ADDIS ABABA UNIVERSITY
SCHOOL OF GRADUATE STUDIES
DEPARTMENT OF EARTH SCIENCE

ENVIRONMENTAL IMPACT MONITORING FOR GILGEL GIBE I DAM USING AN INTEGRATED METHEDS OF REMOTE SENSING AND GEOGRAPHIC INFORMATION SYSTEM (GIS)

By Bahiru Girma

Dissertation submitted for Partial Fulfillment of the Requirements for the Award of the Degree of Master of Science in Remote Sensing and Geographical Information Systems (GIS)

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Acronyms

CSA	Central Statistics Agency
CSE	Conservation Strategy of Ethiopia
DEM	Digital Elevation Model
EIA	Environmental Impact Assessment
EMA	Ethiopian Mapping Agency
EMP	Environmental Management Plan
EMS	Electro-magnetic spectrum
ETM	Enhanced Thematic Mapper
ETM +	Enhanced Thematic Mapper Plus.
FAO	Food and Agricultural Organization
FGD	Focus Group Discussion
Gdb	Geo database
GDP	Gross Domestic Product
GIS	Geographical Information System
GNP	Growth National Product
GPS	Global Positioning System
LC	Land Cover
LU	Land Use
NDVI	Normalized Difference Vegetation Index
NIR	Near Infra Red
NMSA	National Meteorological Service Agency
RGB	Red-Green-Blue
RS	Remote Sensing
SRTM	Shuttle Radar Topographic Mapping
TM	Thematic Mapper
UTM	Universal Transverse Mercator
WCD	World Commission on Dam
WGS	World Geodetic System

Abstract

This research has been conducted in order to assess the environmental impacts of Gilgel Gibe I hydroelectric Dam since its construction using GIS and Remote Sensing techniques. Because of the limited time only some environmental parameters were chosen. These parameters are vegetation cover, land use land cover, health conditions in relation to water born related diseases with particular emphasis on malaria cases. In addition, the socio-economic aspects were also treated.

In order to detect the spatial and temporal change of vegetation biomass in the study area the Normalized Difference Vegetation Index (NDVI) analysis was used. As per the NDVI analysis made on ERDAS Imagine9.2 software the mean statistical values are 86.4325, 81.7561 and 66.5724 for the year of 1990, 2000 and 2008 respectively. According to the results the natural vegetation biomass has been declined for the last 18 years. This is mainly due to the expansion of agricultural land and a dramatic increment of human made structures in the area.

The land use land cover change analysis demonstrated that distribution and pattern of land use land cover of the study area have been undergone through change. Results from land cover change analysis shows an increase in agriculture land from 20.01 % in 1990 to 32.45 % in 2008. The increased agriculture land was mainly at the expense of the natural forest. On the contrary, natural forest decreased from 59.636 % in 1990 to 31.13 % in 2008.The water body covers 2.667 ha during 2000 and 8.866 ha in 2008.This increment was due to the creation of reservoir behind Gilgel Gibe I Dam. Rate of land cover change clearly showed the change of the different cover classes over the study periods.

The post hydropower dam reservoir development witnessed that some water born diseases, particularly malaria case records have shown an increasing trend. It is also found that the creation of reservoir have been exacerbated malaria cases incidences in the area.

Generally, despite the significance of the hydroelectric dam project, based on the FGD and selected representative samples it has been found that the construction of Gilgel Gibe I Dam has an adverse impact on the socio-economic condition of the nearby community and vegetation cover of the area. Thus, in the project site and adjoining area urgent environmental conservation and an appropriate mitigation measures are necessary. This may help to minimize the environmental impact and will also assus the sustainability of the project

Key words: EIA, EMP, GIS, Remote sensing, NDVI, Land use Land cover

1. INTRODUCTION

1.1 Background

Dams have been built for thousands of years for electricity, irrigation, flood control and water supply. The World Commission on Dams (WCD; 2000) indicated that one-third of the countries in the world rely on hydropower for more than half of their electricity supply. Dams often bring losses of agricultural lands, forests and grasslands in the upstream watershed areas due to inundation of the reservoir area (WCD, 2000; Bird and Wallace, 2001), alteration of traditional resource management practices (Rooder, 1994), displacement and impoverishment of people, and the inequitable sharing of environmental costs and benefits (WCD, 2000).

Ethiopia has about 30, 000 MW hydropower potential but it was possible to exploit less than 2% of this by the year 1997 (Solomon, 1998) mainly due to financial shortfall (Alemneh, 2003). As a result only 14% of the population has access to electricity.

The construction of dam for hydroelectric power generation in Ethiopia lends a hand to achieve efficient power supply for the country which will contribute for sustainable development and poverty reduction. It is unquestionable that hydroelectric power generation is more unwavering and environmental friendly than other sources of energy, if it is properly designed and implemented. Proper planning and management aid dam projects contribute for the growth of national GDP and GNP. It also creates job opportunities for several people directly or indirectly.

Despite their significances, however dam construction project have a significant adverse impact on environmental conditions. It is undeniable fact that we human beings are bringing a profound effect upon the natural environment and we are the main agents of environmental degradation and other environmental related problems. Dam construction is one of the factors influencing the natural resources of our environment, it often show negative environmental effects that can be social, economic and physical (Dixon et al., 1989). The social effects of a dam include the involuntary resettlement of people and the disruption of their productive systems and lifestyles and the impact of the relocation on the population inhabiting the new host areas (Dixon et al., 1989). Besides, problems such as lower amounts and delays of payment and lack of participation in the resettlement process cause dissatisfaction in resettlements and hence affect the sustainability of the projects (WCD, 2000). The environmental effects comprise changes in water quantity and quality, and soil erosion and sedimentation (Dixon et al., 1989).Hence, this and other related concern has led to an increased emphasis on environmental studies all over the world.

In Gilgel Gibe watershed area, following the establishment of the Gilgel Gibe I dam more pronounced environmental problems have been observed. These are land use land cover change due to reservoir, vegetation biomass decline, health treat and socio economic impact on the society to mention few among them. In addition, in this project area there exist continuous disturbances on the environment. If the trend goes on, there will be an extreme effect on the environment. Thus, it is a paramount importance to carry out environmental impact monitoring of the dam site and the surrounding watershed.

Generally speaking, environmental impact assessment has been recognized as an integral part of the early planning studies of any project which have a significant adverse impact on the environment that enables to identify any expected negative impacts and to suggest the necessary actions. In addition, EIA also considers different designed alternatives for the project as an essential step for better decision making.

The application of geographic information system and remote sensing can facilitate the sudy of environmental impact assessment and monitoring of the Dam site for a better out come. Besides these application facilitates the assessment of the land use and land cover changes. Results arising from such assessment studies are important for planning and decision making processes.

1.2 Statement of the Problem

The development of dam projects has many advantages for any country. But, sometimes designed projects can have an adverse effect on the environment. Even in a well designed project the impact is unavoidable. It can be said that poorly planned dam construction usually results into socio economic and environmental damages. Even some times in an effort to address some environmental impacts of the project some other disadvantages may arise.

Basically, the question of sustainable development depends on how well the environmental conditions remain relatively unaffected. In the study area the environment is affected through different ways like vegetation biomass decline, land use and cover change due to reservoir ,health treat and effect on the socio economic and so on which directly or indirectly affect the quality of human life and the ecosystem in general. Hence, the extent and severity of the environmental impacts of the project in the area should be assessed to mitigate the negative impacts of the project and even to secure better and long lasting advantages.

One field in which impact assessment is likely of particular value is the formulation of sustainable development strategies. It has the potential to introduce forward looking and objective assessment and valuable for mediation and conflict management (Borrow, 2000). Even though the constructed dam is of paramount importance for the overall level of development through supply of electric power which would serve as a power house for any sector, the surrounding natural environment around Gilgel Gibe I Dam site is under continuous threat. The cause, course, results and location of these problems need to be continuously monitored and addressed in a scientific way. In this regard GIS & remote sensing techniques make the task of impact assessment and/or monitoring more easier and objective.

The main concern of this research work is thus to assess the environmental impact of a Gilgel Gibe I Dam since its construction through gathering data from both primary and secondary sources .In addition, so as to analyze the existing interaction and interrelation ships among the environmental elements and thereby reach at conclusions and suggest feasible recommendations which is very useful for bringing sustainable development.

1.3 Objectives

1.3.1 General objective

To assess the potential impact of the Gilgel Gibe I dam on the surrounding environment since its construction.

1.3.2 Specific Objectives

1. To see the impacts of the Dam on vegetation cover using satellite images of different years.

2. Determining the status of land use and land cover changes following the same project both spatially and temporally.
3. To investigate some socio-economic and health related threats that affect human life following the dam construction.
4. To propose valuable mitigation measures to respond to the negative impacts of the dam on the environment in such a way that it assures sustainable development

1.4 Research questions

To meet the objectives will hopefully help to answer the following research questions;

1. What does it look like land use and land cover patterns of Gilgel Gibe watershed area have before and after the construction of Gilgel Gibe I Hydroelectric Dam?
2. Are there any impact brought by the construction of the dam on the surrounding environment.
3. What is the impact of the dam/ reservoir on the vegetation cover?
4. Is GIS and remote sensing suitable tools for environmental impact assessment and monitoring for dam construction?
5. Is there a need for conducting environmental monitoring for the existing project and how it can assist for sustainable development?
6. What mitigation measures are needed to reduce the environmental impact?

1.5 Significance of the study

Geographic information system and remote sensing integrated environmental impact assessment allows seeing the past-present pace of change and tell their future trends and styles of change. In doing so it is possible to relinquish the existing signs of environmental disasters and its forthcoming consequence.

In light of this, the final outcome of the research is believed to help national and international organizations working on dam construction and related projects in scrutinizing the possible negative impacts of this sector. It can also serves as a reference for policy and decisions makers for analyzing their projects before hand and forward informed decisions.

The thesis is also believed to have a special contribution in identifying the negative environmental impacts of the project and address them in more scientific ways. Furthermore; it helps identifying the future possibilities of occurrence and trend of the negative consequence so as to take pro active measures and avoid the occurrence of similar problems. On the other hand the paper can give a yellow light for the concerned body to take justifiable action at the right time and place. Finally, the findings of the research can serve as an input for further investigations.

1.6 Scope of the study

The scope of the study is to focus on Vegetation cover, land use and land cover, health and socio-economic environmental parameters for assessing post Dam construction impacts, among several factors. Relatively wider area is delineated with special attention to Gilgel Gibe watershed that includes four Woredas namely Sekoru, Dimitu,Tiro afeta and Seka. This is believed to show the direct and indirect impacts not only on the project site but also on the flanking areas. Taking the available time and resource into consideration it is reasonable and convincing to scope the research topic on the above mentioned parameters.

1.7 Limitation of the study

This study faced some limitation. These were lack of successive and high resolution satellite images which hinders short term and detailed land use land cover change detection and further analysis, difficulty of accessing data and some field site, shortage of time and lack of related specific research works in the study area.

1.8 Organization of the thesis

The paper is composed of five chapters. The first chapter introduces the background , problem definition and general and specific objectives of the thesis. In addition it deals with the significance, scope of the research work and the limitation with encountered inadequacies.

The second chapter mainly deals with review of related literatures on environmental impact assessment, Dam impacts and role of GIS and remote sensing in environmental impact assessment and monitoring.

The third chapter gives the general description of the study area as well as the materials used and the methodology adopted so as to achieve the intended objective.

Under Chapter four the vegetation cover condition and land use land cover change in the pre and post project years and the possible aftermaths are discussed. In addition, the effects of the reservoir on the health and socio economic conditions of the society are presented and analyzed with respect to the present and future outcomes.

The final chapter gives summary of the study and forward feasible recommendations helpful for environmental conservation and sustainable development.

2. LITERATURE REVIEW

2.1. The Impact of Dam

As dams are built, the area in which the dam is constructed will see some very strong changes whereby the very physical character of the host location will be altered permanently as a result of several key reasons (WCD, 2000).

Many environmentalists would argue that the environmental impacts that dams have as being the worst impact concerning large-scale dams. If one was to imagine the worst-case scenarios for a dam that has been poorly planned, then it is quite normal to contemplate some ecological nightmares concerning the potential impacts on the local environments of the dam. This classical view on the environmental sustainability of a technology is normal, as it is a natural instinct for an environmentalist to think of how something could be harmful towards the environment before considering anything else. The fact that hydroelectric dams without careful planning or management could mean a whole range of different impacts that might harm the environment is normal. But when thinking of the environment, one has to be very broad in ones scope of interpretation. It is no good merely considering physical impacts to the environment but a necessity to consider all forms of impacts: social, cultural and environmental impacts (WCD, 2000).

It is vitally important to equally consider these impacts as well as considering the other impacts such as the economic and social impacts that dams have. The reason for this is that even though they might have their own individual effects on the host environment, they also have specific impacts when combined with each other, depending on the characteristics of the host environment. Therefore, these impacts should be seen as interrelated, despite the fact that they don't seem to be initially, there are a lot of impacts that are understood to be related after dam construction has taken place. Many of these 'interrelated' impacts are not initially contemplated during the planning stages of a dam because planners responsible in predicting all potential impacts have not considered any reason to link or foresee such impacts related or linked to each other. Furthermore, those responsible for planning of dams see environmental impacts as mutually exclusive from the socio-economic impacts and therefore seldom see any relation between the two(Dixon et al., 1989).

Firstly, with the construction of a dam and its reservoir behind it, comes the noticeable change of the waterway that it is being built on. Previously, a river running undiverted through a valley will be subject to significant changes. The most obvious one would be the barrage built across the river that will stop the 'traditional' flow of water down it. This barrage will in effect slow down the flow of water after the barrage, causing the water levels below the barrage to change significantly. This in effect will alter many things that are related to the river downstream.

If we consider the changes occurring on the opposite side of the barrage, that is to say upstream of the barrage, we would see an opposing set of changes occurring. The water levels upstream of the barrage will also change, this time they will rise. This is because due to the 'blockage' forming at the point of the barrage, less water will be passing through. As this happens, an obvious volume of water will start building up behind that barrage, forming an artificial lake that we call a reservoir. This reservoir in effect covers an area that was formerly above the river that was dry ground, possibly serving as areas of agricultural cultivation or residential housing etc. The proportions (surface area and depth) of the reservoir all depend on the topographical nature of the area that the dam is built in. These proportions often are a decisive factor in the specific environmental impacts that the dam might have on its host environment (Barrow, 2000).

2.1.1. Environmental Impacts

The various environmental impacts of large dams are numerous and can be divided into two specific categories. These two categories are upstream impacts and downstream impacts. A further classification of these impacts can split them into two types of impacts: biological impacts and physical impacts (WCD, 200).

The upstream impacts are the impacts that occur on the side that is situated before the barrage. The upstream impacts are related to the reservoir of the dam, situated behind the barrage. The most common physical impact of large dams is the buildup of sedimentation behind the barrage in the reservoir itself, otherwise known as 'reservoir siltation'. In the case of river that is unaltered by any human initiated activity such as dam construction, natural sediments are carried down the river stream and are deposited naturally along the riverbeds and banks. It also serves as a kind of fertilizer for the crops that irrigated downstream with water from the river. When the agricultural areas become deprived of their natural fertilizers, farmers tend to turn to additional chemical fertilizers, which in turn will pollute the groundwater of these areas constituting another problem in field of environmental issue (WCD, 2000).

Another problem associated with the use of dam reservoirs is the stagnation of the water stored in the reservoir. Stagnation occurs, as the water is stored in the reservoir over long periods of time. There is minimal flow of water as it ‘sits’ in the reservoir waiting to be passed through the turbine and onwards downstream. As the water is stored in the reservoir, it becomes stagnant, as it is starved of oxygen. The stagnation of the reservoir water in effect reduces the number of organisms living and breading in the reservoir. Locals, who might depend on the river habitat to sustain a living such as fisherman, find it problematic doing so when the fish numbers up stream decline as a result of the waters decline in oxygen. A final note on reservoir stagnation is that due to the changes in the landscape, i.e., land becoming covered in water certain climatic changes will occur as the water reservoir will bring down the temperature in the areas that embank the reservoir. This would affect the organism living there, as well as the obvious areas, which can see the disappearance of colonies of wildlife etc (WCD, 2000).

