JIMMA UNIVERSITY

COLLEGE OF SOCIAL SCIENCE AND HUMANITIES

Department of Geography and Environmental Studies

Spatial dynamics of Fincha reservoir and its socio-economic impact on the surrounding society, Horro Guduru Welega zone, Western Ethiopia

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This is to certify that this thesis entitled "**Spatial dynamics of Fincha reservoir and its socio-economic impact on the surrounding society, Horro Guduru Welega zone, Western Ethiopia** ", submitted in partial fulfillment of the requirements for the Master of Science in Geography and Environmental Studies with specialization in GIS and RS at Jimma University, department of Geography and Environmental Studies done by Eba Tariku Daro *RM9025/08* is an authentic work carried out by him under our guidance.

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Acronyms

ETM	Enhanced thematic Mapper
ETM +	Enhanced thematic Mapper plus.
EIA	Environmental impact assessment
FAO	Food and agricultural organization
GIS	Geographical information system
GPS	Global positioning system
OADB	Oromia agriculture development bureau
RS	Remote sensing
TM	Thematic Mapper

Abstract

The benefit derived from the creation of man-made lakes in Ethiopia and other developing countries is usually associated with great risks. The fluctuation in areal extent of reservoir is one of the most common natural processes that affect socio-economic condition of the communities around the shorelines of the reservoir. This research has been conducted to assess the impact of fluctuation in areal extent of Ficha reservoir on the socioeconomic aspects of the surrounding community. The parameters are land use land cover, reservoir cover, socio-economic conditions in relation to fluctuations in areal extent of the reservoir. GIS softwares were used in this study to; classify and detect LULC of the study area using maximum likelihood and LULC change using pair matrix respectively and Delineate water surface area by digitizing and extract using raster clip tool through the use of single band (Band 7). House hold survey was undertaken to analysis socio-economic impacts. Results from fluctuation in areal extent analysis shows, a decrease in the areal extent of Ficha reservoir from 57.3 % in 1996 to 43.3 % in 2012 from the total area of the study area. From 1996 to 2012 grassland and agricultural land were increased. Besides from 2012 to 2016 the grassland and agricultural land decreased. The forest coverage increased from 1996 to 2012 and decreased from 2012 to 2016. On the contrary, areal extent of Ficha reservoir increased from 43.3 % in 2012 to 46 % in 2016. The settlement land cover increased from 1996 to 2012 by 0.06% and also increased from 2012 to 2016 by 0.04%. Generally, despite the significance of the Ficha reservoir, based on the household survey of selected representative samples it has been found that the fluctuation in areal extent of Ficha reservoir has an adverse impact on the socio-economic condition of the nearby community. Thus, an appropriate mitigation measures are necessary.

***Key words**: Fincha reservoir, GIS, Land use and land cover, Remote sensing, Reservoir fluctuation*

CHAPTER ONE
INTRODUCTION

1.1. Background

Ecosystems are being affected by global change drivers from time to time, which are considered by the Millennium Ecosystem Assessment as "any natural or human-induced factor that directly or indirectly causes a change in an ecosystem" (Carpenter *et al.,* 2006). Global change drivers are; anthropogenic drivers, episodic events, and/or natural variability (Carpenter *et al.,* 2006). Due to increased concentration of CO_2 in the Earth's atmosphere, the globally averaged surface temperature is projected to rise by 1.4 to 5.8°C during the period 1990 to 2100 (Ding, 2001). There is a fact that global climate change raises sea levels, increases storm intensity and frequency, and promotes heavy precipitation events and severe droughts (Knutson *et al.,* 2010). Land-use changes such as deforestation can severely impact ecosystem function and ecosystem services and goods. Any specific ecosystem change can be the result of a combination of interactions among drivers and therefore, ecosystems are important study units for understanding the causes and impacts of global change.

There is a fact that global climate change raises sea levels, increases storm intensity and frequency, and promotes heavy precipitation events and severe droughts (Knutson *et al.,* 2010). Land-use changes such as deforestation can severely impact ecosystem function, ecosystem services and goods. Naturally water levels of lakes are fluctuate as a result of seasonal or long-term imbalance between the amounts of water entering (by inflow, precipitation, runoff, and groundwater) and leaving the lake (by evaporation and outflow) (Zohary and Ostrovsky, 2011). The magnitude of those fluctuations depends on factors such as the morphology of the lake and its watershed, the ratio of their areas, intensity of rainfall events, and rates of delivery of rainfall or ice-melt water to the lake, as well as on factors determining water losses such as outflow fluxes or wind speed and air temperature that impact evaporation. Lakes fluctuate seasonally between maximum levels, usually at the end of the rainy season or snowmelt, and minimum levels at the end of the dry season (White *et al.,* 2008).

Majority of the lakes in Ethiopia are found in the Rift valley basin. The total surface area of these natural and artificial lakes in Ethiopia is about 7,500 km2. However, Ethiopian lakes have suffered changes in their hydrological balance (evaporation rates inputs from surface and ground water sources); reduction in the quality of water resource including deterioration of geochemical balance (including salinity, oxygen depletion); disruption of ecosystem (eutrophication, decrease in biological diversity); and the exposures of lake beds to the atmosphere resulting in toxic dust emissions (Julie, 2008).

Dams have been built for thousands of years for the purpose of electricity, irrigation, flood control, and water supply (WCD, 2000). They are also associated with loss of agricultural land, forests, and grasslands in upstream watershed areas due to inundation of the reservoir area (WCD, 2000; Bird and Wallace, 2001), alteration of traditional resource management practices (Roder, 1994), displacement and impoverishment of people, and inequitable sharing of environmental costs and benefits (Bartolome *et al.,* 2000).

Fincha dam was constructed in 1973 as a strategy for fostering economic growth in Ethiopia through generation of hydroelectricity, irrigation, fishery, and tourism (Bezuayehu and Geert, 2008).The diversion of Amarti river to Fincha in 1987 increased the areal extent of Ficha reservoir. This results the inundation of agricultural lands and grass lands which are near to the coasts of the reservoir.

Studies done by the Oromia agriculture and development bureau (OADB, 1996) and Assefa, (1994) have shown that Fincha reservoir has inundated large areas with different land use types and driven people from their original places of settlement. The displaced people have mostly moved to available areas within the watershed, and have often taken up agricultural activities on steep and marginal areas within the watershed. This process of migration and new agricultural activities, in combination with normal population increase, may have caused detrimental land use changes and aggravated the rate of environmental degradation in the upstream portions of Fincha watershed (Assefa, 1994).

The application of geographic information system and remote sensing can facilitate the study of the impact of fluctuation in areal extent of Ficha reservoir on the socio-economy of the surrounding community for a better outcome. Besides these application facilitates the delineation of water surface area using satellite images of different years and to determine the temporal changes in the water surface area of Fincha reservoir. Results arising from such studies are important for planning and decision making processes.

1.2. Statement of the problem

Reservoirs (artificial lakes) have many advantages for any country. But, sometimes areal fluctuations of the reservoirs can have an adverse effect on the socio-economic characteristics of the local people around them. Even a little fluctuation of areal extent of reservoirs can affect surrounding community, because the life of the surrounding communities is interrelated with the reservoir.

The fluctuation of areal extent of reservoirs which affect socio-economy of surrounding community reverses the sustainable development. In the study area the surrounding community is affected through different ways like, inundation of cropland and grassland around the shores of the reservoir when the areal extent increases and lack of water for irrigation and decrease the availability of fish when the areal extent decrease.

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 reservoir is of paramount importance for the development through supply of electric power which would serve as a power house for any sector, used for irrigation, fishing tourism but the surrounding communities are under continuous threat.

There are now a number of opportunities to pursue some of the core social science research issues more closely through remote sensing and GIS. Effort is made on issues of population, equity/ equality, institutions, democratization, (under) development and decision making as they relate to resource use and environment change. Integration between social science and natural science is vital for better understanding of the economy that changed drastically and reflects complex socioeconomic settings. However, there is limited research that applied remote sensing information in socioeconomic research to assess the socio-economic impacts of reservoirs spatial dynamics. Thus, this study tries to fill this gap and estimate socioeconomic impacts of Fincha reservoir spatial dynamics, through the integration of remotely sensed information, socioeconomic and other environmental data in GIS format. The cause, 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 easily and objective.

1.3. Objectives

1.3.1. General objective

The general objective of this study is to assess impact of fluctuation in the areal extent of Fincha reservoir on the socio-economy of the surrounding community using GIS and Remote sensing tools and techniques.

1.3.2. Specific objectives

1. To determine the temporal changes in the water surface area of Fincha reservoir.
2. To investigate the socio-economic impacts of the reservoir spatial dynamics.

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 Fincha reservoir and its environs have during the last two decades?
2. Are there any impact brought by the fluctuation in areal extent of Fincha reservoir on the surrounding society?
3. What is the impact of the fluctuation in areal extent of Fincha reservoir on the socio-economic aspects of the society around the reservoir?
4. What mitigation measures are needed to reduce the socio-economic impact?

1.5. Significance of the study

The study is believed to have a special contribution in identifying the socio-economic impacts of the fluctuations in areal extent of the reservoir on the community. It helps to address the socio-economic impacts in more scientific way. Furthermore, it helps to identifying the future possibilities of occurrence and trend of the negative consequences so as to take pro active measures and avoid the occurrence of similar problems. On the other hand, the study can help the concerned body to take justifiable action at the right time and place.

The study is believed to help governmental and nongovernmental organizations, working research on socio-economic impact of areal extent fluctuation of reservoir and policy and decisions makers, serve as a reference.

1.6. Scope of the study

The scope of the study is focus on the fluctuation in the areal extent of Fincha reservoir and its socio-economic impacts on the society. Geographically, the research is limited to Fincha reservoir and 2 kilometer buffer of the reservoir which intersects four districts surrounding the reservoir namely Horro, Abay Chomen, Guduru and Jimma Genneti. 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 limitations. These were shortage of time, difficulties accessing data and some field sites.

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 fluctuation on areal extent of reservoir and its impact on the socio-economy and role of GIS and Remote sensing in determining the fluctuation and monitoring the impact.

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 temporal changes in the water surface area of Fincha reservoir are discussed. In addition, the impact of fluctuation in the areal extent of the reservoir on socio-economic aspects of the surrounding community are presented and analyzed with respect to the present and future outcomes. Chapter five gives a brief summary of the study and forward feasible recommendations helpful for sustainable development of the society.

CHAPTER TWO
REVIEW OF RELATED LITERATURE

2.1. The history of reservoirs

Mega-projects like Hoover, Grand Coulee and Glen Canyon dams launched the hydro era in the USA in the 1930s (McCully, 1996; Usher, 1997). The 1950s saw the peak of dam development in the U.S.A and Europe. As green movements strengthened in the U.S.A and Europe, it became very difficult for governments and the private sector to build new large dams in Northern countries (McCully, 1996; Usher, 1997). After this period, the dam industry shifted its focus in to the developing world. American dams became poster projects of the technological potential for hydro to turn arid lands into productive agricultural centers, generate cheap electricity and offer unparalleled flood control.

Since the 1950s, multilateral and bilateral aid agencies have been channeling huge project funds to national dam constructing firms. Skylar and McCully, (1994: 12) report that in the World Bank's first year of lending, 72% of loans went to dam projects. These agencies also subsidize private sector dam construction, such as the Mekong river dams, by commissioning feasibility and environmental impact studies.

Researchers have demonstrated the far-reaching environmental and social costs of large dam development, including the loss of fertile valleys, the expansion of waterborne diseases, and the destruction of vital fisheries (Dixon *et al.,* 1989). Human dislocation, impoverishment and community rehabilitation are perhaps the basic concerns with dams in developing countries (Cernea, 1991). Demographic and environmental factors in tropical and sub-tropical developing countries have resulted in higher population densities, greater struggles over land access, and higher rates of siltation and evapo-transpiration than northern industrialized countries.

The greatest difference between American large dams and their counterparts in the developing world is that American dams did not result in massive forced resettlement. The Glen Canyon and Hoover dams did not have associated human displacement. In the entire history of American dam building, approximately 30,000 people have been resettled, 18,000 of which were moved for the Norris dam in Tennessee alone. In the developing world, China and India have had extensive forced resettlement programs associated with dams (McCully 1996; Usher 1997).

2.2. Reservoirs and community

Most communities, from a village to a city, are located along the coasts of water body. Communities depended on rivers for basic needs until fossil fuels became the next most efficient source of available power for industrial development, pulling communities away from networks of navigable waters, and sprawling communities across the landscape. As global energy production shifts away from fossil fuels, and domestic production of energy is increasingly desired. Decision-makers are revisiting hydroelectric dams as a means to increase energy security and help economic growth and development ("Modern hydropower," 2007a). Since hydropower is the original "fuel" of global development, looking back to the industrial revolution, it is no surprise that developing nations are mostly turning to dams with the goal of increasing domestic electricity production and distribution.

The quality and the quantity of food available constitute a very important factor among others in the balance of a population within a complex community as that of the aquatic and terrestrial environments. The creation of embankments such as dams, dikes, etc., may disrupt this balance by interfering with the quality and the quantity of the available food items, living space, inter and intra specific competition and the limn logical conditions (Araoye and Jeje 1999).

2.3. The causes for fluctuation in areal extent of reservoirs

According to their morphology, capacity and runoff, reservoirs are either close to river or to lake systems. Depending on their use, the water level of reservoirs may be either more or less stable, or it may fluctuate according to a periodicity linked to the water cycle and its exploitation – from full to empty in the extreme case. River dams and reservoirs slow down the runoff, and point-bar sedimentation may lead to a meander-type, mature river morphology. Storage reservoirs are artificial lake systems, characterized by lake processes. River and storage reservoirs are mostly established in a morphological context that differs from natural lake morphologies, with the deepest part of the lake close to the dam.

2.3.1. Hydrological system and river dynamics

Major changes in the river system occur upstream and downstream. River diversion may occur upstream in order to bring more water into the reservoir and increase its capacity. This measure may partially dehydrate the landscapes, as is the case in alpine valleys, and it may also influence the surface and the groundwater systems. As a general rule, groundwater levels decrease in areas with diverted rivers and increase in the areas close to, and downstream of, reservoirs.

