2020-03-17

IMPACTS OF LANDUSE CHANGE AND HYDRAULIC STRUCTURES ON RIVER MORPHOLOGY: A CASE STUDY OF SHINA MICRO EARTH DAM, LAKE TANA BASIN.

Zewdie, Ewnetu

http://hdl.handle.net/123456789/10487

BAHIR DAR UNIVERSITY

BAHIR DAR INSTITUTE OF TECHNOLOGY

SCHOOL OF RESEARCH AND POSTGRADUATE STUDIES

FACULTY OF CIVIL AND WATER RESOURCE ENGINEERING

IMPACT OF LANDUSE CHANGE AND HYDRAULIC STRUCTURE ON RIVER MORPHOLOGY: A

CASE STUDY OF SHINA MICRO EARTH DAM, LAKE TANA BASIN.

By

Ewnetu Zewdie Molla

Bahir Dar, Ethiopia

January, 2018

IMPACTS OF LANDUSE CHANGE AND HYDRAULIC STRUCTURES ON RIVER MORPHOLOGY: A CASE STUDY OF SHINA MICRO EARTH DAM, LAKE TANA BASIN.

By

Ewnetu Zewdie Molla

A Thesis in partial fulfillment of the requirements for the Degree of Master of Science in

Hydraulic Engineering

Presented to the Faculty of Civil and Water Resource Engineering, Bahir Dar Institute of

Technology, Bahir Dar University

Advisor: Mengiste Abate (PhD)

Bahir Dar, Ethiopia

January, 2018

DECLARATION

I, the undersigned, declare that the thesis comprises my own work. In compliance with internationally accepted practices, I have dually acknowledged and refereed all materials used in this work. I understand that non-adherence to the principles of academic honesty and integrity, misrepresentation/ fabrication of any idea/data/fact/source will constitute sufficient ground for disciplinary action by the university and can also evoke penal action from the sources which have not been properly cited or acknowledged.

Name of the student Ewnetu Zewdie Signature

Date of submission: 28/06/2010 E.C

Place: Bahir Dar

This thesis has been submitted for examination with my approval as a university advisor.

Advisor Name: Mengiste Abate (PhD)

Advisor's Signature:

BAHIR DAR UNIVERSITY
BAHIR DAR INSTITUTE OF TECHNOLOGY
SCHOOL OF RESEARCH AND GRADUATE STUDIES
FACULTY OF CIVIL AND WATER RESOURCE ENGINEERING

THESIS APPROVAL SHEET

Student:

Ewnetu Zewdie

Name Signature Date

The following graduate faculty members certify that this student has successfully presented the necessary written final thesis and oral presentation for partial fulfillment of the thesis requirements for the Degree of Master of Science in Hydraulic Engineering

Approved By:

Advisor: Mengiste Abate

Name Signature Date

External Examiner:

Adane Abebe (Dr.)

Name Signature Date

Internal Examiner: Michael Mehari

Name Signature Date

Chair Holder:

Michael Mehari

Name Signature Date

Faculty Dean:

Endalamaw Aragie Tefera
Faculty Dean

Name Signature Date

DEDICATION

I dedicate this thesis manuscript to all my families for their love and dedicated partnership in the success of my life and I dedicate this work to my wife Melkie Gettie, and to my children Mekedesmariam, Haregewoyin and Tesfamariam for their affection, help and their moral support during my studies.

ACKNOWLEGMENTS

First of all my thank to above all, creator and governor of the two worlds, the almighty GOD, Jesus Christ, his mother Saint Marry, all his Angels and Saints for the opportunity given to me to pursue this course. He has made me prevail over all the challenges that came my way.

I would like to express my deep heart felt gratitude to my advisor Dr. Mengiste Abate, who helped me a lot from the beginning up to the end of this thesis work. During all this time his valuable guidance, interesting discussions to bring solution for problems, advices and constructive comments made me able to conduct the research confidently. Without his continuous follow-up, correcting the manuscripts and constructive comments the research work may not take the current form.

I thank MoWRIE and BoWRIE for securing a full sponsorship for me so that I could pursue a Master's Degree in Hydraulic Engineering.

The deepest gratitude goes to my wife W/o Melkie Gettie, my children Mekedesmariam, Haregewoyin and Tesfamariam for their consistence support, concern and encouragement. In absence of them contribution this study would have not been materialized.

Finally, I am also thankful to all those who are not mentioned here but have helped and supported me in order to achieve this paper successfully.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABSTRACT

Hydraulic structures such as dams have inevitable effects on their downstream that requires investigation. This study addressed the impacts of land use change and hydraulic structures on river morphology in Shina watershed, Lake Tana basin, Ethiopia. Objectives of this thesis were to assess the impacts of land use change in view of river characteristics, to assess Shina river planform changes and to investigate vertical change of Shina river downstream from the dam. Satellite images of the year 1986, 2001 and 2017 were used for land use/ land cover classification and river planform analysis. To compare the vertical adjustment of the Shina River, current river cross-sections were taken at different intervals and the past cross-sections were developed from the old topographic map of the study area. For the data preparation and analysis image processing software (ENVI 5.1) and Arc GIS 10.2 were used.

From the result of land use /land cover classification, there is a decrease in forest land by 70%, the Bushes and shrubs by 48% and accompanied by increase in agriculture land by 23% and built up area by 26%. The anthropogenic impacts such as farming, deforestation, resettlement and animal free grazing have also aggravated the change of the planform in the downstream part of the river. The overlaying analysis showed that for the considered reach (6km length), starting from the dam for a length of about 3 km the general trend of the river banks were shifted to right and after that the river banks shifts left. Comparisons of cross-sections at junctions of spillway outlet and Shina river, at a distance of 210 m and 410 m from the dam axis to the downstream showed that the river bed degraded by 0.38 m,0.94 m and 0.42 m for the period 2007and 2017 respectively.

The conclusion of this thesis showed that Shina river morphology has been changed due to land use / cover changes and hydraulic structure. Therefore, upstream catchment treatment and downstream river restoration should be done.

Keywords; Channel planform change, vertical change, Dam, Shina River.

LIST OFABBREVATIONS AND ACRONYMS

ADSWE	Amhara Design & Supervision Works Enterprise
AL	Air Length
AOI	Area of Interest
MoWRIE	Bureau of Water resource, Irrigation and Electricity
BoWRIE	Bureau of Water resource, Irrigation and Electricity
CI	Channel Index
CL	Channel Length
DEM	Digital Elevation Model
ENVI	Environment for Visualizing Images
GIS	Geographic Information System
GPS	Global Positioning System
HSI	Hydraulic Sinuosity Index
RS	Remote Sensing
SSI	Standard Sinuosity Index
TSI	Topographic Sinuosity Index
USGS	United State Geological Survey
VI	Valley Index
VL	Valley length
LULC	Land use /Land cover

1. INTRODUCTION

1.1 Background of the Study

Construction of dams affects the morphological process of the downstream river reach by storing water and sediment, by changing the water discharge regime of the river and by releasing relatively clear water to the downstream. This produces significant geomorphological effects, by changing the pattern of erosion and deposition of the main channel of the river, banks and floodplains. The impacts vary according to size of the river and dam, hydrologic regime, environmental setting, history, initial channel morphology, purpose and operation of the impoundment (Graf, 2006; Petts & Gurnell, 2005; Williams & Wolman, 1984; Yang et al., 2011). The downstream effects of dams have already been studied by a number of scientists (e.g. Khan et al., 2014). However as river natures vary, the response to dam construction varies with a number of variables (Brandt, 2000). Abate et al. (2015), who studied the geomorphological changes of the nearby Gumara River to water withdrawal and alteration of Lake Tana level, showed that the carrying capacity of the lower reach of the river is reduced due to deposition of sediment in the river channel.

The knowledge of the river dynamics prior to dam construction, together with the analysis of the historical water and sediment inputs, land use land cover change, river bed and bank material, are used to forecast the effects of the dam construction on the downstream river reach. Even though numerous researches have been made on this topic it is not possible to generalize as the effects vary according to the river nature (Brandt, 2000). Hence, further understanding on different rivers, in spatial and temporal scales, and climatic conditions will contribute to develop wide ranges of knowledges.

The impact of construction of dams and reservoirs on alluvial rivers extends both upstream and downstream of the dam. Downstream of dams, both the water and sediment supplies can be altered leading to adjustments in the river channel geometry and ensuing changes in riparian and aquatic habitats. Williams and Wolman (1984) describes the wealth of pre and post regulation data on river provides an excellent case study of river regulation, channel adjustments, and restoration efforts. Rivers are essentially agents of erosion and transportation, moving the water and sediment supplied to them from the land surface to the oceans. They provide the route ways that carry excess precipitation to the oceanic store, thereby completing the global hydrological cycle. Rivers are dynamic entities whose characteristics vary over time and space with changes in environmental controls (Knight, 1998).

River morphology is concerned with the structure and form of rivers, including channel configuration (planform), channel geometry (cross-sectional shape), bed form, and profile characteristics. Channel morphology changes with time and is affected by water discharge, including velocities; sediment discharge, including quantity and sediment characteristics; the composition of bed and bank materials apart from varied geological controls (Anding quotes Schumn, 1963).

1.2 Statement of the Problem

Though the Government is struggling to secure food, still there is a problem of food security and an increasing demand for water due to the increase in population growth rate.

Dereje (2005) indicated that the fast growth of population and the density of livestock in the basin which has pressure on the land resources resulted in forest clearing and overgrazing. Consequently, the government of the country in the last decades, a number of water harvesting projects either concrete or earthen have been constructed in Ethiopia to be used for irrigation, water supply and hydropower purposes, especially dam projects in many regions. Shina dam is one of these projects, constructed for alleviating food shortage problems. But during construction of dam projects, it is known that the assessment of impacts of dams have almost exclusively emphasized relating pre to post dam hydrology to predict response, which is usually defined in terms of some change in channel cross-sectional geometry, landform or planform change. But there is no any previous study on planform assessment in the area and related research in shina dam even if the dam faced problem on downstream community. Therefore, this research is carried out to investigate river morphology in the area and to identify river shifts. The causes of change do not yet well investigated and documented. This research assesses the impacts of land use change and shina dam on the planform changes on the downstream of the dam based on the year 1986, 2001, and 2017 Landsat images.

1.3 Questions of the Study

When attempting to analyze the impacts of Shina dam on the downstream river morphology, there are fundamental questions that should be answered:

- What sort of changes are to be expected, will the river become deeper or shallower and by how much?
- How these do changes come, does the river become deeper because of a lack of released sediments, or narrower due to reduced flood peaks?

In order to answer these two questions the first step has to be to determine the factors that influence the channel morphology and the aspects of the river morphology that are likely to change.

1.4 Objectives of the Study

The overall objective of this thesis is to investigate the impacts of hydraulic structure and land use change on Shina river morphology.

Specific Objectives

- To assess impacts of land use change in view of River characteristics.
- To investigate the changes in the downstream planform of Shina river before and after dam construction.
- To calculate the vertical changes of Shina River at adistance of 410 m downstream of dam.

1.5 Significance of the Study

Because of uncontrolled agricultural practice and development of infrastructure like dam has great influence on river plan form changes. Therefore, the study will cover the nature of river morphology and assessment of channel changes of river for Shina embankment dam and enhancing the community resilience towards changes, determining the possible impact of hydraulic structures as well as to effectively rehabilitation of river morphology to sustain the environment.

1.6 Scope of the Study

The scope of the work of the study is spatially limited at Shina watershed and Shina reservoir. The research study is delimited to assess planform changes of shina river, and identifying vertical changes in cross-section of shina river. To achieve such targets of the study field observations, collection of secondary data from the relevant organizations, and current River cross section data were used. The Scope of the study of this research goes up to the extent of analyzing and detecting fluvial plan form changes of Shina river starting from Shina Dam till Lake Tana.

1.7 Structure of the Thesis

An introduction composed of the background, problem statement, Research questions, Research objectives, General objective and specific objectives, Significance of the study, Scope of the study and Structure of the thesis are explained in the first chapter. The literature review shows the major factors that elaborate the planform changes such as impacts of dams, shift in river course and its cause, investigation of river channel, methods measuring planform changes, measurement of sinuous, meandering and anastomosing channel, surface morphometric measurement, cross section morphology, related past studies and requirement of GIS and Remote sensing are explained in the second chapter. The third chapter explains materials and methods used which contains description of the study area such as location and accessibility, topography, climate condition, data requirement and source. The fourth chapter explains the results of data analysis and current planform attribute compared with the preceding Landsat image output data. The final chapter which is chapter five includes overall conclusions and recommendations.

2. LITERATURE REVIEW

The purpose of dam is very important for human beings living around the community such as for irrigation, water supply and hydropower resources, but it may have effects on river morphology and land usage or land cover to land owners. Therefore, it is necessary to see the effects of hydraulic structure on the characteristics of river plan form changes.

2.1 Impacts of Dams

The effects of dams on the water balance can be seen in Vorosmarty et al. (1997), Nilsson et al. (2005), and Hanasaki et al. (2006). Haddeland et al. (2006b) studied the effects of dams and irrigation given current conditions and found locally significant changes in the surface water fluxes. Battala et al. (2004) discussed reservoir induced hydrological changes in the Ebro River basin (NE Spain). Saad (2002) has described the Nile River morphology changes due to the construction of High Aswan Dam in Egypt. Impacts of the Three Gorges Project (TGP) on the Yangtze River ecology and management strategies have been studied by Wang et al. (2005). The influence of a dam on the downstream degradation of the bed of Tigris River was described by Thair (1990) downstream hydrologic and geomorphic effects of large dams on American rivers were studied by Graf (2006). Changes in hydrologic regime by dams have been described by Magilliganand Nislow (2005).

2.1.1 Classification of Impacts

There are several ways of classifying the impacts of dams. One way is to classify the impacts in terms of physical, chemical, biological, social, cultural and economic changes. Hydrological impacts may be classified depending upon the place of occurrence. Discussions of physical, chemical and similar impacts of dams are listed below.

Physical: Physical impacts include the change in the river cross-section and topography of the reservoir area, siltation of the reservoir, erosion of the reservoir banks, rising of the nearby water table, increased evaporation of water from the reservoir, micro-climatic changes in the vicinity of the lake due to water impoundment.

Chemical: Chemical changes include the changes in reservoir water quality which may affect the health of flora and fauna dependent on the source water, decomposition of organic material in the lake bottom resulting in the production of methane and hydrogen sulphide, water logging and consequent salinity in the surrounding regions and finally oxygen depletion. Concrete and steel structures and turbines may be subject to chemical attack. Accumulated plant nutrients also play a role in the chemical processes.

Biological: Biological alterations include the submergence of flora and fauna and consequent reduction in species diversity which may affect the ecological balance, possible extinction of some rare species, possible barriers to fish migration, breeding grounds for disease vector like malaria, bilharzias and proliferation of weeds and eutrophication. Methane missions from the biomass degrading in the reservoir may increase concentration of this greenhouse gas in the atmosphere.

Social and Cultural: Dams are widely blamed for uprooting local inhabitants whose ancestral homes and farms are inundated, possible loss of archeological remains, possible increase in disease and finally possible gap in communication within adjacent areas. Construction of dams leads to infuse of migrants to the area who bring in their culture and rituals. This influx may result in cultural diversity as well as clashes.

Economic: Dams are considered to be a great catalyst in economic development. The construction and operation of reservoir systems have known to change the economy of nearby places by the development of the transportation system, higher land productivities, more industrialization particularly agriculture based industries, and creation of direct and indirect job opportunities. The adverse economic effects of dams would include a possible increase in economic disparities as there are some who lose the homesteads, and others who reap the benefits.

2.1.2 Hydrological Impacts

Dams have major impacts on river hydrology, primarily through changes in the timing, magnitude, and frequency of low and high flows, ultimately producing a hydrologic regime differing significantly from the pre impoundment natural flow regime. From a hydrological perspective, a dam divides a river basin into three distinct areas:

A. Catchment area (above the dam)

B. Storage lake area (at the dam)

C. Downstream area (below the dam)

The impacts on each of the three areas are considered separately in the following and finally general impacts are described (Figure 2-1)

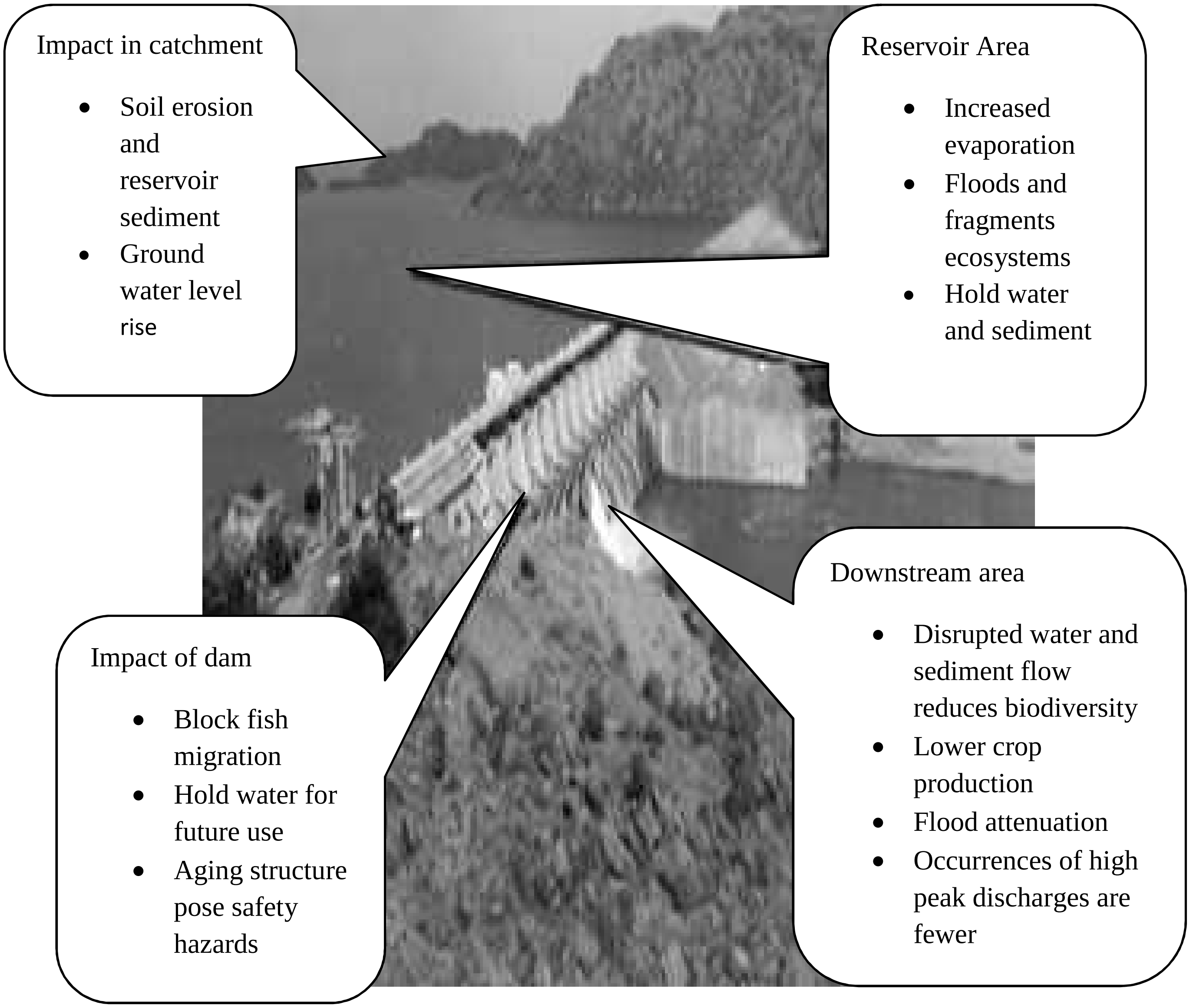


Figure 2-1Pictorial Representation of Impacts of Dams (Source: Graf L. William; 2006)

Impacts on each of the three areas are considered separately in the following

A. Impacts of Dams in the Catchment Area

Generally a dam does not give large impacts in the catchment area but the reservoir itself is influenced in many ways by the processes taking place in the catchment. A catchment process which is of immense interest is soil erosion and consequent reservoir sedimentation. In the peripheral area of the reservoir, the ground water level may rise depending upon the geological conditions.