This brings us to the downstream impacts. Due to the stagnation problem, the problems downstream that are caused by dam construction and planners often overlook the active altering of the river flow. This is quite obvious otherwise these impacts would not outweigh ones affecting the upstream side of the dam. Planners like to predict and safe guard the immediate areas around the dam and reservoir as much as possible, but rarely investigate probable impacts that arise further down the stream.

The physical altering of the river flow by a dam will also cause changes such as thermal damage to the river downstream, as the water coming out of the dam risks being at a colder temperature due to the fact that is has been stored in a deep reservoir. Additional, stagnant water is heavier and hence colder the deeper that the canalization is towards the gate of the dam (Barrow, 2000).

2.1.2. Socio-Economic Impacts

According to the WCD (2000), many people have benefited from the services large dams provide, such as irrigation and electricity generation. Their construction and operation can lead to many positive social and economic impacts. The actual construction of a dam can provide employment for the local communities and also provide incentives for businesses and enterprises setting up shop near the site of the dam. This would be the case where there is incentive to do so. When locals are able to work on the dam, it is only for a limited period of time as when the dam is completed, the use for labour will no longer be required. If there is no other investment around the construction site, then those employment opportunities will diminish.

The most problematic social impact of dams is the displacement of people.This amongst the one of the worst impacts as equally as bad as those who are displaced by war becoming refugees. In cases, people, whole family, community even towns that have been subsiding next to each other for decades are forced to leave their homes and are relocated somewhere else. In many cases today, whole community are split up and resettled into new towns, even in other parts of the country.

Another point important to retain in relation to people displaced by dams is that there is a noticeable difference in the displacement of rural community and urban community. These two types of community can vary the way that they cope with resettlement. It is often the case where urban community is resettled; looking at a larger volume of people that can be moved together. In the case of a rural community it is not so easy and uniform. Often these people have no formal legal rights to the land as it is somewhere they have settled down, whereby in many cases have no legal tenancy of the land. The more indigenous the displaced community might be the more chance that they will be left with nothing (Kassahun, 2000).

Looking at new possibilities for employment after relocation, we will see that a family moving from its home city to another one might not find so difficult in adjusting to their new environment compared to a rural family that has been relocated into a city. Such a family might only have skills needed in rural areas, such as farming skills where rendering it useless in the employment opportunities in the city. This also heavily depends on the level of isolation in rural areas prior to moving to the big city. The more 'indigenous' the community, the more difficult that it might find obtaining jobs after moving to the city from a rural setting due to the fact that they are expected to have certain skills that are no longer relative to the urban job market.

Another problem that arises is the new boundaries that form as a reservoir takes shape. The land which was formerly linked by roads, paths and possibly railways becomes an uncross-able void, often separating families and communities, forcing people to travel much longer distances than prior to the construction of the dam. The formation of a reservoir could be seen as brick wall that has been set up by the planning authorities, in effect redefining the geographical boundaries of a region.

Another important focus point is the affects that dams might have on the general health of the local population. Many of the health problems associated with dams are generally linked to the physical attributes of the dam and reservoir, although many of the mental health problems can be harder to assess such as the stress or trauma experienced by becoming displaced by force.

In areas where by the impacts of reservoirs are climate change, certain warmer climates could see the increase in disease and germs where by the physical changes such as a dry area being turned into a reservoir experiencing heavy stagnation rates. In such cases an increase in malaria causing life-threatening conditions could theoretically take place, increasing the health risks on the local population. If a dam is disrupting the local environment is increasing the chance of disease or germs or unhealthy organism breading then it must be affecting local stakeholders unfavorably.

2.2 Environmental Impact Assessment (EIA) and Monitoring

In the past the environment feature was failed to be consider in holistic manner in the development endeavors of the country, since project evaluation and decision-making mechanisms were unwarrantedly made to focus on short-term technical feasibility and economic benefits. For this reason, past development practices fell short of anticipating, eliminating or mitigating potential environmental problems early in the planning process. This state of play resulted, among others, in situation where the country is plagued with seriously degraded environment. Further development along this line has to be cut short, as efforts in reversing the damage to the environment at a later time is usually costly or even irreversible. In order to ensure sustainable development, it is essential to integrate environmental concerns into development activities, programs, policies, etc. Environmental Impact Assessment as one of environmental management tools facilitates the inclusion of principles of sustainable development aspiration well in advance (Burrough, 1986).

Environmental Impact Assessment (EIA) is a tool used to identify the environmental, social and economic impacts of a project prior to decision-making. It aims to predict environmental impacts at an early stage in project planning and design, find ways and means to reduce adverse impacts, shape projects to suit the local environment and present the predictions and options to decision-makers. By using EIA both environmental and economic benefits can be achieved, such as reduced cost and time of project implementation and design, avoided treatment/clean-up costs and impacts of laws and regulations.

Some writers argued that Environmental impact assessment is an activity to be carried out before a project. But EIA is a very help full procedure to be followed at all stages of development projects even after the establishment of a project as the goal is to mitigate the negative impacts of a proposed activity on the environment. This involves fostering environmentally sound projects and bargaining with projects that are not environmentally sound.

Environmental Impact Assessment (EIA) has been defined by many people in different way. According to Munn (1979) it is defined as an activity designed to identify and predict the impact on the biogeochemical environment and on man’s health and well being of the society. Mitchell (1989) describe that, EIA represents a legislative or policy based concern for possible positive or negative short or long term, effects on our total environment attributable to proposed or existing projects, programs or policies of a public or private origin. Hence, EIA is a planning tool, a formal study used to predict the environmental consequences of a proposed major development project. EIA thus optimizes the value of holistic approach to studying environmental problem and a clear example of the emphasis on preventive, holistic, strategic approaches to environmental protection which acknowledge environmental limits.

Morris and Therivel,(1995) recognizes that an integrated approach (to environmental management) ensure that all problems, at least those known but also those foreseen are put on table at the same time and the linkages established as far as the eye can see before recommending or adopting solutions. Hence, an EIA study agenda of a resource proposal would consider impacts upon natural economic efficiency, income redistribution, preservation and aesthetics, political equity as well as environmental control.

A synthesis of Morris and Therivel (1995) shows EIA should be all encompassing. It should consider both the biophysical and socio-cultural environments. Hence, an EIA is designed to concentrate on the problems, constraints that could affect the viability of the project. It examines impacts of proposed projects on people, homelands, physical and biophysical resources, livelihoods and nearby the project environment.

Still people consider EIA as antidevelopment plans and simple resources wastage. They even think of, it has not been given priority for developing countries that are busy of building their basic development projects. But EIA Should not be consider as antidevelopment it should be seen as an integral part of development, it is complementary rather than conflicting since it enhances sustainability.

2.3 Issues for Assessment of the Impact of Dam and reservoir in Ethiopia

Dams and reservoirs are built for hydroelectric power generation, irrigation, domestic and industrial water supply, fishery development, recreation and flood protection. Ethiopia is endowed with rich water resources, which are divided into 111.1 billion m^3 of annual surface water runoff, and approximately 2.9 billion m^3 of ground water potential (Solomon,1998). However, a very small fraction of the resource is available for use and the water supply can be short at specific localities. According to the same source, clean water supply for domestic and municipal use was provided to only 27.2% of the total population of 51.5 million people. According to the Conservation Strategy of Ethiopia (CSE) only 1% of the water resource potential is used for irrigated agricultural development and hydro-power generation.

The need for self-sufficiency in food through expansion of irrigated agriculture and fishery resources, hydropower generation, provision of reliable water for domestic and municipal use has been steadily increasing and become critical. All these development endeavors involve construction of a large number of dams that might have significant adverse impacts on the bio-physical and human environment. The Agricultural Led Industrialization Development Strategy and new economic policy initiatives mean that dam and reservoir development projects have been given high priority.

Dams and reservoirs may cause irreversible social and environmental damages over a wide geographic area. Environmental impact assessment helps to identify such issues early enough so that corrective measures, options, monitoring mechanisms can be incorporated in the project's design and implementation. Table 2.1 describes issues for environmental assessment of dam and reservoir projects

Table 2.1Issues for environmental assessment of dam and reservoir

ISSUES FOR ENVIRONMENTAL ASSESSMENT OF DAM AND RESERVOIR PROJECTS		
ISSUE	**SOURCES/CAUSES**	**IMPACT**

Alteration of the microclimate	Creation of a large surface area for evaporation	Increase in evaporation leading to changes in temperature, fog and annual rainfall pattern.
Habitat loss Degradation of the natural environment Exceeding the carrying capacity of the natural environment	Expropriation of land for the development of dams and reservoirs Induced development Utilisation of natural resources	Replacement of valuable habitats by the dam or reservoir Degradation of the natural environment during the construction phase Increased population exceeding the ecological carrying capacity of the area Increased pressure on natural resources due to new activities Encroachment of anthropogenic activities into previously protected areas
Barrier impacts Obstruction of migratory pathways Change in the water regime	Control of water flow patterns Construction of obstructive structures across water course	Effect of inundation, altered water flow or ground water level on fauna and flora Dam or associated infrastructure forming a barrier to the movement of wildlife Implications of water flow changes to natural vegetation and wildlife Obstruction of fish migration by technical installations and regulation features Disturbance of feeding and spawning ground of valuable species of fauna and flora
Change in water regime Reduced water quality and increased pollution	Water consumption	Increase or decrease in flood peaks Reduction in the total water flow due to increased evaporation Reduced water quality due to a decrease in the water flow Pollution of water sources during the construction phase Increased concentration of nutrients leading to uncontrolled eutrophication Changes in the seasonal variation in the water flow affects navigation, fishing, cultivation and the drinking water supply downstream Change in the groundwater level in the surrounding area
Erosion Sediment Transport	Changes in water flow	Increased soil erosion in vulnerable areas Acceleration of transport of sediments and nutrients in the water course Repercussions of sediment build-up to downstream erosion, the backwater effect and flooding upstream
Loss of significant sites Degradation of cultural relics	Expropriation of land for dam and reservoir developments	Potential for submergence of culturally/ historically significant sites or objects
Loss of visually appealing sites Aesthetics Tourism potential	Disturbance of the natural environment Modification of the river system	Change in water course or water flow through physical encroachment Creation of "hill side scars" Loss of tourist sites along the river
Displacement of people	Expropriation of land for dam and reservoir development	Potential for displacement of people and the implications of moving (see section 5.10)
Accessibility Utilization of water resources	Regulation of water flow	Decreased accessibility to water for drinking, irrigation or animal husbandry due to reductions in water flow Changes in ground water level because of regulation Water resource use conflict between up- and downstream users
Creation of new livelihood opportunities Decrease in livelihood opportunities downstream	Induced development around dams Downstream water use	Sediment trapping leading to decreased productivity in agriculture and fishing Changes in water regime negatively impacting on fish Increased accessibility leading to new activities which replace the natural environment Establishment of a reservoir displacing other activities to ecologically vulnerable areas
Population growth Socio-cultural conflict	Induced development	Induced growth of the population caused by the project Potential conflict between new population groups and the original inhabitants

		Changes in the traditional lifestyle Increased pressure on natural resources
Risk of disease and infection Accidents	Health and safety	Creation of conditions favourable to growth of disease-spreading organisms Increase in spread of infection due to population growth Risk of reservoir being used as a drinking water source and recipient of sewage Material and personal loss through dam failure, landslides and flood waves Alteration of tectonic activity leading to earthquakes and landslides

Source: (Ethiopia EIA Guide line)

2.4 Remote sensing and GIS for Enviromenta1 Impact Assessment and Monitoring

Remote Sensing is the science of deriving information about the earth's land and water areas form images acquired at a distance (Campbell, 1987). It relies upon measurement of electromagnetic energy reflected or emitted from the features of interest. Remote Sensing as the science or art of obtaining information about an object, area or phenomenon through the analysis of the data acquired by a device that is not in contact with the object, area or phenomenon under investigation (Lille sand et al.,1979).

Regardless of the orientation of the various definitions of Remote Sensing, the acquisition of images of earth surface features, using sensors, through the electromagnetic spectrum, the synoptic view advantage and Remote Sensing's ability to provide data for scientific technological and sustainable management and monitoring of the environment offer a convergence.

The Electro-magnetic spectrum (EMS) is the physical basis for Remote Sensing. It is an abstract idea and diagram of forms of electromagnetic energy for illuminating earth surface features. The source of energy is divided according to wavelengths. The most widely used part of the spectrum is the visible portion (O.4u-O.7u) where the presence of atmospheric window reduces attenuation of energy to a considerable level. Hence, briefly stated, the process of Remote Sensing involves making observation using sensors (camera, scanners, radiometers, radar, and lasers) mounted on platforms (ground, aircraft, satellites, balloons) which may be at considerable height from the earth surface. Then, recording the observations on a suitable medium (photographic films and magnetic tapes) or transmitting/down linking the data to a ground receiving station where the data are corrected for geometric and radiometric distortions. Output products can be provided in computer compatible tapes for users that made requests for the data.

Remote sensing serves as a tool for environmental resources (biotic, a biotic and cultural) assessment and monitoring. Remote sensing has some fundamental advantages that make it a veritable tool in environmental monitoring and management and impact studies. These have been listed by Barret and Curtis (1992) to include: a capability for recording more permanently detected patterns, Play-back facility at different speeds, Opportunity for automatic (objective) analysis of observations to minimize personal peculiarities of observers, Means of enhancing images to reveal or highlight selected phenomena to these can be added, the synoptic view advantage offered by raised platforms ,ability to record data on otherwise inaccessible areas, ability to produce accurate data on large areas at desired time intervals and at relatively lower cost compared to the cost that would be incurred through ground survey methods, ability to record images in multispectral fashion at different stages, at different scale and spatial resolutions. Remote sensing data also possess high geometric precision detail, consistency, cost effectiveness and adaptation to highly difficult terrains. All these combine to make Remote Sensing a veritable tool for obtaining baseline information for establishing baseline conditions of an area at the pre-project analysis stage, as well as monitoring changes in the environmental conditions of such area after the project has been dc-commissioned. This was recognized by Linden (1997) in his classical article: He wrote: Another crucial shift in thinking came courtesy of space programs. Earthbound mortals now have a new perspective from which to interpret their obligations to the Research Journal of Environmental and Earth Sciences 14 biosphere. Lofty images of the home planet, a growing awareness of our power to undermine vital systems and concern about pollution and endangered wild lands have combine to make safeguarding natural resources a broadly shared value'.

The field of GIS and Remote Sensing has been referred to as the technology of today. The largest primary source of digital data for use in GIS is undoubtedly that created by Remote sensing technology on board of satellites and other aircrafts (Jones, 1997). The discipline of Remote Sensing is therefore an important relative of GIS and from some point of view regarded as a sub discipline of GIS (Jones, 1997). The two are thus highly amenable to the study and conduct of environmental impact assessment.

Different schools of thought have had different and varied definitions for Geographic Information system (GIS).GIS as ‘a configuration of computer hardware and software specially designed for the acquisition, maintenance and use of cartographic data’ (Tomlin, 199O). Burrough (1986) sees a GIS as a powerful set of tools for collecting, storing and retrieving at will, transforming and displaying spatial data from the real World. Intera Tydac Tech Inc (1993) - the producer of SPANS GIS defines a GIS as a rapidly advancing computer based technology where information is organized, analyzed and presented with reference to location.

The point of note is that a GIS is a computer-assisted system for the acquisition, storage, analysis and display of geographically and spatially referenced data. The power of a GIS lies in its ability to bring both the spatial and attribute data within a common framework to form a unified database system; and its ability to compare different entities based on their common geographic occurrence through the overlay process.

GIS is indeed a new application-based field that has lend itself to varieties of human endeavors ranging from business, facility management to environmental management and resource application areas. has described G IS as a veritable tool in environmental assessment because it Stores large multidisciplinary datasets and Identify complex interrelationship between environmental characteristics, Evaluate changes over time event it Can be systematically updated and used for more than one project (Eedy,1995).

