GEOSPATIAL ANALYSIS OF THE IMPACTS OF JIBIA DAM ON JIBIA TOWN AND ITS ENVIRONSKATSINA STATE NIGERIA

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BY

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DEPARTMENT OF GEOMATICS,
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MARCH, 2018

DECLARATION

I declare that the work in this project dissertation entitled **"Geospatial Analysis of impacts of Jibia Dam on Jibia Town and Its Environs Katsina State Nigeria"** has been carried out by me in the Department of Geomatics. The information derived from the literature has been duly acknowledged in the text and a list of references provided. No part of this Dissertation was previously presented for another degree or diploma at this or any other Institution

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Name of Student	Signature	Date

CERTIFICATION

The dissertation entitled **"Geospatial Analysis of Impacts of Jibia Dam on Jibia Town and Its Environs Katsina State Nigeria"** by HASSAN MUSA meets the regulations governing the award of the degree of Master in Geomatics of the Ahmadu Bello University, and is approved for its contribution to knowledge and literary presentation.

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ABSTRACT

In order to analyze the impact of Jibia dam on Jibia town and its environment, land use land cover of the area before and after the dam were mapped and analyzed using remotely sensed data. Supervised maximum likelihood classification algorithm was used for the classification of Landsat imageries. The changes in land use and land cover were analyzed. The positives and negatives impact of Jibia dam were also mapped and analyzed. The population growth of Jibia town was analyse by projecting the 1991 population census data of the surrounding localities to 2003 and 2016. Population densities at different periods were computed and compared. The master plan of Jibia dam was compared with the developments of the study area in the post-dam periods under study. Also, questionnaire on the impacts of the dam on the socio-economic activities were administered, retrieved and analysed. The results revealed that, the settlements expand from 1% to 3%. Irrigation area remain fixed. Water body increase from 4% to 9% of the study area. Forest decreased from 3% to 1%. Farmland decreased from 60% to 46% Bareland from 33% to 30% from 1986 to 2016 respectively. The positive impact of Jibia dam is the supply of water and provision of social amenities, construction of service and farm roads Chama park recreational area. While imposed constraint on the expansion of surrounding communities is the major negative impact focused in this study. Jibia town is the most populated settlement around the dam. The development of the study area in the post-dam period did not comply with the design master plan of the dam. The construction of Jibia dam improved the socio-economic activities of people living Jibia town.

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CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Dam is a barrier constructed across the watercourse to impound a round-up water for irrigation farming, domestic needs, a source of energy for hydropower generation, flood control, recreation, transportation etc. As a result, large dam project has gained high popularity both in developed and developing countries. Currently, almost all major rivers in the world have at least one dam to meet the water and energy need of growing population (W.C.D, 2011). However, some of the negative impacts of dam include mass scale displacement of people, change in river hydrology and ecology, change in water quality, destruction of historical Artifact, microclimate change, change in social, cultural, and economic structure of the region, increase in water sourced illness, change in water-soil-nutrient relation, destruction of revering valleys, grassland, Fadama areas and site of historical importance. (Dalil *et al.,* 2013)

In Nigeria between 1962 and 1968 there was an attempt to conceptualized the water resources development, consequently, lake Chad and River Niger Basin commissions were set up in collaboration with neighboring countries to respond to the declining performance of the agricultural sector in the 1970s and especially with the rise in oil revenue during the same period. The strategy of comprehensive River Basin Development (RBD) was adopted. Consequently, several River Basin Development Authorities (RBDA) were established to principally accelerate Agriculture and rural development through an enhanced food and industrial crop production especially in the dryer Northern parts of the country. Sokoto Rima River Basin Development Authority (SRRBDA) is among the initial RBDA established in the Sokoto-Rima Valley North-west Nigeria. Toachieve the set of objectives of the SRRBDA, Several Dams, and

Irrigation Schemes were constructed in the Basin areas, Jibia Dam is one of such Dams. (SRRBDA., 1991)

Jibia Dam was constructed on a Gada River in the 1980s. The Dam is 3680m length, 21.5 meters high, 9.50 meters' crescent length, 1.3m and 1.25m up and down the width of the downstream. The Dam can create 1.2m/s pressure at the base of the Dam. Thus, permit the water to flow through the lower portion of the Dam to the treatment plant and pumping station respectively for Domestic and irrigation needs. The primary purpose of constructing Jibia Dam was to impound water for irrigation farming and domestic needs. The project consists of two-surface Reservoir of 35000m^3 and 45000m^3 for supplying irrigation water to a network of 192km irrigation Canals for distribution of water to 3500 Hectares of farmland in Jibia, Faru, Magama, Mazanya, Kagadama, Farfaru, Lankwasau, and Gadurge section. In addition, a 12,000m^3 capacity treatment plant constructed to supply domestic water to three reservoirs (Makiyawa, Kwalingyar and Kukar Babangida Reservoir) for distribution through lateral and service line pipes to the consumers for Domestic used and firefighting in a surrounding Municipality (that is Jibia, Magama, Mazanya, Kukar Babangida, Farfaru, Wushin Buku, Faru, Dan Tambara, Lankwasau, Garin Malamai). (SRRBDA.,1989)

However, some of the advantages of Jibia dam are: water supply for irrigation farming, domestic water supply and distribution by the Katsina state water board Jibia district, construction of Jibia Chama recreational park at the west bank of the impounded reservoir for Recreational and tourist activities, construction of the control drainage for emptying the excess irrigation water to either reservoir or Gada River for Re-circling. The rising of the level of the groundwater tablet which made digging well easier and more economical. There were large-scale land use land cover changes (from Farmland, Forest, Settlements, Fadama to water body) because of the Dam, this led to the

relocation of people living within the reservoir axis (that is Zandam, Mazanya, Mallamawa, Farfaru Malamai, Farfaru Maguzawa, Makiyawa, etc) to the towns such as Magama, Kwari and Faru town in order to sustain Irrigation farming. Artificial bound imposed by irrigation canals on the expansion of the Jibia town and other surrounding communities and reduction of reservoir storage capacity due the blockage of sediment by the dam are among the negative impacts of Jibia dam

Studies conducted in various regions of the world have indicated that Man's attempts to re-engineer and manage the shrinking and uneven water resources distribution are in direct conflict with natural systems. World Commission on Dams (Water Commission Day, 2003) pointed out that dams have significantly contributed to the human development and the benefits derived from such have been noteworthy. Notwithstanding, the social, economic and environmental cost has been unacceptably high. Resource regulatory bodies and intellectuals have, therefore, begun to think ways to shorten the environmental and socio-economic price of reservoirs. Recently, international initiatives on Sustainable Development (2002), World Water Forum (2003), World Commission on Dams (1997-2002), and the continuing Dams and Development Project of the United Nations Environment Programmes have reaffirmed the commitment of many governments and international agencies (including the World Bank) to dam growth, but in a manner which mirrors modern environmental concerns. (Dalil et al., 2013)

Geographic information system (GIS) is an integrated collection of computer software and data used to view and manage information about geographical places, analyze, spatial relationships and model spatial processes. A GIS provides a framework for gathering and organizing spatial data and related information so that it can be displayed and analyzed. Geographic and geospatial are synonymous, spatial is a space either on

the earth surface, water body, celestial bodies etc. (Longley *et al.,* 2005) this means that geospatial is a subset of spatial. Geospatial technology is a set of technology approaches, such as GIS, Remote sensing, and GPS for acquiring and manipulating geographic data. Advance in geospatial technology, especially the development of both hardware and software component of GIS and remote sensing have revolutionized spatial data acquisition, processing, interpretation and presentation method. (Ghilani, 2008). The uses of GIS as a tool in the process of data identification, and analysis has been well established in the literature and many others similar studies, has shown that GIS and remote sensing could be used for various analyses including Analysis of Geospatial constrain imposed by dam to the surrounding communities. (Li *et al.,* 2009)

1.2 Statement of the Research Problem

The geospatial impacts of dams on the surrounding environment have been extensively documented in many parts of the world (WCD 2003). Studies such as those of Qinghe *et al.,* (2010) on the analysis of the "effect of dam construction on spatio-temporal change of land use of manwan, lancang River Yunnan"; and Vallier (2012) on the" effects of dams on stream habitat and communities". In Nigeria, studies like those of Dalil *et al.,* (2013) on the "Impact of Gurara dam on land cover in the surrounding communities of Kaduna State", Nigeria, Zember *et al.,* (2016) "analysis of environmental and economic effects of Kiri Dam", Adamawa State, Nigeria, (Dukiya, 2013) on the "Spatial Analysis of the Impacts of Kainji Hydropower Dam on the down Stream". These types of studies were not conducted on the impact of Jibia dam in the Region.

The above studies have not address; the relationship between the proximity of the dam location and the expansion of the surrounding communities, the compliance between the master plan of dam and the development of the region, analysis of the vulnerability of

the surrounding communities to flooding, and the impact of dam on the socio-economic activities of people and the effect of dam on population growth of the surrounding communities was not conducted in the reviewed literatures.

1.3 Research Question

a) Does the construction of Jibia influence land use land cover changes?
b) What are the positive and negative impacts of Jibia dam on Jibia town?
c) What is the relationship between Jibia dam and population growth of Jibia town and compliance with Jibia dam Master plan?
d) Does Jibia dam has impacts on the socio-economic activities of people in Jibia town?

1.4 Aim and Objectives of the Study

This study aims at the analysis of the impacts of Jibia Dam on Jibia town and its environs in Jibia local Government area.

The objectives of the study are to:

a) Map and analyse land use land cover changes in the Study area before and after the construction of the dam.
b) Map and analyse positive and negative impacts of Jibia dam in the Study Area.
c) Analyse the Population growth of Jibia town and compliance of developments with Master plan.
d) Analyse the impacts of Jibia dam on the socio-economic activities of people in Jibia town

1.5 Scope of the Study

The impact of a dam can be a mass land use land cover changes, mass-relocation of people, changing of occupation, destruction of the historical and archeological artifact,

altering of the water cycle and so on. In this study, the impacts of Jibia dam on; land use land cover changes, agriculture, flood control, population growth, socio-economic activities, the compliance of the current development with master plan and relationship between the dam location and its imposed constraints on the development of Jibia town between 1986 to 2016 will be analyzed using satellite imageries and come up with the result that will serve as a platform for decision-makers, town planners, environmentalist, water engineers and researchers for better management of the impact of the dam in the study area.

1.6 Justification of the Study

This study used remote sensing imageries, Digital elevation, 1991 population census data and responses of people in the study area. For the analysis of the impacts of Jibia dam on Jibia town. This study analysed the cumulative analysis of the impacts of Jibia dam on the study area to reveal the cumulative impacts of the dam. The outcome of this study will be used by decision-makers, environmentalist, town planners in decision making and planning the development of the area.

1.7 The Study Area

1.7.1 Locational setting

The study area is the water distribution areas from Jibia Dam. it covers about 333.244 sq km surface area. these areas are located around Jibia Dam about 40km north-west of Katsina City, and its bounded by Latitude and Longitude of $13^{o}00'7"$ N, $7^{o}1'5"$48E and $12^{o}57'8"$ N, $7^{o}16'15"$ E respectively. It borders to the north with Niger Republic, to the west with Gurbi village, to the south with Batsari Local Government and Bugaje village, and to the east. It lies on the main high way from Katsina to Gusau, among the

study area is Jibiya town, and it's a head quarter of the Local Government its located about 1km north of the Dam (Yusuf, 2013).

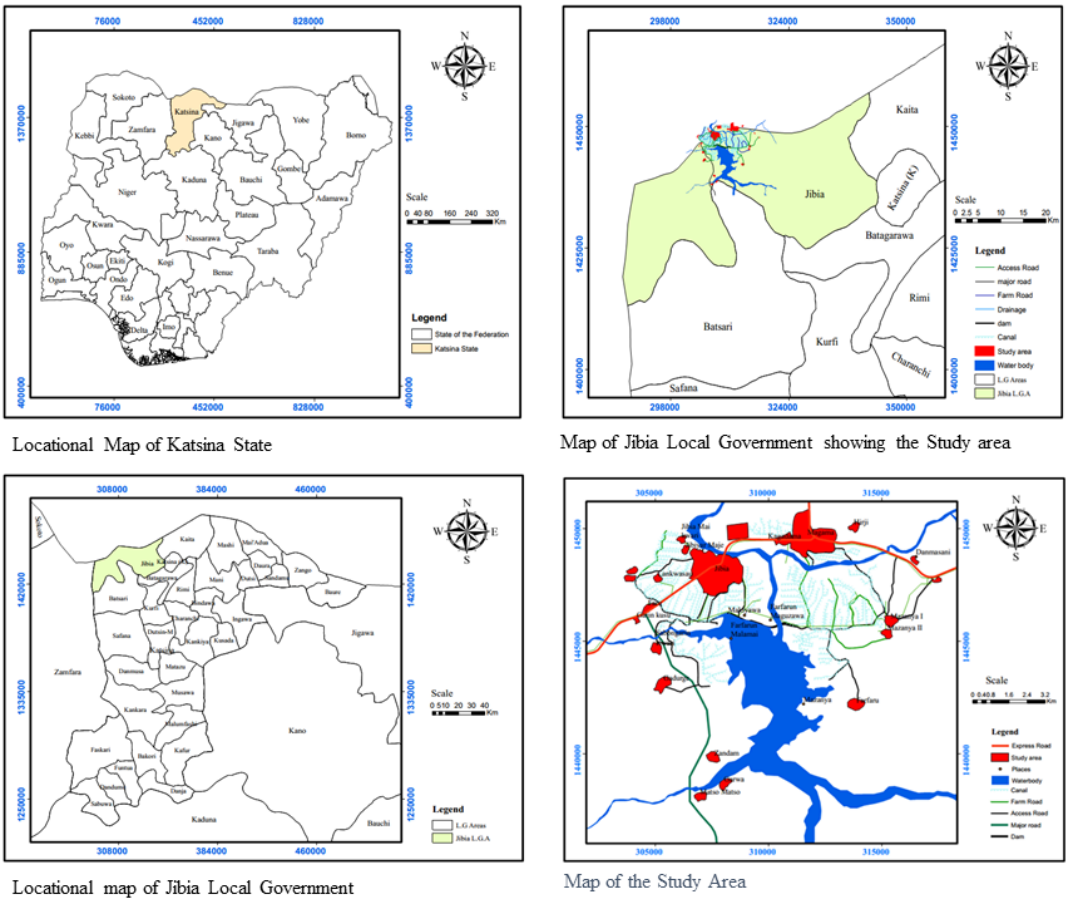


Figure 1 Map of the study area

1.7.2 Climate

The climate of the study area is of Tropical continental type, with wet and dry seasons, roughly following the movement of Tropical Discontinuity. The rainy season lasts for about four months starting from May to late September. The mean annual rainfall is about 690mm and the maximum rainfall has in many instances been experienced in August. This moment, therefore, is the one in which the massive agricultural production takes place. Because there is rain and the land are fertile and conducive enough for the cultivation of agricultural product, the majority of the people concentrates more on agricultural occupation. The dry season, on the other hand, lasts from April to May While the harmattan season starts April effect of it is felt most when a dust-laden dry

air across the Sahara blows over the area. However, unlike during the rainy season, the people of Jibiya and indeed those of other parts of northern Nigeria pursue their non-agricultural occupations like dying, weaving, blacksmithing, tanning, trade and so on. Although there is another large number of people that practice irrigation farming. (Yusuf, 2013)

1.7.3 Water bodies

The study area is largely crossed by rivers. The area is well watered due to the presence of various rivers located within the area. This happens not only in the raining season when water flows down from Ruma and Zandam rivers into the Gada River but even in the dry season when people dug wells around the rivers to get water which they use for daily use and for irrigation farming before the construction of Jibiya Dam in mid-1980s. The Gada River, in particular, has two outlets, with the one which runs up to Madarunfa and into the other lakes in the Niger Republic, and the other which run up to the Gurbin-Baure River, all supplying water to Jibiya area the year round. (Yusuf, 2013). The construction of Jibiya Dam on Gada River during the 1980s also contributes to the constant water supply in Jibiya town and nearby Villages. There is a Surface Reservoir of about 2600 hectares impounded by the Dam. Makiyawa water treatment plant was constructed about 1km away from Jibia town. It should be noted that, apart from supplying water for public use, the impounded Reservoir was also designed to supply water to 3500 Hectares of land which is used for irrigation farming. Primary canals with a total of 17km were constructed to supply water to the 175km secondary canal that crisscrossed this vast area of land. Similarly, the total length of the Main Municipal water distribution pipelines is 70km.It can be seen that both before and after the construction of the Dam, Jibiya is a well-watered area not only in the rainy season but also in the dry season. And this explains the reason why one can find fresh agricultural

products (especially vegetables) in the Jibiya market, independent of the season (Yusuf, 2013).

1.7.4 Jibia Irrigation Project About N106 700, 000.00 equivalent to $63,593,200 was committed for the establishment of the project with the aim of improving food production raise farm incomes and improve the standard of living of the people in the area (Daily, 2012). Jibia Dam was constructed across Gada river to capture runoff water and impound it into reservoir (Hassan and Isah, 2014) the dam is 21m height of embankment 9-meter width, 3680-meter length, 140-meter concrete spillway, 2170m^3 discharge capacity, 142 million m^3 full storage capacity and 1.2 m/s pressure at the base of the Dam (SRRBDA, 1991).

The establishment of irrigation projects in the country was aimed at creating an opportunity for better utilization of the available resources in the area. The Jibia Irrigation project covers 3500 hectares of land for irrigation and impoundment of 2400 Ha water in the reservoir started in May 1989 (SRRBDA, 1991). But Rowland (1993) and Yusuf (2013) insisted that majority of Nigerians large-scale irrigation projects have not achieved the result expected from them. Because the Dam has the catchments area of 3666 sq km and captured 216 million m^3 from Gada river discharge due to the effect that this will cause to the River Development of Gada River Development in the Niger Republic, Nigeria and Niger republic held an interstate agreement and came out with formula for the Sharing of Treated water between the Nations (SRRBDA, 1982). But Hassan and Isah (2014) in his "Assessment of water supply and Distribution from the Jibia Dam" concluded the Jibia Project had failed to achieve its purpose. Pointed out that, the Dam was constructed to supply domestic water to Katsina, Maradi in the Niger Republic and all surrounding villages and towns and yet Jibia treatment Plant and

Irrigation Project had failed to make Sufficient and consistent Supply of Water to at least 20% of Municipalities and Irrigation Sections intended.

1.7.5 Socio-economic activities

Jibia market, located in Jibiya town, has one of the important markets in Katsina emirate and in Nigeria as a whole. Being a market that is located along the Nigeria-Niger border, the market has taken the status of an international market (Yusuf, 2013). Usually, commercial activities take place every weekend starting from Saturday to Sunday for Jibia Market and after every Four months for Border Market. People

The projected population of people in the study area in 2016 is about 109,291, the dominant tribe are Hausa and Fulani. However, the fact that Jibiya developed as a border settlement, the economic, social and religious elements serve as an important variable in understanding the people's composition in the town. It is because of this reason that ethnic groups like Zabarmawa (Songhai), Buzaye (Tuaregs) and Bare-Bari could also be found in the study area especially Jibia town. (Yusuf, 2013)

CHAPTER TWO

LITERATURE REVIEW

2.1 Global Trend of Dam

With the rise, of ancient civilizations came a rise in building dams and diversions for water storage, irrigation, transportation, and flood control. As early as 6500 BC, the Sumerians constructed dams across the Tigris and Euphrates rivers to provide flood control and irrigation of crops (McCully 2001). By the first millennium BC, stone and earthen dams were erected on nearly every continent, enabling the acquisition of water and food to sustain population growth. Dam technology advanced slowly until the Industrial Revolution when larger dams were built in less time and from man-made materials. Today, more than 45,000 large dams (greater than 15 m in height) exist worldwide that provide water supply, flood control, waterpower for mills, hydroelectric power, improved navigation, recreation, and waste disposal. The rapid increase in dam projects during the early and middle twentieth century was driven by socio-economic and political pressure to increase the quality and quantity of water for production while simultaneously minimizing its destructive potential. (Difrancesco, 2007)

Advances in structural engineering, such as the use of pre-stressed concrete (Arthur, 1977), also contributed to the proliferation of dams. Recently, dam construction in developed countries has decreased as a majority of economically viable projects have already been pursued. Moreover, changes in ideology and a growing awareness of the environmental and social impacts of dams have become important factors that influence valuations of dam projects in developed countries (Johnson, 2002).

However, the political-ecological dimension of developing countries and the multiple utilitarian benefits provided by dams continue to favour the proliferation of these structures in regions where the resources offered by free-flowing rivers provide

incentive for industrial and infrastructure development. The potential negative impacts of dams on the environment and natural resource-based livelihoods of local peoples are often considered by decision makers to be acceptable costs relative to the economic benefits these structures can provide (Goodland, 1997).

2.1.1 Purpose of constructing the Dam

The construction of dams is one of the oldest branches of engineering. The earliest dams were for the purposes of irrigation, flood control, and water supply. Later, water was impounded so that its subsequent controlled release could provide a source of energy, first by the use of waterwheels and later by the use of hydroelectric generators. Other purposes include the maintenance of an adequate river flow through the year for navigation, and the provision of facilities for recreation. Most modern reservoirs are design for two or more of these purposes. Usually "the role of water storage reservoirs. is to impound water in the periods of higher flows so that it may be released gradually during periods of lower flows" but sometimes the sole purpose of the impoundment is to provide a new body of standing water for fishing or boating, or for waste heat dissipation from a thermoelectric generating plant. The water level in a reservoir is usually manipulated according to the purpose for which it was built within the constraints imposed by the prevailing climatic conditions. Reservoirs built solely for flood control are usually emptied as soon as possible after flood. Reservoirs for other purposes, however, are usually filled at times of high flow and either drawn down gradually during the rest of the year, or maintained for several months at a fairly constant level, then drawn down rather quickly in anticipation of the next period of high flow (Rutter and Ensgrom., 1964).

2.1.2 Technology of Dam construction

The earliest dams were constructed by blocking the stream with earth. Such dams are still constructed. In its simplest form, an earth-fill dam is a pile of compacted earth Extending across a stream with a fairly gentle slope both upstream and downstream Similar to earth-fill dams are rock-fill dams composed of quarried rock or natural boulders or gravel with a layer of impervious material on the upstream face. A later development in dam construction was the invention of the masonry dam, in Spain (Smith, 1969). The earliest dams were Mansory and gravity type. They are held in place by their weight with long slope downstream toe for the prevention of overtopping. Arched masonry dams are convex upstream with their ends abutting against the walls of the stream valley or against suitable artificial structures. Such dams are held in place by thrust against their abutments and are steeply sloping or vertical both upstream and downstream. Dams may also be built of structural Mansory, or less commonly, of steel or timber. In almost all dams, provision must be made for the safe discharge of excess water by the construction of a spillway and in most instance provision is made to control the rate of discharge. Dam constructed for hydroelectric purposes, must have discharge of water through a penstock to the turbines. Dams for irrigation or water supply also have outlets to the irrigation canals or water supply system. penstocks and other outlets may draw water from well below the surface of the water in the reservoir (Baxter, 2005)

2.1.3 Urban growth

Urban growth is the process of expansion of urban centers spatially brought by the changing economic, social and political activities. In the nineteenth century, a new kind of city emerged, built on productive power, mass population and industrial technology. The process of urbanization once started, continues to gather momentum as more people

migrate from rural areas to cities (NPC, 1998). Yet this subject matter has not commanded sufficient attention from political leaders and even development planners, as an urgent development concern (Tibaijuka, 2002). The protection of urban heritage and preservation of rural flora and fauna are desirable (Adejugbe, 2004) as the only way to ensure sustainable development and healthy habitats.

Rapid population growth and global environmental change are two topics that have received substantial public attention over the past several decades. Population increase became a global public policy issue during the mid-twentieth century as mortality declines in many developing nations were not matched with reductions in fertility, resulting in unprecedented growth rates. The concern for environmental change has become the primarily concern since 1970, with the levels of environmental degradation rising public concern with the extend of contemporary environmental changes and the coming of satellite imagery aiding environmental research (Clarke, 1996).

Population size is inherently linked to the environment as a result of individual resource needs as well as individual contributions to pollution. As a result, population growth yields an increase in demands on air, water, and land environments, due to the provision of necessary resources and serves as a sink for environmental pollutants.

Population size is inherently linked to the environment as a result of individual resource needs as well as individual contributions to pollution. As a result, population growth yields heightened demands on air, water, and land environments, because they provide necessary resources and act as sinks for environmental pollutants.

Population density (population divided by land area) is often used to indicate variation in distribution across regions, and, as such, population distribution is closely related to population size; population density actually represents population size as bounded by a specific locality

2.1.4 Uses of Dam

Reservoirs impounded by dams prevent flooding, provide water for irrigation farming,

domestic needs, industrial purposes, aquaculture, navigation and Hydropower generation. is often used in conjunction with dams to generate electricity. A dam can also be used for storage of water for distribution between locations. Flood gates or levees also prevent water flow into specific land in the region (Baxter, 2005).