B. Impacts in the Area of the Storage Lake

Two major hydraulic changes generally occur after the construction of a reservoir. First, the water area above the dam will change from lotic (i.e. Running water) to lentic (i.e. standing water) in nature, with associated changes in hydrologic and ecological processes. Infiltration and seepage through the bed of water-spread area of the reservoir influence the water holding capacity of the reservoir. Major hydrologic impacts in the lake area are described in the following.

I. Evaporation from Standing Water

It is a well-known fact that evaporation rate is very high for open water bodies. Consequently, a large proportion of the water stored in the surface reservoirs is lost due to evaporation losses. Typically such losses are smaller in the reservoirs that are located high up in the mountains where temperatures and relatively low and exposed surface areas are smaller due to larger depths. But near the foot hills, flatter topography causes water to spread over larger areas. When such reservoirs are located in the areas having higher ambient temperatures, it leads to the loss of larger volume of water due to evaporation.

II. Reservoir Sedimentation

When sediment laden water flows into a reservoir, the coarser particles begin to deposit in the upper reach of the reservoir due to decrease in flow velocity. Subsequently, the finer materials are deposited further into and along the reservoir bed. Sedimentation of the reservoir, therefore, is a natural process and a universal problem. To determine the useful life of a reservoir, it is essential to periodically assess the sedimentation rate in a reservoir. Human actions can considerably hasten the natural process and increase the rate of sedimentation.

III. Impact on Climate

The creation of a large body of water as a result of reservoir filling leads to changes in the microclimate of the storage lake area. As water has high capacity to store heat, reservoirs have a tendency to equalize extremes of temperature. This gives a pleasant and cooling effect.

C. Impacts in Downstream Areas

Impacts upon the hydrological characteristics of the river downstream are primarily related to the ratio of storage capacity and mean annual inflow, purpose(s) of the reservoir, spillway characteristics, and the operation policy of the reservoir. Flood attenuation has a major impact on flow variability downstream and rivers tend to narrow if major tributaries do not help to restore the flow and sediment balance downstream. Major hydrological impacts under this category are discussed below.

a) Flow Characteristics in Downstream River Reach

The most striking and visible impact of dams and diversions just below the structure is the change in magnitude and pattern of runoff rate. Occurrences of high peak discharges are fewer and low flow may not be very low in post-dam situation.

Dams and reservoirs of the world have widely differing features with great differences in regulation and flow release policies. The difference in dam inputs to the downstream reaches introduces changes to the hydrological regime that will vary from dam to dam but in general, there will be a reduction in flow volume downstream of the dam because water may be diverted away from the main channel from the reservoir and some stored water is lost due to evaporation.

b) Aggradation / Degradation

Depending on the features of the dam and the reservoir and its operation policy, a part of incoming sediment load will be trapped in the reservoir and the remaining part will be released into the downstream reaches. Trap efficiency of large reservoirs is commonly greater than 99%, whereas smaller reservoirs generally have lower values. Erosion in the watercourse may increase until a new state of equilibrium is reached due to the interruption in sediment transfer. The change in the runoff rate may also affect groundwater sources downstream. The newly created infiltration conditions can influence the groundwater reformation as well as the groundwater runoff. As bed load decreases, a channel becomes narrower and deeper and tends to meander, and as bed material grain size decreases, braiding occurs at lower slopes and/or discharges (Bridge, 1993). Changes in grain size are also coupled with changes in bedforms. Further; it appears that bed forms and bed load movement appear to be related to frequent flows, as compared to channel capacity and meander morphology which reflect more extreme flow events (Richards, 1982). Degradation is the most immediate morphological impact of dam construction, will extend progressively with time downstream from the dam. The most striking and visible impact of dams and diversions just below the structure is the change in magnitude and pattern of runoff rate.

As bed load decreases, a channel becomes narrower and deeper and tends to meander, and as bed material grain size decreases, braiding occurs at lower slopes and/or discharges (Bridge, 1993). Changes in grain size are also coupled with changes in bedforms. Further; it appears that bed forms and bed load movement appear to be related to frequent flows, as compared to channel capacity and meander morphology which reflect more extreme flow events (Richards, 1982). Degradation is the most immediate

morphological impact of dam construction, will extend progressively with time downstream from the dam

The difference in dam inputs to the downstream reaches introduces changes to the hydrological regime that will vary from dam to dam but in general, there will be a reduction in flow volume downstream of the dam because water may be diverted away from the main channel from the reservoir and some stored water is lost due to evaporation.

2.2 Shift in River planform

A river is a dynamic system and tends to adjust its channel roughness, geometry, pattern and profile with time. When a river carries high sediment loads, it tends to deposit it wherever the slope is gentle leading to the formation of multi-channels and development of meanders.

Rivers play very important roles in society by providing agricultural and municipal water supplies, ecological health (fisheries, riparian species, and food webs), aesthetics and recreation, and dams can enhance or limit these roles. The importance of water as a resource has prompted a broad range of studies, both in scale and context, following the installation of dams (Willliams and Wolman, 1984; Graf, 1988). These studies have shown that along with dams have come initially unforeseen geomorphic (Petts, 1979; Williams and Wolman, 1984; Carling, 1987; Hadley and Emmett, 1998; Salant et al., 2005), biotic (Ligon et al., 1995; Power et al., 1996; Orr et al., 2008) and societal impacts (Born et al., 1998; Darby and Thorne, 2000; Doyle et al., 2000; Johnson and Graber, 2002).

The fact that many river systems experienced anthropogenic modifications prior to dam Construction adds another level of complexity to studies of the effects of dams on rivers (Wohl, 2006; Marston, 1994).

A river is a conveyor of water and sediment (Schumm, 1977). Sediment is produced in spatially varied rates across the watershed and transported downstream by a spatially and temporally variable hydrograph (Darby and Thorne, 1995).

An equilibrium condition means that the stream planform, geometry, and slope reflect an approximate balance between the sediment load entering a reach of stream and the sediment load leaving the same reach over a period of decades (Langbein and Leopold et al., 1964).

Dams influence the magnitude, frequency, timing and duration of flows (Poff and Ward, 1989; Richter et al., 1996), and thus the ability of the river to transport sediment, as well as the amount of sediment available for transport (Williams and Wolman, 1984; Brandt, 2000).

Vegetation type and distribution are influenced by climate and geographic location, as well as discharge regime and land use adjacent to the channel (Hupp and Simon, 1991). Riparian vegetation in turn influences geomorphic processes by altering bank resistance, sediment deposition and hydraulic roughness along the channel boundaries (Simon et al., 2000; Simon and Collision, 2002; Pollen and Simon, 2005). Man induced channel changes are of two basic types; direct and indirect. Direct changes are brought about by some direct and generally purposeful human action upon the stream channel and these are generally related to engineering schemes designed to alleviate existing or impending trials of flowing sedimentation or erosion.

Indirect changes are those brought about by the effects of human activity upon the processes, which control the stream channel form. In alluvial rivers channels form adjusts to maintain hydraulic relationships between the channel boundary and the water and sediment discharge through the channel reach. Slope adjustment can be brought about by aggradations, degradation or changes to channel sinuosity, occurring singly or in combination. Channel gradient decreases where a river adopts a more sinuous course. The processes of aggradations and degradation respectively increase and decrease stream bed elevations, usually over Long River distances, and operate most often in response to changes in watershed controls. The three major patterns are straight, meandering and braided, which are very much linked to the channel slope. An index used to describe the channel planform is the sinuosity, defined as the ratio of channel length to valley length.

Leopold and Wolman (1957) have stated that a reach could be considered meandering when the sinuosity is greater than or equal to1.5.

2.3 Investigation of River Channels

Any quantitative or qualitative approach to river channel analysis should be preceded by the typological classification of the planform configuration of the river, as the type of channel is the criterion which determines the ensuing steps: the sectorisation and segmentation of rivers, the actual morphometric measurements and determining the planform migration of river channels. The geomorphological classification of channel types is relevant because it contributes to a better understanding of the relationships between processes, forms and stability. The progresses made in classifying channel planform shapes resulted in some changes in this regard compared to the earliest classifications made by Leopold and Wolman (1957) or Schumm (1981, 1985).

The recent typology published by Rinaldi et al (2011) combines the latest developments in terms of the classification of channel planform configurations. The transition of channels from one type to another can occur along the same river without any obvious delineating thresholds, as the type of underlying sediment and the stability of the channel changes (Thorne, 1998).

The straight (R) type is extremely rare in nature. It depicts straight channels with relatively uniform widths, low sediment loads, low slope gradients and stable banks which are usually shaped in deposits with high contents of silt and clay. The sinuosity index (Is) ranges from 1 to 1.05.

The sinuous (S) type describes a channel with an Is ranging from 1.05 to 1.5 carrying a mixed solid load (suspended and dragged), which contains small bars positioned alternately in the context of a sinuous thalweg, indicating that accumulation on the bank will be ensued by erosion due to the upstream migration of the bar.

The meandering (M) type describes a whole array of meandering channels (Is equal to or above 1.5) ranging between two extreme situations: a) channels with high sinuosity where the suspended solid load is prevalent, which have high dynamic stability and their typical evolution is towards meander cutoff, and b) less stable meandering channels, due to the mixed solid load with increasing dragged sediments content. The channel width is greater within the meanders. Processes such as meander migration and meander cutoff are characteristic for this subtype of channel.

The sinuous **type** with **alternating bars** and the **wandering (W)** type are transitional from meandering to braided channels. The solid loads carried by the channels in this class typically high, comprise mainly of sand, gravel and boulders. The channel width is relatively high in relation to the depth. Alluvial banks and bars commonly develop within the channel bed, which play an important role in localizing bank erosion.

The **braided (AI)** type is a category of channels commonly occurring in cases where the rivers have a significant dragged sediment load, braided channels enclosing rhomboidal bars, high slope gradients and highly unstable channel, which, in some cases, may lead to avulsion (sudden abandonment of the previous channel).

The **anastomosing (A)** type includes channels comprising of branches divided by islands covered with vegetation, low slope gradients and cohesive banks, and are typically more stable due to the prevalence of suspended solid load.

2.3.1. Cross section Measurements of River Channel

The morphometric variables subject to measurements are discussed below. These parameters are essential for the quantitative assessment of the plan form dynamics of the channel.

The width of channel (also called low floodplain) where the river migrates unimpeded depends on the type and size of channel. In the case of meandering channels, the active belt approximately equals the maximum amplitude of the meanders and includes both abandoned meanders and active ones. In braided channels, the active belt equals the width of the bank full channel, whereas in anastomosing rivers all the channels need to be taken into account in delimiting the active belt. Several researchers established a direct relationship between the width of the active belt and the floodplain width as follows: the floodplain width is approximately tenfold the width of the active belt (Bridge and Leeder, 1976) and even up to 20 times the width of the active belt (Bridge, 2003).

The sinuosity index the sinuosity of the channel within a given reach is described by the ratio between two lengths: the distance between the extremities of the reach measured along the axis of the main channel, and the length measured along the axis of the valley. Unlike the braiding index, which is applied in evenly distanced cross sections, sinuosity can be quantized on reaches of varying lengths, according to the morphology of the channel. The figure below illustrates the method to measure and calculate the sinuosity index by reach. Cross section morphometric measurements on the bank full channel and floodplain are performed in sections perpendicular to the central axis of the floodplain and are equally distanced. The measurements for each time frame are made in the points of intersection of the respective cross sections with the river and its central axis, in accordance with the morphometric parameters considered. The measuring interval is determined according to the level of detail required and the size of the investigated river/reach.

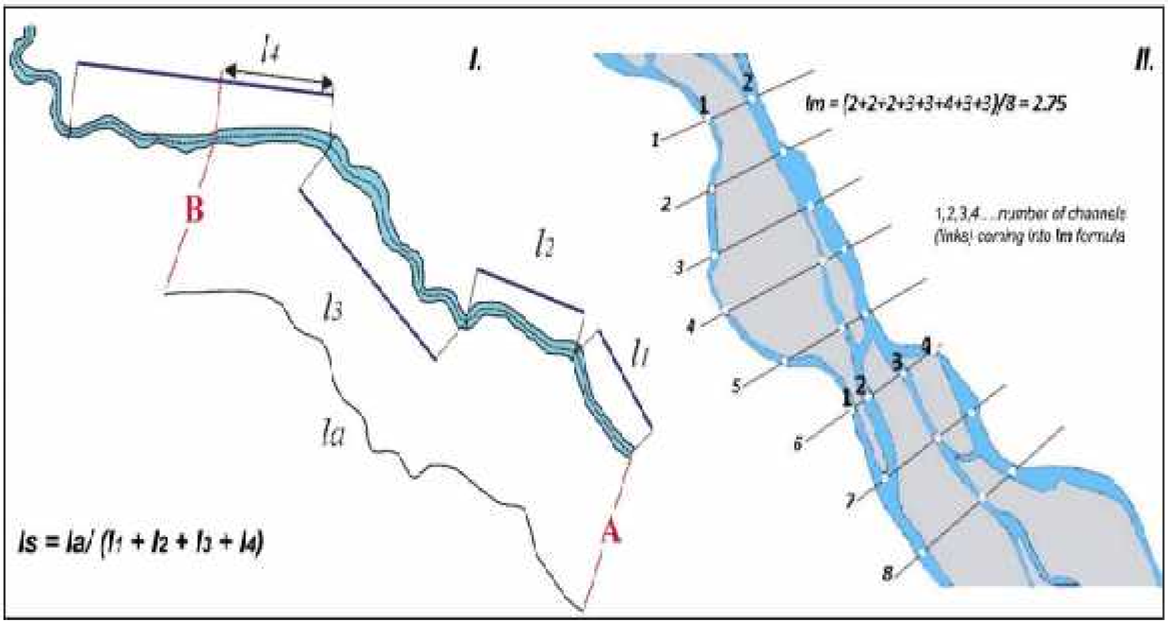


Figure 2-2: Measuring the sinuosity within a reach between points (source: Surian et al., 2009)

2.4 Measurements of Sinuous, Meandering and Anastomosing Channels

This type of measurements refers to the morphometric of sinuous channels, namely of meanders as they were first introduced by Leopold and Wolman (1957, 1960), Langbein and Leopold (1966). The knowledge of these methods comes to support The braiding index has been the subject of numerous calculation formulas; it was concluded (Thorne, 1997; Egozi and Ashmore, 2008) that the fewest errors are obtained by totaling the number of channels (links) transected by the cross section instead of measuring the length of channels or bars (e.g., Brice, 1964). Therefore, the most reliable method of calculation is the one illustrated in the above Figure2-2, according to Egozi and Ashmore (2008):

I_m = number of transected channels (mean values obtained/number of cross sections considered).

The rate of migration of the channel is determined based on the position of the channel at a given time within the floodplain. In order to compute the temporal mobility of the channel, a reference point is required. In the analysis of a sinuous channel the basic morphometric unit is the channel loops or meander loop. The planform of a meander loop can be described by the following elements shown in Figure 2-3: the meander loop length (c), corresponding to the length of the meander loop chord are indicated the two meander loop chords by c1 and c2); the meander loop height (h), measured on the perpendicular line uniting the center of the chord and the intersection with the axis of the channel (at medium discharge values) and corresponding to the meander loop axis; the mean radius of the meander loop (rc), i.e. the radius of the arc of circle circumscribing the meander loop; the meander loop flattening, defined as the ratio between the length and the height of the meander loop (c/h); the meander loop sinuosity, as the ratio between the channel length measured along the river course between the points of intersection of the chord (lc) and the length of the chord (c1+c2);the meander loop orientation, or the azimuth of the meander loop axis, which indicates the direction of migration of the meander; the meander loop apex, is the point of intersection between the meander loop height and the concave bank; the inflection point is the spot on the channel axis where the riffle is located. Two consecutive meander loops form a meander. Depending on the context, the elements of meander loop morphometric also include: the wavelength (lamda) , which measures the distance between the ends of the two successive loops; the meander amplitude (A) is the distance measured perpendicular to the meander length, between the apices of the two meander loops or on the centroid, and provides an insight on the active meandering strip.