An important aspect of an EIA is the public consultations and social surveys. This in addition to the biophysical survey results can be imported into a GIS. GIS also have the capability for site impact prediction, wider area prediction, cumulative effect analysis, and environmental audits and for generating trend analysis within an environment.

Jones (1997) observed that GIS is highly indispensable because of its ability to conduct spatial analysis on input data. Rodriquez -Bachiller (1995) commenting on its application in ETA studies submits that it is a veritable tool for generating terrain maps for slope and drainage analysis, land resources information system for land management, soil information system, geo scientific modeling of geological formations, disaster planning related to geographically localized catastrophe monitoring development, contamination and pollution monitoring, flood studies, linking of environmental database and constructing global database for environmental modeling.

The role of GIS as since a GIS collects and manages environmental data in a standardized manner. Its use is likely to result in more efficient data collection and analysis. For instance flood risk maps captured on a GIS, can be available to planning, housing, communications and insurance organizations. The common use of environmental data sets minimizes duplication of effort and helps engender the team approach required to tackle multi disciplinary environmental problems. Preventing or mitigating environmental impacts often requires the consideration of a number of environmental attributes, whose relationships may be dynamic in that they change over time and in their spatial relationships.

GIS functionality provides the environmental manager with a powerful set of tools for modeling spatial problems where several layers of graphical and tabular data may be involved. For example, well field protection involves taking account of potential hazards to the well field from flooding risk, septic tanks, storage tanks and industrial areas, and delineating buffer zones to protect well fields from such hazards. GIS can resolve these spatial problems accurately and rapidly.

Because of its spatial modeling capabilities GIS can provide useful support to management decision making. *'What* if type models can be run in GIS to simulate the effects of adopting different environmental policy options? A more informed choice can then be made by using GIS as a decision support tool. It can also be used to display the results of other environmental models such as air and water pollution dispersion models together with other layers of information held in the GIS to 'add value' to analytical results and their implications.GIS can be particularly valuable in an environmental monitoring role to identify and delineate spatial changes in environmental conservation provides a measure of flexibility and timeliness when responding to environmental questions. Since the GIS data set can be readily updated in the light of new information or changes in environmental conditions it maintains a far greater currency than a paper map which may be several years old and represents only a snapshot of environmental conditions at a point in time. When the environmental GIS are updated the result of the query is also updated, as the results of the environmental model to which that new data element was added. Hence the environmental GIS can be used for environmental contingency planning or disaster management.

3. METHODOLOGY AND MATERIALS

3.1. Description of the study area

3.1.1. Location

The study area is located in Oromiya region in Jimma zone about 260 km south west of Addis Ababa and about 70 km north-east of Jimma. The area is enclosed with four Woredas namely Sekoru, Omo Nada, kersa and Tiro Afeta (currently known as Dimitu).Astronomically the study area is found within 7º3' to 8º3' and 36º7'to 37º6'.Gilgel Gibe watershed area is reached through the main high ways south west of the capital Addis Ababa that links with Jima town. The highway is located within a few kilometers of the right side of Gilgel Gibe I Dam. The location Map of the study area is given in Figure 3.1

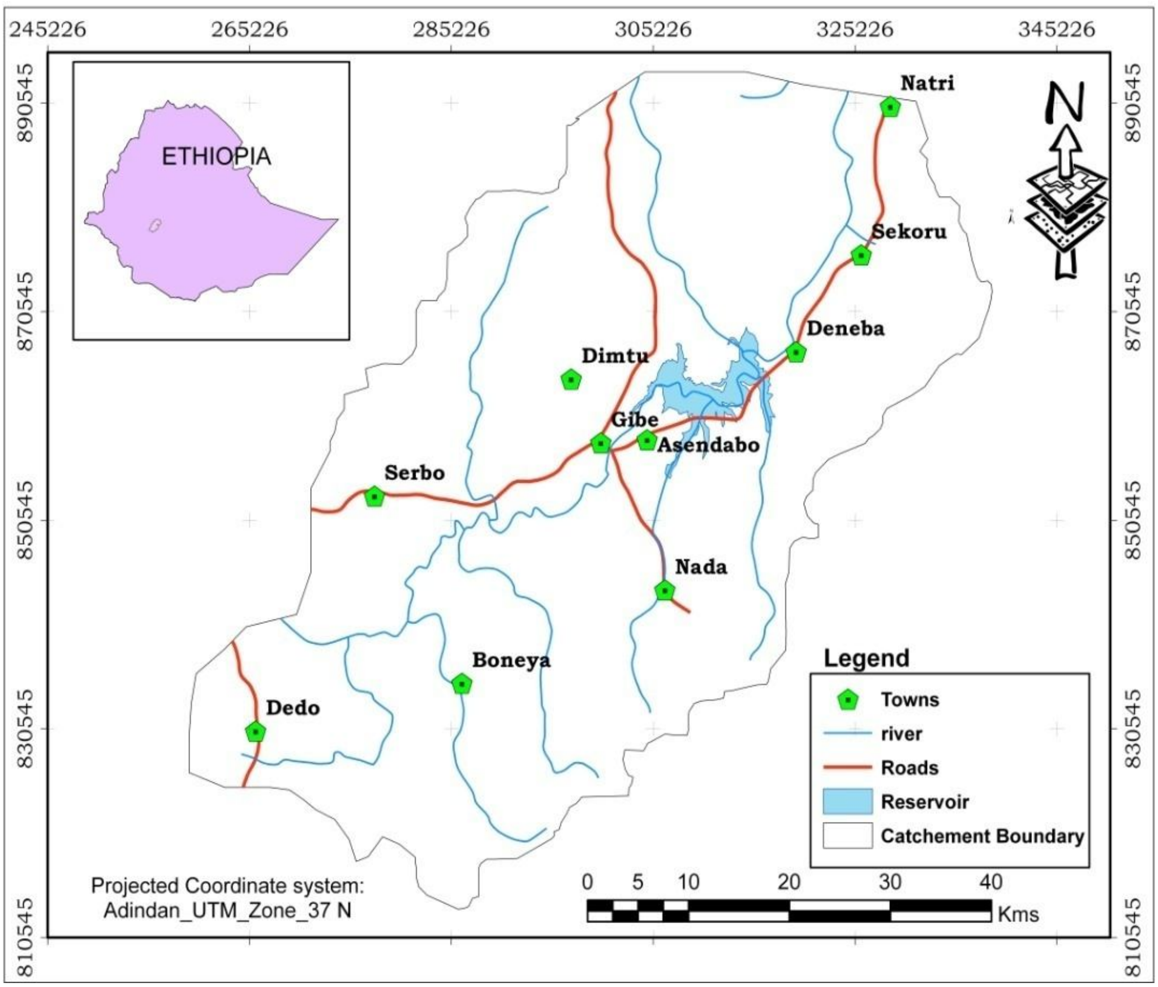

Figure 3.1.The location Map of the study area

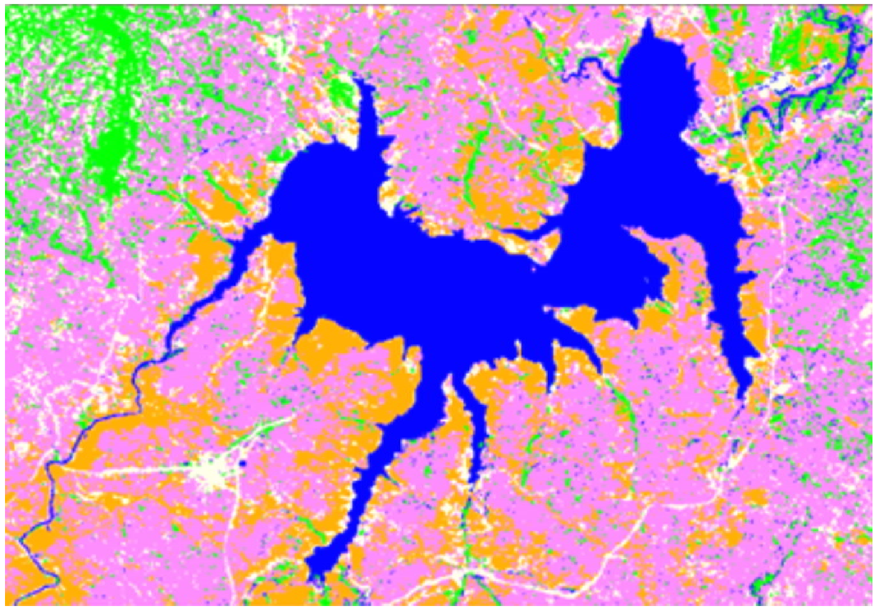

Figure 3.2 The newly created reservoir

3.1.2. Topography

The study area is a fairly flat plateau with an average altitude of 1,650 m a.s.l and consists of a series of gentle slope in glow hills and broad plains surrounded by hills or mountains. The Gilgel Gibe River, which flows through Jimma zone from south-west to north-east, is a tributary of the Great Gibe River (known as the Omo River further downstream) and is extremely variable in course and gradient. The lowest area in the study area is about 1,251 meters above sea level and the highest being 3,345 meters.

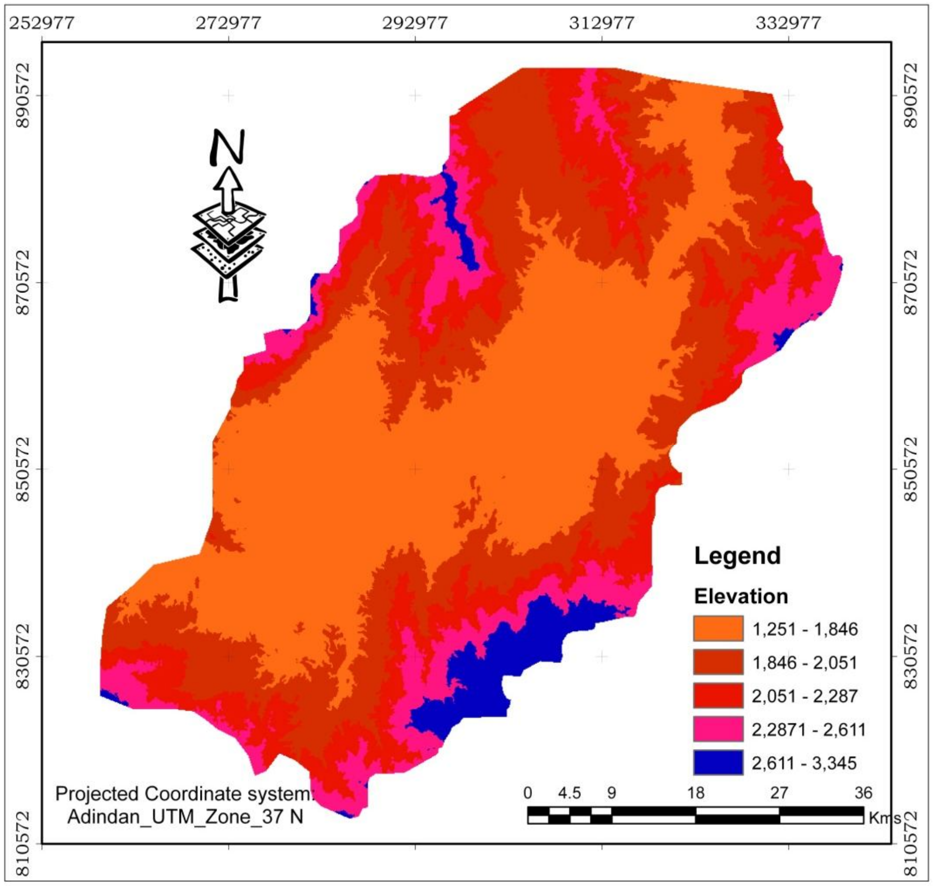

Figure 3.2 Elevation Range in the study area

3.1.3. Climate

The study of the rainfall distribution over a year was based on data from the stations of Abelti, Asendabo, Jimma and Sekoru using the Thiessen method, which assumes that the total amount of rainfall in any station can be applied half-way to the next station, in any direction. As per the data obtained from the above aforementioned stations the annual rainfall of the Gilgel Gibe catchments area varies from a minimum of 1,300 mm near the confluence with the Great Gibe River, to a maximum of about 1,800 mm in the Utubo and Fego mountains. Rainfall decreases throughout the catchments with a decrease in elevation. The average annual rainfall calculated over the whole Gilgel Gibe basin where it joins the Great Gibe River is 1,527 mm; over the Deneba catchment it is 1,535 mm; over the partial catchment between Asendabo and Deneba it is about 1,479 mm, and over the partial catchments area between Deneba and the Great Gibe River it is 1,429 mm. It appears that 60 per cent of the total amount of annual rainfall occurs between June and September, 30 per cent from February to May and only 10 per cent between Octobers to January.(Gilgel Gibe EIA Report,1999).As far as the average annual temperature is concerned it is observed as 19.2°c.Table 3.1 shows monthly mean values of selected meteorological and climatic parameters.

Table 3.1.Mean Values of Meteorological Data in Gilgel Gibe Watershed area 1998

Element	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec
Temp (Min)	8.8	11.3	12.3	14.0	13.9	13.9	13.5	13.3	13.2	11.0	8.8	8.3
Temp (mean)	18.9	19.9	20.9	21.3	20.9	20.1	19.1	19.1	19.5	19.1	18.6	18.5
Temp (max)	29.1	28.5	29.5	28.7	28.8	26.3	24.6	24.9	25.8	27.2	28.4	28.7
H	49.21	51.50	50.21	61.07	64.29	70.14	75.71	74.57	69.64	58.79	51.94	51.46
ETo(mm)	167	160	191	164	161	133	119	123	138	165	159	157

Source: National Meteorological Service Agency

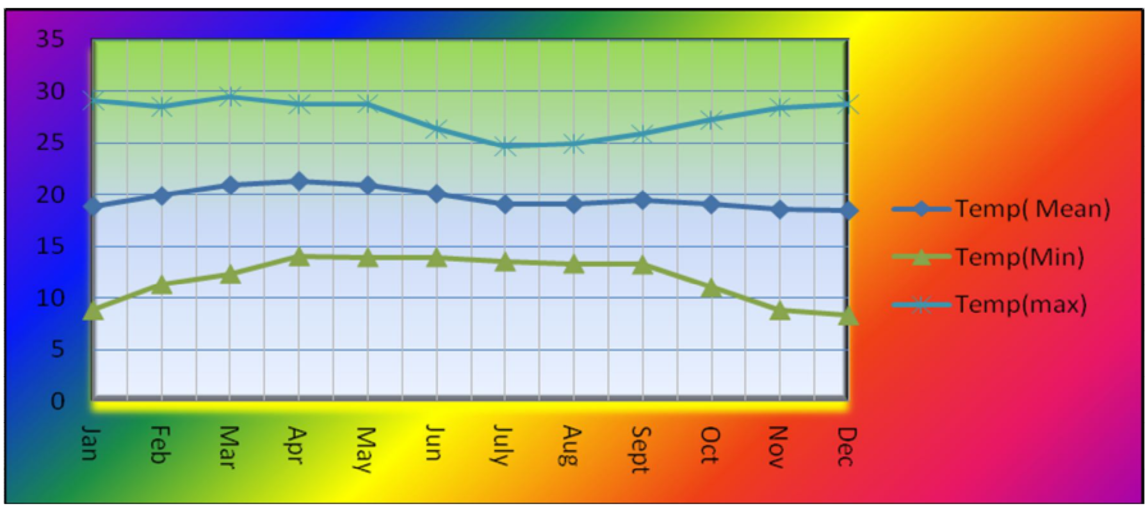

Figure 3.3 Graph showing mean value of temperature distribution of the study area in degree centigrade 1998.