2.2 Impacts of Dam

The impacts of dams on the human, environment, water, climate, rivers, have been extensively documented. Although specific environmental impacts of dams are influenced by local conditions, as well as the size and type of dam constructed, similar environmental impacts of dams have been documented in various regions of the world, and are generally not unique to a specific location or ecosystem (Graf, 1999).

2.2.1 Impact on Man

After the construction of the dam the occupation of people living in the region will change either to fishing, large scale irrigation, transportation and navigation. The creation of a reservoir from damming a river has multiple social and economic impacts on individuals living near the dam project. Resettlement and loss of land from reservoir inundation is the most prominent impact from dam construction. Environmental impacts of dams and consequent reduction in access or availability of fish and other riverine resources may negatively affect human livelihoods as well. Reservoir fisheries may be poor substitutes for river fisheries as a result of lower productivity and the need for periodic restocking of introduced fish populations that are not self-sustaining (Marmula, 2001). In many parts of the world, fish and other riverine resources are critical to sustaining human livelihoods by providing food and financial security (Difrancesco, 2007). Indigenous groups pursuing subsistence lifestyles are often the most heavily

impacted by loss of natural resources from dam construction (McCully, 2001). Reservoirs also increase health risks for individuals that maintain physical connections with aquatic environments. Reservoirs provide breeding habitat for vectors of water-borne diseases, such as malaria and schistosomiasis, which otherwise are found in substantially lower abundances in undammed rivers (Goldsmith and Hildyard 1984). Additionally, flood control is a major incentive for building dams. However, a decreased occurrence of natural flooding reduces downstream sediment deposition important for restoring the fertility of riparian areas (Shoemakeret *et al.*, 2001). Flood control may also give a false sense of security potentially causing more loss of life and property during unusually large flooding events than if no flood control structures were in place. Many cases exist where dam failure during construction or ageing was disastrous for local communities (Graham, 2009).

Although dams and reservoirs may also provide some of these benefits (Anderson *et al.*, 2008), river-based recreational activities and river-front property associated with dam removal may provide more long-term cultural, aesthetic, and recreational benefits (Sarakinos and Johnson 2002; Provencheret *et al.*, 2008). Dam projects can erode the social cohesion which lead to long term losses in culture due to large-scale that displacement of indigenous populations (Garrett, 2010).

2.2.2 Impact on hydraulic system

The main hydraulic effect of dam in the region is the discharge of the collection basin to a stationary reservoir. Therefore, the change (instant) will start to dry downstream partially or totally whenever the reservoir begins to accumulate water. During this temporary or periodically repeating time interval, the hydrological balance can collapse; Irreversible death, disappearance and structural jumps are observed in the water dependent ecosystem. Decay of dead plants and animals in the new impounded

reservoir will speeds up. So, the flow in the upstream will be polluted, lack of oxygen in deeper parts, dark colored of the water for a long time and smells rotten due to the presence of sulphurous hydrogen disposal. Although after this process the stream forms a new and healthy ecosystem in this part of it, neither this new aqua balance nor the terrestrial ecosystem and even the sea environment that the stream joins the sea have the chance to join their previous health (Baxter, 2005).

2.3 Emergence of Dam Construction in Nigeria

Between 1973 and 1976, the Federal Government of Nigeria established River Basin Development Authorities (RBDA) to harness and manage the water resources potentials in the country for agricultural purpose (SRRBDA, 1992). Consequent to the severe drought that prevailed during the period of 1972-74, two River Basin Development Authorities (RBDAs) were established with responsibilities for developing infrastructure for irrigation, increasing agricultural production and undertaking rural development activities in the systems within the authority of the RBDA. Large-scale irrigation involves construction of dams, irrigation canals, drainages and other irrigation facilities in order to irrigate large area of land for agricultural development. Large-scale Irrigation Projects (LSIPs) were introduced in Nigeria to make best use of the available resources in order to boost agricultural production (SRRBDA, 1992).

These projects are managed by the River Basin Development Authorities (RBDAs). One of the earliest RBDAs is the Sokoto Rima River Basin Development Authority (SRRBDA) established in 1973 (SRRBDA, 1992). The Authority covers Sokoto, Katsina, Kebbi and Zamfara States. Many large-scale irrigation projects were created under the SRRBDA, which include Jibiya, Bakalori, Zauro Polder, Wurno and Goronyo (Falalia) Irrigation Project (SRRBDA, 2013).

Jibiya irrigation project is one of Nigeria's large-scale irrigation projects, which is aimed at boosting agricultural productivity of the country. The objective is to improve living standard of the people, through the creation of job opportunities, food production and increased income (SRRBDA,1991). Before its establishment, crop production in the area was mostly limited to the rainy season, and relied on rainfall for moisture supply. A lot of damages had been caused by drought from year to year, in the area. This became a serious threat, sometimes significantly reducing the farmers' production. Although small-scale irrigation practices had been undertaken during the period, mostly along streams and river-banks as well as other Fadama areas, the output obtained from these practices was relatively small. This implies that, before the establishment of the project the amount of agricultural resources in the area, were not optimally utilized. The establishment of JIP was apparently aimed at creating an opportunity for better utilization of the available resources in the area. The project envisages the development of about 3,450 ha of land for irrigation, and impoundment of water in the reservoir started in May, 1989 (SRRBDA, 1991).

2.3.1 Jibia Dam

Jibiya Dam was constructed along Gada River, to boost agricultural production as well as the supply of portable drinking water for the people living within and around the area. Large sums of money (₦146,700,000.00 = $87,433,200.00) were committed in the construction of the Project (Jibiya Irrigation and Water Supply Project), out of which ₦106,700,000. 00 were committed in the establishment of Jibiya Irrigation Project (SRRBDA, 1982). The Dam is located 1.4 kilometer south of Jibia town, it has a maximum height of about 20 m and a length of approximately 3680 m, has created an impounding reservoir with the following features: --

Full storage capacity = $142 \times 106 m^3$

Dead storage capacity = 21×106m^3

Active storage capacity= 121×106m^3

About 3.1 x 106m^3 earth work was involved in the construction of the dam. A 140 m long concrete spill way (62,500 $m^3$of mass and reinforce concrete) was provided, which has a discharge capacity of about 2,170 m^3 to cater for the estimated maximum probable flood flow of the Gada River. The mean annual total discharge of the River is estimated as 216 x106m^3 (SRRBDA, 1991)

2.4 Remote Sensing and Land Use/Cover Change

The history of remote sensing is very brief, and dates back about six decades when aerial photography started being used as an effective mapping tool. There were several scientific and governmental efforts on inventories into land use and land cover in the early years of the last century which were based on the mobilization of huge numbers of participants, but modem remote sensing started in the 1930s, first from aircraft and later from satellites, and these have been the principal means by which land cover is observed, categorized, recorded and quantified (Khorram *et al.,* 1999).

Land use/cover change detection has two main targets. There are differences between images from two dates (or any other sources of change data) can demonstrate patterns associated with a particular theory of environmental change, or the analysis could lead the investigation to reject that theory in favour of some other that might fit the evidence more closely (Khorram *et al.,* 1999). Change detection is useful in many applications such as land use changes, habitat fragmentation, rate of deforestation, impacts of dam on land use-land cover, coastal change, urban sprawl and other cumulative changes through spatial and temporal analysis techniques such as GIS (Geographic Information Systems) and remote sensing, along with digital image

processing techniques (Matthew, 2007). Land cover changes are divided into two major categories. These are conversion between land cover types (between-class changes) or within land cover types (within-class change). The first occurs when there is a complete shift from the initial land use/cover to another type, for example, a change from forest to water body. The second type of change occurs when there is a change in the quantity of the component that makes up that particular class type, for instance, transformation of farm land to irrigation site. To effectively map the change of either of the two-land use/cover types mentioned above successfully with remote sensing, an appropriate technique(s) must be applied as well as suitable data used for land use/cover change detection project. Classification is the process of assigning pixels to classes. The classification process is considered to be a form of pattern recognition, that is, the identification of the pattern associated with each pixel position in an image in terms of the characteristics of the objects or materials (Matthew, 2007).

The objective of image classification in this research is to create cluster classes from multispectral images to make sense of spectral information contained in the images. The areal coverage of different classes of multi-temporal images was compared for changes that have taken place between dates of the image. The accuracy of the land use/cover map produced from classification is affected by the scale as well as the spatial and spectral characteristics of the image data. Effective detection of change with remote sensing data is dependent on the classification accuracy. This is an essential part of successful land use/cover change detection. However, there was a need to create accurate informational categories from the processed satellite image with an appropriate algorithm suitable for the data and to achieve high classification accuracy (Campbell, 2002).

Thematic assessment of land use changes involves procedures of monitoring and mapping which require robust methods and techniques. Given them technological robustness, remote sensing technologies are increasingly affecting land- use change research (Matthew, 2007).

Maximum Likelihood Classifier (MLC) is a parametric decision rule. The MLC decision rule is based on the probability that a pixel belongs to a particular class. The basic equation assumes that these probabilities are equal for all classes, and that the input bands have normal distributions. This was adopted as the classification technique most suitable for land use/cover classification for the MLC, as a per-pixel classifier, was able to handle and show the spatial distribution of land uses and land cover types in Study Area. The landscape structure and land cover dynamics of Study Area makes Maximum Likelihood Classifier (MLC) an appropriate classification method. This is a sophisticated classifier was considered the most appropriate resulted in what Lu *et al.,* (2004) called "salt and pepper" pattern classification.

2.5 Accuracy Assessment of the Classification

It is very important to quantify the errors in land cover/land use maps before they can be used, for the Analysis of the Impacts of a Dam in a Region. The accuracy of land Cover classification is usually expressed in terms of a confusion matrix. This can be used to assess the general quality of the classification, which is sometimes summarized by an overall precision index (percentage of correctly-classified pixels, Kappa Coefficient, etc.). Hence, error matrix was used to assess the accuracy of the classified images. The focus of this aspect is on overall, producer's and user's accuracy, because of useful information derivable from them regarding accuracy of satellite based land use and land cover change detection. An error matrix was considered the most appropriate method to assess the image classification accuracy as well as maps produced from the satellite

imageries. One of the advantages of an error matrix was its ability to generate an overall accuracy as well as producer's and user's accuracy. This allowed the assessment of accuracy of individual land use/cover class. In addition, this affords the researcher the ability to detect the class that has contributed significantly to the reduction in the overall accuracy of the classification and the classes that have similar or confusing spectral signatures with one another (Matthew, 2007).

2.6 Monitoring the Land Use-Cover Changes with Earth Satellite Data

Remote sensing provides an opportunity to measure attributes of land use-land cover (LULC) and record the data in accurate digital maps and files suitable for analysis within Geographic Information Systems (GIS). This data, together with data available from ground- based observations, can be used to monitor changes in space and time, to develop and validate dynamic models of land use development, and to forecast future land-use patterns and changes in other land use attributes. The complex composition of land use materials poses a big challenge to remote sensing feature extraction and classification. (Jensen et al., 1993)

The new generation of satellite sensing systems has generated interest in the remote sensing of land use-cover areas. Welch (1982) outlined the spatial resolution requirements of remotely sensed imagery for classifying land uses. Satellite sensors with a relatively fine spatial resolution, such as those carried on the SPOT or Landsat satellites, have considerable potential in studies of impacts of dam on land use-cover (Weber, 1994). Fine spatial resolution data should be appropriate for the study of impacts of dam to the surrounding communities (Foster, 1985) as each pixel is more likely to contain a single land cover type, and the high spatial resolution data will provide additional detail and increase the potential range of any signal and thereby the spectral variability of each land cover class (Weber, 1994).

Welch (1982) believed that finer spatial resolution imagery would be ideal for Land use-cover studies with high classification accuracy, but recent advances in spatial resolution of satellite images have not really brought about the much-heralded improvement in land

use-cover classification accuracy. This is because most of the features detectable by the sensors are bigger than the one meter or the meter resolution of the images, hence increasing the pixels that are erroneously classified.

Aplin (2003) concluded that spatial resolution requirements for land use-cover will vary considerably according to location and, as such, any land use classification analysis should be considered in the context of its study areas. In addition, there will also be variation in the spatial resolution requirements for different reasons (applications) i.e. why land use land cover areas have been classified in the first place. For instance, land use classification for the purpose of change detection to study the impact of dam on the land use-cover will require higher spatial resolution. While it may be possible to employ or adapt existing per-pixel classification algorithms to produce maps from very fine spatial resolution images, deriving information on land-use is normally much more problematic. This is because land use is an abstract concept - an amalgam of economic, social and cultural factors - one that is defined in terms of function rather than physical form.

Sudhira and Ramachandra (2002) applied standard processes for the analysis of satellite imagery, such as extraction, restoration, classification, and enhancement for the study of land use-land cover changes. Also, the Maximum Likelihood Classifier (MLC) was employed for the image classification. However, to choose the best algorithms for a specific task, users are advised to consider not only classification accuracy, but also comprehensibility, compactness and robustness in training and classification. King

(1989) tried sophisticated statistical procedures and applied them to remote sensing for land cover mapping, but found that the accuracy was very low. Researchers have tried combining statistical and visual interpretation methods to improve accuracy (Matthew, 2007). Others have tried remote sensing mapping and

applied a statistical classification, but have not been successful because it is very difficult to relate the classification to reality. The problem lies with the statistical procedures that generally ignore shape, size, position and association, all of which are fundamental. King (1989) opined that successful mapping depends on knowing what the characteristics of each land cover type are, and using that information to define the appropriate mapping methodology. Different methodologies are required for land cover types with significantly different characteristics.

Some other studies demonstrated that land use-cover classification is more accurate using Landsat MSS imagery than Landsat TM imagery or even SPOT HRV imagery because although spatial resolution was still more coarse than most urban features, there would now be more pixels erroneously classified, adding to the overall increase in "noise" (Aplin, 2003). The material composition and non-uniformity of land use areas makes it impractical to advocate a general classification system, because of the diversity within and between land use that makes them so difficult to classify. However, the variation that makes classification so difficult for land use does not stop with internal features, as they also vary externally according to location (Aplin, 2003). The introduction of satellite imagery provided a great boost to the monitoring and management of environmental resources, for satellite images of a place acquired at different times can be compared to detect changes that have taken place over time. Given its rapid retrieval and global availability, satellite remote sensing is an ideal

means for producing measurements from which to monitor various aspects of land cover dynamics (Donnay and Barnsley, 1999).

Land use change detection using remote sensing data (satellite and aerial) and analysis using GIS have been applied to many studies including the impacts of dam on land use. Land cover mapping and monitoring provide input data into Geographic Information System (GIS) derived models of infrastructure modifications, utility needs, economic development, and the potential vulnerability of the population to natural hazards and environmental damage. The method is very efficient for assessing the change or degrading trends of a region. Remote sensing change detection involves the use of multi-date (time series) aerial photos or satellite imageries of the study area, from which land use/cover maps can be generated by visual interpretation or digital image processing. GIS analysis will give the actual area of each land use class, and the area changed, through the overlay operation (Mather, 2003).

In addition, remote sensing and GIS can be used separately or in combination for analysis of the impacts of the dam on the environment. In the case of a combined application, an efficient, even though more complex approach is the integration of remote sensing data processing, GIS analyses, database manipulation and models into a single analysis system (Sudhira and Ramachandra, 2002). GIS techniques must be employed to integrate diverse spatial data sources, extract information, and convey that information to decision makers in an effective format (Star *et al.*, 1997).The spatially reference is most important requirement for the integration of processing of remote sensing data and GIS data. In doing this there are four major data sources that need to be considered: vector data, socio-economic data, field data and raster data. In doing this there are four major data sources that need to be considered: cartographic data, socio-economic data, field data and image data. By developing a temporal sequence of

remote sensing data products, information for monitoring and management can be provided to the decision and policy-making processes. Geographic information systems provide users with tools for effective and efficient storage and manipulation of remotely sensed and other spatial data for scientific, management and policy oriented information (Star *et al.,* 1997).

There are several problems associated with remote sensing, ranging from spectral and spatial to temporal as well as algorithm, to adequately extract features and derive information from the complex environment with mix-pixel. Land use is typically composed of features that are smaller than the spatial resolution of the sensors: a complex combination of buildings, roads, grass, trees, soil, water etc. (Lu and Weng, 2004). To comprehend the problems associated with the remote sensing of an area, the spatial, spectral and temporal properties of remotely sensed data must be considered with respect to the morphological characteristics of the area (Weber, 1994). However, recent satellite sensing systems have generated an interest in the remote sensing of land use areas. Satellite sensors with a relatively fine spatial resolution, such as those carried on the spot or Landsat satellites have been used in numerous impact studies. (Weber, 1994)

The study of the spatial impacts of dam on land use land cover is important for many planning and management activities, and it is considered an essential element for modelling and understanding the earth as a system (Lillesand *et al.*, 2004). Currently, researchers have developed land cover maps from local to national to global scales for various environmental purposes. The formulation of governmental policies and programmes by urban and regional planners requires continuous acquisition of data about the earth's surface to meet the challenges of rapid changes on the earth's surface, especially in the areas within the dam region. It is known that one of the major factors

responsible for the lack of performance of several urban and regional planning agencies is lack of technical know-how and their inability to adequately monitor the growth of cities, towns and villages in a timely, accurate and cost-effective manner. This leads to a poor performance of their basic environmental and natural resource planning role in the social, economic, and cultural domain (Lillesand *et al.,* 2004).

2.6.1 Digital elevation

The Shuttle Radar Topography Mission (SRTM) as described by USGS Facts sheet 071-03 2003 is a joints project between National Aeronautics and Space Administration (NASA) and the Department of Defense National Geospatial-Intelligence Agency(NGA). The aim of SRTM is to map the Earth's land surface in three dimensions at a level of details unprecedented for such a large area: which was achieved during 11-22 February 2000 vide the space shuttle Endeavour. Successfully collected data (over 80% of the earth's land surface) were further published in form of grid data files (raster) and called Digital Elevation Models (DEMs) with an accuracy of 1-arc second (30 meters, DEM30) 3-arc-second (90-meters. DEM90) and 1-arc-minute (1km DEM1km)

Based on previously mentioned data type many researchers that considered specific application of hydrological aspects were developed. Such as flood estimation on natural and urban catchments. GIS data quality on small watershed stream flow and sediment simulations, use of SRTM data and constructed DEM to identify large-scale oriented landforms as well as interactive use of DEM and Landsat TM satellite images to determine lake basin model through Hec-GeoHMS (Liverman *et al.,* 2006).

2.7 Recent Application of Remote Sensing and GIS on Analysis of the Impacts of Dam to Environment

Zemba *et al.,* (2016) in their effort to study the impact of Kiri dam to environment, classified and analysed satellite images of the pre-and-post dam period. Their outcome revealed that there was a reduction of vegetation, increase in water body because of the dam. They concluded that, there were loss of biodiversity, pollution and soil erosion among other impacts.

Qinghe *et al.,* (2010) studied the spatial-temporal change of land use surrounding Marwan dam using Satelite images of 1974, 1991 and 2004. They use field survey data and land use map in the classification of the images using supervised signature extraction with maximum likelihood algorithm. They applied GIS buffer analysis of 1000, 5000 and 10000-meter zone from the dam to analyse the land use-cover changes within those buffers. They concluded that there were significant land use-cover changes between 1974 to 1991 and the change was steady between 1991 to 2014.

Dalil *et al.,* (2013) use Landsat imageries to study the impact of Gurara dam on land cover in the surrounding communities between 2003 and 2013. They used cross query for analysis of the spatial and temporal changes induce by the dam and found out that there was a significant loss of Fadama, Forest, arable and rock crops.

Dukiya (2013) examined the spatial transformation of the downstream sector of Kainji Dam and its effect on those communities within two and half kilometers away from the river course using satellite image, Topographical maps and field survey data. His findings reveal that Primary vegetation has given way to secondary vegetal cover due to the change in the primary occupation of the people (from fishing to farming) with negative consequences on vegetation and animals. They recommended re-evaluation of the dam be carried out as contained in the Environmental Management Plan (EMP).

In a study carried out in Pathankot and Dharkalan Tensils, Punjab (India) Singh (1986) evaluate the Land cover change detection within the study area. Satellite imageries and digital topographic maps were used. The GIS was applied to analyzed the land use changes and evaluate the socio-economic implications of predicted change. Land cover changes have been detected by image processing technique. Fifteen years period (between 1991-2006) shows some major land cover changes.

2.8 Gaps Identified

The previous studies conducted on the impact of dam to the surrounding environment all revolve round the analysis of the land use land cover change induced by construction of the dam in the region and its impact such as resettlement and loss in the fertility of soil. The method applied was land use land cover mapping and analysis using Landsat imageries and supervise maximum likelihood algorithm. None of the previous studies analyse; the impact of the dam on agriculture, water supply and distribution to the municipalities and the relationship between the dam location and the expansion of the surrounded communities, socio-economic activities of people in the region and the relationship between the dam and the population density of the surrounding communities. The previous studies also did not analyze the compliance of the master plan and the development of the study area overtime to check compliance of the development with the master. The studies conducted have not analyzed the vulnerability of the surrounding communities to flooding.

This study therefore analysed land use land cover change before and after the construction of Jibia dam to reveal the change caused by the dam in the study area using Landsat imageries. The impact of Jibia dam on agriculture, transportation, domestic water and recreational activities was mapped and analysed using maps, google map image. Terrain analysis was carried out to analyse the vulnerability of surrounding

communities to flooding. Proposed master plan of the study area was used to analyse the compliance of the development of the region overtime with the master plan. Finally, questionnaire was administered to analyse the impact of Jibia dam on the socio-economic activities of people in Jibia town

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Framework of Research Methodology

This chapter focuses on the study area, data acquisition, image processing and interpretation of satellite data to extract information. The accuracy assessment was carried out to determine the users, producers, overall and Kappa accuracy. It also includes change detection, analysis the impact of the dam on land use land cover changes, the analysis of the impacts of Jibia dam on: Irrigation farming, flood control, population growth, socio-economic activities of people leaving in the study and the negative impact of the dam on the expansion of Jibia town. Furthermore, it included the comparison between the current land use land cover map and the proposed master plan of Jibia dam.

3.2 Reconnaissance Survey

In order to achieve to the objectives of this study, field and office reconnaissance were conducted.

3.2.1 Office reconnaissance

During office reconnaissance Katsina State Water Board Jibia district was visited to acqu ire the map of the underground pipeline network, information about the silent water supply and distribution facilities and the information about supply and distribution of water to the distribution areas. Sokoto Rima River Basin Development Authority Jibia district was visited to also seek for the map of irrigation water supply and distribution facilities, Master plan of the dam and information about the supply and distribution. Office of the Surveyor General of Katsina State was visited to acquire the administrative of the study area. United State Geological Survey online data portal was visited to access the availability of Landsat and Digital elevation imageries.

3.2.2 Fieldreconnaissance

The study area was visited to have an overall picture and to acquaint with the nature of the study area for the purpose of ground truthing and planning of field work. During this exercise various land use land cover and dam facilities were visited and compare with landsat images in order to reconcile between the features on the ground and image. Inaccessible areas such impounded reservoir and some of forest were viewed from google map image. The coordinates of identified location on the images were captured google earth for geometric correction. Cluster sampling technique was used for the selection of reference data for assessment of mapping accuracy. Six irrigation project area and Jibia town were visited to find out how the area constraint the expansion of Jibia.

3.3 Data Used

The data used in this study is primary and secondary data. The primary data were remote sensing data, field survey data collected during ground truthing and interview map of the study area, while the secondary data were 1991 population census data, photographs and Map of Municipal and Irrigation water facilities.

3.3.1 Remotely sense data

Considerable effort was put into selecting cloud-free data sets and to get data near the same date and the same season in order to reduce seasonal difference effects on the images for classification and change detection. The selected images were acquired between November and February which is considered as dry season in the study area because there are no available imageries to maintain consistency in day but seasonal consistency was maintained. These images were downloaded from the United State Geological Survey (www.earthexplorer.usgs.gov). Table 3.1 gave detail information

about the satellite images used in this research. Table 3.2 shows the Landsat (TM, ETM, OLI/TIRS and STRM Digital elevation) band and their corresponding wavelength.

Table 3.1 Description of remote sensing data

Platform (sensor)	Row/ Column	Data Acquired	Spatial resolution	Temporal resolution	Radiometric resolution
Landsat 4	189/51	08/01/86	30 meters	16 days	8 bits
Land sat 5	189/51	12/02/90	30 meters	16 days	8 bits
Land Sat 7	189/51	1/1/03	30 meters	16 days	8 bits
Land Sat 8	189/51	11/1/16	30 meters	16 days	8 bits
SRTM Digital Elevation	189/51	02/14	30meters		

3.3.2 Population census data

In order to analyze the impacts of Jibia dam on the population growth of Jibia town the population data (1991) of the surrounding communities in the Study area was collected from the National Population Commission, Katsina State Headquarters. The data was based on gender and localities in the study area.