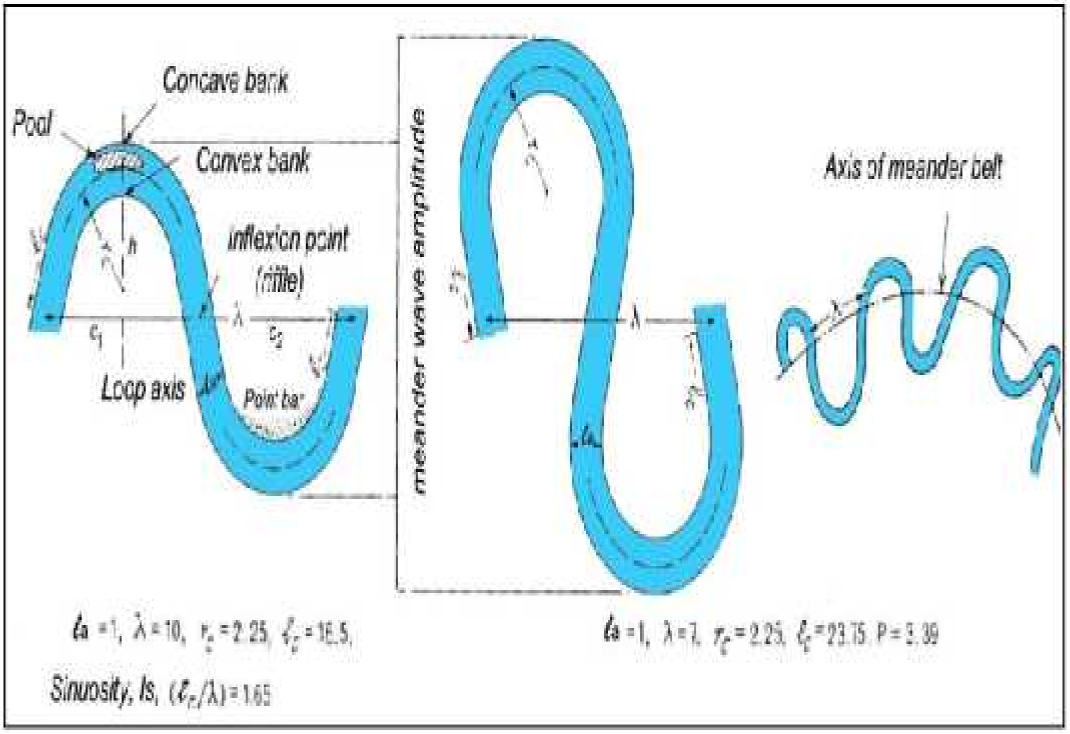


Figure 2-3 The main components of meander geometry (Leopold et al., 1964; Selby, 1985).

2.5 Surface Morphometric Measurements

Whenever highly detailed cartographic materials in terms of the channel and floodplain morphology are available, the method of surface morphometric measurements can be applied in order to investigate the spatial and temporal behavior of several elements of interest. Depending on the nature of the investigation (i.e. the purpose), the data generated for each considered time frame can be used for:

a) Characterizing the channel, the active discharge strip or the floodplain at a certain time (e.g. the percentage value of the elements of interest within the investigated area);

b) Analyzing the spatial dynamics of the elements of interest (repositioning, narrowing, broadening), by overlaying /intersecting the polygons corresponding to different time frames (this type of investigation allows for prediction analyses of future trends in the spatial dynamics of the channel, such as narrowing/broadening, lateral migration, chute bar development, bar/island dynamics, changes in the riparian land cover);

c) Analyzing the temporal dynamics of the elements of interest by statistical analysis of the variations in the surface values of the delineated elements (e.g. variations along the river, statistics on the variations of the mean and total values). The available historical maps have enabled to delineate the boundaries of the vegetation within the channel, as well as outside the channel (marginal vegetation, Comiti et al., 2011).

2.6 Trends of Land-Use and Land Cover Change

Land use changes are complex processes that arise from modifications in land-cover to land conversion process (Noe, 2003). According to (Lambin, Geist, & Lepers, 2003) land-use change is driven by the interaction in space and time between biophysical and human dimensions. There are also the potential impacts on physical and social dimensions. According to (Bronstert, Niehoff, & Bürger, 2002) throughout the entire history of mankind, intense human utilization of land resources has resulted in significant changes on the land-use land-cover. Since the era of industrialization and rapid population growth, land-use change phenomena have strongly accelerated in many regions. Land-use changes are frequently indicated to be one of the main human-induced factors influencing the hydrological system (Dams, Woldeamlak, & Batelaan, 2008). It was estimated that undisturbed areas represent 46% of the earth's land surface (Mittermeier et al., 2003). It is reported that 8000 years ago forests covered about 50% of the earth's land area, as opposed to 30% today (Lambin et al., 2003). Agriculture has expanded into forests, savannas, and steppes in all parts of the world to meet the demand for food. Agricultural expansion has shifted between regions over time; this followed the general development of civilizations, economies, and increasing populations (UN-FAO, 2001). Regardless of the global spatial distribution of land-use/cover changes these studies did not attempt to give the contribution on the land-use trends and processes on the small sub-catchment, which affected its management in the near future.

2.7 Land Use and Land Cover Change: Definitions and Concepts

Land use change is defined to be any physical, biological or chemical change attributable to management, which may include conversion of grazing to cropping, change in fertilizer use, drainage improvements, installation and use of irrigation, plantations, building farm dams, pollution and land degradation, vegetation removal, changed fire regime, spread of weeds and exotic species, and conversion to non-agricultural uses (Quentin, Jim, Julia, Carole, & Andrew, 2006). According to the International Geosphere Biospehre Program and The International Human Dimension Program (IGBP_IHDP, 1999) land cover refers to the physical and biophysical cover over the surface of earth, including distribution of vegetation, water, bare soil and artificial structures. Land use refers to the intended use or management of the land cover type by human beings such as agriculture, forestry and building construction.

Land use land cover change (LUCC) is commonly grouped in to two broad categories: conversion and modification of land use land cover(Meyer & Turner, 1995). Conversion refers to a change from one cover or use category to another (e.g. from forest to grassland). Modification, on the other hand, represents a change within one land use or land cover category (e.g. from rain fed cultivated area to irrigated cultivated area) due to changes in its physical or functional attributes. These changes in land use and land cover systems have important environmental consequences through their impacts on soil and water, biodiversity, and microclimate (Lambin et al., 2003).

Land cover changes have been influenced by both the increase and decrease of a given population (Lambin et al., 2003). In most developing countries like Ethiopia population growth has been a dominant cause of land use and land cover change than other forces (Sage, 1994). There is a significant statistical correlation between population growth and land cover conversion in most of African, Asian, and Latin American countries (Meyer & Turner, 1995). Due to the increasing demands of food production, agricultural lands are expanding at the expense of natural vegetation and grasslands (Lambin et al., 2003).

2.8 Land Use and Land Cover Change Studies in Ethiopia

In Ethiopia, land is a public property and has been administered by the government since 1975. Before 1975 was the imperial era in which land was controlled by the King and the ruling elites (Ambaye, 2012). The land is used to grow crops, trees, animals for food, as building sites for houses and roads, or for recreational purposes. Most of the land in the country is being used by smallholders who farm for subsistence. With the rapid population growth and in the absence of agricultural intensification, smallholders require more land to grow crops and earn a living; it results in deforestation and land use conversions from other types of land cover to cropland.

The researches that have been conducted in different parts of Ethiopia have shown that there were considerable land use land cover changes in the country. Most of these studies indicated that croplands have expanded at the expanse of natural vegetation including forests and shrub lands; for example ((Tegene, 2002); (Bewket, 2003); (Kidanu, 2004); (Abebe, 2005)) in northern part of Ethiopia, (Zeleke & Hurni, 2001) in north western part of Ethiopia, (Kassa, 2003) in north eastern part of Ethiopia; and (Denboba, 2005) in south eastern part of Ethiopia.

(Kassa, 2003) in his study, in southern Wello, reported the decline of natural forests and grazing lands due to conversions to croplands. (Bewket, 2003) have reported an increase in wood lots (eucalyptus tree plantations) and cultivated land at the expense of grazing land in both Chemoga watershed in north-western Ethiopia, and Sebat-bet Gurage land in south-central Ethiopian. The changes of land use land cover that occurred from 1971/72 to 2000 in Yerer Mountain and its surrounding results an expansion of cultivated land at the expense of the grasslands (Gebrehiwet, 2004).

(Hadgu, 2008) identified that decrease of natural vegetation and expansion of agricultural land over a period of 41 years in Tigray, northern part of Ethiopia. He concluded that population pressure was an important deriver for expansion and intensification of agricultural land in recent periods. (Garedew, 2010) in the semiarid areas of the central Rift Valley of Ethiopia, during the period 1973-2000 cropland coverage has increased and wood land cover lost. Similarly, (Feoli, Vuerich, & Zerihun, 2002) also reported the expansion of evergreen vegetation with increase of population.

According to many literatures, population growth has a paramount impact on the environment. For instance, population pressure has been found to have negative effect on Riverine vegetation, scrublands and forests in Kalu district (K. Tekle & Hedlund, 2000), Riverine trees in Chemoga watershed (Bewket, 2003), and natural forest cover in Dembecha Woreda north-western Ethiopia (Zeleke & Hurni, 2001). Similarly, (Pender, Gebremedhin, Benin, & Ehui, 2001) report that the population growth has significant effect on land degradation, poverty and food insecurity in the northern Ethiopian highlands.

However, most of the empirical evidences indicated that land use land cover changes and socioeconomic dynamics have a strong relationship; as population increases the need for cultivated land, grazing land, fuel wood; settlement areas also increases to meet the growing demand for food and energy, and livestock population. Thus, population pressure, lack of awareness and weak of management are considered as the major causes for the deforestation and degradation of natural resources in Ethiopia.

2.9 Application of remote sensing for land use and land cover change

Remote Sensing (RS) is defined as the science of obtaining information about an object, area, or phenomenon throught the analysis of data acquiring by a device that is not contact with the object, area, or phenomenon under investigation (Bawahidi, 2005). It provides a large amount of data about the earth surface for detailed analysis and change detection with the help of sensors. Some of the important data used in the hydrological modeling that are obtained from remote sensing include digital elevation model (DEM), and land cover maps.

Land use land cover is changing rapidly in most parts of the world. In this situation, accurate, meaningful and availability of data is highly essential for planning and decision making. Remote sensing is particularly attractive for the land cover data among the different sources. (Stefanov, Ramsey, & Christensen, 2001) reported that in 1970's satellite remote sensing techniques have started to be used as a modern tool to detect and monitor land cover change at various scales with useful results.

(Geremew, 2013) showed that the information of land use and land cover change which is extracted from remotely sensed data is vital for updating land cover maps and the management of natural resources and monitoring phenomena on the surface. The importance of land cover mapping is to show the land cover changes in the watershed area and to divide the land use land cover in different classes of land use and land cover. For this purpose, remotely sensed imagery play a great role to obtaining information on both temporal trends and spatial distribution of watershed areas and changes over the time dimension for projecting land cover changes but also to support changes impact assessment (Atasoy, Karslı, Bıyık, & Demir, 2006). To monitor the rapid changes of land cover, to classify the types of land cover, and to obtain timely land cover information, multi temporal remotely sensed images are considered effective data sources.

2.10 Related Studies

Studies on channel changes (Dury, 1977; Knight, 1975; Hickin and Nanson, 1975; Lewin and Hughes, 1976) and the field have been reviewed by Gregory (1977, 1979, and 1983). River migration or river changes are taken to include any change in river geometry within the context of the cross section, the pattern or network of a drainage basin (Gregory, 1977). Planform analysis helps us to understand, the changes in channel pattern in both time and space. Planform properties of meandering rivers include not only the geometry and sinuosity of the meandering course, but other properties such as variability of width and development of bars (Brice, 1984). Planform and planform changes are not independent of other aspects of river geometry, and together with these other aspects they deserve to be considered in relation to the hydraul.ics of channels with loose boundaries.

Changes regarding in river channels, both nationally (Dumitriu, 2007;Canciu, 2008, Feier and Rădoane, 2008, Ioana-Toroimac, 2009, Cristea, 2010, Grecu et al., 2010, Perşoiu, 2010, Rădoane et al., 2010, Floroiu, 2011, Perşoiu and Rădoane, 2011; Chiriloaei, 2012; Zaharia et al., 2011), but more so internationally (e.g. Winterbottom, 2000, Gurnell et al., 2003, Surian and Rinaldi, 2003, Rinaldi, 2003, Liébault and Piégay, 2001, 2002, Surian and Cisotto, 2007, Wyżga, 2008; Zawiejska and Wyżga, 2010; Swanson et al, 2011; Zilliani and Surian, 2012) compels to grant special attention to the matter of necessary resources and research methods.

The downstream effects of dams have been studied by a number of scientists already (Khan et al., 2014). However as river natures vary, the response to dam construction varies with a number of variables (Brandt, 2000). The impacts vary according to size of the river and dam, hydrologic regime, environmental setting, history, initial channel morphology, purpose and operation of the impoundment (Graf, 2006; Petts & Gurnell, 2005; Williams & Wolman, 1984; Yang et al., 2011). Construction of dams affects the morphological process of the downstream river reach by storing water and sediment, by changing the water discharge regime of the river and by releasing relatively clear water to the downstream. This produces significant geomorphological effects, by changing the pattern of erosion and deposition of the main channel of the river, banks and floodplains.

Bruijnzeel (2004) assessed the influence of forest cover change on hydrological functions in Southeast Asia. In this study clearing of forests in uplands increased annual water yield reaching its maximum when the forest was completely cleared. The study further founded that surface runoff and erosion declined under well-developed forest cover but increased with clearing of forests. Overland flows and hence watershed sediment yield were found increasing with disturbance and conversion of forests to other land uses in Southeast Asia.

The construction of dams will create a major influence on the river's downstream flow by decreasing the frequency and magnitude of flooding, which will consequently affect the river planimetry change (Emerton, 2003).

Channel incision and enhanced bank erosion studied by (Ali, 2008; Ali et al., 2014a and 2014b) shows the reach has been already subjected to morphological changes in response to the construction of Roseires dam (1966). In particular, the river shows Upstream of Roseires, the Grand Ethiopian Renaissance Hence, the Blue Nile discharge will strongly depend on dam operations with important consequences for the river morphology.

Garede & Minale (2014) were reported river has been subjected to prolonged water withdrawal for agriculture without conserving natural resource. Forest degradation, biodiversity and habitat loss and soil degradation are common problems in the area.

Abate et al. (2015), who studied the geomorphological changes of the nearby Gumara River to water withdrawal and alteration of Lake Tana level, showed that the carrying capacity of the lower reach of the river is reduced due to deposition of sediment. Due to this, there is a recurrent flooding on the floodplain affecting people and animals and destroying crops and infrastructures.

3. MATERIALS AND METHODES

3.1 Description of the Study Area

3.1.1 Location

Shina dam is an embankment dam project across Shina River constructed by Co-SAERAR in 2007 (Commotion of Sustainable Agricultural and Environmental Rehabilitation in Amhara Region). It is located within Lake Tana basin in Ethiopia (Figure 3-1) and is found near Hamusite Town South Gonder Zone of Dera woreda district in Amhara Region latitude of 1305264.57m Northing and longitude of 338540.70 Easting. This project is bounded from North by Merafe, from South by Gobate, from East Wonechete from West Lake Tana. Shina Dam is found at a distance of 62 km far from Bahir Dar Administration and 70 km from Debere Tabore town and 8 km far from Hamusit Town on the left side of the main road from Bahir Dar to Gondar.

Shina River is the main sources of water in the watershed for both humans and livestock on which the study had been undertaken. The total length of Shina River is 14km which flows westwards from Hamusit town to Lake Tana. It is originated from Hamusit town. In the study area, there is about one spring which is tributary to the Shina River. The other source of water is ground water which is easily accessible by developing traditional hand dug well.

The research concentrates on Shina River, which is part of the lake Tana Basin, particularly on the Lake Tana basin. The Area of watershed is 36.12 km^2. The dam has 20.8 m height to impound 126 Mm3 of water for irrigation at elevation range from 1784 m to 1804.8 m above sea level including free board, the goal being to be able to irrigate around 100 ha of the land .The Shina dam has been subjected to prolonged water withdrawal for irrigation.