3.1.4. Geology

The study area is situated on the southwestern Ethiopian plateau. The area is characterized by a series of basic and subsilicic effusive volcanic rocks, frequently inter-layered with reddish pale sols of Tertiary age. The rocks of the area are tentatively ordered as following, beginning with theyoungestrocks:Trachytictuff,Vesicularbasalt,Aphyricaugitebasalt,Weldedtuff(Rhyoliticigni mbrite),Augitebasalt,Augitetrachyte,Augite basalt. In some locations, particularly in the area of the upper reservoir, these rocks are covered with fluvio-lacustrine sediments. The entire volcanic sequence is frequently blanketed by thin, residual, subtropical later tic soils, which have been formed on hill and ridge foot slopes. As well, they are covered with thick, black, plastic clay deposits on the flatter areas and valley of Gilgel Gibe (Gibe I Dam EIA Document 1998). As per the same source the hills on the right side of the Gilgel Gibe River, downstream of the waterfalls, are mostly covered to an elevation of about 1,800 m a.s.l. by thick colluviums deposits together with deeply weathered landslide and/or rockslide material. The basic and sub-silicic volcanic rocks indicated above are of the Ashangi and Magdala Volcanic Group, and are considered the same as the Omo basalt (Miocene-Oligocene Age) and Jimma volcanites. In places these are overlain by younger rhyolite and rhyolitic tuff flows of Pliocene Age.The volcanic layers of the study area generally dip a few degrees in a southwesterly direction and are crossed by minor northeast to south-west and north-west to south-east fractures and faults. The former of these are related to the main tectonic alignments of the region, the Ethiopian Rift.

3.1.5. Soil

The soils of Gilgel Gibe Valley and the adjacent area are made up of Alfisol-type which is relatively fertile soils that have been formed in humid areas under deciduous forest cover. Soil color varies from red and brown through to grey and black. Textures Range from clay to lime-clay or sandy clay. Soils are black in the valley bottom (about 1,650 m a.s.l.), grey brown in the hilly strip (1,660-1,760 m a.s.l.) and red at higher elevations. The middle and high altitude soils are less rich in nutrient elements due to the fact that they have been exploited by man and have been subjected to weathering and erosion (Dawit Degefu,1969).

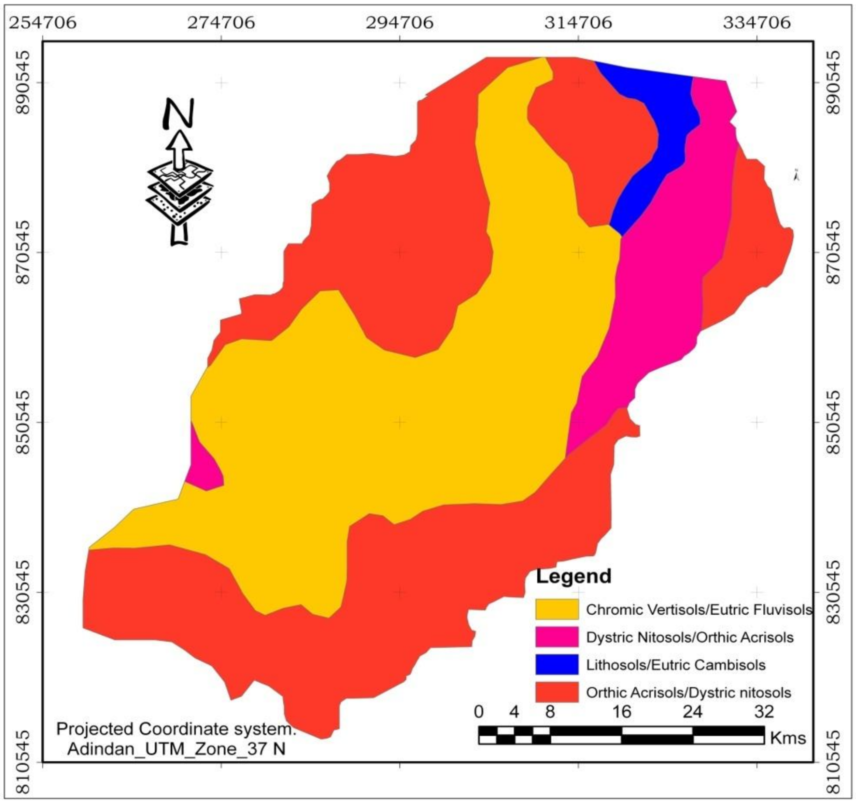

Figure 3.4 Soil Map of the Study Area

3.1.6. Hydrology

Only five sets of annual data (1967-1971) from the Deneba hydrometric station which is located near the dam site are available. The data are insufficient for providing an indication of long term average river flow. These data have been supplemented with the 26 years (1967-1992) of data from the Asendabo station upstream of the dam site. The mean annual discharge for the period between 1967 and 1992 is 36.8 and 50.4 m3/s for Asendabo and Deneba respectively. The discharge at Deneba corresponds to an annual runoff of 1,578 million m3 and a total rainfall volume over the corresponding catchments area of 6,485 million m3. Additional runoff reaches the river between the dam site and the powerhouse site including the Chilelo Tributary. However, while the tributary basin of the upper dam site is 4,225 kM2, the intermediate catchments is only approximately 130 km2 which is less than three per cent of the upper reservoir catchments. The contribution of this intermediate catchment is, however, important in regards to the biological impacts on this stretch of the Gilgel Gibe River (EELPA, 1996).

3.1.7. Vegetation cover

Gilgel Gibe valley has been home for variety of flora and fauna. There are different kinds of trees and grass species which covered the top escarpments to the valley floor. As per the phytosociological survey which was conducted on the feasibility study of Gilgel Gibe I project 1985.Moist evergreen forest is the major vegetation cover type of the study area. It also characterized by evergreen mountain thickets bushes and shrub and different type and family of grasses as well as trees.

3.1.8. Population and Socioeconomic environment

According to CSA (2007) the total population of the four Woredas which are found within the catchments area are about 89, 351.The area is predominantly inhabited by Oromo people same group of Yem and Amhara people are also found. As sited in Kassahun (2000) the dominant economic bases of the people are subsistence farming and livestock production. The most cultivated cereal crops include Teff, Sorghum and maize. Pulses, onions, cabbage, banana, enset as well as coffee are grown in most highland parts of the study area. Due to primitive Farming techniques the productivity of the Crops are low.

3.2. Materials and methods

In the present study both spatial and temporal data are gathered. These data were collected from both primary and secondary data sources. Primary data were generated from the analysis of satellite image, field observation, and the response of people affected by the project, agricultural officers, foresters and elders in the district using interview as well as FGD. On the other hand, secondary data were obtained about the study area from different sources. Besides, published materials including books, journals, research articles and census reports were reviewed. All this data were integrated in GIS environment.

3.2.1. Data Source

The pertinent data types gathered from their respective sources so as to conduct this study was given in table 3.2:

Table 3.2 .Data types and their sources

NO	Types of Data	Sources
1	Topographic sheets : 1:50,000 scale	EMA (Ethiopian Mapping Authority)
2	Mean annual Rain fall and temperature	NMSA(National Meteorological System Agency)
3	Soil type	FAO
4	Satellite imageries and their acquisitions date: •TM1990(date of acquisition Nov.,2000) and 30m resolution) • ETM+2000(date of acquisition Nov.,2005 and30m resolution) •ETM+2008 30 m resolution Nov., 2008	Down loaded from Internet site http://glovis.usgs.gov/
5	Demographic Data	Central Statistical Agency
6	SRTM(30)m resolution	GIS open source
7	GPS ground truth	Study area
8	Water born dieses case report data	Regional Health centers
9	Geological Data	EIA Document of Gilgel Gibe I Dam
10	Digital Photograph	Study area

3.2.2. Materials and Software

The materials required and software used for this research was:

- ERDAS Imagine 9.2: used for Image analyses.
- ENVI 4.5 used for Visual Interpretation and Image analyses.
- ArcGIS9.3: used for GIS analysis and mapping.
- IDRISI32 Release 2: used for GIS analysis.
- Global Mapper 11
- Other soft-ware used in this research includes Microsoft Internet, Word, Excel and SPSS.

- During field work Global Positioning System (GPS) receiver and Digital Camera were used to collect data from the field.

3.2.3. Methods

This section deals with the various activities involved in order to achieve the stated objective of this study .Besides methods and techniques used are also presented:

- Pre-field work
  - Organizing the Literature review so as to substantiate this study.
  - Geo-referencing, digitizing and mosiacking part of the scanned topographic sheet in order to delineate the boundary of the study area.
  - Digitizing of rivers and other features from the topographical map sheets that exist within the study area.
  - Down loading Land sat image from Global land Cover Facilities web site
  - 1990,2000 and 2008 Land sat Image processing and making unsupervised classification
- Field work
  - Gathering information from selected sample taken from displaced people due to the construction of Gigel Gibe I Dam.
  - Making Interview and Focused Group Discussion
  - Collection of Ground control points by using Garmin GPS
  - Making Focused group Discussion
  - Making Critical observation on the field
- Post- field work
  - Digitization of contours with 20 meters interval from 1:50.000 scale topographic map and generation of Digital Elevation Model (DEM) from SRTM and merging the two together.
  - Supervised classification based on the ground truth.
  - Making change detection between 1990, 2000 and 2008 Land sat satellite imageries.

- Besides, Land cover land cover change analysis was carried out using NDVI and post classification change detection comparative methods.
- Analysis of health and socio economic impact brought by the project

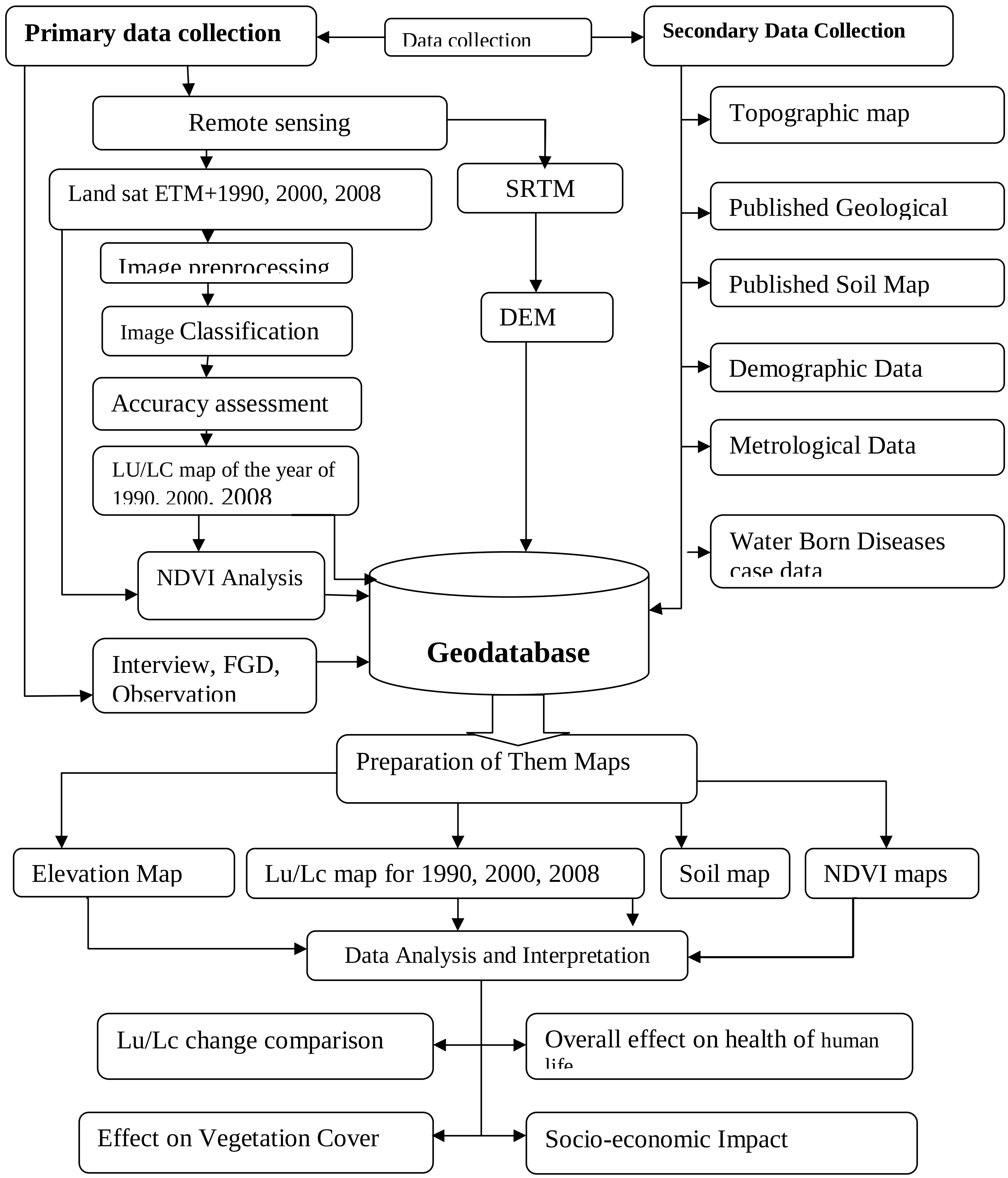

Figure 3.5 The General framework of the research methodology

3.2.4. Data Analysis

3.2.4.1 Image Processing and Classification

Image Processing

Digital image processing involves the manipulation and interpretation of digital image with the help of a computer (Lillesand &Kiefer, 1979). Satellite imagery has to be well processed prior to use for further applications. It is in fact essential to rectify the raw satellite image under the pre-processing stage such as geometric and radiometric correction. Image restoration also involves the correction of distortion, degradation, and noise introduced during the image processing. Image restoration produces a corrected image that is as close as possible, both geometrically and radio metrically, to the radiant energy characteristics of the original scene. To correct the remotely sensed data, internal and external error must be determined (Jensen, 1996).

In pre-processing phase, it is usually necessary to georeference the images on projection and datum that Ethiopia has already selected, UTM projection and Adindan datum. In this respect, all the images used which are in WGS 84 projection have been re-projected in to the country's datum and projection. This is mainly because datum and projection conflict would undoubtedly limit the use of various themes (layers) at time. In other way, if remotely sensed data are to be used in association with other data within the context of a geographic information system, then the remotely sensed data and the products derived from such data will need to be expressed with reference to the geographical coordinates that are used for the rest of the data in the information system.

Histogram equalization that is to apply a nonlinear contrast stretch that redistributes pixel values so that there are approximately the same number of pixels with each value within a range; haze and noise reduction with the view to overall reduce the amount of haze and noise from an input image were in general done so as to enhance the interpretability of the images. However, those enhancement techniques did not bring as such significant change consequently.

With regard to bands selection, all the bands that are present in each image are not used for land use / land cover classification. Depending on the nature of each band's application, some bands were selected. After attempting different band combinations by considering their specific applications, false co lour composite of band 4(green), 5 (red)and 7 (near infrared) of MSS (multi spectral scanner) and 2 (green), 3 (red) and 4 (near infrared) of TM and ETM+ were applied to classify the study area.

Landsat imagery is acquired in a very precise manner, to better emphasizes particular land cover aspects. Some of the parameters of this precision involve a scène radiometry, providing distinct characteristics to components of the image scene. These measures help determine what the images are good for, from a science perspective. For example, Bands 1, 2 and 3 are used together to approximate how the real world appears. Bands 4, 5 or 7 from ETM+ are used in combination with 1, 2or 3 to demonstrate vegetation conditions. It is sometimes necessary to convert the radiometric values from the initial at sensor measures, to compensate for atmospheric interference. Basic information that were used for image interpretation and band combinations for Land sat images as referred from GLCF site is provided in the table below.