According to the mode of management, irrigation improves agriculture, but may also increase soil Stalinization (Cause, 2001). In the case of reservoir contamination, either chemical or microbiological, impacts on human health may be expected. Downstream of a reservoir, river dynamics may suffer major modifications, particularly a change in the distribution of runoff. This is caused by the water storage and the exploitation of the reservoir volume for irrigation, production of electricity or other purposes. The reduction of the floods of the River Nile is a well known example. In the alpine region, Loizeau and Dominik (2000) have shown the potential impact of reservoir exploitation in the drainage basin of the Rhone River on the oxygenation of Lake Geneva.

The downstream effects of flushing a reservoir are inundation, massive sediment transport and damage to the ecological communities. There may also be an increase in the erosive capacity of the river, linked to the decrease in sediment charge as a result of reservoir sedimentation. The erosion may affect the river banks (Palmieri *et al*., 2001), the river bed itself and any constructions, such as the basement of bridges (Doutriaux, 2006).

2.3.2. Physico-chemical cycles

According to WCD (2000), 46 per cent of the water in the 108 most important rivers of the world is first flowing into a reservoir before it continues its way to a natural lake and/or to the sea. The efficiency of reservoirs at trapping sediment is frequently reported as 70 -90 per cent of the sediment volume delivered from the watershed (Sundborg, 1992; Toniolo and Schultz, 2005).

As a result, approximately 30 to 40 per cent of suspended matter transported by the world river network is no longer reaching the coasts of seas, oceans and some major lakes, but is retained in man-made reservoirs, at least for the lifetime of these infrastructures (Vörosmarty *et al*., 1997).

Retention of water, and therefore of dissolved matter, is shorter but also has to be considered. The ability of a reservoir to trap solid matter is a key process, which has many other environmental implications.

The capacity of reservoirs is reduced by a mean of 1 per cent per year by sedimentation (WCD, 2000). Sediment flushing generally allows the export of sediments along erosion channels within the reservoir during lowering of the reservoir level. Flushing efficiency may vary according to the basin topography, compaction of sediments and other parameters and, in some cases, may not prevent the gradual filling of a reservoir with sediment. Therefore, in order to maintain water storage capacity it may be necessary to use other strategies, such as dredging or elevation of the dam (Vischer and Hager, 1998).

2.3.3. Carbon and oxygen cycles

Oxygen depletion by the oxidation of particulate and dissolved organic carbon may lead to deoxygenated or even anoxic conditions in deep water and in the sediment. The main hazards associated with this are:

- Eutrophication of deep reservoir water and of water transferred down-stream or infiltrated to the groundwater.
- Remobilization of nutrients, metals and organic contaminants from sediments and their availability to organisms (plants, sediment dwellers).
- Infiltration of pore water charged with contaminants and dissolved organic carbon to the groundwater (Wildi *et al*., 2003, 2004).

2.3.4. Soil, surface and groundwater and environmental toxicity

Stalinization may occur in arid conditions in relation to irrigation, mainly due to the maintenance of a high groundwater level when evaporation and evapotranspiration are strong (Cause, 2001). In addition, contamination of soil in the floodplain by reworked contaminated reservoir sediments during floods may be expected. This mechanism is linked to the accumulation of contaminants in reservoirs (Jüstrich *et al*., 2006).

During sedimentation along the reservoir axis, the coarse fraction (sand and coarse silt) diminishes in suspension, whereas the fine fraction (fine silt and clay) increases as a proportion of the total fraction. As a consequence, and because contaminants are mainly adsorbed onto the fine fraction, suspensions and sediments formed from particle settling at the outlet of a reservoir contain higher concentrations of contaminants and have a higher toxicity than suspensions and sediments at the inlet of the reservoir (Jüstrich *et al*., 2006).

Eutrophication can be caused mainly by nutrient release from the sediments, DOC-consumption and nitrification. Stratification, mainly thermal stratification, can also occur in deep reservoirs and may result in oxygen depletion. Evaporation can also lead to an increase in the salinity of the water. A major impact on surface water quality may stem from biological processes such as bacterial contamination due to the release of water from wastewater treatment plants (Poté *et al*., 2008) and diffuse run-off.

2.4. Environmental consequences of fluctuation in areal extent of reservoirs

The effects of fluctuation in areal extent of reservoirs on the structure and function of the littoral zone in lakes have not been extensively studied. Most of the information originates from studies of water level manipulation in ponds and reservoirs.

2.4.1. Consequences of fluctuation in areal extent of reservoir on physiographic elements

Shallow systems with gradually sloping shorelines are more affected than lakes with steep littoral slopes, since larger areas are flooded or exposed, respectively. Two physiographic parameters are modified by fluctuation in areal extent of reservoir:

1. Shoreline morphometry, especially in convoluted shorelines where changes of water level can significantly modify the area of lagoons and consequently change habitat availability and affect biomass production .
2. Littoral slope and substrate composition. In general, gentler slopes and softer substrates are associated with falling water levels and vice versa.

2.4.2. Consequences of fluctuation in areal extent of reservoirs on water quality

water quality can be greatly affected by fluctuation in areal extent of reservoirs, as a result of the introduction of organic matter and nutrients from re-flooded terrestrial areas the increased concentration of dissolved materials due to water loss by evaporation. The increased turbidity due to shoreline erosion and resuspension of bottom sediment or to rapid re-flooding of shallow lakes.

2.5. Socio-economic impacts of reservoirs

2.5.1. Socio-economic benefits of reservoirs

According to the WCD (2000), many people have benefited from the service of large dams, such as irrigation and electricity generation. Reservoirs can control flood patterns, divert rivers, store water for drinking and irrigation, and generate power (Workman, 2009). In terms of modern hydropower, Reservoirs (artificial lakes) are the primary way to manipulate a river for human benefit. Also, they control flood patterns, dams have allowed many civilizations to develop in extreme proximity to rivers, where volatile flood plains would otherwise not allow it. Reservoirs are so to speak, a way to "budget" a river. They can ensure a reliable river flow year round and bring water to otherwise arid landscapes ("Modern hydropower," 2007a). However, reservoirs intervene with the world's natural hydrology in the same way deforestation fragments ecosystems, and the sustainability of this intervention is up for debate.

The presence of reservoirs has increased globally due to the amazing ability humans possess to manipulate natural processes for their benefit. International Rivers states, "At the end of the twentieth century, the dam industry had choked more than half of the world's major rivers with more than 50,000 large dams". In the United States alone, the exact number of dams is unknown. It is estimated that there are above 2.5 million small dams, 78,747 dam structures requiring federal hazard safety oversight, and in addition to this there are 99,000 state regulated dams (Workman, 2009). Modern dam development is driven by politics, economics, and energy wants. North America's largest dams were developed for a variety of purposes: navigation and recreation (24%), flood control (13%), irrigation (11%), hydropower (11%), water supply (10%), and for multiple purposes (30%) (Workman, 2009). Dams come in a broad range, built for various purposes, with various materials, and in various environments. On the contrary, modern decision-making and design for dam projects is quite different, where the design of the dam may not fit the hydrology of the host river. Additionally, time and funding limits pre-construction cost benefit analysis for economic, environmental, and social factors. The cost benefit analysis of dams must be re-evaluated to maximize potential benefits and to minimize costs.

Dams are not built without good reason. Where economic incentive exists; typically social benefits exist as well. Dam projects have the potential to manipulate rivers to benefit local populations. Flood protection is an important service that allows communities to live comfortably along a river without fear of volatile flood patterns (Yuksel, 2009). In some scenarios dams provide increased water supply for arid populations and increase livelihood value (Workman, 2009). In many scenarios, a dam used for hydroelectric production supports other. In many developing countries, hydroelectric power provides electricity generation where other forms are not possible due to limited infrastructure or limited import of fossil fuels (Evans et al., 2009). Hydropower avoids price fluctuations, providing a reliable form of electricity, while fossil fuel prices are constantly fluctuating and in general, increasing with time (Evans et al., 2009).

Currently, 1.6 billion communities are without access to electricity and 1.1 billion people are without a reliable drinking water supply. Water and electricity are both necessary resources for economic development, and reservoirs can increase access to both, through irrigation, flood control, water supply, and electricity production (Yuksel, 2009).Uses of reservoirs such as irrigation contributing to occupations in the agricultural industry (Workman, 2009). Reservoirs also have the potential to increase navigability of waterways allowing increased river transportation of goods and services for the local people.

Within the realm of electricity generation, hydroelectric power is so-to-speak, a low hanging fruit for economic development. “[Hydroelectric] potential exists in 150 countries and about 70 percent of economically feasible potential remains to be developed”. The technology is established and available. Aside from the high upfront cost of dam construction and maintenance, the direct cost of hydroelectricity is virtually zero (Evans et al., 2009). Hydroelectric dams also have a lifespan of 50 years – 100 years, which allows enough time to pay back construction costs and produce a net profit (Yuksel, 2009).

Additionally, hydroelectric power is relatively low in cost and high in efficiency compared to other modes of electricity generation, both conventional energy (fossil fuels) and alternative energy (renewable). Cost wise, hydroelectric power is the most affordable form of alternative energy and comparable in price to conventional energy (Table1). Efficiency wise, hydroelectric power is highly efficient compared to other conventional and alternative sources of electricity

(Table1). As a result, hydroelectric dams are a popular mode of economic development, especially in developing nations (Yuksel, 2009).

Table 1 Comparison of cost and efficiency for modes of electric generation

Type of electric generation	**Mode of electric generation**	**Cost U.S. $ / kilowatt**	**Efficiency**
Alternative/Renewable	Hydroelectric	0.05	>90%
Alternative/Renewable	Photovoltaic (solar power)	0.24	4% - 22%
Alternative/Renewable	Wind	0.07	24% - 54%
Alternative/Renewable	Geothermal	0.07	10% - 20%
Conventional (Fossil Fuel)	Coal	0.042	32% - 45%
Conventional (Fossil Fuel)	Natural Gas	0.048	45% - 53%

Source: (Evans et al., 2009)

2.5.2. Socio-economic costs of reservoirs areal extent fluctuation

While economic incentive leads to social benefit, environmental costs lead to social costs. It is evident historically and currently that reservoirs produce social costs because the rate of large scale hydroelectric dam construction has slowed (Evans et al., 2009). Construction has slowed for a variety of socially interrelated reasons; politicians and civilians alike are mobilizing against dam construction (Hildyard, 2008). Historically, the social impact of dams has been overlooked and underestimated. Since the 1900s, 40 - 80 million people have been displaced by dams worldwide (Workman, 2009). While electricity is a tool for development, it presents a tradeoff detrimental to local livelihoods.

With increased mobilization against dams, private companies own more dams than public entities. When a privately owned dam is constructed, public funding must be reallocated to compensate for externalized costs, taking away from funding for public goods and services such as healthcare and education. The private company is often depends on a public utility for distribution. However, due to cost overruns and other unforeseen expenses, the hydroelectricity rates are often higher than what the public can afford, leaving the private firm bankrupt. In this case, after the public entity has compensated for the externalized costs of the dam, they are unable to reap the benefits of increased energy security. Also, at the end of a dam's lifespan, the public typically must pay for the cost of decommissioning for risk of collapse and flooding, regardless of whether the dam was publically or privately owned. Cost of decommissioning is often as high as the cost of construction alone. Based on these trends, it is obvious that the public is placed in the most vulnerable position within the context of dam construction (Hildyard, 2008).

Reservoirs also strain the relationship between communities and their water bodies. Communities are centered around coasts of rivers and other bodies of water because they rely on the water as a resource. A dam interrupting a river leads to unpredictable social impact. First, many communities must resettle to provide land for the dam and the reservoir. Hydropower dams restrict navigability of a river at any scale. From a three meter dam and a canoe, to the three gorge dam and a barge, dams fragment rivers and control its navigation. In some scenarios, communities could become isolated from others if river travel is the easiest and most efficient form of transportation. Isolating communities could have detrimental impacts on livelihoods by limiting trade of goods and services (Yuksel, 2009).

In addition to decreased navigability, dams prove to deprive communities of water, especially downstream. With interrupted hydrology, dams cause deepening of riverbeds. This leads to a depletion of groundwater and local wells. It is typical after the closing of a dam, that there is an increased need for irrigation downstream for lack of groundwater supply (International Rivers, ret. on jan. 2017). More directly, each kilowatt hour of hydroelectric generation requires 36 kilograms of water. This is relatively high compared to other renewable energy resources such as wind, which requires only 1 kilogram of water per kilowatt hour (Evans et al., 2009). In a community where water is scarce, dams present an increased risk to water security.

In many scenarios, dams can lead to shortage of water after contractors claim it will improve water supply. Post dam construction, irrigation may be necessary for agriculture downstream where it was once a water rich land. This is a result of redistribution of water resources and must be managed. For example, if more water is needed for irrigation, then less drinking water will be available to the local communities. In addition to water, other natural resources providing income for local people will be impacted. Forest health will reduce the production of non-timber resources such as honey or medicinal plants (Yuksel, 2009). Lack of fish migration and eventual extinction of species will decreases fisheries productivity (International Rivers, ret. on jan. 2017). Even the general decrease in biodiversity could have a deadly impact on the local ecotourism industry (Barcott, 2008).

Another important focus point is the impacts that reservoirs might have on the general health of the local population. Many of the health problems associated with reservoirs are generally linked to 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 in to 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 reservoir 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.

2.6. The types of socio-economic activities and sustainable reservoir management in Ethiopia

Ethiopia's economy and majority of the people's livelihoods are dependent on agriculture. To develop the socio-economy of Ethiopia and eradicate poverty, the policy and interventions should focus on agriculture as an entry point. In line with this, the government, bilateral and multilateral donors, NGOs and various institutions share the concepts and priorities identified in the "Plan for Accelerated and Sustained Development to End Poverty (PASDEP)." There are key challenges that need to be strongly addressed on transforming agriculture by overcoming a multitude of problems including biophysical and water management issues to help achieve the targets of PASDEP and sustainable socioeconomic growth in Ethiopia.

Civilization of human being and socioeconomic development are strongly associated with the capacity to manage and utilize water for beneficial purposes such as agriculture, power production, clean water supply, etc and cope with the negative externalities of impact of water such as flood, drought, contaminations, etc. Water is closely linked with hunger, poverty and health.