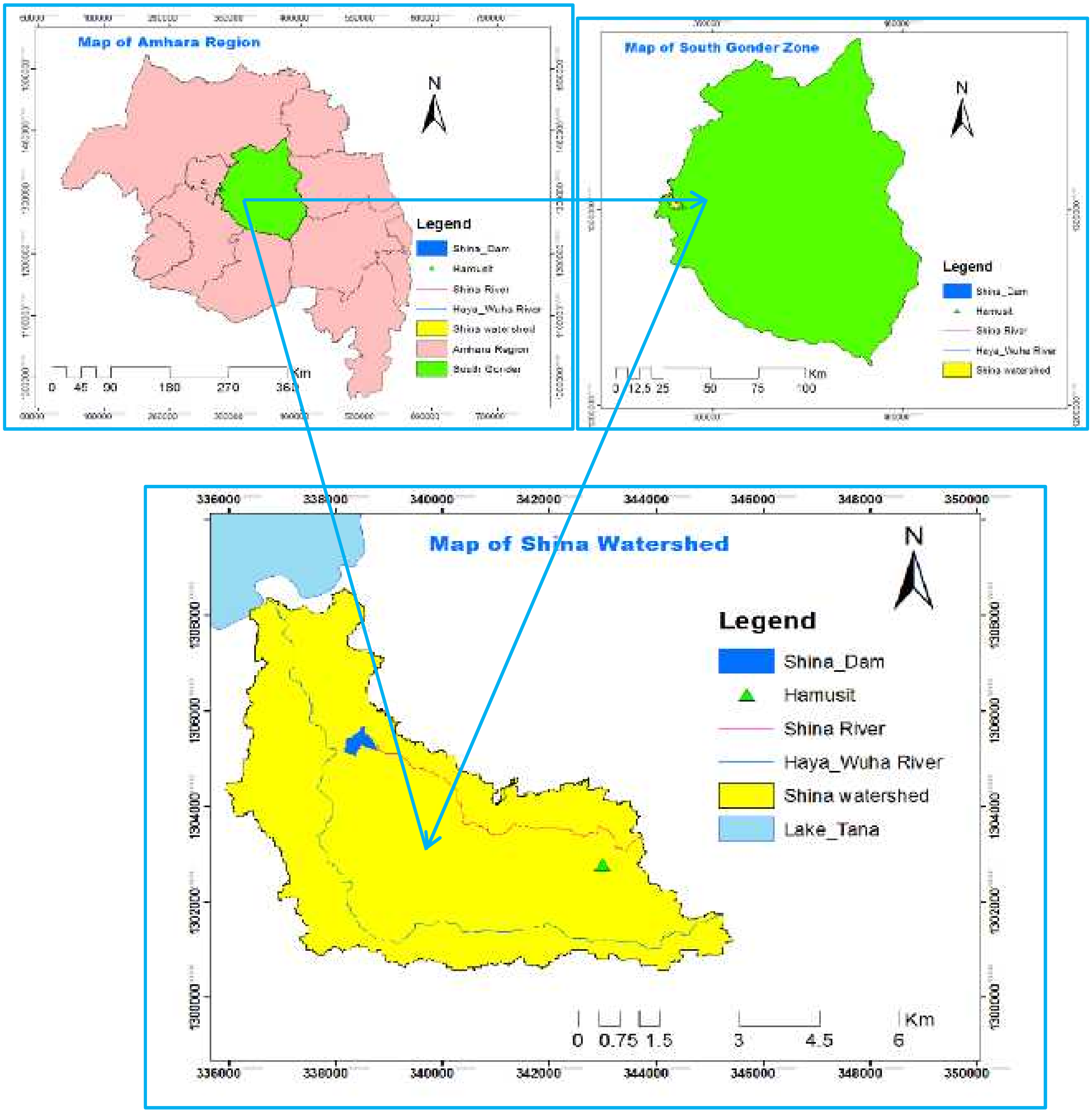


Figure 3-1 Location of the Study area

3.1.2 Land use and Land cover

The terms of Land use and Land cover are often used interchangeably even though the distinction between the two is important. Land use refers to the actual economic activity for which the land is used whereas land cover refers to the cover of the earth's surface (Anderson et al., 1976). The land use of the study area can be categorized mainly as agricultural, forest, bush, Built up area, and water bodies. The information contained in the land use map tells how the different uses of the surface are distributed inside the area under study. It can be seen from land use map later, that the watershed is mainly occupied by agriculture land. In the study area, five major land use/ land cover types have been identified as Such land use/ land cover types comprise 75.1 % cultivated land (agricultural area); 9.91% shrubs and bush land; 6.6% forest land,; 0.69%, water body and 7.7% built up area .

3.1.3 Soil types

Soil texture of the study area contains clay, clay loam, silt clay, heavy and sandy loam but clay texture is dominant in the watershed (ADSWE, 2015). Heavy clay soil is the major soil texture, which comprises 40.9% and covers 444.7 ha and followed by loam, which comprises 27.22 % of the total area.

3.1.4 Climate

The rainfall is uni-modal, and mostly characterized by excessive and uniform in its distribution. There is a meteorological station at Hamusit town, which is located in the study area. Based on the (1986-2016) 29 years rainfall data of this station, the area receive peaks rain fall in July and August and receives on average 1540 mm of precipitation annually.The catchment receives 80% of the rain-falls in the main rainy season ("Kiremt"), which starts in June and extends to September/October.

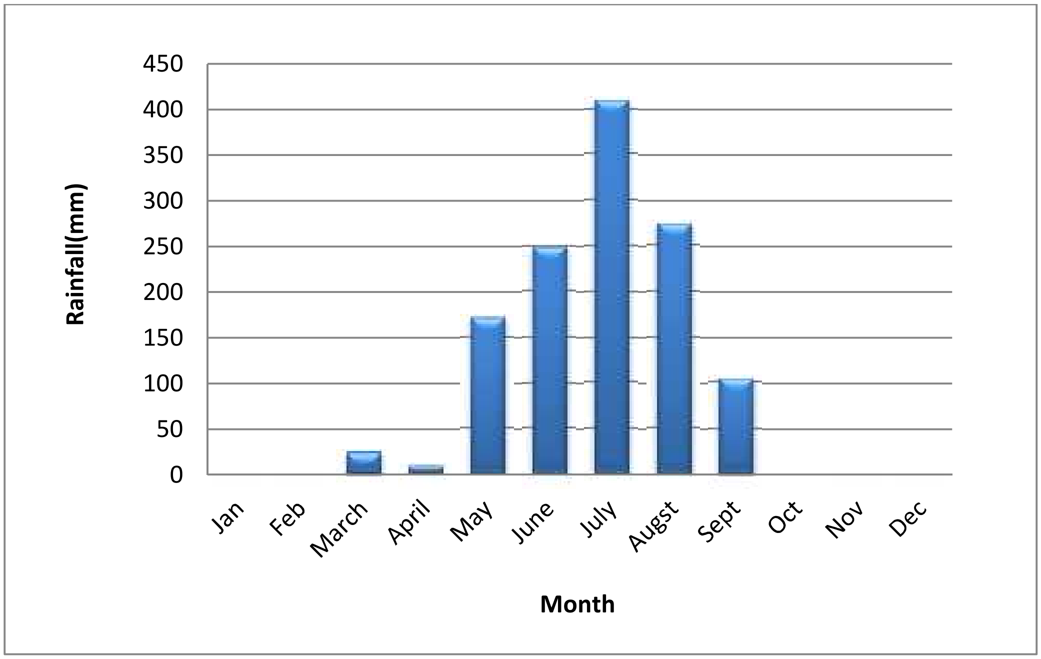


Figure 3-2 Shina watershed Average monthly Rainfall

3.1.5 Topography

Since slope is the most important terrain characteristic and plays a vital role for soil erosion, it is very important to have an understanding of its spatial distribution in the study area. Therefore, the slope map of the study area was prepared from DEM processing using ArcGIS. The watershed is characterized by a slope ranging from 0-44%.

3.2 Methods

In order to assess channel response to altered flow and sediment discharge, multiple analyses across a range of spatial and temporal scales and surveys of channel cross sections and longitudinal profiles were used. Clear methodology is crucial for the effectiveness of the study; not only from time and budget point of view, but also from the quality of the research result. Pre field work, field work and post field work phases were followed to attain the objectives of this study. The pre-field work phase of the study included the selection of suitable research methodology to carry out the study, searching literatures related to the topic from different sources, gathering the available data from different sources, collection of materials for field data collection. During field work, river cross-section survey was conducted; in addition transect walks to observe watershed management condition and characteristics of watershed for checking watershed data obtained from different data sources were done. Data collected during field and pre-field work was processed during post field work. Digitizing original Shina topography map, quantifying vertical change in the river and preparation of all the required maps had been done at this phase of work.

3.2.1 Data Requirement and Sources

Data required for the river planform alteration investigation are spatial in nature. Major parts of the collected data were; landsat image, DEM, Map of Shina watershed, Rainfall data, climate data and River cross-section survey data. Landsat images (Table 3-1) and DEM were obtained from USGS website (http://lansat.usgs.gov/landsat8.php and http://gdex.cr.usgs.gov/gdex). Map of Shina watershed was obtained from Bureau of Water Resource, Irrigation and Energy, climate data was collected from Bahir Dar meteorological station

After collecting the required data, spatial analysis were made to prepare different raster and vector maps. Shina River planform change analysis was done from satellite images of 1986, 2001 and 2017. Digitizing and overlaying techniques in Arc GIS 10.2 environment were used. The years were selected in such a way that it is possible to capture the occurrence of major changes. Two periods are assessed through this change detection: 1986 and 2001, and the year 2001 and 2017.

3.2.2 Cross section and Longitudinal profile surveys

For surveying works, Ground Control points (GCPs) were identified from the old topo map and the corresponding points were found on the existing natural features. These points were used as benchmarks for surveying task. From the known GCPs, using Total station, river cross sectional surveying works (fifty seven cross sections) were conducted for a total length of 6 km just below the Dam. For detail analysis, the total length of channel was divided into 3 reaches (Reach 1 has a length of 3km, Reach 2 has 1km and Reach 3 has 2km).

Table 3:1 Satellite Image data for the study area (Source: USGS).

Satellite	Path/Row	Acquisition Date
Landsat5	170/52	1/28/1986
Landsat7	170/52	2/5/2001
Landsat8	170/52	1/8/2017

3.2.3 Digital Elevation Model

Topography is defined by a Digital Elevation Model (DEM), which describes the elevation of any point in a given area at a specific spatial resolution as a digital file. Digital elevation model is one of the essential inputs required by ARC_GIS to delineate the watershed. DEM is used to analyze the drainage pattern of the watershed, slope and stream length within the watershed.

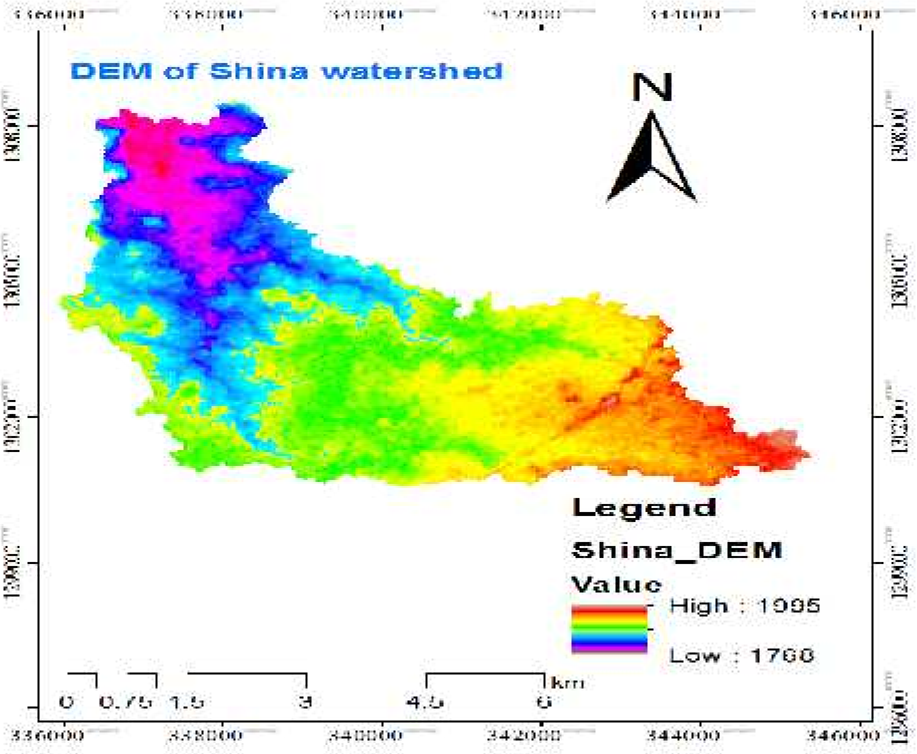


Figure 3-3 Shina watershed DEM Map

3.2.4 Land cover and land use Assessment

3.2.4.1 Land cover descriptions

In this study a total of five land cover/land use classes are considered by using the following definition (Anderson et al., 1976).

1. **Urban or built-up land**

Urban (built-up) land includes areas that have developed intensely. These areas include cities, towns, villages, residential areas, transportation developments, power and communications facilities, industrial and commercial complexes and other built structures. Land that is less intensely developed but located within densely developed urban areas, such as residential lawn or garden, is also included in this category. This land cover also includes mixed urban land cover i.e. areas that are dominated by urban development though not entirely developed (Anderson et al., 1976).

2. **Agricultural land:**

Agricultural land is land devoted to the production of food. This includes cropland, pasture, and other agricultural land such as agricultural areas near wetlands (Anderson et al., 1976).

3. **Bush and shrubs:**

Bush land comprises areas where the potential natural vegetation is predominantly grasses, grass like plants. These areas are generally unaltered, but may be seeded to encourage plant species growth (Anderson et al., 1976).

4. **Forest land:**

Forest lands are areas where trees capable of producing timber or wood products dominate. There are several types of forest within this land cover group including deciduous forest dominated by trees that loss leaves seasonally, evergreen forest dominated by needle-leaf or other evergreen trees, and mixed forest with a mixture of deciduous and evergreen trees (Anderson et al., 1976).

RK **Water=**

Areas covered by water are not difficult to identify from imagery. These areas include streams, lakes, reservoirs, ponds (Anderson et al., 1976).

3.2.4.2 Land cover classification

The land cover classification was made by using ENVI 5.1 software. Because of the existence of field data of the study area the imagery was classified using a supervised classification algorithm. The supervised classification involved the selection of a number of known sites for each class throughout each image. Once these sites were identified Maximum Likelihood supervised classification was completed in ENVI 5.1 image analysis software. The Maximum Likelihood classification is based on statistics and involves the calculation of Bayesian probabilities in order to classify each pixel into the class to which it most probably belongs (Jensen, 1996). The following steps are followed for the land use classification in using ENVI software.

Methodology followed for objective one:

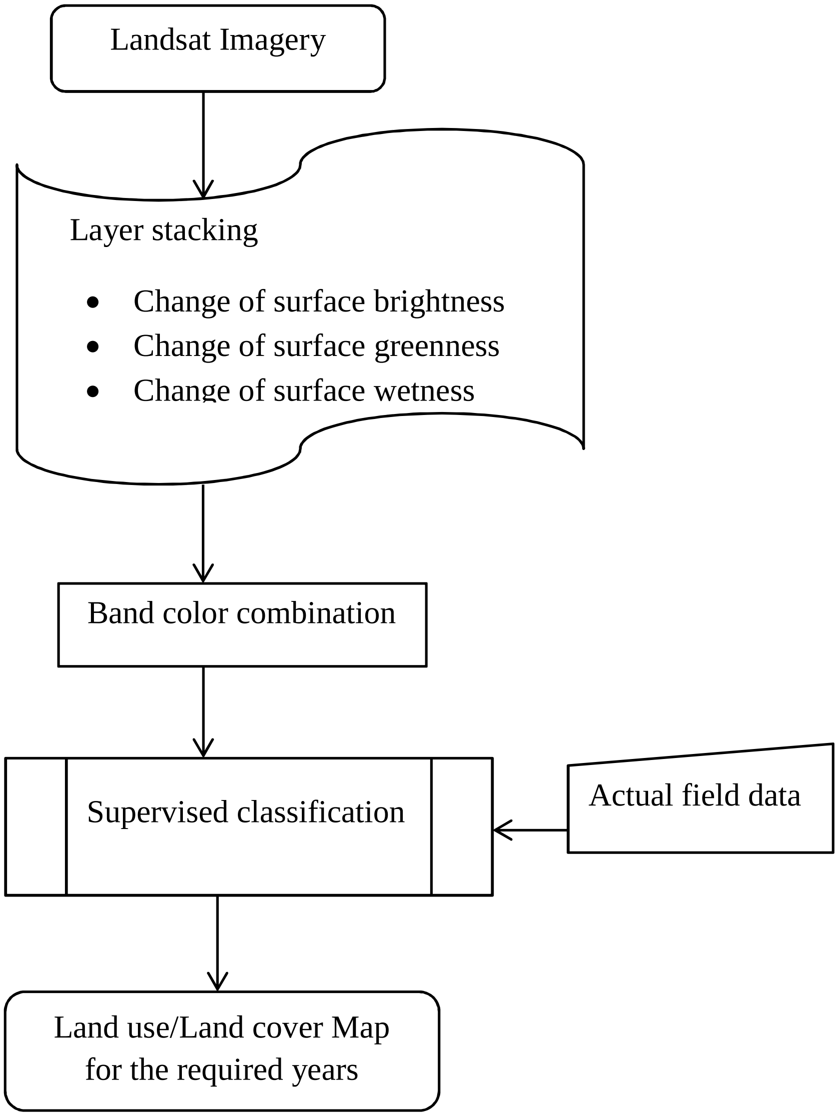


Figure 3-4 Steps followed for land use land cover map preparation for the three years.

3.2.4.3 Land Cover Classification Accuracy Assessment

Accuracy assessment was performed on the resulting classified imagery. This process involves generating a set of points in the classified imagery and comparing them with actual points on the ground through field work. In order to complete the accuracy assessment 50 points for each land cover class were collected in field level. The land cover classification assigned to each pixel was then compared with the same location on the reference sources to see if the classification result was accurate. The overall land cover classification accuracy was good as shown in the table below. Although no real standard for accuracy has been established by the remote sensing community, 80% accuracy is considered acceptable (Congalton R.G, 2004).

Table3.2: Error Matrix for the Accuracy Assessment

		CLASSIFICATION				
		Forest	Agriculture	Range land	Pasture land	Built up
REFERENCE	Forest	Nff	Nfa	Nfr	Nfp	Nfu
	Agriculture	Naf	Naa	Nar	Nap	Nau
	Range land	Nrf	Nra	Nrr	Nrp	Nru
	Pasture land	Npf	Npa	Npr	Npp	Npu
	Built up	Nuf	Nua	Nur	Nup	Nuu

Where Nfarpu is the number observed in which f, a, r, p and u represents the different land use.

The overall accuracy from the error matrix is the total number of correctly classified pixels divided by the sum of total ground truth points. In addition the kappa statics is used for the accuracy assessment. Kappa value lies between -1 and 1, where -1 represents no agreement at all whereas 1 indicates a perfect agreement.

$$K = \frac{p_{o} - p_{c}}{1 - p_{c}}$$

Where P_o is observed accuracy and P_c chance by agreement

3.2.5 Methods Determining River Planform Changes

Several methods are currently used to investigate the spatial behavior of the channel during a given time frame or in successive time frames, by manually or automatically (GIS applications) determining the morphometric parameters of the river. Below briefly present three of the methods used to investigate planform changes. These are successive cross section measurements of the floodplain; measurements along the central axis of the channel (single channel or main drainage channel) and surface morphometric measurements.