Table 3.3 Landsat image Spectral Bands and their Application

Band	Band name	Application
0.45 - 0.56	Blue	-Soil and vegetation discrimination
0.52 - 0.66	Green	-Green vegetation mapping and cultural/urban features
0.63 - 0.69	Red	-Vegetated and non-vegetated mapping
0.76 - 0.90	NIR	-Delineation of water body -Soil moisture discrimination
1.55 - 1.75	MIR	-Vegetation moisture discrimination -Soil moisture discrimination
10.4 - 12.5	TIR	-Vegetation and soil moisture analysis -Thermal mapping
2.08 - 2.35	NIR	-Discrimination of minerals and rocks -Vegetation moisture analysis

Image Classification

The overall objective of image classification procedures is to automatically categorize all pixels in an image into land use / land cover classes or themes (Lillisand and Kiefer, 2000). Remotely sensed data of the earth may be analyzed to extract useful thematic information. Notice that data are transformed in to information. Multispectral classification is one of the most often used methods of information extraction (Jensen,1996).In classifying the images, supervised image classifications techniques was applied, and training site was established based on the ground truth taken during field work. Among different algorithms in the drop down lists of supervised classification, maximum likelihood image classification was utilized.

Post Classification Smoothing

According to Lillesand and Kiefer (1994) classified data often manifest a salt-and paper appearance due to the inherent spectral variability encountered by a classifier when applied on a pixel-by- pixel basis. To remove this one means of classification smoothing involves the application of majority filtering, smoothing the classified image with an operation of a moving window passing through the classified dataset and the majority class within the window is determined.

One way of discriminating changes between two dates of imaging is to employ post classification comparison. This kind of change detection methods identifies and provides where and how much change has occurred. It also provides to and from information and results in a base map that can be used for the subsequent year. In this approach, two dates of imagery are independently classified and registered. Then an algorithm can be employed to determine those pixels with a change in classification between dates. When evaluating the change detection made in this research against with the ideal scenario, the requirements stated by many authors are least met owing to in availability of satellite images that fulfill the standard. Change detection was carried out between the TM image taken in 1990 with30m spatial resolution with that of ETM+ 2000 and 2008 having 30m spatial resolution, eight bands including panchromatic only for ETM+. As the process progressed to finalize change detection, basic steps such as having identical land use/ land cover classification category in their order, adjusting varied pixel size into 30m were done. Upon completion of all the necessary steps, the two classified images were taken into GIS analysis of matrix in ERDAS software for making matrix of land use /land cover changes between 1990, 2000 and 2008.

NDVI Image Comparison

Spectral band ratio is one of the most common mathematical operations applied to multi-spectral data. Ratio images are calculated as the divisions of digital number values in one spectral band by the corresponding pixel value in another band. Based on the reflectance pattern of vegetation, different models of vegetation indices are developed to explain the healthiness, vegetation cover and biomass condition of vegetations. Various mathematical combinations of the Landsat channel 3(Red band) and channel 4(NIR band) data have been found to be sensitive indicators of the presence and condition of green vegetation. Among others, NDVI is the most common used index for forest vegetation biomass monitoring .The absolute value of NDVI for vegetation change analysis is between -1 and 1. The NDVI empirical analysis is computed using equation 1.

$$NDVI = \frac{NIR\ Band - R\ Band}{NIR\ Band + R\ band} \quad \ldots\ldots\ldots\ldots\ldots\ldots = \text{Equation 1}$$

Where, NIR=Image of Near-Infra Red,

R= Image of Red

As to vegetation conditions, NDVI values vary from1 to +1. Healthy vegetation yields have high positive NDVI values because of their relatively high reflectance in NIR and low in visible wavelength. Later on, after conducting NDVI analysis, the mean and standard deviations values are summarized using ERDAS Imagine9.2 software to evaluate the trends of vegetation cover change condition of the study area.

4. RESULTS AND DISCUSSION

4.1. IMPACT OF GILGEL GIBE I DAM ON THE SURROUNDING "ENVIRONMENT"

4.1.2. General conditions of natural vegetation cover

As can be indicated by the baseline information in the EIA document for Gilgel Gibe I Dam Moist evergreen mountain forests and the riparian vegetation with in Gilgel Gibe Watershed area are the major vegetation cover. Before the construction of the dam in pre 2000 the region didn't experience that much change in the vegetation cover. The area which is currently covered by the reservoir and downstream from the dam that extends about 16 Km was covered with the riparian forest and woody savannah. As it was evidenced from ETM+ satellite image of 1990 there was no apparent intrusion to the valley. Besides, the area which is currently occupied by the new settlers, which were previously resided on the current reservoir area, was once covered by natural vegetation.

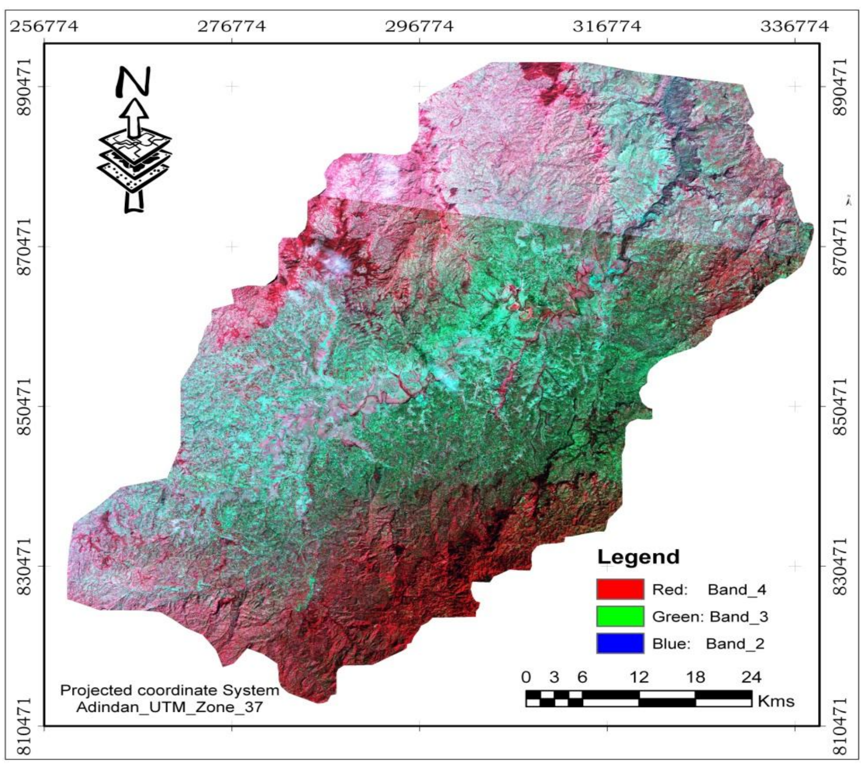

Figure4.1.RGB/432ETM+ satellite images of Gilgel Gibe watershed area 1990 with 30 meter resolution.

From discussion made with selected focused groups, the new settlement areas were exposed for deforestation for the purpose of fuel wood, for different construction purpose and farming activities. The reservoir has occupied the land area of about 60 km square hence clearing of vegetation cover had been occurred on this area. This can be directly observed on the archived land sat ETM+2008 satellite image.

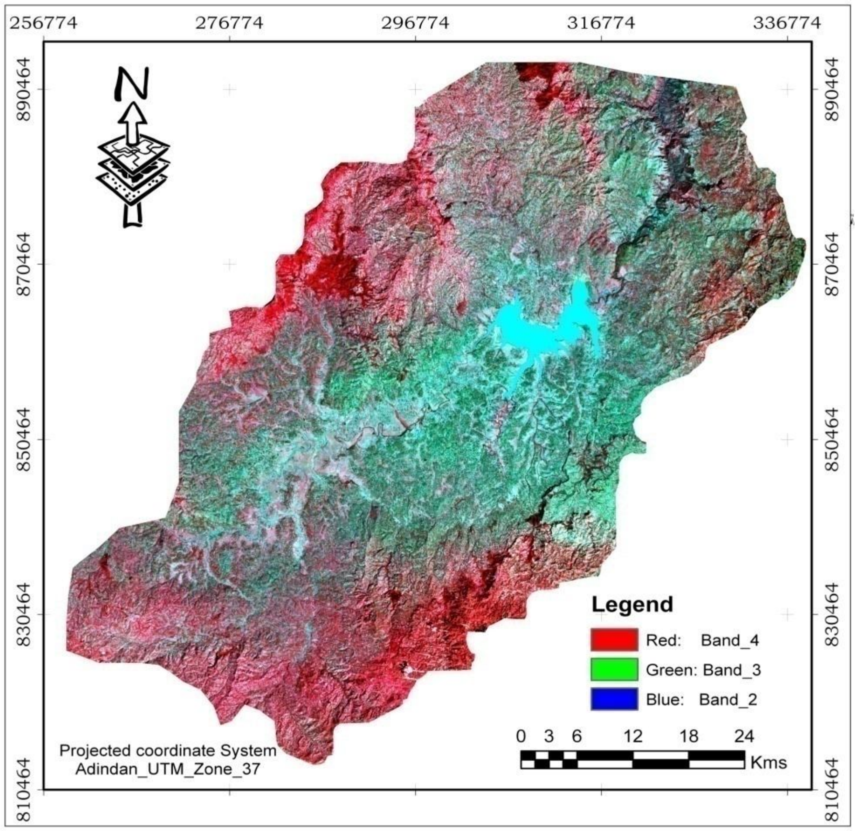

Figure 4.2 RGB/432ETM + satellite images of Gilgel Gibe watershed area 2008 with 30 meter resolution

As per the EIA report of the project the EMP established that the loss of riparian vegetation would have been compensated by creation of a buffer zone of over 10 Kms that encircle the reservoir and that extended on both sides of the river along the downstream, this zone should not be used among other things, for grazing and farming purposes. But according to the observation made by the researcher currently the buffer zone is used for intensive cattle grazing. From this point of view it is sound to say that the general condition of Vegetation cover of the area is getting deteriorated. Figure 4.3 shows the proposed 10 Km buffer zone around the reservoir which is supposed to be protected.

In addition, EIA required during the dry season a minimum release flow water of 1.1 m3/s. But release of water has not been made yet except during the rainy season (http://www.stopgibe3.org/pdf/The%20Gilgel%20Gibe%20Affair.pdffa,2008).This resulted in the drying up of the river in the downstream. Besides the Satellite image of land sat ETM+2008 clearly portray that those riparian vegetation along 16 km of the downstream are deteriorating. Hence, the vegetation cover of the proposed area was not recovered as it was previously planned

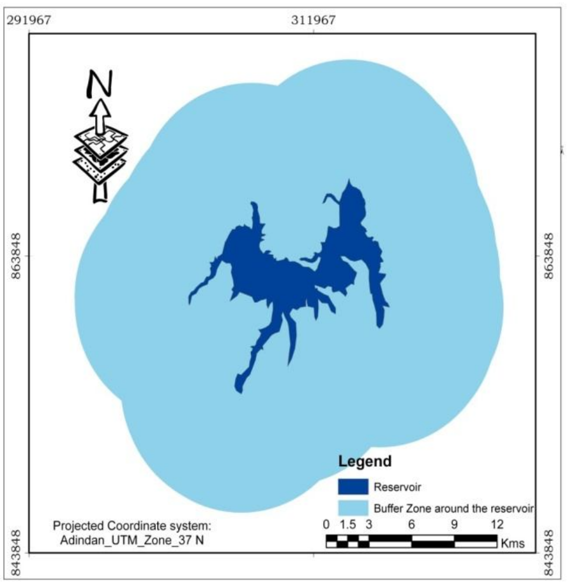

Figure 4.3 Ten Km buffer Zone Created around the reservoir

Figure 4.4 Land along the reservoir left behind from intensive grazing purpose

4.1.3 The Normalized Difference Vegetation Index

Normalized difference vegetation index (NDVI) is a method used to analyze vegetation cover of an area. NDVI can be calculated from reflected measured in the visible and near infrared channels form satellite based remote sensing. It shows the temporal and spatial change of vegetation cover. The difference between two images is calculated by finding the differences of each pixel in each image and generating an image based on the result.

The NDVI analysis of the 1990 TM Multi spectral scanner image of the study area reveals that there is more vegetation biomass/NDVI>O) as compared to the later years.

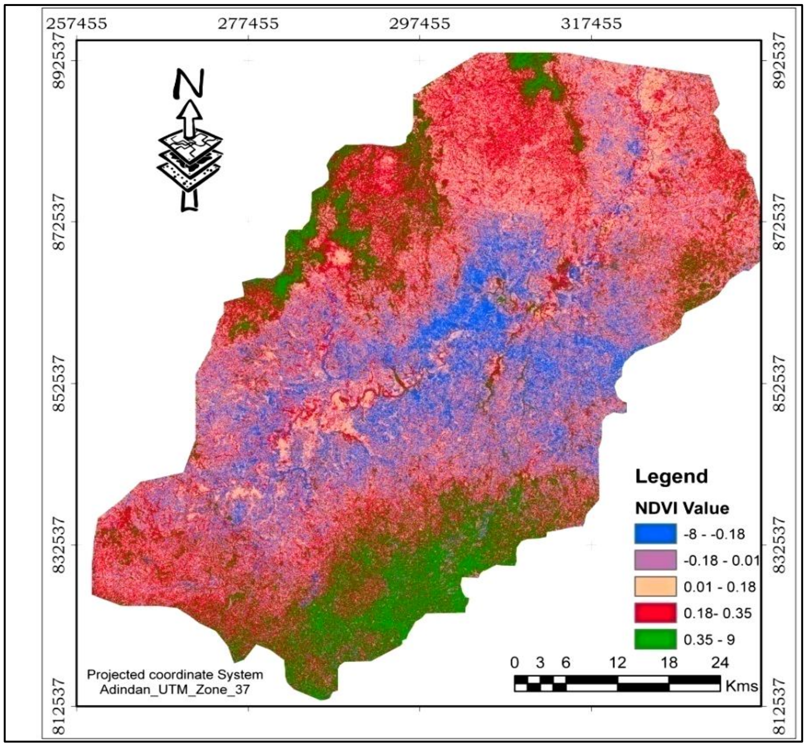

Figure 4.5 The Normalized Difference Vegetation Index results of 1990 TM image

The results of the Normalized Difference Vegetation Index of 2008 image shows lesser vegetation biomass compared to 1990 image. The construction of the dam is one factor which is responsible for such biomass decline. In figure 4.6 the colour that appears deep blue is the newly created reservoir after the dam construction. Besides the expansion of cultivated area and built up areas are apparent in the NDVI analysis. This area appeared to be purple and NDVI< 0.0. This means that many areas that were formerly under vegetation cover are turned up in to human made feature.

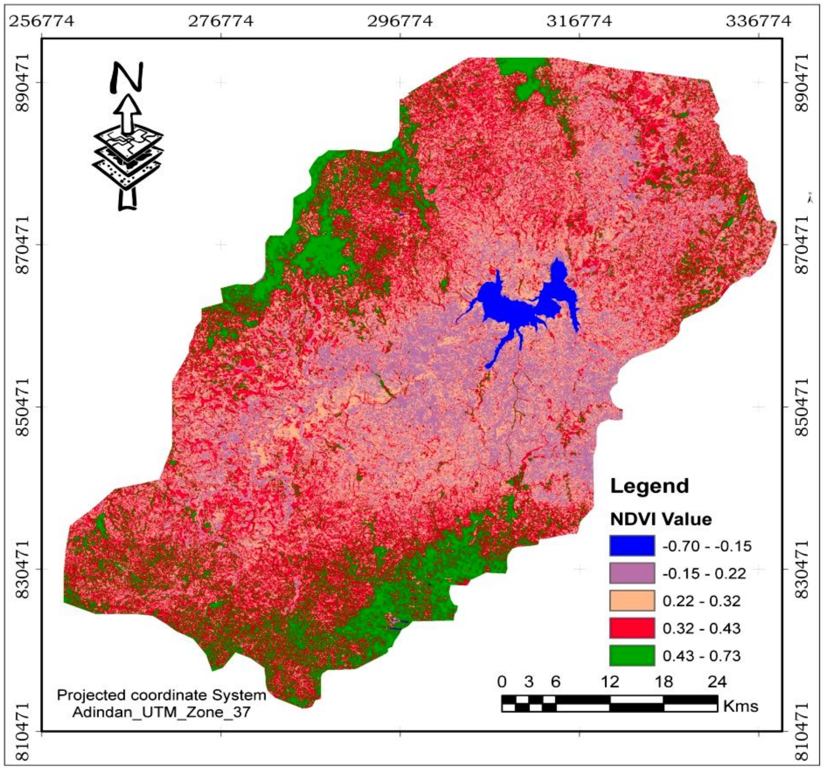

Figure 4.6 The Normalized Difference Vegetation Index results of ETM+2008 Image

Even though, the environmental management plan of the project tells us about the compensation for the vegetation clearance during the EIA preparation, the NDVI analysis of ETM satellite image which was taken during September 2008 was witnessed that the rehabilitation program is not as much as the expected.