Ethiopia has 12 river basins from which 8 are basins with significant quantities of flow. One of the basins is a Lake Basin having numerous lakes fed by a number of rivers and streams. The remaining 3 are dry basins receiving deficit rainfall that can not produce river and significant runoff overcoming evaporation.

2.7. Issues for assessment of the impact of dam and reservoir in Ethiopia

Dams are built for hydroelectric power generation, irrigation, domestic and industrial water supply, fishery, 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. However, a very small fraction of the resource is available for use and the water supply can be short at specific localities. Clean water supply for domestic and municipal use was provided to only 27.2% of the total population of 51.5 million people (Solomon, 1998). 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 effects 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.

Table 2 Issues for impact assessment of dam and reservoir in Ethiopia

Issue	Source/causes	Impact
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
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

Source: (Ethiopia EIA guide line)

2.8. GIS and remote sensing for impact assessment of reservoir

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).

Remote sensing serves as a tool for socio-economic impact assessment. Remote sensing has some fundamental advantages that make it a veritable tool in socio-economic impact assessment. 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.

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. 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 impact assessment.

The role of GIS as since a GIS collects and manages environmental data in a standardized manner (Tomlin, 199O). 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 impacts often requires the consideration of a number of attributes, whose relationships may be dynamic in that they change over time and in their spatial relationships.

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 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 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 (Goodchild, Parks and Steyaert, 1993). GIS can be particularly valuable in an environmental 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 (Bailey and Gatrell, 1995). Hence the environmental GIS can be used for environmental contingency planning or disaster management.

CHAPTER THREE

METHODS AND MATERIALS

3.1. Description of the study area

3.1.1. Location

Astronomically Fincha reservoir is located 9º25'10" to 9º35'56"N and 37º10'4" to 37º21'44"E. In administrative terms, it is situated in the Horro Guduru Welega zone, western Ethiopia. In physical terms, it is located in the Fincha watershed, Blue Nile basin.

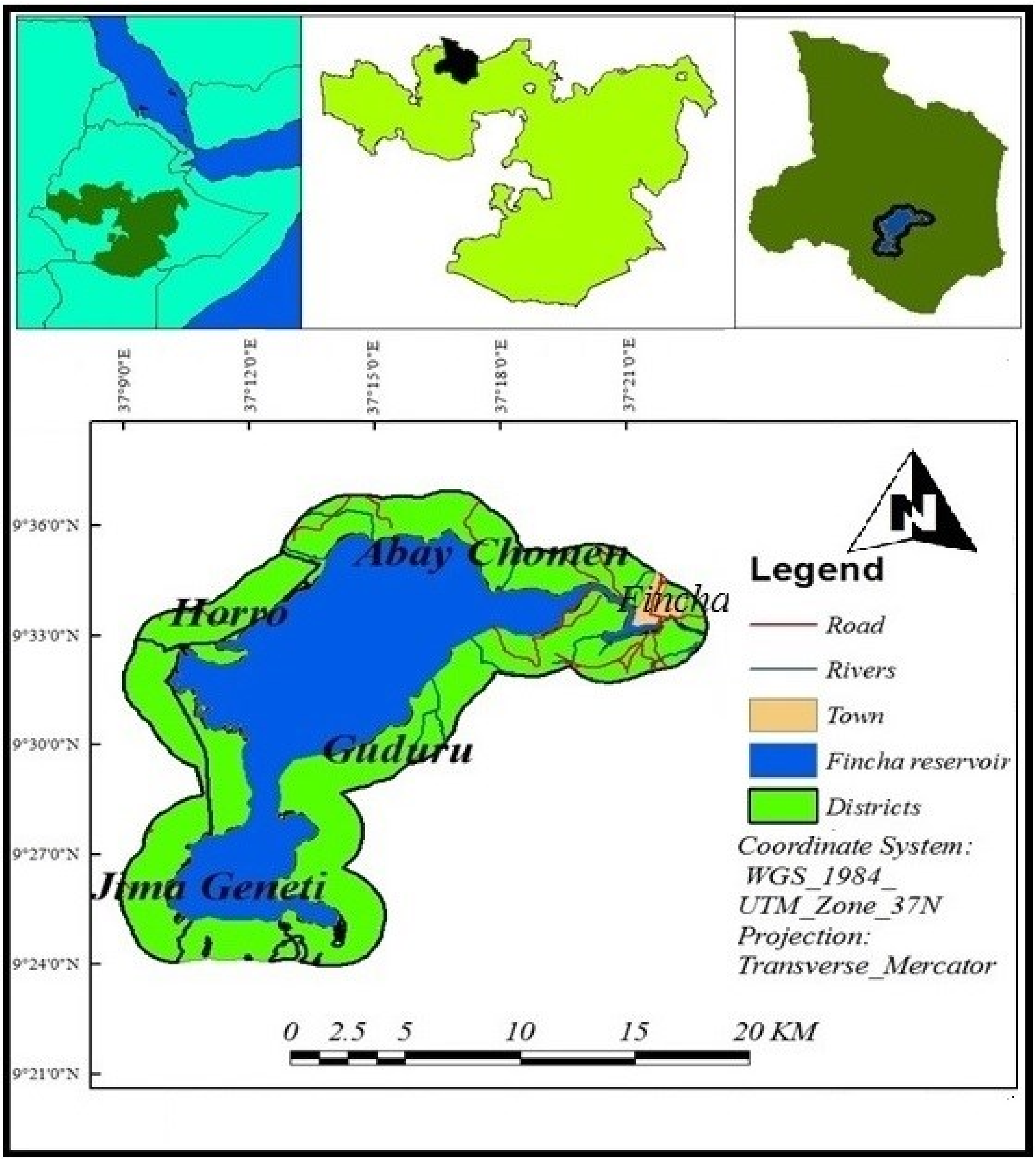

Figure 1 Location of the study area

3.1.2. Climate

Due to its high elevation which ranges from between 1,900 m to 2,412 m, the Fincha reservoir and its surroundings have a temperate humid climate. The yearly average rainfall over the period 1970-2003 was 1823 mm (Bezuayehu and Geert, 2008). About 80% of the annual rain falls between May and September (Bezuayehu and Geert, 2008). The monthly mean temperature varies from 14.9ºC to 17.5ºC. The average annual reference evapo-transpiration is 1,320 mm, with low monthly variations.

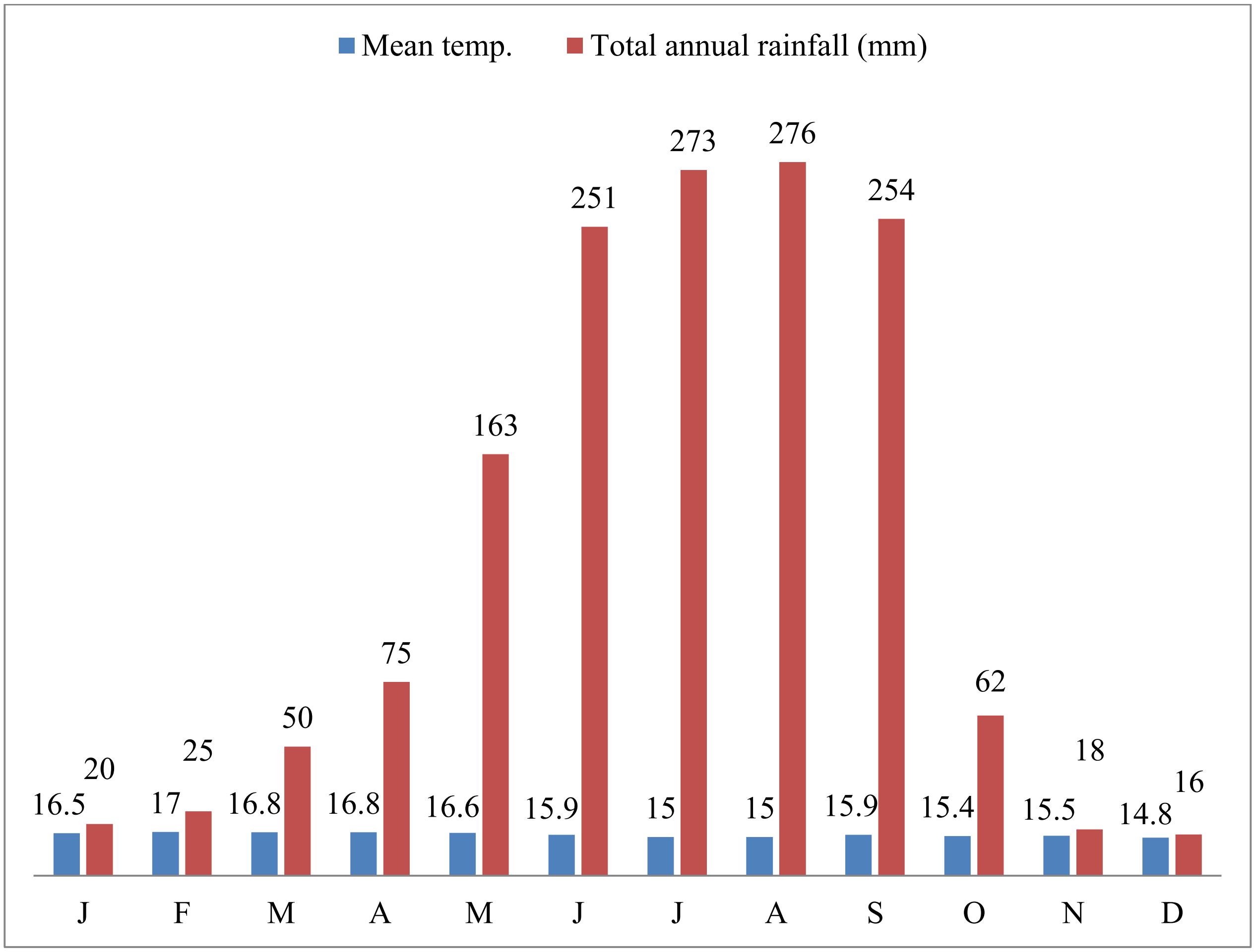

Figure 2 Meteorological data of the study area

3.1.3. Hydrology

The study area has important wetland, reservoir important for hydropower production and rivers which follows towards the reservoir (Bezuayehu and Geert, 2008). Ficha reservoir is covers area of 155km^2.

3.1.4. Soil

The types of soils in the study area ranges from clay to clay-loam and loam based on their texture. The clay and clay-loam is (82%) and this land is mainly under water reservoir and swamp (Bezuayehu and Geert, 2008). The rest area especially around the boundary of the study area (2km far from the reservoir) is covered by loam soil.

3.1.5. Topography

The elevation of Fincha reservoir and its surroundings ranges from 1,900 m to 2,412 m. Some area of the surrounding the reservoir (11%), which can be described as a wide rolling plateau, is within the altitude range of 2,200 m-2,400 m.

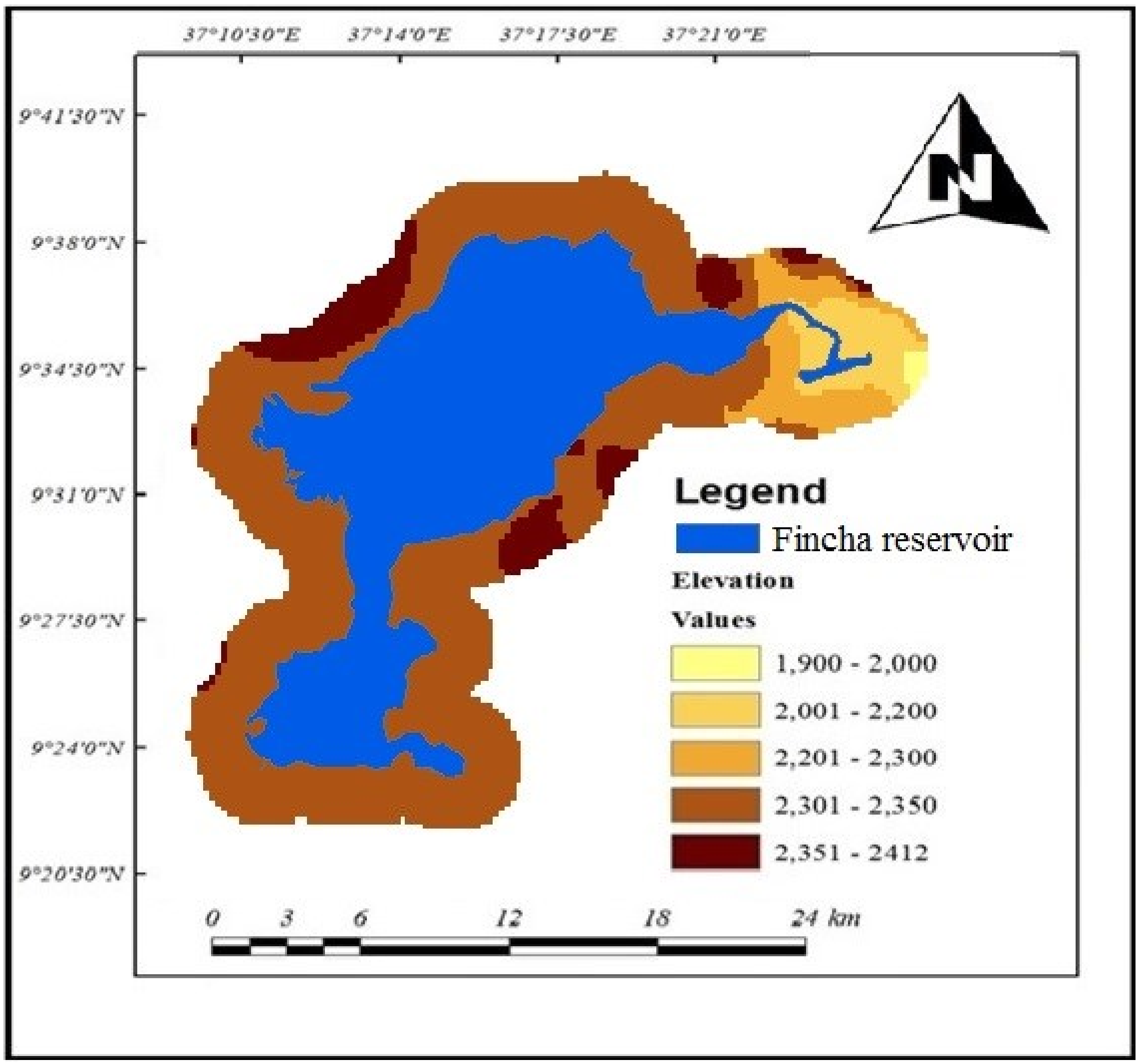

Figure 3 Elevation range in the study area

About 81% of the watershed is flat (0-3% gradient) and this land is mainly under water reservoir and swamp. Gently sloping (3-8% slope) to sloping (8-15% slope) areas cover about 6% of the territory (Bezuayehu and Geert, 2008). While steep, (10-20% slope) areas cover about 3% of the study area.