3.3.3 Ground control points

The coordinates of locations where samples of different land use and land cover classes and generated from high-resolution Google Map for accuracy assessment of image classification. During the field survey, 16 Ground Control Points (GCP) were also collected using GPS for the purposes of geometric correction. These GCPs were captured from distinct features on the map and images such as road junctions, buildings, and much other landscape feature identifiable clearly on the map and the satellite images. The points were used for the minimization of geometric distortion of the Images by georeferencing with ArcGIS Software. This was also used to unify the coordinate system of the Satellite Images for the spatiotemporal analysis.

3.3.4 Maps of Dam facilities

In this Study, the map of the general layout of irrigation water facilities is among the Data used, it was obtained in Vector format from Sokoto Ruma rivers basic development authority, Jibia district, the Map of the general layout of municipal water supply and distribution facilities was collected from the Katsina State Water Board Jibia district. In addition, the Administrative Map of the study area was released by the office of the Surveyor General of the Katsina State.

3.4 Device and Software Used

A handheld GPS receiver Garmin 75x was used for capturing the position of the distinct location on both of the images and map and for navigation in the study area during ground truthing. ERDAS IMAGINE version 2014 was used for image pre-and-post processing analysis of the remote sensing images. ArcGIS version 10.4.1 was used for mapping, data integration and further analysis of relationships, patterns and trends in a multi-temporal approach. Besides, Microsoft windows accessories for tabulations and graphical representations were used to present, describe and analyze land use/land cover dynamics and trends of changes that were undertaken during three periods. SPSS version 15 was used for statistical analysis

3.5 Image Processing

Image processing is the manipulation or alteration of the image by means of the computer for the purpose of making the image ready for analysis (Gonzalez, 2012). In order to achieve the major objective (Mapping and analysis of land use land cover changes) of this research several image processing techniques such as layer stacking, subsetting, geometric, radiometric and spatial enhancement, classification, Filtering and change detection were conducted in order to make the remote sensing images ready for analysis.

3.5.1 Image pre-processing

The data was imported into ERDAS imagine software version 2014 on the band by band basis. Band 1-5 and 7 were then layer stacked for both land sat TM 1986, 1990, ETM+2003 and OLI/TIRS 2016. Bands 6 (TM4-5), 6(ETM) and 8 (2003 and 2016) were excluded in both images because they are thermal infrared (TTR) and 60-meter spatial resolution this was considered not suitable for this research. The study area was clipped out from the stacked images (1986, 1990, 2003 and 2016) because

(i) The study area covered small area on the Images

(ii) It saved processing time and reduced storage space

(iii) It was easier to carry out geometric correction on a small image

3.5.2 Geometric correction

Geometric rectification algorithm is used to register the image to map projection. Variation in altitude and velocity of the sensor, panoramic distinction earth curvature and relief displacement are the sources of distortion that prevents raw image be used as Map (Lillesand, 2004). Acceptable image rectification result on the two images should have a root mean square error of less than one-meter ground coordinate points(GCPs) captured during ground Truthing was used for the Re-Georeferenced of the Land 8 Image and the remaining Images were corrected by Image-to-Image rectification. About 16 GCPs were digitized on both images but 6 GCPs were checks for the assessment of the transformation. Since GCPs can be located with precision and accuracy on accurate maps yet are also easily located on digital images (Campbell, 2002).

3.5.3 Image enhancement

Image enhancement is a process of manipulating an image so that the result is more suitable than the original for a specific application (Gonzalez et al, 2012). Image enhancement depends mainly on the analyst judgment. In order to equalize the

wavelength on the images and to minimize details on the images, this study carried out the following image enhancement techniques such as histogram equalization, filtering techniques (low-pass–smoothing the Images). On multiband images in order to attain the research objectives (Analysis land use land cover changes)

3.6 Selection of Training Data

Training data was based on ground truthing, a cluster of a pixel representing various land cover categories was selected as a training set. The selection of training data was carefully planned and aimed at the true representation of the informational class with the field observation serving as a guide. The training area was delineated, and the frequency of all spectral bands examined to ascertain a homogenous training data and to assess the usefulness of the selected training data

3.7 Image Classification

Several methods have been developed for image classification over the years by scientists (researchers). To achieve high classification accuracy several classification techniques were tried for their effectiveness in classifying land use/cover in this Study. Maximum likelihood classifier achieved the highest classification accuracy. The supervised classification with maximum likelihood classifier was used because it gave a better result.

The ground-truth data agreed with this outcome after the classified image was smoothened. The MLC effectively handled this problem better than other types of classifiers tried for this research. To determine the level of classification accuracy, post-classification accuracy assessment and filtering was performed which provided clear and homogenous information categories.

In order to overcome the problems of misclassification of a pixel due to the inseparability of their spectral resolution manual digitization was added to the classification process in order to address this problem. The land covers that have these problems were a settlement and revering areas. Because open space cannot be separated from settlements and farmland with the similar soil type with rivers and Irrigation project site from farmlands. The focus of this study is to analyze the constraint against the settlements and without accurate determination of an area, there will be uncertainty in the analysis and decision making based on the result obtained. In view of this, the settlements in the study area were vectorized and later rasterized. The location of the settlements and water body was erased from the classified images and merge the classified images with digitized settlements and water bodies the extent of the land use land cover was quantified and tabulated.

3.8 Error Matrix for Accuracy Assessment of the Classification

It is very important to quantify the errors in land cover/land use maps before they can be used, for the Analysis of the Impacts of a Dam in a Region where it was constructed. The accuracy of land Cover classification is usually expressed in terms of a confusion matrix. This can be used to assess the general quality of the classification, which is sometimes summarized by an overall precision index (percentage of correctly-classified pixels, Kappa Coefficient, etc.). Hence, error matrix was used to assess the accuracy of the classified images. One of the advantages of an error matrix was its ability to generate an overall accuracy as well as producer's and user's accuracy. This allowed the assessment of the accuracy of individual land use/cover class. This also made it possible to identify land use classes that are not spectrally separable. In this study, 446 points were generated from the MSS Landsat image of 1986 using random cluster sampling

according to a rule that for any land cover class there should be a minimum of ten times the total number of

the classes Lillesand (2004). While 443 was generated from the individual images (1990, 2003 and 2016) in the post-dam period using the same sampling method. The total number

of a point was equal because the pattern of land use land cover in the post-dam period were the same. The generated points then matched with the corresponding number of the classes of the classified images in excel and converted to text to be recognized by Erdas imagine software and finally, the accuracy assessment was conducted for all the classified images.

3.9 Change Detection

Change detection is the process of identifying differences in the state of an object or phenomenon by observing it at different times. It can also be referred to a difference between the percentages of the difference in land use land cover of the former (e.g 1986) from the later (e.g 1990) The sum of the changes detected from the land cover classes will be zero due to loss and gain among the land covers. (Lillesand, 2004). The importance of land use/cover change detection is its ability to reveal the areas that require the greatest attention of planners and administrators for communities to achieve development in a harmonious and orderly manner that guarantees a functional, sustainable and aesthetically pleasing environment. The objective of change detection is to get reliable information from the images to take an informed and reliable decision on the subject matter. In this case, the post-classification comparison to detect the changes was carried out by comparing the land use land cover images. These classified images were used as inputs and the result was the change map that will display from-to change information and the kind of landscape transformation that has occurred. The Change

matrix table displays the amount of land use land cover transfer among the land cover classes.

3.10 Determination of the Rate of Development

In order to determine the extent and rate of change in the land cover dynamics in the region, the following variables were computed. These variables can be described by the following formula: (Yesserie, 2009)

$$Ca = Ta(t2) - Ta(t1) \qquad 3.1$$

Changed area (Ca)

$$Ce = \frac{Ca}{Ta(ti)} \times 100\% \qquad 3.2$$

Change in extend (% Ce)

$$Cr = \frac{Ce}{(t1) - (t2)} \times 100\% \qquad 3.3$$

Annual rate of change (Cr)

where t1 and t2 is the beginning and ending time of the land cover studies conducted

Total area (Ta)

3.11 Determination of the Imposed Constraint

After data integration, in order to measure the direction of development and constraint overtime in the study area the constraint from the irrigation canals and rivers were mapped and the purpose for the analysis of the imposed constraint on the development of Jibia town and its environment. The palace is located along a Gada river. That is why the measurement of the expansion of town was measured from the central location of the town from which the lines were drawn in the North, West, South, East, North-East, North-west, South-East and South-West. Direction from this point, the expansion of

development was measured from the center to the extent of the town at different epoch. The expansion was determined by subtracting the distance from the central point in thetown to the boundary on the former epoch (1986) from the later (1990 for example) the result is the expansion of Jibia town from one epoch to another in that direction. The same procedure was adopted across the remaining epochs

3.12 Mapping

For the better understanding of the impacts of Jibia dam on Jibia town and revealing the dam facilities that cannot be classified from the classification conducted. Mapping of those facilities was carried out.

3.12.1 Dam Facilities

One of the objectives of this study is to analyze the impacts of the dam on Jibia town in the study area. For better visualization and analysis of these impacts, Mapping of dam facilities is essential. Since remote sensing imageries used in this study has the spatial resolution that cannot discern features that have spatial resolution smaller than 30 meters its appropriate to use other data that is capable of revealing the features such as Irrigation Canals, Underground Pipelines, control drainages and Farm Road. In order to complement this effort, Map of Irrigations canals and Pipelines in vector format were overlaid on the map of the study area. While the location of Access road, Farm road, Chama park and control drainages were vectorized from Google map image. and used for mapping the Facilities. These features were overlaid on the various map of the study area. The maps produced were the map depicting the Irrigation canals, Pipelines, Control drainages, Accessibility of Surrounding communities to Jibia town and map that depicted the impact of Jibia dam Irrigation farming.

3.13 Comparison between Jibia Dam Master Plan and the Development of the area Overtime

Effort to obtained the master plan of Jibia from Sokoto Rima River Basic Development Authority, Jibia and Dutsin-ma was not successful. Because the map was lost to fire accident that occurred in the zonal office at Dutsin-ma. But the details of the map were documented. This study used both the written document about the plan, image of the pre-and-post dam period and the results of the cross-checked interview were used to understand what was the actually information on the map. From this analysis, it was found the Federal Government of Nigeria provided Sabon garin Kwari as the resettlement for the displaced people. To analyse the compliance of this plan and the development of the area overtime, the Base map of the compensation area was mapped in four epochs (1986, 1990, 2003 and 2016). Changes in the area were analyse and the rate of expansion was computed and compared with those of Jibia and Magama towns

3.14 Terrain Analysis

Flood control is one of the purposes of dam construction and it can be categorized as the positive impact of Jibia dam. In order to reveal how the construction of Jibia dam helps in controlling flooding shuttle radar topographic mission digital elevation was obtained (two scenes covered the area).

1. These scenes were mosaic and the extent of the study area was clipped.
2. The clipped image was then enhanced by adjusting its brightness and transparency.
3. A fill operation was conducted to level small holes.
4. Digital elevation model, flow direction, and flow accumulation map were generated.

5. The accumulation map was then reclassified and the stream was converted to feature to depict the accumulation lines in vector
6. Finally, the Digital elevation model, flow accumulation lines, and the surrounding communities were overlaid to produce the map shows the level of vulnerability of Jibia town to flooding

3.15 Analysis of the Population Growth in Jibia

In order to analyse the impact of Jibia dam on population growth of Jibia town. The result of 1991 population census was collected from national population commission. The reason for the choosing 1991 data instead of 2006, 1991 broke the data in localities. the rate of population was obtained from the national population commission

The areas of the communities in the study area was extracted from the classified landsat images and the population of the people in those localities were projected to 2003, and 2016 using the relation in equation 3.4

$P_n = Po e^{RT}$ (U.S. Census Bureau, 1985) (3.4)

Where

P_n is the estimated population at time T

P_o is the current population at time zero

R growth rate (the value was obtained from NPC, Katsina State)

And T in the time interval (year)

Using the areas of the localities extracted from map of the study area at 1991, 2003 and 2016 the population density maps were generated. The correlation between the change in population and area were analyzed using SPSS version 15.0 software

3.16 Data Integration

The main purpose of data integration is to allow data from different sources to be referenced in the same spatial domain so that this data can be effectively overlaid with other data for further analysis. Since data from different sources may use different map projections, there is a need for their conversion into a standard and common map projection. However, this task was performed with utmost attention to overcome data been inaccurately geo-referenced, which can result in spatial inconsistency among different data sources even though the same map projection is utilized.

Data integration in this research started from the pre-processing stage where all satellite images and map were geo-referenced to a common coordinate system. The UTM Zone 32 WGS84) datum was selected. This established the basis for data integration through to the later stage. All the products of image processing, the land use/cover (LULC) map, was overlaid on the Map of Dam Facilities for spatial analysis of the impacts of the dam on Jibia town in this projection.

3.17 Interviews and Questionnaires

3.17.1 Interviews

The interview was conducted in line with Schein's (1983) 'interactive clinical interview' technique that involves some series of joint explorations between the interviewer and the interviewee. Some lines of enquiry were prepared to serve as guides during the interviews. These were based on the focus of the research: land use and land cover change and transformation, positive and negative impact of the dam, population growth and socio-economic factors. The interviews were flexible, with questions drafted to obtain specific information from the key respondents while at the same time getting their views of the general impact of the dam.

In addition, responses during the interviews were triangulated to crosscheck bias among respondents. The interviews were not tape-recorded, but notes were taken during the sessions with the consent of the interviewees. The main reason for interviewees' objection to tape-recorded interviews was the fear of persecution by government if their position became public. In order to get honest opinions, the tape-recording idea was dropped. The data and information collected was collated, coded and analysed and potential irregularities, patterns and explanations were flagged and placed into relevant categories that were conceptually linked to the research structure (research questions and objectives).

3.17.2 Narrative inquiry

This is the process of gathering information for the purpose of research through storytelling. The historical background of the impact of Jibia dam was inquired from traditional elders. This was told orally as most of the information was not written. This was used because it was considered the best way to gain a comprehensive general knowledge of the historical background of the study area as well as change over time. The non-restrictive nature of this method allowed the respondents opportunity to recount and reveal all that they know about the research topic without limitation posed by other means of information and data gathering methods.

During the inquiry session notes were taken of important information, which helped to improve understanding of the study area and gave a good general perspective of the landscape structure before the construction of the dam, creation of reservoir and irrigation project site. In addition, some areas that had gone through various land use/cover changes were identified.

3.17.3 Questionnaires

Sampling methods were used to select representatives of each category of people and places to be sampled for data collection. Since data cannot be collected from the entire population, suitable sampling methods were considered for different tasks involved in the administration of questionnaires for this research. The Quota sampling technique was used because of its combined advantages.

Quota sampling was also adopted which is the non-probability equivalent of stratified sampling. Like stratified sampling, the researcher first identifies the strata and their proportions as they are represented in the population. Three technical and administrative of both Sokoto River Rima Basic Development Authority and Katsina State Water Board Jibia district were selected and interviewed. Ten residents from Jibia town (five people from each ward). Thirty farmers (five from each irrigation site) were selected and interviewed. Their experience and knowledge were taken into consideration at the selection stage to select a sufficiently large number to be reasonably confident that the stratum represented the population.

The people interviewed were men because women are not allowed to participate in the activities outside their husband house due to dominance of Islamic religion. They were aged between 50-65 years because the requirement of the research is to acquire information in both the pre-and-post dam period. Descriptive statistic was used for the analysis of the responds by the respondents.

CHAPTER FOUR

RESULTS AND DISCUSSION

This chapter presents the results of image pre-processing, land use land cover classification, validation of land use land cover mapping, changes detection, direction of development, rate of development, analysis of the impacts Jibia dam Irrigation farming, analysis flood control, tourism, socio-economic activities, population growth analysis of the constrain, the result of the analysis of compliance of current development with master plan and the discussion of the results respectively.

It describes land use land cover changes as a result of the construction of Jibia Dam, in1986, 1990, 2003 and 2016 derived from classification comparison and change detection. The accuracy of the classified images was thoroughly assessed to determine the degree of accuracy and validity of the information derived from the classified images. The chapter also presented the result of classifying satellite images to detect the land cover/use classes that have changed over time, the direction and rate of change. Analysis of constrain imposed by Jibia dam and Gada river on the development of Jibia town and its environs. analysis of the compliances with the proposed Jibia dam master plan is also covered in this chapter.

4.1 Image Pre-Processing

The acquired imageries were layer stacked and subset to fit the study area in order to make image processing faster. The accuracy achieved from geometrical correction were 18.234m, 17.457m 16.234m and 14.123m for 2016, 2003, 1990 and 1986 images respectively. Furthermore, they are radiometrically corrected to remove noise and haze, in order to improve the object recognition and spatial enhancement

4.2 Results of the Impact of Jibia Dam on Land Use Land Cover Changes (1986-2016)

There were five major Land use land cover classes in the pre-dam period. These classes consist of Settlements, Forest, Bareland, rivers and Farmlands. Before the construction of Jibia Dam there was no impounded reservoir except the river in which water flow during rainy season between April to September. There was no Irrigation project site then see figure 4.1 for details.

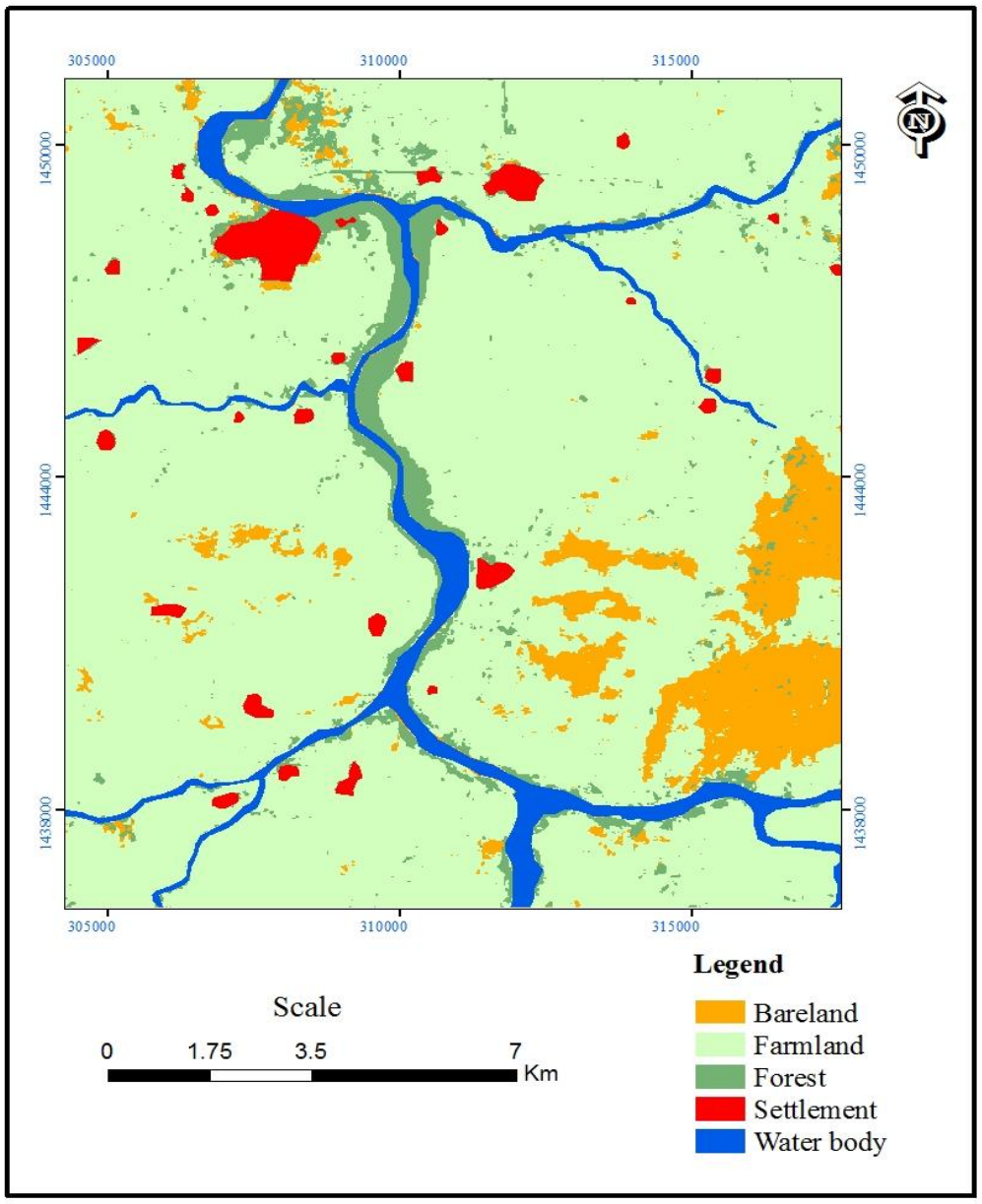


Figure 4.1 The 1986 Classified Image

In 1990 after the construction ofthe dam. Two land use land covers were introduced in the area. Namely impounded reservoir and modern irrigation project area. Figure 4.2 depicted the detail of the land use land cover. This triggered large scale land use land cover changes and large mass scale relocation of people whose settlements were put under impounded reservoir.

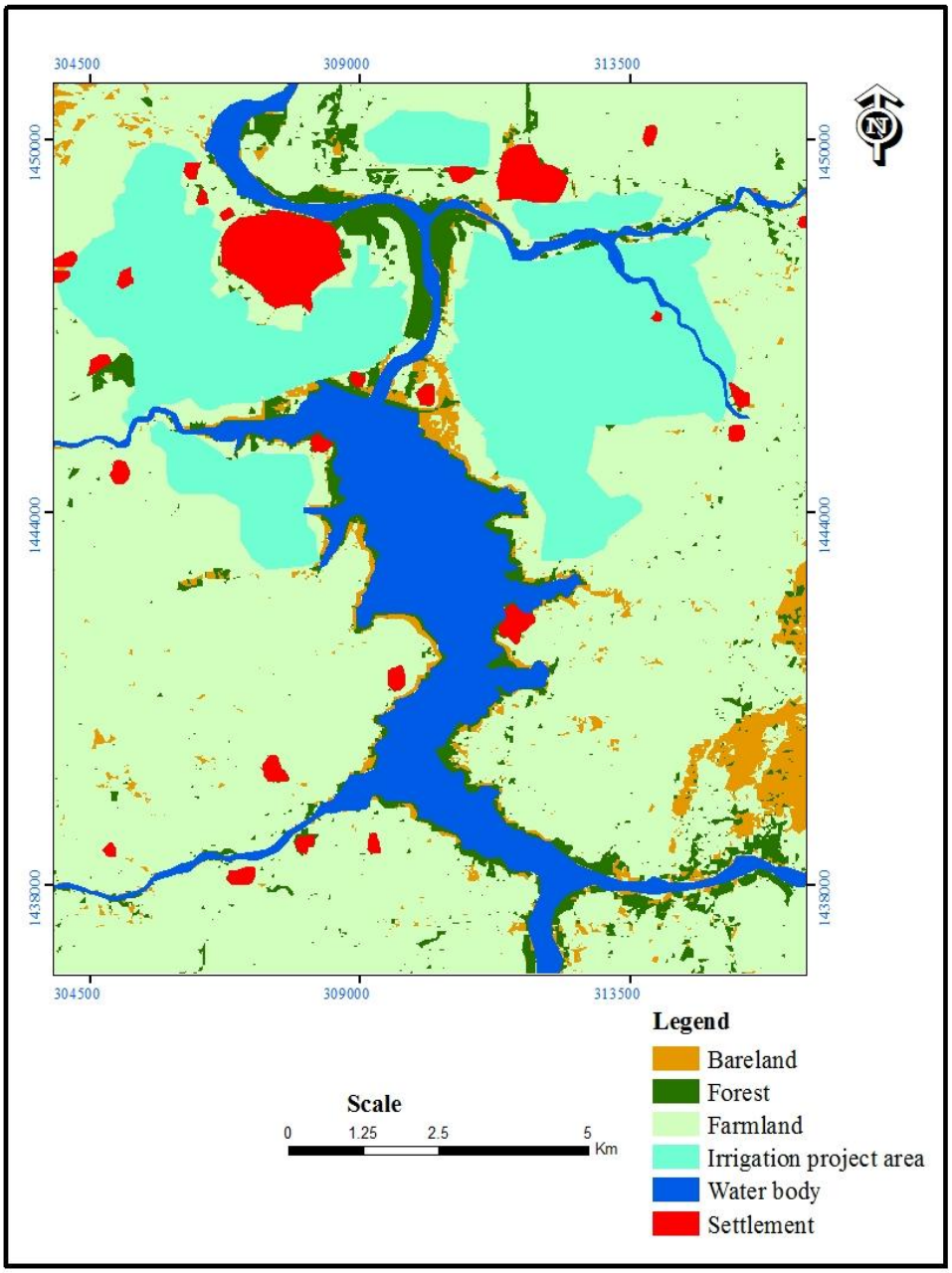


Figure 4.2 The 1990 Classified Image

In the year 2003 the Land use-land cover of the Study were similar with those in 1990. The differences were the expansion of reservoir and settlement. This happened due to continuous eroding of the reservoir and relocation of people for greener pasture. Some settlements are about to their expansion limit by reaching the restricted irrigation project area see Figure 4.3