Table 4.1The Normalized Vegetation Index result of the1990, 2000 and 2010 satellite images

Year	Land sat TM		Land sat ETM+			
	Mean	Standard Division	Mean	Standard Division	Mean	Standard Division
1990	86.4325	67.5673	-	-	-	-
2000	-	-	81.7561	61.0917	-	-
2008	-	-	-	-	66.5724	53.4218

Table 4.1revels that the mean and standard deviation of the 1990, 2000and 2008 image has been decreasing this is an evidence for the vegetation cover decline.

4.2. Distribution and pattern of changes in land use land cover of the study area.

4.2.1 Land Use Land Cover

One of the main purposes of this section of the paper is to analyze land use land cover changes that have been observed in Gilgel Gibe Watershed over a period of 18 years, and describe the possible causes and implications of these changes on the surrounding environment, community and the hydropower dam itself. For the purpose of observing the land use land cover change of the study area it is undoubtedly paramount important once to select major classes. Accordingly, only the most important major land use land cover classes were selected. These classes are forest cover, agricultural land, water body, built up and bare land. The selected major Land use Land cover classes and their description are given in table 4.2

Table 4.2.Selected major Land use Land cover classes and their description

Land use class	Description
Water Body	Areas completely inundated by Water and covered with River
Forest	Areas covered with natural and human made forest which includes highland and riparian forest.
Agricultural land	Land surface that is used for cultivation, including fallow plots, and left for Grazing
Bare Land	The area which devoid of plants and do not use for any purpose
Built up/Settlement	Includes Towns, settlement and roads

4.2.2 Land use Land cover of the study area in 1990

In this part of the discussion an attempt was made to see what kinds of lands uses land cover in the study area were found prior to the constructions of the dam. Hence, in order to come up with this aim the lands TM image of 1990 had been used. As per the results obtained from image classification 59.64 % of the land were covered with Forest, agricultural lands accounts about 20 %, 6.6% of the land were covered with built-up, 12.65% of the land were covered with bare land and 1.08 of the area was covered with water which takes a negligible percentage share as compared to the other land cover classes in the study area (Figure 4.8 & Fig 4.7).

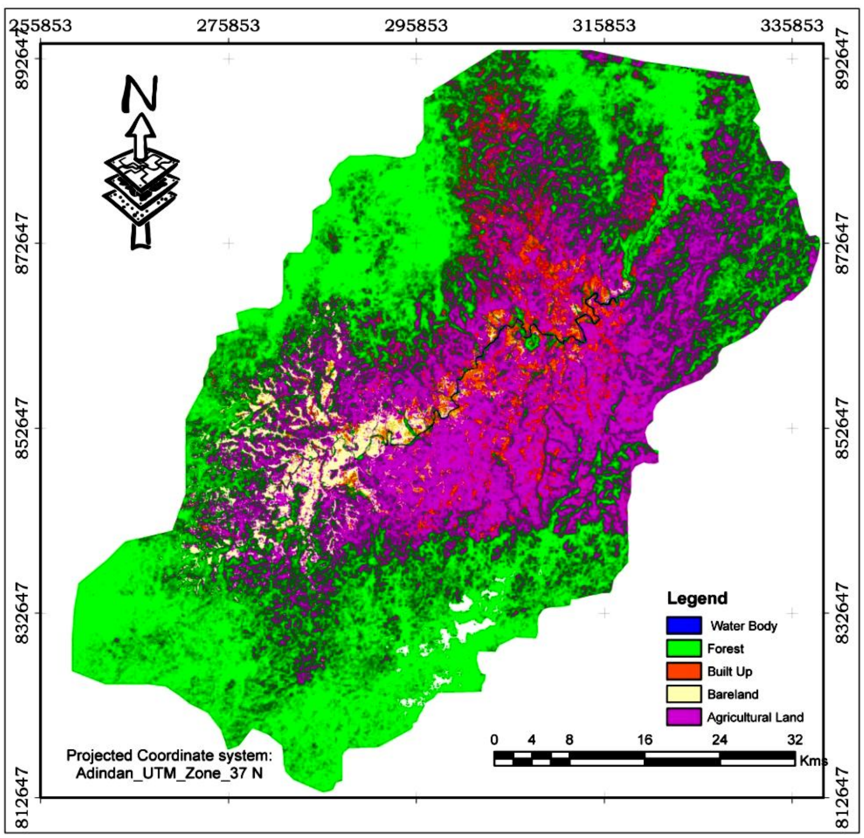

Figure 4.7 Lands use Land cover map of 1990

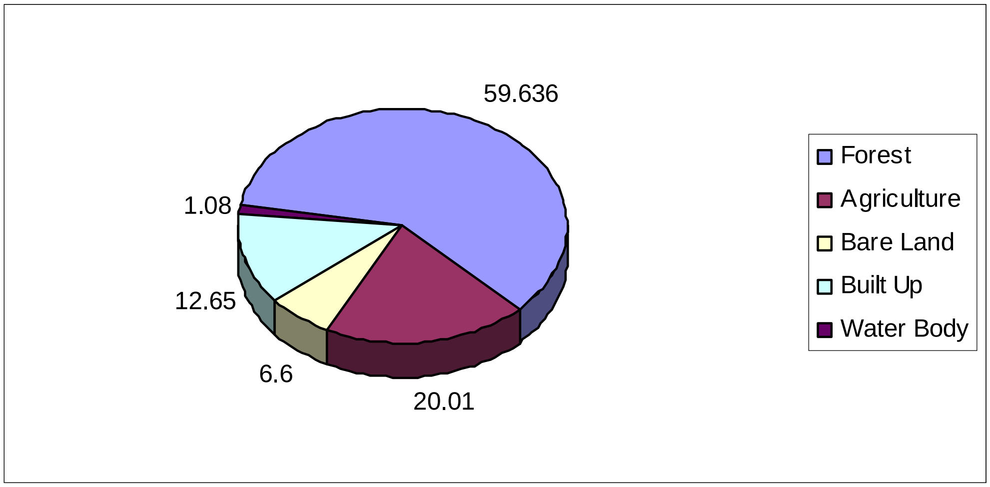

Figure 4.8 Proportion of 1990 Land use Land cover classification

As can be seen in figure 4.8 the dominant land use within the study area in 1990 was agriculture land and forest cover. Along the Gilgel Gibe valley riparian forests were identified from the image. According to the information obtained from unstructured interviews made from the local people. This forest provides a source of fuel wood, building materials and other materials used for a variety of domestic requirements. In addition, no large water body except the river was identified. The human made features in the area were composed of Towns, small villages, roads, and ponds are observed on 1990 classified image of land sat TM.

4.2.3. Land use Land Cover of the study area in 2000

During this time the dam had been under construction for about three years. As can be seen form Land sat ETM+ image of 2000 some artificial developments have been observed following the construction of the dam (see figure 4.9). As it is evidenced from the classified image 43.59 % of the study area was covered with Forest, Agricultural land accounts about 27.08%. In addition, the percentages share of built up was about 18 %.And 0.78% and 9.82% of the area were covered with water body and bare land, respectively (figure 4.10).

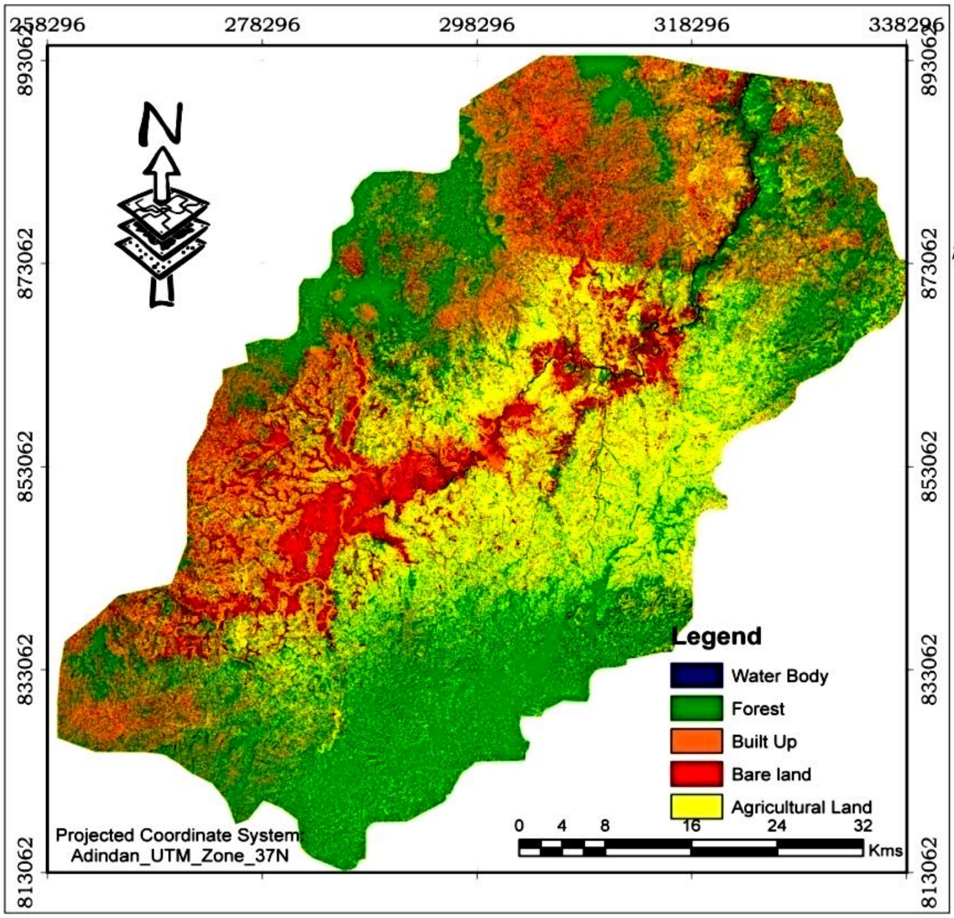

Figure 4.9 Lands use Land cover map of 2000 image

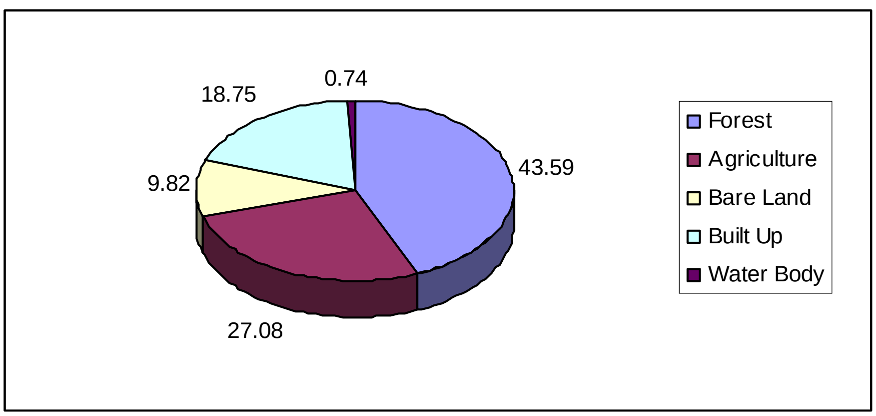

Figure 4.10 Proportion of 2000 Land use Land covers classification

4.2.4. Land use Land cover of the study area in 2008

It is an obvious fact that things are always in the state of dynamic change. For all these to happen both nature and human beings are responsible. For most development endeavor in most cases development induced change can never be avoided. The question is how we sustainably act on our environment.

In order to see what environmental change had been seen for the last 18 years and to come up with the cause and its implication in this part of the theses the land use land cover map of 2008 is presented. It is sound to see the recent condition of the land use land cover of the area after the construction of the dam. Hence, this will give us a chance to see the effect of the construction of the dam and what remedial actions were proposed. To see the gap between what was proposed and what is actually implanted.

During this time the reservoir occupied about land area of nearly $60km^2$. Clearing of all large forms of vegetation within the reservoir area of Gilgel Gibe I dam had been occurred. In addition new built up area were introduced. In the southern parts of the region due to the resettlement program areas of agricultural land and settlements were expanded. Due to this expansion the new settlement areas were exposed for forest encroachment, this is one main reason for the decline in the forest coverage in the study area. In addition some areas which were previously used for grazing land, cultivation and settlement were removed and replaced by the newly created reservoir. Hence the constructed Dam had both on sight and off sight impact.

According to ETM+ 2008 the percent share of the water body was 2.46%. The forest cover contributes about 31.13%.Besides, Agricultural land covered about 32%.Due to increase in the number of population and expansion of settlement areas the percentage share of built up areas increased to 27.34% in the region (Figure 4.11 & 4.12).

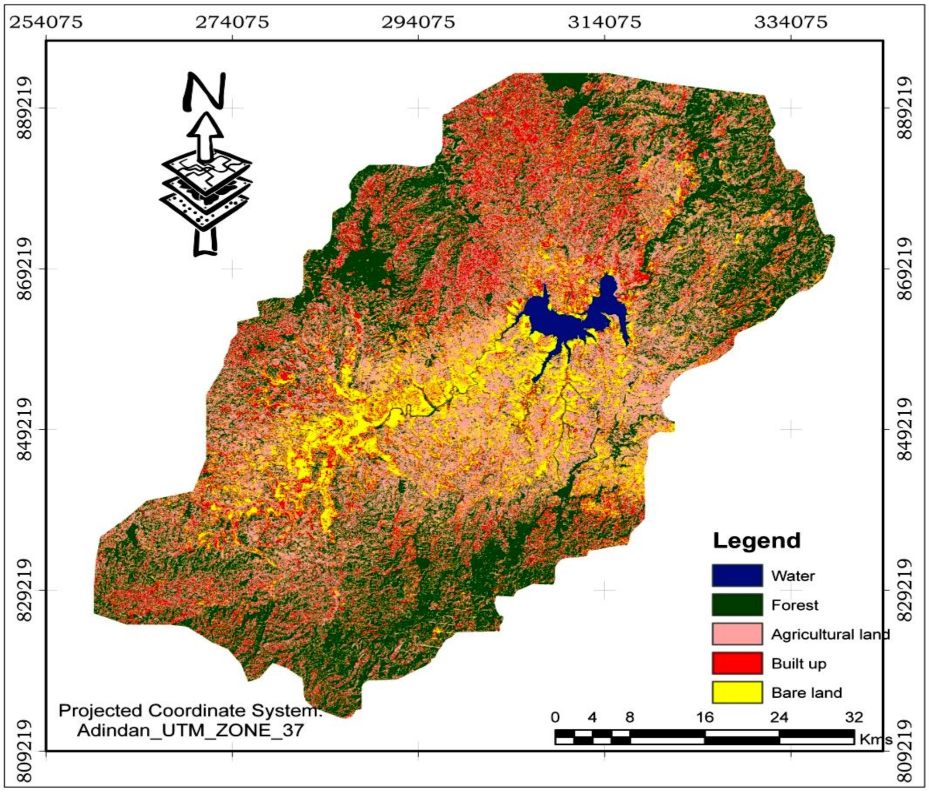

Figure 4.11 Lands use Land cover map of 2008 image

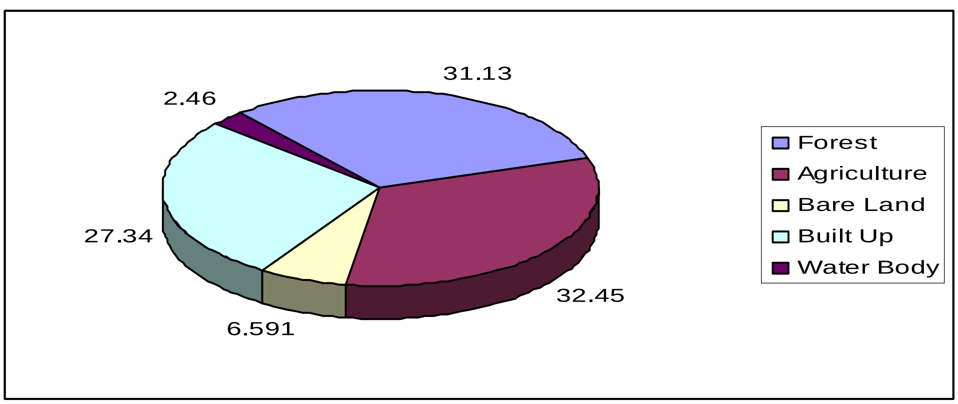

Figure 4.12 Proportion of 2008 Land covers classification

Generally, as observed, there has been land use land cover change in the study area this is due to both human made and natural factors. The construction of the dam has facilitated the alteration of the ecosystem and brought changes in the land use and land cover of the study area.