3.1.6. Population and socio-economic setting

Population density in 2015 was 121 people per km^2, with an average family size of seven people per household. In 2015, the average land holding size was 2 ha, with an average per capita land holding size of 0.2 ha. Integrated crop-livestock production is the main agricultural system in the study area. Many farmers own cattle, sheep, goats and horses. The traditional runoff trenches, which dispose of surface runoff from the field are used in teffields and perform well on flat lands. Their performance, however, is poorer on steep lands and often leads to increased soil erosion.

3.2. Materials and methods

3.2.1. Data collection

For this study both spatial and temporal data were collected. These data were generated from; satellite image. Another spatial data (GPS points) were collected from field observation.

3.2.2. Data type and source

The pertinent data types, their resolution and acquisition date so as to conduct this study was given in table3:

Table 3 Source and characteristics of satellite images used for the study

Data type	**Resolution**	**Path/row**		**Acquisition date**
		path	**row**	
Landsat TM	30mx30m	169	53	Nov. 1996
Landsat ETM+	30mx30m	169	53	Nov. 2012
Landsat OLI	30mx30m	169	53	Nov. 2016

The researcher selected the three satellite images because of the fluctuation in the areal extent of Fincha reservoir mostly occurred during the last two decades.

3.2.3. Image processing

1. Geometric correction

The major task of the image preprocessing is the geometric registration. In this work, Landsat data was registered using the Universal Transverse Mercator (UTM) Projection Zone 37 North with a World Geodetic System (WGS) 84 datum. The first-order polynomial transformation and the nearest neighbor method of sampling were used to maintain the original pixel brightness values and to resample the pixels at a spacing of 30 m in both directions.

2. Image Classification

In classifying the images, supervised image classifications techniques was applied. Maximum Likelihood assumes that the statistics for each class in each band are normally distributed and calculates the probability that a given pixel belongs to a specific class. Each pixel is assigned to the class that has the highest probability that is, the maximum likelihood.

In order to make use of the multitude of digital data available from satellite imagery, it must be processed in a manner that is suitable for the end user. This processing includes categorizing the land into its various use functions. In supervised land classification, the individual processing the imagery guides the image processing software to help it decide how to classify certain features. This is done by the use of a vector layer containing training polygons. The researcher also used ground control points (GPS point. Google earth and high resolution satellite images) for supervised classification.

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.

After supervised classification the researcher, reclassified in ArcGIS, and then calculated the value again using ArcGIS tool raster calculator, for preparing pair matrix.

$$\text{Change detection} = \text{FirstImg} \times 100 + \text{LastImg}$$

Where, FirstImg=previous year satellite image

LastImg=resent year satellite image

3. Post classification

After accomplishing classification of each land use land cover classes, some post classification techniques were applied on the classified image. Some of them are accuracy assessment and class statistics analysis.

i. Accuracy assessment

Accuracy assessment is crucial post classification technique by which the overall accuracy of satellite image classification as compared with the actual condition could be compared. The accuracy assessment is used to compare certain pixels in the thematic raster layer to reference pixels, for which the class is known. This is an organized way of comparing classification with ground truth data, previously tested maps, aerial photos, or other data.

ii. Class statistics analysis

This is another post classification technique, which helps to know what percent, and area coverage of each land use land cover has for each period. Finally, the researcher did the analysis after preparing pair matrix of 1996 and 2012 as well as 2012 and 2016 of the study area.

4. Water surface area delineation and extraction

There are different techniques to detect water in the remotely sensed images. In this study the grey scale view was used for better detection of water in the Landsat image through the use of single band (Band 7). The enhanced remotely sensed image was a black and white image where water bodies are represented in black. The researcher was used the digitizing method for the delineation of the water surface represented in black and then raster clip tool is used to extract the water surface area. The researcher was used pixel counts or pixel number of the extracted water surface area to calculate area of the reservoir.

3.2.4. Socio-economic impact analysis

Socioeconomic impact analysis examines how an act of development could potentially impact a community, the social and economic aspects of the potential impact, and the community's attitude towards resulting changes. Potential impact outcomes include: demographic changes in the community, changes in retail/service and housing market, demand for public services, employment and income levels, and aesthetic quality for the community. This research is considering the impact of fluctuation in areal extent of Fincha reservoir.

1. Household survey

Socioeconomic impact analysis can be completed with a variety of tools. In this case, the socioeconomic impact analysis is retroactive, and the research aimed to quantify impact that has already occurred across a broad population. A questionnaire is the most efficient option and allowed me to cover a broad sample size, in a minimal time period, while generating uniform results (Saris &Gallhofer, 2007). Additionally, questionnaires are designed to include demographic data for each participant, making it possible to statistically analyze the results by demographic variables such as: level of development, industry of occupation, and location of home and/or workplace. Use of a questionnaire allowed the research project to evaluate perceived socioeconomic impact on the local community, gather participant demographics, and examine factors that determine perceived level of impact within the target population.

2. Design of household survey

The goal of the household survey was to generate quantitative data linked to demographic data in a time efficient manner. The household survey was developed with the objective of assessing the impact of fluctuation in areal extent of Fincha reservoir on the socio-economy of the surrounding community. The household survey was contains two main parts. And under each part different sections were included. Moreover a general objective was specified to each part. Part I was about House Hold profile; the main objective of this part was to assess the demographic characteristics of the household, and Part II was about socio – economic Issue, the main objective of this part was to assess the socio- economic impact brought by the fluctuation in areal extent of Fincha reservoir.

3. *Sample size determination and sampling technique*

The sample size determination formula was developed by (Jeff, 2001) to determine the total sample size for this inquiry.

$$S = \frac{X2\ NP(1-P)}{d^2(\text{N-1})+\text{XP(1-P)}}$$

Where:

S = required sample size.

X2 = the table value of chi-square for 1 degree of freedom at the desired confidence level (3.841).

N = the total population size

P = the population variability (assumed to be 0.1 since the population is homogeneous in terms of geography, similar social class and similar economic activity (cash economy) as urban economy is monetized economy).

d= the degree of accuracy expressed as a proportion (0.05).

A structured household survey questionnaire was prepared to collect the necessary primary data. The structured household survey questionnaire was first prepared in English and translated in to Oromo language for practical field work. Sample respondents were selected randomly from each kebeles. The quantitative and qualitative data collected through household survey, field observation and secondary data were sorted organized and analyzed on descriptive statistics using tables, charts and figures. The sample households selected from the four rural Kebeles, namely Gudetu Jimma, Didibe Kistana, Homi and Yeron Amma Tole were selected purposively for the study, because the kebeles are close to the reservoir and have road accessibility.

The total number of households in the study area is 24,681. From total number of households in the study area the four rural kebeles are constitutes 888 households which the researcher was selected from those households 120 sample households.

$$S = \frac{3.841 * 888 * 0.1(1 - 0.1)}{(0.05)^2(888\text{-}1)+3.841*0.1(1\text{-}0.1)}$$

$$S = \frac{306.97}{2.56} = 120$$

To determine respondents from each sample frame in study area namely: site1; Gudetu Jimma, site2; Didibe Kistana, site3; Homi, and site4; Yeron Amma Tole that represent n_1, n_2, n_3 and n_4 respectively and calculated as:

$$N_1=S(\frac{n_1}{N})$$

$$n_1=120(\frac{224}{888})=30$$

$$n_2=120(\frac{218}{888})=29$$

$$n_3=120\left(\frac{226}{888}\right)=31$$

$$n_4=120\left(\frac{222}{888}\right)=30$$

The populations of the study area are peasant communities over all four Kebeles within the study area. Therefore, this can help to limit the numbers of sample size and the selected sample unit can represents over all large population behaviors.

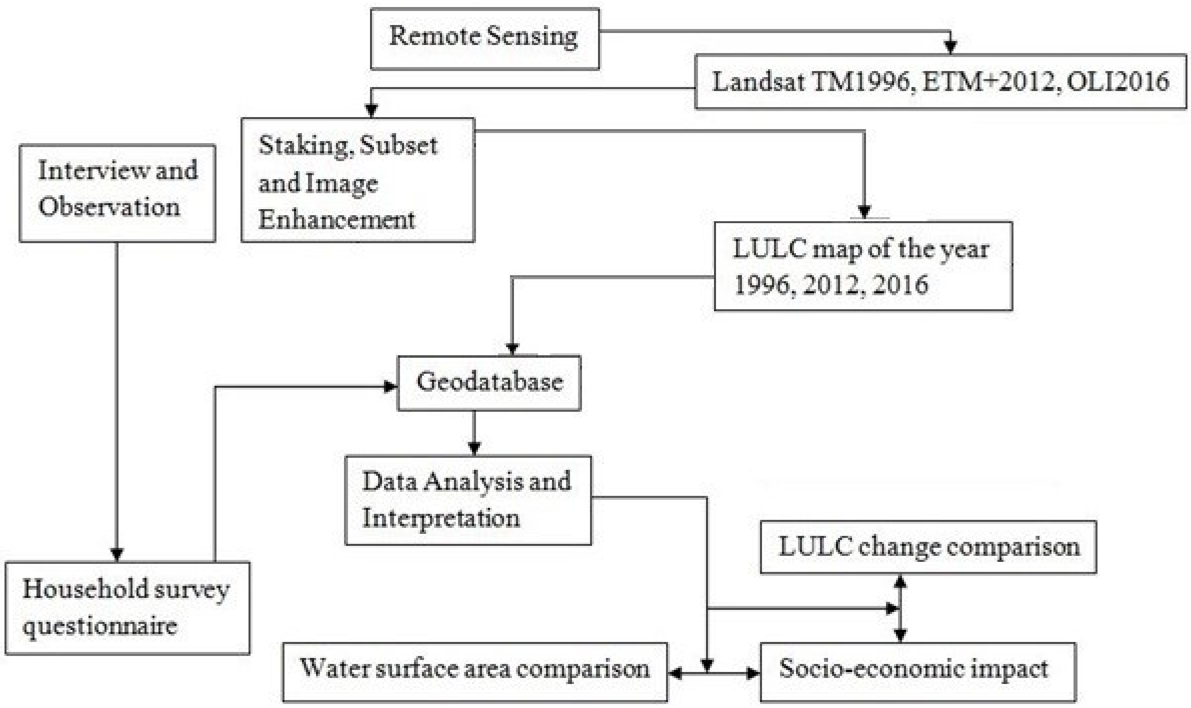

Figure 4 Conceptual framework

CHAPTER FOUR
RESULTS AND DISCUSSION

4.1. 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 the study area over a period of 20 years. 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 reservoir, grassland, agriculture, forest and. The major land use land cover classes and their description are given in Table 4.

Table 4 Major Land use land cover classes and their descriptions

Lu/Lc	Description
Reservoir	Areas completely inundated by water
Grassland	Areas covered with grass and plots left for grazing
Agriculture	Land surface that is used for cultivation, including fallow plots
Forest	Areas covered with natural and human made forest which includes highland and riparian forest.
Settlement	Includes Towns, settlement and roads

4.2. Land use land cover of the study area in 1996

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 in1996. Hence, in order to come up with this aim the lands TM image of 1996 had been used. As per the results obtained from image classification 56.4 % of the land was covered with reservoir, grassland accounts about 12.84 %, 21.88% of the land was covered with agricultural land, 2.52% of the study area was covered by settlement and 6.36% of the area was covered with forest (Table 5). The dominant land use within the study area in 1996 was reservoir and agricultural land cover.

