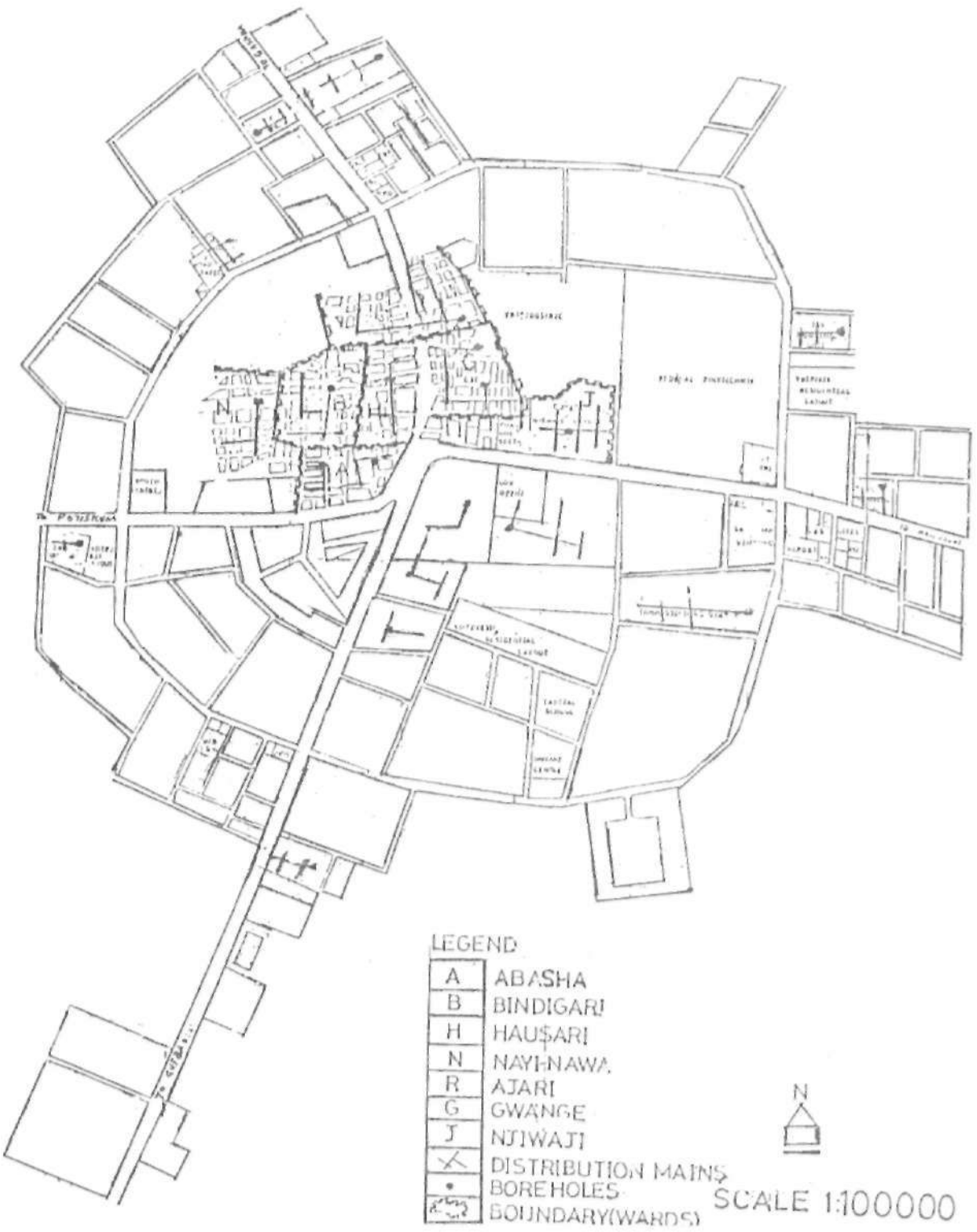


FIG. 3.3 EXISTING WATER DISTRIBUTION IN DAMATURU(1997)

SOURCE: PLANNING DIVISION, DEPT. OF LAND SURVEY(1997

ABDU Y.
M. Sc. II(1998)

TABLE 3.6 **DISTRIBUTION OF BOREHOLES AND WELLS WITHIN DAMATURU URBAN AREA**

SECTORS	NO OF BOREHOLES	AV.SUPPLY (L/D)	NO OF WELLS	AV.SUPPLY (L/D)	TOTAL SUPPLY
DAMATURU OLD TOWN	9	1,944,000	9	139,500	2,083,500
HOUSING ESTATE	10	2,160,000	-	-	2,160,000
N. SETTLEMENTS	3	648,000	32	356,500	1,004,500
TOTAL	22	4,752,000	41	496,000	5,248,000

Source: Field Survey (1997)

For a detailed understanding of water supply situation in the area, the three sectors of the urban area have to be further analysed.

3.2.1 DAMATURU OLD TOWN

This constituted the major population group in the urban area (66%). From what subsequent findings will reveal, this area experiences serious shortage of water supply with average per capita of 40 liters per person per day.

Table 3.6 shows the distribution of available sources of water in this part of the town.

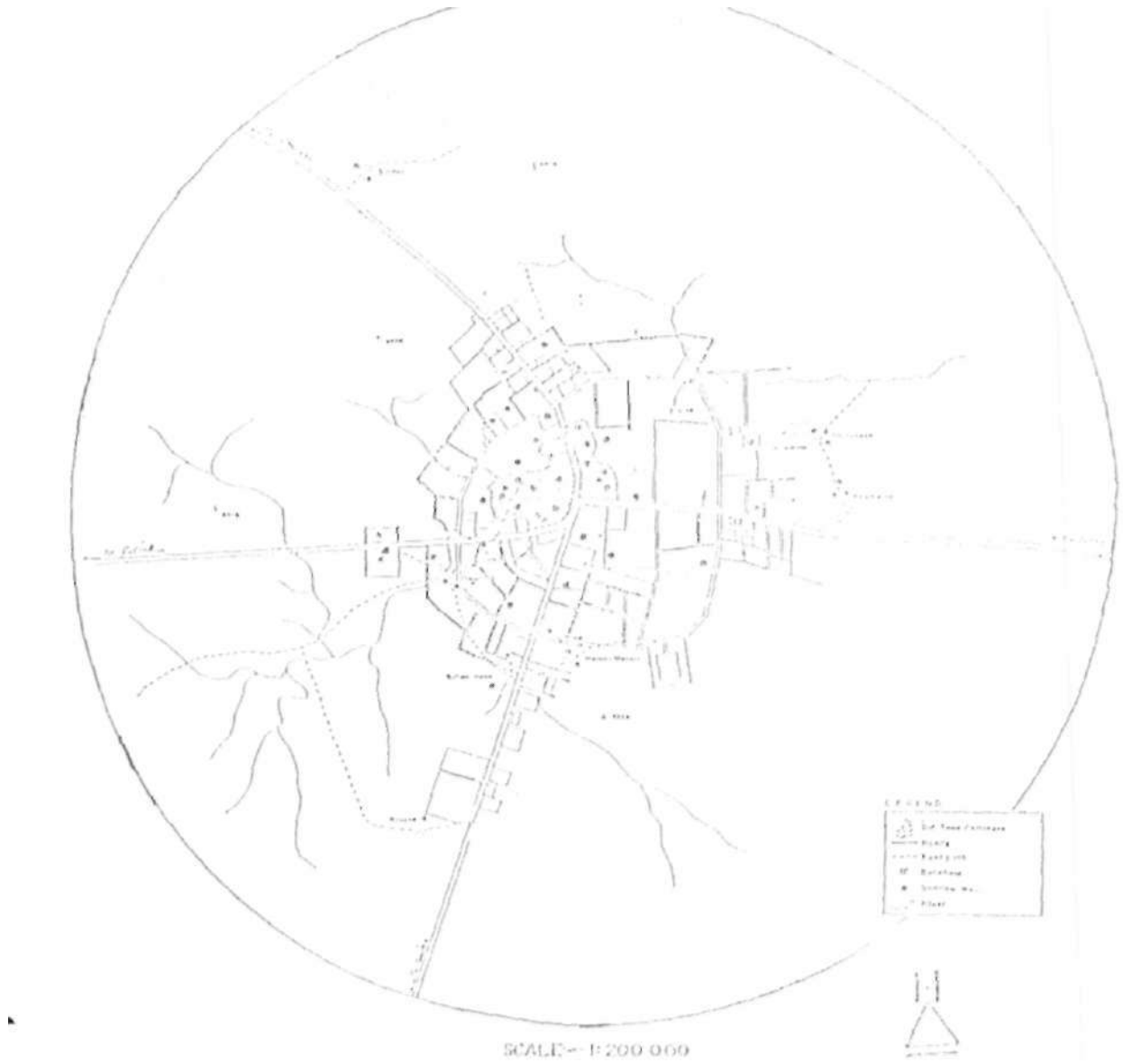


FIG. 3.4 DISTRIBUTION OF BOREHOLES AND WELLS IN DAMATURU TOWN AREA

ABDU Y
Msc II 1998

SOURCE: PLANNING DIVISION, DEPT. OF LAND SURVEY (1997)

TABLE 3.7 **DISTRIBUTION OF BOREHOLES AND WELLS AND THEIR ESTIMATED DISCHARGES BY WARDS IN DAMATURU OLD TOWN.**

WARDS	NO OF B-H	AV. SUPPLY (L/D)	NO OF WELLS	AV SUPPLY (L/D)	TOTAL SUPPLY	PER CAPITA
ABASHA	2	432,000	1	15,500	447,500	52
GWANGE	2	432,000	1	15,500	447,500	54
BINDIGARI	1	216,000	1	15,500	231,500	31
HAUSARI	1	216,000	1	15,500	231,500	34
NJIWAJI	1	216,000	2	31,000	247,000	33
AJARI	1	216,000	1	15,500	231,500	33
NAYI-NAWA	1	216,000	2	31,000	247,000	42
TOTAL	9	1,944,000	9	139,500	2,083,500	*40

AV: Average, BH: Boreholes, L/D: Liters/Day *Average per capita.

Source: Field Survey (1997)

One basic observation about water supply in this area was whether supply was through house connection, shallow/concrete wells, public stand-pipes, water-vendors or both and the extent to which these sources were being shared among households. Thus, table 3.7 expressed the density of households and people per any of the above sources in the various wards or neighbourhoods.

TABLE 3.8 **ESTIMATED PROPORTION OF SHARING WATER SUPPLY SOURCES IN DAMATURU OLD TOWN**

WARDS	NO H-H	2% OF WHOLE	WELLS	S-P	W.V	H-C
ABASHA	1223	24	2	11	6	5
GWANGE	1189	24	3	10	5	6
BINDIGARI	1074	21	3	8	5	5
HAUSARI	986	20	2	7	6	5
NIHWAJI	1086	22	5	7	5	5
AJARI	995	20	2	8	5	5
NAYI NAWA	839	17	3	6	3	3
TOTAL	7392	148	22 (15%)	57 (38%)	35 (24%)	34 (23%)

H-H = HOUSEHOLDS, W-V = WATER VENDORS

H= CONNECTION: HOUSE-CONNECTIONS

Source: Field Survey (1997)

From the above table, it was deduced that only 34 sampled households representing 1700 households (23%) in the old Damaturu town were connected with pipe borne water, while the remaining 114 sampled households representing 5,692 households (77%) either depend on public stand-pipes or water vendors for their domestic water supply.

This implies that out of the Estimated 51,744 people in old Damaturu town, only 11,900 people derive pipe borne water within their compounds while the remaining 39,844 people derive water through other means.

The implication of this was that supply had to be complemented through other means which might be contaminated.

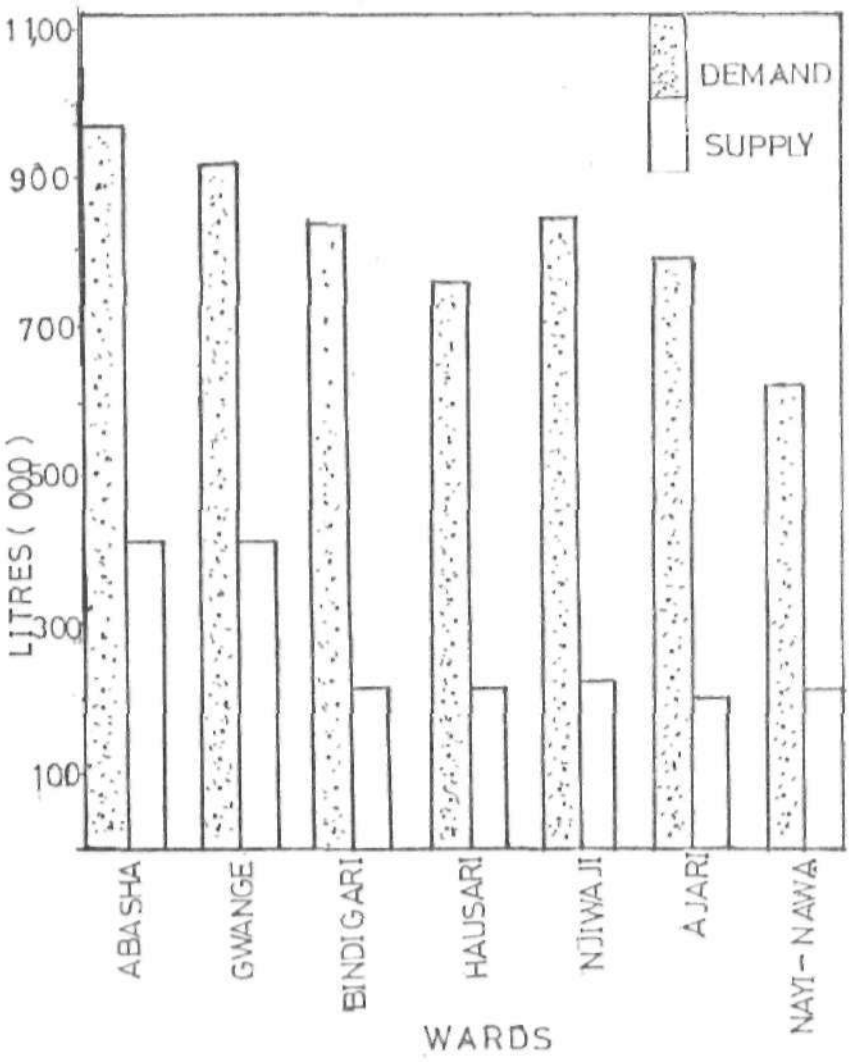


FIG 3.5 ESTIMATED PROPORTION OF WATER DEMAND AND SUPPLY BY WARDS IN DAMATURU OLD TOWN

ABDU Y.
M. Sc II(1998)

SOURCE: FIELD SURVEY (1997)

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3.2.2 NEIGHBOURING SETTLEMENTS

There were eight smaller settlements that have become part of the Damaturu urban area. They comprised of an estimated number of 2120 households with about 14,840 estimated number of people in all (i.e 19%) of the total population of Damaturu urban area. Three of these settlements were within walking distance to boreholes sites while the remaining either depend on shallow/concrete wells or seasonal streams/ponds as the case may be for water supply. This area experiences relative shortage of water supply with estimated average per capita of 63 liters per person per day. Out of the 32 shallow/concrete wells, 9 were not functioning while the remaining 23 produces about

TABLE 3.9: **DISTRIBUTION OF BOREHOLES AND WELLS AND THEIR ESTIMATED DISCHARGES IN NEIGHBOURING SETTLEMENTS.**

SETTLEMENTS	NO OF B-H	AV.SUPPLY (L/D)	NO OF WELLS	AV SUPPLY (L/D)	TOTAL SUPPLY	AVERAGE PER CAPITA
MALAMATARI	1	216,000	4	Abandoned	216,000	89
DAMAKASO	-	-	6	93,000	93,000	46
MAISNDARI	1	216,000	2	Abandoned	216,000	94
PAMPAMARI	-	-	3	46,500	46,500	42
SABON KASA	-	-	4	62,000	62,000	41
DIKUMARI	1	216,000	3	Abandoned 77,500	216,000	98
SINDIKI	-	-	5	77,500	77,500	49
KASESA	-	-	5		77,500	45
TOTAL	3	648,000	32	356,500	1,004,500	*63

B H = BOREHOLES, (L/D) = LITERS/DAY, AV= AVERAGE

* AVERAGE PER CAPITA

Source: Field Survey (1997)

While there were no house-connections in the entire neighbouring settlements, only 13 of the sampled houses representing 640 households (30.2%) derive water from stand-pipes, seven (7) of the sampled households representing 346 households (16.3%) buy water from vendors. The remaining 23 sampled household representing 1134 household (53.5%) rely on shallow/concrete wells for their domestic water supply.

