BIOPHYSICAL CHARACTERISTICS AND LANDUSE/LANDCOVER CHANGES IN THE UPPER KUBANNI RIVER BASIN,

KADUNA STATE, NIGERIA

BY

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A THESIS SUBMITTED TO THE POSTGRADUATE SCHOOL,AHMADU BELLO UNIVERSITY,ZARIA, KADUNA STATE, NIGERIA IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF MASTERS OF SCIENCE IN GEOGRAPHY.

JUNE, 2011

DECLARATION

I hereby declare that this thesis has been written by me and that the information contained is a record of my own research work. It has not been presented in any form for the award of any degree at Ahmadu Bello University or any other University.

All sources of information obtained from other literary or internet publications have been duly acknowledged by means of references.

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AYUBA GRACE DATE

CERTIFICATION

This thesis titled 'Biophysical Characteristics and Landuse/landcover Changes in the Upper Kubanni River Basin, Kaduna State, Nigeria' by AYUBA GRACE has been read and approved for its contribution to knowledge and literary presentation as meeting the requirement of the regulations for the award of master of Science degree in Geography.

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The thesis is dedicated to my Heavenly Father who is the source of inspiration of this research.

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ABSTRACT

The study is on Biophysical Characteristics and Landuse/landcover Changes in the Upper Kubanni River Basin, Kaduna State, Nigeria. The objectives are mainly to assess the local vegetation cover; evidence of firewood gathering and grazing activities. Soil erosion and the spatial variation were also assessed as well as the intensity of landuse/landcover changes and the significance of these baseline data to water resource development in the Upper Kubanni Reservoir. The data for local vegetation cover and soil characteristics were obtained through field survey. Data on the vegetation cover was obtained using the modified technique of Whittaker (1970). Two N-S transects were also developed across the study area within which three quadrangles of 100m x100m (10000sq meters) were sampled. Soil samples were collected from profile pits at 0 cm – 120cm depth. The soil samples taken from the pedogenic horizons of the profiles were weighed and subjected to laboratory analysis particularly that of the physical soil properties. Landuse/landcover changes over the years were obtained from three sets of Land Sat imageries for the years 1987, 1994 and 2005. The results of the study showed evidence of vegetation degradation characterized by few trees and are short statured. Beside the absence of periodical grasses, the degradation was aided by the excessive wood harvesting, cultivation and overgrazing activities on the basin. The soils of the study area as shown from the results were mainly loamy in texture with preponderance of sand fraction. And the aggregate stability index was relatively stable. But the soil bulk density result of 1.53 mg^{m3} for a sandy loam soil is tending towards the threshold. The landsat imagery showed that cultivation and grazing rank highest in the landuse/landcover on the basin, while built up areas continued to rise. Important to note also is the disappearance of natural open savanna vegetation which was being replaced by shrub regrowth. Gully growth has been on the increase. But a decrease in growth of gullies was observed in the year 2009, which may not be unconnected to the tree planting exercise carried out by Ahmadu Bello University. These results have implications on increasing sediment yield into the Basin.

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND TO THE STUDY

The last three decades witnessed great impact of uncontrolled exploitation of environmental resources with little attention given to the consequences on the environment in Nigeria. However, the rapid social and economic developments have also influenced the desire to initiate and implement appropriate environmental policies and laws to safeguard man's wellbeing and control his development plans. It is obvious that when development imperatives circumscribe the limit of resources available, problems are created thus affecting the enhancement of the environment quality and its sustainability (Keith, 1998, Glen, 2009).

Consequently successful economic development therefore, depends on the rational use of resources and the reduction in adverse environmental impact of development projects. An impact assessment is a primary tool for achieving that objective by inserting critical information into the process of project identification, preparation and implementation. (Glasson, Therivel and Chadwick, 1999).

Adequate knowledge of biophysical, landuse/landcover changes will help to avoid environmentally unsound development or unintended adverse effects of development projects in the environment.

The technological development efforts of government and entrepreneurs in providing access to basic amenities of life such as potable water, good roads and electricity have gradually resulted in removal of vegetation and or degradation of the environment at local, regional, even global levels. Lameed and Ayodele (2008) asserted that environmental impact assessments are increasingly being introduced in decision making processes of government with the sole aim of influencing policy makers on the impact of the proposed or existing projects development in those areas. However, effective assessment impact will have to be based on particular baseline data since the latter gives general profile of the project area(pre or post). Besides, information on the state of the environment will help to facilitate proper impact assessment hence, adequate safeguard measures can be taken.

Dams and reservoirs indeed, serve as integral units of technological development, yet the change from lotic to lentic environment brings about changes in the physical, chemical and biological phenomena (ABUCONS, 1992). Similarly, ecological studies report that deforestation, removal of top soil in the course of dam construction changes the ecology of

terrestrial ecosystem and biotic communities. That situation is further retarded in the savanna regions where the landuse associated with the project development encourages the cutting down of trees.

Consequently there is an urgent need to address the environmental degradation associated with project developments such as those of the Upper Kubanni Basin. An effective managerial tool sufficient to protect the environment from degradation requires a profile of biophysical characteristics and the landuse/landcover changes for future interventions (Emeka et al, 2008).

1.2 STATEMENT OF THE RESEARCH PROBLEM

Development of the upper Kubanni reservoir was mooted by the Ahmadu Bello University Management in the early 1970s in response to the urgent demand for more water following increase in student population and growth of Samaru Township. The feasibility studies carried out were limited to the technical problems associated with the reservoir. They considered only the geological, geotechnical and hydrometeorological situations and the data largely provided by various academic departments of the University. No known impact assessment was conducted!

The Kubanni reservoir has been studied from different points of view. For example Iguisi's study of recent sedimentation in the reservoir showed that, as much as 30% of the storage capacity has been lost to siltation since its completion in 1974/1975 (Iguisi, 1997). However, a recent estimate of sediment yield contributing to the reservoir siltation is also incomplete (Yusuf, Iguisi, and Bello 2007). The reason is that the study was only within the 5.25km^2 headwater area of the northern/most tributary (one out of the four tributaries draining into the reservoir). As such the sediment yield estimate may be froth with large estimation errors. Similarly, previous studies of landcover and landuses are scanty and probably based on casual observations since 1997 to date. Therefore to characterize the biophysical elements, landuse/landcover changes for the entire catchment area upstream of the reservoir is necessary so as to reveal the general ecological profile of the basin.

Indeed, some discreet parts of the Kubanni reservoir catchment have been studied in the past for various purposes. Studies on the nature of the soils, particularly in relation to gullying and erodibility and in other neighbouring headwaters abound (Ojiah, 1998; Smith, 1982; Duniya, 2006). Also studies of gully erosion (Ologe, 1970, 1972; Bello, 1973) and Ahmed (1989) provide useful estimate of soil/gully erosion contributions in the catchments area. However, some of the studies do not fall directly within the upper Kubanni reservoir catchment of about 57.25km. So, there was no known benchmark studies prior to the development of the Upper Kubanni Reservoir Project.

Furthermore, since 1999, a concern over the main source of water for the Ahmadu Bello University main campus over the past 30 years is being silted up such that tree and landcover improvements have been undertaken probably to increase water yield. Also, there have been attempts at dredging of the dam probably to safeguard the reservoir from the threatening effects of siltation but even at that under appropriate statutes there is the requirement for the conduct of environmental impact assessment (EIA) studies for dredging projects. But to save the situation, it becomes neccesary to characterize the present state of the physical environment so that quality control programmes can be developed based on a firm adequate baseline. Odu, C.T. and Shell Petroleum Development Co. of Nigeria Ltd (1991 noted that a successful planning and implementation of an environmental protection programme must necessarily and mainly rely on baseline data and factual information relating to the environment to be protected. Thus, the thrust of this investigation is to characterize selected biophysical elements and the landuse/landcover changes of the Upper Kubanni Basin.

1.3 AIM AND OBJECTIVES OF THE STUDY

The aim of the study is to characterize the selected baseline data for the purpose of environmental impact assessment of the Upper Kubanni post Reservoir Development. To achieve the above aim, the objectives are to:

a) Identify, map and describe the:-

i. Nature of the local vegetation cover; evidence and extent of firewood harvesting and livestock grazing that have disturbed the landcover.

ii. Soil physical properties of the study area

iii. Soil erosion, types and their present conditions (spatial variations)

b) Characterize the spatial variation and intensity of landuses.

c) Explain the significance of the above selected baseline data to water resource development in the Upper Kubanni Reservoir Basin

1.4 SCOPE OF THE STUDY

The study covers about 57.5km^2 catchment encompassing areas of all the four tributaries draining into the reservoir. Ideally, each of the four tributary basins should be sampled and studied. Data will be collected on the three selected elements of the environment listed in the objectives and relate them to the reservoir basin condition using the "whole catchment approach."

1.5 THEORETICAL FRAMEWORK

Human modification of surface drainage varies in scale from small canalization to large scale river regulation or redirection. These actions have profound consequences on the environment such as loss of some river habits, and increase in magnitude of siltation etc. Indeed man's exploitation of the natural resources for various developmental purposes do result in environmental degradation. Therefore there is a growing concern since 1970s over the improvement on the quality of the environment.

Adequate information on the state of the environment will have the benefit of indicating current potential future problems that need to be addressed as well as the provision of a platform for planning continuous environmental improvement of the project site (Akpofure 2009).

CHAPTER TWO

DESCRIPTION OF THE STUDY AREA

INTRODUCTION

This chapter intends to describe the location of the study and its significance.

2.1 LOCATION, POSITION AND SIZE

The upper Kubanni drainage basin is located in the area bounded by latitude 11^0 8' 58 – 11^0 25' N and longitude 7^0 36' 45" – 7^0 38' 22". It covers an area of about 57.5km^2 and on its northern watershed bounded by the Institute of Agricultural Research (IAR) and the Ahmadu Bello University Teaching Hospital. On the west, it extends up to Ungwan Barau and Ungwan Maigama settlements. To the southern boundary is the Kufena Hills and Unguwan Zarumi and to the east is the Ahmadu Bello Main Campus Samaru and the College of Aviation Technology (NCAT) Zaria (Figure 2.1)

Kubanni Dam is an earth fill dam located downsteam of the confluence of the two main tributateries of the river. Constructed in 1974, it is located about 1.6km south of the ABU Main Campus. Being an earth dam, it was built by excavating the Kubanni river valley in width and depth and using the over burden as an embankment across the valley (Ogunrombi, 1979; Iguisi, 1997; RCWRS 2004). While the embankment has a clay and concrete core, its spill way is a

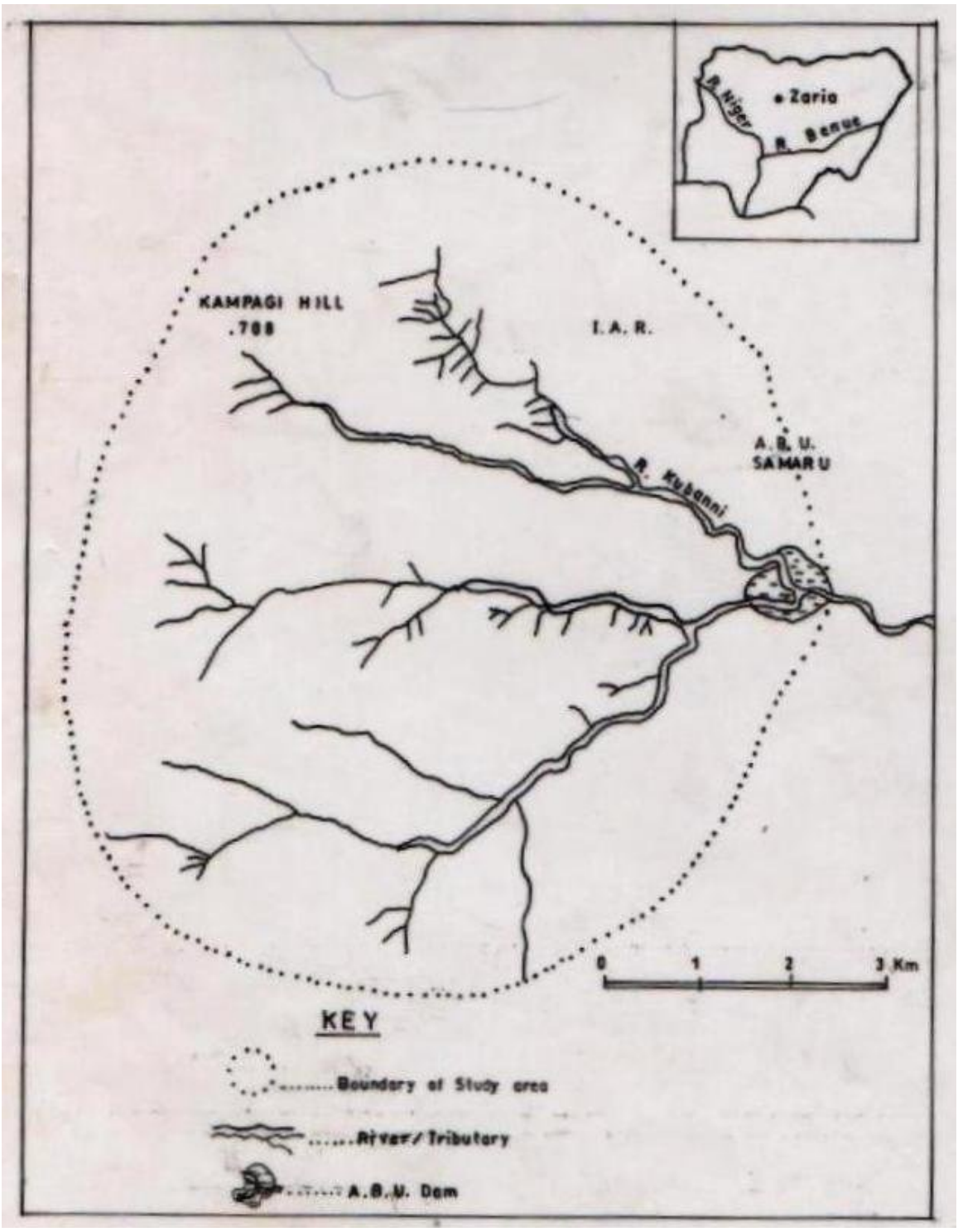


Figure 2.1: Location of study area

concrete and circular hollow raised from the lake bed unto the crest of the lake so that water in excess of its storage capacity spills into the hollow and is evacuated through pipes under the embankments and the crest of the dam, which serves as a road, has a protective cover of bituminous tar lining. Summary of finding Details of the impounded reservoir created by the dam are shown in Table 2.1.