One of the most determining of river plan form changes is calculating sinuosity index in a river at different reaches with in a selected river or supposed reach that can be easily quantified. Mueller’s sinuosity indexes are briefly described (Mueller, 1968; Haggett and Chorley, 1969; Prasad, 1982).

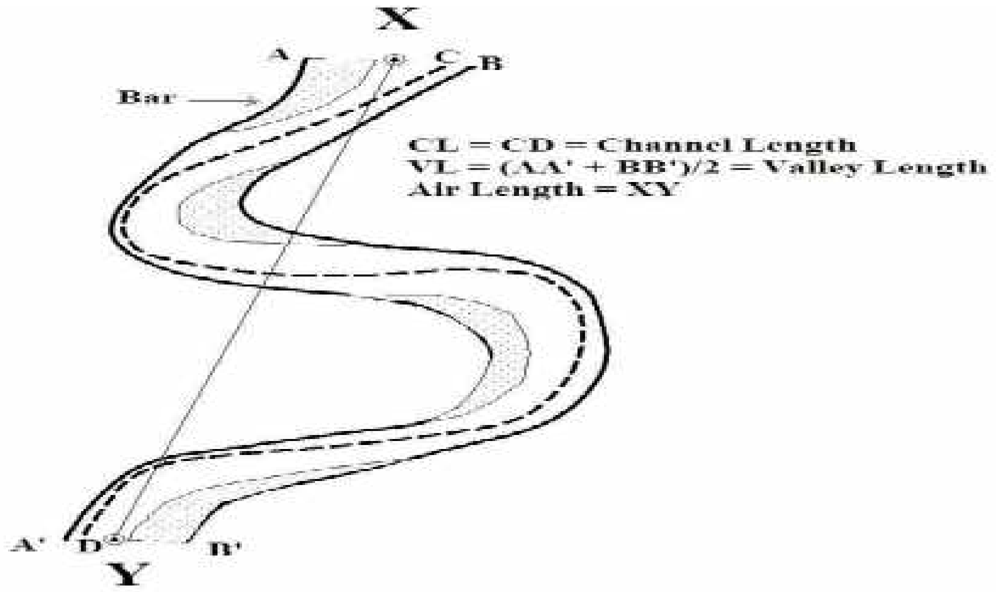


Figure 3-5 Parameters Taken for Muller’s Sinuosity Index (source: Mueller, 1968; Haggett and Chorley, 1969; Prasad, 1982).

CL= the length of the channel (thalweg) in the stream under study

VL= the valley length along a stream, the length of a line which is everywhere midway between the base of the valley walls (in this case one half of total length of right and left banks of a reach)

Air= the shortest air distance between the source and mouth of the stream (in this case shortest air length of a reach)

CI (Channel Index) = CL / Air

VI (Valley Index) = VL / Air

HSI (Hydraulic Sinuosity Index) = % equivalent of (CI – VI) / (CI– 1)

TSI (Topographic Sinuosity Index) = % equivalent of (VI – 1) / (CI – 1)

SSI (Standard Sinuosity Index) = CI / VI

3.2.5.1 Analysis of channel planform change within the GIS

(a)Vector overlay within a GIS may be thought of as a similar procedure to a manual overlay. Any number of overlays may be undertaken and information on river center may be displayed in different colour or line styles to differentiate between the dates that the vectors represent. The magnitude of planform migration at any location can be directly measured so that a variety of analyses can be supported.

(b) Area Map Overlay combines any two raster maps for the same location but at different dates by employing a classification matrix. Each grid cell has a unique spatial location, so the same landscape element may be compared between different map dates and represented as reclassified map showing the locations of net erosion, deposition and no change between the two chosen dates.

3.2.6 Methods Determining Vertical Changes of River Morphology

This objective can be determined with an elevation difference of a digitized base map (2007) and 2017year current survey of river cross-section data at the proposed site or study area of this thesis the so called Shina watershed at Dera woreda near Hamusite town.

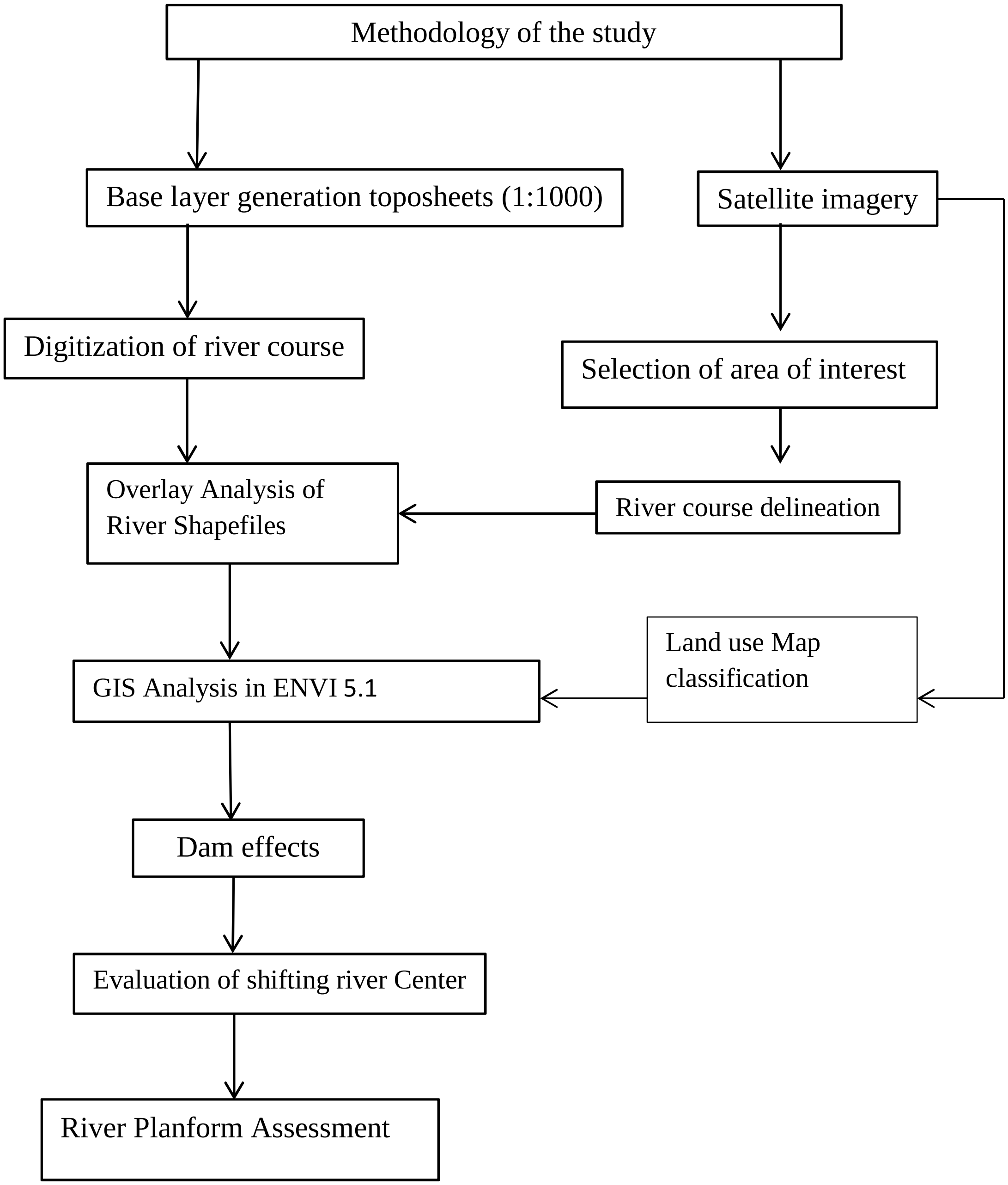


Figure 3-6 Methodology for Assessment of River planform

3.2.7 Creation of Data Base

The river course has been delineated from toposheets at a scale of 1: 1,000. The analog maps were converted to digital form through scanning. These digital data was then edited and converted to vector form. The drainage map and boundary maps were then imported to GIS Software.

3.2.8 Processing of Remote Sensing data

3.2.8.1 Import and Visualization

ENVI software (the Environment for Visualizing Images) is a revolutionary image processing system. From its inception, ENVI was designed to address the numerous and specific needs of those who regularly use satellite and aircraft remote sensing data. ENVI provides comprehensive data visualization and analysis for images of any size and any type, all from within an innovative and user-friendly environment.

One of ENVI’s strengths lies in its unique approach to image processing. It combines file-based and band-based techniques with interactive functions. When a data input file is opened, its bands are stored in a list, where they can be accessed by all system functions. If multiple files are opened, bands of disparate data types can be processed as a group.

The data of satellite different dates pertaining to the years 1986, 2001 and 2017. The data were processed and analyzed using the ENVI Imagine 5.1 software. Initially, each band was checked individually for the pixel values. The spectral and spatial profile tools of ENVI Imagine were used to check for the pixel values of water, soil and vegetation and verify whether the bands 1, 2, 3 and 4 correspond to the actual red, green, NIR and MlR bands. Subsequently, False Color Composite's (FCC's) of bands 3, 2 and 1 were prepared for all the scenes and used.

3.2.8.2 Selection of Area of Interest (AOI)

The sizes of the full scenes of the satellite remote sensing data were large in comparison to the study area. Hence, the study area was separated from the full image using a utility in the ENVI Imagine software, namely, area of interest (AOI). A polygon was digitized which covered the entire study area and some portions surrounding it. The data corresponding to the AOI was saved in a new file.

3.3 Materials

Field equipment such as hand held GPS with horizontal accuracy ±3m; Meter**,** Total station, and Camera are used in my field work. ARC GIS 10.2, Google earth and ENVI 5.1 imagine software was used for this study. The study's implementation required research techniques developed in a variety of fields. In addition to office work and field surveys, it involved the use of GIS and RS analysis. These techniques were used to identify land cover changes and their effects on the hydrological response to the river morphology pre to post dam construction. The following materials and software were also used in the study's implementation: ArcGIS, ENVI 5.1 and satellite images of the years 1986, 2001, and 2017. The main data collected were as follows

- Fifty seven cross-section data on Shina River was collected at intervals of 105 m.
- DEM (Digital Elevation model) with a resolution of 30 m.
- Landsat images of year 1986,2001 and 2017)
- Rainfall Data from Hamusite station (1986-2016).

Assessing annual average surface runoff depth between 1986, 2001 and 20017 and estimating the hydrological response to land cover changes and projections was carried out in the watershed. Field surveys were conducted from April 28, 2017 to May 7, 2017.

Fieldwork included watershed visualization and well investigation of the area and collecting necessary data for helping me for my thesis which is the impact of hydraulic structures on the river morphology and the effects of hydrology with respect to the watershed as the result affecting the river morphology. And also I further investigate the influence of human activities on land cover changes. Land cover mapping and change detection analysis were performed by classifying cloud free Landsat images from year 1986, 2001 and 2017.

Field survey at the site River cross-section

Figure 3-7 Field Surveying at Shina River.

4. RESULTS AND DISCUSSION

4.1 Land Cover Classification Accuracy Assessment

Error matrices were developed to be sure more about the land cover classification. These matrices show the results of the accuracy assessment for the field points. Fifty points were identified from each class of the land cover classification. Each classified point was then compared with these field data to ascertain the classification accuracy. A perfect classification for a land cover would result if all 50 sample pixels assigned to a particular land cover were found to actually have the land cover they were assigned. The number of sample pixels misclassified is displayed in each matrix along with the number of accurately classified sample pixels for each year of classified imagery that was systematically studied. In the error matrices, each number off the diagonal represents some error either inclusion error, where a pixel was included in the wrong class, or exclusion error, where a pixel was excluded from its proper class.

Table 4:1 1986 Classification error matrix

		classification					
		Forest	Cultivated	Built Up	Bush land	Water	Total
Reference	Forest	43	7	0	0	0	50
	Cultivated	10	41	0	0	0	50
	Built Up	0	7	23	0	0	30
	Bush Land	0	15	0	35	0	50
	Water	0	0	0	6	4	10
	Accuracy %	86.0	82.0	77	70.0	40.0	77

The error matrix for 1986 reveals that forest was most often accurately classified in that year of imagery followed by agricultural land, built up, and bush land. Some areas covered by agricultural, forest, and bush land were sometimes mistaken for built up area. The confusion between forest and agricultural land and bush land is understandable since these land covers share similar spectral characteristics. Built up area sometimes mistaken for agricultural land. This may have resulted due to the proximity of built spaces to cultivated areas.

Table 4:2 2001 Classification error matrix

		Classification					
		forest	cultivated	built up	Bush land	Water	Total
Reference	forest	41	9	0	0	0	50
	cultivated	5	42	1	2	0	50
	built up	0	10	40	0	0	50
	Bush land	0	15	0	35	0	50
	Water	0	0	0	3	5	10
	Accuracy%	82	84	80	70	50	78

The error matrix for 2001 reveals that cultivated area was most often accurately classified in that year of imagery followed by forest, built up, and bush land. Some areas covered by agricultural, forest, and bush land were sometimes mistaken for built up area. The confusion between forest and agricultural land and bush land is understandable since these land covers share similar spectral characteristics. This may have resulted due to the proximity of built spaces to cultivated areas.

Table4:3 2017 Classification error matrix

		Classification					
		Forest	Cultivated	Built Up	Bush Land	Water	Total
Reference	Forest	39	10	0	0	5	50
	Cultivated	5	42	1	2	0	50
	Built Up	0	20	45	0	0	63
	Bush Land	0	7	0	43	0	50
	Water	0	0	0	0	5	5
	Accuracy%	78	84	71	86	100	80

The 2017 classification error matrix shown in table 4:3 above reveals that water was accurately classified, followed by bush land, cultivated land, and forest land. In the 2017 classification, built up area was commonly mistaken for cultivated land. The overall efficiency of classification is 77% in the year 1986, 78% in the year 2001 and 80% in the year 2017, whereas the kappa coefficient is 0.71, 0.75 and 0.80 in the year 1986, 2001 and 2017 respectively.

4.2 Land use Land cover map of 1986

Land cover map was developed for the year 1986 and this reveals that 26.5% agricultural land, 35.8% bush and shrub land, 27% forest land, 10.3% built up and 0.4% water. The distribution in the figure 4-1 below shows that most of the watershed is covered by bush and shrub land.

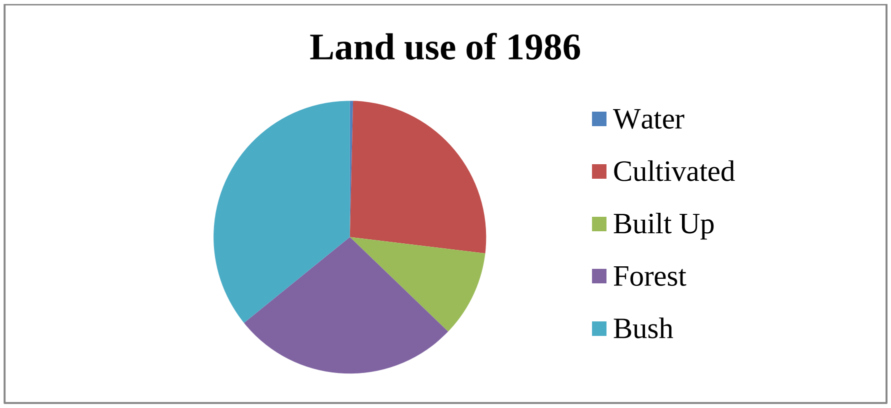


Figure 4-1 Pie chart showing the land use/ land covers classification for the year 1986

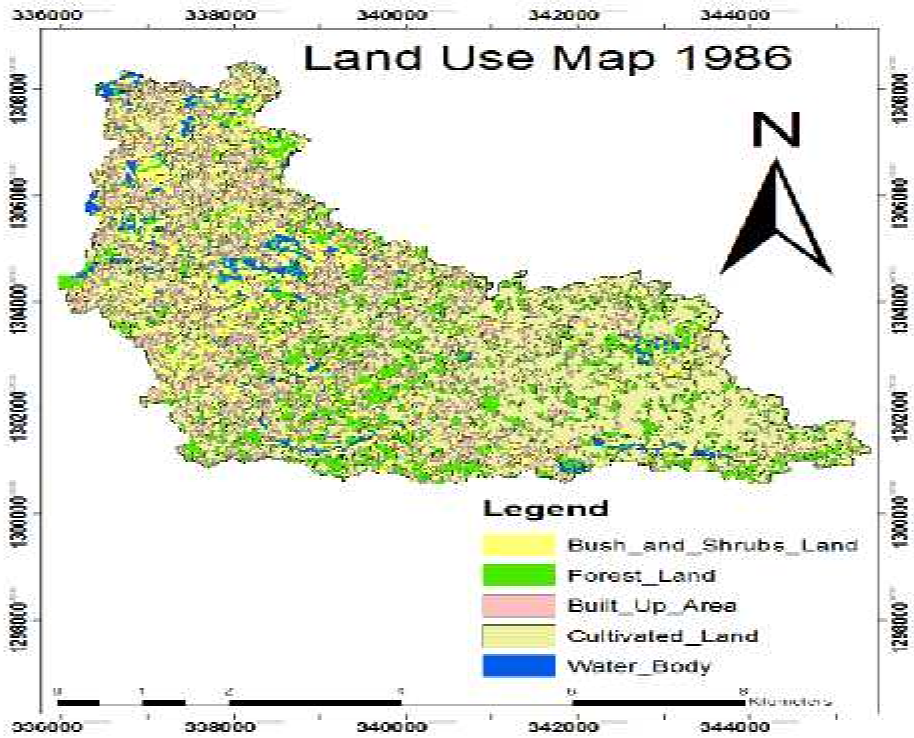


Figure 4-2 Land use map for Shina watershed for the year 1986.

4.3 Land use Land cover map of 2001

The Land cover map for the year 2001 and the pie chart below tells as 13.12% bush and shrub land, 74.75% cultivated, 10.63% built up area, 0.86% forest land, and 0.64% water. The distribution in the figure 4-4 below also shows that most of the watershed is covered by agriculture.