When this was related to the entire population of the neighbouring settlements about 7938 people (53.5%) relied on shallow/concrete wells, about 4,480 people (30.2%) derived water from stand-pipes, about 2,422 people (16.3%) buy water from vendors. No household was connected with pipe borne water.

TABLE 3.10 : **ESTIMATED PROPORTION OF SHARING WATER SUPPLY SOURCES IN NEIGHBOURING SETTLEMENTS**

SETTLEMENTS	NO OF H-H	2% OF WHOLE	WELLS	STAND-PIPE	W-V	N-C
MALAMATARI	346	7	1	5	1	-
DAMAKASO	288	6	5	-	1	-
MAISANDARI	327	7	2	4	1	-
PAMPAMARI	159	3	2	-	1	-
SABON-KASA	217	4	3	-	1	-
DIKUMARI	245	5	1	4	-	-
SINDIRI	226	5	4	-	1	-
KASESA	312	6	5	-	1	-
TOTAL	2120	43	23 (53.5%)	13 (30.2%)	7 (16.3%)	

Source: Field Survey (1997)

3.2.3 HOUSING ESTATES

These were scattered in different parts of the urban area. For ease of analysis, the study grouped them according to their locations along the four major roads. They comprised of high, low and medium categories. According to Ministry of Works and Housing Damaturu (1997), there were a total of 2024 units with an estimated population of about 12,144 people. Among the three sectors of the urban area, the Housing Estates enjoyed an effective water supply, because there were 10 boreholes with an estimated total supply of 2,160,000 liters per day.

There were no shallow/concrete wells.

TABLE 3.11: **DISTRIBUTION OF BOREHOLES AND THEIR ESTIMATED DISCHARGES IN HOUSING ESTATES.**

ESTATES	NO OF B-H	AV SUPPLY (L/D)	POPULATION	AV. PER CAPITA
MAIDUGURI ROAD	3	648,000	4,320	150
GASHUA ROAD	4	864,000	3,720	232
GUJBA ROAD	2	432,000	2,904	148
POTISKUM ROAD	1	216,000	1,200	180
TOTAL	10	2,160,000	12,144	*178

* AVERAGE PER CAPITA

Source: Field survey (1997)

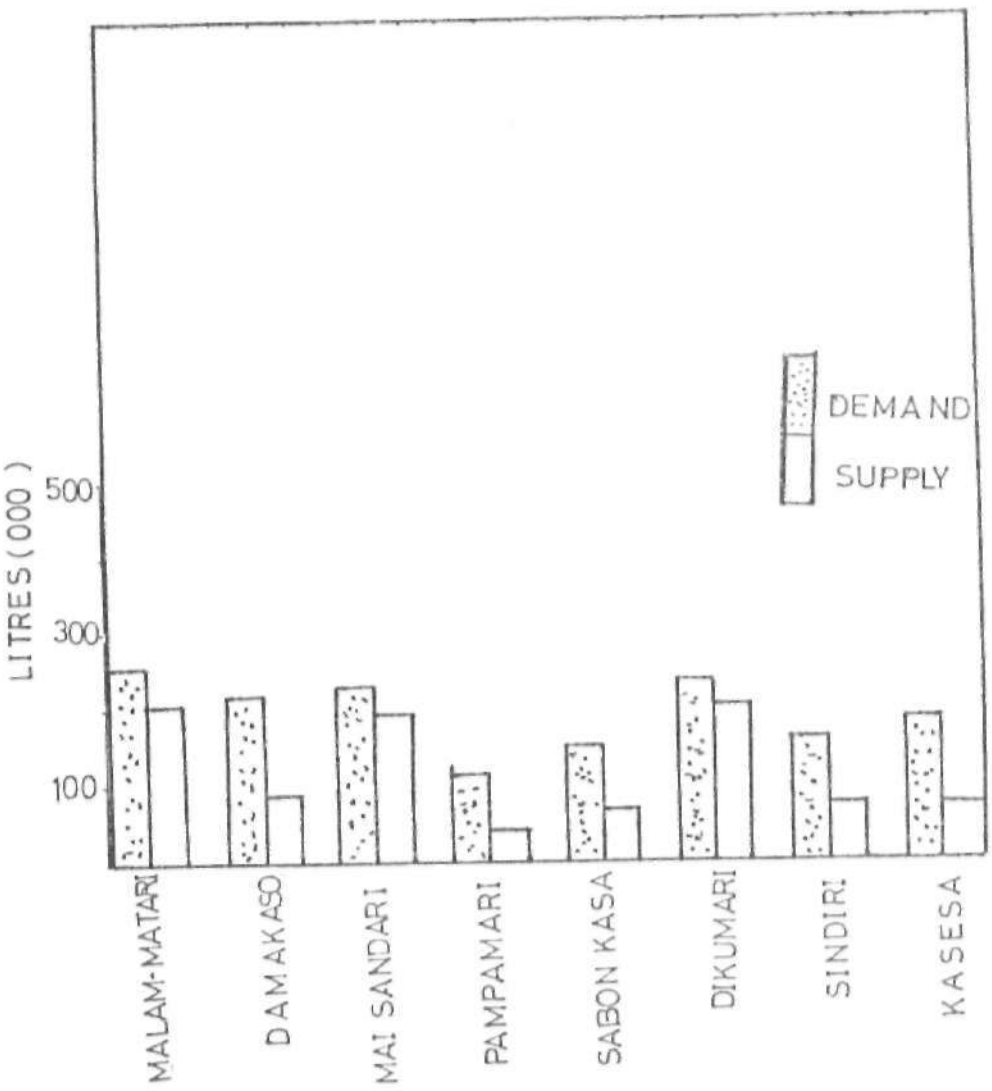
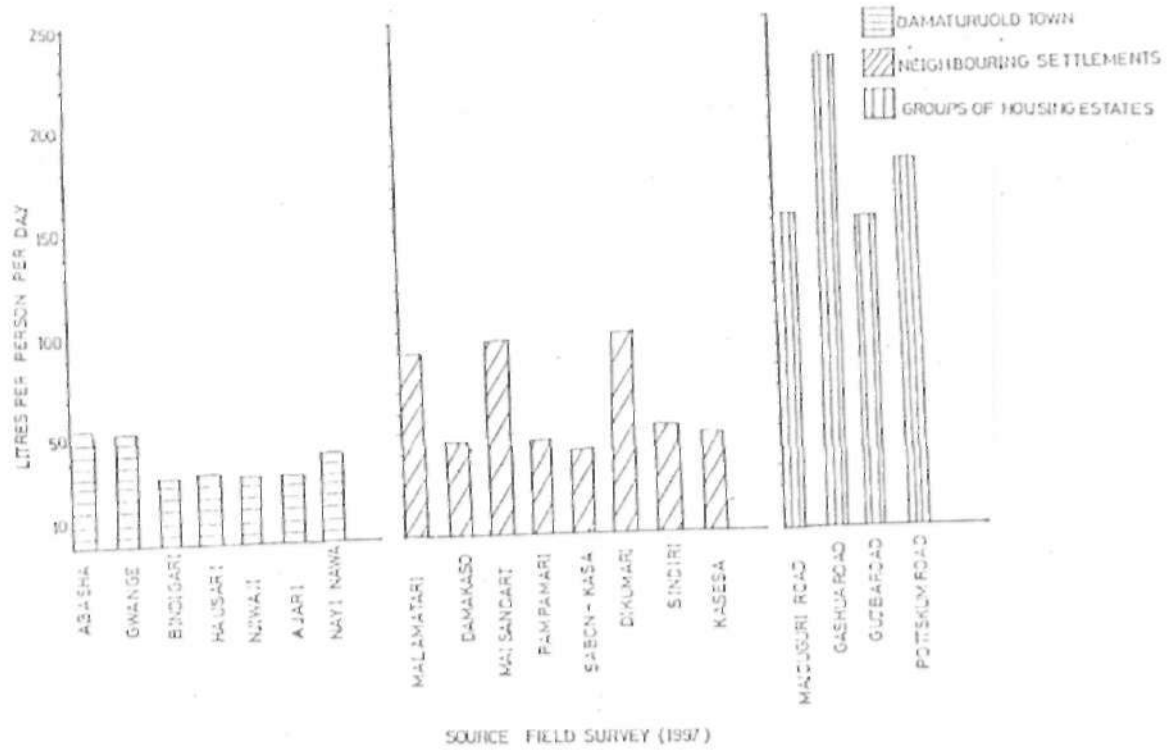


FIG.3.6. ESTIMATED PROPORTION OF WATER DEMAND AND SUPPIY IN NEIGHBOURING SETTLEMENTSIN DAMATURU URBAN AREA

ABDU Y.
M. Sc II(1998)

SOURCE: FIELD SURVEY (1997)



SOURCE FIELD SURVEY (1997)

FIG.3.7 ESTIMATES OF PER CAPITA WATER SUPPLY IN DAMATURU URBAN AREA

ABDU Y.
M. Sc. II(1998)

Among these housing estates, there were some which existed before the creation of Yobe State. They were constructed by the then Borno State Ministry of Works. Out the total Units, about 165 were connected with pipe borne water supply. Table 3.11 shows the number of units connected.

TABLE 3.12 PROPORTION OF CONNECTED HOUSES AMONG THE HOUSING ESTATES

ESTATES	NO OF H-H	POPULATION	STAND-PIPE	H-C	DEFICIT
MAIDUGURI ROAD	720	4320	8	720	-
GASHUA ROAD	620	3720	6	570	50
GUJBA ROAD	484	2904	5	369	115
POTISKUM ROAD	200	1200	4	200	- -
TOTAL	2024	12.144	23	1859 (92%)	165 (8%)

Source: Field Survey (1997)

On the whole, Table 3.12 below summerised the existing water supply in Damaturu urban area.

TABLE 3.13: SUMMARY OF EXISTING WATER SUPPLY IN DAMATURU URBAN AREA.

SECTORS	ESTIMATED POPULATION	WATER SUPPLIED	AV. PER CAPITA	*COMMENT
DAMATURU OLD TOWN	51,744	2,083,500L/D	40L/P/D	VERY INADEQUATE
HOUSING ESTATES	12,144	2,160,000 L/D	178L/P/D	ADEQUATE
NEIGHBOURING SETTLEMENTS	14,840	1,004,500 L/D	68L/P/D	INADEQUATE
TOTAL	78,728	5,248,000		

*Based on 115 Liters/person/day accepted in the Fourth National Development Plan (1980-1985).

3.3.0 SOCIO-ECONOMIC CHARACTERISTICS OF HOUSEHOLD

This was viewed as the social position and/or the spending power of the households for utilities and services in Damaturu urban area. The social position held by the households may be portrayed as occupation, education and family size while the spending power implies the income which may include cash and material assets of the households. In other words, the religious belief of the household head, household size, level and type of education of household members, occupation and income of household and the ownership of water supply sources used generally constitute the socio-economic characteristics of the household in relation to water supply.

3.3.1: HOUSING-TYPE IN DAMATURU URBAN AREA.

There are three major house-types in Damaturu Urban area. The traditional house-type which predominates in the Damaturu old town was of two types. The traditional mud-brick type constitutes the dominant house type in Damaturu old town. The traditional thatch and mud constitutes the major house-type in the neighbouring settlements. Most of these house-types are large compounds normally containing various households using a single toilet and a single water source.

The housing Estates Constituted another category of house-type which were modern concrete made characterized by water system such as showers, water closets, flush-toilets and taps. This category of houses were grouped along the four major roads in Damaturu town.

3.3.2 LEVEL AND TYPES OF EDUCATION AND FAMILY SIZE

Two types of education predominate in the Damaturu urban area. Koranic and western types of education. Residents of the old Damaturu town have largely Koranic education. There were more than 30 traditional Koranic schools in this part of the town with average population between 30 - 70 students in each. There were few Islamiyya Schools in Gwange and Bindigari wards all utilising primary schools premises.

The average household size in the old Damaturu town and the neighbouring settlements was estimated at 7 persons. Largely people were farmers and petty traders, shoe-shiners, water vendors and civil servants.

The housing estates were predominantly occupied by elites ranging from intermediate to senior civil servants. The residents attained western type of Education with various qualifications and working experiences. The average household size in most of the housing estates stands at six persons per household. All the housing estates have a single Islamiyya school each.

3.3.3: HOUSEHOLD OCCUPATION AND INCOME

Being one of the socio-economic aspect that influence water consumption, the study discovered three dominant income levels in Damaturu urban area. The ability to afford utilities and services depends on the occupation and income of the households.

It was discovered that secured employments and engagements in other economic activities have improved income levels of most residents. Thus, about 53.1% (24.6% Males and 28.5% Females) earn between less than =N=500-=N=1000 per month. This represented the low income group which when supplemented with food crops grown by individuals and occasional incomes can

afford water rates per month per single house tap.

About 40.6% (26.9%) Males and 13.7% Females) fall within the medium income groups with earnings between =N=1001 - =N=3,500 per month. This was largely civil servants.

It was estimated from the daily expenditure that the lowest monthly household expenditure on water was =N=100 and the highest amount was =N=1,500.

The computed average monthly water bill that domestic users were willing to pay per month per household was =N=120 with range between =N=60 to =N=300. Both actual potential costs were higher for hospitals, restaurants, hotels, small-scale industries e.t.c. This contrasts the amount paid as water bill to the Board which varies from =N=10 to =N=200.