Table 2.1 Facts about the Ahmadu Bello University Kubanni Dam Reservoir (as at 2008)

Length of body of the dam	765m
Open water table, January 2008	592,100M^2 59. 21ha
Average weighted depth of water below	2.65m

circular spillway, in wet season	
Total and active water storage, wet season 2007 with spillway flowing	1,568,725m^3
Rate of sitatio3n between years 1974 and 2008	30,331m^3/y
Total water losses and active on storage, (seepage plus evaporation)	536,634m^3 per dry season
Seepage under dam body	4,400m^3 per dry season
Loss to evaporation from open water table in 176 days of fry season	531,234m^3 or 0.897m
Safe yield in dry season of year 2008	5,864m^3/d
Water pumped to the campus in year 2008	3,447m^3/d or 606,672m^3/dry season
Predicted date of safe yield falling to 3,447m^3/d in dry season	Year 2022
Predicted date of safe yield falling to 3,447m^3/d in wet season	Year 2039
Predicted date of complete siltation	Year 2059

Source: Ahmadu Bello University committee on protection of the Kubanni dam drainage Basin (2008)

2.2 GEOLOGY

The study area is located within the Basement Complex Rocks in the north central Nigeria. Russ (1977) described the Basement Complex Rocks as rich in high grade meta sediments of mainly quartzite's (forming ridges) containing (Figure 2.2) schist and phyllites. It is over one of the crushed quartzitic ridges that the ABU dam was situated. The Federal Department of Agricultural Land Resources also described the complex as an undifferentiated basement complex while the area is underlain by undifferentiated older alluvium and younger laterrites. (Wright and McCurry1970) classified the basement complex rocks of Zaria into 3 principal groups.

1. Younger metasediments found in a north – south tresding belt and west of the area.
2. A re-mobilised older crystalline complex made up of gruliss migmatite and ancient metasediments.

Granites and granodiorite of late Precambrian to lower Paleozoic age which includes groups one and two above. The granites are grouped into porphyroblastic, biotie granite, porphyroblastic hornblende granite, granodiorites- porphyroblastic and fine to medium grained biotite granite. These rocks are thoroughly weathered and deep (up to 30m) chemical weathering has created pockets of classic humid tropical processes that have also evolved distinctive lateritic landscape (Thorp, 1970 and Iguisi, 1997).

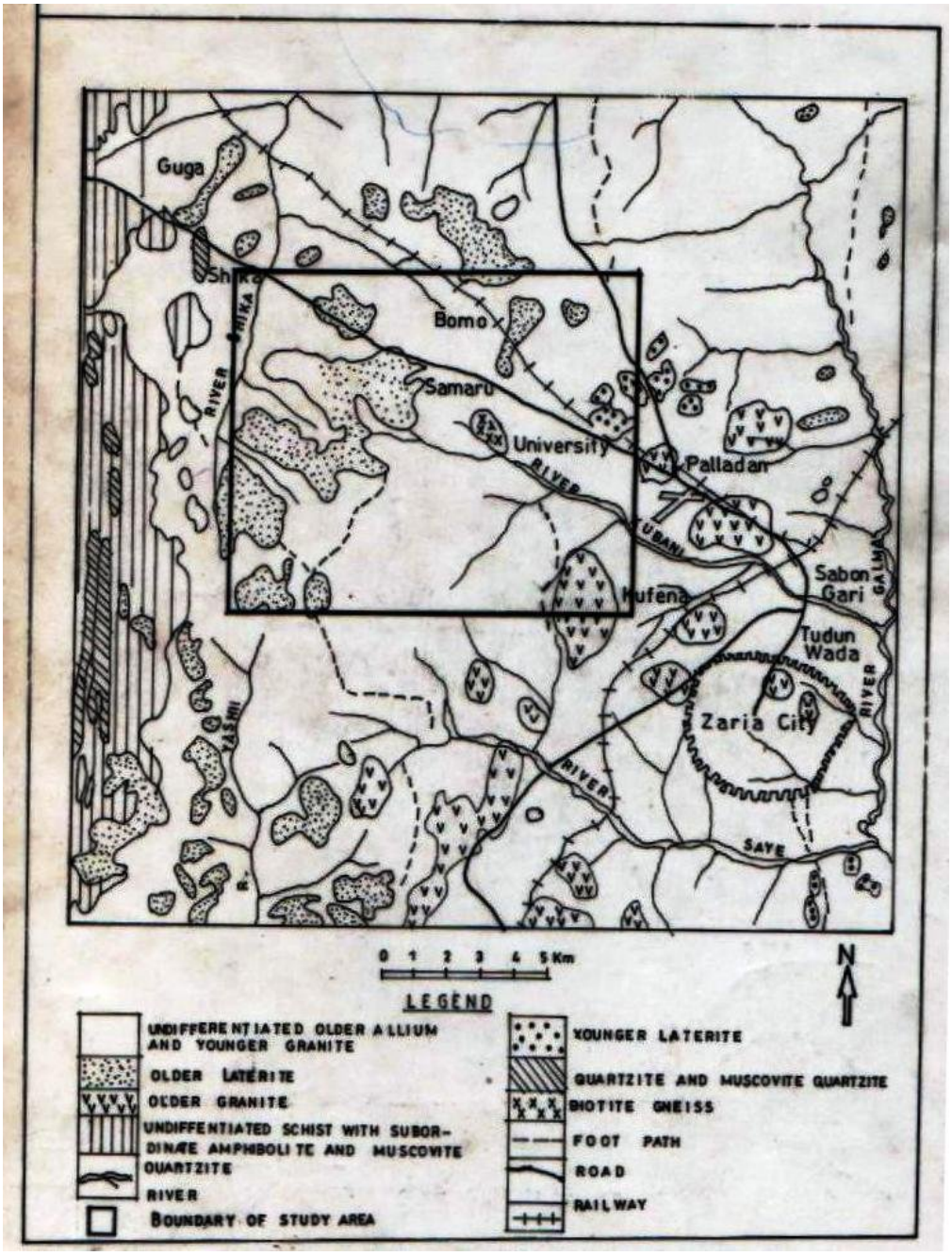


Figure 2.2: Geology of the study area (Zaria

Source: - AFTER WRIGHT AND McCURRY (1970)

Superficial materials on the plain include laterrites, alluvium metasediments and Aeolian drift. The laterrites and alluvium are further differentiated into older and younger types depending

on their origin formation and age. Also found in the basin are thin deposits of wind blown brown silt from Sahara during many decades of hamattan season (Bello, 1973; Wright and McCurry 1970).

Along the stream channels are found younger laterrites which are generally light brown than the older laterrites found on the summit of the plains being mostly residuals and have been dissected to form isolated tabular hills (mesas and buttes) (Thorp, 1970; FDARL, 1990).

Also alluvium occurs within the inner valleys of the catchment with distinctive characteristics. These characteristics of the superficial materials have important implications for the ongoing degradation in the basin.

2.3 RELIEF AND DRAINAGE

The Kabanni Basin in part of the undulating Zaria plain which in turn forms the extension of the high plains of northern Nigeria. In addition, to the infinite horizontality, the relief is dotted with isolated rocky hills of different shapes and configuration called inselbergs. Among these are rocky hills rising to 820m and the TukurTukur hills 797m lying immediately to south of the Kubanni Dam. The valleys are incised into the surrounding plains (figure 2.3). Continued erosion processes have formed distinctive micro-landforms including degraded bluffs and

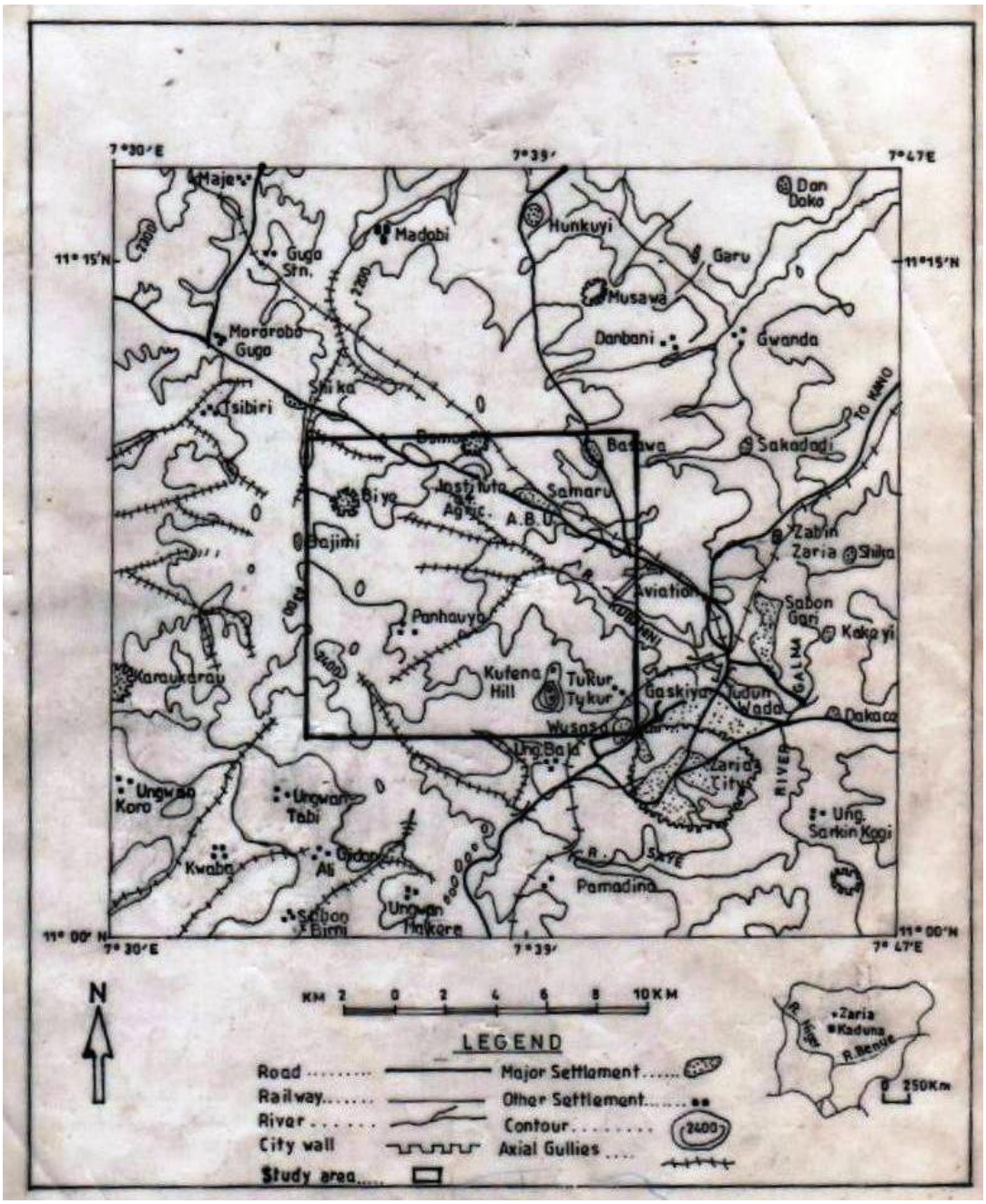


Figure 2.3: The Drainage and relief of the study area.