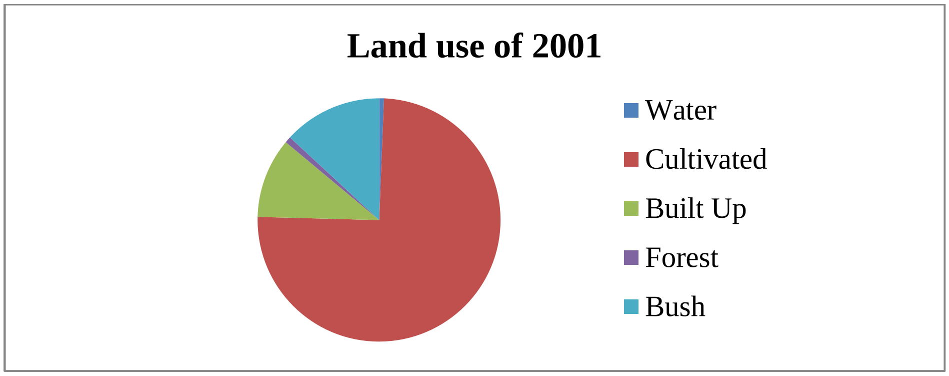


Figure 4-3 Pie chart showing land use/ cover classification for the year 2001

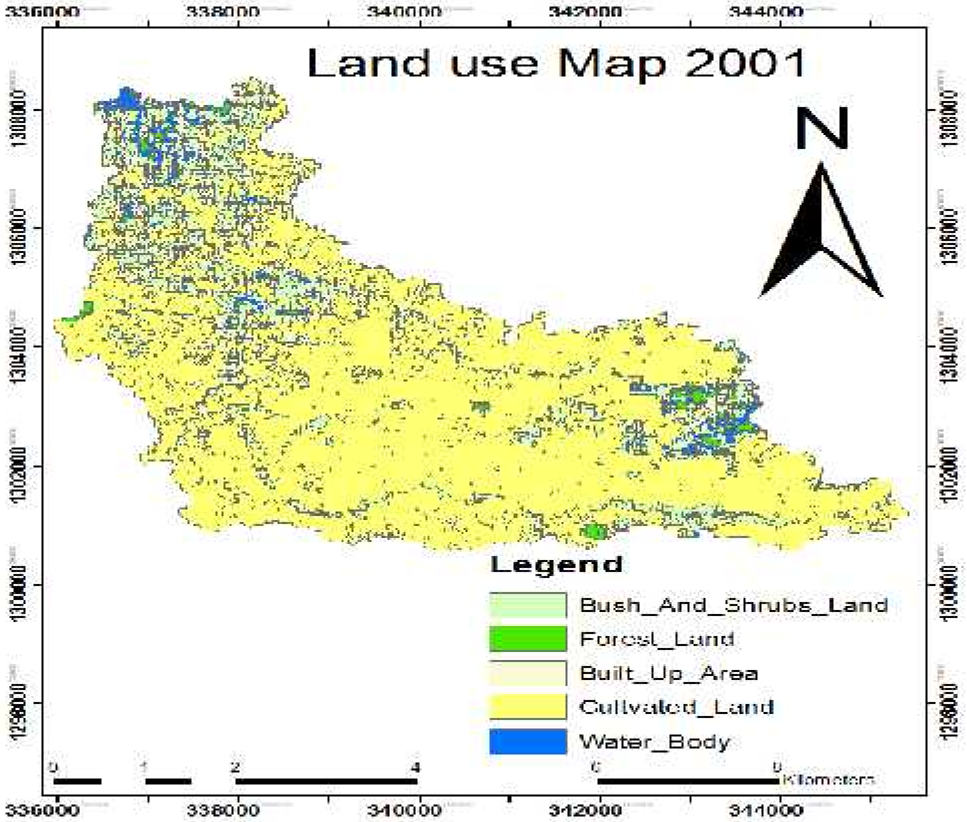


Figure 4-4 Land use map for Shina watershed for the year 2001.

4.4 Land use Land cover map of 2017

Land cover map was developed for the year 2017 and this reveals that 76.6% agricultural land, 12.9% built up, 9% bush and shrub land, 0.5% forest and 0.9% water. The distribution in the figure 4-6 below shows that most of the watershed is covered by agriculture.

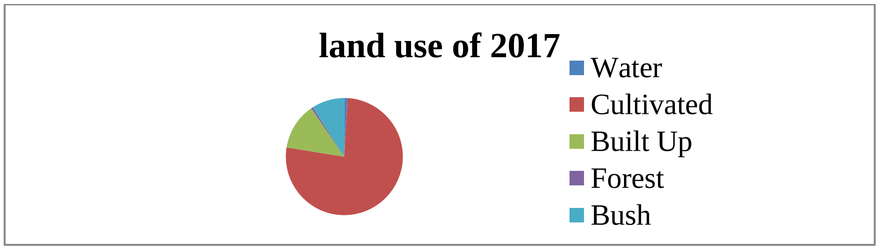


Figure 4-5 Pie chart showing land use/ covers classification for year 2017.

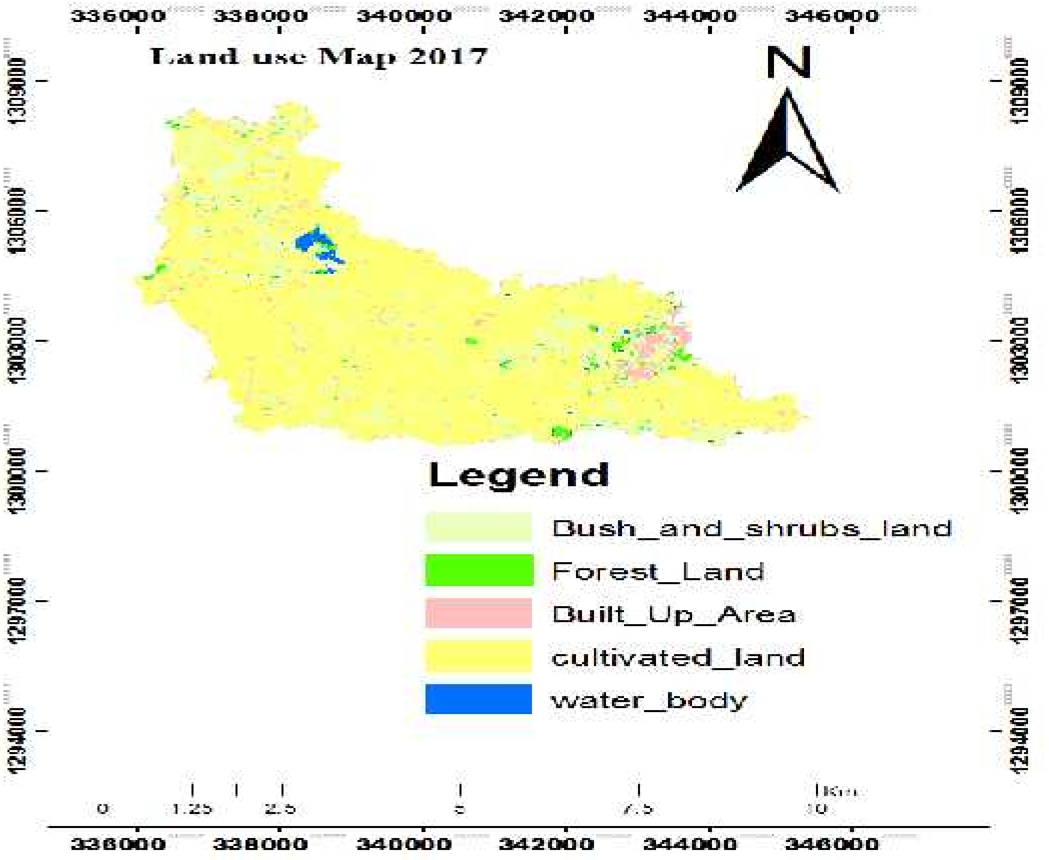


Figure 4-6 Land use map for Shina watershed for the year 2017

4.5 Land use/land cover changes from 1986 to 2017

As shown below there is a decrease in the forest and bush and shrub land by 7% and 48% respectively and an increase in the agricultural land and built up area by 23% and 26%.The total change is summarized as in the table 4:4 below.

Table 4:4 Comparison of land covers for the three years

	1986		2001		2017		% change		
Land use	Area (km2)	Area %	Area (km2)	Area %	Area (km2)	Area %	1986-2001	2001-2017	1986-2017
Water	0.337	0.379	0.82	0.64	1.42	0.9	0.3	0.3	0.6
Cultivated	26.844	26.5	26.65	74.75	17.56	76.6	0.4	1.9	2.3
Built Up	1.518	10.30	3.94	10.63	5.64	12.9	0.3	2.3	2.6
Forest	0.415	27	0.41	0.86	4.71	0.5	-0.3	-0.4	-0.7
Bush	7.002	35.8	4.3	13.12	6.79	9.0	-0.7	-4.1	-4.8

As it has been seen from the above table 4:4, the catchment land use is changed not only land use but also hydraulic structures have influenced shina watershed .so this change in relation to the river characteristics also changed like planform and vertical adjustment before and after dam construction.

4.6 Discharge Determination

To complement the landuse change analysis, the runoff coefficients were determined. The River is not gauged river. Direct runoff is calculated by using SCS unit hydrograph method. Thus, it is preferred to base the flood analysis on rainfall data, which is better both in quantity and quality of data. In the hydrologic analysis for drainage structures, it must be recognized that there are many variable factors that affect floods. Some of the factors that need be recognized and considered on an individual site by site basis are; rainfall amount and storm distribution; catchment area, shape and orientation; ground cover; type of soil; slopes of terrain and stream(S); antecedent moisture condition; Storage potential .

4.6.1 Direct runoff analysis by SCS unit hydrograph method

Direct runoff or overland flow is a flow that occurs along a sloping surface and it occurs whenever the rate of water application to the ground surface exceeds the rate of infiltration. It is the major component of the hydrologic cycle. Direct runoff is calculated by SCS (The United States Soil Conservation Service). This method is widely adopted and more reliable method for flood estimation. The approach considers, watershed parameters, like Area, and Curve number.

- Direct runoff,

$$Q = \frac{(P-0.2 * S)^2}{(P+0.8*S)}$$

Where,

P= Quantity of precipitation (mm)

S = Maximum run off potential difference,

$$S = \left(\frac{25400}{CN}\right) - 254$$

Runoff coefficient (C) will be obtained:

C=Q/P ,where Q is direct runoff(mm) and p is precipitation(mm)

Curve number (CN)

Curve number (CN) is achieved based on USSCS method by watershed characterization in terms of land cover, treatment, hydrologic condition and soil group. From the watershed analysis curve number at an antecedent moisture condition III state is 75, 80 and 88 in the year 1986, 2001, and 2017respectively.

4.6.2 Rainfall Data

Even though there is a lack of data at the site, it has been used the rainfall data at the nearest metrological station Hamusite town for calculating the runoff coefficient by using SCS methods. In order to compute Surface runoff for the watershed, yearly average rainfall is collected from Hamusit Metrological station.

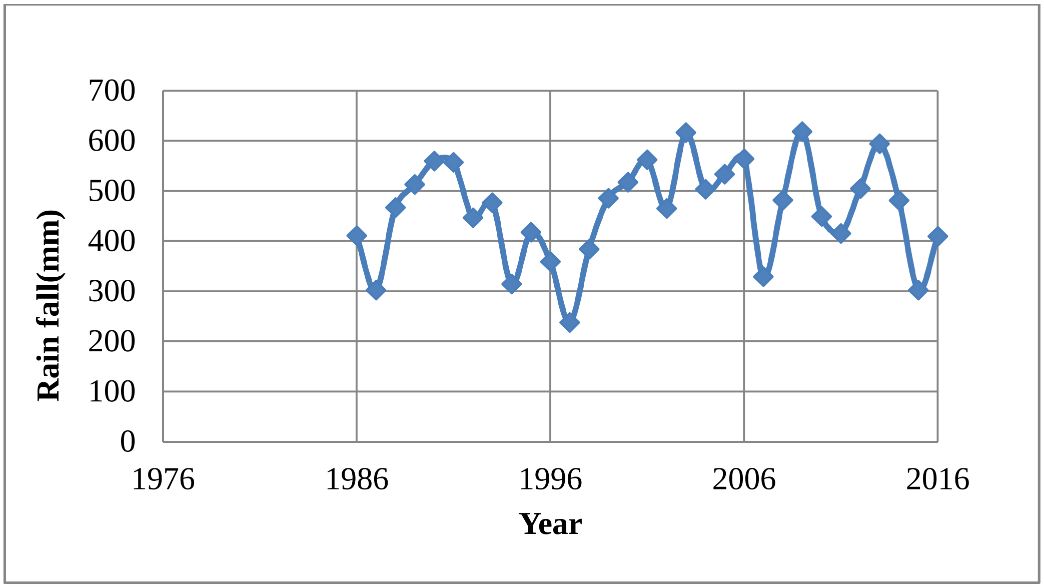


Figure 4-7 Shina watershed average yearly Rainfall distributions

Table 4:5 Determination of Runoff coefficients for the three years.

Selected years	Average Rainfall, P(mm)	Average Runoff ,Q(mm)	Average runoff coefficient.
1986	101	79	0.65
2001	122	71	0.69
2017	103	82	0.81

As it has been seen in the above table 4-5, it describes that Runoff coefficient increases from the year 1986 to 2017. So, it means that the catchement landuse has become less forested and less grassed as a result the catchement producing more runoff that enables to modify in view of river characteristics which means that land use change and river morphology effects is already identified as a result of change in runoff coefficient . From land use/land cover classification map (section 4.5) also shows that, Agriculture and Built up area increases from the selected years because of population growth whom extremely depend on Agricultural activities like farming, deforestation, and settlement in the watershed which in turn increases runoff coefficient.

Therefore, runoff coefficient is depend on different hydrological factors which indicates the variation of rainfall at different seasons showing a change on land use and land cover within the watershed at the selected years. So, as a result affects the river morphology.

Runoff

The annual rainfall variation in the produced flows from the Shina watershed reflects slightly changes before and after dam construction .According to the available data, there is a strong seasonality in rainfall; the rainy season covers only 3 months of the year which are June, July, and August, and 80% of the river flows occur during this period. Most of the tributaries in the basin are drying out during the prolonged dry season .The analysis of runoff for the Shina catchment from 1986 to 2016 shows that to a certain degree changes on land use land cover in the watershed before and after dam construction. But the change comes from not only runoff but also human activities expanding traditional agriculture practice like farming, resettlement, and deforestation in the area.

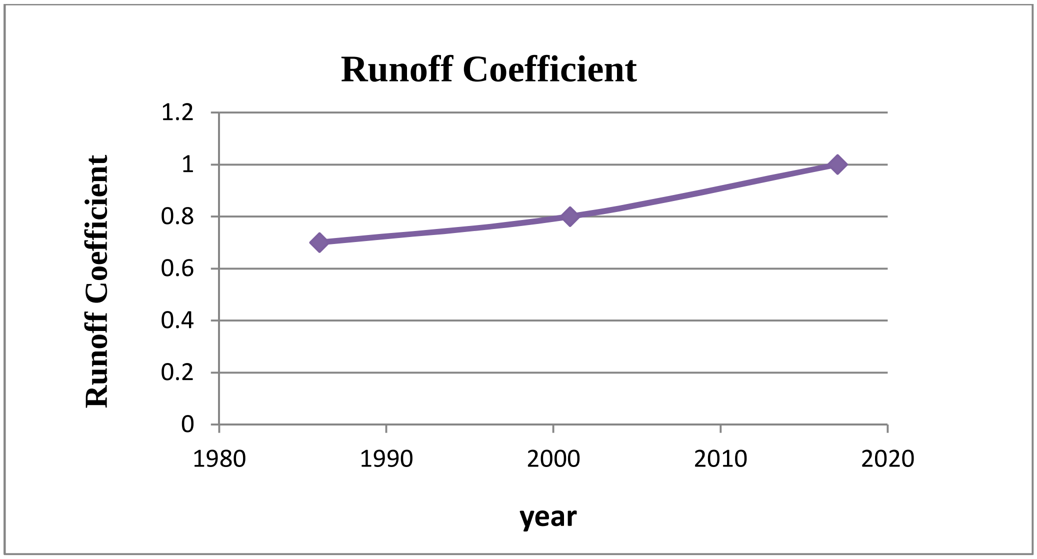


Figure 4-8 Runoff characteristics generated by rains during a year

Analyzing the results for three years (1986, 2001 and 2017), the medium runoff Coefficient oscillates several times accordingly, of course, to the recorded rainfall quantities. Therefore, the result shows that runoff coefficient is an increasing trend with respect to the selected years respectively.

4.7 Human Activities in Shina Watershed

The hydrological response to land cover changes induced by human activities in the area more pronounced corresponding such as agriculture for securing food, resettlement, deforestation to satisfy their daily needs, and Animal encroachment influences watershed. Thus, the current sole dependency of the community solely on farming activities is unsafe in terms of both the environment and causing erosion in the watershed. Therefore, Based on the amount of soil lost from watershed causes river planform change.

4.8 River Planform Analysis

Between years 1986, 2001 and 2017 channel river center shapefile has aggraded and incised to varying degrees throughout the study area. Incision and aggradation are reflected in changes in thalweg and water surface elevations.