4.2.5. Land Use Land Cover Classification for 1990, 2000 and 2008

The major land cover classes for 1990, 2000and 2008 are quantitatively analyzed for the area covered by each land cover unit. Generally there was a continuous land cover change took place for most land cover types in those18 years and the results are given in Table 4.3.

Table 4.3 Result of the classification for the three periods

Land Cover types	Area for 1990 (ha)	1990 Area in %	Area for 2000 (ha)	2000 Area in %	Area for 2008 (ha)	2008
Forest	214,654	59.636	156,933	43.59	112,079	31.13
Agriculture	72,030	20.010	97,479	27.08	116,836	32.45
Bare Land	23,785	6.60	35,366	9.82	23,725	6.591
Built Up	45,567	12.65	67,508	18.75	98,447	27.34
Water Body	3,917	1.08	2,667	0.74	8,866	2.46
Total	359,953	100	359,953	100	359,953	100

For a clear and informative comparison of the land cover change area value for the three periods including 1990, 2000and 2008 are given with each land cover class area value in hectare and percentage share for each of the area covered. Further, chart 4.13 was analyzed to give briefly the tabular information (Table 4.3) and it shows the land cover distribution for the aforementioned three years.

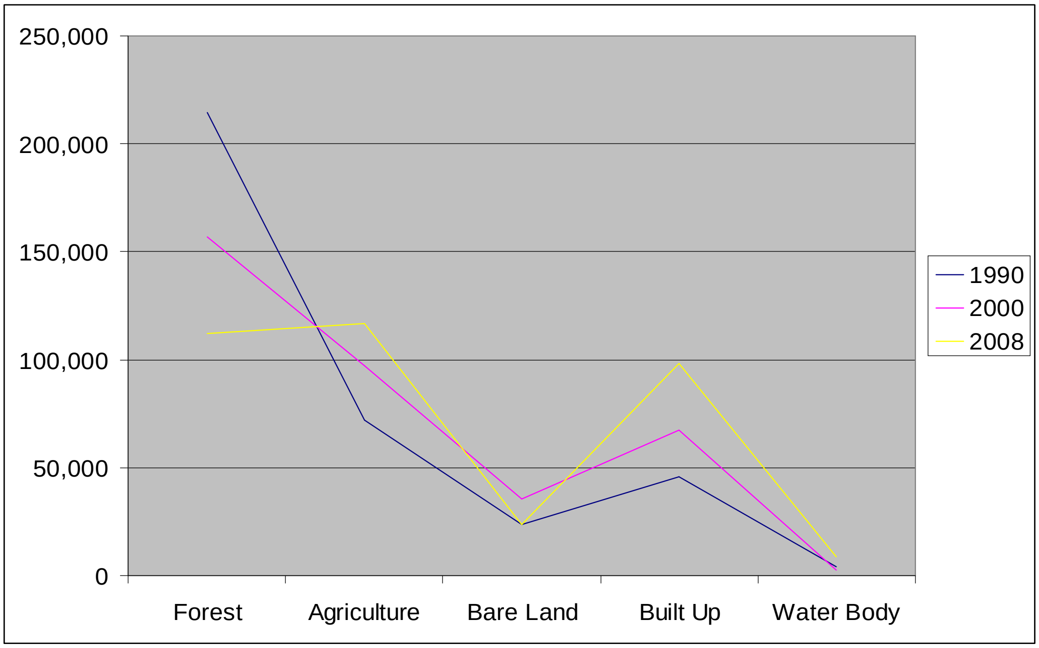

Figure 4.13 Change of Land Use Land cover for the three years

As can be seen from figure 4.14 the percentage share of forest cover had been declined for the last 18 years, whereas agricultural land and Built up shows an increment trends. Besides from 1990 to 2000 the contribution of water body shows slight decline but in 2008 its percentage share shows an increment trend this is because of the creation of an artificial lake behind the Gilgel Gibe dam I.

4.3. Land Use Land Covers Dynamics

4.3.1. Rate of Land use Land Cover Changes

The land cover dynamics for the past 18 years which are given in the above thematic Land cover maps are discussed below with various statistical analyses and cover change comparison factors. Generally, the land cover change from 1990 to 2008 has been discussed in two periods. The first period has 10 years of gap i.e. from 1990 to 2000 and the second period is from 2000 to 2008 that has 8 years of gap. The cover dynamics discusses the rate of land cover change from 1990 to 2000 and 2000 to 2008. Table 4.4 clearly shows the land cover change rate for the past 18 years.

The rate of change was calculated for each land use land cover using the following formula:

Rate of change (ha/year) = (X-Y)/Z

Where X = Recent area of land use/ cover in ha.

Y = Previous area of land use/ cover in ha.

Z = interval between X and Y in year

Table 4.4 Summary Statistics of land use / land cove rate of change from 1990 to 2008

Land Cover Class	1990 to 2000		2000 to 2008	
	Area change(ha)	Rate of change (ha/yr)	Area change (ha)	Rate of change (ha/yr)
Forest	-57,721	-5,772.1	-44,557	-5,569.63
Agriculture	25,449	2,544.9	19,357	2,419.63
Bare Land	11,581	1,158.1	-11,641	-1,455.1
Built Up	21,941	2,194.1	30,939	3,867.38
Water Body	-1,250	-125	6,199	774.88

Comparison of the land cover changes for the past 18 years clearly shows that water body and bare land cover shows little change as compared to the others between 1990 and 2000 year whereas agricultural land and built up shows medium change but forest lands shows higher negative change in the same time. For the time of 2000 to 2008, agricultural, built up and water body shows the positive change and forest and bare land shows negative change (Table 4.4).

Agricultural land and built up areas shows a continuous increment for the past 18 years with a rate calculated for the first period 1990-2000 2,554.9 ha/yr and 2,194.1ha/yr, respectively and for the second period for 2000-2008 2,419.63 ha/yr and 3,867.38ha/yr respectively. In addition forest cover shows a decline trend, during the first period it declined by -5,772.1 ha/yr and during the second period forest coverage decline by -5,569.63 ha/yr .This rate of change is one of the highest among other types of land use land cover class. Agricultural land and built up expanded at the expense of forest cover (Table 4.4).

Finally when we see the area coverage change rate of water body, as per table 4.4 during the first period from 1990-2000 it shows a decline trend by-125 ha/yr where as during the second period between2000-2008 it showed an increment rate by 774.88ha/yr. This is due to the creation of a big reservoir behind Gilgel Gibe I Dam since 2003.

The following graph in Figure 4.16 helps for comparison of the cover dynamism for 1990, 2000 and 2008 year.

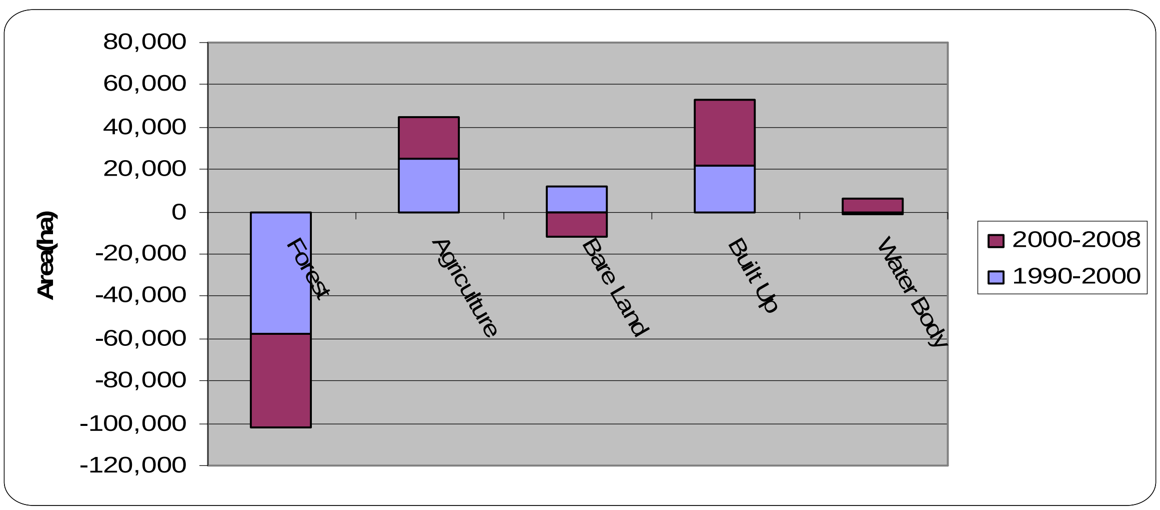

Figure 4.14 Land use Land cover dynamics for the two period's between1990 and 2008

4.4. The condition of water born related disease in the pre and post development of the dam.

Among much health related problems brought by dam construction water borne diseases may put in the first place. According to the EIA document of Gilgel Gibe I it was stated that the reservoir will lead to an increased potential for water borne disease. As per the same source, the reservoir would be suitable for the transmission of three main types of parasitic infections namely malaria Onchocerciasis (river blindness) and bilharzias (Schitosmomiasis). The transmission vectors of these to humans involve a vector or intermediate host linked to the presence of water.

In addition, the reports of Jimma zone health office (2005) confirm the endemic nature of malaria and the presence of bilharzias and reviver blindness in the area. The researcher also family believe that, gently sloped perimeters together with the creation of the reservoir can provided ideal conditions for the vector responsible for the transmission of malarial and bilharzias and it has exacerbated the situation.

Currently, there are three health centers in the study area which are relatively adjacent to the reservoir. Namely Sekoru health center, Asendabo health center and Deneba Clinic. Deneba clinic is very near to the reservoir than the other centers. Malaria case data was collected from these health centers. According to the data obtained from these health centers, Malaria cases were increased from 2004 year on wards. This is the time when the reservoir had accumulated huge amount of water. From unstructured interview made with local elders and health workers, the accumulation of water in the reservoir had been facilitated the spread of malaria in the surrounded area. In 2008-09 slight decline in malaria had been recorded (Fig 4.17)

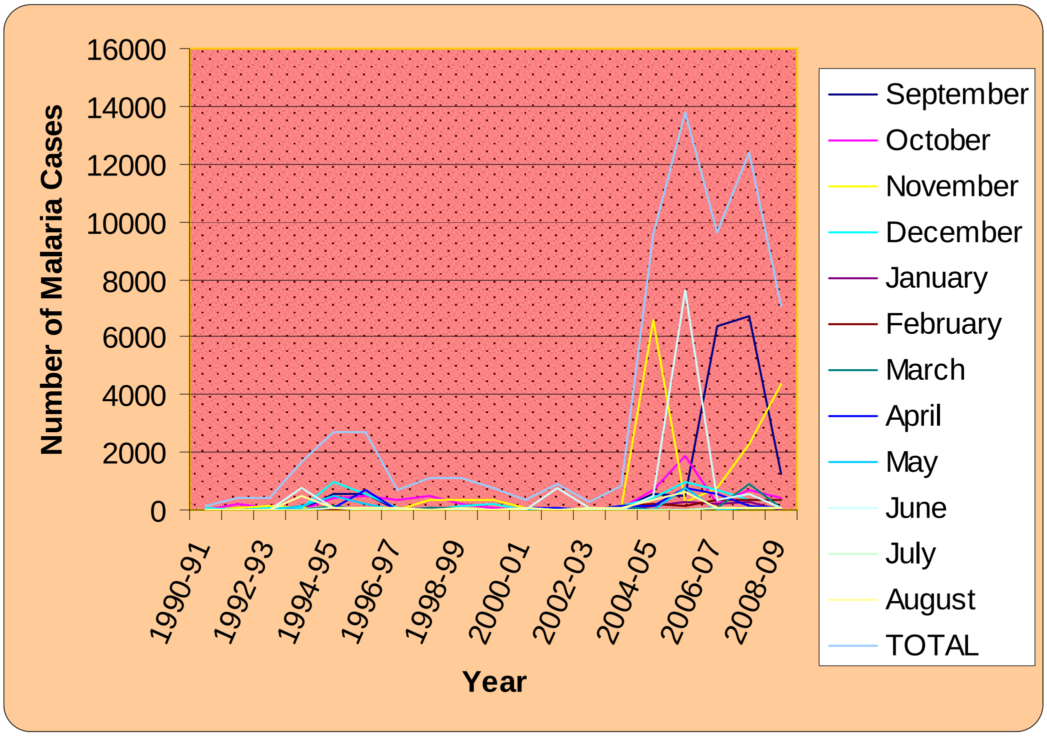

Figure 4.15.Graph showing Malaria cases in Deneba, Sekoru and Asendabo health centers during the years 1990-2008

According to Figure 4.17 Malaria is a real health threat in the last two decade. The existing environmental condition together with the creation of the reservoir could be a factor behind the problem. In addition, the fluctuation in malaria cases records arises from the inconsistent use of anti-malaria chemical sprays in the region. As can be seen from figure 4.17 the cumulative reported data of the three health centers witnessed a decline in malaria cases from1995 to 2005. But after 2004 there was a dramatic increment, as recorded.

The zone office for malaria control at Jimma has indicated that malaria is endemic in the study area. The main transmission season is between Septembers and November. Plasmodium Vivax is the dominant malaria species. The major mosquito vector is Anopheles Gambia. The accumulation of water in small ponds facilitates for the spread of malaria case let alone a creation of a large reservoir that covers an area of 60 km square.

As indicated by the results of the seasonal blood surveys and subsequent classification the area was put under the zero round spray category (Assefa, 2008). Nevertheless, the same source indicated that all malaria cases increase significantly after the creation of the reservoir since 2004.

The environmental modifications create a fertile ground for some insects and pathogenic organisms which give birth to the spread of disease (Assefa, 2008).The classic example here is the creation of the reservoir and increasing in the malaria cases records as indicated in fig 4.17.It is found out that there is a positive correlation between the expansion of the reservoir and malaria cases.

EMP of the project proposed mitigation measures for infectious water-borne disease through caring out periodic screening at the nearby health clinic on the samples of the resident population to evaluate any cases of infection and to take a remedial action. But the result from data obtained from the nearby health centers and other research outcomes portrayed malaria cases are still a real problem in the area.

4.5. Socio-economic impacts of a hydropower reservoir in Gilgel Gibe watershed area.

This section of the paper analyze the social and economic changes brought as the result of a hydropower reservoir since its inception in the surrounding environment , and explains the possible causes and implication on the community. In addition an attempt was made to monitor the mitigation measures taken as per EMP of the EIA document of Gilgel Gibe I Dam. For this Semi structured and structured interview, checklist were used. And Focus Group Discussion with key informants was also made. Figure 4.18 shows places where representative samples were selected.