3.3.4: EXISTING LANDUSES IN DAMATURU URBAN AREA.

Population increase has occasioned growth in the size of urban activities which are translated over space. From 1991 to 1997, Damaturu urban area has grown to occupy a built-up area of about 2879.20 hectares. The developed area was about 2054.06 hectares (71.4%) while vacant land was about 825.14 hectares (28.6%). Being the largest landuse, residential area occupy about 51,04%, followed by public and semi public 29.34%, Roads/Streets 6.08%, industrial 3.42% and commercial 3.41%.

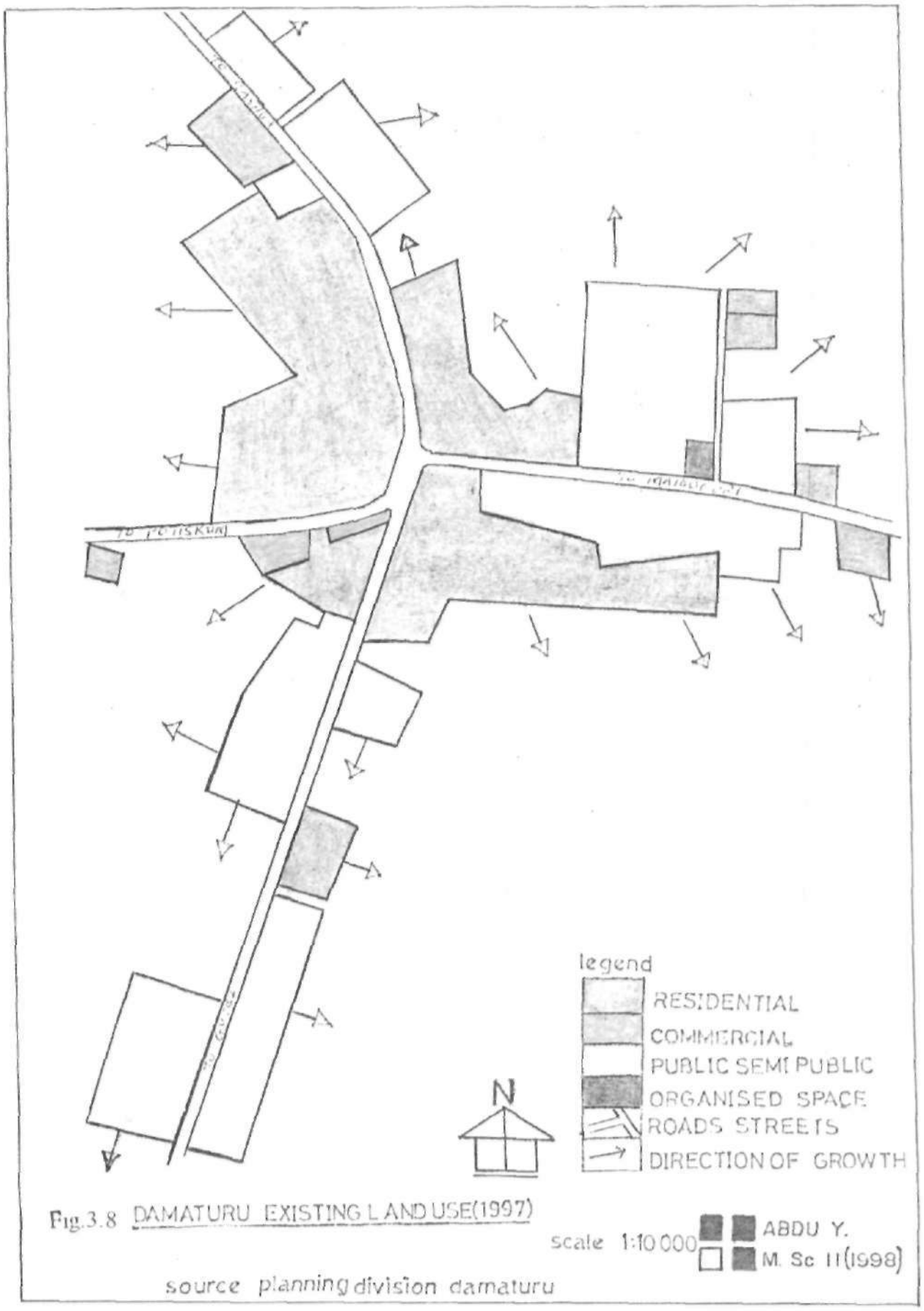


Fig.3.8 DAMATURU EXISTING LAND USE(1997)

TABLE 3.14 EXISTING LANDUSES IN DAMATURU URBAN AREA.

LAND USES	AREA (Hectre)	%
RESIDENTIAL	1048.45	51.04
COMMERCIAL	70.05	3.41
INDUSTRIAL	70.20	3.42
PUBLIC/SEMI-PUBLIC	602.59	29.34
ORGANISED OPEN SPACE	45.78	2.23
ROADS STREETS	124.89	6.08
OTHERS	92.10	4.48
TOTAL	2054.06	100

Source: Field Survey (1997)

3.4:0 THE COST OF EXISTING WATER SUPPLY IN DAMATURU

Water supply projects are generally capital intensive in nature. Declining government's subvention to water Agencies has been one significant bane towards effective and sustain able water supply in the country.

The survey, however, discovered that while revenue generated by Yobe State Water Board in Damaturu town rarely exceeds =N=60,000 per month (about =N=720,000 per year), the Board expends about =N=12,894,980 annually to provide water in Damaturu. YBWB (1997). The flat rate of =N=15 per single house tap has made it difficult for the

Board to raise any substantial revenue that can even repair the grounded vehicles of the Board (See Appendix I).

3.5: EXISTING ESTIMATED WATER DEMAND IN DAMATURU URBAN AREA

Water consumption per head has been discovered to be dependent upon the socio-economic characteristics of the population such as, housing type, family structure, household size and income among others. Thus in the absence of any industrial activity in the whole area of study, the perdominsant water consuming activity has been domestic/ residential which can only appropriately assessed by the per capita of the population.

In neighbouring Settlements, the per capita demand for water was discovered to be lower compared to Damaturu old town and housing Estates due to traditional housing types which characteristically demand less water.

Therefore, in order to estimate existing demand for pipe-borne water supply in the study area, estimates of the per capita water consumption of the sampled households of between 90-140 litres as well as the national per capita of 115 litres were considered and in the end, 115 litres per head was adopted.

Table 3.15 ESTIMATED EXISTING DEMAND FOR PIPE-BORNE WATER SUPPLY IN DAMATURU URBAN AREA

SECTORS	AVERAGE PER CAPITA	POPULATION	DEMAND	SUPPLY	ACTUAL ESTIMATED DEMAND
D.T.O.T	115	51,744	5,950,560	2,083,500	3,867,060
H.E.	115	12,144	1,396,560	2,160,000	OVER- SUPPLY
N.S	115	14.840	1,706,600	1,004,500	702,100
TOTAL		78,728	9,053,720	5,248,000	4,569,160

NOTE: D.T.O.T - Damaturu Old Town

3.5.1 : COST OF MEETING EXISTING WATER DEMAND IN DAMATURU URBAN AREA

In order to meet the existing demand for pipe- borne water supply in Damaturu urban area (4,569,160 L/D), about 21 boreholes were needed. Considering the average cost of drilling and maintaining a borehole (=N= 3.2m), about =N=67.2 million was needed to meet-up the present demand for water in Damaturu Urban area.

3.6.0 PROJECTEED WATER DEMAND IN DAMATURU URBAN AREA TO THE END OF THE PLANNING PERIOD (2010)

In order to forecast pipe-borne water demand for the planning period,

analytical technique was adopted. In this technique, water consumption was disaggregated into two major components of domestic and industrial demands. Future increases in each of these components were predicted and then aggregated to obtain an overall water demand for the entire urban area. Factors likely to influence these major components were identified and their effects assessed.

3.6.1 DOMESTIC WATER DEMAND FORECAST IN DAMATURU URBAN AREA

Residential water demand forecast mostly depends on trends in population growth and characteristics as well as socio-economic situation.

POPULATION GROWTH TREND AND PROJECTION FOR DAMATURU URBAN AREA

After considering the national rates of population growth of 5.5% and 2.83% for 1963 and 1991 respectively, and 5% rate of urban growth for the same year, the study approached the trend from the previous years since when the town became the state capital in 1991. Between 1991 to 1994, average rate of annual population growth of Damaturu was estimated between 6.5 -7%. However, between 1995 to 1997, the rate of growth started to decline between 6% to 5.5% particularly when the civilian administration was halted. Musa (1994)

Based on this trend, the rate of growth of 5% was adopted between 1997 - 2000, 4.5% growth rate between 2001 - 2005 and 4% growth rate between 2006 - 2010.

TABLE 3.16 DOMESTIC WATER DEMAND ON THE BASIS OF POPULATION PROJECTION FOR DAMATURU URBAN AREA

YEARS	2000		2005		2010	
SECTORS	POPN	DMD	POPN	DMD	POPN	DMD
DTOT	59,900	6,888,500	74,648	8,584,520	90,821	10,444,415
H.E.	14,059	1,616,785	17,521	2,014,915	21,317	2,451,455
N.S.	17,179	1,975,585	21,408	2,461,920	26,046	2,995,290
TOTAL	91,138	10,480,870	113,577	13,061,355	138,184	15,891,160

In order to verify the demand for water, the study has estimated water demand from grassroots levels. In this way, Figure 3.17 indicated the estimated proportions of both existing demand and supply of water in different wards in Damaturu old town.

While table 3.17 shows the estimated number of boreholes required to meet the present demand in Damaturu old town.

TABLE 3.17: ESTIMATED NUMBER OF BOREHOLES TO MEET THESE DEMANDS IN DAMATURU OLD TOWN

WARDS	EXISTING WATER SUPPLY	EXISTING WATER DEMAND	DEFICIT	AVERAGE BOREHOLES DISCHARGE	NUMBER OF BOREHOLE REQUIRED
ABASHA	447,500	984,515	537,015	216,000	2
GWANGE	447,500	957,148	509,645	"	2
BINDIGARI	231,500	864,570	663,070	"	3
HAUSARI	231,500	793,730	562,230 627,230	"	3
NJIWAJI	247,000	874,230	569,375	"	3
AJARI	231,500	880,975	328,395	"	4
NAYINAWA	247,000	675,395		216,000	1
TOTAL	2,083,500	5,950,560	3,867,060	216,000	18

Source: Field Survey (1997)

Similarly, the study further estimated water demand in the neighbouring settlements. (See Table 3.6) But in the same way, table 3.18 shows the estimated number of boreholes to meet such demands accordingly.

TABLE 3.18 ESTIMATED DEMAND FOR WATER AND NUMBER OF BOREHOLES TO MEET THESE DEMAND IN THE NEIGHBOURING SETTLEMENTS

SETTLEMENTS	EXISTING WATER SUPPLY	EXISTING WATER DEMAND	DEFICIT	AVERAGE BOREHOLE DISCHARGE	NUMBER OF BOREHOLES REQUIRED
[illegible] AMATARI	216,000	278,530	62,530	216,00	-
[illegible]AMEASO	[illegible]	231,840	138,840	"	1
[illegible]AMATARI	216,000	263,235	47,235	"	-
[illegible]	[illegible]	127,995	81,095	"	-
SABONKASA	[illegible]	174,685	132,685	"	1
DIKUMARI	216,000	251,160	35,160	"	-
SINDIRI	77,500	181,930	104,430	"	-
KASESA	77,500	197,225	319,725	216,000	1
TOTAL	1,093,500	1,706,600	702,300	216,000	3

Source: Field Survey (1997)

3.6.2: INDUSTRIAL WATER DEMAND FORECAST IN DAMATURU URBAN AREA

Since 1991 wheen the State was created, several efforts have been made to influence industrials take-off in the State as a whole and in Damaturu in particular.

The fact that the entire state inherited only two industries at Nguru represents a serious case for rapid development. It is for this reason that at the North-eastern States trade fairs in Maiduguri (1995), Yola (1996) and Damaturu (1997) various raw materials found in the state were displayed to motivate private investors to come and set-up industries in the state and particularly in Damaturu.

As part of the incentives, Government, inspite of policies to influence industrial development in the State Capital, industrial layout was designed to be allocated without any charge to interested individuals who may want to set-up industries in Damaturu.

However, according to a publication of the Yobe investments company (1997) - a subsidiary of the Ministry of Commerce and Industry, responses from private investors have been received on the setting-up of some industries which include Gum-Arabic processing Industry, Maize/Corn griats (Biski) and chalk Manufacturing industry. While on its part, the State Governmeent has finalised preparations for setting-up of Damaturu Oil Mills.

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However, as at 1997, none of these industries existed. But inview of Governments bid in encouraging inddustrial development and proposals by the Yobe investment Company for industrial take- off in Damaturu, Industrial water demand forecast must involve a fraction reserved for such industrial activities which appear feasible within the plan periods.

PHASE I (1997-2000)

According to Yobe Investment Company (1997), Damaturu oil mills - a Joint venture between Government and private investors and corn-grits (Biski)- a Subsidiary of Zaki flower mills Azare would be set-up in Damaturu before the end of the first phase. Traditionally, these industries have moderate

water demand, thus roughly constitute about 7% (733,661 litres/Day) of the daily water demand by the year 2000. Moreover, out of the 7 applications submitted to YSWB (1997) for setting-up of Block Making Industries, 4 (2 manual, 2 modern) were to start production within this phase. With a standard water requirement of 11,000 L/D, about 44,000 L/D would be required. Thus, a total of 777,661 L/D would be required by the end of this phase.

PHASE II (2001 - 2005)

Based on their proposals submitted to Yobe investment Company (1997), Gum-Arabic processing and chalk manufacturing industries were scheduled to Commence operation within this phase. While chalk manufacturing proposed to set-up between the last quater of 2001 to second quater of 2002, the Gum-Arabic processing proposed to set-up by the end of this phase.

For most of its cleansing operations for forward linkage, Gum-Arabic processing requires less water. According to YSWB (1997) this operation requires about 2% (261,227 L/D) of total daily water demand by the end of this phase.

Similary, the chalk manufacturing industry requires about 5% (653,068 L/D) of the total daily water demand for its manufacturing activities. Of the remaining 3 Block making industries (1 manual, 2 moddern) would be set-up in Damaturu in this phase, constituting about 33,000 L/D. Therefore, the over all water demand in this phase stands at about 947,295 L/D.