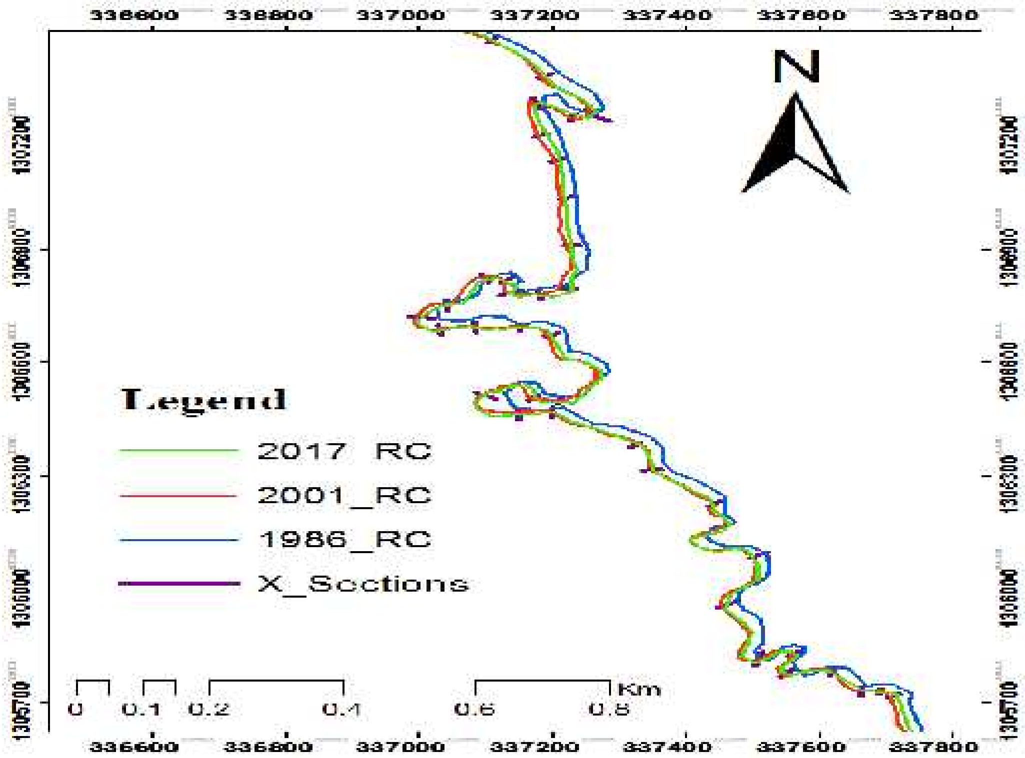


Figure 4-9 Overlapped River Centers at cross-section for selected years.

The study has been carried out with the help of remote sensing data and ARC GIS 10.2 tool,ENVI 5.1 software and Google earth.All the data were processed and analyzed individually in a GIS environment.After overlaying these shapefiles in figure 4-9 , fifty seven cross-sections were assigned for explanation.The extent of shina river planform changes and its direction of shifting were identified and Shina river has undergone planform changes at the downstrem reach.Considerable planform changes were observed and identified at the beginning of the outlet of shina dam and the mouth of the river or at the inlet of Lake Tana.The analyzed sections labled up to 57 cross-sections and explanations of each detail results were explained below.

4.8.1 River Cross Section Analysis

Reaches Between Cross Sections 57 and 35

These cross sections found near just downstream of the dam. At this location most major planform changes were occurred. This sub reach that extends from the outlet of Shina dam to the selected cross-section, the channel River centre line (generally) slightly shifted (figure 4-9). The channel river center at reach one cross sections 57 to 35 shifted to right banks from 2001 year river center downstream of the dam both in the years of 1986 and 2017 river center.

In this reach, there is a great shifting of river center line as described in the appendix 6, table 5. Therefore, because of presence of dam, the river course sidetracked its direction disturbing the downstream river morphology. Not only dams, but also land use change, a combination of the two grounds influenced the river morphology.

Reaches Between Cross Sections 35 and 22

The channel river center change from 2001 river center shifted left bank at reach two both in the years of 1986 and 2017 river center. There is deep cut off cross sections. This is because of human activities like deforestation, agricultural farming, resettlement and animal free grazing causes severe erosion to the watershed resulting change in river planform.

Reaches Between Cross Sections 22 and 1

At this reach both 1986 and 2017 year river channel center slightly shifted to left bank except cross-sections 4,5,6,15,16,and 22 channel river center slightly shifted to right bank in the year of 2017.

Generally, the channel slightly shifted to the right bank from reach one 3km downstream of the dam in the year 1986 and 2017 river center change from 2001 river center line (Figure 4-9,Appendix 6,table 5). Therefore, hydraulic structures such as dam greatly affect the river morphology. Impacts of hydraulic structure such as Small scale dams can change the river direction as well as affects river characteristics or physical and hydraulic parameters such change of river width, and depth.

4.8.2 Sinuosity Index analysis

Sinuosity parameters such as channel length; valley length and air length for each reach have been measured from landsat images and topo sheets using Arc GIS 10.2. Using these parameters, hydraulic sinuosity indexes (HSI), topographic sinuosity index (TSI) and standard sinuosity index (SSI) were evaluated. HSI and TSI have been used in understanding the topographical and hydrologic characteristics of watershed. River channel has been classified into straight, sinuous, meandering and braided depending on the SSI. Sinuosity parameters and indexes for the three years are given below in Table 4-11. Based on the value of SSI, river channels are classified into straight ($1 < SSI < 1.09$), sinuous ($1.09 < SSI < 1.28$), meandering ($1.28 < SSI < 2$), and torturous ($SSI > 2$). (Source: International Journal of Earth Sciences and Engineering, April 2015, pp.49-51).

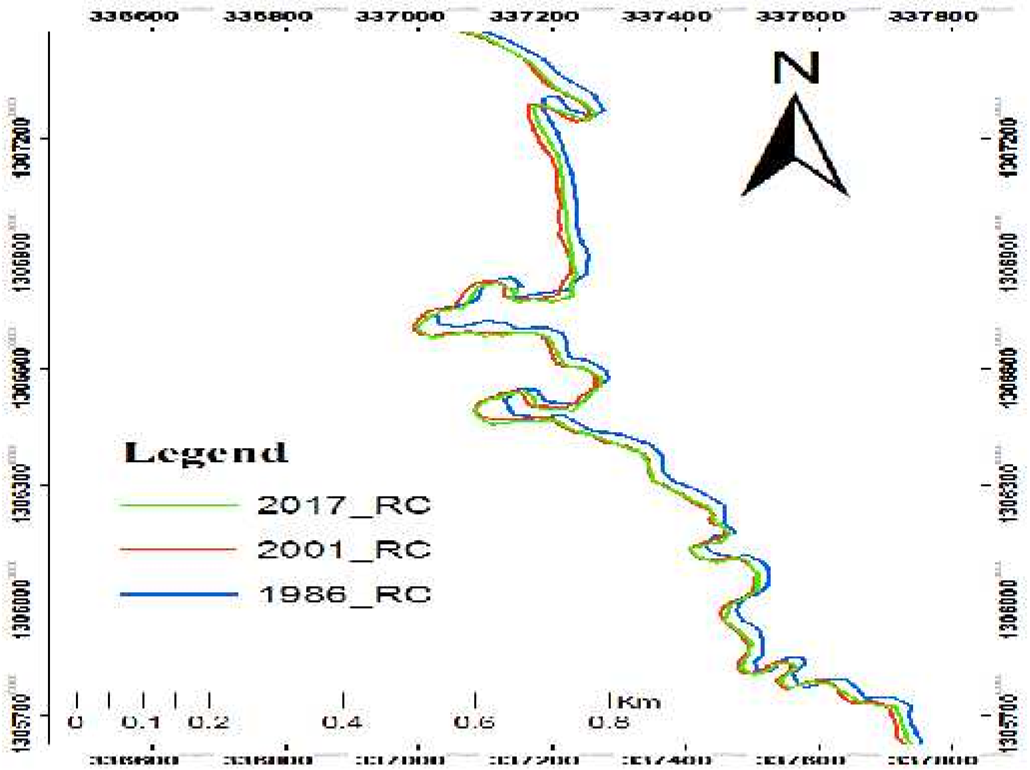


Figure 4-10 Overlapped digital central flow lines of Shina river.

All the three years of river center shapefile come under the category of meandering channel as shown in the following table.

Table 4:6 Sinuosity parameters

Rivers Centerlines	CL	VL	AL	CI	VI	HSI	TSI	SSI
1986	5.56	2.78	1.39	4.00	2.00	0.67	0.33	2.00
2001	5.52	2.76	3.43	1.61	0.81	1.32	0.32	2.01
2017	5.51	2.75	3.38	2	0.81	1.30	0.30	2.10

CL: Channel length VL: Valley length AL: Air length
CI: Channel Index VI: Valley Index HSI: hydraulic sinuosity index
TSI: Topographic sinuosity Index SSI: standard sinuosity index

Channel index for the main channel in all rivers are high (CI > 1.2). The analysis showed that the difference between channel index and valley index is considerable for rivers indicating the main channels in the watersheds have fully developed valleys. On the other hand 2001 river shape file has not much difference between CI and VI, pointing to the fact that their valleys are yet not fully developed.

The hydraulic sinuosity index and topographic sinuosity index are valuable tools in determining the stage of basin development as well as the controlling factors of sinuosity. HSI and TSI showed an interesting range. TSI is highest for the three basins, which is due to fact that these rivers passes through hilly terrain, and are highly controlled by the topography. From the sinuosity analysis, it can be noticed that the influence of topography on sinuosity decreases as the river channel shift from upper to lower reaches of the basin. Consequently, role of hydraulic factors become prominent in the lower reaches. It is clear that as elevation decreases, TSI decreases and consequently HSI increases. From the value of SSI, it is clear that sinuosity increases towards the lower reaches of the basin. Therefore, the river channel classified as meandering.

4.9 Vertical change analysis

Vertical change of River can be calculated from elevation difference between 2007 years digitized topomap and currently surveyed shina river cross section as discussed below. River cross section profile gives useful information on vertical plan form change along river center line in study area. For this study river center line was used to analyze river profile change. The difference between year 2007 topomap of shina watershed and currently survey Shina river profile represents the vertical changes on river center line within 10 years.

From profile analysis, average change of river depth was found to have been degraded by 0.38m, 0.94 m and 0.42 m respectively at a distance of junction point between the spillway out let and the river, 210m, and 410m respectively downstream of the Dam. This indicates that there is degradation below dam. Hydraulic structures were greatly affects the river profile from the above determination values indicate how the vertical channel pattern changes due to the presence of structures like dam and it has been explained briefly below in the table.

Table 4:7 Elevation Difference of the two Maps.

Cross section	River Centre		2007year Elevation	2017year Elevation	Elevation Difference	Chainage (m)
	Easting	Northing				
54	337791.428	1305234.454	1778	1777.623	-0.377	0
53	337691.5303	1305341.991	1777	1776.062	-0.938	210
52	337705.4474	1305442.321	1776.5	1776.076	-0.424	410

From the above table 4:7, it describes the vertical change of the river at a length of 410 meter downstream of a dam was assessed and explained .therefore the result shows demeaning of the river at a junction point of the spillway outlet and the river, at a distance of 210m, and 410 meter degraded by 0.38m, 0.94m, and 0.42m respectively.

This is because of obstruction of dam from which clear water is releasing to the downstream whereas aggradation is occurred at the upstream of the dam due to sedimentation retained by the dam that comes from the upstream of the watershed. Vertical changes of river profile is explained graphically as below, the red color indicates river profile 2017, whereas the blue color indicates 2007 digitized Shina river profile.

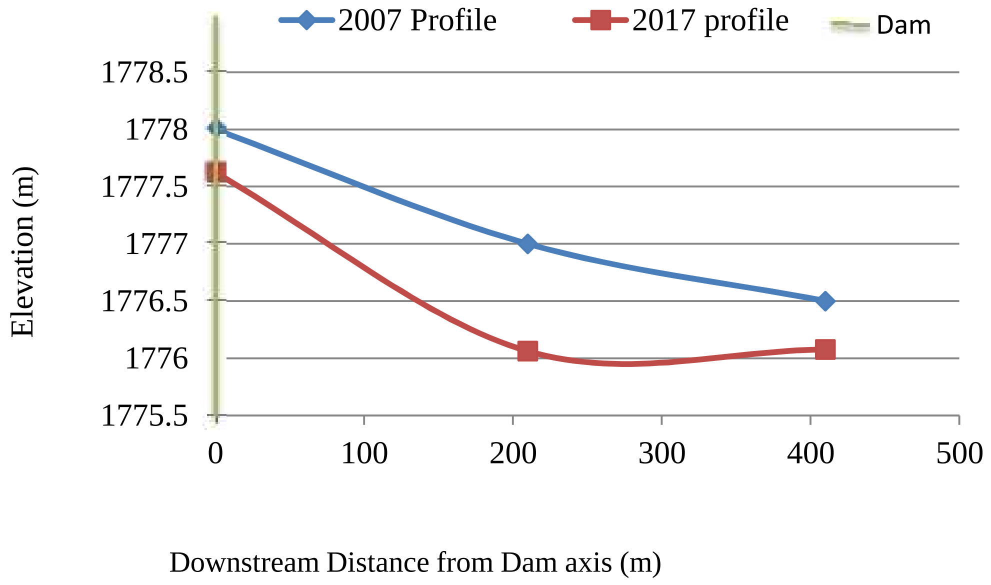


Figure 4-11 Vertical River Bed profiles of Shina River downstream from dam axis between 2007map and 2017survey.

Due to the availability of the data that only having base map of shina watershed about 410 with comparisons of current surveyed shina river crossections data it is possible to calculate the change in river depth at a selected crossections. As it can be described in the above figure 4-11 the vertical change of the river profile shows degradation just near downstream of the dam but furthest of the dam, it may be decreased proportionally.

5. CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

In this thesis, satellite images and river cross sections were used to evaluate the impacts of land use/cover change and hydraulic structures on the morphology of Shina River, Lake Tana. For the data preparation and analysis image processing software (ENVI5.1) and Arc GIS 10.2 were used.

From the result of land use /land cover classification, there is a decrease in forest land, the Bushes and shrubs and accompanied by increase in agriculture land and built up area. The anthropogenic impacts such as farming, deforestation, resettlement and animal free grazing have also aggravated the change of the planform in the downstream part of the river. The overlaying analysis showed that for the considered reach (6km length), starting from the dam for a length of about 3 km the general trend of the river banks were shifted to right and after that the river banks shifts left. The Sinuosity index of Shina River is 2.0, 2.01 and 2.1 in the year 1986, 2001, and 2017 respectively. This revealed that the three years of river center line shows meandering River channel pattern downstream of the dam.

Change detection (land use/cover change) analysis from satellite images and the trend analysis of the runoff coefficient of the Shina watershed showed that the runoff generation of the watershed is increased. The River planform changes occurred at different reaches downstream of the dam. Three reaches were analyzed .The result shows reach one shifted to right banks from 2001 river center downstream of the dam both in the years of 1986 and 2017 river center, whereas reach two and three shifted to left bank both in the years of 1986 and 2017 river center

Vertical change analysis was also made from the Shina River cross section extracted from the existing watershed topomap in the year 2007 and river cross-section survey data in the year 2017.Comparisions of cross-sections at junction of spillway and a distance of 210 m, 410 m from the dam axis to the downstream showed that the river bed is degraded by 0.38 m, 0.94 m and 0.42 m respectively for the period 1986, 2001, and 2017.

5.2 Recommendation

Shina river morphology has been changed due to the impacts of land use / cover change and hydraulic structure. The land use/land cover change should be controlled in the watershed and some measures should be taken for the stabilization of the land cover change and downstream river restoration should be done.

During field work it was confirmed that the reservoir water is seeping at the outlet of spillway. The irrigation system is not functional this time due to clogging of the outlet structures. In order to preserve the reservoir and achieve the purpose for which it was constructed, means reduction of seepage from spillway of the dam hereby recommended.

There is no bottom outlet structure for Shina dam project. Therefore, Designers should consider bottom outlet structures for sediment discharge.

REFERENCES

Aguda, AS, Farinde, TA, Adegboyega, SA, & Olawole, MO. (2012). Spatio-temporal assessment of urban growth of medium-size and nodal towns for sustainable management: using GIS. Management of Environmental Quality: An International Journal, 24(1), 94-106.

Ahmed, M, Abdulhamid, Adnan, & Kende, Sani Abdullahi. land use and biodiversity changes in the watershed of karaduwa drylands: insight from around the zobe dam, katsina state, nigeria.

Andrews, Edmund D. (1980). Effective and bankfull discharges of streams in the Yampa River basin, Colorado and Wyoming. Journal of Hydrology, 46(3-4), 311-330.

Balamurugan, G. (1991). Sediment balance and delivery in a humid tropical urban river basin: the Kelang River, Malaysia. Catena, 18(3-4), 271-287.

Baldyga TJ, Miller SN, Driese KL, GichabaCM (2008) Assessing land cover change in Kenya'sMau Forest region using remotely sensed data. Afr J Ecol 46(1): 46–54.

Berg, Robert R. (1968). Point-bar origin of Fall River Sandstone reservoirs, northeastern Wyoming. AAPG Bulletin, 52(11), 2116-2122.

Bewket, Woldeamlak. (2003). Towards integrated watershed management in highland Ethiopia: the Chemoga watershed case study.

Bewket, Woldeamlak, & Sterk, Geert. (2005). Dynamics in land cover and its effect on stream flow in the Chemoga watershed, Blue Nile basin, Ethiopia. Hydrological Processes, 19(2), 445-458.

Bormann H, Breuer L, Graff T, Huisman JA (2007) Analysing the effects of soil properties changes associatedwith land use changes on the simulated water balance: A comparison of three hydrological catchment models for scenario analysis. Ecol Modell 209(1): 29–40.

Brandt, S Anders. (2000). Classification of geomorphological effects downstream of dams. Catena, 40(4), 375-401.

Brice, James Coble. (1964). Channel patterns and terraces of the Loup Rivers in Nebraska: US Government Printing Office.

Burrough, Peter A. (1986). Principles of geographical information systems for land resources assessment.

Castilla, Guillermo, & Hay, Geoffrey G. (2007). An Automated Delineation Tool For Assisted Interpretation Of Digital Imagery. Paper presented at the ASPRS 2007 Annual Conference. Tampa, Florida-May.

Comiti, F, Da Canal, M, Surian, N, Mao, L, Picco, L, & Lenzi, MA. (2011). Channel adjustments and vegetation cover dynamics in a large gravel bed river over the last 200years. Geomorphology, 125(1), 147-159.

Dile YT, Berndtsson R, Setegn SG (2013) Hydrological response to climate change for Gilgel Abay River, in the Lake Tana Basin-Upper Blue Nile Basin of Ethiopia. PloS One 8(10): e79296.