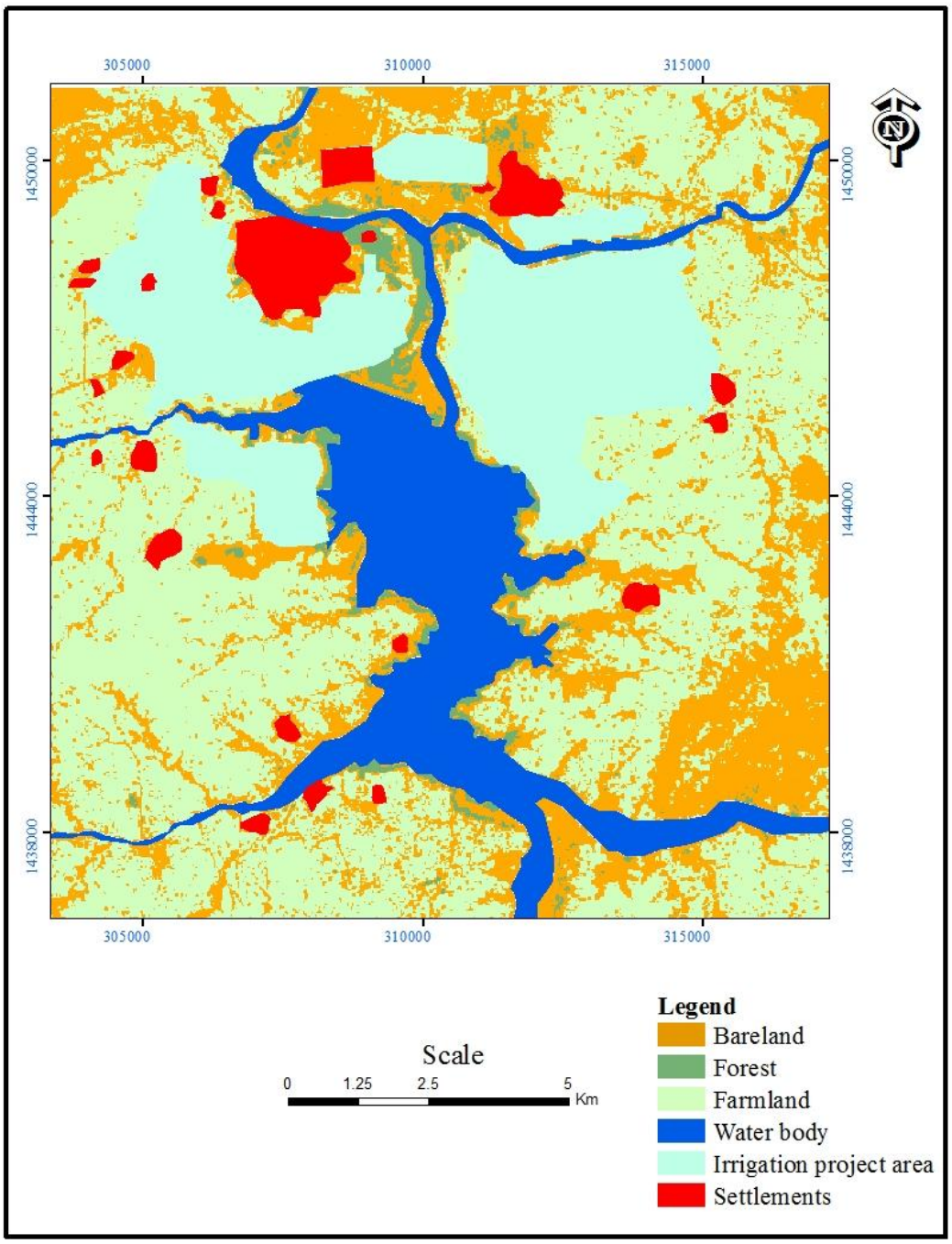


Figure 4.3 The 2003 Classified Image

The 2016 classified image of the area depicted the land use land cover classes. The shows the encroachment of settlement in the Modern Irrigation Site (which is fixed). This happens due to the imposed constrain by the irrigation canals, Gada and Gurbin Baure Rivers. The map also depicted the shrinking of the impounded reservoir because of high demand of water, sediment deposition due to blockage by the Dam see Figure 4.4.

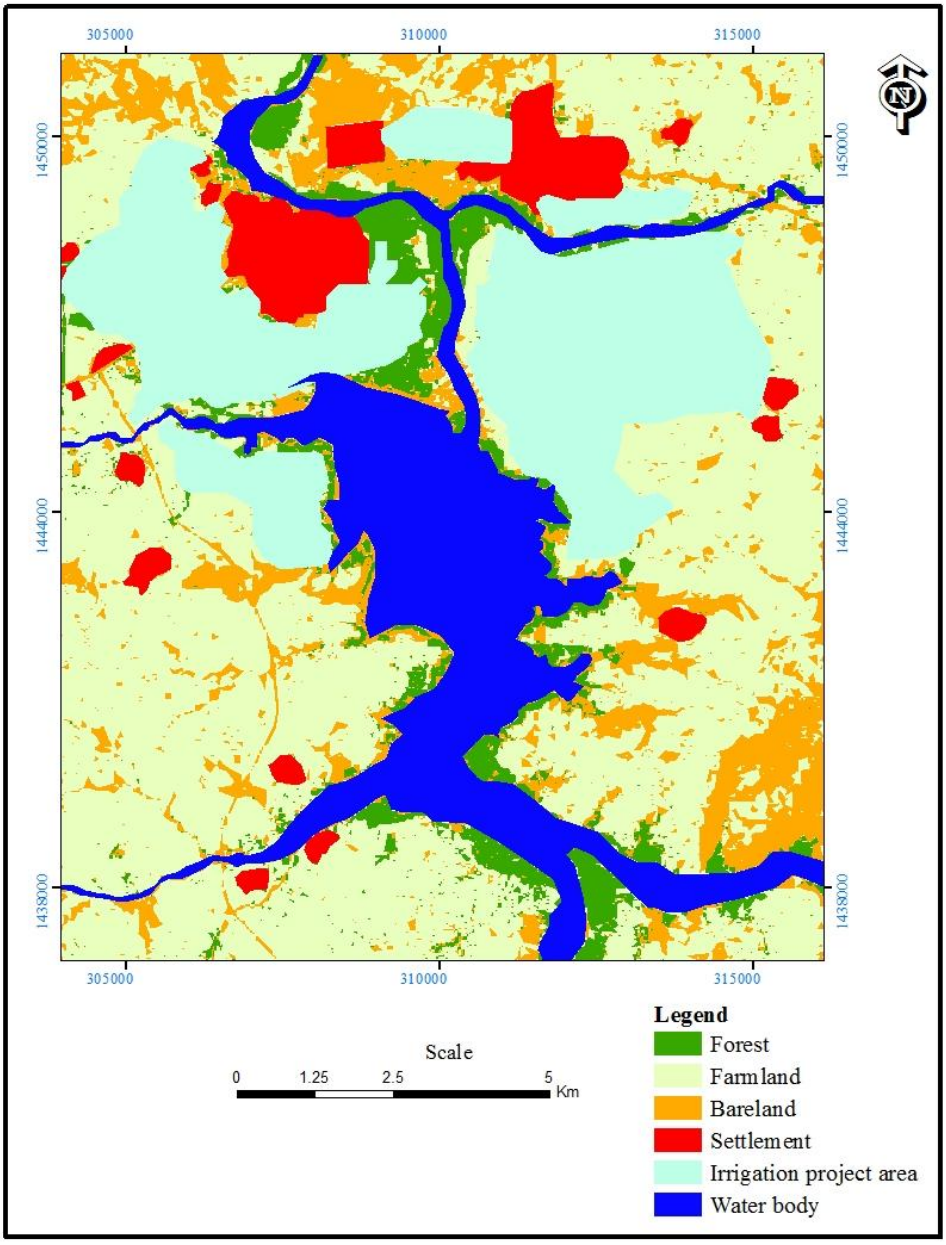


Figure 4.4 The 2016 Classified Image

4.3 Mapping Accuracy

Kappa is a measure of how well image classification agrees or are accurate with the referenced data. The KHAT values below are used as a measure of how well remotely sensed classification agrees or are accurate with the referenced data. Landis and Koch (1977) grouped KHAT values as: 0.80 (i.e., 80%) represents strong agreement; 0.40 and 0.80 (i.e., 40-80%) represent moderate agreement; and a value below 0.40 (i.e., 40%) represents poor agreement (Congalton and Green, 1999).

From the results of mapping accuracy generated below (Table 4.1, 4.2, 4.3 and 4.4), the overall classification Accuracy obtained from the Classification of 1986, 1990 and 2003 range from 78 to 86% which is in strong agreement with the land use land cover and the reference data. These quality test of the classification prove that, the results obtained can be used for application such town Planning, Monitoring of land use land change and analysis etc

Table 4.1 Accuracy assessment of land use/cover map of the study area at 1986

		Reference						
	Land use land cover classes	Water Body	Bareland	Forest	Settlement	Farmland	Row Total	User Accuracy (%)
Classified	Water body	95	0	4	0	3	102	93.13
	Bareland	0	101	2	0	0	103	98.05
	Forest	4	0	99	9	0	112	88.39
	Settlement	0	0	3	80	1	84	95.23
	Farmland	3	22	5	32	97	159	61.01
Column Total		102	123	113	121	101	560	
Producer Accuracy (%)		93.13	82.11	87.61	66.11	96.03		
Overall Accuracy (%)				84.28				
Overall Kappa statistics = 0.8886								

Table 4.2 Accuracy assessment of land use/cover map of the study area at 1990

		Reference						
	Land use land cover classes	Water Body	Bareland	Forest	Settlement	Farmland	Row Total	User Accuracy (%)
Classified	Water body	80	0	0	0	0	80	100
	Bareland	0	26	1	0	2	29	89.65
	Forest	0	0	85	13	2	100	85.00
	Settlement	0	0	7	99	0	106	93.39
	Farmland	0	11	16	9	92	128	71.88
Column Total		80	37	109	121	96	443	
Producer Accuracy (%)		100	70.27	77.98	81.81	95.83		
Overall Accuracy (%)				86.23				
Overall Kappa Statistics = 0.7764								

Table 4.3 Accuracy assessment of land use/cover map of the study area at 2003

		Reference						
	Land use land cover classes	Water Body	Bareland	Forest	Settlement	Farmland	Row Total	User Accuracy (%)
Classified	Water body	88	0	0	0	0	88	100
	Bareland	0	26	11	10	2	49	53.06
	Forest	0	0	85	13	2	100	85.00
	Settlement	0	0	17	99	0	116	85.34
	Farmland	0	11	16	9	92	128	71.88
Column Total		88	37	129	131	96	481	
Producer Accuracy (%)		100	70.27	77.98	81.81	95.83		
Overall Accuracy (%)				79.00				
Overall Kappa Statistics = 0.8231								

Table 4.4 Accuracy assessment of land use/cover map of the study area at 2016

		Reference						
	Land use land cover classes	Water Body	Bareland	Forest	Settlement	Farmland	Row Total	User Accuracy (%)
Classified	Water body	72	2	0	0	0	74	97.29
	Bareland	0	22	7	4	4	37	59.45
	Forest	6	0	63	5	4	78	80.76
	Settlement	0	0	17	104	1	122	85.24
	Farmland	2	13	22	8	89	134	66.41
Column Total		80	37	109	121	98	445	
Producer Accuracy (%)		90	59.45	57.79	81.81	90.81		
Overall Accuracy (%)				78.65				
Overall kappa Statistic = 0.7261								

Table 4.5 and 4.6 present the percentages, extent and overall change of land use land cover of the area under study. Modern Irrigation project area had 0% before the dam and occupy about 34 sq. km which is 10% and remain fixed throughout the periods. Farmland has the highest covered but suffer significant conversion to Reservoir, Water body and Settlement respectively.

Table 4.5 Percentage of land use land cover classes in the study area

LULC Classes	1986 (%)	1990 (%)	2003 (%)	2016 (%)	Overall	Trend

					change (%)	
Settlement	1.11	1.2	1.80	2.73	+1.62	Gain
Jibia Irrigation Site	0.00	10.4	10.36	10.36	+10.36	Gain
Water body	3.62	7.3	9.20	8.97	+5.35	Gain
Forest	2.56	2.4	1.34	0.83	-1.73	Loss
Farmland	59.64	54.7	41.18	45.62	-13.46	Loss
Bareland	33.08	24.0	36.13	31.47	-1.61	Loss
Total	100	100	100	100		

Table 4.6 Result of quantifying land use land cover classes of the study area

Classes	1986 (sqkm)	1990 (sqkm)	2003 (sqkm)	2016 (sqkm)	Overall change %	Trend
Settlement	3.68	4.03	6.01	9.11	1.62	Gain
Jibia Irrigation Site	0	34.61	34.52	34.52	10.36	Gain
Water body	12.05	24.42	30.64	29.90	5.35	Gain
Forest	8.52	8.15	4.45	2.78	-1.73	Loss
Farmland	198.75	182.19	137.22	152.03	-13.46	Loss
Bareland	110.22	79.81	120.39	104.89	-1.61	Loss
Total	333.24	333.24	333.244	333.244		

4.4 Results of Land-Use Land-Cover Change Detection

The result obtained from change detection using post classification change analysis. Land use land cover map at different epoch and the result of land use land cover transfer are presented below.

4.4.1 Land use land cover change detection between 1986-1990

These are the changes that took place between pre-and-post Dam periods. These periods were observed to be the time land use-land cover underwent significance changes in the Study area. The water body increased by 3.68% almost doubled due to the construction of Jibia dam, while the settlements increase by about 1.62% only due to the destruction

of villages in the axis of reservoir like to Jibia and Satellite towns such as Magama, and Faru contrary to the Master plan of the dam. Bareland (which consist of all non-economical land) also decrease by -9.08% due to the conversion of some to impounded reservoir. Farmlands also suffer land use conversion to reservoir, Modern Irrigation, forest and settlement which accounted for about 4.94% decrease in Farmlands. In addition, the river is usually surrounded by forest and small-scale irrigation in some places. Conversion of those rivers to reservoir causes the correspondent losses to forest and old irrigation Site and that Forest losses 0.16% of its coverage. Modern Irrigation Site was created out of Farmland and it remains fixed throughout the period due to imposed ordinance that prohibited any development within the area. In general reservoir and modern irrigation each increased and Bareland, forest, settlements and farmland each loss at various extent due to the impact of the dam. For details see map in Figure 4.5

Table 4.7 showed land use land cover transfer among classes. There was a significant land use land cover change transfer from farmland to Jibia irrigation project area and to water body due to the construction of the dam. From the table settlement, water body are the most persistent land covers. While farmland, forest lost significantly to water body. Forest, farmland and bareland suffered losses to water body, irrigation project area and settlement respectively.

4.4.2 Land use land cover change detection between 1990-2003

Table 4.10 is the details of temporal change between 1990 and 2003. This period is considered as the post dam period. In this period, the water body has increased by 1.9% against Farmlands due to erosion. Bareland has increased by 12.13%. Forest has decreased by 1.06%. Settlements has increase also by 0.6% due to the influx of people for commercial purposes, farmlands have decrease by -13.23 % in connection with

increase of water and forest because of their proximity. Modern irrigation site remained the same due to the prohibition of the development within the area. The water, Bareland, forest and Settlements have increase while farmland decrease and modern irrigation site remain the same. Also, due to holding of water within the reservoir this might the reason for rise in water tablet thereby encourage the growing of trees. For more details of land use land cover see the land use land changes transfer map (Figure 4.9).

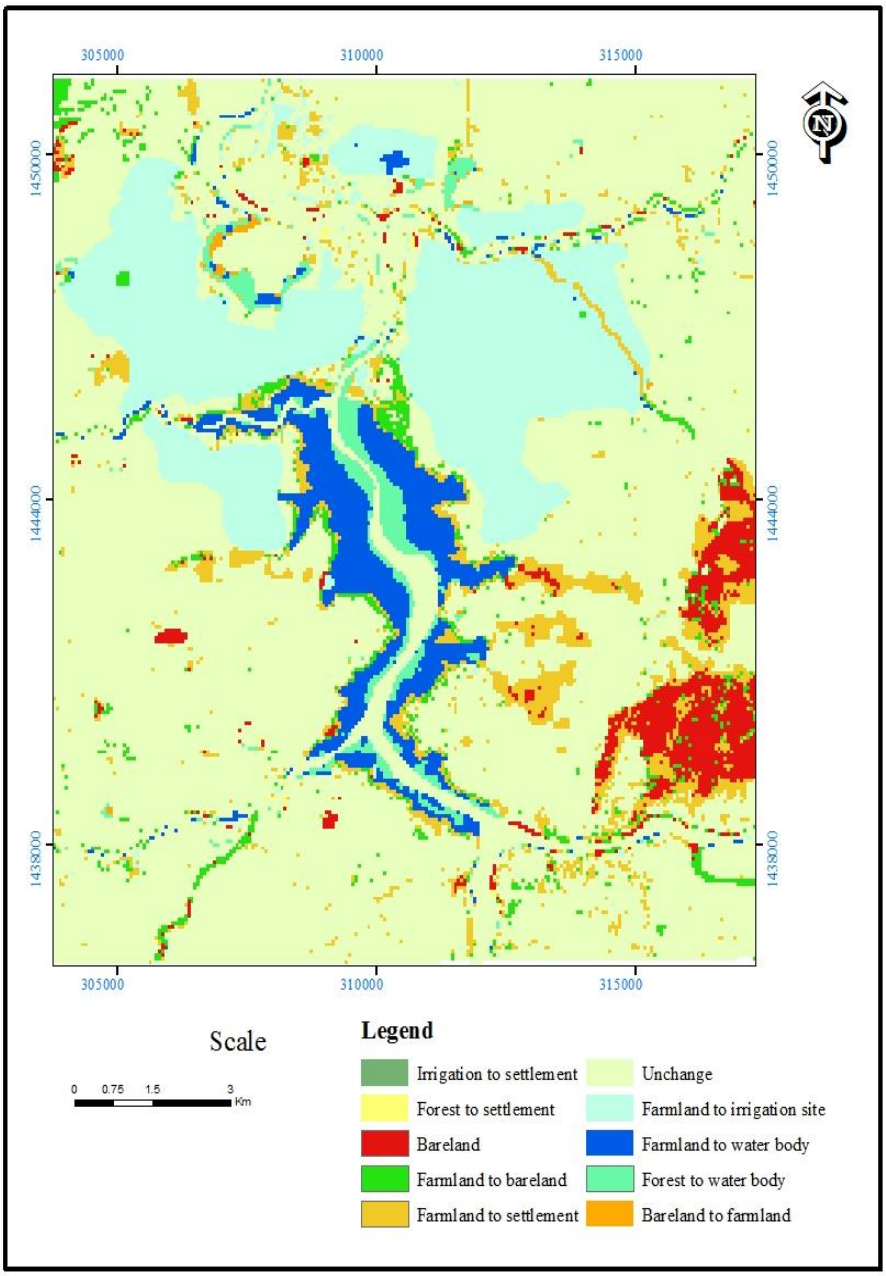


Figure 4.5. Highlight of change area from 1986 to 1990

Table 4.7 Land use land cover change transition matrix (between 1986 to 1990)

1986	1990					
LULC Classes	Settlement	Farmland	Water body	Forest	Bareland	Total row
Settlement	2.830	0.285	0.07	0.349	0.501	4.035
Farmland	0.134	145.295	0.219	0.836	35.707	182.191
Water body	0.041	10.281	9.462	2.761	1.876	24.421

Forest	0.350	2.185	0.833	2.685	2.103	8.157
Jibia Irrigation Site	0.316	31.663	1.242	1.398	0.000	34.619
Bareland	0.015	8.954	0.316	0.498	70.576	79.819
Total	3.686	198.754	12.053	8.528	110.223	333.244

Table 4.8 1986 and 1990 land cover change derived from post-classification comparison.

LULC Classes	1986 Area (sqkm)	1990 Area (sqkm)	Change Area	Changes %	Remark
Settlement	3.686	4.0355	0.3495	9.481823	Gain
Jibia Irrigation site	0	34.6195	34.6195		Gain
Water body	12.053	24.4205	12.3675	102.6093	Gain
Forest	8.528	8.1575	-0.3705	-4.34451	Loss
Farmland	198.754	182.1915	-16.5625	-8.33317	Loss
Bareland	110.223	79.8195	-30.4035	-27.5836	Loss
Total	333.344	333.344			

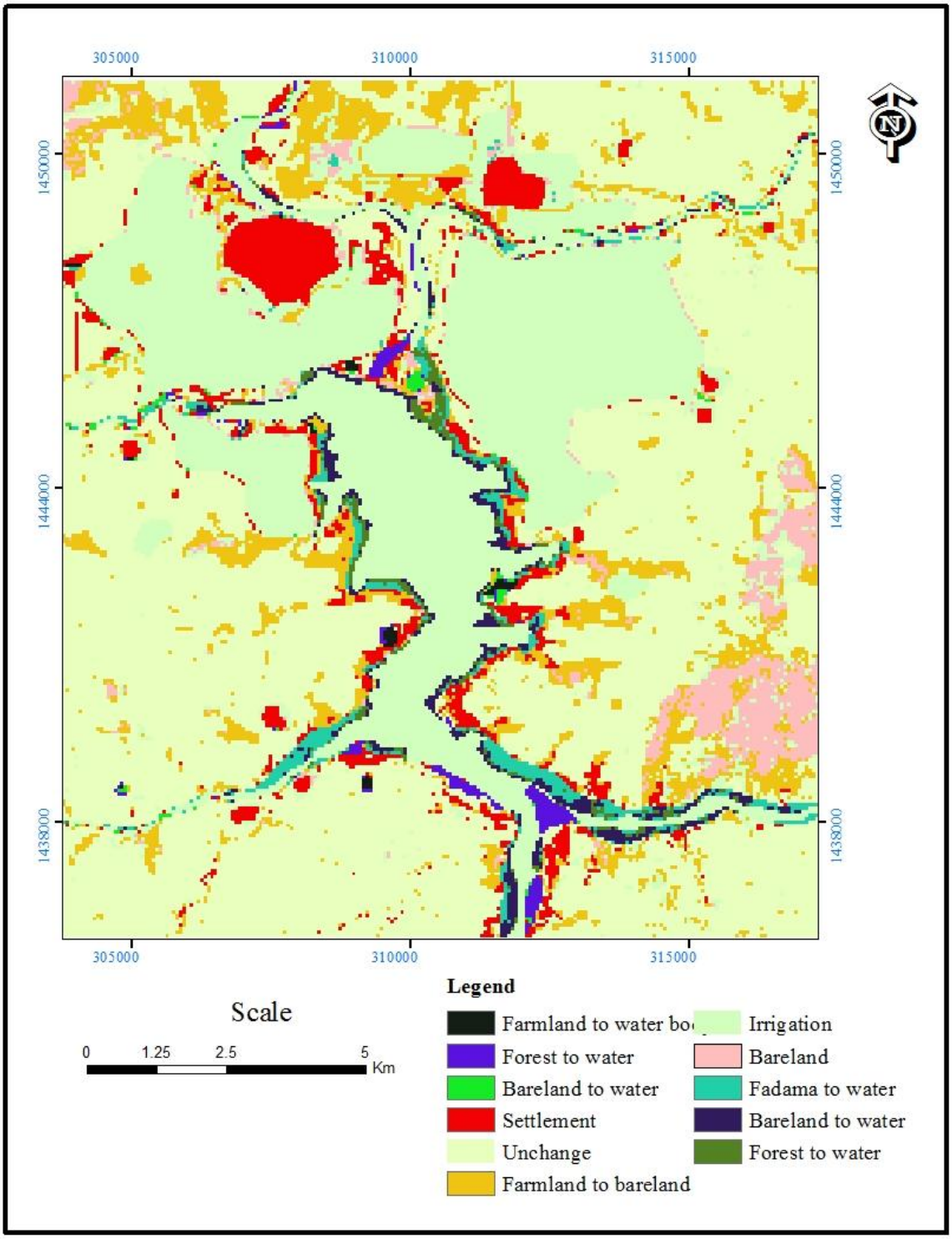


Figure 4.6 Highlight of change area from 1990 to 2003

Table 4.9 Land use land cover change transition matric (between 1990 to 2003)

				1990			
LULC Classes	Settlement	Jibia Irrigation Site	Water Body	Forest	Farmland	Bareland	Row total
Settlement	2.993	0.86	0.056	0.182	1.079	1.136	4.035
Jibia Irrigation Site	0.100	33.119	0.749	0.119	0.432	0.100	34.619
2003 Water body	0.642	0.056	21.109	0.205	2.486	0.491	24.421
Forest	0.646	0.026	4.991	2.080	0.383	0.700	8.158
Farmland	0.215	0.353	1.756	1.377	128.815	49.675	182.191
Bareland	1.403	0.115	1.984	0.495	0.575	68.289	79.819
Total	6.000	34.529	30.645	4.457	137.225	120.391	333.244

Table 4.10 The 1990 and 2003 land cover change derived from post-classification comparison.