Source:- TOPOGRAPHICAL MAP OF ZARIA SHEET 102.

erosional scarps and stripped micro pediment (Duniya, 2006; Thorp, 1970, Bello 1973). The Plains being thoroughly weathered are stripped of their regolith and the prevailing landuse contributes to the on going degradation in the basin.

The basin is being drained by a sixth order stream called Kubanni and is flowing West to East to join the River Galma. Its channel system is ephemeral and assumes dendritic patterns which are and deeply incised by numerous systems of gullies (Ologe, 1971; Bello 1973; Thorp 1971).

2.4 CLIMATE

The climate of upper kubanni basin in the Zaria region is the Aw type characterized by distinct wet and dry seasons. (Kopens, 1928; Ahmed, 1989). The characteristics of the climate are determined by the oscillations of two contrasting air masses (i.e. The Tropical Maritime and the Tropical Continental Air Masses). The tropical maritime originates from the Gulf of Guinea and ushers in the rainy season. The tropical continental originates from the Sahara Deserts and ushers in the dry cold and dusty season called the harmattan that occasionally limits visibility and reduces solar radiation. (Oguntoyinbo, Areola and Filani, 1978).

The two air masses are separated by a discontinuity zone known as Inter Tropical Discontinuity (ITD). The ITD moves north and south of the country. The location of zones is in relation to the surface position of the ITD and determines the weather condition at anytime of the year. The orientation of the surface position of the ITD over the country reaches the northernmost and southern most positions in August and January respectively on the average. However, the southward movement is usually faster than the northward movement (Fig. 2.4a & b). A shows the approximate average monthly surface positions of ITD during its south ward movement along the meridian of Zaria, and B. The position of the ITD during the northward movement is also shown in figure 2.4b. Thus from October/November - April Zaria lies north of the surface position of the ITD and under the influence of the north-east depending on the synoptic condition over

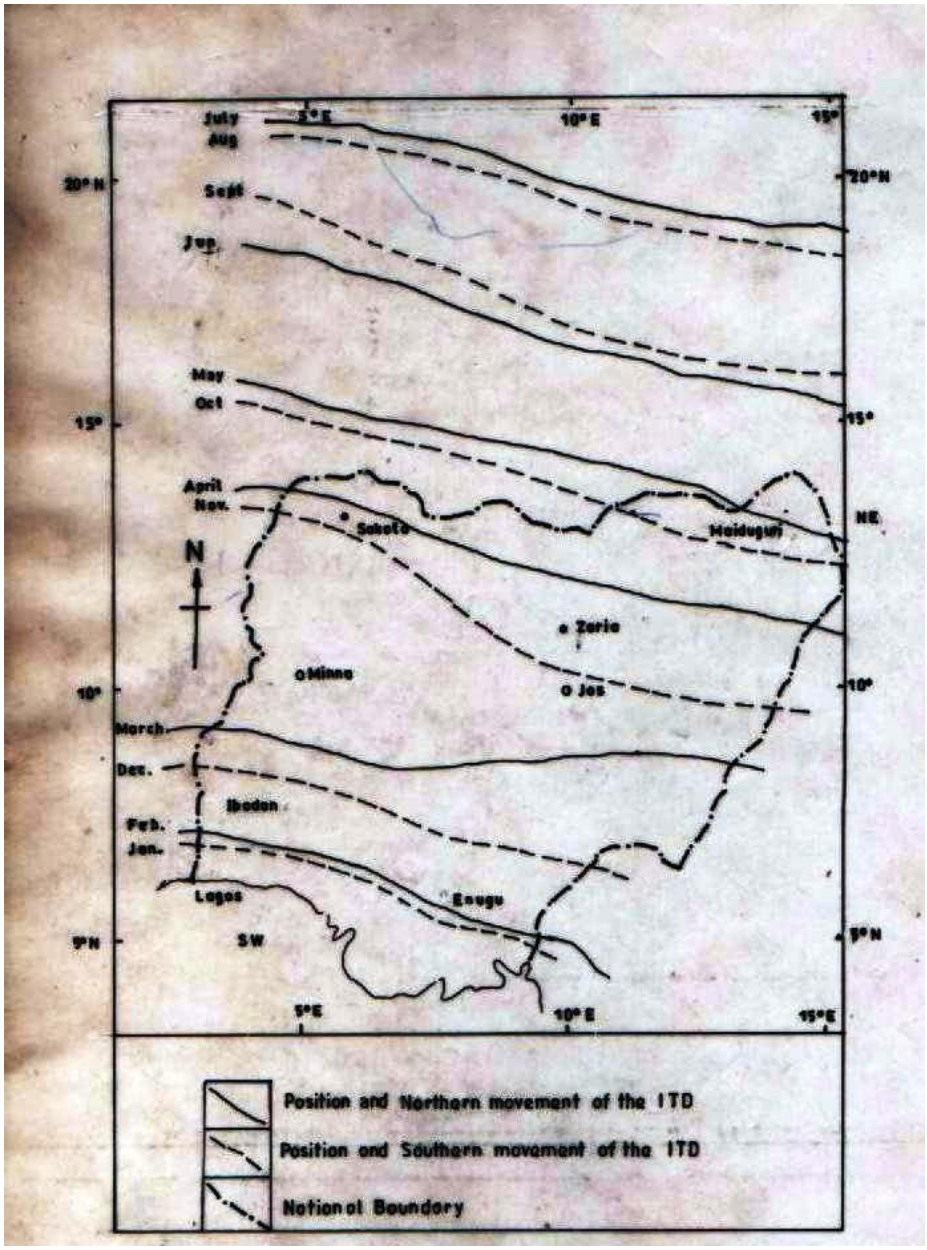


Figure 2.4a: Surface position of ITD relative Zaria location.

Source: - YAKUBU (2004) MODIFIED FROM OBASI (1965)

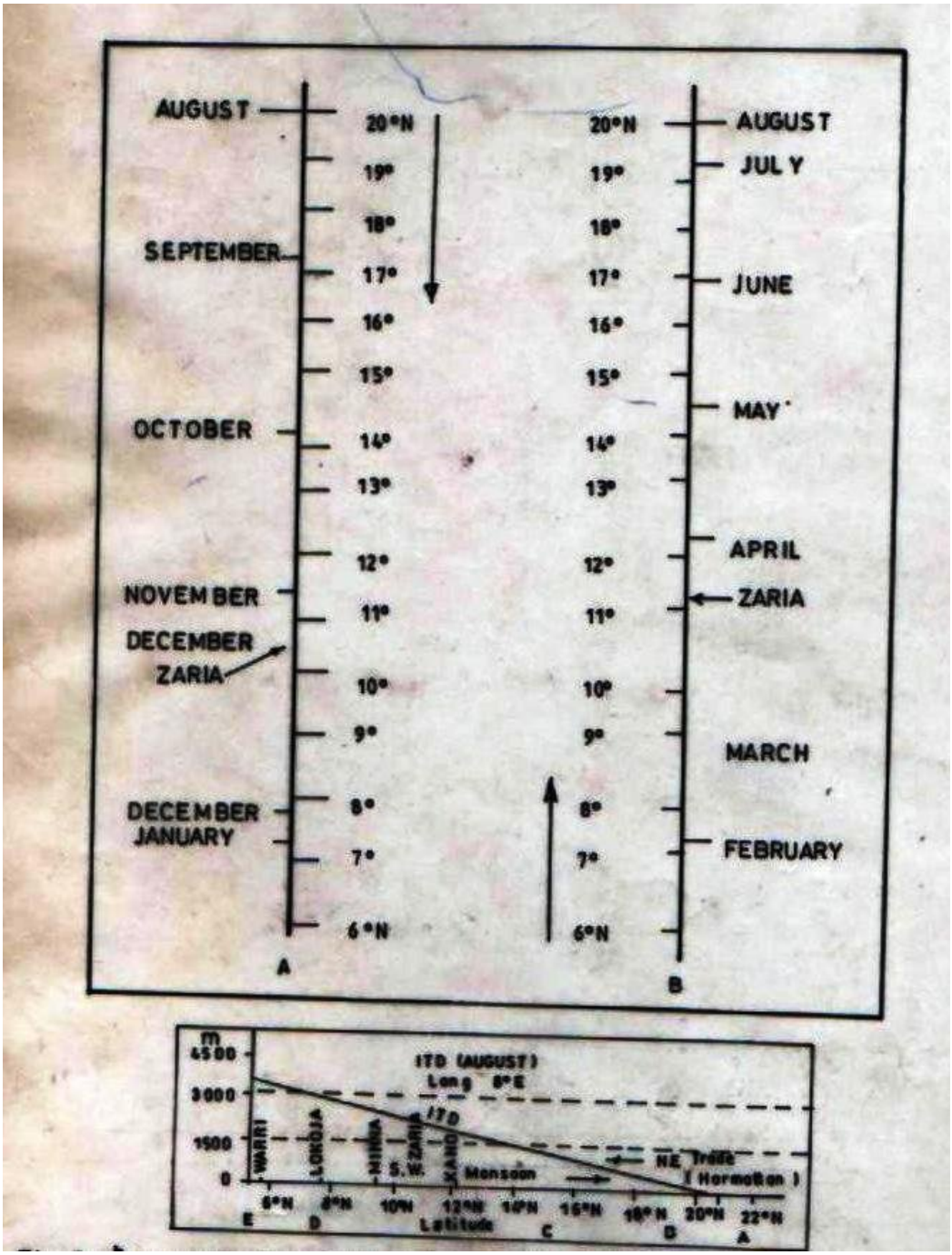


Figure 2.4b Approximate average surface position of ITD along the meridian of Zaria during: (A) Southward movement and (B) Northward movement. (After Hore P.N.1970)

Africa and for the rest of the year, from May – October Zaria is under the domain of tropical maritime air.

Below is a statistical characteristic of rainfall for a period years (1974 – 2009).

Table 2.2: Statistical characteristics of rainfall for a period of 36 years (1974 – 2009) in Samaru

Months	Means (mm)	Standard deviation(mm)	Co-efficient of variation	Standard error
January	0.0	0.0	0	1.55a
February	0.123	0.463	37.18	1.72
March	4.55	9.577	210	7.76
April	43.66	42.53	97	13.11
May	125.67	73.00	35	12.08
June	175.250	66.16	37	16.03
July	252.38	89.28	35	13.38
August	7316	74.53	23	15.27
September	171.796	83.64	47	10.19
October	50.022	56.74	113	10.19
November	0.173	0.949	547	0.173
December	0.322	1.796	556	0.32

Source: Data processing Unit Meteorological station of College of Agriculture (2009)

Analysis of the long term records of the rainfall data (1974 – 2009) shows that the catchments area have a mean annual rainfall of c.975.3mm. However, mean maximum of up to 1060mm have been recorded between (1928 to 1983) by (Ahmed 1989) It is important to note that variations in total distribution and intensity have also occurred in the basin for example total annual rainfall of 682mm was recorded in 1983, 1322.3mm in 2001.

(Iguisi 1997, Kowal *et al* 1972) stated that rainfall intensities are between 25mm/hr and 125mm/hr. Showing considerable variation in distribution and intensity, such rainfall have enormous surface flow and potential for accelerated erosion during torrential rain storms associated with the early rains in the catchment area (Yusuf *et al,* 2007).

The mean monthly temperature is about 27^0C but it is highest between the months of March and May which represent the hot dry period. It is lowest in December/January dropping to about 22^oC. The extremes variation in the climatic condition plays important role in the

determination of the state of the land viz a viz the water resource development (the reservoir) in the basin.

2.5 SOIL

Considerable variations exist in the soil types, however, it is described as leached ferruginous type. Topographical factors play a vital role in determining their detailed characteristics. For instance around Kufena hills is the young coarse or weakly developed soils (regosols). But the soils in the valley bottomland (fadama) belongs to the intrazonal group especially hydromorphic soils or vertisols (klinkerberg 1970) due to the accumulation of organic matter and alluvium and presence of moisture.

The soils are mostly dark-grey clays (vertisols) and poorly drained most of which have been formed in alluvial material, therefore, variations in texture can be expected. The fadama are of special importance, they are fairly rich in nutrients and have a good ample water supply which persists into the dry season.

Generally the character of the soil is such that as soon as rainfall begins, infiltration process could be high but the pores soon get sealed up and further infiltration is impeded resulting in overland surface flow and channels initiated (Makeri 1989; Kyari; 1997).

2.6 VEGETATION

The vegetation of the region is described as Northern Guinea Savanna type. The term connotes woodland vegetation type characterized by large surface coverage with few scattered trees and shorter grasses with tuff and occasional gallery forest along the water courses (Hore, 1970). Unfortunately, these characteristics of the vegetation cover are hardly preserved due to clearance for cultivation and other forms of intensive and extensive land use.