Doughty, Robin W. (1982). Man and Environmental Processes. Edited by KJ Gregory and DE Walling.(Boulder: Westview Press, 1979. v+ 276 pp. Illustrations, references, and index. 26.50,cloth; 13.50, paper.): Duke University Press.

Dury, GH. (1977). Underfit streams: retrospect, perspect and prospect. River Channel Changes. Wiley, Chichester, 281-293.

Egozi, Roey, & Ashmore, Peter. (2008). Defining and measuring braiding intensity. Earth Surface Processes and Landforms, 33(14), 2121-2138.

Franklin, Janet, Duncan, Jeff, & Turner, Debra L. (1993). Reflectance of vegetation and soil in Chihuahuan desert plant communities from ground radiometry using SPOT wavebands. Remote Sensing of Environment, 46(3), 291-304.

Garedew, Efrem. (2010). Land-use and land-cover dynamics and rural livelihood perspectives, in the semi-arid areas of Central Rift Valley of Ethiopia (Vol. 2010).

Gebrehiwet, Kahsay Berhe. (2004). Land use and land cover changes in the central highlands of Ethiopia: The case of Yerer Mountain and its surroundings. Citeseer.

Geremew, Asmamaw Adamu. (2013). Assessing the impacts of land use and land cover change on hydrology of watershed: a case study on Gigel-Abbay Watershed, Lake Tana Basin, Ethiopia.

Githui FW (2009) Assessing the impacts of environmental change on the hydrology of the Nzoia catch-ment, in the Lake Victoria. PhD thesis, Vrije Universiteit Brussel, Brussels, Belgium.

Gregory, KJ. (1977). The context of river channel changes. River Channel Changes,'John Wiley and Sons, Chichester, pp1-12.

Graf L. William; 2006. "Downstream Hydrologic and Geomorphic Effects of Large Dams on American Rivers", Vorosmarty et al. (1997), Nilsson et al. (2005), and Hanasaki et al. (2006).

Haddeland et al. (2006b) studied the effects of dams and irrigation given current conditions and found locally significant changes in the surface water fluxes

of Hydrology, Geomorphology, 79(3-4), pp. 336-360. Processes and Landforms, 32(11), 1641-1656.

Helmschrot J, Flugel WA (2002) Land use characterisation and change detection analysis for hydrologi-cal model parameterisation of large scale afforested areas using remote sensing. Phys Chem Earth 27(9–10): 711–718.

HernandezM, Miller SN, Goodrich DC, Goff BF, Kepner WG, Edmonds CMet al. (2000) Modeling run-off response to land cover and rainfall spatial variability in semi-arid watersheds. InMonitoring Ecologi-cal Condition in the Western United States. pp. 285–298.

Hernandez-Guzman R, Ruiz-Luna A, Berlanga-Robles CA (2008) Assessment of runoff response to landscape changes in the San Pedro subbasin (Nayarit, Mexico) using remote sensing data andGIS. J Environ Sci Health A Tox Hazard Subst Environ Eng 43(12): 1471–1482.

Hickin, Edward J, & Nanson, Gerald C. (1975). The character of channel migration on the Beatton River, northeast British Columbia, Canada. Geological Society of America Bulletin, 86(4), 487-494.

Hooke, Janet M, & Redmond, CE. (1989). Use of cartographic sources for analysing river channel change with examples from Britain. Historical Change of Large Alluvial Rivers: Western Europe. John Wiley & Sons New York. 1989. p 79-93. 3 fig, 5 tab, 48 ref.

HörmannG, Horn A, Fohrer N (2005) The evaluation of land-use options inmesoscale catchments: Prospects and limitations of eco-hydrological models. Ecol Modell 187(1): 3–14.

Jain, SK, & Ahmad, Tanvear. (1993). Migration behaviour of river ganga between Allahabad and Buxar using remotely sensed data. Journal of the Indian Society of Remote Sensing, 21(1), 37-43.

Jensen JR (2005) Introductory Digital Image Processing a Remote Sensing Perspective. New Jersey:Pearson Education, Inc.

Knight, MJ. (1975). Recent crevassing of the Erap River, Papua New Guinea. Geographical Research, 13(1), 77-84.

Lane, Emory Wilson. (1955). Importance of fluvial morphology in hydraulic engineering. Proceedings (American Society of Civil Engineers); v. 81, paper no. 745.

Leopold, Luna Bergere, & Wolman, Markley Gordon. (1957). River channel patterns: braided, meandering, and straight: US Government Printing Office.

Lo, CP, & Quattrochi, Dale A. (2003). Land-use and land-cover change, urban heat island phenomenon, and health implications. Photogrammetric Engineering & Remote Sensing, 69(9), 1053-1063.

Middleton, M, Närhi, P, Sutinen, ML, & Sutinen, R. (2008). Object-based change detection of historical aerial photographs reveals altitudinal forest expansion. Proceedings of the GEOBIA, 2008–Pixels, Objects, Intelligence: Geographic Object Based Image Analysis for the 21st Century, 6-7.

Noe, Christine. (2003). The Dynamics of land use changes and their impacts on the wildlife corridor between Mt. Kilimanjaro and Amboseli National Parks.

Pickup, G, & Warner, RF. (1976). Effects of hydrologic regime on magnitude and frequency of dominant discharge. Journal of Hydrology, 29(1-2), 51-75.

Ravazzani G, Ghilardi M, Mendlik T, Gobiet A, Corbari C, Mancini M (2014) Investigation of climate change impact on water resources for an alpine basin in northern Italy: Implications for evapotranspira-tionmodeling complexity.

Rinaldi, Massimo, Surian, Nicola, Comiti, Francesco, & Bussettini, Martina. (2012). Guidebook for the evaluation of stream morphological conditions by the morphological quality index (MQI). Version, 1, 85.

Romulus C, Iulia F, Ema C (2014) Assessment of surface runoff depth changes in Sărăţel River basin, Romania usingGIS techniques. Cent eur j geosci 6(3): 363–372.

Savary S, Rousseau AN, QuilbeR (2009) Assessing the effects of historical land cover changes on run-off and low flows using remote sensing and hydrological modeling. J Hydrol Eng 14(6): 575–587.

Surian, Nicola, & Cisotto, Alberto. (2007). Channel adjustments, bedload transport and sediment sources in a gravel-bed river, Brenta River, Italy. Earth Surface

Tadele. (2007). Impact of land use/cover change on streamflow: the case of Hare River Watershed, Ethiopia. Paper presented at the Catchment and lake research, proceedings 2nd Lake Abaya research symposium (LARS), Arba Minch, Ethiopia.

Tegene, Belay. (2002). Land-cover/land-use changes in the derekolli catchment of the South Welo Zone of Amhara Region, Ethiopia. Eastern Africa Social Science Research Review, 18(1), 1-20.

USDA (2004) Estimation of Direct Runoff from Storm Rainfall. National EngineeringHandbook. Wash-ington, DC: USDA. pp. 79.

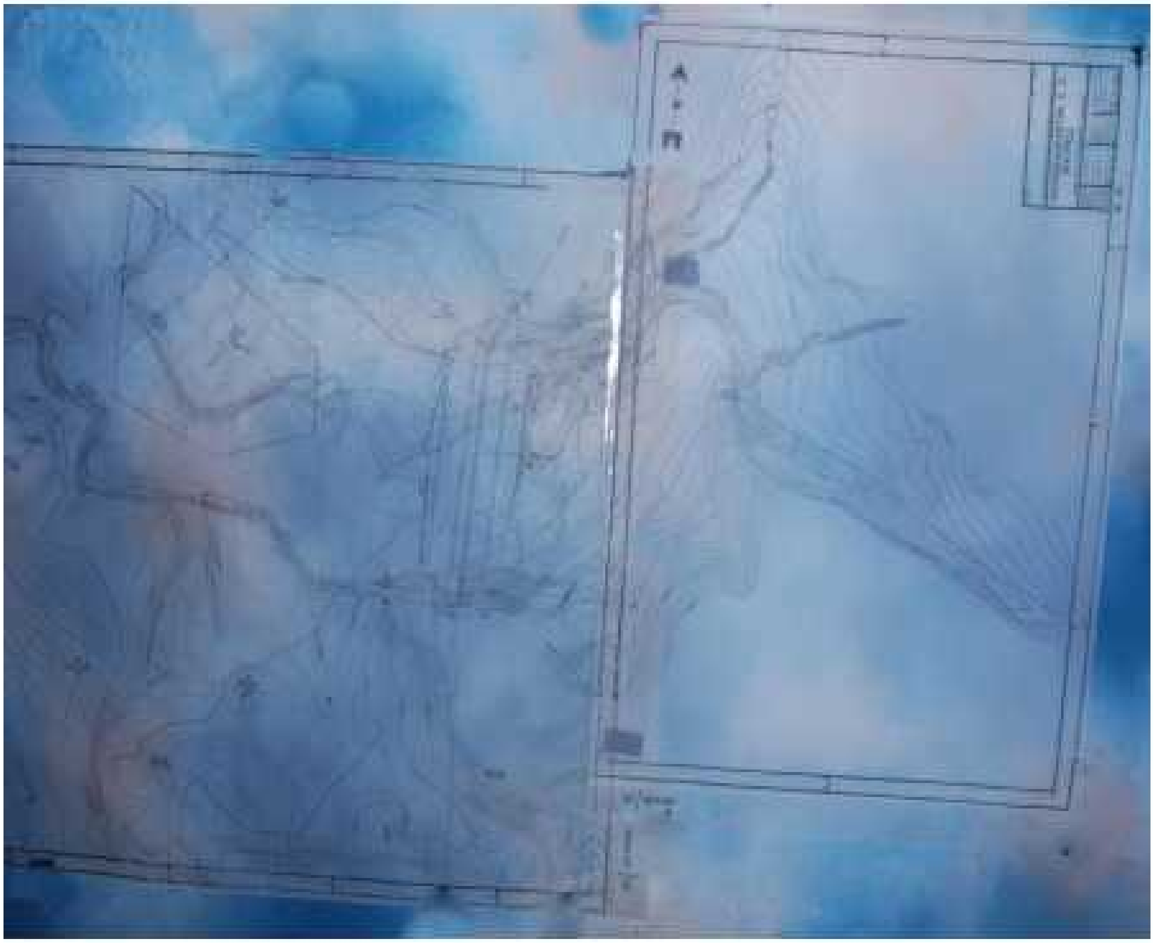
Yang X, Ren L, Liu Y, Jiao D, Jiang S (2014) Hydrological response to land use and land cover changes in a sub-watershed of West LiaoheRiver Basin, China. J Arid Land 6(6): 678–689.

APPENDIX

Appendix 1 Digitized points from Shina Map (2007)

Point Code	Easting	Northing	Elevation
1	337790.472	1305213.45	1780
2	337788.617	1305228.613	1779
3	337791.428	1305234.454	1778
4	337791.629	1305238.213	1980
5	337688.2918	1305338.197	1780
6	337690.1439	1305340.737	1779
7	337691.5303	1305341.991	1778
8	337692.6416	1305343.182	1978
9	337693.356	1305344.214	1779
10	337694.1497	1305345.484	1780
11	337696.0812	1305443.83	1780
12	337700.0499	1305442.798	1779
13	337702.7487	1305442.48	1778
14	337705.4474	1305442.321	1776.5
15	337713.6231	1305441.448	1780
16	337710.5274	1305441.925	1779

Appendix 2 Base map of Shina Dam (2007)



Appendix 3 Meta data for 1986

Field	Value
Landsat Product Identifier	LT05_L1TP_169053_19860128_20170218_01_T1
Landsat Scene Identifier	LT51690531986028XXX03
Acquisition Date	1/28/1986
Spacecraft Identifier	LANDSAT_5
Collection Category	T1
Collection Number	1
Sensor Mode	N/A
WRS Path	169
WRS Row	53
Geometric RMSE Model	5.988

Appendix 4 Meta data for 2001

Field	Value
Landsat Product Identifier	LE07_L1TP_170052_20010205_20170207_01_T1
Landsat Scene Identifier	LE71700522001036SGS00
Acquisition Date	2/5/2001
Scan Line Corrector	ON
Collection Category	T1
Collection Number	1
Sensor Mode	N/A
WRS Path	170
WRS Row	52

Appendix 5 Meta data for 2017

Field	**Value**
Landsat Product Identifier	LC08_L1TP_170052_20170108_20170311_01_T1
Landsat Scene Identifier	LC81700522017008LGN01
Acquisition Date	1/8/2017
Collection Category	T1
Collection Number	1
WRS Path	170
WRS Row	52
Target WRS Path	170
Target WRS Row	52
Nadir/Off Nadir	NADIR

Appendix 6 Channel river center change from 2001 river center

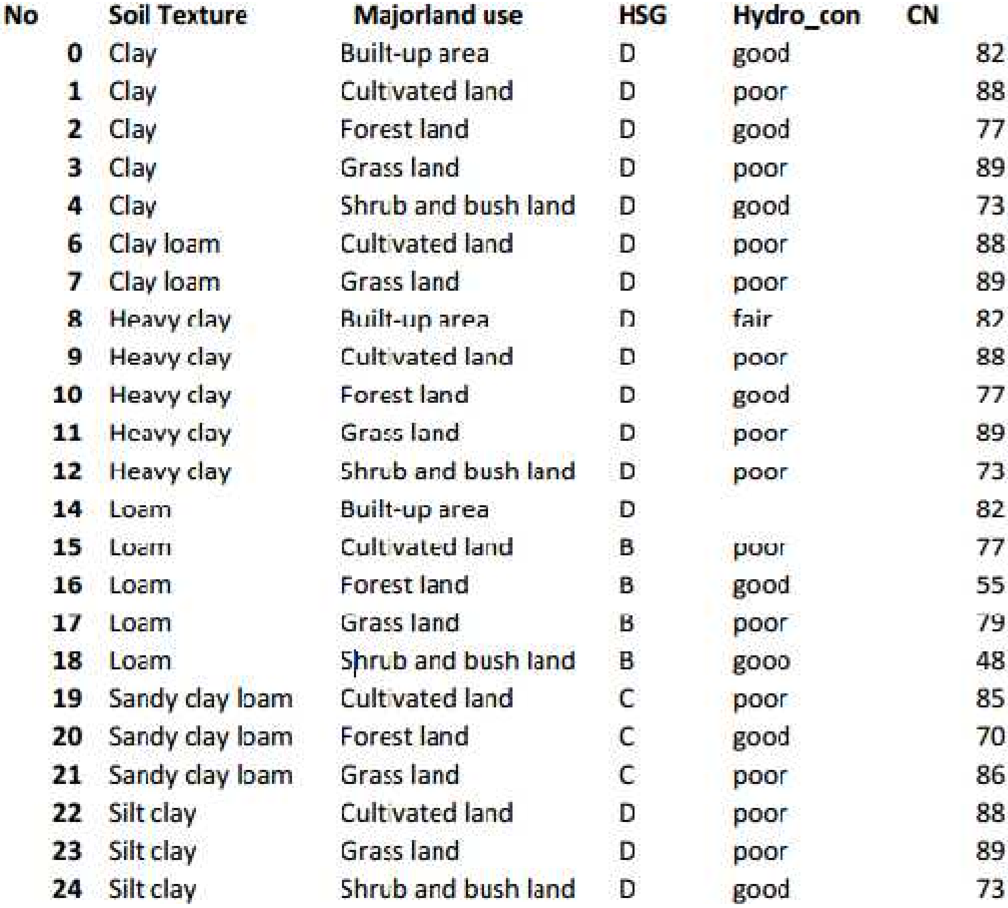
Cross-section	1986 river center Shift (m)	2017 river center Shift (m)
0	-30	-11
1	-29	-11
2	-29	-18
3	-29	-27
4	-4	+6
5	+4	+9
6	-5	+4
7	-31	-25
8	-32	-24
9	-24	-16
10	-16	-18
11	-116	-111
12	-95	-95
13	-28	-23
14	-22	-14
15	-8	+14
16	+22	+13
17	-33	-30
18	-31	-19
19	-20	-12
20	-24	-17
21	-28	-23
22	+4	+22
23	+12	+16
24	+11	+8
25	+23	+18

26	-7	+1
27	+5	+8
28	-34	-32
29	-26	-31
30	-21	-24
31	-9	-10
32	-30	-24
33	+11	+12
34	+26	+19
35	-47	-43
36	-11	-16
37	-7	-7
38	-25	-21
39	-28	-25
40	-22	-23
41	-21	-18
42	-26	-18
43	-5	-10
44	-23	-16
45	-25	-19
46	-9	-12
47	-21	-19
48	-16	-18
49	-32	-19
50	-19	-14
51	-3	+3
52	-45	-43
53	-132	-126
54	-125	-127

55	-121	-119
56	-229	-225
57	-196	-196

Note: the +ve values indicates shift to the right and –ve values indicates shift to the left.

Appendix 7 Shina watershed curve number computation summery



No	Soil Texture	Majorland use	HSG	Hydro_con	CN
0	Clay	Built-up area	D	good	82
1	Clay	Cultivated land	D	poor	88
2	Clay	Forest land	D	good	77
3	Clay	Grass land	D	poor	89
4	Clay	Shrub and bush land	D	good	73
6	Clay loam	Cultivated land	D	poor	88
7	Clay loam	Grass land	D	poor	89
8	Heavy clay	Built-up area	D	fair	82
9	Heavy clay	Cultivated land	D	poor	88
10	Heavy clay	Forest land	D	good	77
11	Heavy clay	Grass land	D	poor	89
12	Heavy clay	Shrub and bush land	D	poor	73
14	Loam	Built-up area	D		82
15	Loam	Cultivated land	B	poor	77
16	Loam	Forest land	B	good	55
17	Loam	Grass land	B	poor	79
18	Loam	Shrub and bush land	B	gooo	48
19	Sandy clay loam	Cultivated land	C	poor	85
20	Sandy clay loam	Forest land	C	good	70
21	Sandy clay loam	Grass land	C	poor	86
22	Silt clay	Cultivated land	D	poor	88
23	Silt clay	Grass land	D	poor	89
24	Silt clay	Shrub and bush land	D	good	73