Table 5 LULC class, their corresponding areas for the year 1996

Class	Count(Pixel values)	Percentage (%)	Area (ha)
Reservoir	201134.3	56.4	15757.89
Grassland	45790.15	12.84	3587.43
Agricultural land	78028.69	21.88	6113.16
forest	22681.1	6.36	1776.95
Settlement	8986.85	2.52	704.07
Total	356621.1	100	27939.52

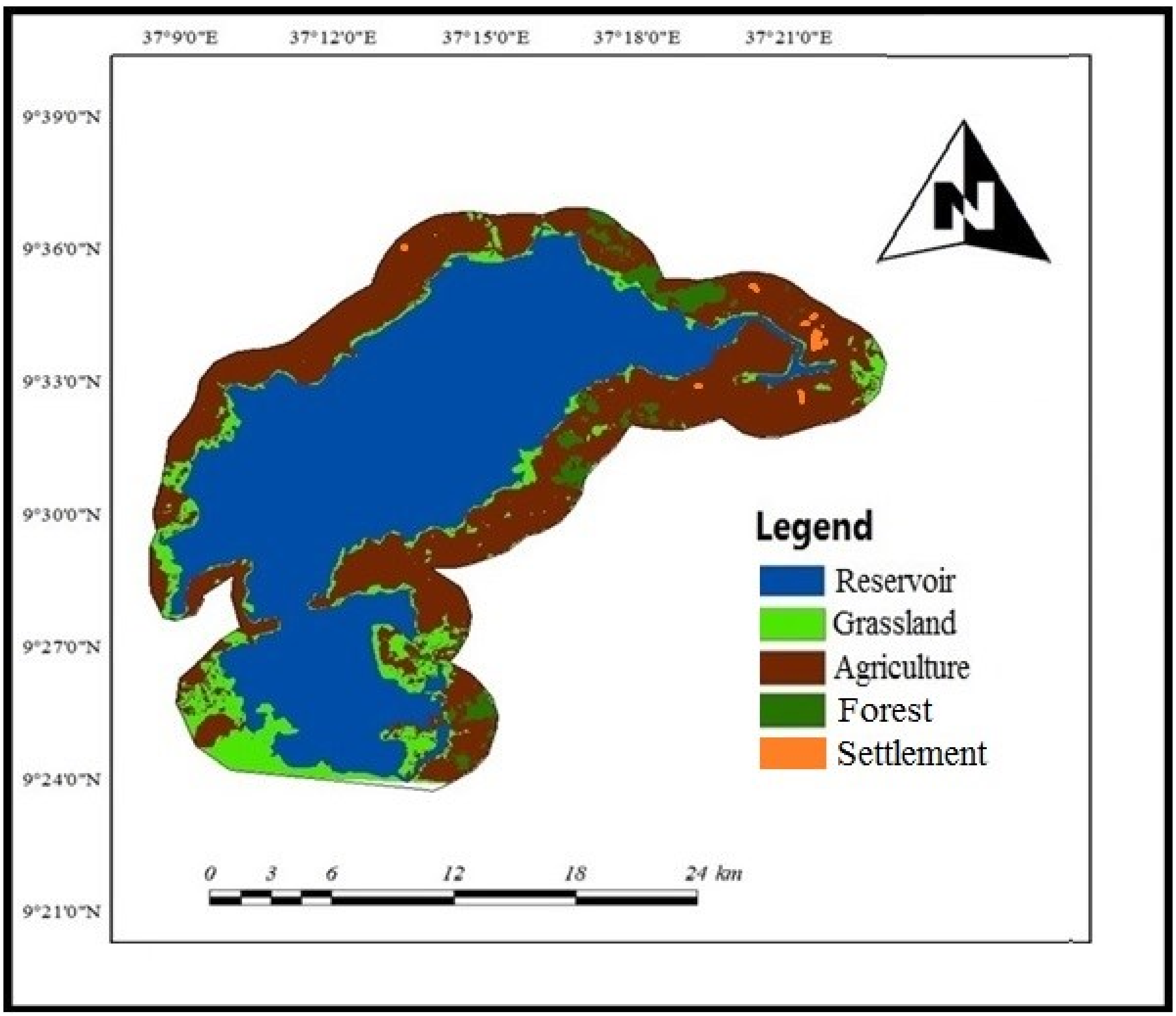

Figure 5 Land use land cover map in 1996

4.3. Land use land cover of the study area in 2012

As it is evidenced from the classified image 42.65 % of the study area was covered with reservoir, grassland accounts about 19.62%. In addition, the percentage share of agricultural land was about 28.56 %, 2.58% of the land is covered by settlement and 6.59% of the area was covered with vegetation (Table 6).

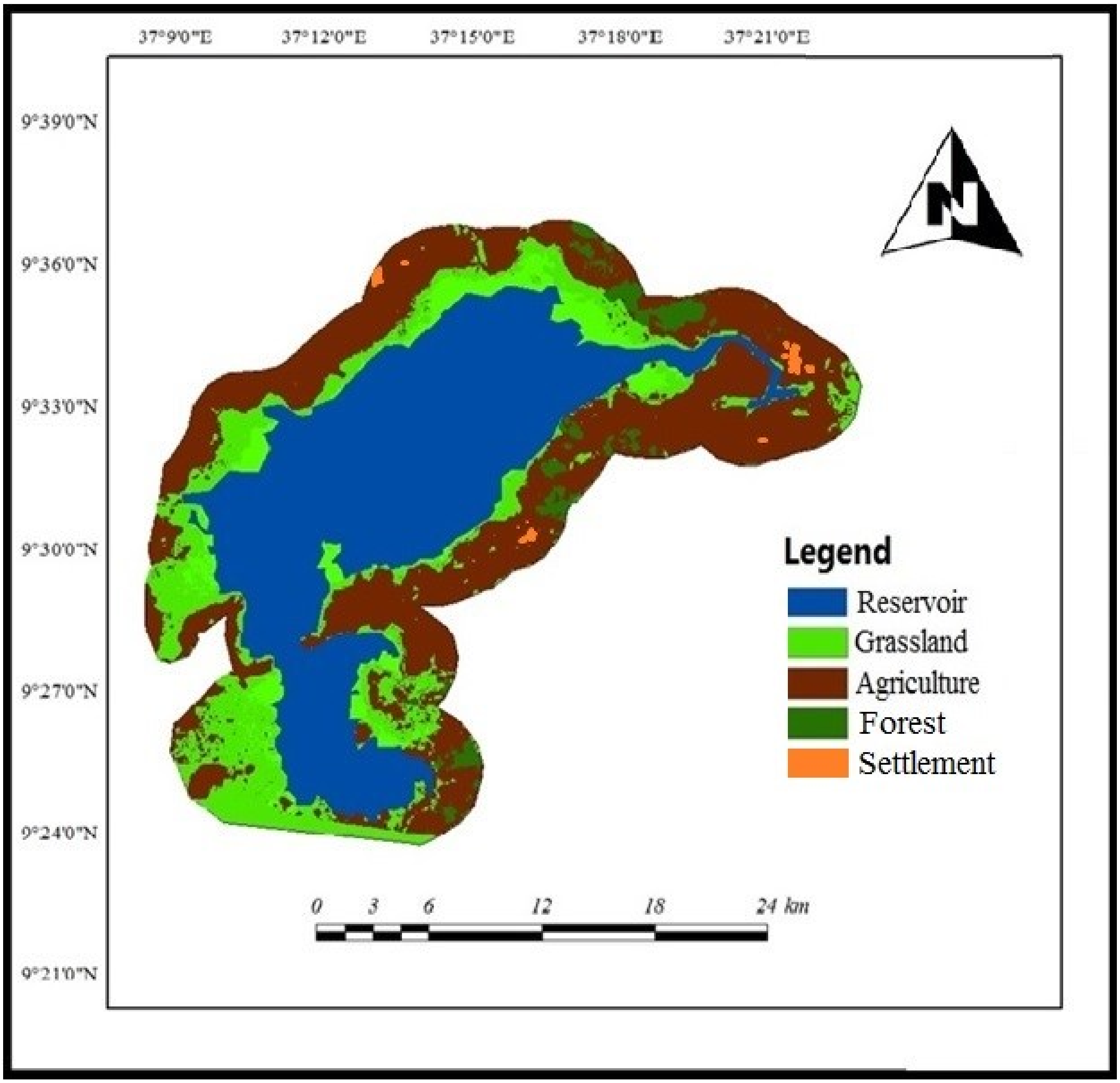

Figure 6 Land use land cover map in 2012

Table 6 LULC class, their corresponding areas for the year 2012

Class	Count (Pixel values)	Percentage (%)	Area (ha)
Reservoir	152098.89	42.65	11916.21
Grassland	69969.05	19.62	5481.73
Agricultural land	101850.98	28.56	7979.53
Forest	23501.33	6.59	1841.21
Settlement	9200.82	2.58	720.84
Total	356621.1	100	27939.52

There has been decrease in water surface area of Fincha reservoir due to different factors. Water surface area of Fincha reservoir decreased by 14% compared to that of 1996 from total area of the study area. Due to this fluctuation the shorelines of the reservoir were exposed for regression of the reservoir, this is one main reason for the increment especially in the grassland and cropland coverage in the study area in 2012.

4.4. Land use land cover of the study area in 2016

According to ETM+ 2016 the percent share of the reservoir was 54.4%. The grassland cover contributes about 13.73%. Besides, agricultural land covered about 23.78%, 2.62% of the land was covered by settlement and the percentage share of land covered by forest 5.47% (Table 7).

Table 7 LULC class, their corresponding areas for the year 2016

Class	**Count(Pixel values)**	**Percentage (%)**	**Area (ha)**
Reservoir	194001.88	54.4	15199.09
Grassland	42223.94	13.73	3308.04
Agricultural land	84804.49	23.78	6644.02
Forest	26247.31	5.47	2056.35
Settlement	9343.47	2.62	732.02
Total	356621.1	100	27939.52

From interview with selected sample respondents, grassland and cropland along the shorelines of the reservoir were exposed to inundation by the reservoir, when the reservoir increases in areal extent. Given these fluctuations in the areas of reservoir, swamp and grazing land, it is useful to make a distinction between land that is potentially available to the community, and land that is unsuitable for permanent agriculture i.e. the reservoir and swamp. Parts of the swamp area can be used for grazing during relatively dry years, when the extent of the reservoir is limited. The most important changes are the reduction in the area of potential available land for community use, a strong increase in cropland area and a reduction in permanent grazing land area.

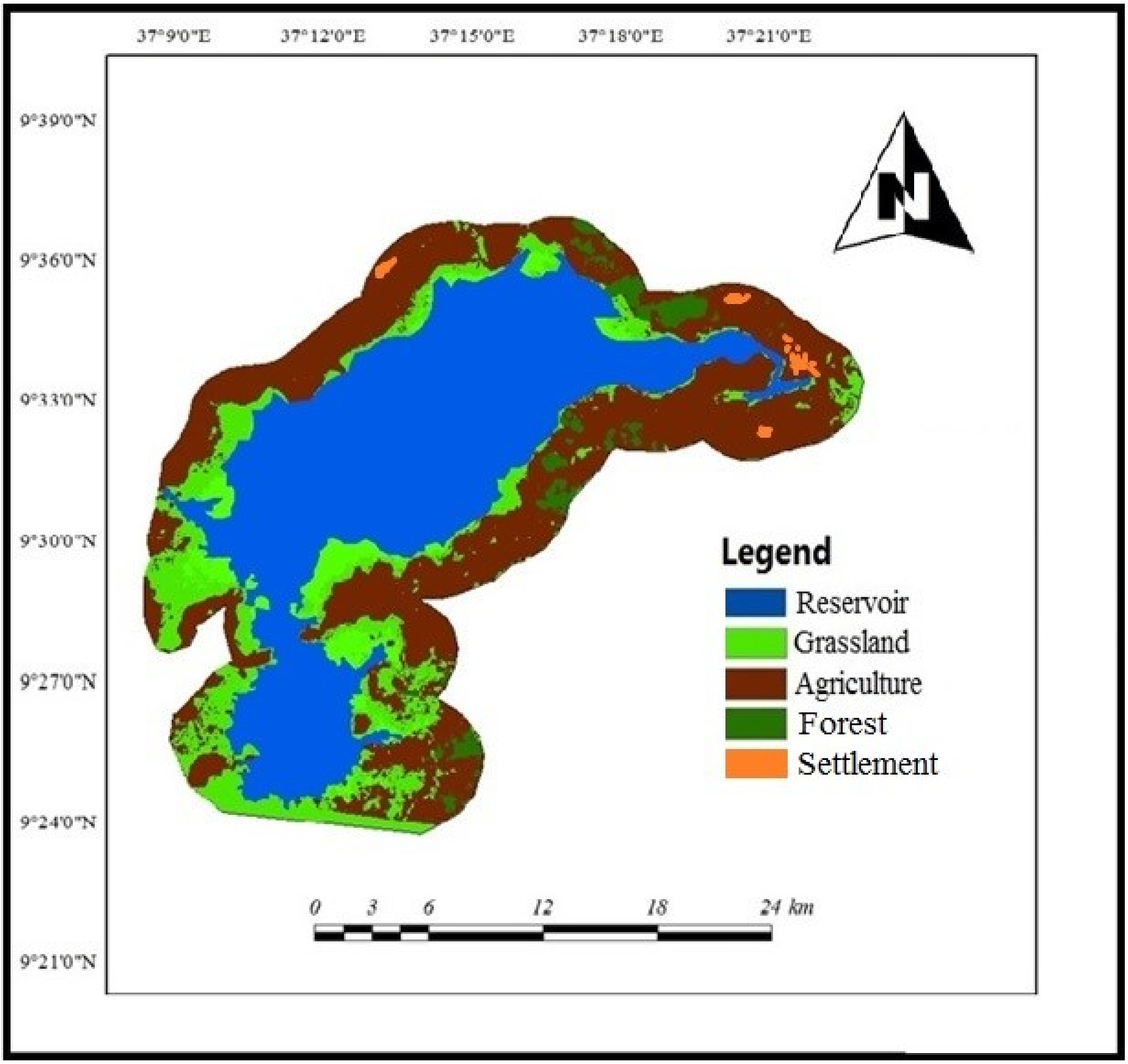

Figure 7 Lands use land cover map in 2016

The temporal change in water surface area of Fincha reservoir examined in this work shows that the water surface area was nearly the same in the periods of 2012 and the 2016. By comparison, the water surface areas in 2012 and 2016, we can see that in 2016 the water surface area had increased by 8.6km^2.

4.5. Land use land cover classification for 1996, 2012 and 2016

The major land cover classes for 1996, 2012and 2016 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 those 20 years and the results are given in Table 8.

Table 8 Summary of LULC class statistics of 1996, 2012 & 2016

Land Cover types	**Area for 1996 (ha)**	**1996 Area in %**	**Area for 2012 (ha)**	**2012 Area in %**	**Area for 2016 (ha)**	**2016 Area in %**
Reservoir	15757.89	56.14	11916.21	42.65	15199.09	54.4
Grassland	3587.43	12.84	5481.73	19.62	3308.04	13.73
Agricultural land	6113.16	21.88	7979.53	28.56	6644.02	23.78
Forest	1776.95	6.36	1841.21	6.59	2056.35	5.47
Settlement	704.07	2.52	720.84	2.58	732.02	2.62
Total	27939.52	100	27939.52	100	27939.52	100

The percentage share of reservoir cover had been declined from 1996 to 2012 but in 2016 its percentage share shows an increment trend. According to Bezuayehu and Geert (2008), before 2001 many people thought that Fincha reservoir area was expanding but since 2001 it has receded in all directions due to reductions in annual rainfall. Hence the interface between swamp and grazing land changes depending on the magnitude of rainfall and the gradient of the reservoir bed. In the inundated area, a low longitudinal gradient of 1:476 m/m was determined between the dam and the remotest part of Fincha reservoir. This is the main cause why such a large reservoir area can be impounded by a dam only 20 m high with a crest length of 340 m.