2.7 LANDUSE

Landuse in the areas will be discussed in greater detail in chapter five. It is sufficed to say here that while the topographical map (Zaria sheet 102SW and the associated aerial photos of 1963 table 2.3) show scattered cultivation and clusters of villages/settlements. The towns and urban sprawling/developments have entrenched geomorphic processes that are difficult to treat or arrest.

Table 2.3 Landuse in Kubanni basin (1971)

Catchments Area	Percentage of basin area
Open Savanna Wood Land	07
Shrub regrowth	17
Cultivation and Recent	
Fallow Land	46
Gully area	12
Rock out crops	03
Built up areas	12
	97

Aerial photos taken in 1962 (after Ologe, 1971)

The above table 2.3 shows that landuses on the Kubanni Basin before the 1970s fall into about seven (7) classes cultivated and fallow land was classified as the same and represents the highest percentage of 46, while the next was shrub regrowth and woody savannah at 17, and land degradation in form of gullied area was low about 12%. But drastic changes began to take place in the years that followed; between 1970 and 1990s as fallow land seems to have disappeared and have been replaced by all round year cultivation. Consequently cultivated area as at 1989 occupied 48-49%,shrub regrowth/wood land dropped from 20% to 4%.(Ahmed 1989).While degradation in form of gullied area increased from 18% to 23%, presently, overgrazing has become a very important landuse in the basin and seems to play a complimentary role with cultivation. In the same vein, overgrazing and cultivation occupy about 53.37% of landuses in the basin (Land sat imagery 2005).

The changes in the landuse of the area, over the years would have intensified and certainly have some implications on the geomorphic processes and consequently on land degradation and which will have effect on the reservoir development.

CHAPTER THREE

LITERATURE REVIEW

3.1 INTRODUCTION

Human beings and their activities have been responsible deliberately or accidentally for altering the distribution of resources both physical and socio-economic. Controlling the negative effects on the world's ecosystem has been a major challenge (World Conservation Monitory Centre, 2005). That led to the environmental movements of the 1970s and the subsequent promulgation of laws, decrees, Acts and conferences at global and local levels aimed at providing safeguard measures. In the same vein (Grossman and Krueger, 1991; Vincent et al, 1997; Boyce 2003) said degradation of all categories of environmental resources records intense deterioration during development processes and overtime economic growth should lead to better environmental quality. Yet it can be argued that economic growth alone has not led to better environmental quality, rather environmental policy intervention aimed at safeguarding the environment. Odu, (2007) argued that, good environmental interventions can be achieved only when it is guided and founded upon basic baseline data, and it is a measure through which the impact of development activities and ecosystem change could be characterized and assessed.

The literature review will focus on historical development of environmental impact assessment (EIA), its growth and spread in the developed and the developing countries with particular reference to its growth in Nigeria. Other areas to review include reservoir development and the impact on physical environment as well as case studies of landuse/landcover on the upper Kubanni.

3.2 HISTORICAL DEVELOPMENT OF ENVIRONMENTAL IMPACT ASSESSMENT (EIA)

The interactions between economic and social development and the reciprocal impact on human and biophysical world have also been recognized by governments in many parts of the world (Glasson, Therivel and Chadwick, 1999). Very often the impacts are usually negative on both socio-economic and especially on the physical environmental resources that have caused great concern and led to the promulgation of laws and regulations on exploitation of physical environmental resources. Conferences aimed at improving the quality of the environment have also been held especially in countries with advanced economy to encourage healthy physical and social development projects. Foremost among such laws is the Impact

Statements (IS). Such statements are meant to describe and state clearly the probable environmental consequences of development project action in advance, with emphasis on prevention of the negative effects. Some examples of IS policy or Acts are: National Environmental Policy Act of 1969 the United State Contributions

The first legislation requiring environmental impact statement was enacted in the US in 1969. The national environmental policy act was adopted by the Nixon administration in 1970. Amongst other things "NEPA" required federal agencies to include in every recommendation for legislation. The purpose of the Act are; to declare national policies which encourage productive and enjoyable harmony between man and his environment; to promote effort which will prevent or eliminate damage to the environment and stimulate the health and welfare of man; to enrich the understanding of the ecological system and natural resource important to the nation.

Recognizing the impact of man's activities and the interrelationship with all the components of the ecosystem, particularly, the profound influence of population growth, high density urbanization, resource exploitation, new and expanding technological advances; also the recognition of the critical need of restoring and maintaining environmental quality such that man and nature can exist in productive harmony, prompted the decision and declaration requiring that each federal project that may affect the quality of human environment be preceded by an evaluation of its potential impact on the environment. The evaluation would be presented in an Environmental Impact Statement, EIS (Botkin and Keller, 2005: pp. 659-664).

NEPA was a general worded law that required substantial interpretation. Howbeit, it became an important vehicle for preventing environmental harm. The 1970s saw a series of influential law-suits and court based decision over projects that needed the backing of NEPA. It has become a powerful environmental safeguard in the project planning process. However, NEPA's operations then, seem to have created more problems than it was established due to involvement in lawsuits (Dr. Loff; Glasson *et al,* 1999). To resolve the problem of NEPA, Council on Environmental Quality (CEA) was established and given authority to set enforceable regulations for interpreting and implementing NEPA. These were issued under President Carter (1978) with that NEPA process became more useful for decision makers and to the public emphasizing real environmental issues (Glasson *et al,* 1999: pp 28-37).

3.2.1 The Birth of EIA in the USA

EIA originated from the USA with the passage of the National Environmental Policy Act NEPA, adopted by the Nixon administration in 1970. However that was not the first instance when legislative support had been given to environmental protection consequent upon adverse environmental degradation problems. An example is the soil and wildlife conservation services

established following the extermination of valuable recreational and the loss of valuable land and soil resources/nutrients to the soil erosion that ravaged the environment in connection to developmental activities. It was obvious that American's efforts were mainly on the adverse impacts of man's actions with little consideration on identification and disclosure of the impacts at decision or planning stage of development projects. Issues of environmental degradation and pollution were being argued for, on the basis of expanded protection and preservation of resources and pollution regulation policies. (Jain *et al,* 1977).

The environmental legislation via NEPA indeed brought with it innovation to many federal projects and awareness to the American public the requirements of major actions in a systematic, comprehensive considerations of the environment. It emphasized better consultation and public participation in analytical process in order to achieve an acceptable improvement in the quality of the environment. The new legislation notwithstanding its vintage position on the improvement of environmental quality was not devoid of some antagonism. Both the public, environmental groups and federal agencies had one cause or the other for resorting to court for action, seeking modifications or even abandonment of projects particularly where they believed the Act was not adhered to. Although most of the earlier litigations were thought to be related to procedural requirements, hence were modified with focus placed mainly on contents of EIS and agencies decisions on completion of statements. That further generated problems of projects abandonment and delays and that resulted in a reduction of projects and developments activities in the USA at that period especially where such projects were found to be incapable of providing satisfactory EIS.

Subsequently the controversies surrounding the interpretation and enforcement of NEPA was resolved through the establishment and empowerment of Council Environmental Quality (CEQ) in the office of the president given extensive charter and responsibilities that was equally complimented with executive orders and directives from respective federal agencies. It is on record that nearly all the agencies have issued circulars and guidelines in that regard (Jain *et al,* 1977). Since then EIA had become established down to the grassroots level of the American system. Of particular interest is the California system established under the Californian Environmental Quality Act (CEQA) widely recognized as one of the most advanced EIA system in the world.

3.2.2 The Spread of EIA Worldwide

The EIA system has been established in shades and spread to other parts of the world since the enactment of NEPA and has been accepted in countries like Canada in 1973, Australia in 1974, West Germany in 1975, and France 1976, and recently to the less developed countries. The approval of European Directives on EIA in 1985 stimulated the enactment of EIA legislation in most of the former USSR constituent countries in 1990s. The early 1990s also saw a large growth in the number of EIA regulations and guidelines established in Africa and

South America countries. By 1996, the countries in both regions began to establish EIA as an environmental safeguard or requirement for proposed physical development. Countries such as Algeria, Costa Rica, Guatemala Togo, Nigeria, Tunisia had to initiate provisions for establishing some form of environmental protection agency which now exists in the framework of environmental legislation of more than 100 developing countries. (Glasson e*t al.,* 1999).

3.2.3 Historical Development of EIA in Nigeria

Like most post-colonial countries, Nigeria organizes its economic development on periodic basis aimed at rapid industrialization as a means of economic development. The first National Development Plan (1962-1966) emphasized the development of infrastructure, while subsequent plans focused on the creation of industrial complexes. The industrial activities were full of exploitations of resources that encouraged environmental degradation and pollution in uncontrolled manner. Policies aimed at integrating development programmes with environmental issues during planning stages were non-existent. The harvest of this neglect soon manifested. Typical is the Kaduna industrial complex where textile mills were established to encourage industrialization and provide employment opportunities. Today this cluster of mills constitutes environmental nuisance and a core source of water pollution (Al-Amin, 2004).

As a consequence of the illegal dumping of toxic wastes in Koko (In the former Bendel State in 1987), the Nigerian Government promulgated Waste Decree which provided the legal framework for the effective control of the disposal of toxic and hazardous waste into the environment within the confines of Nigeria. In 1988, a regulatory body. (The Federal Environmental Protection Agency FEPA) was promulgated. FEPA is charged with the overall responsibility of protecting and developing the Nigeria environment avoiding environmental degradation. For the preservation and protection of the Nigerian environment, State and Local Government Areas were also encouraged to establish similar regulatory bodies for the purpose of maintaining good environment quality as it applies to their particular terrain (Echefu & Akpofure, 2007).

The specific EIA Decree NO. 86 of 1992 is particularly directed at regulating the industrialization development programme. The decree made EIA mandatory for both public and private sectors for all development projects.

3.3 EIA OPERATIONS IN NIGERIA

The EIA process is the various stages a project undergoes from proposal to approval for implementation, resulting in the issuing of an Environmental impact statement (EIS) and certificates. The National procedure Guidelines show practical steps from project conception to commissioning. (Fig. 2.5).

The proponent initiates the process in writing to the responsibility officer. A notification form is duly completed with all relevant information on the proposal. FEPA does internal screening to determine the project's category. Where no adverse environmental effects exist, the EIA is issued and the project commences with appropriate mitigation and monitoring measures.

The environmental impact assessment process requires input from a variety of individuals including: professionals and civil servant with expertise in environmental science and engineering; local officials who are knowledgeable in local, state, and federal environmental management procedures and regulations; and members of the community who posses both expertise and interest in the local environment and natural resource

It is important to note that in EIA, there is no standard model or format. The format will depend on the type of development that will be carried out in the area.

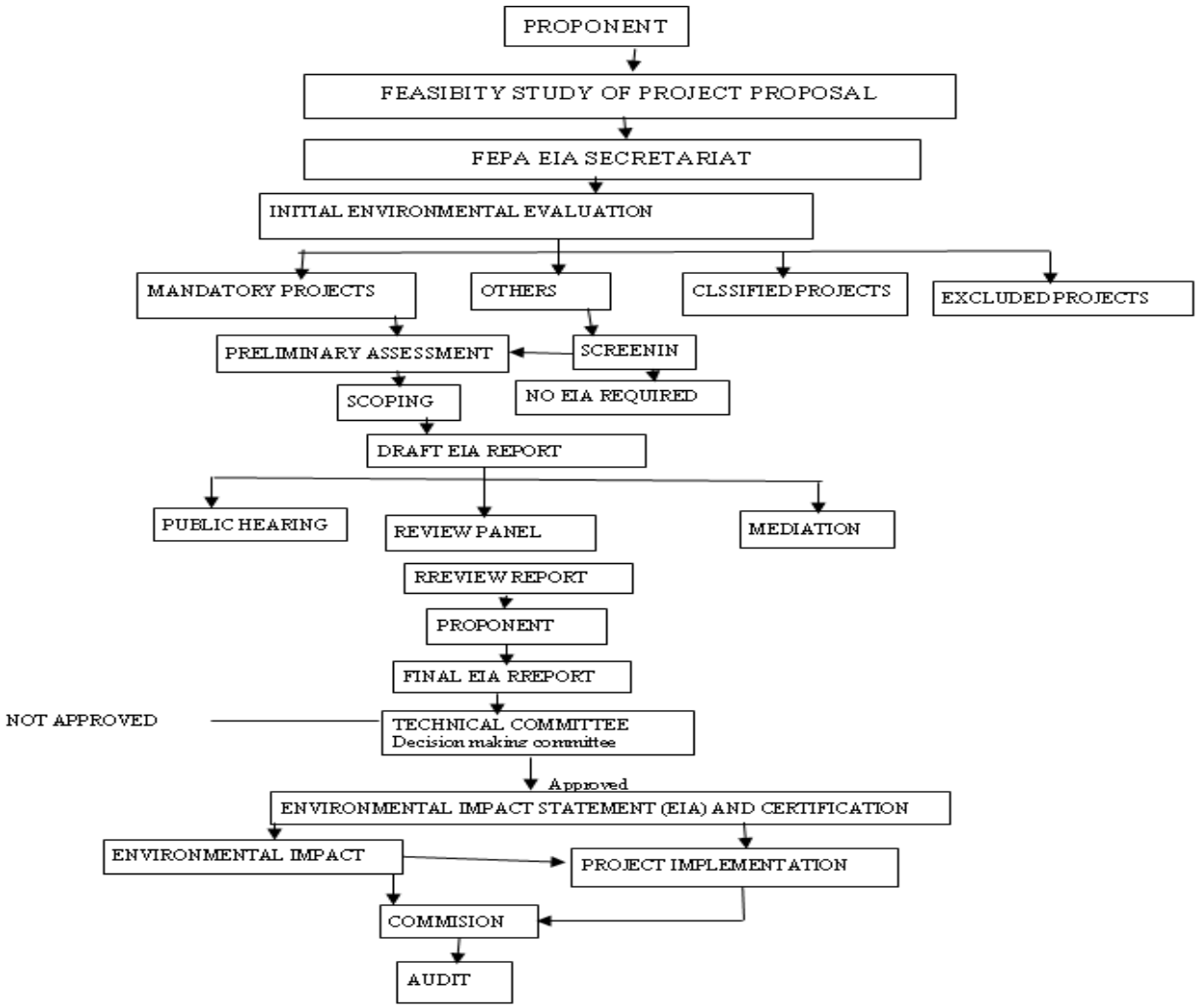


Figure 2.5: Flow Chart of FEPA Procedures

3.4 RESERVOIR DEVELOPMENT AND THE PHYSICAL ENVIRONMENT

The risks and problems associated with dams and reservoir development are considerable and enormous including loss of land by erosion, biological resources, and siltation which in turn reduces the water storage capacity and limiting the lifespan of the reservoir (Botkin and Keller, 2005; Gettis and Malinoswski, 2005)