CHAPTER FOUR

WATER RESOURCE POTENTIALS IN DAMATURU AND ITS IMMEDIATE ENVIRONMENT

4.1 INTRODUCTION

The importance of assessing water resource potentials as a prerequisite for rational and sustainable supply and management of water resource is paramount in this study. The occurrence and volume of surface and sub-surface water resources potentials relied squarely on the amount and characteristics of rainfall and other climatic elements that have characterized the region. For this, any meaningful assessment of water resource potentials of this area must begin by analysing rainfall and other climatic elements (Fig. 4.1)

4.2 RAIN WATER POTENTIAL

This appeared to be the most important climatic element in the region that influences the amount of surface and underground water resource potentials. Rainfall in this area is characteristically unimodal in distribution. The rainy season starts in June or July, peaks in August and finishes rapidly in September or october. (Hess, et al., 1994). The rest of the year is virtually dry. The mean annual rainfall in Yobe State over a period between 1931-1973 and 1973-1986 showed a drop from 500 -

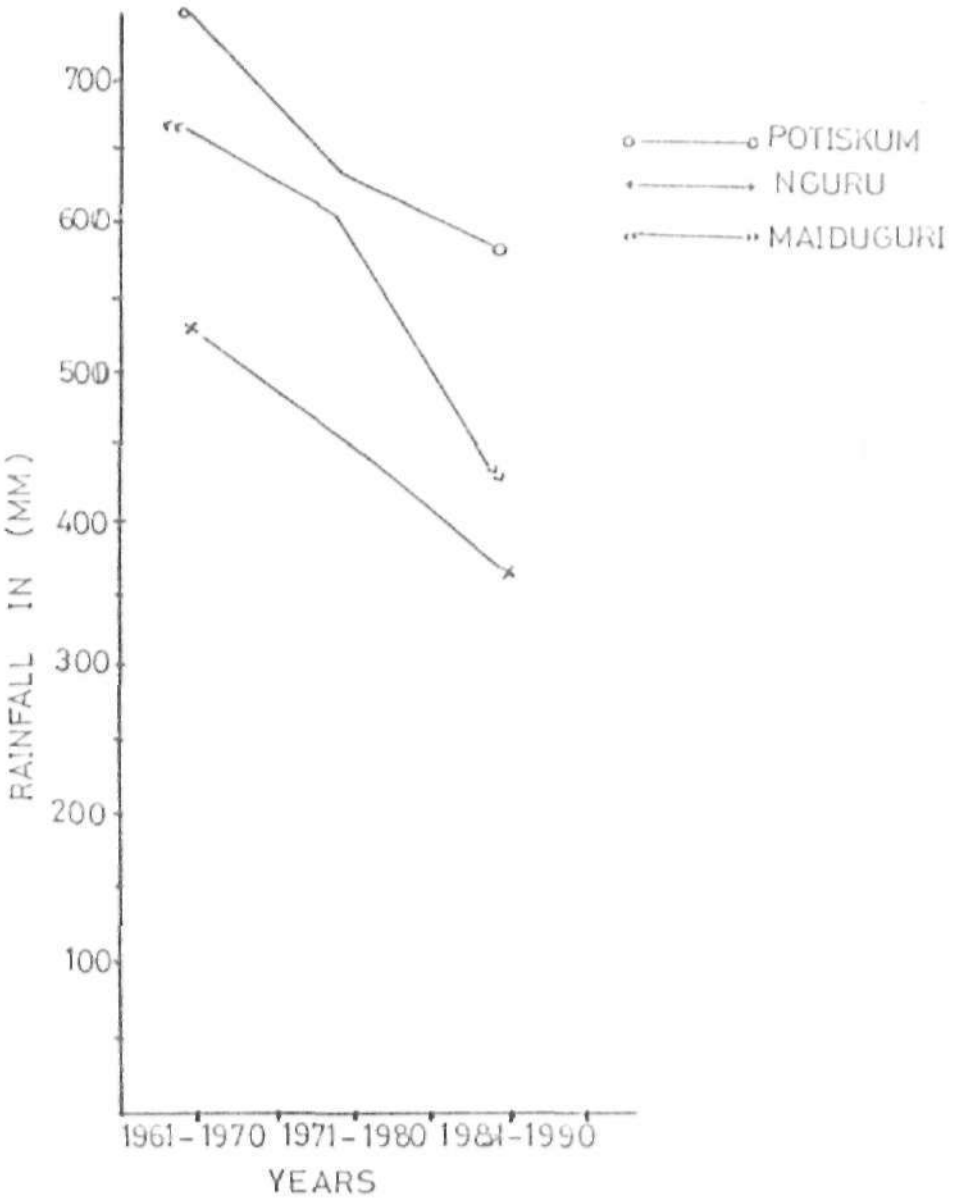


FIG 4.1 MEAN ANNUAL RAINFALL TREND BY DECADES(IN MM)

ABDU Y.
Msc II (1998)

Source: (Hess, etal, 1995)

300 mm on a state wide basis. The mean annual rainfall declines from Southwest to Northeast. Similarly, the mean annual rainy days for 1930-1960 (Hess, et al. 1995) confirmed the decline in the number of rainy days from 100 days to about 30 days on a state-wide basis. The onset of rains is earlier in the South and is delayed by about two weeks per degree of latitude northwards; however, the retreat of rains is much faster, averaging less than seven days per degree of latitude southward (Hess, et al., 1995).

4.2.1 RAINFALL VARIABILITY AND ITS EFFECTS ON WATER RESOURCE POTENTIALS AROUND DAMATURU REGION

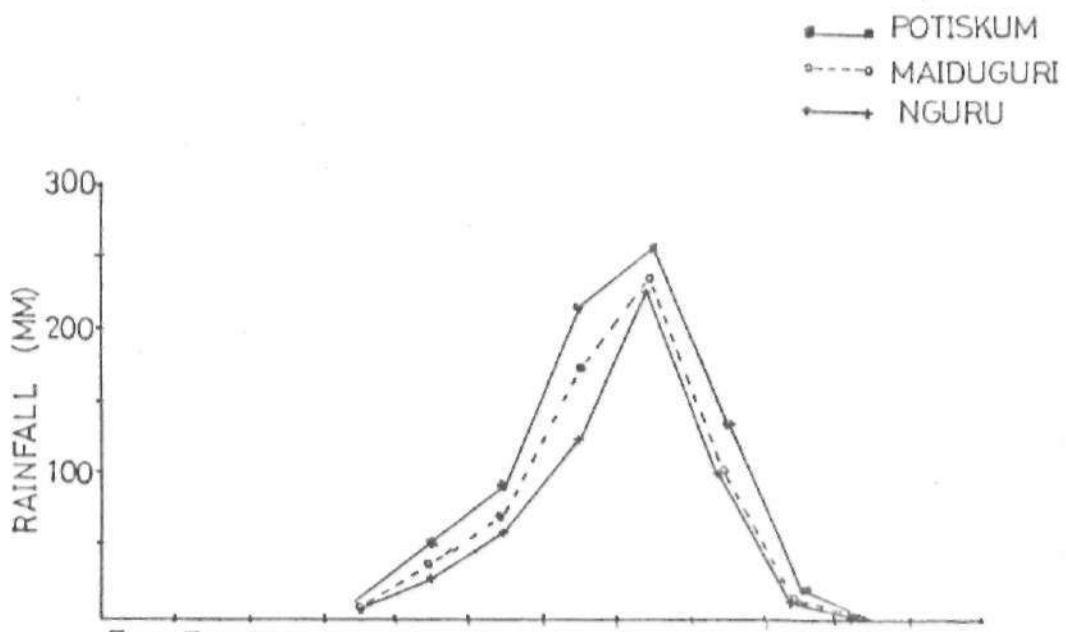
Rainfall in this area has been characterized by high variability in the probabilities of its annual total for different periods. The mean annual rainfall figures for some stations in the region conceal considerable year to year variations.

TABLE 4.1 RAINFALL VARIABILITY FOR SOME STATIONS IN YOBE STATE (1973-86)

STATION	DISTANCE FROM STUDY AREA	DIRECTION	ALTITUDE	RAINFALL VARIABILITY (RV)
NGURU	210 KM	N.W	343M	27.18
POTISKUM	90 KM	W	415M	20.58
DAMATURU	-	-	320M	24.88
GUJBA	22 KM	S	358M	13.12

Source : Hess, et al. (1995)

Hess, et al. (1995) estimated the degree of rainfall variations in this region.



Source: Hess, etal (1995)

ABDU Y.
M. Sc II(1998)

FIG. 4:2 AVERAGE MONTHLY RAINFALL FOR THREE STATIONS AROUND THE STUDY AREA

TABLE 4.2 : **ESTIMATES OF MEAN ANNUAL RAINFALL AND COEFFICIENT OF VARIATION FOR SOME STATIONS (IN MM)IN THE REGION**

STATION	MEAN (MM)	DISTANCE FROM DAMATURU	CO-EFFICIENT OF VARIATIONS	MEAN (MM)	CO-EFFICIENT OF VARIATIONS
NGURU	556	210 KM	23	434	27
POTISKUM	805	90 KM	18	662	27
MAIDUGURI	*690*	*94 KM*	*20*	553	29

Source: Hess, et al. (1995)

It is clear from these evidences that rainfall pattern has drastically changed between 1930-1990 in this area. A decline in annual rainfall might arise from a reduced seasonal duration, reduced number of rain-days within season or a reduced rain per rain-day or a combination of the three.

4.2.2: RAINFALL SEASONALITY AND ITS EFFECTS ON WATER RESOURCE POTENTIALS AROUND DAMATURU REGION

The alternation of distinct wet and dry season is controlled by the annual north-south movement of inter-tropical convergence zone (I.T.C.Z). The movement of this zone and the resultant rainfall pattern over this region vary considerably from year to year. The northward movement of the I.T.C.Z which reaches the southern fringes of Yobe State in about April is the harbinger of rains. In the south, the wet season starts in April and lasts for about 130 days with mean annual rainfall of about 900mm (Figure

4.2). In the north, the wet season starts much later (May or June) and lasts only

90 days with mean annual rainfall of about 500mm. Throughout the State rainfall pattern is mono-modal with a peak around mid August to early September. While from November to March, dry dust laden north-easterly harmattan prevails.

Declining annual rainfall has generally been dominated by a reduction in the mid-season rainfall. The August rainfall at Maiduguri and Nguru, and the September rainfall at Potiskum had all declined by about 4-9mm per year (Hess, et al., 1995). At all the sample stations, the duration of rainy season had reduced by 1.2 days each year. The average amount of rain (12.4mm per day) per rain-day did not differ among all the stations.

More importantly, there has been a dramatic fall in the number of rain days at each station regardless of weather or not each seasonal duration has remained stable. At Potiskum and Maiduguri both west and east of Damaturu, the mean number of rain-days per year over the period 1961-90 was similar with average of 48 days (Hess, et al., 1995). Records from the centre for Arid zone studies, university of Maiduguri, revealed a seasonal change of 4mm between wet and dry seasons.

4.3.0 TEMPERATURE AND ITS EFFECTS ON WATER RESOURCE POTENTIALS AROUND DAMATURU REGION

The temperature of Yobe State can be tlescribed to be higher in the northern and comparatively lower in the southern parts. The State experiences a cool temperature between November to March with monthly means falling to between 2.0C° -2.5C° (68° - 72.5°F). The maximum temperature is experienced between April-May. In April, mean maximum temperatures in most parts are in excess of 39C° (102°F) while Mean temperatures are generally about 31°C (88°F). Maximum diurnal temperatures of about 43°C (110°F) are common in central (Damaturu area) and extreme northern parts of the state.

4.4.0 POTENTIAL EVAPOTRANSPIRATION AND ITS EFFECTS ON WATER RESOURCE POTENTIALS AROUND DAMATURU REGION

This is another climatic element that affects surface and underground water resource potentials. It varies over the state being higher in the northern part. The area is characterized by high evapotranspiration incidence of about 1792 mm on average state-wide basis. While rainfall amount and incidence decreases northwards, evapotranspiration increases in the same direction due to over head sun. This restricts water availability from the shallow panels, seasonal streams and limiting underground

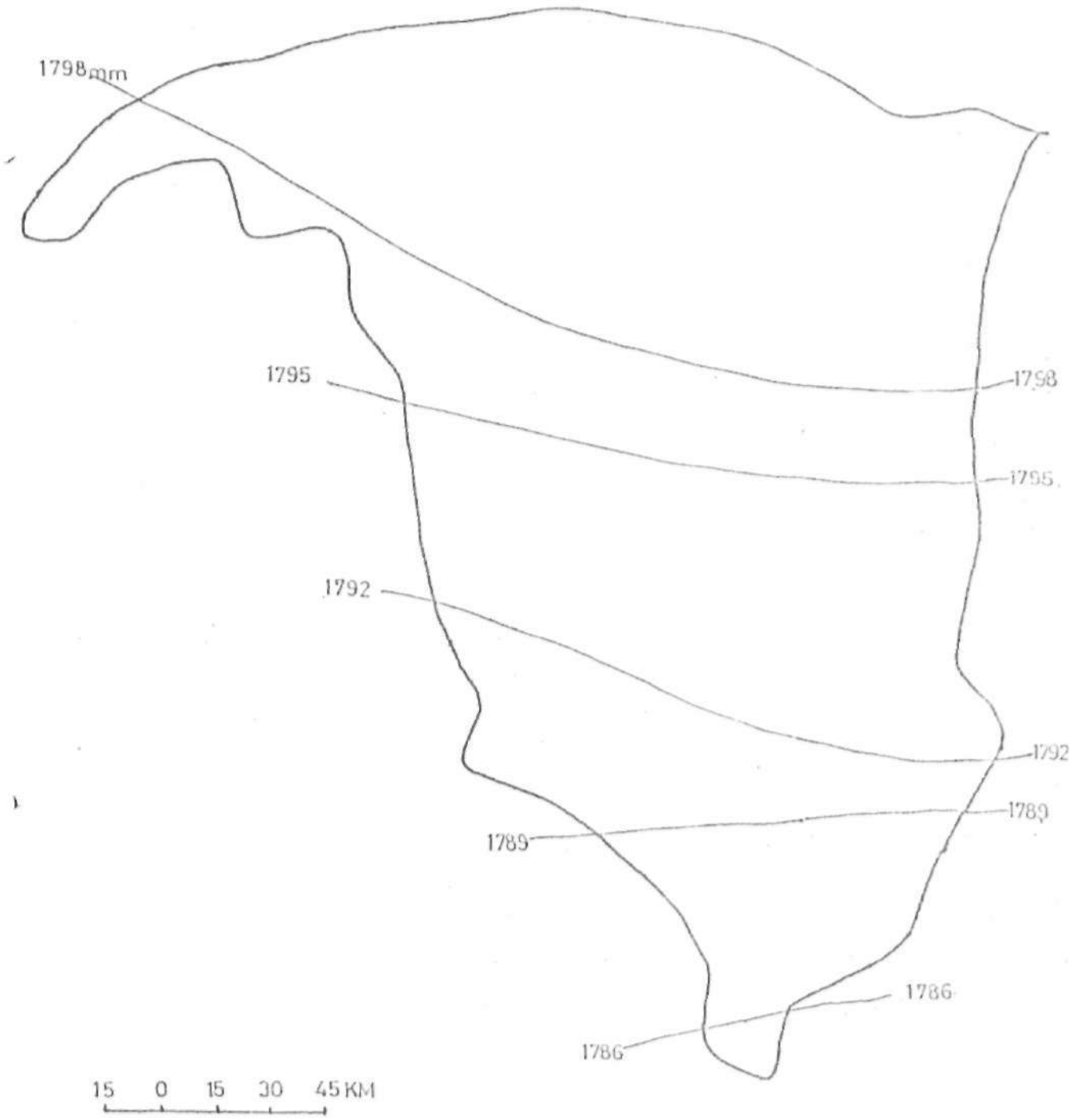


FIG 4.3 YOBE STATE: MEAN ANNUAL EVAPOTRANSPIRATION

SOURCE: (Musa, 1994)

ABDU Y.
Msc II (1985)

KASU

water potential (Figure 4.3). In filtration is high in the northern parts due to previous nature of dominant sandy soil while it is low in the southern part where the eroded clay soils from high land areas dominates.