LULC Classes	1990 Area (sqkm)	2003 Area (sqkm)	Change Area	Changes %	Remark
Bareland	79.8195	120.3905	40.571	50.83	Gain
Farmland	182.1915	137.2245	-44.967	-24.68	loss
Forest	8.1575	4.4575	-3.7	-45.36	loss
Jibia Irrigation Site	34.6195	34.5295	-0.095	-0.27	Unchanged
Settlement	4.0355	6.0025	1.967	48.74	Gain
Water body	24.4205	30.6445	6.224	25.49	Gain
Total	333.244	333.244			

Table 4.9 described the land use land cover change transfer among the land cover classes. from the table settlement, water body and irrigation project area are the most persistent land use land cover. While farmland and forest losses to settlements and water body. Table 4.9 demonstrated the percentage change of each land cover from its former state. The water body, settlements Gain while farmland and forest loss. Irrigation project area still remain the same.

4.4.3 Land use Land cover change Detection Between 2003-2016

The Map in Figure 4.5 and Table 12 shows the land use land cover changes that took place in the Study area between the 2003 and 2016. From the Table 4.12 the water body has decreased by 2.4% this may be because of the Sediment transfer to the reservoir and blockage by the dam or increase in demand of the water from the dam. Bareland has reduced by 12.9%, forest has decrease by 37.8% because of deforestation to expand farmlands or being the forest as a source of firewood, settlement has increase by 52% and farmland has further reduced by 1.8% to settlement and irrigation Site remain almost the same.

Table 4.11 shows the land use land cover transfer among the land use land cover classes between 2003 to 2016. The water body shrinked. From the table Settlement and irrigation project site were the most persistent land use land cover. From the (Table 4.12) Settlement increase, Irrigation project area remain the same and the remaining land use land cover decreases. The magnitude of changes decreased in this period

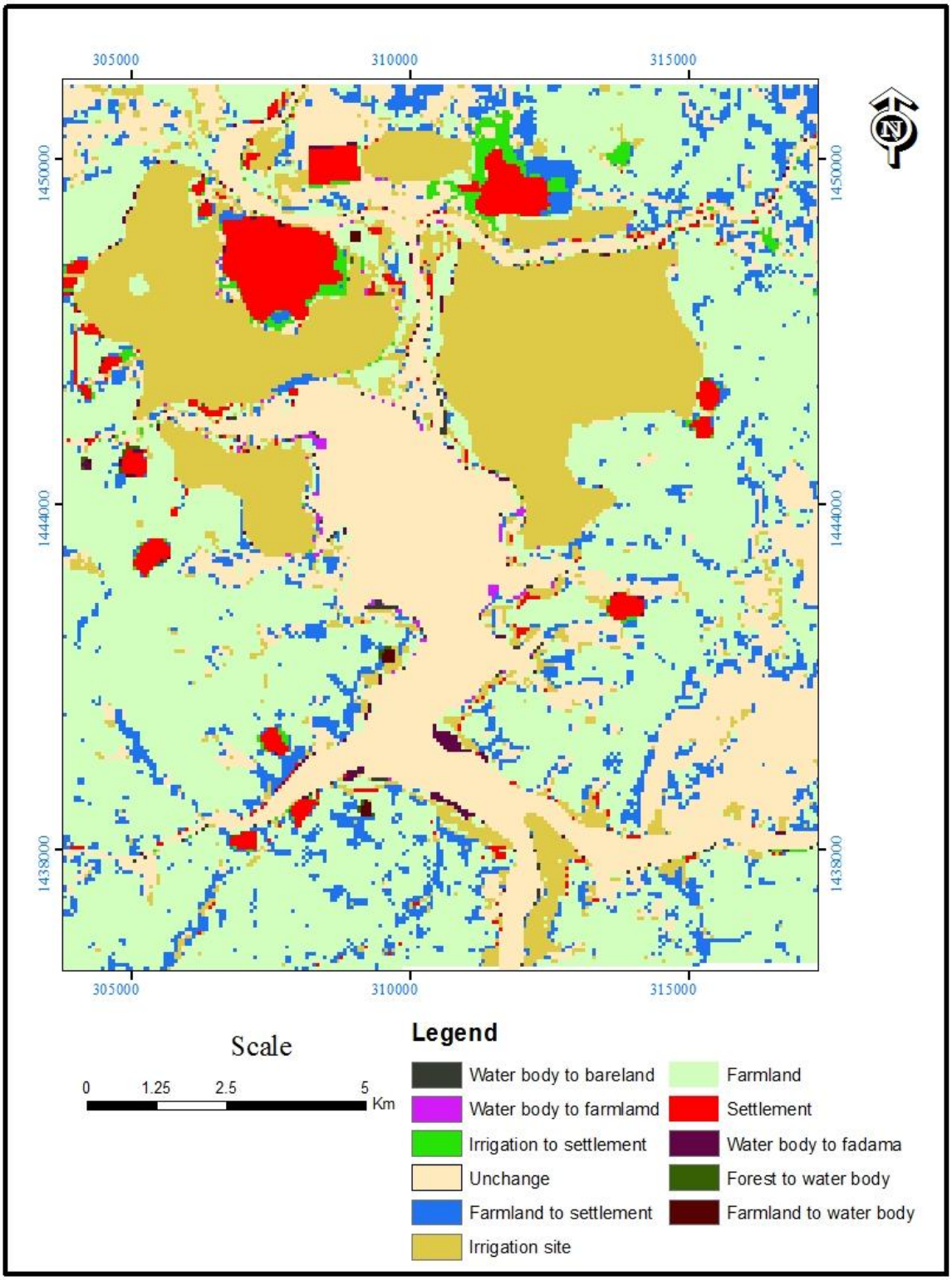


Figure 4.7 Highlight of change area from 2003 to 2016

Table 4.11 land use land cover change transition matrix (2003-2016)

				2016			
LULC Classes	Settlement (sqkm)	Irrigation Site (sqkm)	Water body (sqkm)	Forest (sqkm)	Farmland (sqkm)	Bareland (sqkm)	Row total (sqkm)
Settlement	5.955	0.086	0.056	0.182	1.272	1.559	9.114
Irrigation Site	0.026	33.750	0.093	0.119	0.432	0.100	34.526
Water body	0.000	0.056	27.068	0.205	2.486	0.079	29.905
Forest	0.004	0.026	0.346	2.072	0.383	0.000	2.779
Farmland	0.141	0.353	1.756	1.377	97.867	50.536	152.034
Bareland	0.001	0.115	1.321	0.495	35.003	67.945	104.886
Total	6.00	34.52	30.64	4.45	137.22	120.029	333.244

13

Table 4.12 The 2003 and 2016 land cover change derived from post-classification comparison.

LULC Classes	2003 Area (Sqkm)	2016 Area (Sqkm)	Change Area	% Change	Remark
Settlement	6.00	9.11	3.11	51.83	Gain
Jibia Irrigation. Site	34.52	34.52	0.00	0.00	Unchanged
Water body	30.64	29.90	-0.73	-2.41	loss
Forest	4.45	2.77	-1.67	-37.65	loss
Farmland	137.22	152.03	14.81	10.79	loss
Bareland	120.39	104.88	-15.50	-12.87	loss
Total	333.244	333.244			

4.5 Land Use Land Cover Change between 1986 and 2016

The post-classification comparison of land cover classes gives the change that took place between 1986 and 2016. The land cover classes show detail of spatio-temporal changes between land cover types at level classification, as the classification scheme at this level is based on the land cover change. Construction of Jibia Dam in the 1980s have contributed immensely to the rapid land use land cover changes in the surrounding

Environment. Also, Natural and Artificial bound by the rivers and modern Irrigation Site are the constrains against the expansion of the communities around the Dam. These variables also acted as the main dictators of the direction of developments.

4.5.1 Settlements

This land cover types accounted for 1.11% of land cover in the area in 1986 (Table 4.5). By 1990, this land cover type occupied 1.2% (Table 4.5). In 2003 this land cover occupied 1.8% of the area in the period of 13 years. Finally, by 2016 the Settlements accounted for 9.11sq km which is 2.73% (Table 4.5) of the study area. Most of the growth took place at the town (Jibia and Magama) periphery where forest and agricultural land cover is the major target for urban growth such as residential, commercial, etc. The lack of effective governmental policy to protect forest and agricultural land (as it did to modern Irrigation Site) has made this an easy target. This has now reached the imposed bound by the Rivers and Irrigation Canal because all the land allocated for these uses has been totally developed and people have started erecting building in Control drainages and Irrigation site.

4.5.2 Bareland

This land cover type is considered as Non-Economical land, (which include Bare soil, Bareland). What is happening to this class cannot be ignored or underestimated, because this land cover type occupied 33.1% of the Study Area in 1986. But by 1990 it was reduced to 24.52% due to conversion of parts of Gada River to water body because of the construction of the Dam. By 2003 this land cover type accounted for 36.2% due to desertification approach as result low rainfall within that period. Bareland finally occupied 31.5% of the total with the decrease of 4.7% because of the transformation ofthis land cover to other land uses. Bareland is located in the north direction of the Study area.

4.5.3 Water bodies

This land cover appears in 1986 to have occupied 3.6% (Table 4.5) of the Study Area. By the year 1990, this land cover accounted for 7.3% (Table 4.5) of the area with the increase of 3.7% because of the dam and accumulation of water from Gada River. In the year 2003, the reservoir occupied 9.2% (Table 4.5) of the Study which is 1.9% increase (over the 1990) due to the accumulation of water in the reservoir and blockage by the dam. In 2016, this land cover occupies 9.0% (Table 4.5) with the corresponding decrease of 0.2% because of the shrinkage of the Reservoir due to the increase in demand and deposition of sediments. Yusuf (2013) in his study to determine the amount of the Siltation found out that the impounded reservoir losses its 36% storage capacity due siltation and warned that if the current were not reverse by dredging the reservoir by 2046 the reservoir will have filled up by Sediment and this can cause.

4.5.4 Agriculture and forest

Agriculture and forest was found to have been reduced overtime that why they were discuss together. These land cover types accounted for 62.2% of area under study in 1986 but this has since been reduced by about 5.1% in 1990. In 2003 these land covers cover 42.52% which is 14.58% decrease. As they are an easy target for town expansion, creation of reservoir and Irrigation Project site. In 2016 agriculture and forest accounted for about 45.92% these land covers increase by 3.4% because of the conversion of Bareland to farmland and afforestation in some selected location in the study area by the department of forestry of the state. Most of the urban/built land cover changes (growth) have taken place either on the farmland or forest cover. Other land cover types such as Bareland have also contributed in no small way to the decrease in this land cover class, because most of the areas for land reclamation is were forest.

4.5.5 Modern irrigation site

Modern Irrigation Site was not existing in the pre-dam period (1986) but in 1990 it occupied 10.5% of the Study area this land use was extracted from Farmland as one of the Goal of to enhance food production in the dryer northern Region. Because of strict law that conserve this area from encroachment the area remains almost intact throughout the period. Because everything on Earth is related to everything but near and recent things are related than distance thing (Toddler law of Geography) that is this policy have negatively affected the towns like Jibia, Magama, Kagadama, Jibiyar Maje, Lankwasau, etc. Because they are congested and this also lead to the high price of Land in the Area.

4.6 Rate of Land Use Land Cover Changes in the Study Area.

The average annual rate of change in settlements and water body as computed using (using equation 3.3) are 2.37% and 25.43 from 1986 to 1990 respectively (see Table 4.13). This implies a dramatic expansion of water body, due to creation of the dam in the study area and change in the morphology of the size of the study area and extents. On the other hand, Farmland, forest, Bareland areas showed an average reduction of change approximately -2.08, -1.09, and -6.90% annually (Table 4.13). The rate of change for water body was very significant between 1986 and 1990. However, there had been a marked change in the expansion of water surface in the second temporal season of the study period of 1990 and 2003.

In general, the change values in the Table 4.13 indicated that increase in Settlements, creation of Jibia Irrigation site and Impounded reservoir areas mainly emanated from conversion of farmlands to other land use land covers in 4 years period (1986-1990). Besides the summary, statistics, graphical representations of the classification and

visual comparison offer a general insight into the relative amounts of the defined classes across the landscape and the changes observed

Table 4.13 Extent and rate of development between 1986 and 1990

LULC Classes	1986 Area (sqkm)	1990 Area (sqkm)	Change Area	Extent	Rate %
Settlement	3.69	4.04	0.35	0.09	2.37
Jibia Irrigation Site	0.00	34.62	34.62	0.00	0.00
Water body	12.05	24.42	12.37	1.03	25.65
Forest	8.53	8.16	-0.37	-0.04	-1.09
Farmland	198.75	182.19	-16.56	-0.08	-2.08
Bareland	110.22	79.82	-30.40	-0.28	-6.90
Total	333.244	333.244			

Table 4.14 below presented the Extent and rate of increase and decrease among the land use land cover classes between 1990 and 2003. This period in the study area is consider as post dam period. In this interval also the settlements, water body land covers classes are in positive trends of increasing the areal Extent and annual rate of expansion. The annual rate of expansion of settlement and water body are 5.35% and 2.59% respectively. This implies that, there is declined in the expansion of water body after the construction and creation of a dam and reservoir. Between 1986 to 1990 water body expand almost twenty times greater than settlement. But in the post-dam period the rate of expansion of settlement is more than twice that of water body. Since the development of settlements and expansion of water body occur as a result of land cover conversion from farmland and forest their rate of decrease also continue. These land covers decrease at this rate 4.8, and 2.47 for forest and farmland respectively. Bareland also increase at the rate of 5.11 annually probably due to the approach of desertification.

Table 4.14 Extent and rate of development between 1990 to 2003

LULC Classes	1990 Area (sqkm)	2003 Area (sqkm)	Change Area	Extent	Rate %
Settlement	4.03	6.0025	1.967	0.49	4.87
Jibia Irrigation Site	34.61	34.5245	-0.095	0.00	-0.03
Water body	24.42	30.6445	6.224	0.25	2.55
Forest	8.15	4.4575	-3.7	-0.45	-4.54
Farmland	182.19	137.2245	-44.967	-0.25	-2.47
Bareland	79.81	120.3905	40.571	0.51	5.08
Total	333.244	333.244			

Finally, the period between 2003 and 2016 is that last epoch in this study. From the statistic in the Table 4.14 the rate of expansion of settlement was found to have declined from 5.35 between 1990-2003 to 3.25 between 2003 to 2016 due constraint imposed by the Jibia Irrigation site, Gada and Gurbin Baure rivers, and settling of displaced people in Jibia and Magama towns due to the commercial activities instead of Sabon Garin Kwari which was designed by the Federal Government to relocate the displaced people. The Irrigation Site remains almost unchanged due to the prohibition of development within the area. Even though there is evidence of encroachment to this land cover from the ground truthing observation made in November 2016. But the Extent is negligible and if the ordinance that prohibits the development within this area is not strictly imposed people will continue to convert this Irrigation project site to settlement. The annual rate of decrease of water body declined from +2.59 in the second period of the study to -0.15 due to sediment deposition. Other land covers such as Forest, Farmland and Bareland decrease at the rate of -2.36, -0.67 and -0.81% for Forest, Farmland, and Bareland respectively.

Table 4.15 Extent and rate of changes between 2003 to 2016

LULC Classes	2003 Area (sqkm)	2016 Area (sqkm)	Change Area	Extent	Rate %
Settlement	6.0025	9.114	3.11	0.52	3.24
Jibia Irrigation. Site	34.5245	34.526	0.00	0.00	0.00
Water body	30.6445	29.905	-0.74	-0.02	-0.15
Forest	4.4575	2.779	-1.68	-0.38	-2.35
Farmland	137.2245	152.034	14.81	0.11	0.67
Bareland	120.3905	104.886	-15.50	-0.13	-0.80
Total	333.244	333.244			

In addition, water body expand faster (Figure 4.7) than any land cover in the between 1986 to 1990. Due construction of the dam and impounded reservoir. The second fastest growing was Settlement due to population growth. Bareland was fastest growing land cover in the second epoch. Settlement is still second to Bareland between 1990 and 2003 but with higher rate than the former, in the least period is growing land use land cover was Settlements. The remaining land use land cover change at less than one percent rate. While others such as Farmland and Forest decreased. This means that from now forward it's the Settlement that will keep expanding against farmland and forest areas.

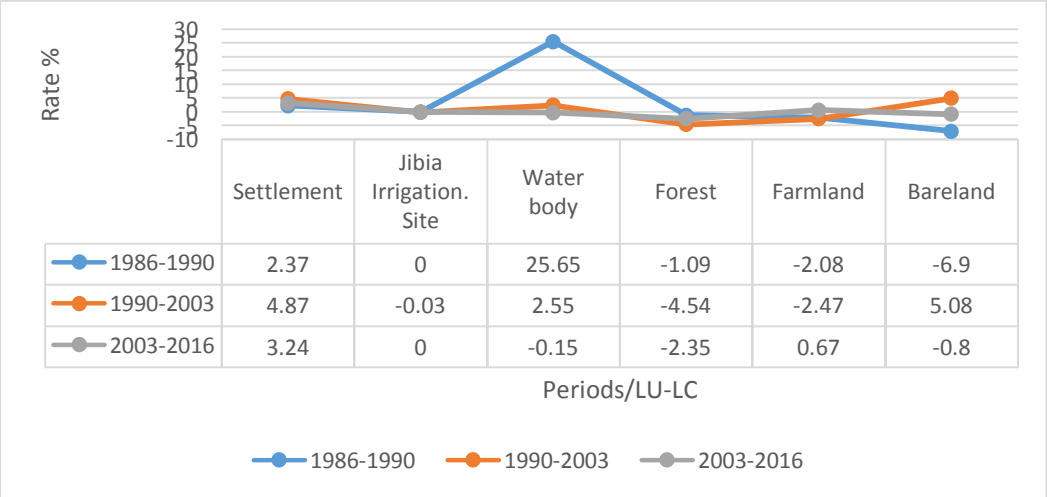


Figure 4.8 Graphical representation of the rate of land use land cover changes overtime

4.7 Some Positive Impacts of Jibia Dam on Jibia Town

4.7.1 Domestic and irrigation supply and distribution facilities

From the result of the interview conducted with the staff of both Irrigation project and Katsina state water board Jibia district, the Jibia dam was constructed for the purpose of Irrigation farming, domestic water supply distribution and flood control; in order to improve agriculture, standard of leaving and to create jobs opportunities in the region. Consequently, Makiyawa water treatment plant with the capacity of 12600 m^3 was established and commissioned in 1989 together with four storage reservoir each with about 2000 m^3 capacity located in the study area for storage and firefighting. A total length of Pipelines of 70 km, also 8 boosters Machine for maintaining a constant pressure in the Pipes network were installed. Taps were also erected in Jibia town at 200m intervals in order to distribute water to the Residences that are inaccessible to supply Pipes. The network of pipelines provides a platform for extension to newly develop areas. Figure 4.9 demonstrated some of the physical facilities for domestic water supply and distribution and how they networked about 9 communities including Jibia town of the surrounding communities.

It was also revealed that at the dam consists of a pumping station and two compensation reservoirs: R1 and R2. The pumping station supplies the two reservoirs with irrigation water. The station is divided into: left side (P1) and right side (P2). Also, four pumps are arranged in sequence at each side, one pump out of four is a standby. Water from the pumping is taken directly from the valve chamber to the reservoirs, from where the water is supplied to the main canals, then to the lateral canals and finally to the field for irrigation. Figure 4.10 depict the network of Irrigation canal across the Irrigation project area for the supply and distribution of water for Irrigation farming and how they surrounded some of the communities.

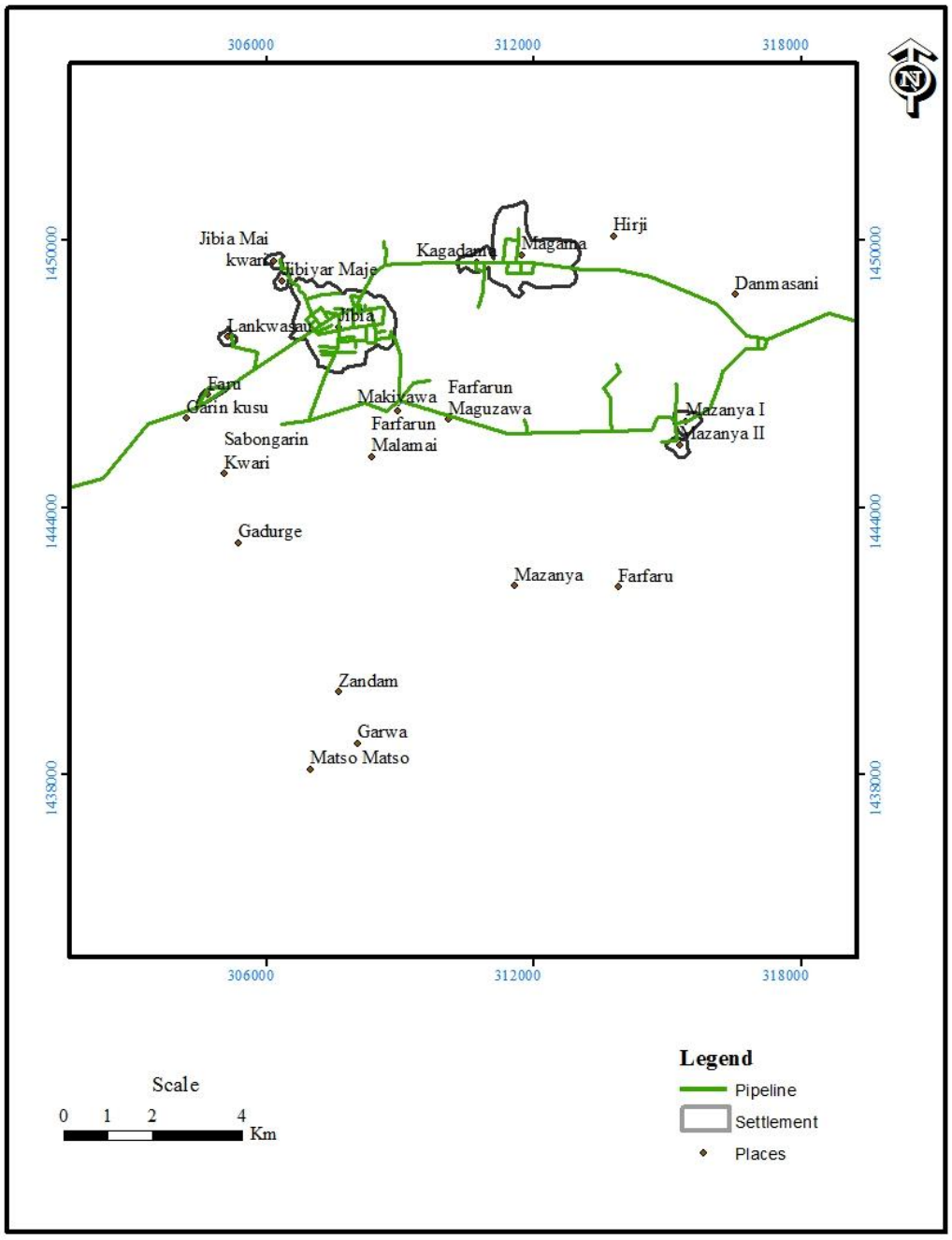


Figure 4.9 Networks of Pipelines in the Study Area

Source: Katsina State Water Board, Jibia district

4.7.2 Impact of Jibia dam on irrigation farming

Agricultural development is one of the main purposes of constructing the project. Before the construction of Jibia dam, irrigation farming was carried out in Fadama and river bank which covers 8.52 sq. km (Table 4.5). After the construction of Jibia dam, the irrigation project area was created and it covers about 34.61sq km (Table 4.5) out of

which 2.06sq km is for irrigation by gravity area and 32.61sq km is for irrigation by pumping. These canals supply water to sub-canals and finally to irrigation plots, and then to the various locations of the plots This means that, even if there is no supply of water old irrigation area and gravity area will produce crops.

In addition, 114 km of drainage, 50 km of service roads and 110 km of farm roads were constructed. The irrigation system includes a pumping station and two compensation reservoirs (with capacity of 35,500 m3 and 45,500 m3). Figure 4.11 depicted the map of forest in which old irrigation area, the new irrigation project area and the interconnected roads for conveying crops from farm to Jibia market.