On the other hand, Keith (1998), observed that one third of the problems associated with reservoirs/ dam development has to do with inadequate spillway design, another one third is probably caused by seepage through the dam design and for the remaining third are due to

foundation problems or liquefaction of earth dams as a result of earthquakes or landslide generated.

Most studies on dams and reservoirs have shown that most of the problems associated with dam developments are related to the landuse practice around the basin where the project is sited. Also human activities such as overgrazing and bush burning encourage accelerated erosion.

Considering the problems associated with dam development on the physical social and economic environment, the idea of reservoir/dam development is being discouraged. Nevertheless, in view of the increase in the population at a growth rate of 1.2 percent, the demand for water use will continue to rise That notwithstanding, there are but a few acceptable sites for dams and reservoir development with appropriate safeguard policies and environmental impact assessments both at pre and post project developments.

3.5 STUDIES ON LANDUSE/LANDCOVER ON THE UPPER KUBANNI BASIN

Studies of landuse/landcover carried out within the Upper Kubanni Basin in the past two decades ago (Ahmed 1989) showed that (1) the basin had four classes of landuses/landcover. (Table 3.1).

Table 3.1 Landuse classes in the upper kubanni basin for the period 1963- 1989

Type of landuse	Percentage area covered		
	1963	1976	1989
Urban area	12	18	24
Cultivated area	46	48	49
Gullied area	02	14	23
Rural uncultivated area	30	20	0.4

Source: Ahmed 1989.

Table 3.1 summarizes the landuse/landcover classes on the Kubanni basin for the period before and shortly after the development of the reservoir. Then cultivated area ranked highest with 46 percent in 1963 and a slight increase to 48 and 49 percent in 1976 and 1989 respectively. Rural uncultivated (Savanna woodland) rank second highest in 1963 at 30 percent but declined to 20 percent in 1976 and subsequently decreased so low to about 0.4% in 1989.

Urban growth and developmental infrastructures steadily increased over the period at a percentage of 12 in 1963 and rises to 18 and 24 in 1976 and 1989 respectively. But for gullied area which was very insignificant of about 2 percent in 1963 it increased to 14 and 23 percent in 1976 and 1986 respectively. The later periods witnessed uncontrollable farming activities immediately along the margins of the area upstream of the reservoir.

However the method employed in the previous studies in identifying and finding the area extent or intensity of each landuse/landcover was limited because it was based on calculations derived from air photographs and topographical sheets of 1963. Notwithstanding, changes in the landuses have occurred in the basin over time. The Urban and Regional Planning Department, of Ahmadu Bello University, Zaria (Master Plan 1975/76) worked on the increase and intensity of landuses in the basin. It showed also four landuses/landcover classes including urban agriculture, built up area, gullied areas and rural areas (Savanna woodland). However, there was no indication of how the areal extent or intensity of each was derived. Therefore making effective comparism over the years on landuse/landcover will be spurious.

In this study, the present researcher resorted to using remote sensing and GIS to update the current landuses/landcover status of the study area. It will suffice to say here that changes have been noticed and they will be discussed in chapter 5.

CHAPTER FOUR

METHODOLOGY

INTRODUCTION

In this chapter, types and sources of data required are explained in 4.1. Section 4.2 describes the techniques used for the vegetation survey and how the data are collected. In section 4.3 methods and procedure of data analysis are presented.

4.1 SOURCES OF DATA FOR THE STUDY

Therivel and Morris (1995: P181-187) suggested certain factors to be borne in mind for obtaining data in baseline studies. For example, they considered that accuracy and precision are required. Besides, there should be availability of resources and timing consideration for the chosen methods.

For a water resource project of this nature, a great deal of effort towards its development and protection for present and future use, will largely have to depend on the supply of accurate and reliable information (data) on the state of the resource and the environment where it is found.

4.2 METHODS AND PROCEDURE OF DATA COLLECTION FOR THE STUDY

Direct field surveys were undertaken for the vegetation and soil surveyin the study area. That gives the opportunity for field visual inspection of the nature of habitat and communities present in the area of study. Also detailed and direct observation of some of the physical properties of soil such as the soil profile characteristics especially colour from top to bottom, laboratory analysis were taken. Thus, updated soil condition during the period of the study was obtained.

Remote Sensing – the landuse/landcover classes and their extent were obtained from remote sensing and geo information system application techniques were used. The RS and GIS have the advantage of providing accurate and current landuse information that can serve as indisputable and sound biophysical data for Upper Kubanni Basin. (Glasson *et al,* 1999: p104-108). The change detection was obtained from three categories of imageries for 1975; 1987 and 2005.

4.2.1 Vegetation Survey

North –south transects about one kilometer apart, were established across the catchments (figure 4.1) . Five quadrangles of 100m x 100m (10,000 sq metres) in each location were marked corresponding to the natural vegetation characteristics of the area.(Whittaker 1970).

Within each 10,000 sq metres, the number of the woody plants species were enumerated and recorded. Herbaceous species were also evaluated using smaller quadrants of 5 by 5m in the 10,000 sqmetres. Five of such quadrants were taken in each plot. The herbaceous plants in each plot were enumerated, recorded and were harvested for above ground biomass determination. (Whittaker, 1956: p. 1-80).

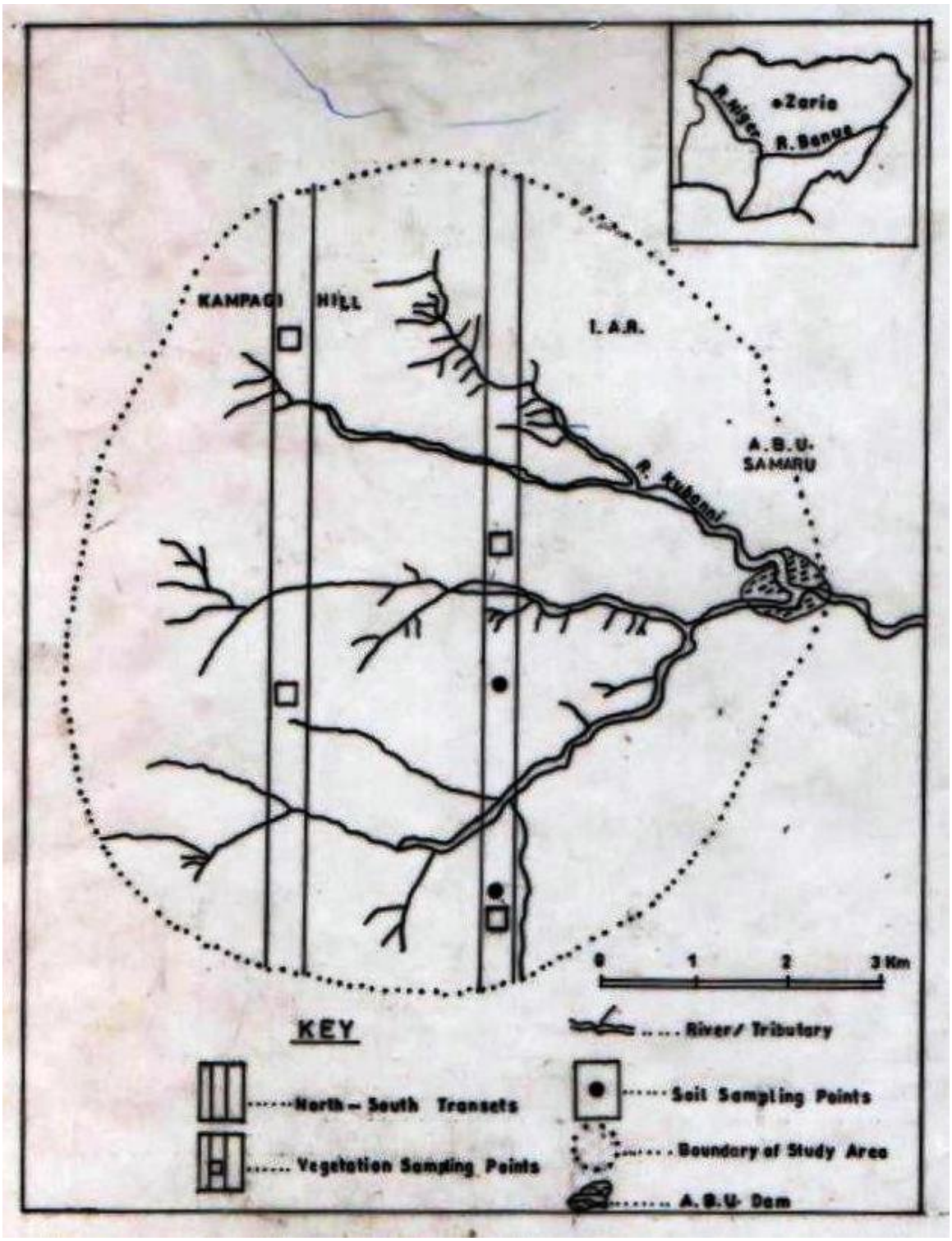


Figure 4.1 : Showing vegetation and soil sampling point

4.2.2 Soil Survey

Soil samples were collected from the fresh cut face of the profile which by location coincides with roughly mid-way between two adjacent vegetation characteristic in the 100 x 100m plot(figure 4.1). The soil profile pits were however limited to two pits due to limited resources, and the fact that the area is generally described as ferruginous and fairly uniform in its profile.

A total of 16 samples were collected, from each horizon two samples were taken at 0cm to 40cm on the surface, and at 40 to 80cm depth, 80 – 120cm and 120cm to 160cm at the lowest horizon. (Table 4.1).

Table 4.1: Samples Site

Horizon	**A**	**B^1 and B_2**	**B_2 and B_3**	**C**
Pit I	2	2	2	2
II	2	2	2	2

The soil samples taken from pedogenic horizons of the two soil profiles weigh three to five kilogram. The bulk samples from each horizon were homogenized through mixing.

These sampled soils were sieved through a 5-mm sieve before air drying. The air-dried bulk soil samples were each divided into two subsamples; one subsample was ground and passed through 2-mm sieve. The five earth separates (<2-mm) were used for laboratory analysis. The other subsample was left intact for soil aggregate size separation.

4.2.3 Satellite Imagery Work

Firstly, topographical map sheet 102 SW was acquired and used to delineate the study area and also to update the landuse and landcover map of the study areas.

Secondly, three sets of landsat imageries which are landsat MSS Multispectral Scanner (80m resolution), landsat thematic mapper (30m Resolution) of 1987 and enhanced thematic mapper of 2005 (15m resolutions) were acquired in CD Rom from the department of Remote Sensing/GIS, Federal Ministry of Agriculture Mando in Kaduna for change detection of the various epochs (i.e. 1972, 1987 and 2005).

Therefore, the following sets of Remote Sensing and GIS softwares were not only used for the processing of the imageries but also for the identification of various landuse/landcover classes as well as analysis of the landuse/landcover. These include Earth Resources Data Acquisition System Software (ERDAS Imaginine 8.7), ASCVIEW 3.2a Software and Arcinfo

Software).Earth Resources Data acquisition software ERDAS Imaginine Version 8.7) software was used for the processing of the images. The raw satellite image was converted from Tag image file format (Tiff) using ERDAS compatible with other ERDAS imaginine files.