TABLE 4.3: **ESTIMATES OF AVERAGE EVAPOTRANSPIRATION FOR NGURU, DAMATURU AND POTISKUM FOR WET AND DRY SEASONS**

DAILY EVAPOTRANSPIRATION		AVERAGE NO OF DAYS	AVERAGE ANNUAL TOTAL EVAPOTRANSPIRATION
DRY-DAYS	5.0mm	255 DAYS	1275mm
RAIN-DAYS	4.7mm	110 DAYS	517mm
TOTAL		365 DAYS	1792mm

SOURCE : Hess, et al. (1995)

4.5.0: SOIL TYPES AND THEIR EFFECTS ON WATER RESOURCE POTENTIALS AROUND DAMATURU REGION

Soil types have been associated with water systems interms of water holding capacity of different soil types. Three soil types have characterized this region as recognised by Federal Ministry of Agriculture and Rural Development (1989).

In the northern plains are weakly developed soils due to low rainfall which limits leaching and weathering. The sandy soils in this part are deficient in organic

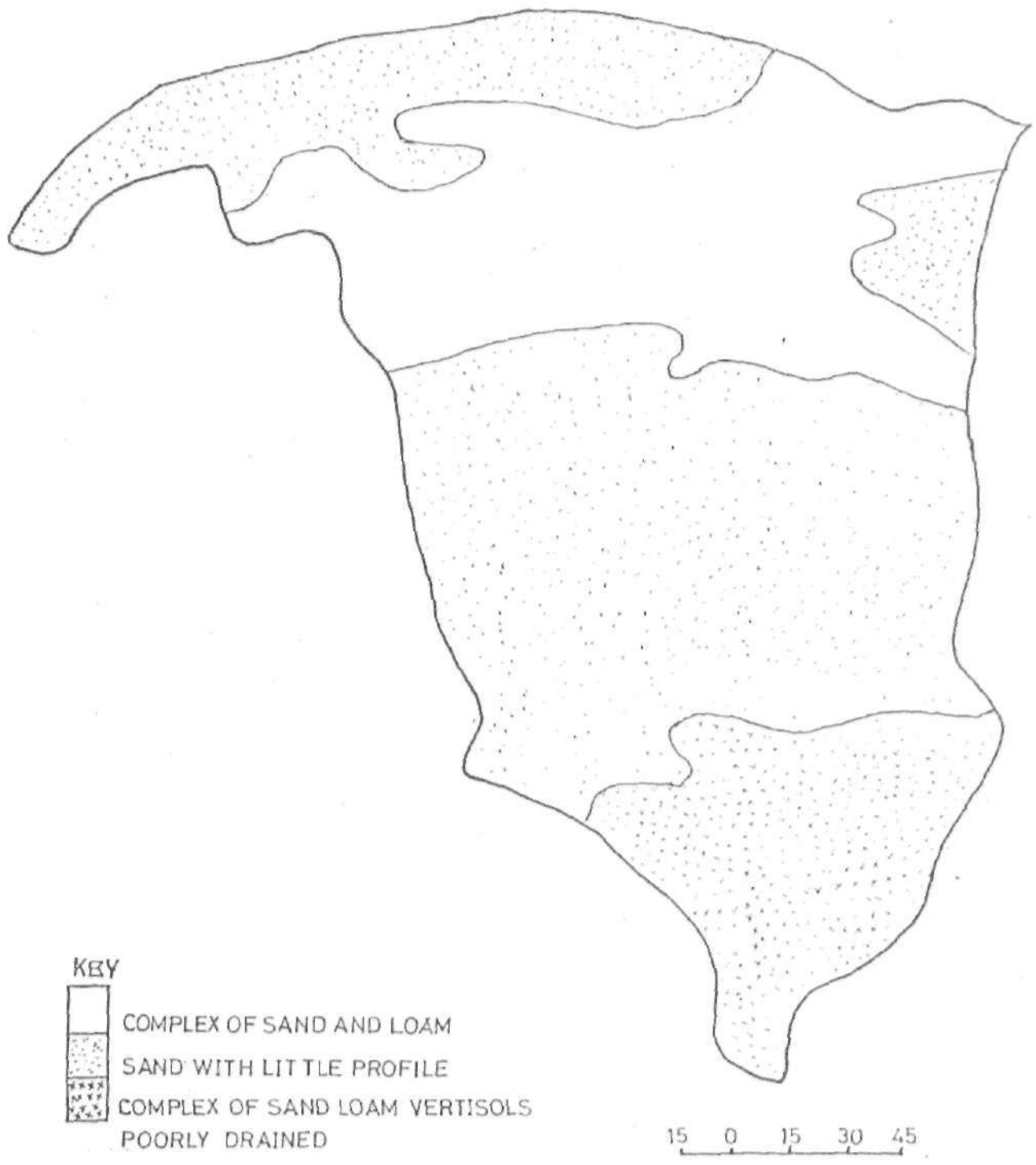


FIG. 4:4 YOBE STATE: SOIL TYPES

SOURCE: Musa (1994)

matter and weatherable materials and thus, have low capacity for retaining water.

Soils of the Yobe river complex are also weakly developed but have a wide range of textures reflecting past riverine deposition. The soil pattern ranges from weakly developed to poorly drained clayey vertisols.

The layered sands and clays of ferruginous tropical soil type predominates in the southern part of Damaturu plains (Figure 4.4)

By and large, the northern parts are dominated by loose sandy soils characterized by poor water holding capacity while the southern part are characterized by vertisols and clayey soils with relatively high water holding capacity.

4.6.0 : ADVANCING DROUGHT CONDITION AS EVIDENCE OF DECLINING RAINFALL AND ITS EFFECTS ON WATER RESOURCE POTENTIALS AROUND DAMATURU REGION.

Stebbing (1935) raised the alarmists view by quantifying the degree of desert encroachment in the northern parts of Nigeria. He postulated that the climate of this area immediately south of the Sahara was becoming drier and that desert conditions were spreading southward. He maintained that the threat of desert condition was too obvious as it was some 96 kilometres (60 miles) north of Kano-Damaturu line and was advancing at the rate of one kilometre per year. Thus, Kano city and Damaturu area were in the danger of being overwhelmed by the drought

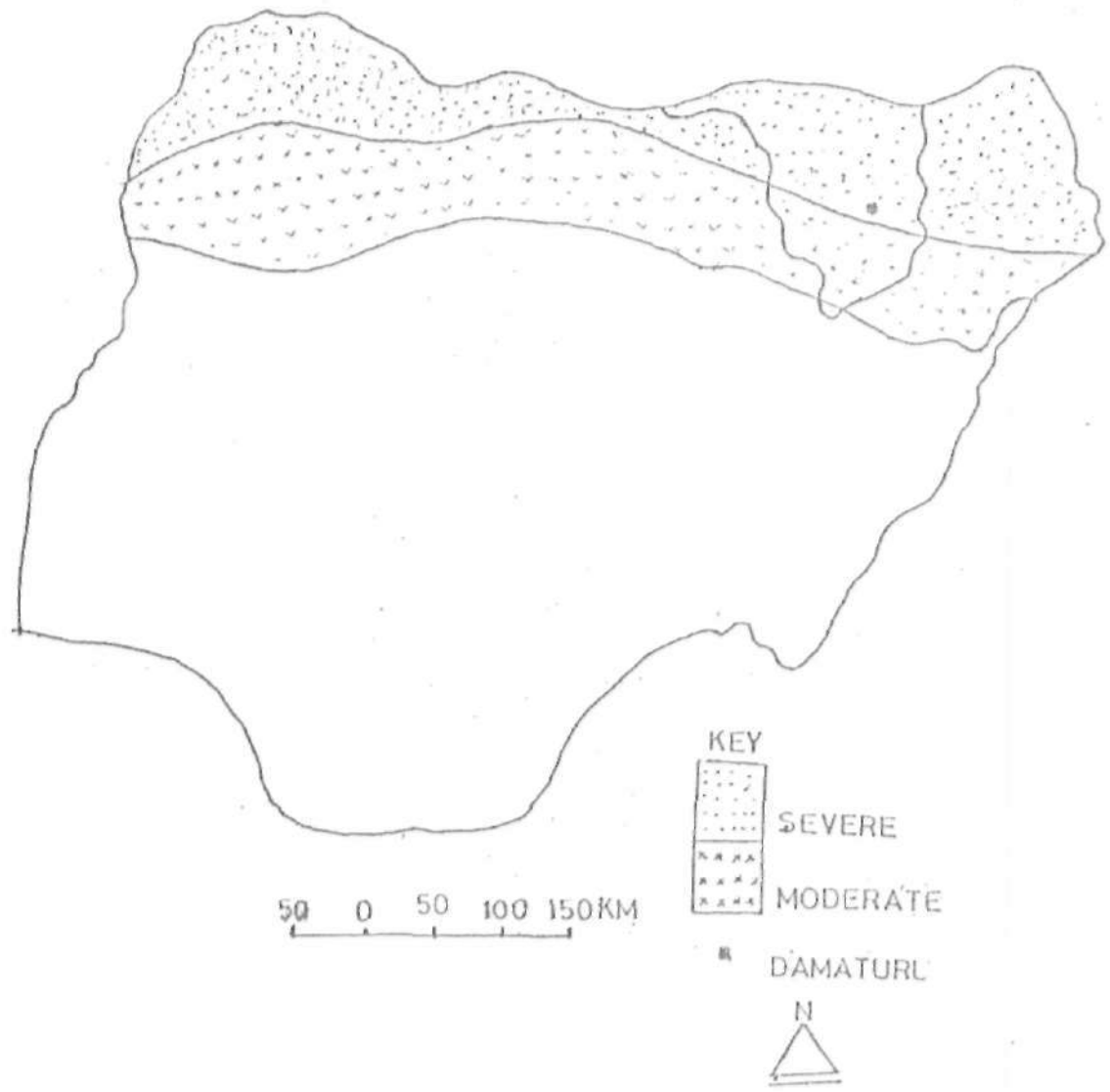


FIG. 4.5 STATUS OF DESERTIFICATION & DROUGHT AS IT AFFECTS THE STUDY AREA

ABDU Y.
Msc II (1998)

(ADAPTED FROM Stebbing (1935)

conditions in the following 50 years or less.

Contrary to this opinion, Brynmor (1935) argued that if desert conditions occurred, it would be difficult to find evidence of it in the field which includes signs of sand encroachments, declining rainfall, lowering of water table and shrinkage of streams and lakes.

However, the drought conditions of early 1970s which affected this area have confirmed and magnified stabbing's assertions.

Drought conditions which directly facilitated the water resource development problems exhibit southward approach, with devastating effects on underground and surface water resource potentials (Figure 4.5)

4.7.0 UNDERGROUND WATER RESOURCE POTENTIALS AROUND DAMATURU REGION

Presently, underground water (boreholes) is the only source of pipe-borne water supply in Damaturu and other towns in the region. Being so important as this, surveys were conducted to estimate the level and volume of the underground water resource in this region.

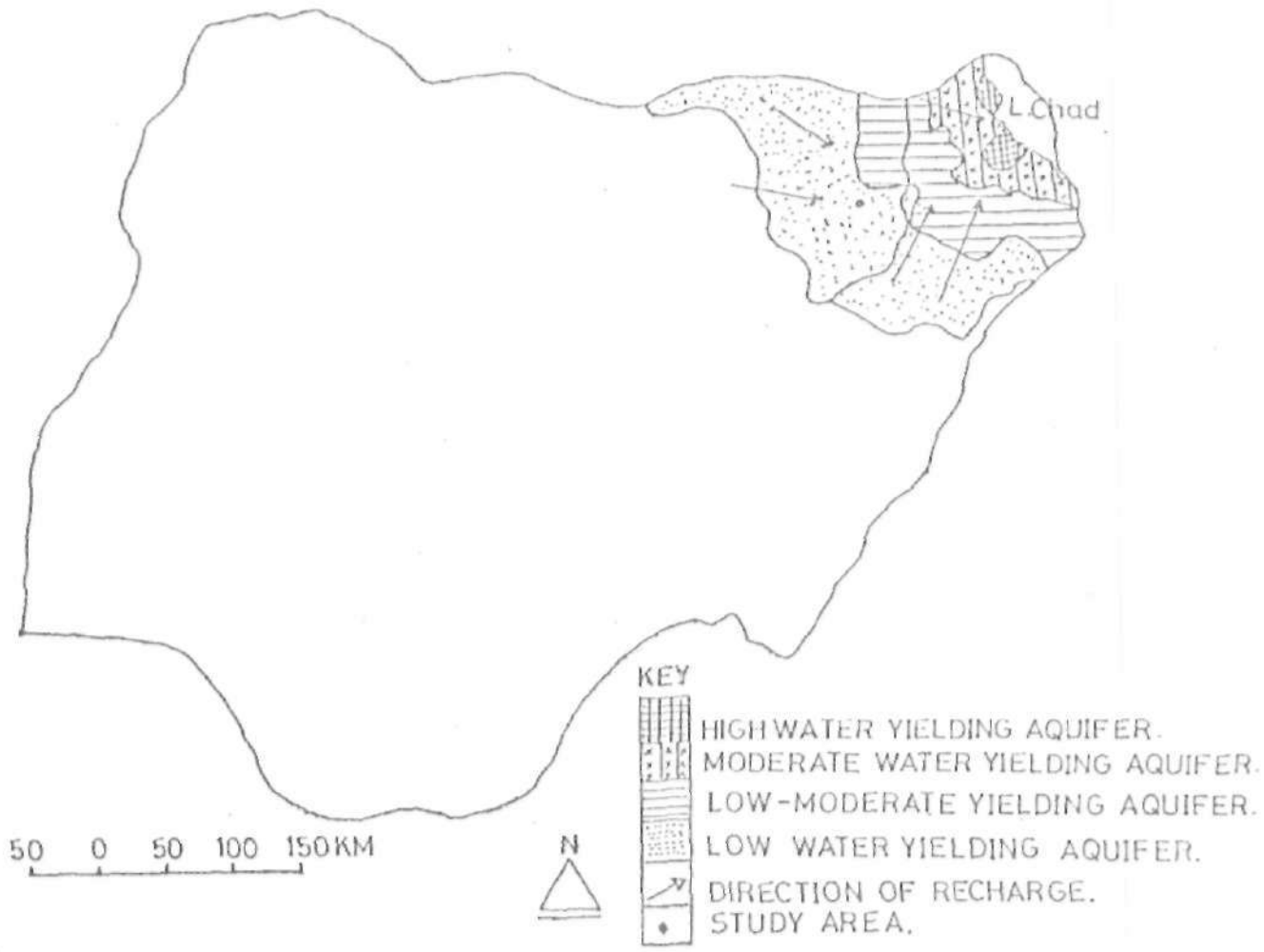


FIG. 4: 6 GROUNDWATER RESOURCE POTENTIALS AND DIRECTION OF RECHARGE AROUND THE STUDY AREA.