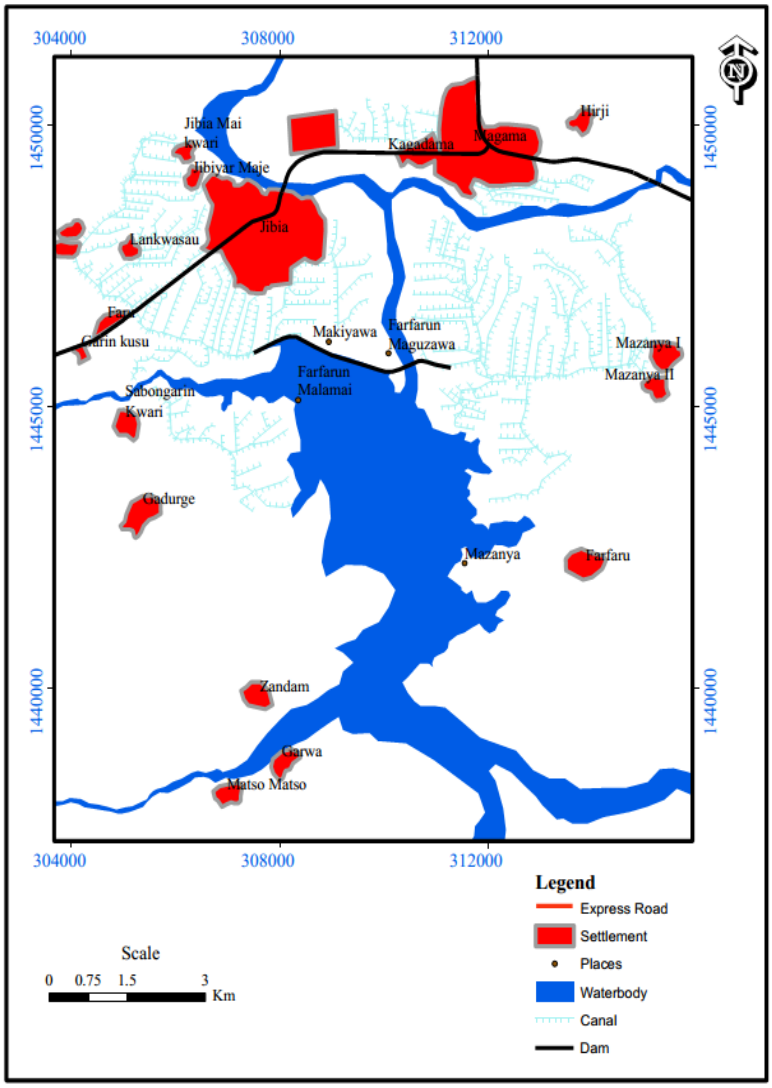


Figure 4.10 Network of Canals in the Study Area

4.7.3 Impact of Jibia dam on flood control in the downstream areas

Also, the removal of excess water from the field is vital in an irrigation system. Excess water in the field can cause water logging, leaching, and hydrological drought, among other problems. To avoid this, a very good drainage system was constructed in Jibiya Irrigation Project. This study mapped out 114 km drainages that drain excess water from irrigation project area to Gada river. Also during rainy season these drainages divert the accumulated water flow away from Jibia town as a measure to prevent excess flooding in the town. Figure 4.12 depicted the control drainage and how they empty excess irrigation water and rainfall to Gada river.

Figure 4.13 is the flood vulnerability maps (overlaid maps of settlements, digital elevation model and flow accumulation map of the study area) from this map, none of the settlements is vulnerable to flooding in the study area.

4.7.4 Accessibility of farm product to Jibia market

To develop the project and to ensure trouble-free operation of all agricultural and hydraulic work throughout the year, laterite service roads were constructed. These roads surround the entire irrigation areas. Several rings were formed allowing access to every irrigation plot. Moreover, these service roads are connected to the village with their service centers at distance as short as possible for the area to be easily linked to the center. The pumping station and compensation reservoirs are connected to the road network and 50 and 110km service and farm roads, respectively were constructed. Figure 4.14 is the map of the study area that shows all the road in the area constructed to ease transportation of farm product to Jibia market

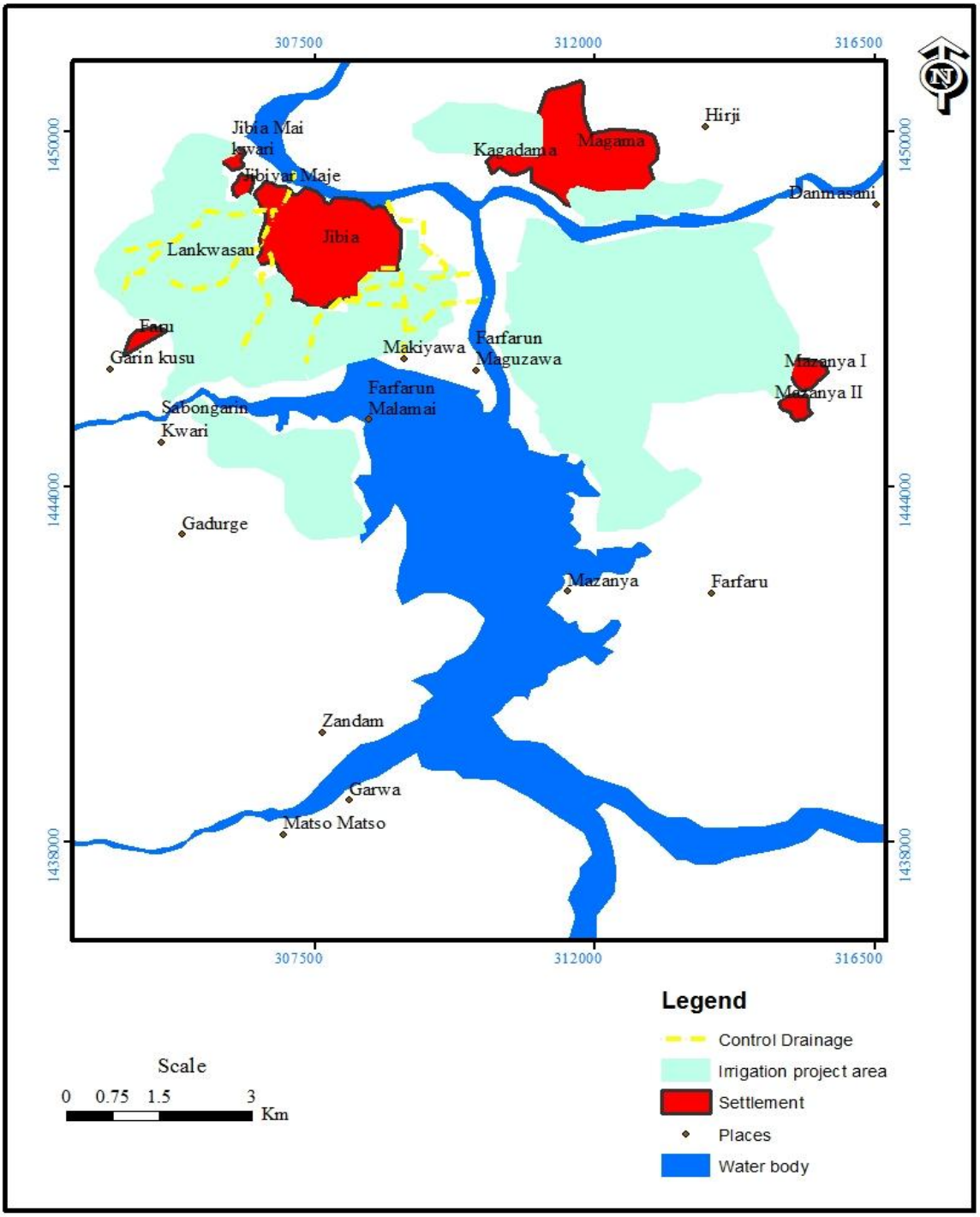


Figure 4.11 Network of control drainage in the study area

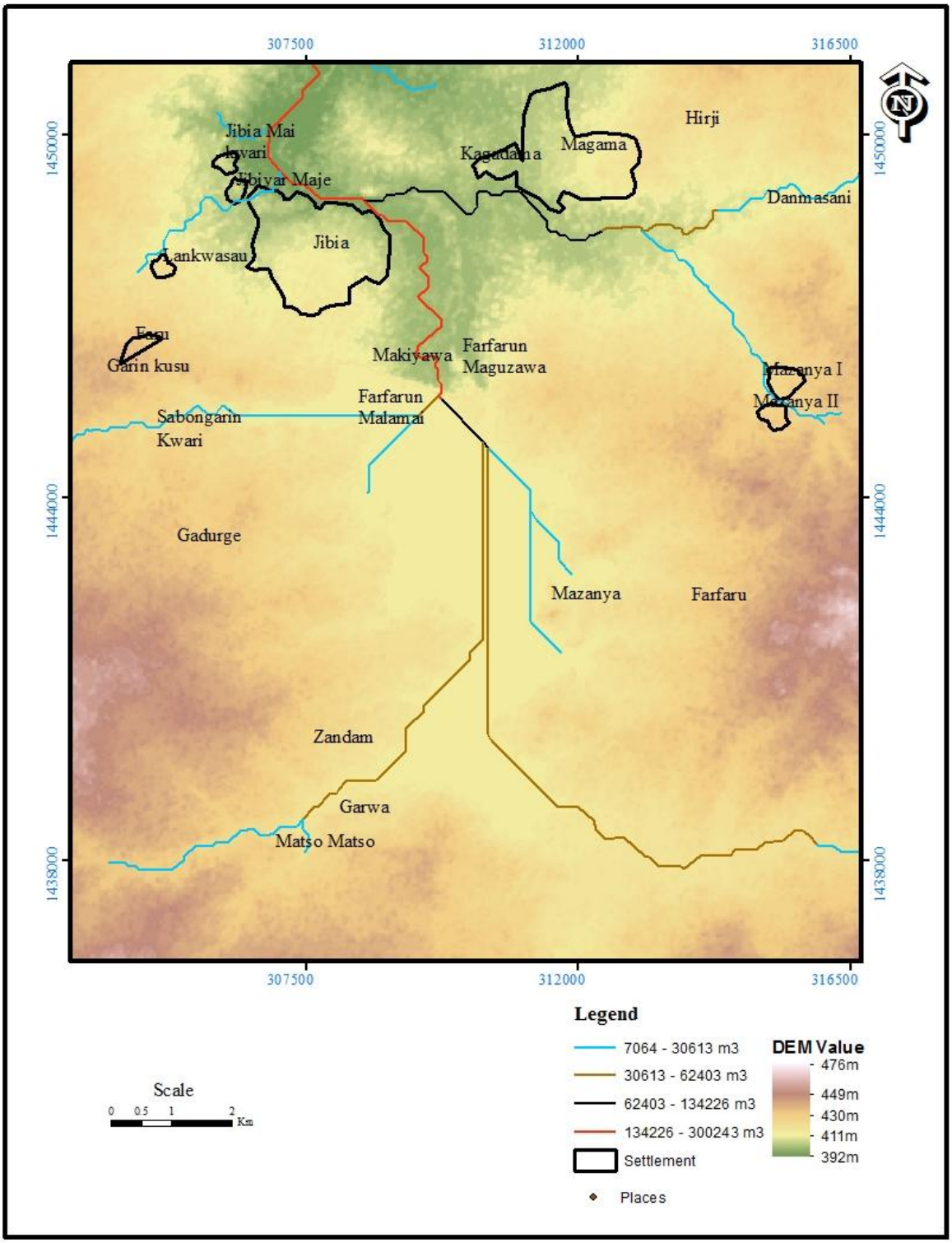


Figure 4.12 Overlaid Maps (DEM, Flow Accumulations and Settlements)

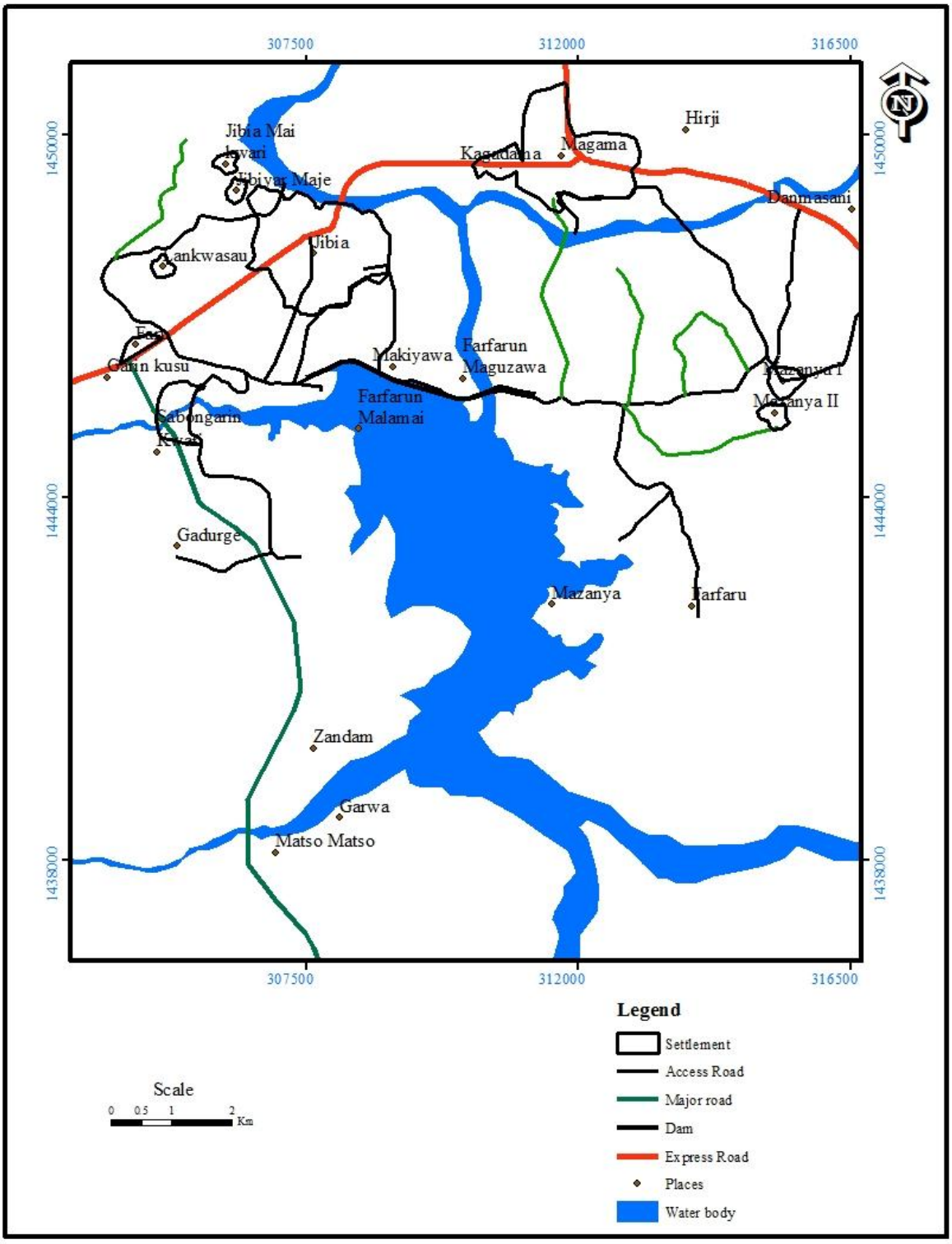


Figure 4.13 Network of Road

4.7.5 Impact of dam on recreational activitiesJibia dam also paves the way for construction of Chama part on the bank of the reservoir and it attracted people from

within and outside of Katsina State during festival period. Below (Figure 4.15) is the map that depicted the location of Chama park in the Study area

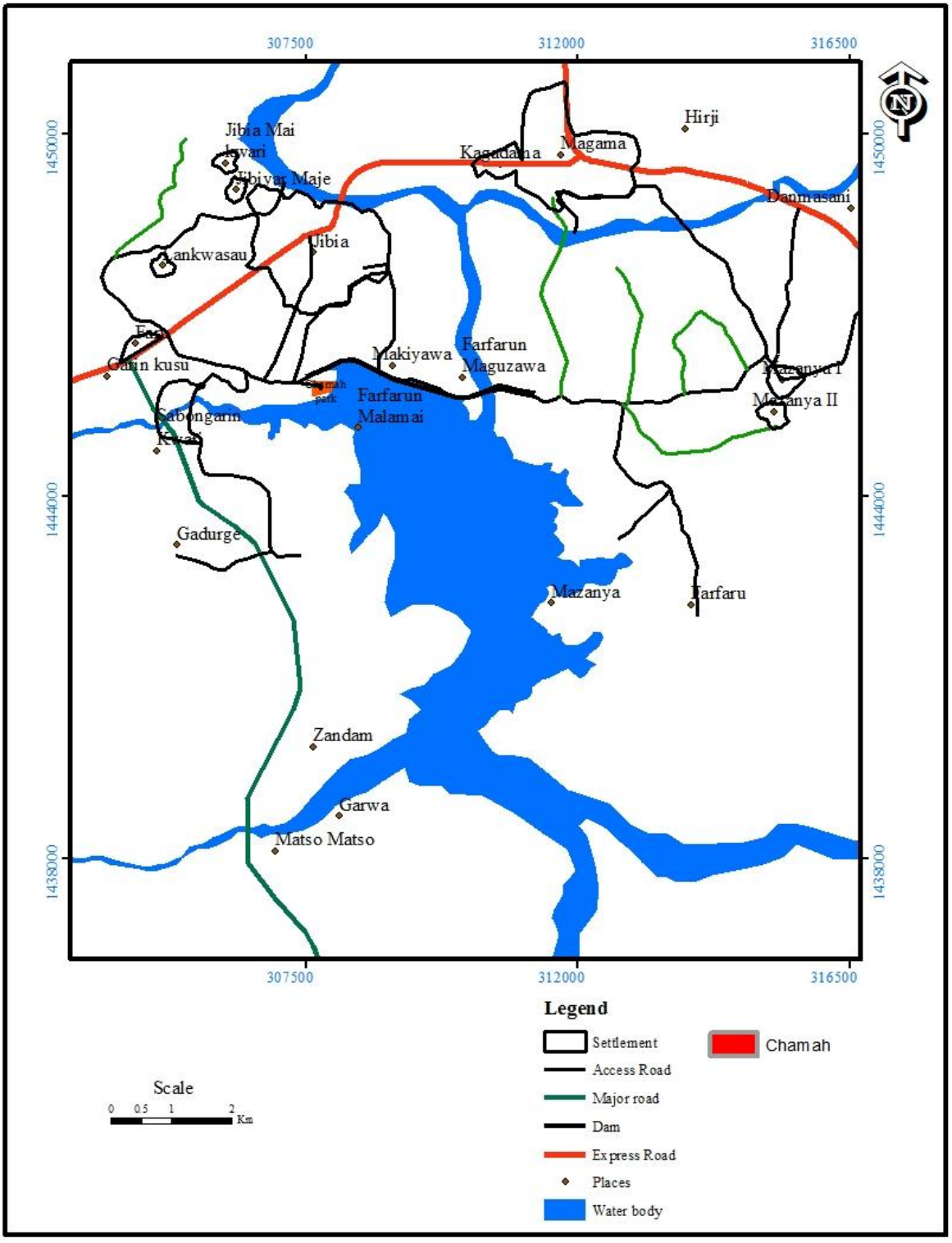


Figure 4.14 Recreational Area (Chama Park)

4.8 Negative Impact of Jibia Dam

4.8.1 Analysis of the Negative Impacts of Jibia Dam and Gada River on Jibia Town

Immediately after the construction of the dam, the Irrigation canals was casted and installed for the purpose of transporting water from the source across the farmlands for the purpose of Irrigation farming. These serve as a second dictator of the direction of development in most of the surrounding towns including Jibia town. This serve as a constrain to the expansion of the nearby settlements. Causing congestion and rapid escalation of landed property. This constrain was measure from the center of Jibia town to its boundary. The distance from the central point of the town in 1986, 1990, 2003 and 2016 to the boundary in eight directions was measured and presented in Table 4.16. The expansion of the town was determined by subtracting D1 from D2 (that is distance in measured 1986 from 1990) the result is presented in Table 4.16

Table 4.16 Distances from the central point in Jibia town to the extent of the town in 1986, 1990, 2003 and 2016

Direction	1986 (m)	1990 (m)	2003 (m)	2016 (m)	1986-1990(m)	1990-2003 (m)	2003-2016 (m)
North	585.47	610.47	647.88	703.64	25	37.41	55.76
West	1021.98	1147.93	1332.18	1668.21	125.95	184.25	336.03
South	707	872.5	1230.23	1716.53	165.5	357.73	486.3
East	793.75	859.4	929.538	1109.548	65.65	70.138	180.01
North-West	519.624	652.124	1143.854	2021.054	132.5	491.73	877.2
North East	715	731.6	748.17	765.07	16.6	16.57	16.9
South-East	581.85	712.49	869.99	1228.49	130.64	157.5	358.5
South-West	394.234	784.244	1485.494	2242.744	390.01	701.25	757.25

From the Table 4.16 the expansion of Jibia town in the north, north-east and east direction were very slow throughout the period of study. This is because the town was bounded by Gada river from the north and partly north-east direction (see Figure 4.16). The expansion was steady in the West and South-east direction between 1986 and 2003

and fast between 2003 and 2016. The expansion of the town in the south, north-west and south-west were very fast throughout the study period.

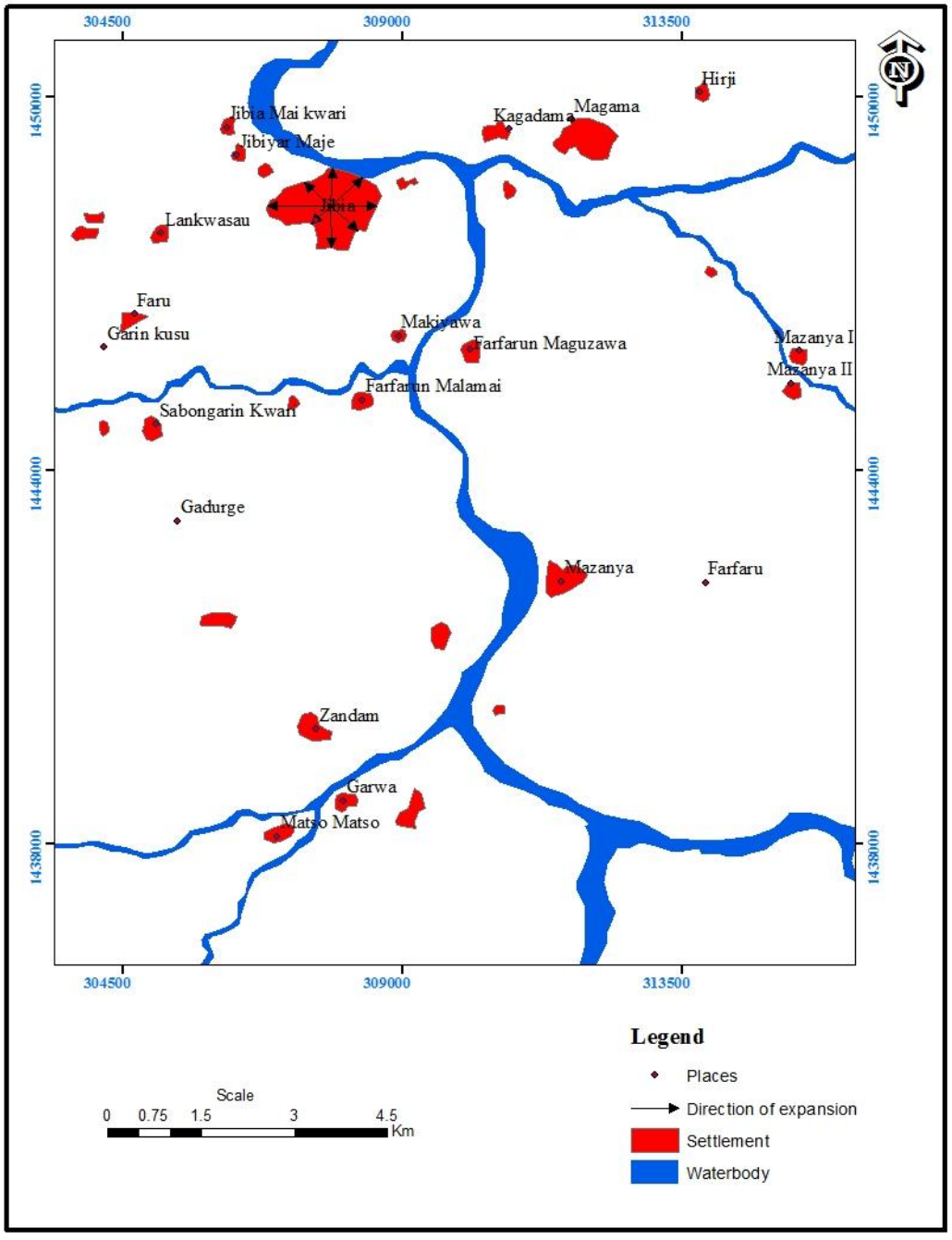


Figure 4.15 Direction of development of Jibia town in 1986

This expansion can be seen from the maps in Figure 4.17, 4.18 and 4.18 respectively. From these maps, Jibia town was moving closer to Irrigation project area in the south, south-west and west direction were faster than any direction in the town. Among these three

mentioned directions south direction is the fastest (see Table 4.16) and on map the expansion in this direction encroached the Irrigation project area since 2003 while the expansion in the

remaining directions encroached the restricted area in 2016. South-west, north-west and south direction are newly developed areas where immigrant and settlers reside in the town