4.2.4 Survey of Spatial Distribution of Gullies

A reconnaissance survey of the Upper Kubanni Basin was carried out to locate the gullies along the tributaries. The Zaria sheet 102 SW(1:50,000) was used as a guide. Also, Ahmed's work (1989) served as a base for the comparison of the areal extent/increase in the spatial distribution of gullies in the study area over the period 1989-2009.Direct field observation and measurement of the axial gullies was done using linear tape graduated in metres.

4.3 METHODS AND PROCEDURE OF DATA ANALYSIS

4.3.1Vegetation Diversity

The diversity of the species was evaluated using Shannon-Weiner Index (1949) of diversity index.

$$H^1 = \frac{\sum pi \log pi}{\frac{ni}{N}}$$

Where

H^1 = Summation of pi log pi

pi = ni

N

ni population of each specie

N = total population

4.3.2 Soil Analysis

Aggregate size distribution was determined by wet and dry-sieving 100g of the soil through 2.0-, 1.0-, 0.25-, 0.053- and <0.053-mm mesh sieves.

Mean weight diameter (MWD) for both wet and dry sieved subsamples was calculated as the accumulated sum of each fraction times the corresponding mean mesh size of both two sieves passing and retaining the fraction i.e.

$$MWD = \sum_{i=i}^{n} x_i \overline{w}_i$$

Where:

x_i – Mean diameter of each size fraction (mm)

w_i – Proportion of the total sample weight occurring in the size fraction

n – Number of size fraction.

The air dried five earth subsample (<2.0mm) was used to determine the particle size distribution using the hydrometer method (Gee and Bauder, 1986) along with sodium hexa meta phosphate (calgon).

- soil bulk density was determined using the undistrurbed core samples.

The total porosity of soil was calculated from values of soil bulk density and particle density i.e.,

Porosity (%) = 10 [1 - D_b ( )

Where:

D_p = soil particle density (assumed to be 2.65gg/cc)

D_b = soil bulk density

Moisture Content

The moisture content was determined as

$$WC = \frac{WSI - WS2}{DW - VS1}$$

Where:

Wc = water content ($9/cm^3$)

WS1 = weight of soil before drying

WS2 = weight of the soil after oven drying

VS1 = volume of the soil

DW = Density of water in the sample (see table 4.2)

Table 4.2: Bulk Density and Moisture Content

Soil profile	Horizon	Soil dept (cm)	Weight of wet soil (g)	Oven dry weight of soil (g)	Weight of empty core (g)	DW	MC
I	A	0-40	275.90	275.53	93.39	1.7	18.37
	B_1 & B_2	40-80	279.09	261.06	99.37	1.7	18.03
	B_2 & B_3	80-120	236.75	288.73	94.96	1.4	8.02
II	C	120-160	303.17	291.30	108.58	1.30	11.87
	A	0-40	383.47	344.60	117.08	1.6	38.87
	B_1 & B_2	40-80	285.36	251.31	92.00	1.6	34.05
	B_2 & B_3	80-120	357.64	314.96	111.44	1.4	42.68
	C	120-160	326.60	298.82	116.75	1.3	27.78

4.3.3 Data Analysis on Distribution of Gullies in the Upper Kubanni Basin

Gully density was calculated using the following formula;

$$d = \frac{\sum L}{a}$$

where d = gully density

$\sum$ = sum of gully lengths

a = the area drained by the gullies was determined by strip method.

CHAPTER FIVE

RESULTS AND DISCUSSION

INTRODUCTION

This chapter presents the results and discussion of the study which are built around the biophysical characteristics and landuse/landcover changes in the Upper Kubanni River Basin.

RESULTS

The results based on the objectives presented include those of the:

- vegetation inventory of the Upper Kubanni River basin in section 5.1
- data on soil characteristics especially of the physical parameter around the drainage basin were presented using the analyzed samples in section 5.2
- the state of the landuse and landcover changes were described in section 5.3

5.1 VEGETATION INVENTORY

The composition of the plant species in the study area is described below. In section 5.1.1 the woody plant composition and the diversity index for each surveyed location is described. The description of the herbaceous/grasses composition are presented in 5.1.2

5.1.1 Woody plants species

Kampagi Hill

It is the summit of the Upper Kubanni Reservoir Basin. It gradually rolled to form the plain site of Ahmadu Bello University Teaching Hospital.Within one hectare (10,000sq meters) of the kampagi summit, a total of 45 woody plants species were numbered. However, the total population of woody plants was one thousand four hundred and seventy (1470). The most abundant species were *Deta rium microcarpum* with a population of 324 individuals, followed by *Afrormosia laxiflora* 238; *Isoberlinia doka* 221; and *Guiera senegalensis* 120. The total diversity of plants in the surveyed plot was 2.63. (table 5.1)

Table 5.1: Total number of woody plants/total population and the diversity

Sampling points	Woody plant species	Total population	Diversity index
Kampagi	45	1470	2.63
Panhauya	15	256	1.03
Daurayi	34	1258	1.62
Unguwan Yarsarki	22	2329	1.09

Source: Field work, 2009

A woody specie diversity of 2.63 at kampagi was appreciable given a range of zero-five(Magurran, 2004) . The high indexes of 2.63 suggest that the vegetation was not too degraded and could be rehabilitated. There was an evidence of compositional shift as *Isoberlinia doka,* the expected dominance took second place. The presence of high number of *Gueira senegalensis*, a plant of disturbed habitats indicated some disturbance factor or factors, the obvious one from observation are fuel wood gathering and grazing.

Panhauya

The plant cover in the locality is generally poor particularly in terms of natural vegetation. However the surroundings are marked with secondary vegetation cover particularly farm lands.On the surveyed hectre plot (100m x 100m), 15 woody plants species were encountered and the total population of woody species were 256 plants. The most populous woody plant was *macrosphyra longistyla* with 50 individuals followed by *Jatropha curcas,* 18. The total diversity of woody species was 1.03. That represents very low woody vegetation diversity and could be related to farming and grazing activities going on in the area.

Daurayi

The woody plant species at Daurayi was 34 with a total population of 1258 woody plants on the hectre surveyed. The species with the greatest population was *Gueira senegalensis* being 543 in number followed by *Isoberlinia doka* 443 individuals on the hectre, *Annona senegalensis* 81 individuals, and *Dichrostachys cinerea* 56 individuals. The total diversity of woody plants was 1.62.

Unguwar Yarsarki

At Unguwar Yarsarki, the woody vegetation had 22 species and a total of 2481 species were enumerated in the hectare. The plants with highest number of individuals were *Isoberlinia doka* 2329 (Table 5.1), followed by *Mesosphyra longistyla* 62, On one hectare of land surveyed, the total species diversity index of was 1.09.

Implication of diversity index

Generally, the Shannon diversity index as calculated ranges from 0 – 5 (rarely greater than 5) has the consequence that a value less than midpoint between 0 and 5 is regarded as low diversity. While a value from mid point and above is high (Magurran2004), showing that the vegetation is rich and have not been subjected to much interference by human activities

5.1.2 Herbaceous plant species

These are plants with soft stems.

Panhauya

A total of 21 herbaceous species were enumerated with a population of 112. The highest population was *Tetrapogon elegans* being 45 followed by *Seteria barbata* also 22 and *Chloris pilosa* 18. The total herbaceous plant diversity was 2.18 (table 5.2)

Table 5.2 Herbaceous Plant Species and diversity in Panhauya Diversity

Type/species	**Average population**
Chloris pilosa	18
Pennisetum pedicellatum	3
Setaria barbata	22
Thelepogon elegans	1

Forbs	
A*canthospermum hispidum*	1
Ageratum conyzoides	1
Bidens pilosa	1
Chaemocrista rotundifolia	6
Commelina benghalensis	1
Corchorus tridens	1
Leucas martinicensis	1
Indigofera errecta	1
Senna occidentalis	1
Sesamum alatum	0
Sida acuta	1
Sida linifolia	1
Sida urens	1
Striga gesneroides	1
Synedrella nodiflora	1
Urena lobata	1
Walteria India	1

Index **2.18**

Daurayi

A total of fourteen herbaceous species with a population of nineteen (19) plants in twenty five square meters were obtained in the location. *Andropogon gayanus*; *Eragrostis sp senna. obtusifolia* and *Sporobolus pyramidalis* had the highest population. The total diversity in the location was 2.24 as shown in. table 5.3

Table 5.3 Herbaceous species and diversity at Daurayi

Type/species	Average population
Andropogon gayanus	2
Ctenium newtonii	1
Hyperthelia dissolute	1
Pennisetum pedicellatum	1
Sporobolus pyramidalis	2
Eragrostis	9
Borreria verticellata	2
Leucas martinicensis	1
Senna obtusifolia	2
Sida linifolia	1
Stylosanthes humilis	1
Urena lobata	1
Vernonia spp	1
Walteria Americana	1

Diversity index 2.24

Unguwar Yarsarki

On the 25square meters within the hectare surveyed, only 25 species of herbaceous plants were encountered with a total population of 69 plants, the annual grass is most populous with 25 individuals, followed by *Ageratum conyzoides,*9 individuals and *Chloris pilosa*, 4 and *Borerea verticellata* 4. The total diversity was 2.50 (table 5.4).

Table 5.4 Herbaceous plant species and diversity in Unguwar yarsarki

Type/species	**Average population**
Andropogon sp	3
Chloris pilosa	4
Daclylotenliumaegyptium	1
Eragroshs tenella	1
Pennisetum pedicellalum	3

FORBS	
Acanthospermum hispidum	1
Ageratum conyzoides	9
Alysicarpus vaginalis	20
Aspilia Africana	1
Borreria radiate	3
Borreria veriticellata	4
Chaemocresta rotundi folia	1
Ethalia conyzoides	1
Autenbalgia	2
Monectima ciliatum	1
Oldenlavidia herballae	1
Senna oblusifolia	1
Sida acuta	1
Sida urens	1
Spigelia anthelmia	1
Spriga hermonthica	1

Diversity Index 2.50

5.1.3 Herbage yield

At parhauya, the potential grass herbage was 3.2 tonnes per hectare while forbs yielded 2.6 tonnes. At Unguawan yarsarki, grass herbage was 2.8 tonnes while forb was 2.4 tonnes. At

Durauyi, forbs yielded herbage higher than grass at 3.2 tonnes while grasses yield 1.7 tonnes as shown in table 5.4.

Implication of herbaceous species

Majority of the herbs in the surveyed locations were forbs (non- grasses) i.e. the grass component was devoid of the Andropogoneae. Andropogonneae are largely perennial and offer a preferred choice for livestock in the course of grazing. This character is a name of vegetation degradation (Vankulen and Breman 1990). The grazing pressure on this vegetation is expected to be severe and further exacerbating the degradation (Vankenlen and Breman1990).

Table 5.5 Herbage (Dry matter) yield in studied areas

Location	Daurayi	Unguwan yarsarki	Panhauya
Component:			
Grass	1.7	2.8	3.2
Forb	3.2	2.4	2.6
Total	4.9	5.2	5.8

Herbage yield in tons/ha.

5.2 RESULTS OF SOIL SAMPLE LABORATORY ANALYSIS

The soil sample collection technique for particle size, aggregate stability, bulk density and porosity using soil profile pit approach has already been explained in chapter 4. Here the results of the laboratory analysis are presented.

5.2.1 Particle Size Distribution

The proportion of the various primary soil particles showed that the soils were loamy in texture. However, the Barau soil series were finer with clay and silt fractions recording significantly ($P<0.1$) higher amount than in the Pahanya soil series (Table 4.6). Soil textural class for Barau was sandy clay loam while that of Pahanya was sandy loam. The increases in clay fraction in the Barau soils were high enough to cause a change in the soil textural classification. The preponderance of sand fraction in the two locations is indicative of inherent coarse nature of these soils. Many workers (Kowal and Kassam, 1976, Jaiyeoba, 1995 and Samuel, 2004) have reported dominance of sand fractions in soils of the Nigerian savanna.

One implication of the soil textural class of these sampled soils in the two locations is that the Barau soil series will naturally exhibit a higher water and nutrient retentive capacities than the Panhaya soils. A sandy clay loam soil will check leaching relative to a sandy loam.

Table 5.6: Results of Particle size and Aggregate Stability for Panhauya Barau.

	Sand	Silt	Clay	Mean Weight	Diameter (mm) dry	Stability
Panhanya	78.0a	8.67b	14.0b	4.00a	2.89a	1.44
Barau	60.0b	18.67a	21.3a	2.14b	2.52b	0.68
Standard error	3.83	2.981	1.764	1.187	0.837	0.35a

5.2.2 AGGREGATE STABILITY

The distribution of the aggregate size classes showed that the soils of Pahanya had higher aggregate stability. The mean weight diameter, which is an index of soil aggregate stability, had values which are significantly higher ($P<0.05$) for Pahanya over soils of Barau (Table 5.6). The results show that the soils of Pahanya possess more stable macroaggregates, especially of the largest class (>2.00mm); since such classes strongly influence mean weight diameter (Ogunwole & Ogunleye, 2004).