ABDU Y.
Msc II (1998)

SOURCE Ezenwa (1988).

The first published account of the hydrology of the Chad Basin formation (on which Damaturu town is located) was by Raeburn and Jones (1934). From their findings, they suggested that the area might contain artisan water. This led to the drilling of the first borehole by the Nigerian Geological Surveys in 1955, which described the distribution of pressure water in the area.

Subsequently, Miller etal (1968) investigated the ground water hydrology further with special emphasis on the flow life of the artisan system. These investigations reports revealed that the area which underlies Yobe State and Damaturu in particular, contained three underground water bearing zones in the upper, middle and lower aquifers.

The upper zone aquifer occurred between 30-90m below the surface. It is believed that recharge into this aquifer comes from local rainfall. The upper aquifer is in hydraulic continuity with the water table.

The middle zone aquifer is the most extensive and most important underground water source. This zone is believed to be between 60-90m below the surface and widely stretched over most parts of Yobe State. From the top of this aquifer to its bottom is estimated to be between 75m-375m. The recharge potentials is thought to be in three directions. As Musa (1994) showed, the main directions of flow are towards Munguno area, Damaturu-Magumeri and Bama-Gulumba areas.

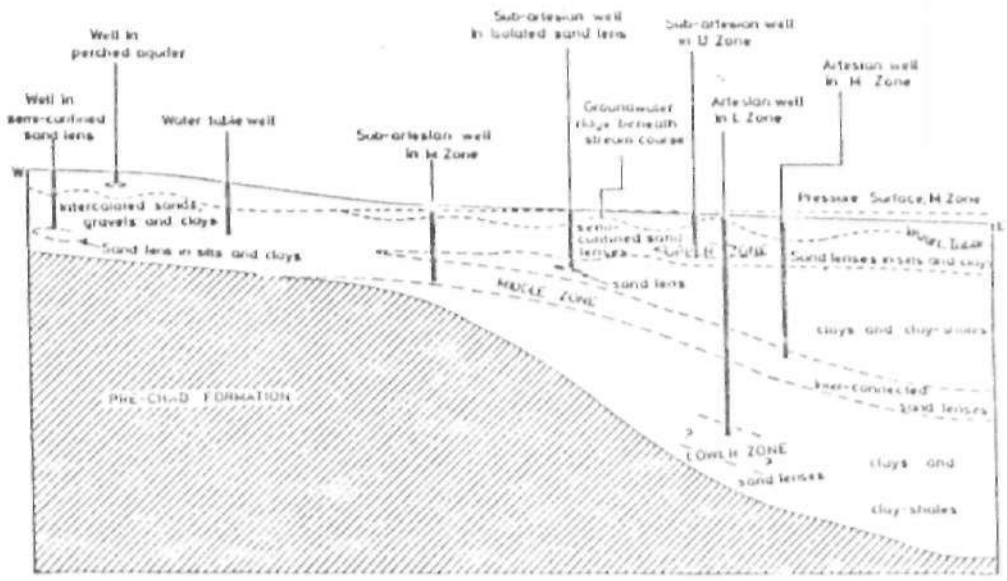


FIG. 4.7 GROUNDWATER BEARING ZONES IN THE DAMATURU REGION

ABDU Y.
M. Sc II 1998

Source: Oguntoyinbo (ed)(1974)

The lower aquifer has been identified to be between 400m-680m below the ground surface. According to Musa (1994) the water table is independent of the annual rainfall of the area. This is an exogenous ground receiving its recharge from wetter distant source where the three aquifers apparently merged.

Ezenwa (1988) estimated the total annual recharge of these aquifers to be about 53.67 million cubic metres per year while withdrawal rates stands at 66.70 million cubic metres per year (Table 4.4) This indicates that recharge within this area is less than withdrawal by about 13.03 million cubic metres per year. The recharge towards Damaturu-Magumeri area comes mostly from a variety of rock types in the southern and western parts of the study area. Average decline of water table from 43 boreholes in 13 years (1958-1971) for the middle aquifer was about 403 liters/year. But this figure was obtained before the drought periods in the region which drastically affected underground water table and availability of surface sources. (Figure 4.6)

TABLE 4.4 : **ESTIMATED RECHARGE AND WITHDRAWAL FROM CHAD BASIN (ON WHICH DAMATURU IS LOCATED)BASED ON:ANYAECHE(1985) ADEGOKE (1985) AND EZENWA (1988)**

AQUIFERS	RECHARGE MILLION M^3/YEAR	WITHDRAWAL MILLION M^3/YEAR	DIFFERENCE MILLION M^3/YEAR
UPPER (BOREHOLE)	14.83	18.00	13.17
MIDDLE (BOREHOLE)	31.54	34.40	2.36
LOWER (BOREHOLE)	7.30	14.30	7.0
TOTAL	53.67	66.70	13.03

Source : Ezenwa, et al. (1988)

4.8.0 SURFACE WATER RESOURCE POTENTIALS AROUND DAMATURU REGION

Yobe State lies within two major drainage basins.

4.8.1 YOBE RIVER SYSTEM:

This lies in the northern part of the State and drains parts of the basement complex area of north central states and parts of Jos Plateau. The major rivers here include Jama'are river, Hadejia river and Komadugu Gana river. These rivers are closely related to the rainfall amounts in the basement complex area. This river system is seasonal and remains dry for about 2-4 months at some stations in the north-eastern direction. Table.

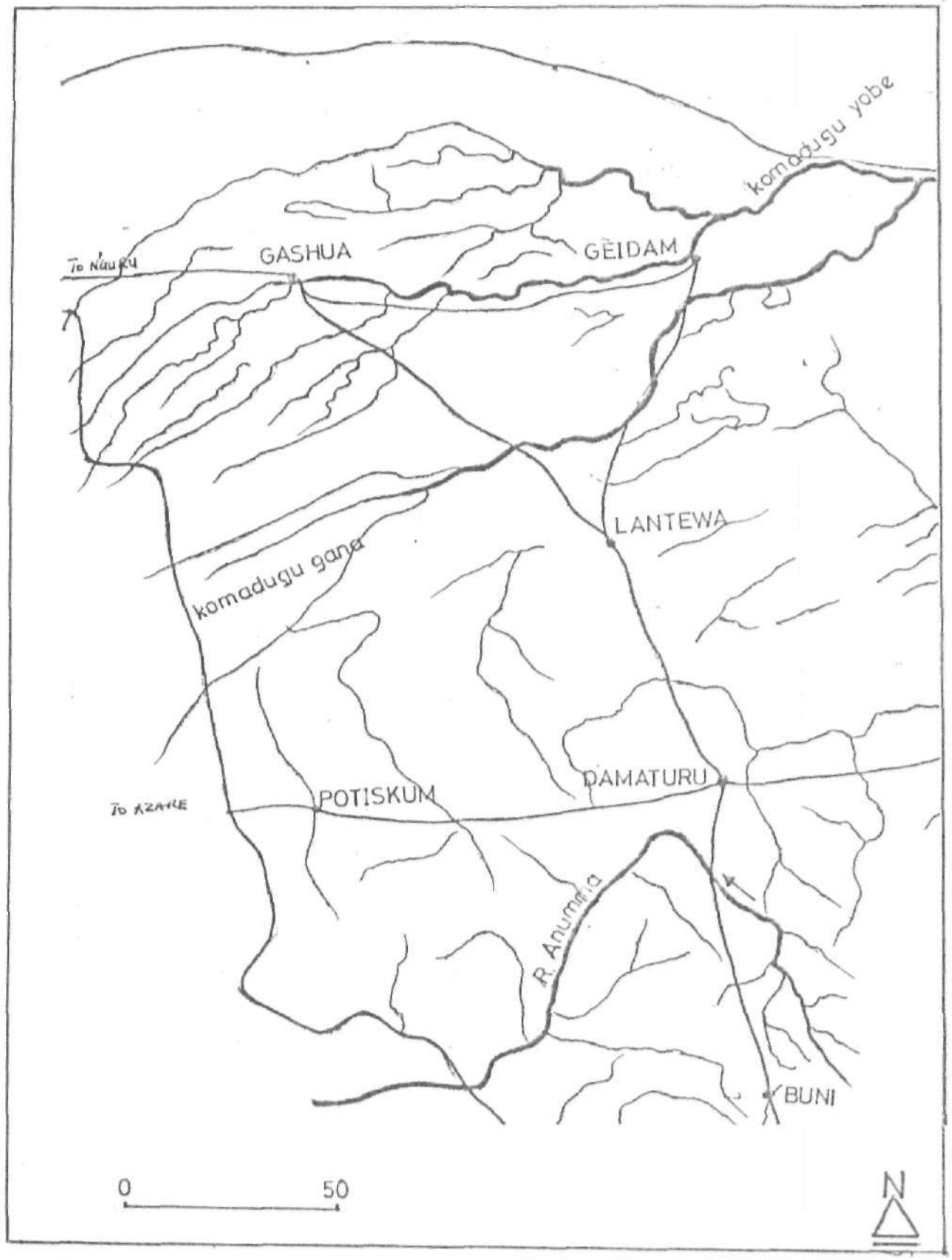


FIG.4.8 SURFACE WATER RESOURCE POTENTIALS AROUND THE STUDY AREA

ABDU Y.
Msc II (1998)

Source: Musa (1994)

4.8.2 DAMATURU RIVER SYSTEM:

This lies in the Southern part of the State mostly comprising Damaturu-Gujba enclave with various tributaries draining into Benue drainage basin. The major rivers within this enclave include River Anumma and River Gongola (Figure 4.8). River Anumma is less than 30km South of Damaturu and is estimated to have an average annual yield of about 60.10 million cubic metres. This River drains northward before swinging westward to join River Gongola, both of which empties in to the Benue River Basin.

TABLE 4.5 : **AVERAGE ANNUAL YIELD(M^3-S^{-1} OF RIVERS YOBE AND ANUMMA**

MONTH	RIVER KOMADUGU YOBE (YIELDS)	RIVER ANUMMA YIELDS
APRIL	0.4	9.51
MAY	0.25	10.48
JUNE	14.5	16.01
JULY	43.7	54.36
AUGUST	85.7	93.60
SEPTEMBER	131.4	140.07
OCTOBER	167.5	180.00
NOVEMBER	97.5	102.60
DECEMBER	43.2	60.48
JANUARY	6.2	30.15
FEBRUARY	1.8	15.01
MARCH	0.76	9.03
TOTAL	49.4	60.10

Source: Oyebande (1978), Musa (1994)

CHAPTER FIVE

PLANNING, IMPLEMENTATION AND MANAGEMENT STRATEGIES FOR SUSTAINABLE WATER SUPPLY IN DAMATURU

5.10 INTRODUCTION

Water related infections such as diarrhoea, dysentery and infectious skin and eye diseases continue to claim many lives and deform many others in the country. A lot of money has been expended on curing such diseases with regrettably often scant attention and minimal investments being directed at the prevention of such diseases by ensuring adequate provision of good quality drinking water through a water policy that will address adequately both issues of supply and demand rather than the existing supply oriented policies. Huge investments have been made by government to sink boreholes with greater objective on supply. The supply-oriented approach is reflected in the goals of national water supply policy:

(i). To meet the basic needs of the population through the provision of accessible, safe, reliable and affordable water supply;

(ii). To meet water requirements of industrial, agricultural, commercial and institutional users to boost economic growth.

Before comprehensive water resource planning and management can be successfully carried out, the awareness of the need to plan and manage water must find expression in urban, regional or national water policy that address both supply and its driving force-demand (Oyebande, 1975). The issue of demand which should be the cornerstone seemed to have inadequately been reflected in the policy. Demand is largely based on social and economic characteristics of the population which are highly variable within urban setting while the supply-oriented approach rather seemed technical-cum-ecological (physical) directly dealing with source. The socio-economic characteristics help to pass judgement on such indices as efficiency and affordability of water supply services.

Therefore, water supply planning and management should strike a balance between economic, social and ecological objectives particularly between goals of economic growth and water resource-use efficiency. What makes certain resources worth holding is the expected threat of future scarcity from over exploitation and depletion. hence the conventional economic approach is to ask what is the optimal rate of extraction or depletion of this economically valuable resource. Ideally, for any particular resource, this will depend on its relative demand and supply overtime. Thus, while demand will rely and be based on socio-economic objectives of development, the supply will have to be based on ecological (source) considerations and consequences and how the two major components (demand and supply) inter-relate in order to achieve sustainable water supply in Damaturu.

In summary, if the sustainability of ecological process and resource systems underlying economic activity is recognised to have value, then it must be explicitly included as one of the objectives to be pursued by physical planners and policy makers. In practice, the pursuit of sustainable water supply may require balancing several goals spread over these system - economic, social and ecological (Barbier, 1987).

The absence of rational allocation measures of water as a scarce resource in this area based on demands among competing landuses or to meet incompatible situation of excess demand over supply has shrouded several water supply planning and management efforts. The pursuit of sustainable economic development will require reconciling crucial trade-off-not the least being the trade-off between economic growth and appropriate resource management objectives. Since no one model provides the means for understanding how the ends of both economic/urban growth and ecological sustainability might be achieved (Barbier, 1987). The basis of existing management approaches have inherent disabilities to cope with both ecological aspects of water supply planning and management as well as socio-economic aspects of demands. Undoubtedly for planning and management of sustainable important environmental resource such as water must rely on these two perspectives.

5.2.0 : EXISTING WATER SUPPLY AND DEMAND

At present, groundwater through boreholes is the only source of pipe-borne water supply in Damaturu urban area. Average water production capacity of borehole around Damaturu has been 3 liters/second about 216,000 liters per day per borehole. The daily average discharge from the existing twenty two (22) boreholes is estimated at about 5,248,000 liters per day. Water from wells constitutes 496,000 liters daily about 9.5% of the total daily water supply. Average supply by shallow wells stands at about 15,500 liters per day per shallow well.

Based on the estimated average per capita demand of people of 115 liters per person per day, average total daily domestic water demand in the entire Damaturu urban area stands, at about 4,569,160 liters. This implies that about almost the same amount of water is required to meet up the existing demand. In other way, it further implies that about the same number of boreholes are required to satisfy the demand.