In 2016 the areal extent of Fincha reservoir is increased by 8.6 square kilometer and decreased by 35.5 square kilometer compared to 2012 and 1996 respectively. During this time the areal extent of Fincha reservoir was 46% of the total area of the study area. This was increased by 2.7% compared to that of 2012. Generally, as observed, there has been increment in water surface area of Fincha reservoir in 2016 compared to that of 2012 due to different factors. Due to this increment the shorelines of the reservoir were exposed for inundation of the reservoir in 2016, this is one main reason for the decline especially in the grassland cropland coverage in the study area in 2016. In addition some areas which were previously used for grazing land and cropland were removed and replaced by the reservoir.

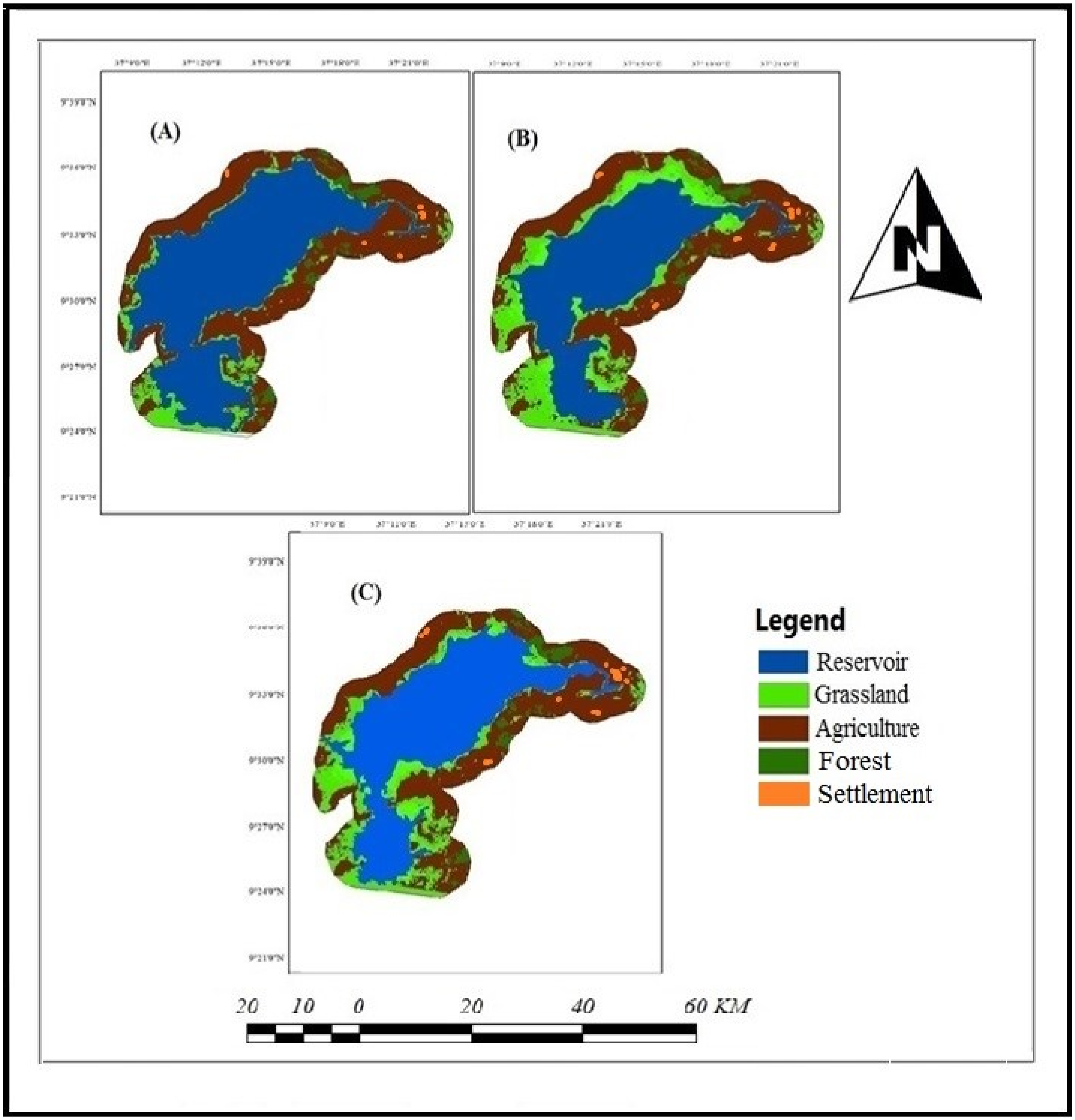

Figure 8 Lands use land cover map of 1996(A), 2012(B) and 2016(C)

4.6. Post classification and accuracy assessment

Accuracy of LU/LC can be described using percentage. The higher the percentage of the accuracy, the better the classification. In this study accuracy assessment has been done for all period of classification. The diagonal values of the accuracy assessment table describe the correctly classified percent of each land use land cover classes and the other non diagonal values are those which are incorrectly classified classes. The overall accuracy assessment also describes the overall LULC classes accuracy of classification for a single period

4.6.1. Accuracy assessment for LULC mapping of 1996

The LULC classification accuracy of the year 1996 was relatively poor as compared with the other periods. The reason behind this is the TM data of the year 1996 has a lot of error. The overall accuracy of this period of classification results 97.75% and accuracy of each LULC classes is present in the table below (Table 9). The accuracy assessment table describes the percentage of accuracy of mapping each land use and land cover classes.

Table 9 Confusion matrix of 1996(%)

Land use land cover class	**Reservoir**	**Grassland**	**Agriculture**	**Forest**	**Settlement**
Reservoir	**100**	0	0	0	0
Grassland	0	**96.02**	1.94	0	0
Agriculture	0	3.98	**98.06**	2.03	2.01
Forest	0	0	0	**96.68**	0
Settlement	0	0	1.38	0	**97.99**
Total	100	100	100	100	100

4.6.2. Accuracy assessment for LULC mapping of 2012

The land use land cover classification accuracy of the year 2012 was relatively better than 1996 but less than 2016 image. The overall accuracy of this period of classification results 98.98% and accuracy of each land use and cover classes is present in the (Table 10).

Table 10 Confusion matrix 2012(%)

Land use land cover class	**Reservoir**	**Grassland**	**Agriculture**	**Forest**	**Settlement**
Reservoir	**100**	0	0	0	0
Grassland	0	**98.24**	0	0	0
Agriculture	0	1.76	**97.74**	0.03	1.01
Forest	0	0	1.28	**99.97**	0
Settlement	0	0	0.98	0	**98.99**
Total	100	100	100	100	100

4.6.3. Accuracy assessment for Lu/Lc mapping of 2016

The land use land cover classification accuracy of the year 2016 was relatively better as compared with the other periods. The reason behind this is the use of panchromatic channel that has better resolution than the other land sat images. The overall accuracy of this period of classification results 99.62% and accuracy of each land use land cover classes is present in the (Table 11).

Table 11 Confusion matrix 2016(%)

Land use land cover class	**Reservoir**	**Grassland**	**Agriculture**	**Forest**	**Settlement**
Reservoir	**100**	0	0	0	0
Grassland	0	**99.58**	0.15	0	0
Agriculture	0	0.42	**99.44**	0.16	0.76
Forest	0	0	0	**99.84**	0
Settlement	0	0	0.41	0	**99.24**
Total	100	100	100	100	100

4.7. Land use land cover change detection using pair matrix

4.7.1. Land use land cover change detection using pair matrix from1996 to 2012

The total size of the study area covers about 27939.52 hectares. From this total area 11902.23 hectares or 42.6 % is covered by reservoir starting from 1996 to 2012. The reservoir is changed in to grassland, agricultural land, and forest due to different factors. From 1996 to 2012 about 11902.23 hectares/ 42.6 % of the areas were covered by reservoir (no change).

From the total land covered by reservoir in 1996, about 19.55 hectares/0.07 % were converted in to grassland in 2012. From the total land that covered by reservoir in 1996 about 5.58 ha/0.02 % of the land was converted in to agricultural land in 2012. In addition to this, from the areas covered by reservoir in 1996 about 0.21 ha/0.001 % of the area was converted in to forest in 2012.

Grassland of the study area has five probabilities to be converted in to other features due to various reasons. From the total grassland cover areas of 1996 about 0.51 ha/0.002 % was changed in to reservoir in 2012. In 1996 about 5470.5 ha/19.58 % of the study area was covered by grassland and the same areas were covered in 2012 (no change). From grassland covered areas of 1996 about 11.17 hectares/0.04 % was changed in to agricultural land in 2012. From the aggregate grassland covered areas in 1996 about 0.62 hectares/0.003 % was converted in to forest in 2012.

For agricultural land of the study are, as the researcher has mentioned before all land use land cover types have five probabilities of change. From the agricultural land covered areas in 1996 about 0.15 hectares/ 0.0005 % was changed in to reservoir in 2012. On the other hand in 1996 the areas were covered by agricultural land but, about 3.91 ha/ 0.014 % of the area was converted in to grassland in 2012. In 1996 about 7970.93 hectares/ 28.53 % of the area was covered by agricultural land and it remains as it was in 2012 (remain unchanged). Finally, the total agricultural land in 1996, about 0.11 hectares/ 26.85 % of the land was changed in to forest in 2012.

From forest in 1996, about 0.09 ha/ 0.0002 % of the land was converted in to reservoir in 2012. From the total forest in 1996 about 5.58 ha/ 0.02 % of the area was changed in to grassland in 2012. In addition to this, from the forest of the study area in 1996 about 8.38 ha/ 0.03 % was changed in to agricultural land in 2012. Finally, about 1830.03 ha/ 6.55 % of the study area were covered by forest in 1996 and it was the same amount of land under forest (no change) in 2012. On the other hand about 709.66 hectares/2.54% of the land was covered by settlement no change from 1996 to 2012. From settlement covered areas of 1996 about 16.77 hectares/0.06 % was changed in to agricultural land in 2012.

Table 12 Land use land cover change detection from 1996 to 2012 (%)/ hectares

Class no.	**Land use values**	**Count(Pixel values)**	**Percentage (%)**	**Area (ha)**
1	Reservoir (no change)	151920.58	42.6	11902.23
2	Reservoir to grassland	249.63	0.07	19.55
3	Reservoir to agricultural land	71.32	0.02	5.58
4	Grassland (no change)	69826.41	19.58	5470.55
5	Grassland to agricultural land	142.64	0.04	11.17
6	Agricultural land to grassland	49.92	0.014	3.91
7	Agricultural land (no change)	101740.43	28.529	7970.93
8	Forest to grassland	71.32	0.02	5.58
9	Forest to agricultural land	106.98	0.03	8.38
10	Forest (no change)	23358.68	6.55	1830.03
11	Settlement (no change)	9058.17	2.54	709.66
12	Others	24.96	0.007	1.95
Total		356621.1	100	27939.52

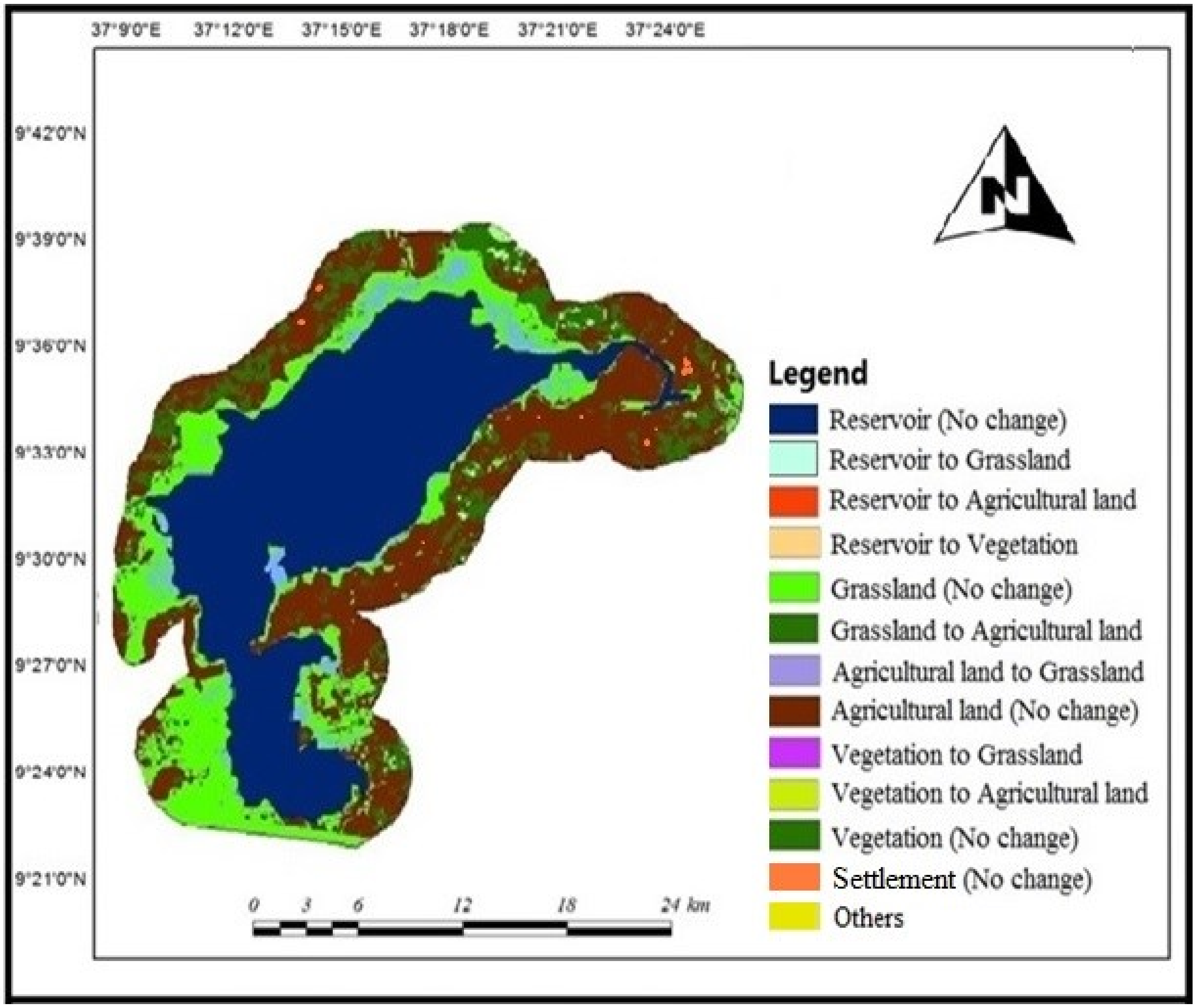

Figure 9 Change detection map from 1996 to 2012

4.7.2. Land use land cover change detection using pair matrix from2012 to 2016

The area 15187.92 hectares or 54.36 % is covered by reservoir starting from 2012 to 2016. The reservoir was changed in to grassland, agricultural land, and forest due to different factors. In 2012 & 2016 about 15187.92 hectares/ 54.36 % of the areas were covered by reservoir (no change).