The Mean Weight Diameter (MWD) by wet and dry sieving are indicative of a soil's resilience to resisting water and wind erosive force respectively (Unger, 1997). One slight snag here is that the mean weight diameter determined by wet sieving was not corrected for sand fraction before calculating the MWD.

The aggregate stability index also confirmed Pahanya to be more stable and by inference, better structured than the Barau soils.

5.2.3 OTHER SOIL PHYSICAL PROPERTIES

Surface soil bulk density was not significantly different between the two soils. However; Panhaya soils recorded higher bulk density reading (Table 5.7). Soil bulk density is one index of a good quality soil (Ogunwole & Ogunleye, 2004). This is because very high soil bulk density results in compaction of soil which adversely affects crop development. For a sandy loam soil texture, soil bulk density of 1.53Mgm^{-3} is close to the threshold that tends toward compaction. However, it is still within the permissible limit for this textural class. In the case of a sandy clay loam, 1.48Mgm^{-3} is also close to the threshold but within permissible limits.

Table 5.7: Results of particle density, bulk density and porosity

location	Particle density	Bulk density	Total porosity
		Mgm^{-3}	(0/0)
Panhanya	2.51	1.53	39.35
Barau	2.53	1.48	41.78
Standard Error	0.019	0.128	4.747

The implication of these results is that soil management interventions are required to improve the health of the soils of these two locations before they become heavily degraded. Evanylo and McGuim (2000) suggested soil bulk density values of 1.55 to 1.65Mgm^{-3} as critical since such density levels could restrict agriculture and development. There were similarities in the values of total soil porosity between soils of the two locations (Table 5.7) However; soils of Barau were more porous (42%) than that of Panhauya. From the textural classification of Barau soil, it will not be out of place to infer that the high value of total porosity will largely have been

contributed by the proportion of capillary pores or value of capillary porosity of this soil.

Results of soil particle density revealed that the soils of the two locations have similar densities. This is expected as their textural classes are similar.

5.3 LAND USE/LAND COVER CHANGES

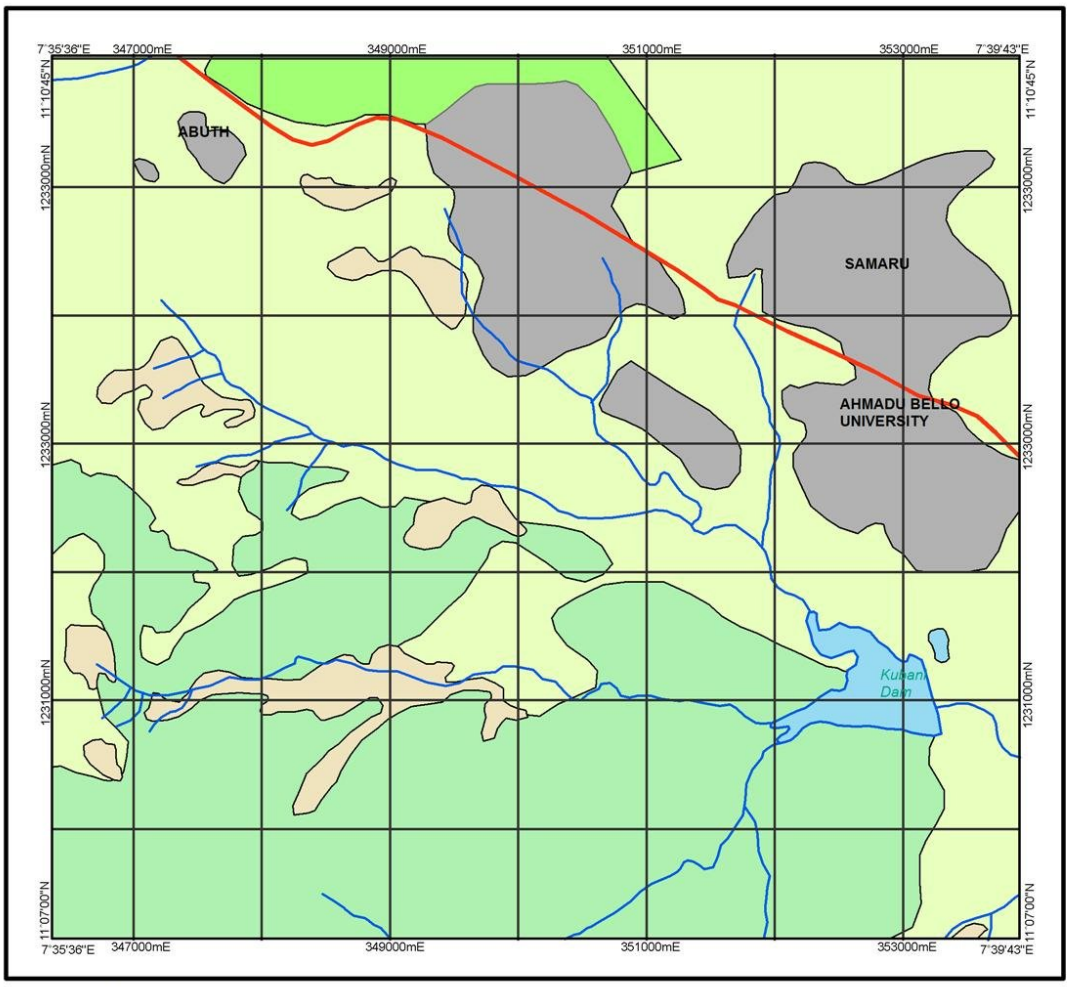
Details of the materials, instruments and methods used in monitoring types of land uses and land cover changes have already been described and explained in chapter 4. Here the concern is to describe evolving land cover changes over the years. The summary of the observable type of landuses and land cover changes monitored throughout the period of the photo-years are presented in table 5.7 extent of the area covered by the photo-years. The most important landuse class is the scattered cultivation and the grazing contributing about 44.1% in 1987 (22.9km) increasing to 54.4% in 1994 (28.2km) and 53.4% in year 2005 (27.7km)

The landuse/landcover classes and the changes are presented in table 5.8 showing the area covered by each class in km^2 and the percentages and the changes that have occurred since the period of 1987. However changes from 1965 to 1986 were not appraised because as at that period, there was no or rather insignificant effect on the landcover changes associated with the introduction of development project particularly the reservoir on the Upper Kubanni Basin

Table 5.8: Results of landuse/landcover changes analysis for periods 1987, 1994 and 2005

YEAR/PERIOD	**1987**		**1994**			**2005**		
Landuse classes	Km^2	%	Km^2	%	%change 1987-1994	Km^2	%	%change 1994-2005
uilt up area	7.98	15.39	9.97	19.22	3.83	13.3	25.65	6.42
Extensive cultivation grazing	22.86	44.08	28.24	54.44	10.36	27.68	53.37	-1.07
Gullied area	2.16	4.17	5.77	11.12	6.96	7.57	14.60	3.47
Intensive cultivation	1.4	2.70	1.02	1.97	-0.73	0.91	1.75	-0.22
Shrub regrowth/open savanna	16.83	32.45	6.2	11.95	-20.50	1.66	3.20	-8.75
Water body	0.63	1.21	0.67	1.29	0.08	0.743	1.43	0.14
Total	51.86	100	51.87	100	0	51.861	100	0

Source: Field survey, 2009.



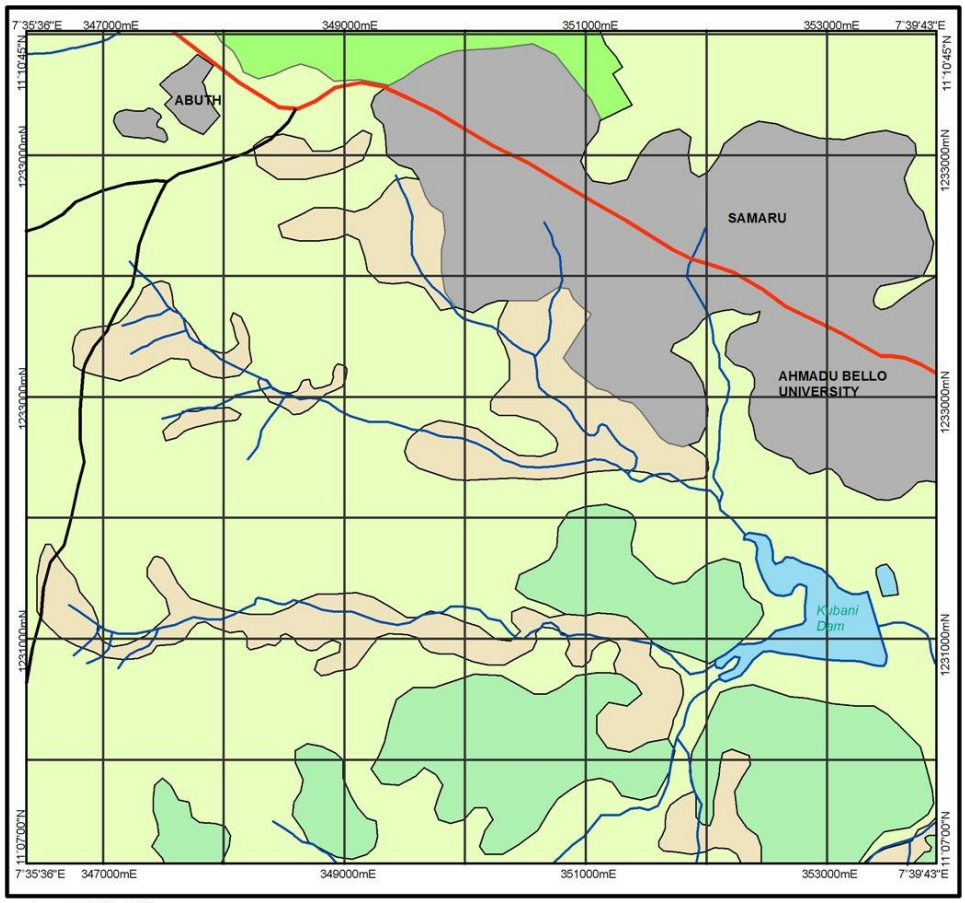
Source: Landsat TM (1987)

Scale:- 1 : 45,000

Legend

- Road
- Stream
- Built-up Area
- Extensive Cultivation/grazing
- Gully
- Intensive Cultivation
- Open Savannah
- Water Body

Figure 5.1: Landuse/Landcover Changes in Upper Kubanni Basin; 1987



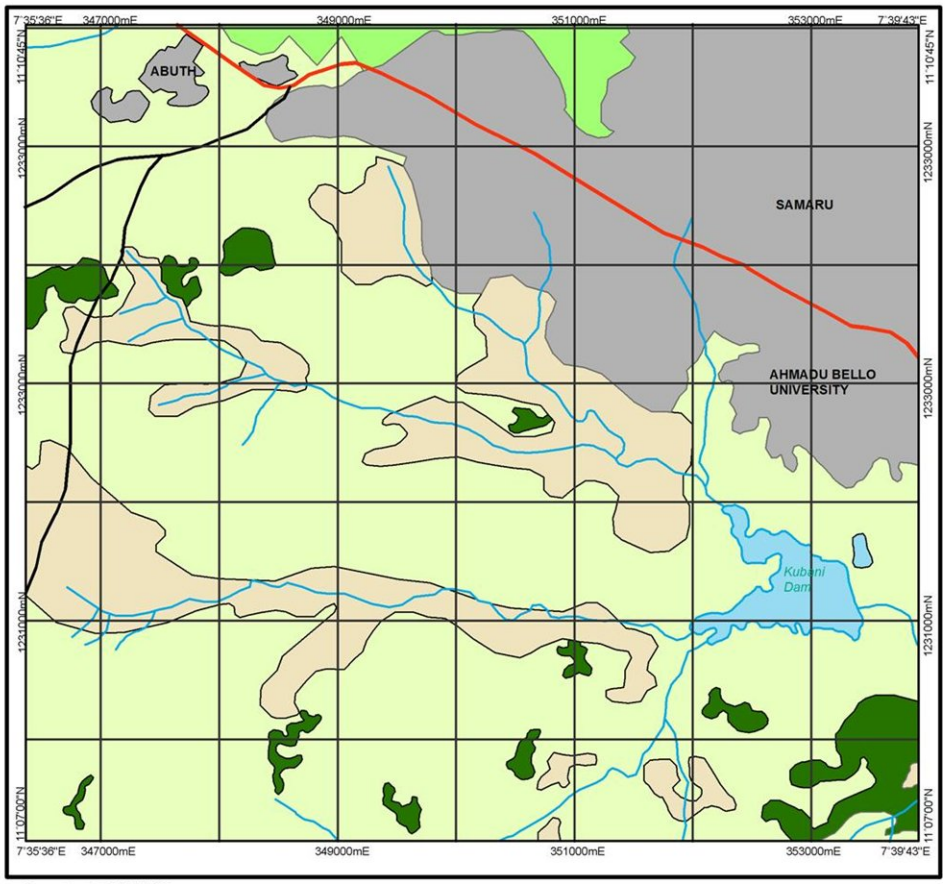
Source: SPOT Xs (1994)

Scale:- 1 : 45,000

Legend

- Major road
- Minor road
- Stream
- Built-up Area
- Extensive cultivation/grazing
- Gully
- Intensive Cultivation
- Open Savannah
- Water Body

Figure 5.2: Landuse/Landcover Changes in Upper Kubanni Basin:1994



Source: Landsat ETM (2005)

Scale:- 1 : 45,000

Legend

- Major road
- Minor road
- Stream
- Built-up Area
- Extensive Cultivation/grazing
- Gully
- Intensive Cultivation
- Shrub Regrowth
- Water Body

Figure 5.3: Landuse/Landcover Changes in Upper Kubanni Basin:2005

The high percentage of land area (i.e. 53.37% in 2005) under cultivation and grazing could be explained in connection to the high population growth experienced in Zaria Township generally resulting in cultivation of every available land and for grazing purposes, so as to meet the high demand for food and livestock.