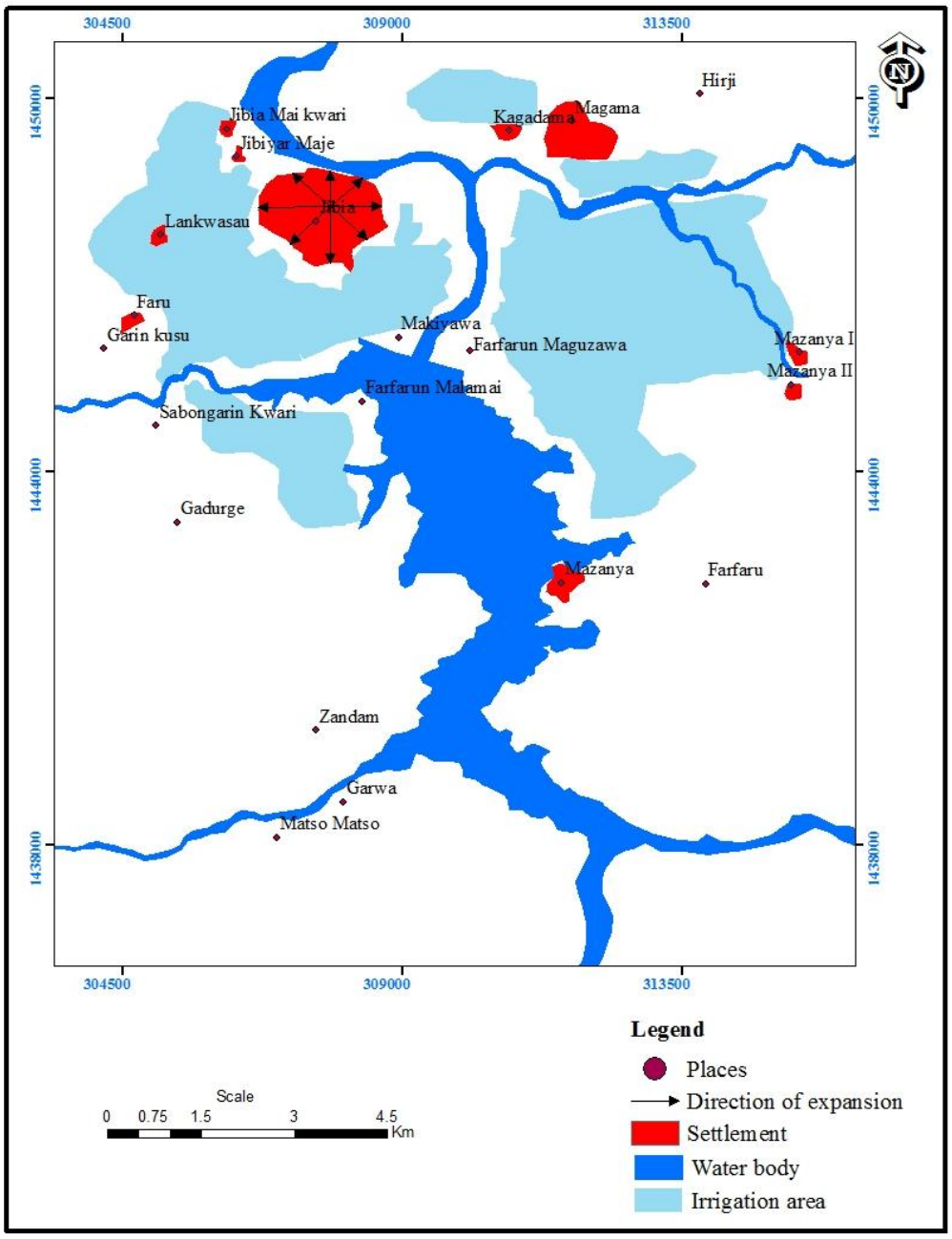


Figure 4.16 Direction of development of Jibia town in 1990

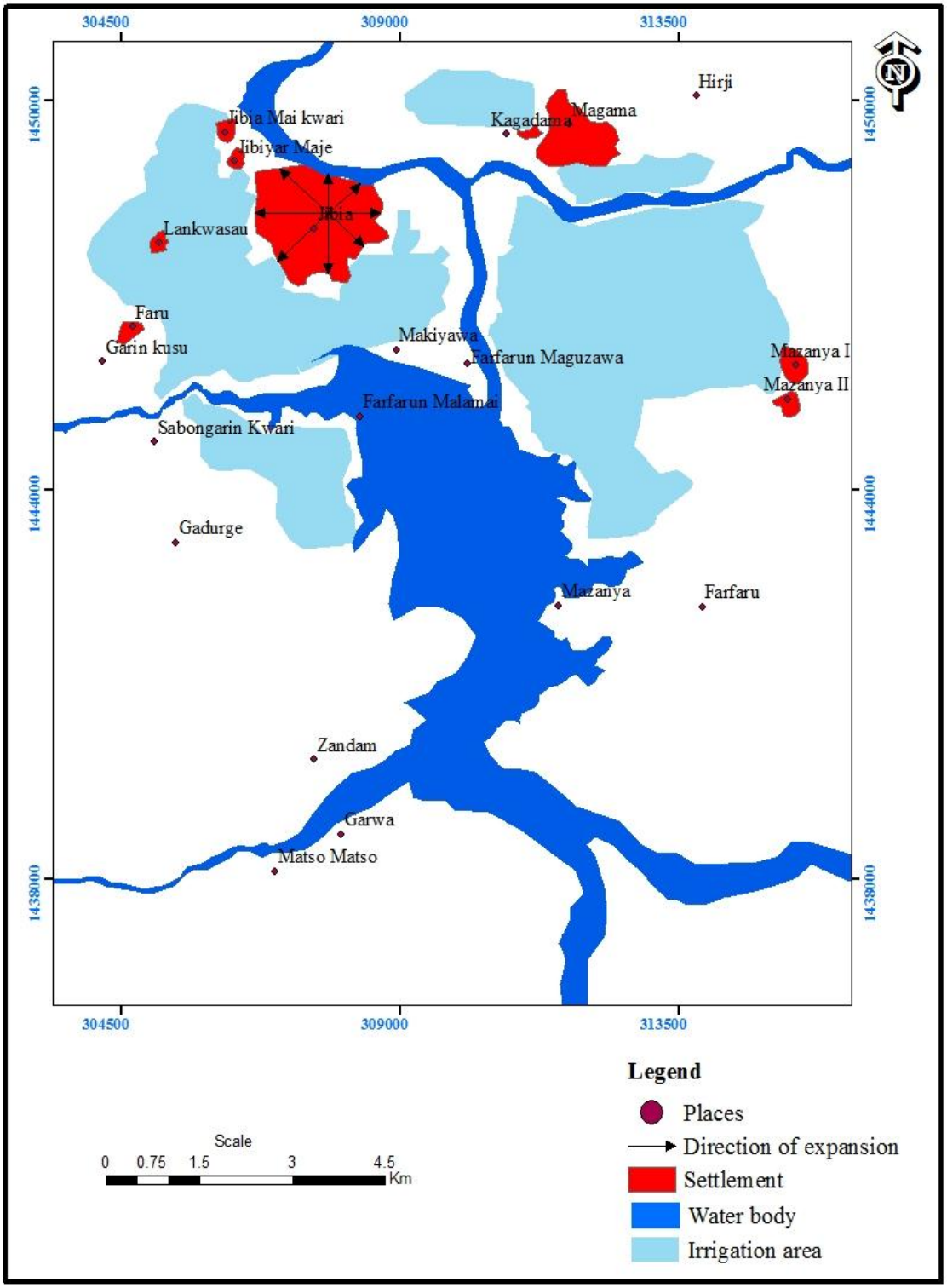


Figure 4.17 Direction of development of Jibia town in 2003

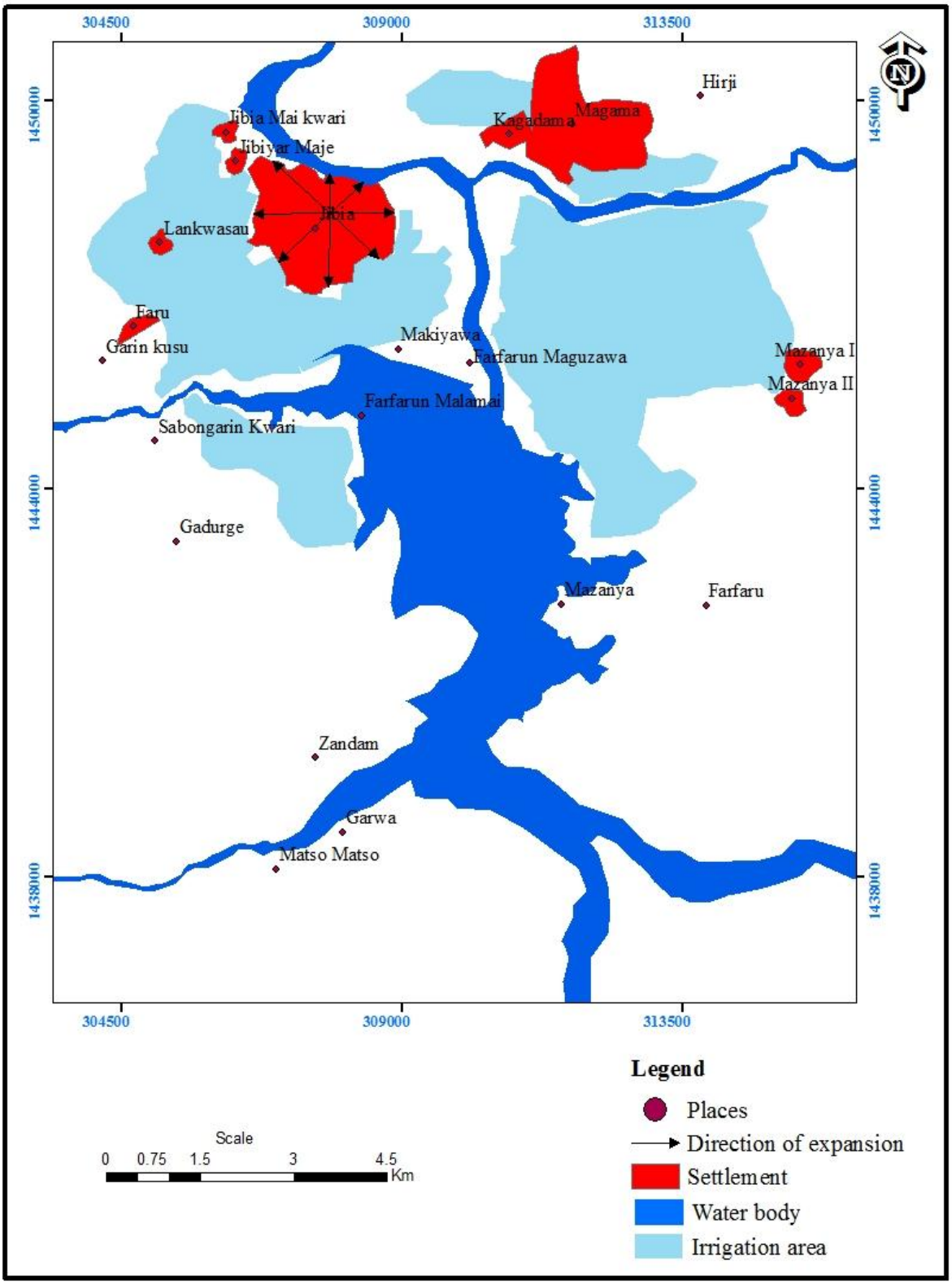


Figure 4.18 Encroachment of settlement in Irrigation project area at 2016

4.9 Analysis of the Population Growth of Jibia Town

After the construction of Jibia dam the population density of people in Jibia town was 153 people per hectares (see table 4.17). During this period Jibia town was the most populated area due Migration of displaces people. Figure 4.20 depicted the population density of Jibia, Jibiyar Maje, Jibiyar Maikwari and Magama Village in the same range of density. From the table 4.14 the population density of the town in 2003 rose to 182 people per hectares in Jibia town while that of Jibiyar Maje, Jibia Maikwari and Faru villages were between 120 to 140 people per hectares due to the imposed constrain by Irrigation canals. At that time the expansion of Jibiya town was not constrained by Canals. Figure 4.20 depicted the population density of Jibia darker than that of Faru, Lankwasau, Jibiyar Maje and Maikwari. Implying that, the density of Jibia kept increasing due to population growth and migration of displaced people to the town and lack of corresponding expansion of the town to accommodate the fast-growing population.

Population density of Jibiya town in 2016 was 224 people per hectares. About 42 people increased per hectares due to the imposed constrain on the town by Irrigation canal and Gada river from all directions. From 1991 to 2016 the population density of people in the Study area kept increasing from 153 to 182 and 224 people per hectares in 1991, 2003 and 2016 respectively. While that of Jibiyar Maje, Jibia Maikwari, Faru decreased in 2003 and 2016 due to the illegal encroachment to Jibiya Irrigation Project area and migration to Jibiya town for commercial activities. Because they were constraining since 1991 while Jibiya experience constrain after 2003. Figure 4.20 depicted the population density of Jibia town higher than that of Faru and Jibiyar Maje. In 2016 Jibiya town's population density is greater than that of all communities. The impact of Jibiya dam on the population growth of Jibia is the attraction of people from different

locations in the local Government for Irrigation farming opportunities. Secondly displacement of people from the reservoir axis to Jibia and finally constrain imposed by Irrigation canals on the development of Jibia town from all directions. Table 4.18 shows the percentage increase in population and surface area of the localities. From the table the population of all the communities are growing at the same rate.

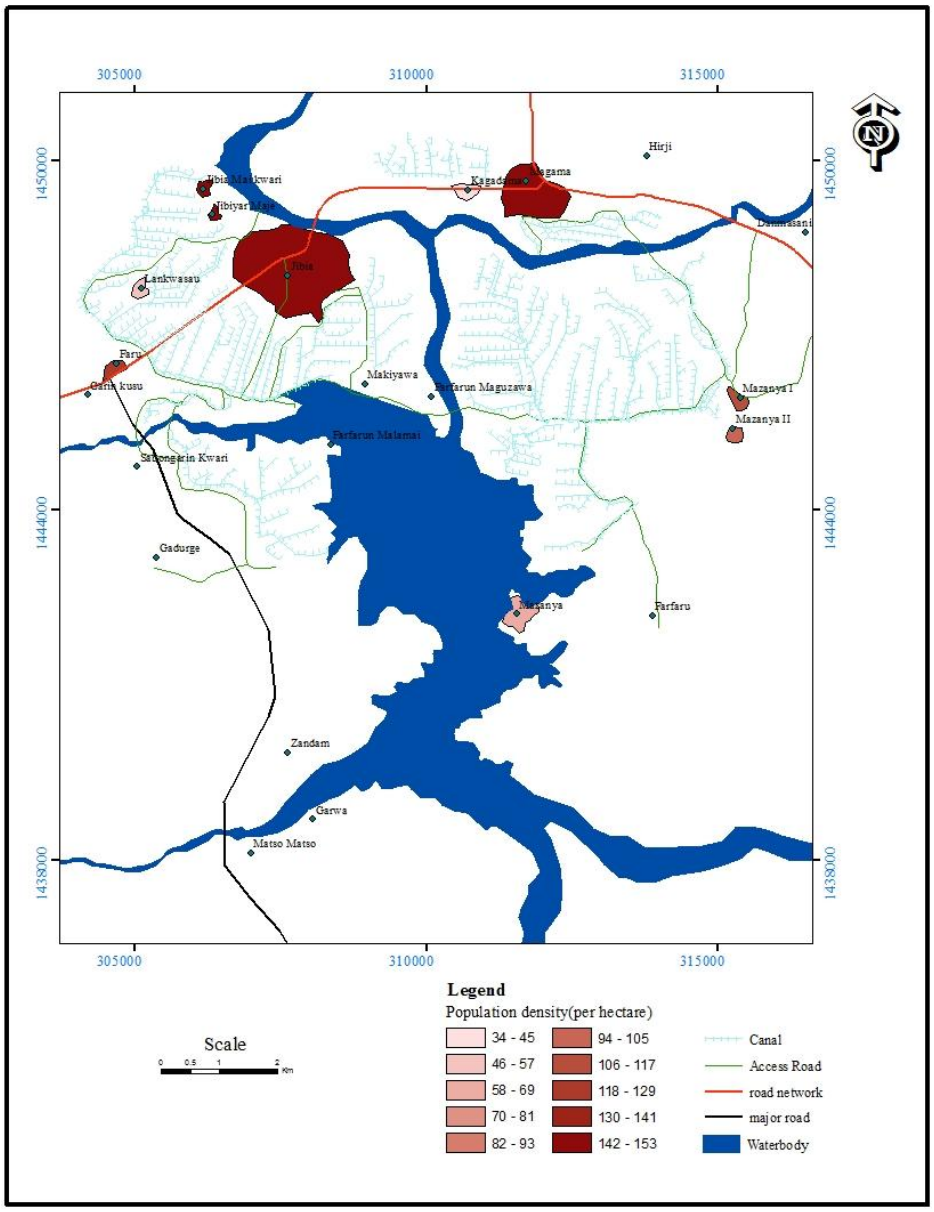


Figure 4.19 Population density of some Part of the Study Area at 1991

The only difference is in the expansion of the surface areas of the communities. Between 1991 to 2003 the surface area of Jibia increase by 20% while Jibiyar Maje, Mazanya I and II increase by 79.5%, 124%, and 71% respectively. The population of these communities

increase at the same rate with while their expansions is about four to times that of Jibia town. That is why Jibia is more congested than they are. Communities such Faru and Magama were expanding at the nearly the same speed with Jibia. Lankwasau was not expanding due to the imposed constrain by Irrigation canals from all direction. Between 2003 to 2016 Jibia town expanded by 20% while Magama, Jibiyar Maje, Lankwasau expanded by 187%, 48.3% and 44.9%. Magama town expanded about nine times than that of Jibia and Jibiyar Maje expand about two and half than that of Jibia town. Jibia town is the most congested in the Study area due to lack of rapid expansion of the town due to spatial constrain

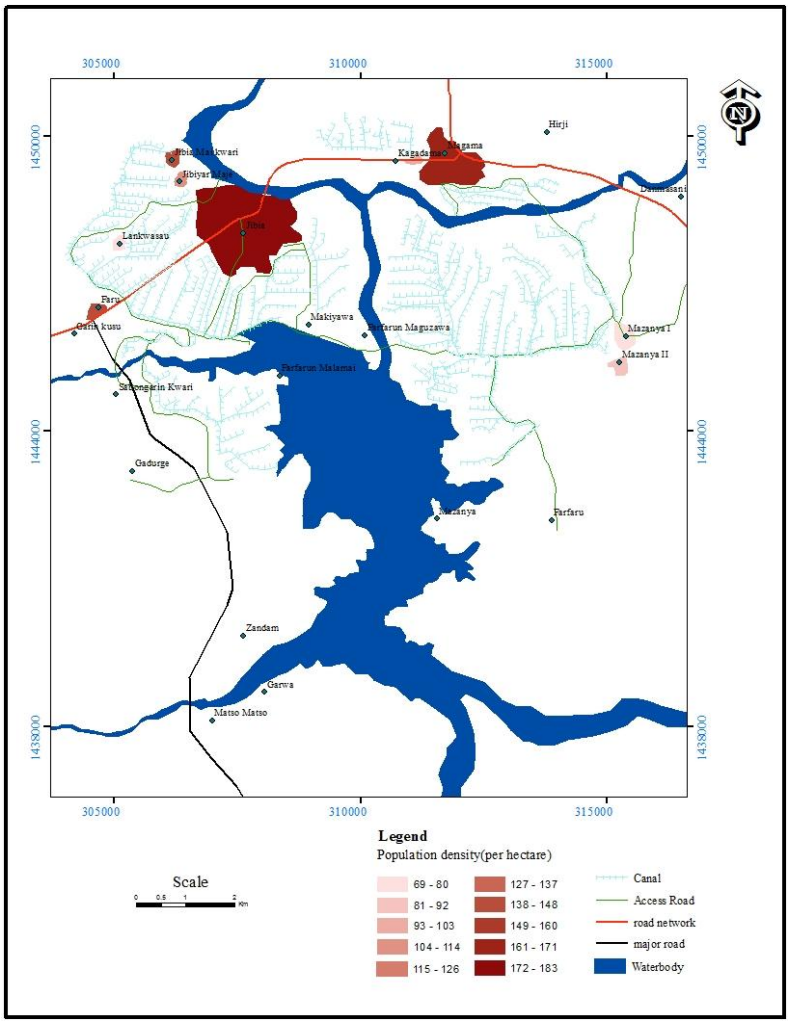


Figure 4.20 Population density of some Part of the Study Area at 2003

In addition, the population growth of communities' area was compared with the expansion of the communities in the Study area. Figure 4.23 compares the percentage increase in population and spatial extent of the communities. From the graph the rate at which population growth are the same since the rate was used for the projection of the population but the speed of expansion differs across the communities in the study area. Magama town is the most fastest growing town with about 198% increase while Jibia is low with about 20% increase in the same intervals. This means that, the population growth of Jibia town did not correspond with its spatial expansion due to constrain and immigrant who cannot construct houses Figure 4.24 compared the population density of the surrounding communities. Jibia town is the most congested followed by the communities surrounded by the Irrigation canals

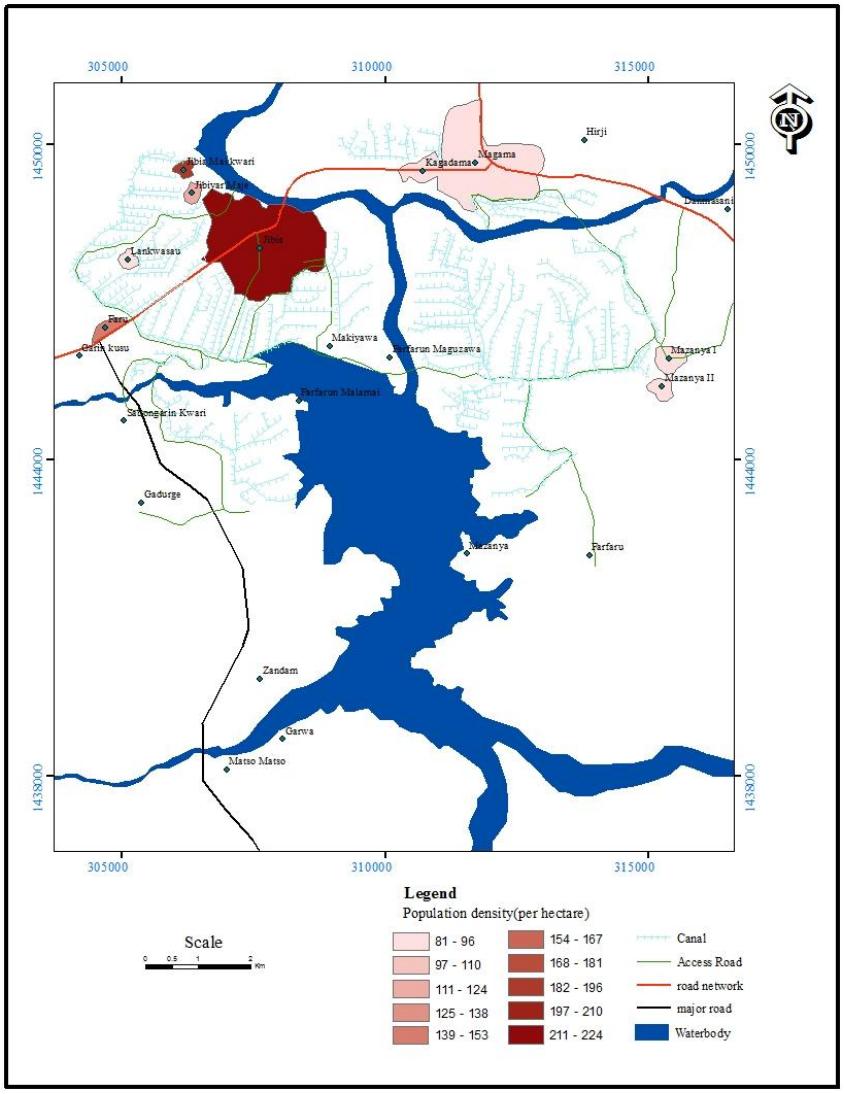


Figure 4.21 Population density of some Part of the Study Area at 2016

Table 4.17 Population, area(ha) and population density of the study in 1991, 2003 and 2016

Localities	Population			Area(ha)			Population Density/hectare		
	1991	2003	2016	1991	2003	2016	1991	2003	2016
Jibia	35802	51316	75792	233.28	281.00	337.8	153	182	224
Jibiyar Maje	516	739	1092	3.61	6.48	9.61	142	114	113
Jibia Mai Kwari	872	1249	1846	5.88	8.69	9.70	148	143	190
Magama	11572	16586	24497	80.26	98.70	283.9	144	168	86
Mazanya I	911	1305	1927	8.44	18.97	23.3	107	67	83
Mazanya II	621	890	1314	6.43	11.02	15.1	96	81	87
Lankwasau	379	543	802	6.77	6.82	9.81	56	79	82
Faru	955	1369	2021	7.84	9.74	13.5	122	141	150

Source: National Population Commission, Katsina State

Table 4.18 Percentage of population and area change from 1991 to 2016 of the study area

Localities	Population				Area			
	1991-2003		2003-2016		1991-2003		2003-2016	
	Change	%	Change	%	Change	%	Change	%
Jibia	15514	43.33	24476	47.7	47.72	20.5	56.8	20.21
Jibiyar Maje	223	43.22	353	47.8	2.87	79.5	3.13	48.3
Jibia Mai Kwari	377	43.23	597	47.8	2.81	47.8	1.01	11.62
Magama	5014	43.33	7911	47.7	18.44	23	185.2	187.64
Mazanya I	394	43.25	622	47.7	10.53	124.8	4.33	22.83
Mazanya II	269	43.32	424	47.6	4.59	71.4	3.99	36.21
Lankwasau	164	43.27	259	47.7	0.05	0.7	3.04	44.9
Faru	414	43.35	652	47.6	1.9	24.2	3.76	38.6

4.9.1 Correlation analysis

The correlation analysis conducted between the change in population and area between 1991 and 2003 reveals that there is a strong positive (+0.983) correlation between the population growth and an increase in areas of the surrounding communities. This means that change in population causes 98.3% change in area between 1991 and 2003) see Table 4.19 for details. The correlation between the change in population and area between 2003 and 2016 is weak positive (+0.446) correlation this means that change in population causes 44.6% expansion in the surface area of the surrounding communities. This means that in the study area population growth without the corresponding increase in area due to the constraints imposed by the dam. See Table 4.20

Table 4.19 Correlation analysis of change in area and population between 1991 and 2003

Variables		Change in population	Change in area
Change in	Pearson Correlation	1	.983

population			
	Sig. (2-tailed)		.000
	N	8	8
Change in area	Pearson Correlation	.983	1
	Sig. (2-tailed)	.000	
	N	8	8

** Correlation is significant at the 0.01 level (2-tailed).

Table 4.20 Correlation analysis of change in area and population between 2003 and 2016

Variables		Change in population	Change in area
Change in population	Pearson Correlation	1	.446
	Sig. (2-tailed)		.000
	N	8	8
Change in area	Pearson Correlation	.446	1
	Sig. (2-tailed)	.000	
	N	8	8

** Correlation is significant at the 0.01 level (2-tailed).

4.10 Analysis of the Compliance of the Current Development and Master Plan of the Study Area.

According to the Master plan of the dam, the damming project will take place 1.4km south of Jibia town and the Villages such as Makiyawa, Farfarun Malamai, Farfarun Maguzawa and Mazanya village will be relocated to Sabon garin Kwari (S.R.R.B.D.A., 1982) (shaded with light green color in Figure 4.26) located about 2km west (away from the axis) of the dam and Jibia Irrigation Project area. The relocation of such people to the Sabon garin Kwari would have prevented Jibia town from congestion. The result obtained from the ground truthing revealed that, there was no provision for social amenities that will attract the displaced people in compensation area. The outcome of these impasse results to the scattering of those displaced people everywhere in the study area for accommodation and shelter. Most of them settled in Sabon garin Jibia and Magama causing rapid population growth, congestion and inflation of the land property.