From the total land covered by reservoir in 2012, about 3.42 hectares/0.01 % were converted in to grassland in 2016. From the total land that covered by reservoir in 2012 about 1.16 ha/0.02 % of the land was converted in to agricultural land in 2016. In addition to this, from the areas covered by reservoir in 2012 about 2 ha/0.001 % of the area was converted in to forest in 2016.

Grassland of the study area has four probabilities to be converted in to other features due to various reasons. From the total grassland cover areas of 2012 about 19.55 ha/0.07 % was changed in to reservoir in 2016. In 2012 about 3296.86 ha/11.8 % of the study area was covered by grassland and the same areas were covered in 2016 (no change). From grassland covered areas of 1996 about 5.59 hectares/0.02 % was changed in to agricultural land in 2012. As well as from the aggregate grassland covered areas in 2012 about 0.61 hectares/0.002 % were converted in to forest in 2016.

Table 13 Land use land cover change detection from 2012 to 2016 (%)/ hectares

Class. No.	**Land use values**	**Count(Pixel values)**	**Percentage (%)**	**Area (ha)**
1	Reservoir (no change)	193859.23	54.36	15187.92
2	Grassland to reservoir	249.63	0.07	19.55
3	Grassland (no change)	42081.29	11.8	3296.86
4	Grassland to agricultural land	71.32	0.02	5.59
5	Agricultural land to reservoir	71.32	0.02	5.59
6	Agricultural land to grassland	35.66	0.01	2.79
7	Agricultural land (no change)	84661.84	23.74	6632.84
8	Forest to grassland	71.32	0.02	5.59
9	Forest to agricultural land	71.32	0.02	5.59
10	Forest (no change)	26104.66	7.32	2045.17
11	Settlement (no change)	9222.22	2.586	722.522
12	Others	121.25	0.034	9.49
Total		356621.1	100	27939.52

For agricultural land of the study area as the researcher has mentioned before all land use land cover types have four probabilities of change. From the agricultural land covered areas in 2012 about 5.59 hectares/ 0.02 % was changed in to reservoir in 2016. On the other hand in 2012 the areas were covered by agricultural land but, about 2.79 ha/ 0.01 % of the area was converted in to grassland in 2016. In 2012 about 6632.84 hectares/ 23.74 % of the area was covered by agricultural land and it remains as it was in 2016 (remain unchanged). Finally, the total agricultural land in 2012, about 0.01 hectares/ 0.00003 % of the land was changed in to forest in 2016.

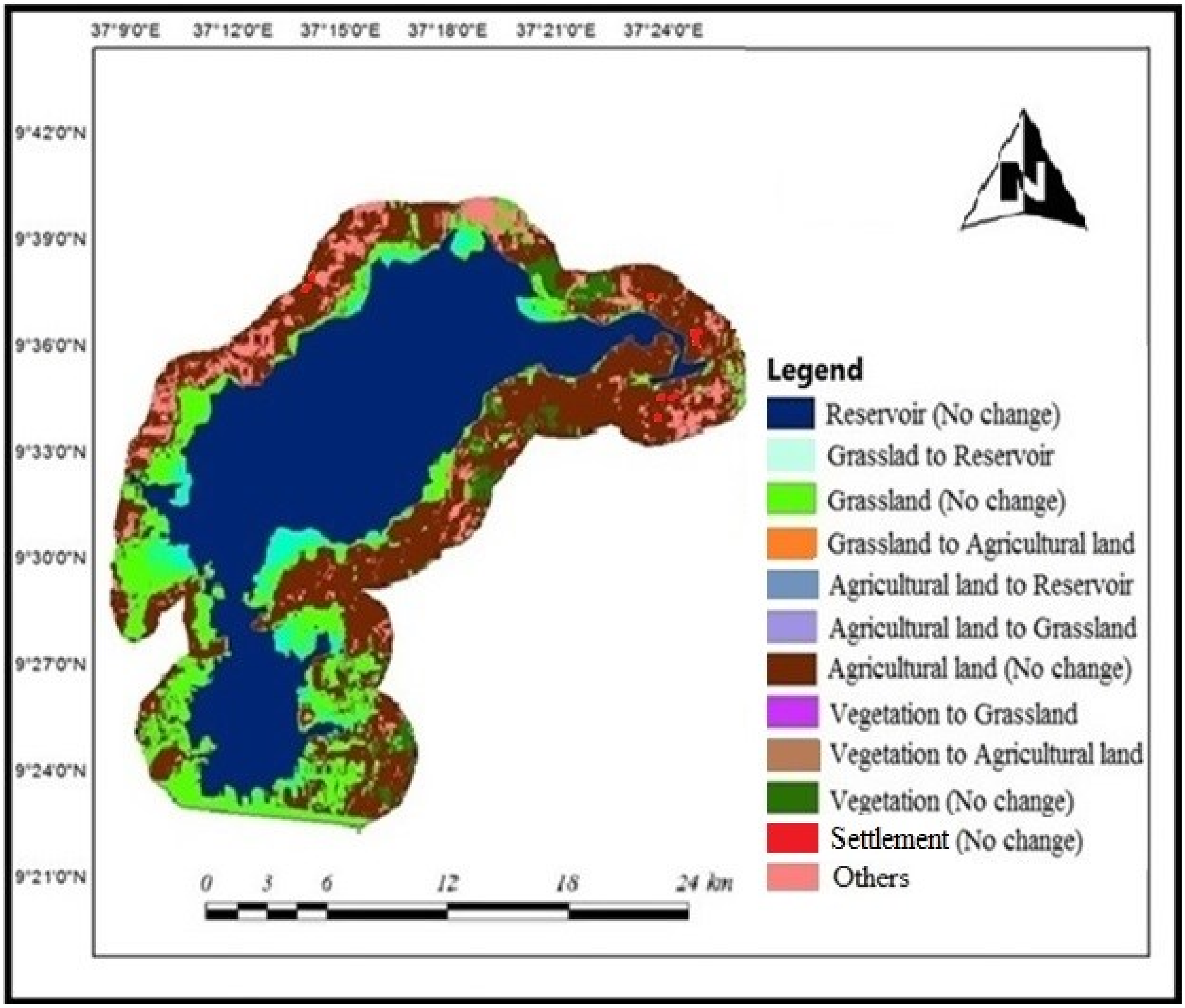

Figure 10 Change detection map from 2012 to 2016

From forest in 2012, about 0.17 ha/ 0.0005 % of the land was converted in to reservoir in 2016. From the total forest in 2012 about 5.59 ha/ 0.02 % of the area was changed in to grassland in 2016. From the forest of the study area in 2012 about 5.59 ha/ 0.02 % was changed in to agricultural land in 2016. Finally, about 2045.17 ha/ 7.32 % of the study area was covered by forest in 2012 and it was the same amount of land under forest (no change) in 2016. From the total settlement cover areas of 2012 about 11.18 ha/0.04 % was changed in to agricultural land in

2016. In 2012 about 722.52 ha/2.59 % of the study area was covered by settlement and the same areas were covered in 2016 (no change).

4.8. Locations of most fluctuated shoreline of Fincha reservoir

The southwestern, western, northwestern, northern, northeastern and south eastern shoreline of the reservoir has experienced the greatest decrease in the areal extent from 1996 to 2012. The southwestern shoreline of the reservoir has experienced the greatest increase in the areal extent from 2012 to 2016. These is because of southwestern shoreline of the reservoir has flat surface.

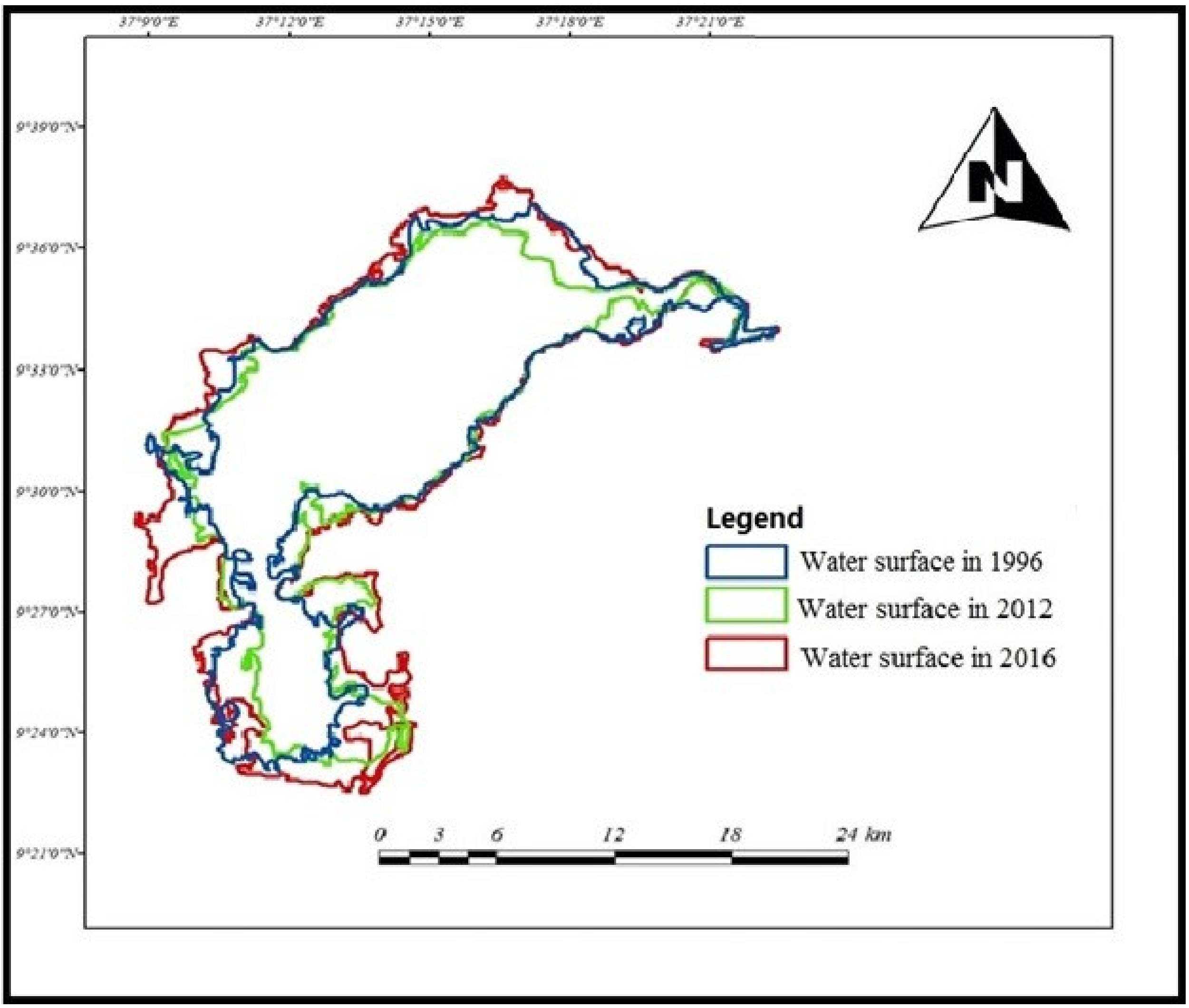

Figure 11 Water surface area of Fincha reservoir in 1996, 2012 & 2016

4.9. Rate of fluctuation in areal extent of Fincha reservoir

The areal extent fluctuations for the past 20 years which are given in the above thematic fluctuation in areal extent maps are discussed below with the fluctuation comparison factors.

Generally, the fluctuation in areal extent from 1996 to 2016 has been discussed in two periods. The first period has 16 years of gap i.e. from 1996 to 2012 and the second period is from 2012 to 2016 that has 4 years of gap. Figure 12 clearly shows the rate of fluctuation in areal extent of Fincha reservoir for the past 20 years.

The rate of change was calculated using the following formula: rate of fluctuation (sq km/year) = (X-Y)/Z *Where* X = Recent areal extent in sq km.

Y = Previous areal extent in sq km.