However, the slight decline of -1.07% in the land area under cultivation and grazing from 28.24km^2 in 1994 to 27.68km^2 2005 was observed. figure 5.3 that may not be unrelated to the intervention measures carried out by the University authority to control the siltation threat posed on the reservoir. Built up area as presented in table 5.8 shows a significant increase of about 7.98km^2 which represents 15.39% of the landuse classes in 1987 as well as 9.97km^2 and 13.3km^2 in 1994 and 2005 respectively. These indicate percentage increase of 19.22% and 25.65% respectively. That could be attributed to the expansion of the Ahmadu Bello University residential area and services. Added to this is the development of the Ahmadu Bello University Teaching Hospital (ABUTH) particularly towards the head water area of the northern tributary. Satellite imagery 1987, 1994 and 2005.

Table 5.8 shows that, in 1987 open savannah was the second most important landcover which occupied about 16.83km^2 (32.45%) but declined to 6.2km^2 and 1.66km^2 in 1994 and 2005 respectively indicating decrease of -20.50% and -8.75%. By 2005 there seems to be a total disappearance of open savanna wood land, which is being replaced by shrub regrowth and pockets of secondary vegetation. Except for a small area of land at the Institute of Agricultural Research (IAR) which occupies about 50metres. With the sharp decline of the open savanna as shown in the table 5.8, there seems to be a corresponding increase in gullying.

Gullied area shown in table 5.8 occupied 2. 73 ting 4.17 percentages in 1987 rose to 5.77km^2 in 1994 and 7.57km^2 in 2005. Thes centage increase of 3.47 and 14.60 respectively.

As shown in the table 5.8, intensive cultivation occupies a very small portion of about 1.4km^2 in 1987 yet is on the decrease i.e 1.02km^2 to 0.91km^2 in 1994 and 2005 respectively. These indicates percentage decrease of -0.73 and -0.22 respectively . The continuous decrease could be due to the seasonality of rainfall.

The table 5.8 also shows that water body occupies a land area of 0.63km^2 representing 1.21% in 1987, with a slight increase to 0.67km^2 and 0.743 km^2 in 1994 and 2005 respectively that indicate percentage increase of 0.08 and 0.14 in 1994 and 2005 respectively. It shows there is a slight appreciation in the water level especially in 2005.

5.4 EROSION TYPES AND SPATIAL DISTRIBUTION

Erosion of various forms are evident on the basin. Towards the mid-stream on the sub-catchment for example, there is the presence of numerous rills, sheet erosion and gullies . The head land area of the basin is an active gully incision

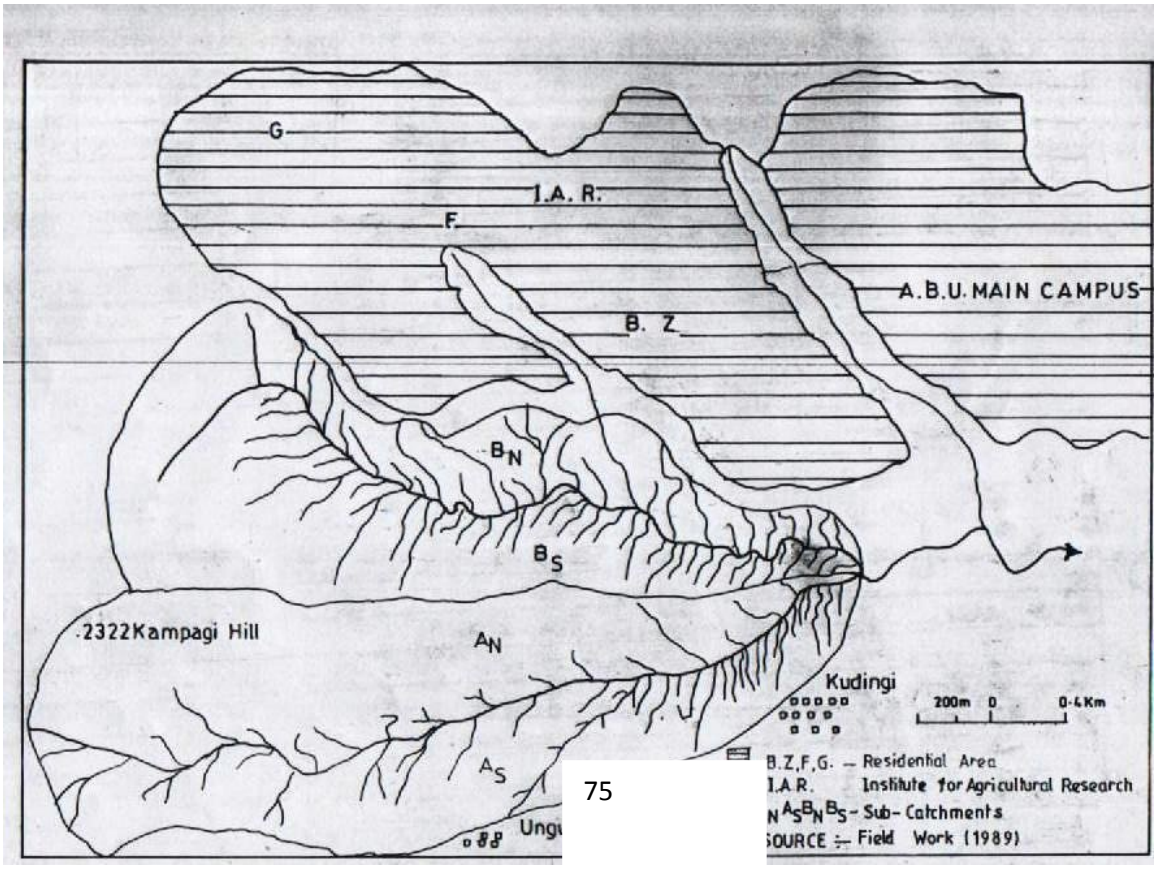


Figure 5.4: Gully Distribution in the Upper Kubanni Basin. (After Ahmed M, 1989).

zone marked with high frequency of gullies. Also p are dormant gullies along the basin most of which have been taken over by thickets of shrubs and grasses. Figure 5.5 shows distribution of gullies on the upper kubanni basin, these have consequently reduced the basin to an undulating badland or degraded land. The increasing variation in the intensity of gullies over the years may be related to the major landuse practiced in the entire basin being farming and overgrazing as earlier discussed .

Table 5.9: Variation on Gully densities withi 77 **:chments of the Upper Kubanni Basin in 1963, 1989 and 2009**

Catchment	AS	AN	BS	BN	TOTAL
$\sum l$	4.90	1.15	5.50	3.90	15.45km
A	5.63	4.00	4.55	5.83	20.00km^2
B	0.87	0.29	1.21	0.67	0.77km/km^2

After: Ologeko, 1971

Catchment	AS	AN	BS	BN	TOTAL
$\sum$ L	4.88	1.5	6.76	4.79	18.93km
A	5.63	4.00	4.55	5.83	20.0km^2
B	1.04	0.38	1.48	0.82	0.95km/km^2

After: Ahmed M.I. 1989

Catchment	AS	AN	BS	BN	TOTAL
$\sum$ L	7.37	2.41	6.29	5.26	21.33km
A	5.63	4.00	4.55	5.83	20.0km^2
B	1.31	0.60	1.38	0.90	1.07km/km^2

Field work: 2009

$\sum$ total length of gullies on sub-catchment.

a = area of sub catchment

b = density of sub catchment.

A and B are the sub catchments

N and S are North and South of Sub catchments (figure 5.5)

Table 5.9 shows the results of the analysis of gully measurements for different points of the upper Kubanni basin at different periods of time. The basin as a whole has experienced increase in gully density by a factor of 0.23 between 1963 to 1989 when density was 0.77 and 0.95km/kmm^2 respectively (Ahmed, 1989). The basin density thereby increased by factor of 1.13 in 2009 when the density was 0.95km/km^2 and 1.07km/km^2 .The analysis for the three periods shows some level of differences in the rate of increase in gully densities. Sub catchment As however, have records of the highest rate of increase in gully development indicating 0.87km/km^2 in 1963 to 1.04 in 1989, again rising to 1.26 in 2009. While for sub-catchment Bs there was increase equally between, 1963 and 1989 at 1.21km/km^2 to 1.48km/km^2 respectively but later in 2009 decreased to 1.38km/km^2. Variation indeed exists in the spatial distribution of gullies on the basin as well as is their characteristics. Dormant gullies are also predominant along the basin most of which have been taken over by thickets of shrubs and grasses.

SUMMARY AND CONCLUSION

INTRODUCTION

This chapter gives an overview of study in 6.1, presents the findings in 6.2 and the consequent conclusion and recommendations in 6.3.

6.1 OVERVIEW OF THE STUDY

Kubanni reservoir sustains farming, livestock rearing and a water supply scheme for Ahmadu Bello university main campus and its environ. Therefore, continued yield of water on the reservoir is contingent upon a good vegetation cover and good soil properties. Satellite imagery of the upper Kubanni Basin of 1987 indicated a vegetation cover of 32.45% representing 16.83km^2 out of the

57.25km^2. But by the year 1994, there was a decline to value of 11.95% (6.2km^2) which further dropped to a very low percentage as at 2005.

Soil bulk densities are at high level indicative of compaction, reduced porosity with high sand fractions. For landuse/landcover, it can be said that there were very little changes between 1965 and 1987. But in the period 1987-2005, significant changes have taken place as shown in the satellite imageries of 1994 and 2005. These changes have negative effects such as the ongoing siltation of the reservoir. Vegetation degradation has set in due to intensive cultivation, overgrazing and fuel wood exploitation as corroborated by (Tiseer and Suleiman 2000). The preponderance of *Guiera senegalensis* and the lack of perennial herbs is an indicative of degradation. These factors are particularly high in panhauya, ungwar yarsarki, Daurayi and kampagi. These villages continue to supply urban samaru with natural resources ranging from food crops, fuel wood, vegetables, fruits etc. Though the soils of upper Kubanni are inherently coarse, the recent preponderance of sand fractions is not unconnected to the major landuse activities in the area.

The built up area has also increased with the advent of the Ahmadu Bello University Teaching Hospital (ABUTH) in the north weste 81 pper kubanni. These activities also add to the vegetation and soil degradation.

6.2 FINDINGS OF THE STUDY

The study has revealed the following:

- Severely degraded vegetation (woody and herbaceous) in the upper kubanni basin.
- Critically impoverished soil physical characteristics in the area.
- High percentage of land area occupied by cultivation and overgrazing.
- Closely related to the above is the loss of primary vegetation which is being replaced by shrub regrowth and secondary vegetation.

- Population increase induced landuse changes resulting in increase percentage of land under agricultural use and building infrastructure.
- Also there are reforestation attempts particularly around the immediate catchment of the Ahmadu Bello University reservoir.

6.3 RECOMMENDATIONS/SUGGESTIONS FOR FURTHER STUDIES

In view of the importance of the Kubanni reservoir to the Ahmadu Bello University community and the surrounding samaru settlement, it is recommended that continuous and periodic monitoring of the biophysical condition of the area be carried out in order to arrest any negative changes that might result in the degradation of the Basin.

Also the ongoing tree planting exercise should be expanded and sustained in order to encourage gully stabilization and prevent sedimentation or the likelihood of eventual siltation of the reservoirs.

6.4 CONCLUSION

The soil condition from the results obtained will demand management interventions that could improve the health of the soils. Although the ABU management attempt at the tree planting exercise is beginning to make some inputs that need to be sustained and expanded. It was observed that good vegetation cover has the multiple advantage of improved soil conditions, stabilization of gullies and control of overland flow. Hence there will be reduction in the ongoing siltation of the dam.

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