Increased socio-economic activities have made water demand more dynamic. Thus, based on the projected domestic and industrial water demand in the future, total demand has increased progressively implying increase in the number of sources (boreholes) or developing an entirely new water source or both. Table 5.1 implies that while about twenty-one (21) boreholes are required to provide the required

amount of water to meet the existing demand, about (59) boreholes may be required to meet the demand for water by the end of the planning period (1997-2010)

TABLE 5.1: **ESTIMATED NUMBER OF BOREHOLES REQUIREED TO MEET DOMESIC AND INDUSTRIAL WATER DEMAND IN DAMATURU URBANS AREA.**

	1997		2000	2005	2010		
SECTOR	EXT. NO. B-H	PRO. NO. B-H	PHASE 1	PHASE II	PHASE III	PRO. TOTAL	GRAND TOTAL
DOMESTIC AREA	22	21	2	11	14	48	70
INDUSTRIAL AREA	-	-	3	4	4	11	11
TOTAL	22	21	5	15	18	59	81

SOURCE: Field Survey (1997)

In order to avoid misplacement of water resources that created wastage and ensure proper water distribution and use, estimate of the number of boreholes has been made and allocated to various segments of the Damaturu urban area. Table 5.2 shows the breakdown and allocation of boreholes to different sectors of the Damaturu urban area.

TABLE 5.2: **ESTIMATED NUMBER OF BOREHOLES REQUIRED TO MEET DOMESTIC WATER DEMAND IN DAMATURU URBAN AREA**

YEARS	1997		2000	2005	2010		
SECTORS	EXISTING NO OF BOREHOLES	PROPOSED NO. OF BOREHOLES	PHASE I	PHASE II	PHASE III	TOTAL	GRAND TOTAL
DAMATURU OLD TOWN	9	18	2	6	6	32	41
HOUSING ESTATES	10	-	-	2	4	6	16
NEIGHBOURING SETTLEMENTS	3	3	-	3	4	10	13
TOTAL	22	21	2	11	14	48	70

Source: Field Survey (1997).

5.3.0 UNDERGROUND WATER STRESS

Giving the amount and distribution of rainfall, existing and potential rates of evapotranspiration as well as soil types and characteristics of Damaturu region vis-a-vis the nature and condition of existing water supply source (borehole) which has been described as depleting at the rate of 4 metres every year extraction of this large amount of water on daily basis will certainly lead to decline in the future underground water yield. This is contrary to sustainability of water as an environmental resource. This is why this study considered it wise to divide the planning period into three phases (Table 5.1). Thus, while boreholes (about 63) are to be maintained as source of water supply in the first two phases (1997-2005), surface water resource has been proposed to be developed in the region to serve as surface reservoir for both water supply and underground water recharge. This necessitates the need to develop a surface water source to complement the underground

water resource potentials if drilling of such numerous borcholes and their associated consequences of depleting water table and occasional subsidence are to be avoided in the future. In line within this, the Damaturu river system located in the southern part of the study area has been proposed to be developed for this purpose.

5.4.0 DEVELOPMENT OF SURFACE WATER SOURCE

It has been demonstrated that increased ground water extraction will in no way meet water demand in the next thirteen years without serious environmental consequences. As a result, the need to construct a dam on the course of River Anumma less than 30 kilometres south of Damaturu town is proposed. (See Figure 4.7 and Table 4.5). The river being the obvious potential source of water has more advantages even though it is ephemeral and seasonal. There is also need to harness rain water by creating and widening existing channels and streams in the form of earth dams to impound the underground water resource potential. There is need to establish a rain gauge network stations to monitor the trend in temporal and spatial characteristics of rainfall in the region. Though, consequences of this action are tremendous in the form of displacements, destruction of farmlands over-flooding among others, the benefits are believed to be more beneficial in the overall development of the entire area in the long run.

5.5.0 CONJUNCTIVE WATER DEVELOPMENT AND UTILIZATION

The concept of conjunctive water development and utilization involved the coordinated and planned development and operation of both surface and sub-surface water resources to meet requirements in a manner that water is conserved and optimal beneficial use is obtained. This concept will definitely be most beneficial in this area where serious environmental problems related to water resources such as shrinking water table, decreasing rainfall amounts, increasing evaporation and relatively sparse vegetation cover and few ephemeral rivers as well as high water demand occasioned by rapid population growth.

Conjunctive water development and utilization is based on the hydrological linkage between surface and sub-surface water storage, where surface reservoir would be used to impound and recharge the ground water storage (Ayode, 1988). This process helps to moderate the surface water and in the same way minimize the dangers associated with dam construction. While this concept will definitely improve the ecological balance, it will also serve to reduce the effect of over flooding thereby achieving greater water conservation.

Thus, the concept appears relevant to the persuasion of sustainable development in utilizing resources to satisfy present needs without compromising the ability of the future generations to meet their own needs. This is true considering the rate of existing exploitation of the underground water resources which does not justify the ability of the

future generations to meet their own water demands if existing source and rate of exploitation should be continued.

5.6.0 PROPOSED ALTERNATIVE WATER CONSERVATION METHODS

Conservation involves a whole lots of different adjustments and for efficient, economical and sustainable water supply, there is need for integrated and coordinated planning for conservation, utilization and control (Oyebande, 1975).

5.6.1 CONTROL/MINIMIZING EVAPORATION LOSS AROUND PROPOSED RESERVOIR SITE

Observed evaporation rates have been found to be very high between 1790 - 1800mm. This implies or represents the annual loss from a free water surface in this area. Therefore, if water is to be stored for use during the dry season (up to seven months) much of it will be lost to the atmosphere. It is for this reason that it is profitable to try to reduce such water losses by employing evaporation suppression controls. One such control involves the introduction or planting of trees around the margins of the reservoir site where they will serve both to intercept winds and produce shade. This implies landscaping the reservoir area, moreover, an extension of tree planting over the whole or part of the catchment area will afford valuable assistance in minimizing the danger of damage by flood water and reducing evaporation within the whole catchment area.

Evaporation rates can also be reduced through the introduction of certain plants such as the "water cabbage" of West Africa which is a free floating plant that grows very quickly in both running and stagnant water (Musa, 1994). However, the issue of using plants in evaporation controls needs further investigations for in some cases the loss due to transpiration of plants is even greater than due to evaporation from free surface water. That is why this approach is more theoretical than practical.

5.6.2 LEAKAGE DETECTION AND CONTROL

Substantial water losses occur through leakage from distribution system when pipes burst or joints are bad. It is estimated that 40% of water pumped in most distribution system in the world is 'lost' through leakages and waste, which implies that 40% of the money invested in providing water is all wasted as a result of additional treatment and pumping which is very crucial particularly where water agencies are faced with declining financial base (Musa, 1994). Its minimisation could substantially improve both water quality and quantity as well as reduce its unit cost. There is need to establish how much water is wasted everyday via leakage from distribution system. This will help in recognising the benefits to be gained by Yobe State water Board if a conscious effort is made to improve leakage detection and control as proposed.

Waste prevention can be pursued by checking unsuitable materials, defective mains and ageing and corrosion of pipes. In order to eliminate or reduce this, water meters at the pumping stations and at salient locations throughout the distribution system are proposed

to be installed. The result recorded will then indicate the daily yield of each borehole and the amount passing each location at a time. Simple water balance will detect area of loss, allowing investigation of possible pipe faults to be concentrated in those sections. This in effect implies the purchase and replacements of pipes, meters, leak-noise correlators and other water supply equipments.

5.6.3 RECYCLING OF WATER

Recycling of renovated water from households, offices, institutions and industries is becoming a practical and permanent source of 'new' water especially if this can be channelled in an artificial drainage in order to recharge underground reservoir (Oyebande, 1975).

The general attitude to water in Damaturu and in many urban centres in the country puts at in a unique position from the point of view of resource economics. Water is often regarded as a free good or a cheap one which should not be taxed. This kind of myth or misunderstanding surrounding water has often led to its wasteful use. There is an urgent need to mobilise people that water is not a free but a valuable and expensive good which must be conserved with great care.

5.6.4 WATER RESOURCE POLLUTION CONTROL

Considering the number of boreholes to be drilled in residential areas by the second phase of the planning period as well as the population densities and ensuing economic activities in such areas, borehole sites are in the danger of being polluted due to encroachments by development activities. These activities may contaminate water in the underground aquifer which serves as a valuable source of water supply from shallow wells and even borcholes.

Protection of groundwater supply sources requires a broad-based pollution control policy in the form of minimum separations depending on the hydrological and hydrogeological environment, between groundwater supply source and waste disposal sites/units. In other words, the maintenance of development free zone around borehole sites must be enforced and backed-up by a strong development control.

Therefore, based on aquifer conditions and existing and proposed activities (Landuses) between 15-30 metres development free zone for all proposed borehole sites should be maintained. Intensive investigations with careful monitoring of groundwater quality and table through detection wells in selected field stations need more concentration in the area.

5.7.0 WATER DEMAND MANAGEMENT

In view of increasing costs of providing more water by developing new sources and declining government's subvention and grants to Yobe State Water Board, attempts should be made to initiate policy measures aimed at managing and controlling demand for water in Damaturu. The following measures have been proposed to achieve effective management of water demand in Damaturu urban area.

5.7.1 WATER PRICING MEASURES

The present method of charging for water is ineffective in bringing about its management. Existing water prices are on the basis of either rateable value of the property, (or some surrogate measures such as the number of water points in the premises, the floor area of the premises or the number of rooms or flats in the premises), the amount of water consumed and the cost of providing the service at a particular locations.

While there is no way the amount of water consumed can be charged arbitrarily without meters, there is still no doubt that if water changes are to be fixed on the basis of cost of providing the service, they would be prohibitive and out of the financial means of the greater proportion of the people in the town.

Therefore, away must be found for Yobe State Water Board to generate more funds. It is admitted that charges can not be significantly increased when supplies are intermittent or inadequate. Consumers are also likely to resist any attempt to distribute costs according to ability to pay since the higher income groups already pay higher income tax than the lower income group.

Therefore, inorder to achieve efficient allocation and management of water demands, marginal cost should govern the pricing adopted. This implies that consumers should pay according to cost that water incurs if it increases the supply.

5.7.2 METERING

Water meters along with appropriate rates and efficient billing and collection systems are essential for reducing waste, promoting savings and detecting losses. Although installing, maintaining and reading meters is an expensive exercise, they must be introduced to allow authorities to manage demand closely and, thus, conserve water. Metering all supplies as is done for electricity will necessitate the need to manage and change the people's attitudes towards water.

5.7.3 WATER-USE RESTRICTIONS

Water-use restrictions may be voluntary or enforced by law. Care must be taken to ensure that the consumption of water is not restricted below the desirable minimum

(per capita) compatible with the rising standard of living of the people. Consumers are entreated to report promptly cases of burst, pipes and leakages around their premises or anywhere else that such occur. If entreaties fail, the bye-laws will have to be enacted by the Yobe State Water Board to ensure that water is not wasted or squandered. The penalty for damaging water pipes by individual or construction firms should be made stiffer and enforced more diligently.

5.8.0 AVERAGE ESTIMATED COST OF MAJOR PROPOSALS

Pipe-borne water supply in Damaturu comes from the existing twenty-two boreholes located in different parts of the town. This costs the Yobe State Water Board (1997) about Thirty-five thousand, six hundred and sixteen, four-hundred and thirty-eight naira (=N=35,616,438) to provide 5,248,000 liters per day, approximately Thirteen Million naira (=N=13,000,000.00) annually as capital cost for fuel, lubricants, electricity bill and maintenance.

The cost of drilling and maintaining a borehole was estimated at about three million, two hundred thousand (=N=3.2 million) consulint Nigeria Limited (1997). This includes the cost of storage tank, stand-by generating set but excludes the cost of fuel, lubricants electricity bill and running costs. In a similar estimates the Yobe State Water Board and National Water Rehabilitation Project both put the cost of drilling a borehole at =N=2.5 and =N=2.8 million respectively even though the costs vary according to the depth of

borehole and weather it is by government or private water Engineering Company. Therefore, based on these estimates, the average cost of borehole is estimated at =N=2.8 million. This includes the cost of storage tank, stand-by generating set but excludes maintenance cost such as fuel, lubricants, electricity bill among others. When these costs are added-up, the total cost per borehole stands approximately at =N=3.2 million. Thus, the overall cost by the end of the second phase is estimated to be about =N=131.2 million for the total of about 41 borcholes recommended.

However, to meet up the existing (1997) water demand of 4,569,160 liters effectively about Sixty-Seven million, Two hundred thousand naira (=N=67,200,000) would be needed to sink about twenty-one boreholes and maintain them. While the overall capital expenditure of the Board stands at about fifty million naira (=N=50,000,000.00) for the whole state including rural water supply. Similarly, the Yobe State Water Board hardly generates Sixty-thousand naira (=N=60,000.00) per month (roughly about Seven-hundred and twenty thousand naira (=N=720,000.00) annually in Damaturu urban area as revenue from consumers. Based on the proposal for constructing a dam, about =N=500 million would be required in the next eight years. Thus, the overall cost for this proposal is estimated at about =N=660,849,980.00. This estimate does not include other costs of water supply services, equipments such as pipes, fire-hydrants, valves, leakage detectors, water treatment plants, chemicals, labour, compensation e.t.c.

5.9.0 FRAMEWORK FOR IMPLEMENTATION OF SUSTAINABLE WATER SUPPLY IN DAMATURU URBAN AREA

Part of the essential purpose of this study has been to propose effective machinery for implementation that will translate these proposals for water supply into reality as well as propose framework for managing these proposals on a sustainable basis.

Considering the amount of funds (=N=631,200,000) and efforts required for the construction, installation and maintenance of water supply facilities in Damaturu in view of the current state government's dwindling financial position as well as growing demands from other sectors of the economy, there is need for efficient arrangement which should reflect participation of various consumers and producers of water services such as government agencies, private organisations, non-governmental organisations and community-based-organisations. The responsibility of ensuring the right enabling environment for partnership (participation) to operate rests with government which needs to provide the legal, fiscal and policy framework and atmosphere required to mobilise the energies and resources of all the various sectors so that these sectors can develop, provide and maintain the overall water supply services in Damaturu urban area in a safe, healthy and sustainable manner.

5.9.1 PARTNERSHIP APPROACH FOR SUSTAINABLE WATER SUPPLY IN DAMATURU

Partnership (participation) has been defined as a process by which people influence the flow and quality of utilities and services available to them. It is based on voluntary relationship among various actors which may include public institutions, community-based organisations, private enterprises individuals as well as group users.

In the context of water supply project of this magnitude, the benefits of partnership derived not only from cost reduction and resource mobilisation during implementation, it also forms more effective targeting of water supply schemes to the real existing and future needs of the residents of Damaturu urban area. Similarly, it enhances "user-ownership" of water supply facilities, consequently helping to ensure fuller and more efficient water use, better maintenance and more reliable and continuous operations. In view of the low literacy level of the people, short time frame and the existing acute shortage of water supply in Damaturu, a functionally-based approach to partnership framework is to be pursued even though other strategies would still be utilized when necessary. The main objectives of the functionally-based strategy of partnership framework includes the assignment or designation of responsibilities (functions) within which each stake holder may pursue a particular interest and exercise capacities as well as to establish effective collaboration among these various stakeholders.