Z = interval between X and Y in year

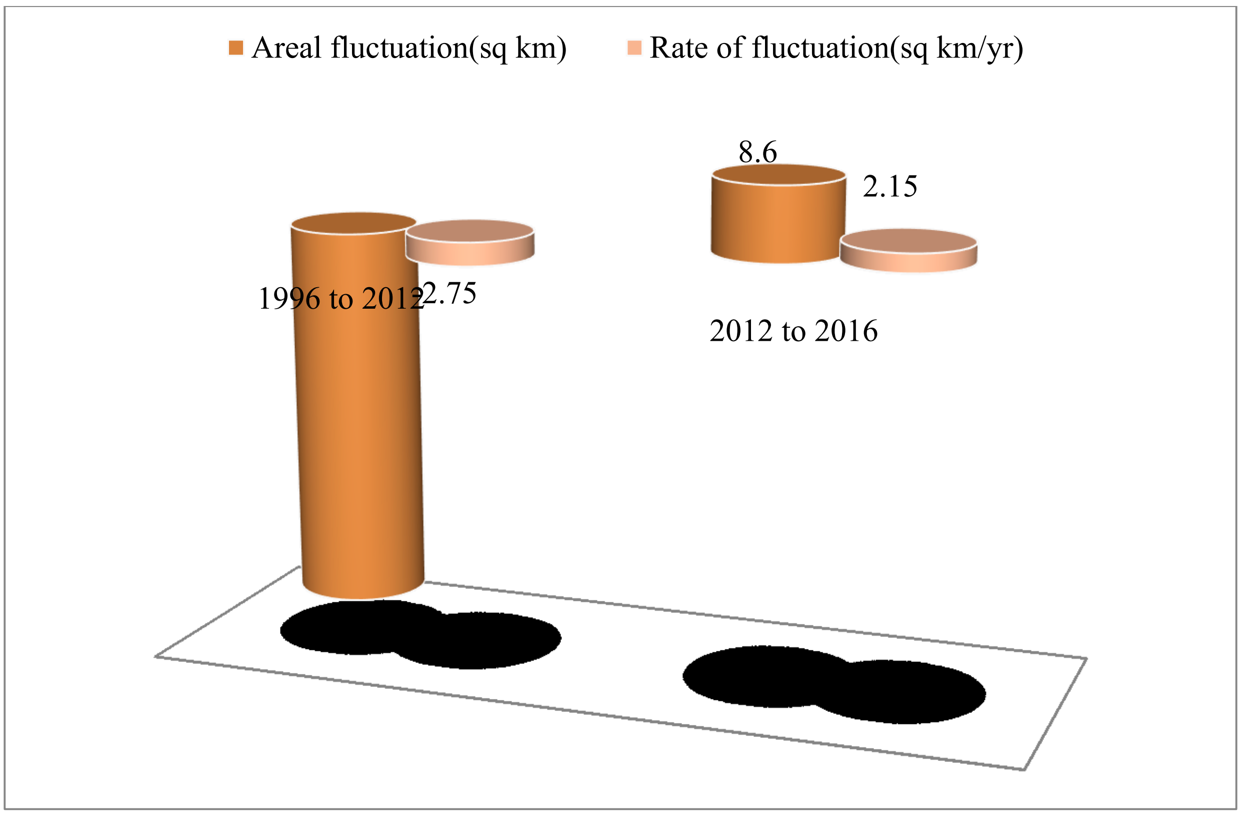

Figure 12 Rate of fluctuation in areal extent of Fincha reservoir from 1996 to 2012 & 2012 to 2016

4.10. Socio-economic impacts of fluctuation in areal extent of Fincha reservoir

This section of the paper analyzes the socio-economic impacts brought as the result of the fluctuation in the areal extent of Fincha reservoir on the surrounding community. The timely and accurate change detection o f the earth's surface features is extremely important for understanding relationships and interactions between human and natural phenomena in order to promote better decision-making (Lu *et al.,* 2003). The integration of remote sensing and socio-economic data has been given a big boost with the dissymmetric approach (Langford and Unwin, 1994).

4.10.1. Demographic characteristics of the respondents

The demographic characteristics of the respondents are indicated in Table 14. On average the interviewed households consists of 5.9 persons. The majority of the family heads were men (68%). Out of this 9% of them were without any formal education, while 52% and 39% 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 14 Demographic characteristics of samples

Characteristics	Description	Percentage
Sex	Male	60
	Female	40
Age	Young	20
	Middle	50
	Old	30
Education	No enrollment/Illiterate	15
	Primary	25
	J/ secondary	20
	Secondary	40

4.10.2. Socio-economic impacts encountered by respondents

According to the information obtained from respondent almost all resettles were dislocated involuntarily and they were encountered many problems. The survey result indicated that 95 % of the respondent lost grassland, 74 % of them lost cropland and has Barrier for accessing schools, market places, major roads and health center for 43 %.

Table 15 Problems encountered by respondents during fluctuation in areal extent

Problems	No of respondents	Percentage
Grassland Loss	114	95
Agricultural land Loss	89	74
Barrier for accessing schools, market places, major road and health center	43	52

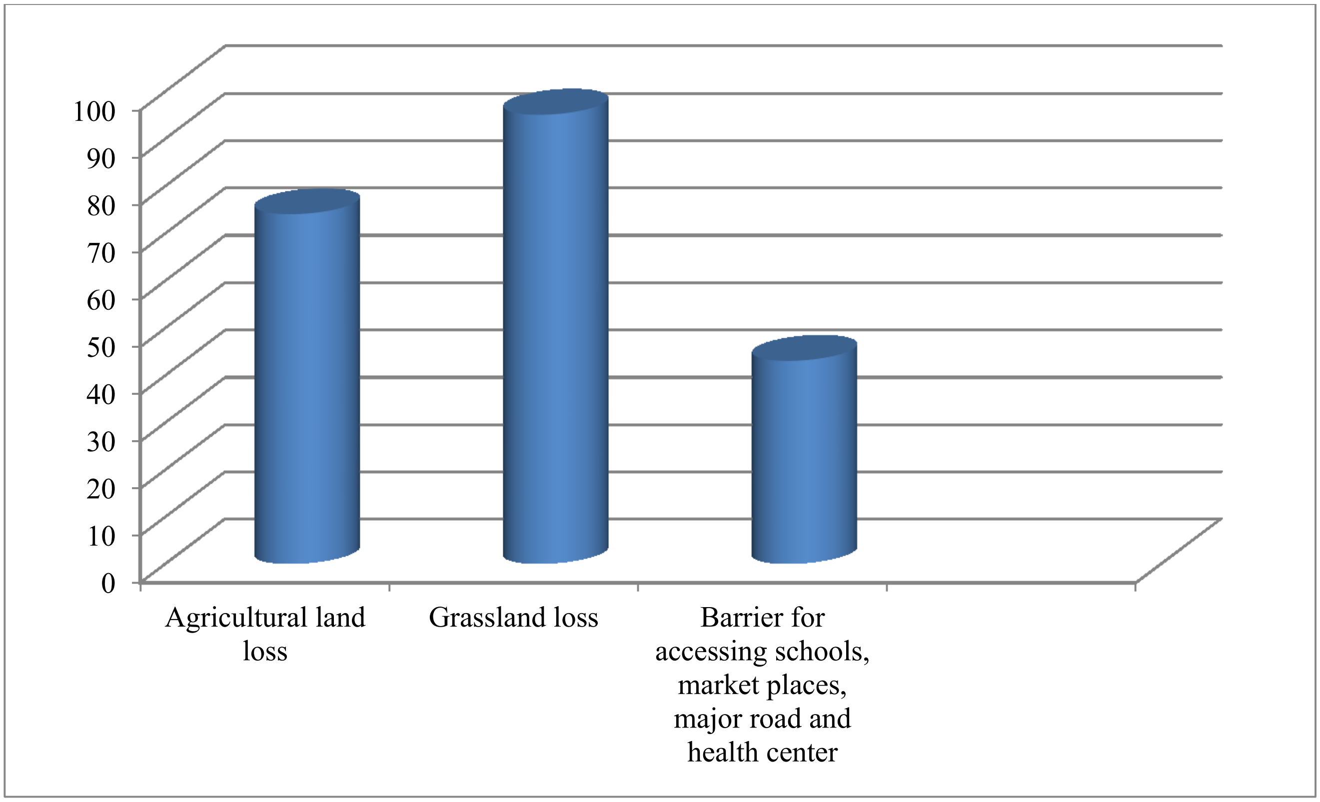

Figure 13 Problems encountered by respondents during fluctuation in areal extent

4.10.2.1. Inundation of grassland

The annual and inter-annual fluctuation in the areal extent of Fincha reservoir brings loss of grassland. As indicated in following figure out of 120 respondents 95% of the respondents were lost grassing land. Nearly the entire sample was kept their livestock on communal land which was mainly located around the shores of the reservoir. This makes an overwhelming majority of the sample to have a negative attitude toward the fluctuation in areal extent of the reservoir.

Based on the responses of the surveys, fluctuation in areal extent of the reservoir has been a major issue since 2014. Based on LULC detection from the total grassland cover areas of in 2012 about 21.62 hec/0.07 % was changed in to reservoir in 2016 (inundated by the reservoir). The reservoir is also the main cause for the decrement in the area of permanent grazing land. Due to the current shortage of permanent grazing land, livestock numbers have decreased (Bezuayehu and De Graaff, 2006) and farmers are forced to use the swamp as pasture, which frequently results in drowning of animals.

Figure 14 Partial view of Fincha reservoir grassland inundated by reservoir

4.10.2.2. Inundation of cropland

Agricultural land can be broadly defined as land used primarily for production o f food and fibre which include the following categories: cropland and pasture, orchards, groves and vineyards, nurseries and ornamental horticultural areas, and confined feeding operations (Lille sand *et al.,* 2004). Cropland now occupies almost 77% of the land potentially available for community use, indicating that there is hardly any possibility for further expansion to accommodate new families. The fluctuation in the areal extent of Fincha reservoir inundates crop especially along shoreline of the reservoir.

The post classification analysis revealed that from 2012 to 2016 the grassland and agricultural land decreased were as reservoir coverage was increased. According to the LULC change detection from the agricultural land covered areas in 2012 about 5.54 hectares/ 0.02 % were inundated by Fincha reservoir in 2016.

Figure 15 Partial view of the reservoir cropland inundated by reservoir

According to the survey result out of 120 respondents 74% of the respondents were lost their crop due to the fluctuation in the areal extent Fincha reservoir. As evidenced to most of the respondents the fluctuation in areal extent in recent decades especially from 1996 to 2016 have seen very large increases in the economic damage and disruption caused by inundating crops around shorelines of the reservoir. Climate change is hence one of several factors likely to affect the future evolution of damage from the fluctuation in the areal extent of the reservoir.

4.10.2.3. Barrier of accessing schools, market places, major road and health center

As per the information obtained from the respondents the fluctuation in the areal extent of Fincha reservoir (when it was increases) has barrier for accessing schools, market places, major roads and health center for 43 % of the total respondents120. This is likely due to the increase in the areal extent of the reservoir. As information obtained from the samples under the problem of accessing schools, market places, major road and health center the fluctuation is both annual and inter-annual, while the inter-annual fluctuation is occur mainly during the summer season.

CHAPTER FIVE
CONCLUSION AND RECOMMENDATIONS

5.1. Conclusion

So as to see the possible socio-economic impacts of the fluctuation in areal extent of Fincha reservoir some parameters were selected some of the Geographic Information System and remote Sensing technologies were also used. Accordingly, it is found out that the fluctuation in areal extent of Fincha reservoir has been adversely affecting the socio-economy of the surrounding community since the last 20 years.

The result of land use land cover analysis portrayed that there was a continuous land use land cover change for the last 20 years. Based on the analysis four land cover classes was identified. These include reservoir cover, grassland, agricultural Land and vegetation. The post classification analysis revealed that from 1996 to 2012 among others reservoir coverage declined were as grassland and agricultural land were increased. Besides from 2012 to 2016 the grassland and agricultural land decreased were as reservoir coverage was increased. The vegetation coverage increased from 1996 to 2012 and decreased from 2012 to 2016. The settlement land cover increased from 1996 to 2012 and also increased from 2012 to 2016.

From the total land covered by reservoir in 2012, about 3.42 hectares/0.01 % were converted in to grassland in 2016. From the total land that covered by reservoir in 2012 about 1.16 ha/0.02 % of the land was converted in to agricultural land in 2016. From the total grassland cover areas of 2012 about 19.55 ha/0.07 % was changed in to reservoir in 2016. From the agricultural land covered areas in 2012 about 5.59 hectares/ 0.02 % was changed in to reservoir in 2016. On the other hand in 2012 the areas were covered by agricultural land but, about 2.79 ha/ 0.01 % of the area was converted in to grassland in 2016.

The information obtained from response of 120 sample respondent specifically those who were victims of the areal extent showed that, the areal extent of Fincha reservoir has brought an adverse impact on the socio-economic status of the society. Such people were lost their crops and grassland.

5.2. Recommendations

- There was nothing done by the concerning body against the negative impacts of fluctuation in areal extent of the reservoir. Even the hydropower produced by the reservoir was not serving the community under threat of fluctuation in the areal extent of the reservoir. Thus, the hydropower produced by the reservoir should serve the communities under continuous threat and they need to be compensated.
- The reduction of the water surface area has impacts on the socio economic aspect of the area. One is when water surface area decreased the economically beneficial fish production decreased and also lack of water for irrigation. The other is, when water surface area decreased agricultural land accessibility increased, especially for the newly emerged farmlands and increased availability of grazing land. The increment of the water surface area has also impacts on the socio economic aspect of the area. When water surface area increased the economically beneficial fish production increased and also availability of water for irrigation. The other is, when water surface area increased grassland and cropland would inundated by the reservoir. Thus, science-based policies and strategies should be adopted to practice farming and related activities which are friendly with the fluctuation in water surface area.
- There is a need to release some amount of water from the reservoir (dam) when the areal extent of the reservoir increases so as to minimize its impact on the socio-economic aspects of the society.
- Research based preventive approaches should be adopted so as to mitigate the impact fluctuation in the areal extent of the reservoir on the socio-economic aspects.

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Appendixes-1

Household survey

Socio-economic impact assessment of fluctuation in areal extent of Fincha reservoir

This Household survey is developed with the objective of assessing the impact of fluctuation in areal extent of Fincha reservoir on the socio-economic aspects of the surrounding community. The Household survey contains two main parts. 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 Socio – Economic Issue

Objective;

The main Objective of this part is to assess the socio- economic impact brought by the fluctuation in the areal extent of Fincha reservoir.

Socio-economic impact assessment of the fluctuation in areal extent of Fincha reservoir

Questionnaire No ______________

Survey Area: Region ______________________ Zone _______ District _______ Sample Site_________________________ 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						
7						

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- Socio Economic Issues

2. How can you describe your socio economic status with respect to the fluctuation in areal extent of the reservoir? Improved - 1, No change -2, decline – 3, I don't know-4, other (specify) _5

3. Do you have additional source of income than livestock and crop production? Yes __1 'No __2

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

5. How many live stocks do you have? >15_______1 '<15 _____2

6. Where do you keep you livestock? On farmland-1, communal land-2, on other's land –3, other (specify) ---4

7. How do you evaluate the availability of grasses, when the reservoir areal extent increases, increases __1, decrease ___2, No change -3, other (specify) -4

8. What about your livestock productivity, when the reservoir areal extent increases, increases __1, decrease ___2, No change -3, other (specify) -4

9. Do you practice irrigation near the reservoir? Yes __1 'No __2

10. Does the increment of areal extent of the reservoir inundate your irrigated crops? Yes __1 ‘No __2

11. What about the decrement of areal extent of the reservoir on your irrigated crops, does it have negative impact? Yes----1, No---2

12. If yes specify

13. Does the increment of areal extent of the reservoir a barrier for accessing schools, market places, major roads, health center. Etc. Yes----1, No---2

Thank you.