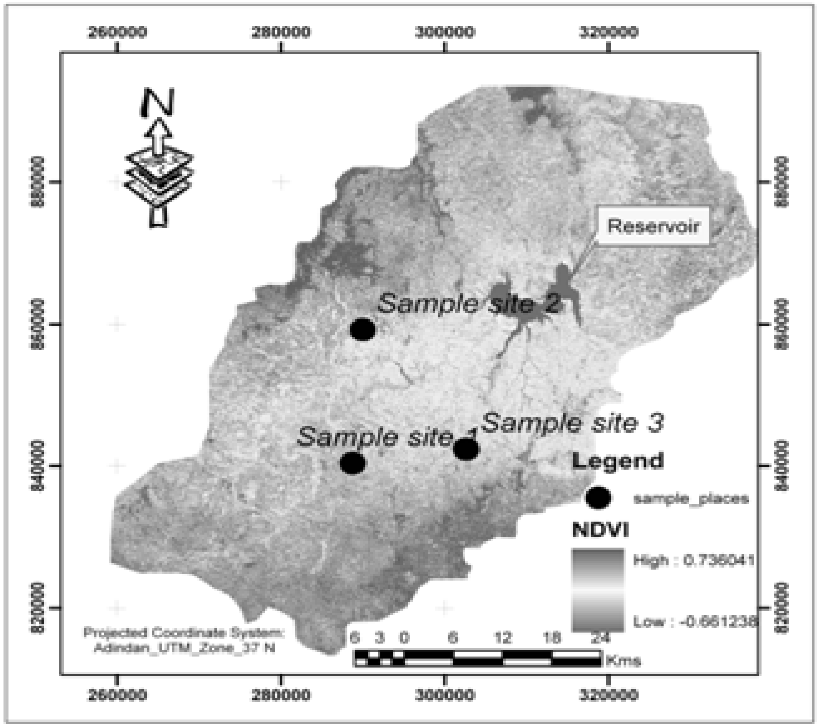

Figure 4.16 The location map of Respondents sample site

The three sample sites are selected from resettlement area site 1 known as Bore, site 2 is Bulbulla and site 3 is Degosso peasant association. 40 sample unite were selected randomly from each site. Totally 120 household respondents were taken from the three sites.

4.5.1. Demographic characteristics of the Respondents

The demographic characteristics of the respondents are indicated in table 4.5.On average the interviewed households consisted of 6.9 persons. The majority of the family heads were men (75%).Out of this 25% of them were without any formal education, while 43% and 32% of the respondents got primary and secondary education, respectively. The present improvement in education facilities in the area had created better education opportunity for young people.

Table 4.5 The Demographic characteristics of selected sample respondent

Characteristics	Description	Percentage
Sex	Male	62.5
	Female	37.2
Age	(Young) (18 -30yr)	54
	Middle (31-55 years)	28
	Old (>55 years)	16
Education	No enrollment/Illiterate	25
	Primary (1-6)	43
	J/ secondary (7-8yr)	20
	Secondary (9/12y)	12

Source: Survey Result

4.5.2. Displacement, resettlement and compensation

The failure to recognize people as partners in the planning process is a major characteristic of dam construction in Ethiopia (Dessalegn, 2002). Consequently, the construction of dams has caused community relocation against their will. Dams often inundate large area, force many people to relocate, and disturb socioeconomic and cultural systems. Examples are the Gilgel-Gibe hydropower dam that has relocated about 2, 474 families representing 15, 351 people (WRDA, 1994), According to the same source an area of approximately 60 km2 inundated and this affected 18 kebeles belonging to 4 Weredas. Those people who were living in these places have abandoned their homes as well as the land they used for agriculture and grazing. According to the information obtained from respondent almost all resettles were dislocated involuntarily and they were encountered many problems. The survey result indicated that 73.83 % of the respondent lost their agricultural land, 54% of them lost grazing land, all of them lost their homes and 29.1% of them lost other means of livelihood.

Table 4.6 Problems encountered by respondent during Resettlement Process

Problems	No of respondent	Percentage
Loss of agricultural land	85	70.83
Loss of grazing land	65	54.1
Loss of homes	120	100
Means of livelihood	43	29.1
Psychological and economic stress	92	72.6
All the above mentioned	102	85

Source: Survey Result

Regarding the respondents attitude towards the compensation, information showed that the majority of the resettlers had dissatisfied by what they had been compensated (Table4.7).No balanced compensation for the loss of physical properties and agricultural resource on their land holding as compared to their previous one had been obtained.

Table 4.7 Peoples attitude towards resettlement and compensation Process

Number of Respondent	Attitude	Percent
13	Satisfied	10
83	Dissatisfied	69.16
19	No Response	15.84

Source: Survey Result

The information obtained from the interviews ,Key in formant and FGD indicate that land compensation was made far away from their previous place and was not preferred by the displaced people . The example below reminds us the situation about the compensation:

> *"A house hold leader named kuma, he had owned 40 hectares of fertile land before his land and his previous village was inundated due to the construction of Gilgel Gibe I*

dam. After inundation he was forced to resettle involuntarily. The new land holding became smaller in size and less fertile compared to the lands inundated. He had received compensation payment which is very much less than what he had lost including other agricultural resource and asset he left behind."

As per the information obtained from the respondent they had been given 2 ha of land compensation for all displaced people regardless of their previous land size. On the EMP of the project it was stated that the area to be resettled is sufficient in size and agriculturally and socially suitable. Based on the information obtained from the respondent land which was compensated for the resettles(2h regardless of their previous holding)were couldn't much with mitigation measures proposed on the EMP of the project. In addition from the interview made with one respondent by the name of Kuma as stated in the above paragraph shows the fertility of the current land is less fertile than the previous land he had hold. This implies that there is a discrepancy between the impact created by the reservoir and the mitigation measures taken.

4.5.3 Loss of livelihood

The construction of dam can bring loss of livelihood. In order to see the impact it is sound to make comparison between the Environment Management plan in the EIA document of the project and with the information obtained from the respondents. In EMP of the project document it was stated that:

> *"There should be no loss of livelihood for the population to be relocated. The government has a full flagged plane to provided a resettlement site that is equal in size and quality to the land that they currently use. All people will be able to continue with their means of livelihood".*

As indicated in table 4.6 out of 120 respondents 43% of the respondents were lost their means of livelihood. The result from the information obtained from the respondent indicated that there is a gap between what was proposed and gained by the settlers. Hence there is a need to make appropriate compensation measures in order to rehabilitate the displaced people.

4.5.4 Loss of Agricultural resource and Food production

According to the survey result about 90% of the respondents were lost their agricultural assets and resource which were found on their previous land holding due to the resettlement process. In additions , due to poor yield on their current land holding and the average crop productivity has been declined .The key informant also pointed out that quality and size of their current land is the primary cause for decline in crop production. In addition the information obtained from other previous study can go concomitantly with field survey.

As per the report by Dessalegn(2002) there was loss of about 6,138 metric tons of food and grain per annum due to the resettlement processes. Besides, paddy, wheat and maize alone account for 5,400 metric tons. The removal of about 8.600 ha of cultivable land resulted in decline agricultural production and possibly a consequent increase in pressure on the surrounding land.

5. CONCLUSION AND RECOMMENDATIONS

5.1. Conclusion

So as to see the possible environment impact of the dam some parameters were selected some of the Geographic Information System and remote Sensing technologies were also used. Accordingly, it is found out that the Gilgel Gibe watershed area has been adversely affected since the construction of Gilgil Gibe I Dam. Generally the project has both positive as well as negative impacts on the environment.

During the construction time mitigation measures were proposed on the EMP of the EIA document of the project in order to minimize if possible to avoid the negative adverse impact brought by the project since its construction. But some gaps were identified.

There has been large scale vegetation reduction observed. The mitigation measures taken didn't respond to compensate sufficiently for the vegetation clearance taking place in the study area. The NDVI image analysis of 1990, 2000 and 2008 ETM+ image shows that vegetation biomass has been diminishing. The intensification of agricultural land, emergence of built up and the development of dam have been working behind for such decline. There are efforts made by EELPA to rehabilitate the forest resource. But the amount and rate of deforestation on one side and the reforestation and afforestation programs on the other side are in comparable in any measure. In line with this loss of vegetation cover is responsible for the progress of runoff and accelerated soil erosion this intern exacerbated the problem of siltation in the reservoir. This again put the future life of the reservoir in question.

In addition the result of land use land cover analysis portrayed that there was a continuous land use land cover change for the last 18 years. Based on the analysis five land cover classes was identified .These include Forest cover, Agricultural Land, Bare land, Built up and water body. The post classification analysis revealed that from 1990 to 2000 among others forest coverage declined were as built up and agricultural land were increased .Besides from 2000 to 2008 the same trend was observed for the above aforementioned three classes but the coverage of water body shows an increment trend because of the creation of reservoir behind Gilgel Gibe I Dam.

Records of water born related disease taken from Asendabo, Deneba and Sekoru health centers with particular emphasis on malaria Case portray that there have been an increasing malaria cases following the construction of the Dam. There is positive correlative between malaria cases and accumulation of the water in the reservoir. Although the mitigation measures taken and the improvement of health facility has improved the situation, the number of patients boost up by a large number. This shows there is still a need to make plausible measures in order to responds for the problems associates with water born disease.

The information obtained from FGD, unstructured interview made and response from 120 sample respondent specifically those who were victims of displacement showed that. The project has brought an adverse impact on the socio-economic status of the society. Such as people were resettled involuntarily, they lost their agricultural and grazing land. Besides, the settlers also lost their means of livelihood and other agricultural resources. Resettlers were compensated with 2 ha of land regardless of their previous land holding. In addition the respondent also stressed that the size and quality of land is not equivalent with their previous land holding.

In the nut shell, despite the positive consequence of the project, it has a negative impact on environmental component. Especially, on vegetation cover, land use land cover, health and socio-economic .But this does not, in any way, mean that the problems out weight the benefits. Mitigation measures were taken to avert the negative impact created by the project but still there is a need to undertake a periodic environmental impact monitoring to minimize the impact and so as to ensure sustainable development. If the current trends keeps on the problem would get more complex and difficult to reclaim. Thus, urgent attention should be given for environmental rehabilitation and conservation.

5.2 Recommendations

- Had this research been done in comparison with the no project scenario in other similar watershed area it would have been possible to exactly quantify and see exclusively the impact of dam from other factors. Hence, those people or institutions who are engaged in these kinds of research topic are recommended to see the no project scenario for a better out comes.

- Community participation in any project development and in environmental rehabilitation program must be given top priority.

- There is a need to undertake a continuous environmental monitoring within reasonable period of time by the concerned body. Hence, those human educed environmental problems can be reduced before they become worse.

- GIS and remote sensing techniques are found to be suitable tools for environmental impact assessment and monitoring, thanks to the technology, hence it is highly recommended to intensively apply these techniques.

- There is a need to release the proposed amount of water (1.1m3/s) from the dam as the result the riparian vegetation and the aquatic life can be saved down to the dam.

- In addition to disease controlling strategies, research based preventive approaches should be adopted so as to mitigate the escalating malaria and water born disease case records and their far reaching impact on production and productivity.

- The environmental considerations should not be disregarded in any way and with any justification seeing that well organized environmental management positively contribute for better productivity and sustainability.

- The rehabilitation of devastated vegetation biomass should be given first line attention as it helps to maintain the soil, water, climate and biodiversity of the area.

- There should be well organized and effective afforestation and reforestation programs to reestablish the ecosystem. Some areas like the surrounding escarpments, river side's, agriculturally non suitable and marginal lands can be delineated and protected as the forest area.

- Finally this research paper focused on four environmental parameters among others hence, it is recommended to consider other uncovered parameters by other researchers.

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Appendixes-1

Household survey Questionnaire

Post Resettlement Impact on natural and Socio-economic environment around Gilgel Gibe watershed area

This questionnaire is developed with the objective of assessing and or monitoring the natural and socio economic impact brought by Gilgel Gibe I dam construction on the surrounding environment .

The questionnaire contains three main parts. And under each part different sections are included. Moreover a general objective is specified to each part.

Part I House Hold profile

Objective;

The main objective of this part is to assess the Demographic characteristics of the household,

Part II Resettlement Issues

Objective;

The main objective is to assess the impact of the resettlement on the dislocated population.

Part III Socio – Economic Issue

Objective

The main Objective of this part is to assess the socio- economic impact brought by the project.

Post resettlement Impact on socio – economic environment around Gilgel Gibe watershed area

Questionnaire No ___________

Survey Area: Region __________________ zone ______ Woreda ______

PAs____________________ Village_____________

Respondent's Name ______________ Age ____ sex___ Educational Status ___________

Position in the House hold ______________ position in the village ______

Interviewer's Name _____________ Date of Inter view__________

Part -I- Household profile

Section A. Demography

1. How many are you in the household? _______________

No	Name of the HH	Sex Male =1 Female =2	Marital Status (code a)	2 what is Your responsibility In the HH? (code b)	3 what is The educational status (code c)	4.whatis his / her Occupation (code d)
1						
2						
3						
4						
5						
6						

Code a   single -1; Married - 2; divorce -3

Code b   father =1; Mother 2; daughter = 3; son = 4; relative   =5; other

Code c Illiterate =1; grades + 4=2; grades 5-8=3 grade 0-12 =4; above (specify) =5

Code d farming =1, artesian =2 commerce =3; daily laborer=4; other =5

Section –II- Resettlement Issues

2. did you or your family have been displaced from you former residence? Yes ____1, No________

No	1 Name of the person who went for resettlement	2 To which area?	3 when the years ?	4 what was the cause for resettlement (code a)	5. Returned or not? Yes 1 No.2	6.what was the reason for the return (code b)	7 Got A Land yes -1 No-2	8.If you got, who gave you the land code c)
1 2 3 4 5 6								

Code a =due to the project =1, b- loss of productivity = 2, shortage of land = 1, other (specify) =4

Code b: shortage of land, disease = 2, loss of productivity =3, other (specify =4)

3. Was the resettlement program voluntarily? Yes – 1: No -2

4. Did you encounter any problem during the resettlement program?

Yes______1: No____2

5. If yes what risks?

a. Loss of agricultural land ( )

b. Loss of grazing land (   )

c. Loss of homes (   )

d. Other means of livelihood ( )

e. Psychological and economic stress (   )

f. Conflict with people in host area

g. Other (specify)

6. Have you been compensated –yes___1, No___ 2. Are you satisfied=1, No=2

7. Have you been compensated equivalent land in terms of size and quality as compared to your previous land? yes___1, No___ 2

8. Did you lost any agricultural assets or resources on your previous holding? Yes ___ No ___2

9. Have you been compensated equivalently?

10. Is there any change in land management practice after the resettlement program? Yes 0 1; No._2

11. What is the change? Use of organic fertilizers = 1,

Use of inorganic fertilizers = 2, change in tillage system =3, decrease in fallowing period = 4, other specify (5)

12. How could you come up with this change?

Thorough extension agents __1, NGOS ___2, my own initiative-2, other (specify) -4

Section -II- Socio Economic Issues

13. How can you describe your socio economic status after the resettlement program?

Improved - 1, No change -2, decline – 3, I don't know-4, other (specify)-5

14. Do you have additional source of income than crop production? Yes __! 'No __2

15. What are the sources? Daily labor work __1, selling fuel wood –2, selling of livestock =3, other (specify) =4

16. Do you have live stocks? yes______1 'No ____2

17. How do you evaluate you livestock productivity after the resettlement program increases __1, decrease ___2, No change -3, other (specify) -4

18. Where do you keep you livestock?

On farmland-1, communal land-2, on other's land –3, other (specify) ---4

19. Do you observe sign of overgrazing in the current settlement area?Yes ----1' No-2

20. Does the presence of the reservoir created a barrier for accessing schools, market places major roads, health center. Etc Yes----1,No---2

21. Did you get any benefit after the development of the project? If Yes __1' No ___2

22. If yes specify

Thanks!!!

D E C L A R A T I O N

I here by declare that the dissertation entitled "Environmental Impact Monitoring for Gilgel Gibe I By Using Remote Sensing and GIS" has been carried out by me under the supervision of Dr. Mohammed Umer Department of Earth Sciences, Addis Ababa University, Addis Ababa during the year 2010 as a part of Master of Science programme in Remote Sensing and GIS. I further declare that this work has not been submitted to any other University or Institution for the award of any degree or diploma.

Place: Addis Ababa
Date: 2010

(Bahiru Girma)