Other negative effect of accumulation of displaced people in Jibia town are high population density land use transformation (such conversion flood control drainage at the outskirt of Jibia to Built-up area and transformation of Irrigation site to settlements) and land cover conversion which is the conversion of Farmland and forest to settlement at the periphery of Jibia town

In Table 4.21 is the area of Jibia, Magama and Sabon garin Kwari village. From the table Kwari was 0.03 sqkm in 1986 and developed to 0.19 sqkm it expanded by 0.16 sq km at the rate of 3.4% annually. This is an indication that, there was no relocation of six settlements to Kwari as proposed in the above Master plan. Jibia was 1.48 sqkm while Magama was 0.39 in 1986 which means that Jibia town was almost four times as big as Magama. But in 2016, Jibia and Magama were 3.29 and 2.79 sqkm respectively Jibia was Just 1.18 times as big as Magama town. Jibia and Magama expand at 4% and 20% annually (see Table 4.22). This clearly indicated that Jibia town suffers constrain as result of the dam construction.

Table 4.21 Extent of Settlement in Jibia, Magama and Kwari Village

Town/Village	Area in 1986 (sqkm)	Area in 1990 (sqkm)	Area in 2003 (sqkm)	Area in 2016 (sqkm)
Jibia	1.48	1.89	2.67	3.29
Magama	0.39	0.57	0.96	2.79
Kwari	0.03	0.11	0.16	0.19

Table 4.22 Rate of expansion of Jibia, Magama and Kwari village

Town/Village	Area in 1986 (sqkm)	Area in 2016 (sqkm)	change (sqkm)	Rate of change %
Jibia	1.48	3.29	1.81	4

Magama	0.39	2.79	2.39	20
Kwari	0.03	0.19	0.09	3.4

The Figure 4.26 below depicted the map of the overlaid maps of Jibia, Magama and Kwari Village respectively. From the map Sabon garin Kwari was not expanded rapidly as it was expected according Master plan in figure 4.26 above. The expansion of the village from 1986 to 1990 was very negligible. It expanded only from 1990 to 2016 and from the map the expansion was natural due to population growth of the inhabitant of the area. There was no sign of rapid development in the area. We can now infer that, the displaced people settled in Magama and Jibia town instead of Sabon garin Kwari. And this the reason why Jibia town is congested.

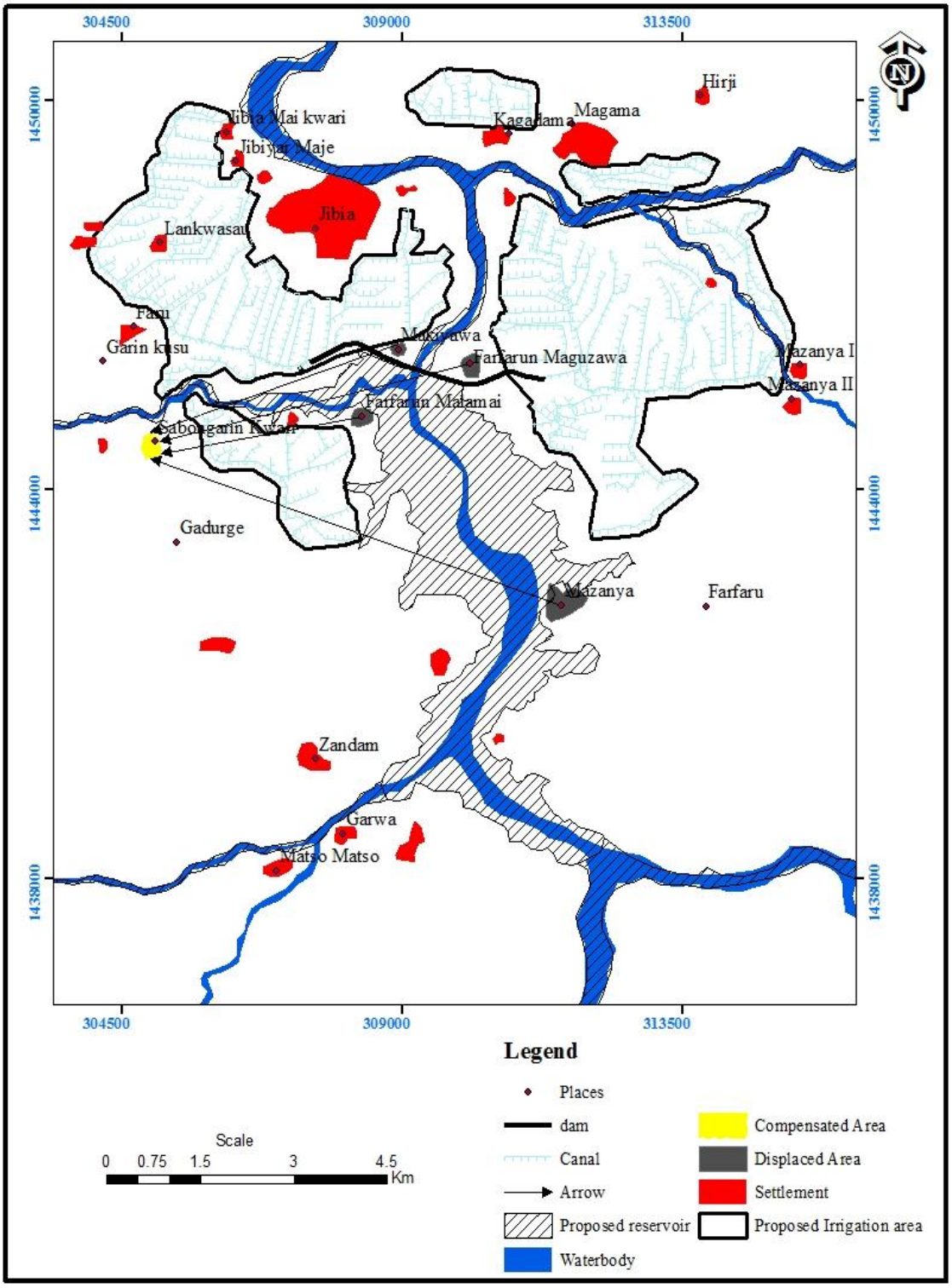


Figure 4.22 Master Plan of Jibia dam

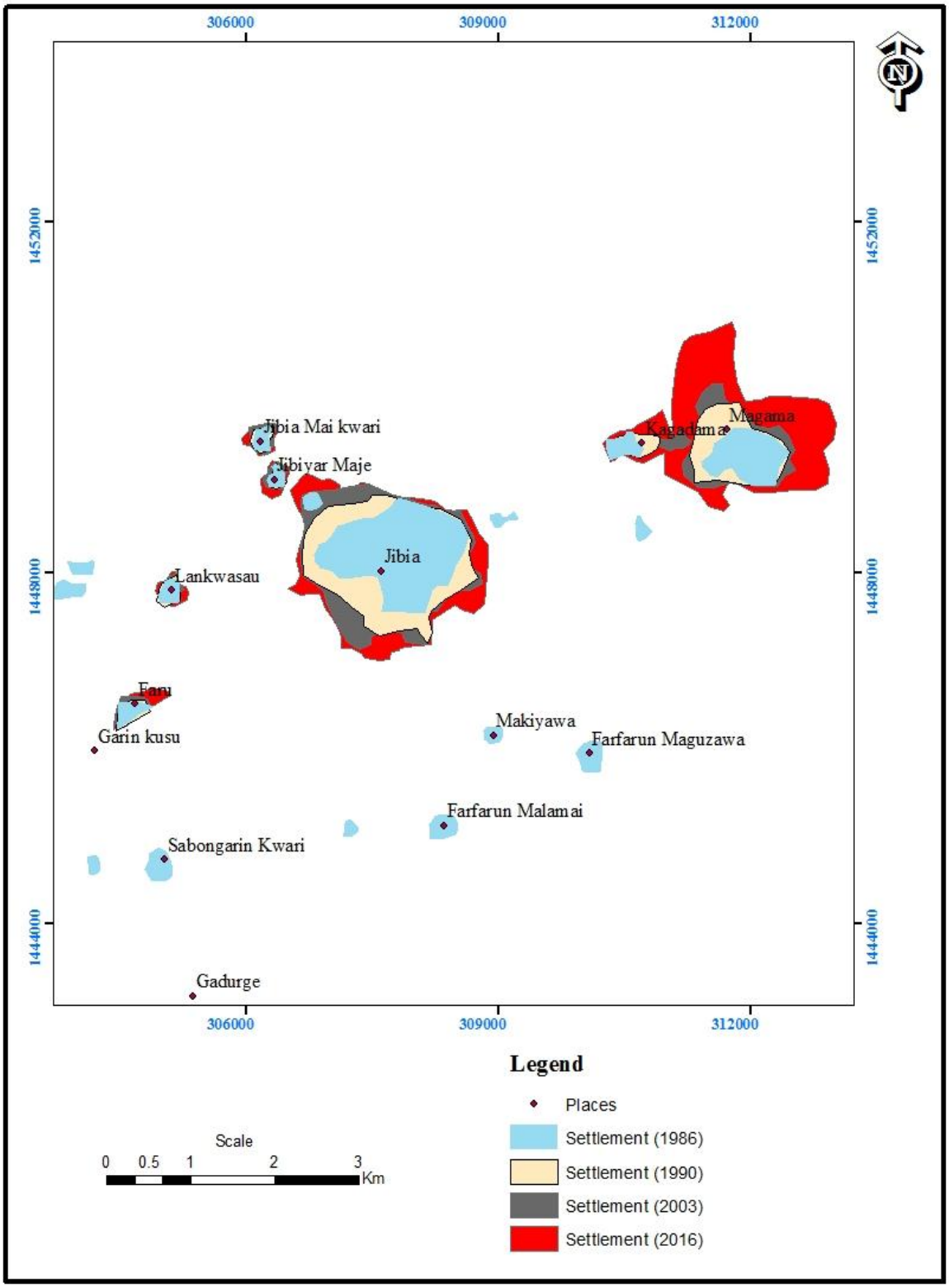


Figure 4.23 Overlaid Maps of the Study Area

4.11 Analysis of the Impacts of Jibia Dam on the Socio-Economic of People Leaving in Jibia Town

All the respondents were male their occupation is mostly farming and trading. With age from 50 years and above because the dam was constructed about 28 years back, the requirement of the research is to compare the socio-economic activities in the pre-and-post dam period. Young people cannot provide the required answer for this study. Their level of education are mostly Primary and Secondary qualifications. They are all married.

According to the respondents living in Jibia town, the sources of domestic water in the pre- dam period were wells and holes dug in the dry rivers. But 75% of the respondents admitted that there is supply and distribution of adequate water in the town. 95% felt that, the alternative sources of water are boreholes and untreated Irrigation water depending on your proximity to the source. 60% accepted that, the supply and distribution of treated by Katsina state water board had significantly reduced the cases of water borne diseases. 100% of the respondents also accepted that, the surrounding communities were cut-off from domestic water supply. This implies that, Before the construction of the dam the sources of water were wells in the town and rivers while in the post dam period the alternative sources are borehole and canals water this means that, Jibiya dam revolutionize the sources of domestic water in Jibiya town.

About 97% of the respondents agreed that, there was Irrigation farming but in small scale along the river bank. With the minimum yield of vegetables using old and difficult technique of watering. The sources of water for Irrigation in the Pre-dam period were wide-short-well dug in the rivers. The calabash will be tired to a thread and the farmer kept fetching and pouring water to the farm through channels. The respondent agreed that before the dam during dry season the men migrate to other places to look for work

leaving their family behind instead of staying adle in the town for the seven months of the dry season. In this time, they consume and consequently deplete the grains they have preserved during the farming season. They also admitted that, the construction of Jibia dam lead the cultivation of large farms since the is network of canals were all over the Irrigation area for watering of crops. But 90% agreed that, there is no supply of water to three of six hydraulic areas. The impact of the dam revolutionized the method of watering. Improves yield, allowed the production of both food and cash crops and also attracted the expert to visit the area to train the farmers on how enhance the farming practice. Jibia dam open the way for farmers to seek loan from the Financial institutions. 70% of the farmers secured loan from Central bank of Nigeria to produced Rice this year.

85% of the respondents admitted that, there was no mass scale flooding in the Jibia town before the dam and they agreed that, the 110km control drainage constructed to divert excess water away from Jibia town is a measure to prevent future occurrences of flooding in Jibia town.

20% of the respondents felt that they lost their Fadama and houses to reservoir and they were not adequately compensated. 97% agreed that, the construction of Jibia dam changed digging well to Plumbing and introduced Modern Irrigation Farming, construction of canoe, canoeing practice. 50% of the respondents agreed that during pre-dam period Men travel to Southern part of the country to seek of work and trade. While others remain adle at home depleting the grains they produced during rainy season.

The residents of Jibia town admitted that, there was no service, farm road in the pre-dam period except footpath and during rainy season the surrounding communities were not accessible easily because there were no bridges. 95% of the respondents agreed that, Jibia dam project ease accessibility to the surrounding communities and Jibia market

due to the construction of 50km Service road, 110km farm road and bridges across Primary canals. 60% of the respondents agreed that, there was no recreational areas in the pre-dam period but in 1998 Chama Park was constructed for recreational activities and it attracted people from within and outside Katsina State.

Finally, 90% of the respondents felt that, the only drawback of Jibia dam project is the imposed constrain on the expansion of Jibia town and its consequences of the escalation of the land price.

4.12 Cumulative Effects Analysis of the Impacts of Jibia Dam

Jibia Dam was constructed across Gada river to impound water for Irrigation farming and domestic water supply to the surrounding communities. This causes the instant conversion of about 2500 hectares of arable land to reservoir and the restriction of 3500 hectares of farmland for Irrigation purpose. Jibia dam project revolutionized the sources of domestic from well-water to treated tap water. It also changed irrigation farming watering from fetching-and-pouring using calabash to supply using canals. This project increased yield and it paved the way for cultivating various crops other than vegetables. Jibia dam project also paved the way for farmers to obtain loans from financial institutions. It opens the opportunity for farmers to be trained from agricultural training institutions. Jibia dam project introduced new occupations such as fishing, canoeing, plumbing etc the project also improved; flood control, accessibility from farmlands to Jibia market, surrounding communities to one another and Jibia market.

However, the drawback of Jibia project is the poor implementation of resettlement of the displaced people, imposed constrain against the expansion of the surrounding communities which causes congestion and high price of landed property in Jibia town. Finally lack of water supply to all water distribution areas.

Cumulatively the positive impacts of Jibia dam over-weigh the negative impacts. Therefore, the cumulative impact of Jibia dam in the study area is positive.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

This study has shown that information from satellite remote sensing when integrated with GIS can play a useful role in understanding the nature and extent of changes in land use/ land cover. The change detection analysis integrated with spatial metrics performed in this research allowed for the monitoring of land use/ land cover changes overtime and space. The analyses provide valuable insight into the extent and nature of changes that has taken place in the study area from 1986 to 2016 and lays foundation for further research to be conducted that may aim at integrating socioeconomic impact of dam on land use land cover changes and prediction of future land use land cover changes. The findings of this study revealed that; the construction of Jibia dam improved the socio-economic activities of people in Jibia, affect the population density of the surrounding communities due to constraints, the development of the study area have not complied with the master plan of Jibia dam.

Conversions from farmlands to water body represent the most prominent land cover change. Between 1986 and 2016 water body expanded from 3.62% to 8.97%, the change was rapid between 1986 and 1990 due to the construction of the dam. The change remains steady between 1990 to 2003 and the water body shrank between 2003 to 2016. While agricultural lands decrease from 59.64% to 45.62% between 1896 and 2016. Construction of Jibia dam in 1980s lead to the expansion of Irrigation farmlands from 3% to 10% of the study area between 1986 and 1990, this land use remains the same throughout the study period. Forest shrank from 2.56% to 0.83% between 1986 and 2016. The settlement expanded from 1.11% to 2.73%. Bareland also shrank from 33.08% to 31.47%. This implies that some land use land covers such settlements, water

body, irrigation project area increased. While land use land cover such as farmlands, forest and Bareland also loss to others.

Construction of Jibia dam lead to the production of both crops, change in watering technique to farmlands and also open opportunity for farmers to get loan and capacity building from Financial and research Institutions. The dam also paves the way for the establishment of 12,000 m^3 capacity Makiyawa water treatment plant and 70km pipe network for domestic water supply to the residents of Jibia town and the surrounding communities. This change the sources of water from well to Tap and Irrigation canals water. Jibia dam also cause the construction of service and farm road to ease accessibility from the surrounding communities to Jibia town and vice-versa. The dam also impacted on flood control by constructing 110km control drainage to divert excess water from farmland to Gada river. Present of Jibia dam also paves the way for constructing Chama Park recreational area for tourism activities. Jibia dam reduce that rate of rural-urban migration because of job opportunities.

Meanwhile, the negative impacts of Jibia dam in this study focusedon the imposed constraints on the spatial expansion of Jibia town in all directions and consequently causes the escalation of land price and congestion of people in Jibia town. But the impact of this bound was found to have manifested between the year 2003 and 2016.

The result of the population growth reveals that Jibia town and some of the communities surrounded by irrigation project area is becoming congested over the years due to population growth that did not correspond to the expansion of the towns surrounded by irrigation canals. Correlation analysis conducted revealed that between 1991 and 2003 the increased in population cause the expansion of the communities by 98.3%. While between 2003 and 2016 the increase in population induced 44.6%

expansion of the communities. We can infer that between 1991 and 2003 there was no imposed constraint on the spatial expansion of communities.

This study also reveals that, there was no compliance between the development and the propose Jibia dam master plan. Because it was designed that all the displaced persons shall be relocated to Sabon garin Kwari as a compensated area but this study found out that there was no rapid expansion or development in Sabon garin Kwari village and this implies that, the displaced person abundant the compensated area due to lack of social-amenities and settled in Jibia and Magama town which according to plan was not destination for displaced people due to imposed constraints on their development or expansion.

5.2 Recommendations

(i) In order to alleviate the dramatic land use land cover change and its adverse socio-economic impacts in the study area, social amenities should be provided in Sabon garin Kwari village to attract the people of Jibia town. This would be useful to protect and to prevent conversion of agricultural land and forest and the transformation of Irrigation area to built-up areas in the region and further reduce environmental degradation in the form of soil erosion and desiccation and socio-economic impact in the form of high price of land, high population density.

(ii) Sokoto Rima River Basic development authority, Jibia district should establish GIS unit that will be task with the responsibility of monitoring land use land cover changes in form of encroachment in its project area with a view of protecting the area from transformation to other land use and review the compliance of the current development with the proposed Master plan for proper planning and management of the project area.

(iii) The Federal Government should be conducting dredging of impounded reservoir regularly as a measure to maintain storage capacity of the reservoir and to prevent the downstream areas from flooding due to siltation as a result of blocking the path of sediment by dam. It should also review the compensation provided through the authorities to the displaced people and farmers whose properties was converted to reservoir.

(iv) The Government should upgrade domestic and Irrigation water facilities for the effective and adequate supply of water to all distribution areas.

5.3 Contribution to Knowledge

The contribution of this study to knowledge are;

a. This study analysed the cumulative impacts of Jibia Dam in the study area and concluded that, the cumulative impacts are positive despite some challenges
b. Established the relationship between the Dam Location/Site and Socio-economic activities of the Surrounding Communities in the Study area

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APPENDIX

Appendix 1

I am a postgraduate student of the Department Geomatics, Faculty of Environmental Design Ahmadu Bello University Zaria, conducting a research on "Geospatial Impacts of Jibia Dam on Jibia town, Jibia Local Government Area, Katsina State" I hereby seek for your kind gesture to help me fill this questionnaire in order to make the research a successful one. Be assured that all information supplied will be confidentially treated.

Village/Community……...L.G. A

……

Section A: Socio-Economic Variable

1. Name ……

2. Sex: Male ( ) Female ( )

3. Age (years)……

4. Marital status: Married ( ) Single ( )

5. Highest level of Education:

(a) No Formal Education () (b) Primary school Education () (years)…… (c) Secondary School Education ( ) (years)…… (d) Tertiary Education ( ) (years)……

6. What is the size of your household size.....?

7. What is your major occupation? (a)Farming ( ) (b) Trading ( ) (c) Civil servant ( )

(d)Others (Specify): ……

Section E: Information on Domestic Water Sources

8. What was the Sources of domestic water in Jibia town before the Construction of the dam?

9. Now, are you getting adequate and Consistent supply of domestic water?

10. If Yes, how many hours per day and how often per week?

11. In case of power failure, what are your alternative source of domestic water?

12. Do you think the dam helps in reducing water borne diseases?

Section C: Information on the Impacts of the Dam on Irrigation Farming

13. Was there a present of Irrigation Farming before the construction of Jibiya dam?

14. What was the Sources of water for Irrigation farming then?

15. And how do you water your crops before the dam?

16. Is the present of the dam improved Irrigation Farming in terms of;

Extent of Farmland?

Method?

Type of crops?

Yield?

Accessing loan from Financial institutions?

Section D: Information on the Impact of Jibia Dam on Flood Control

17. Do you witness the occurrences of Flooding in Jibia town before the dam?

18. If yes, does it occur now?

19. If no in which way does the dam prevented the flooding?

20. What damages it caused in the past?

Section E: Information on the Impact of Jibia Dam on the Socio-Economic Activities

21. Do you lose your Farm or House to Reservoir or Irrigation Project area?

22 if yes were you compensated properly?

23 Does the construction of Jibia dam change occupations and brought new ones?

24 If yes what are the occupations that the project eliminated?

25 What are the occupations introduced by the dam?

26 Where you use to be during dry season

27 Before the dam did you have access roads to nearby Villages around Gada River?

28 How did you travel to nearby villages during rainy season considering the Study area have Many rivers and water flow for the period of four months?

29 in the pre-dam period where you use to go for recreation activities during festival?

30. Can you count Spatial constrain on the expansion of Jibia town as one of the disadvantages of the dam?

31 Can you link the high price of land in Jibia town to constrain imposed by Jibia dam on the expansion of Jibia town