KASHIM IBRAHIM LIBRARY

5.9.2 IDENTIFICATION OF POTENTIAL PARTNERS IN WATER SUPPLY IN DAMATURU

Giving the magnitude of the challenges that water supply in Damaturu poses, the entire community must value and take advantage of the wisdom, knowledge and skills of every person. Thus, partnership ensure the right of all members of its society to take an active part in the affairs of the community in which they live and ensure participation at all levels.

Therefore, various potential partners in water supply in Damaturu have been identified on the basis of the following factors:

(a) Water Supply in urban areas as an important component of urban development efforts has intricate relationship with other urban activities, utilities and services, which all have bearing and impacts on the environment, as such water supply schemes need a multi-dimensional and technical approaches for effective operations.

(b) Most usually, water supply schemes are capital intensive in nature and that multi-national loans are to a large extent not part/conditions of sustainable development principles, thus, local financial sources have to be mobilised jointly to fund such projects/schemes.

(c) Generally, pipe-breakages, leakages, spoilt taps etc. are some of the maintenance problems of water distribution system causing inadequate supply and often contaminate water due to development activities such as constructions. These problems may be conveniently minimised or eliminated when consumers and grassroots community organisations (still contractors) are directly involved in the water supply process either physically (through construction, installations, or maintenance) or financially through investments, community foundations and/or donations.

(d) Most urban water projects are designed to be internally revenue generating venture to supplement the dwindling and meagre government subvention. In the partnership framework which involves private sector, there is need for public awareness to pay water bill promptly which can only be achieved properly through participation of the general public and community members.

However, the following partners have been identified:

1. FEDERAL GOVERNMENT THROUGH:

   (a) Petroleum Trust Fund (P.T.F)

   (b) National Water Rehabilitation Project (N.W.R.P.)

   (c) Urban Development Bank of Nigeria (U.D.B.N)

2. YOBE STATE GOVERNMENT THROUGH:

   (a) Yobe State, Water Board (Y.S.W.B)

3. DAMATURU LOCAL GOVERNMENT COUNCIL

4. NON-GOVERNMENTAL ORGANISATIONS (N.G.Os)

5. COMMUNITY-BASED ORGANISATION (C.B.O)

6. PRIVATE SECTOR ACTORS.

5.9.3 **ROLE ASSIGNMENT TO INDIVIDUAL PARTNERS AND FRAMEWORK FOR CO-ORDINATION**

One of the ideals of partnership principle is the need to designate specific role(s) to individual or group potential partners (stakeholders) on the basis of previous similar project(s) or estimated financial potentialities.

1. PETROLEUM TRUST FUND (P.T.F)

   (a) Provision of Fund

   (b) Expert Advice

2. NATIONAL WATER REHABILITATION PROJECT (N.W.R.P)

(a) Rehabilitation of Water Supply Facilities

(b) Drilling of Boreholes

(c) Laying of Water mains

(d) Expert Advice

3. URBAN DEVELOPMENT BANK OF NIGERIA (U.D.B.N)

(a) Provision of Fund

(b) Expert Advice

4. YOBE STATE WATER BOARD (Y.S.W.B)

(a) Rehabilitation of Boreholes

(b) Installation of Water Supply Facilities

(c) Construction of Dam and Boreholes

(d) Collection of Water Bill

(e) Expert Advice

5. DAMATURU LOCAL GOVERNMENT COUNCIL

(a) Provision of Fund

(b) Awareness Campaigns

(c) Construction and Maintenance of Water Supply Facilities

6. NON-GOVERNMENTAL ORGANISATIONS (N.G.Os)

(a) Provision of Fund

(b) Provision of Water Supply Facilities

(c) Expert Advice

(d) Awareness Campaigns

7. COMMUNITY-BASED ORGANISATIONS

(a) Construction/drilling of boreholes

(b) Installation and Maintenance of Water Supply Facilities

(c) Provision of Local/Simple Equipments and Labour

(d) Awareness Campaigns

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8. PRIVATE SECTOR ACTORS

(a) Provision of Funds

(b) Construction or drilling of Boreholes

(c) Installation and Maintenance of Water Supply Facilities.

At this point, participation or civic engagement requires the establishment and strengthening of participatory mechanisms which will ensure that all voices are heard in identifying problems and priorities, setting goals, exercising legal rights, determining service standards, mobilising resources and implementing policies and programmes of the water supply project in Damaturu.

This co-operation results in organisation of specific forums/co-ordinating committees by local authorities, Non-governmental organisations, community-based organisations, the private sector, professional and technical experts, foundations, women groups, youth e.t.c At these forums or committees each partner group formulates its declaration or commitments to the implementation of these water supply proposals which will then be presented to co-ordinating committee.

In order to strengthen this participation, specific "partnership groups" have been established at different stages of planning process for identifying issues which are specific to partners and their priorities and programmes for the implementation of water supply in Damaturu.

SUSTAINABLE WATER SUPPLY DEVELOPMENT PROCESS

STAGES	*STAKEHOLDERS (PARTNERS)*	*ROLES*
PARTICIPATORY PLANNING STAGE	STATE WATER BOARD DAMATURU LOCAL GOVERNMENT COMMUNITY-BASED ORGANISATION	-DESIGN OF COMPREHENSIVE WATER SUPPLY -SURVEYS AND STUDIES OF SURFACE WATER SOURCE -DETERMINE EXISTING WATER BILL -POLICY PROMULGATION/EDICTS -AWARENESS CAMPAIGNS
FINANCING STAGE	PETROLEUM TRUST FUND *NAT. WATER REHAB.PROJECT* *URBAN DEV. BANK* NON-GOVTAL ORGANISATIONS DAMATURU LOCAL GOVT. PRIVATE SECTOR ACTOR COMMUNITY-BASED ORG.	-MOBILISING THE IDENTIFIED PARTNERS -CONSULTATION AMONG PARTNERS *-PROVISION OF FUNDS* -EFFECTIVE COST RECOVERY MECHANISMS
IMPLEMENTATION MONITORING AND EVALUATION STAGE	*COMMUNITY-BASED ORG.* NON-GOVTAL ORGANISATION STATE WATER BOARD NAT. WATER REHA. PROJECT DAMATURU LOCAL GOVT. PRIVATE SECTOR ACTOR	- *CONSTRUCTION AND MAINTENANCE OF WATER* SUPPLY FACILITIES - REHABILITATION OF WATER SUPPLY FACILITIES - AWARENESS CAMPAIGNS - PROVISION OF WATER SUPPLY FACILITIES - MONITOR AND GUIDE IMPLEMENTATION - *MANAGEMENT OF THE PROJECT AND PROGRAMMES*

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APPENDIX A.

YOBE STATE WATER BOARD (REVISED WATER RATES PER MONTH 1997)

	=N=
House with single Tap	15.00
Two/Three Bedroom	30.00
More than three Bedroom	60.00
Emirs Palace	300.00
Government Offices	
Head Office	500.00
Area Office	200.00
Public Stand-pipe	100.00
Liquor House	500.00
Hotels with Boarding	
First class: 50 and above Rooms	60.00 per room
Second Class less than 50 Rooms	30.00 per room
State Hotels	60.00 per room
Restaurant	100.00
Motor Park	200.00
Power House	500.00
Boarding school	1,200.00
Day School	600.00
Primary School	600.00

General Hospital	500.00
Private Hospital/Clinic	300.00
Prison	1,000.00
Police Station (Lock-ups)	300.00
Manual Block Making	750.00
Machine Block Making	1,500.00
Carwash	2,000.00
Building Construction Site	
Categories: Large	2,000.00
Medium	1,500.00
Small	500.00
Party Secretariat	500.00
Area Office	200.00
Banks	1,000.00
Market	200.00 per tap
Petrol Filling Station	200.00
Hair Dressing Salon	200.00
Private Offices	100.00
Slaughter House (Abattoirs)	1,000.00
Dispensaries/Maternity (out patient)	
Parks, Round about, Nursery	1,500.00
Cinema	100.00

Government Water Tankers	100.00
Private Water Tankers	100.00
Government House (Domestic Garden)	2,500.00
Deputy Governors House (Domestic Garden)	1,000.00
Secretary to State Government Residence	500.00
Presidential Lodge	1,000.00

Source: Yobe State Water Board (1997)

APPENDIX B

TOTAL VOLUME OF WATER PER YEAR

S/NO	STATION	LOCATION	INVOICE *NUMBER*	DISCHARGE	REMARK
1.	DT	GASHUA RD	DA/2	2L/SEC	144m³/day
2.	DT	PAMPAMARI	DA/5	4L/SEC	288m³/day
3.	DT	GUJBA ROAD	DA/6	3L/SEC	316m³/day
4.	DT	AFFORESTATION	DA/10	4L/SEC	288m³/day
5.	DT	STATE LOWCOST	DA/12	3L/SEC	216m³/day
6.	DT	MIN. OF WORKS	DA/13	2L/SEC	144m³/day
7.	DT	POLICE QTS	DA/14	2L/SEC	144m³/day
8.	DT	GUJBA ROAD	DA/15	6L/SEC	432m³/day
9.	"	GUJBA ROAD	DA/16	8L/SEC	576m³/day
10.	"	NAYI NAWA	DA/17	2L/SEC	144m³/day
11.	"	40 HOUSING	DA/18	4L/SEC	288m³/day
12.	"	SEC. COMPLEX	DA/20	4L/SEC	288m³/day
13.	"	WAZIRI ESTATE	DA/21	4L/SEC	288m³/day
14.	"	250 GASHUA ROAD	DA/23	2L/SEC	144m³/day
15.	"	250 GASHUA ROAD	DA/24	4L/SEC	288m³/day
16.	"	ABBA IBRAHIM ESTATE	DA/25	4L/SEC	288m³/day
17.	"	200 HOUSING PT.RD	DA/26	REPLACED	REPLACED
18.	"	INDUSTRIAL LAYOUT	DA/28	NOT	COMMISS.
19.	"	BINDIGARI	DA/27	2L/SEC	144m³/day
20.	"	ABUJA LAYOUT	-	6L/SEC	432m³/day
21.	"	SPORT CENTRE	-	4L/SEC	288m³/day
22.	DAMATURU	3-BEDROOM GASHUA RD	-	NOT	COMMISS.

NB: Average Borehole Discharge per second = $\frac{70}{22}$ = 3.0

liters/second = 216,000 liters per day.

Average total Daily Discharge by Boreholes

= 216m³ x 22 = 4,75m³/day.

= 4,752,000 liters/day

Source: Yobe State Water Board (1997) Damaturu.

APPENDIX C

QUESTIONNAIRE 'A' DATE.....

WATER BOARD

NAME:.....

RANK:.....

WATER SUPPLY

1. When was the Board establish? . . . . . .
2. When did the Board start operation? . . . . . .
3. What was the initial capacity per day? . . . . . .
4. What is the present capacity per day? . . . . . .
5. Is the supply being guided by demand for various uses in the town? . . . . . .
6. What is per capita supply target if there is one? . . . . . .
7. Has the board been able to meet this target? . . . . . .
8. Is the supply based on flat rate or metered? . . . . . .
9. Does the Board use Rationing? . . . . . .
10. Which of the Rationing methods used? . . . . . .
    (a) Time Ration
    (b) Sector Ration
    (c) Both
11. What is the official time gap of Rationing? . . . . . .
12. Is the Board working with other organisations or agencies? . . . . . .
13. Is the Board being guided by a supply master plan in distribution? . . . . . .

REVENUE GENERATION AND FUNDING

14. What is Board's source(s) of funds?

    (a) State Government (b) Federal Government

    (c) Damaturu Local Government (d) Foreign Aid.

15. What is the average amount per year in Naira? . . . . . .

16. How much did Damaturu water Board alone generate as revenue last year? . . .

17. What was the initial Govt allocation to Damaturu Water Board compared to those of other towns? . . . . . .

18. What was the initial water Bill per tap? . . . . . .

19. What is the present water Bill per tap? . . . . . .

20. What is the consumers attitude to payment of water Bill? . . . . . .

21. Is the Board planning to increase water Bill? . . . . . .

22. If yes, why and to how much? . . . . . .

    . . . . . .

23. How much does the Board spend as production cost on the average per liter? =N= . . . . . .

24. Has there been any increase in the cost of production per liter between say 1994 - 1996? . . . . . .

SOURCE

25. What is the present source of supply? . . . . . .

26. How many Boreholes did the Board start operation within 1991/92 and what was

the cost per borehole? . . . . . .

. . . . . .

27. What is the average discharge per borehole in liters? . . . . . .

28. How many boreholes are now functioning? . . . . . .

29. What is the estimated cost per borehole now? . . . . . .

30. What was the initial total supply by those boreholes? . . . . . .

31. What is the average life span of a borehole? . . . . . .

32. What is the present total supply by those boreholes? . . . . . .

33. What is the source of Recharge to the ground water source? . . . . . .

34. Is there any artificial source of Recharge around the area? . . . . . .

35. How reliable is the underground water source in the next 10-15 years to come?

36. Is the Board considering developing a surface water source to complement the groundwater source? . . . . . .

37. If yes, where and how feasible? . . . . . .

. . . . . .

DISTRIBUTION

38. When was first distribution network installed in the town? . . . . . .

39. How rampant is the problem of leakage? . . . . . .

40. How many functional stand-pipes are in different parts of the town and how many are they in total? . . . . . .

. . . . . .

41. How many reservoir tanks does the board have? . . . . . .

42. How many fine hydrants are now being utilized? . . . . . .

APPENDIX D

QUESTIONNAIRE 'B' DATE.....

1. House Number . . . . . .
   Ward/Estate . . . . . .
2. PERSONAL INFORMATION OF RESPONDENT
   i) Age..... ii) Occupation . . . . . .
   iii) Sex..... iv) Literacy level . . . . . .
   v) Town/State/Country of origin . . . . . .
   vi) Marital Status . . . . . .
3. Monthly Income . . . . . .
4. Which source(s) of water do you rely on for your water supply?
   (i) Well . . . . . .
   (ii) Spring
   (iii) Public stand-pipe . . . . . .
   (iv) Water Vendor . . . . . .
5. If well or spring sources, why? . . . . . .
   . . . . . .
6. If public water supply, which of the following do you use? . . . . . .
   (a) Public Stand-pipe ( )
   (b) Private house-connections ( )
   (c) Water vendor ( )
   (d) Public open concrete well ( )
7. How much do you pay as water rate? . . . . . .
8. How much water do you use for the following household activities in liters? . .
   (a) Cooking/drinking . . . . . .
   (b) Laundry . . . . . .
   (c) Washing/Personal Hygiene . . . . . .
   (d) Other (Ablutions) . . . . . .
9. Do you think water supply is enough in the town? . . . . . .

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10. If No, specify in liters/gallons . . . . . .

11. How much do you spend on water vendors every day? . . . . . .

12. In case water supply improves, will you be ready to agree to pay increased water bill? . . . . . .

13. If yes, how much?

(i) =N=30 (ii) =N=50 (iii) =N=100 (iv) =N=150

14. Is the supply from stand-pipes sufficient? . . . . . .

15. How in your own opinion do you think Govt can improve water supply in Damaturu? . . . . . .

. . . . . .