Addis Ababa University Institute of Technology
School of Civil and Environmental Engineering

Impact of Land use/Land Cover change on the Stream flow:
(Case Study of Megech River Watershed, Abay River Basin, Ethiopia)

A thesis submitted to the School of Graduate Studies in Partial fulfillment of the requirements for the degree of Master of Science in Civil Engineering (Major Hydraulic Engineering)

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Approval page

This thesis entitled with case study on Impact of Land use/Land Cover change on the Stream flow :(Case Study on Megech River Watershed, Abay River Basin, Ethiopia) were approved by the following advisor, examiners and chairman and submitted to school of Civil and Environmental Engineering, Institute of Technology, Addis Ababa University in partial fulfillment of the requirement of the degree of Master of Science in Hydraulics engineering.

By Sileshi Fana

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List Abbreviations

ACRONYMS AND ABBREVIATION

CN	Curve Number
DEM	Digital Elevation Model
ENS	Efficiency of Nash-Sutcliffe
ETM	Enhanced thematic mapper
GIS	Geographical Information System
GLUE	Generalized likelihood Uncertainty estimation
HRU	Hydrologic Response Unit
HSPF	Hydrologic Simulation Program FORTRAN
IM	Inverse Modeling
LULC	Land Use and Land Cover
L95PPU	Lower 95% Prediction Uncertainty
MCMC	Markov Chain Monte Carlo
M95PPU	Middle 95% Prediction Uncertainty
NMA	National Metrological Agency
ParaSol	Parameter Solution
PSO	Particle Swarm Optimization
SCS	Soil Conservation Service
SWAT	Soil and Water Assessment Tool
TM	Thematic Mapper
USDA	United State Department of Agriculture
U95PPU	Upper 95% Prediction Uncertainty
95PPU	95%PredictionUncertainty
USGS	United State of Geology Survey
WGEN	Weather generator

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Abstract

The main goal of this study is to identify the impact of land use/land cover changes on the hydrology of Megech Watershed. Specifically, the study was analyzed the historical land cover changes at (2000, 2010 and 20018 years) that have occurred in the catchment and its impact on stream flow of watershed because the recent input data gives more accurate results. Population growth, deforestation and higher demand for farm lands have effect on natural resource of the Megech river catchment of Abbay River basin. Assessing the problem and finding solution at catchment level is use full to minimize the effect of the problem. Decision support tools are needed for successful assessment for impact of land use on stream flow and application of soil and water conservation measures at upstream of watershed. Land cover change analysis has shown that the settlement (town) area has increased from 2.21% to 9.13%, agricultural land increased from 46.3% to 70.49% and forest area has been decreased from 6.43% to 0.8% between 2000 - 2018 years. In this study, the effect of land use and land cover changes on stream flow was observed. Soil& water assessment tool (SWAT) model set up were run to evaluate the impacts of land use changes on stream flow using three land cover years of 2000, 2010 and 2018.

Sensitivity, calibration, validation and uncertainty analysis were also conducted using sequential uncertainty fitting–version 2 (SUFI-2) in SWAT-CUP (Calibration and Uncertainty program) using stream flow historical data. Model calibration and validation were conducted for land use 2000, 2010 and 2018 years by using measured (gauged) data near to watershed by using SWAT-CUP. For 2000 land use, calibration from 1999-2001 and validation from 2002-2003, for 2010 land use, calibration from 2008-2010 & validation from 2011-2013, for 2018 land use, calibration from 2014-2016 & validation from 2017-2019 years was conducted. The Results from calibration for three land use show acceptable range (0.82, 0.63 and 0.71 for NSE and 0.82, 0.79 and 0.74 for R^2) between observed and simulated stream flow respectively. The results of validation were also acceptable range (0.66, 0.78 and 0.75 for NSE and 0.71, 0.84 and 0.78 for R^2) respectively.

The mean monthly stream flow for both dry and wet season were decreased by 3.31m^3/s and 1.88m^3/s due to land use/land cover changed in the catchment from 2000-2018 years respectively.

Keyword: SWAT, SWAT-CUP, LULC change, Arc-GIS and Stream flow

1. Introduction

1.1 Background

Activities concern with human being such as Industrial and Commercial Development, Human health and welfare, irrigation activity to get food security and sustainable development of ecological and economical point of view are depend on adequate supplies water; however, water resources are influenced by many parameters. Hydrologic modeling and water resources management studies are inter-related with each other to the spatial processes of the hydrologic cycle at watershed, sub-watershed and basin level. This cycle is influence by several factors such as natural and anthropogenic activities which consequence are increase impervious ground surfaces, decrease infiltration rate and increase runoff rate, Especially, land use/land cover (LULC) change has a significant impact on the watershed hydrology by affecting the magnitude and pattern of surface runoff, groundwater and soil moisture content thus, understanding the interaction between LULC and hydrological cycle is imperative. The LULC changes are caused by a number of natural and human driving forces (Meyer and Turner 1994). LULC studies are carried out on hydrology of the watershed in the different regions of the World and in Ethiopia using Soil and Water Assessment Tool (SWAT) but only a few studies have focused on explaining the impact of LULC change on river flow with hydrologic modeling. The dynamic nature of land use arising from an increasing population at an alarming rate mostly common in developing countries like Ethiopia (Haile and Assefa 2012). The anthropogenic activities result in an expansion of agricultural land and urbanization thereby deforestation. Many hydrological studies have shown that LULC changes have affected the hydrology of various watersheds of the World (Ambika 2012) and this LULC change can lead to alter both the infiltration and runoff amount by following the falling of precipitation (Hougton 1995).

Land use/land cover (LU/LC) plays a vital role in water transport in the hydrologic cycle and primarily aids in reducing overland flows. Due to its effect on evaporation, transpiration and solar radiation interception, LU/LC is a driving factor in the energy balance within the hydrologic cycle. The hydrology of local watersheds can vary drastically and water quality as well as water flow patterns is often dependent on a combination of soil, LU/LC and elevation characteristics unique to the area. For example, as forested area is lost and developed land expands it has shown to reduce base flow and/or an increase in soil erosion generally occurs.

To study sustainable water resources and land use planning and development understanding the consequences of changes in land use and land cover scenarios is required. The development of new patterns of land use and land cover conditions can be enhanced by careful planning for the wellbeing of people. The scientific framework for the analysis of land use systems have changed by the modeling tools which can addresses both spatial and temporal dynamics. There are some proportional alterations in the basin condition and hydrological response as a result of changes in land cover and land use scenarios. This is appropriately becoming one of the main existing land management issues.

LU/LC monitoring is an important aspect to determine the LU/LC change and likely impacts on the ecosystem that often lead to several environmental impacts, such as soil erosion, soil moisture, soil nutrients, change in microclimate and so forth. These impacts not only affect within the watershed boundary but also bring in several harmful effects downstream. Knowledge of LU/LC change is important for water planning and management activities and technological, institutional and natural resource policy forces also play an important role in changing land use pattern. Therefore, changing LU/LC is becoming far more important from both ecological and economical point of view. In recent years, understanding the occurrences of natural processes at the watershed scale by the application of the model became an essential tool. Geographic Information System (GIS) based spatial modeling has grown into an important tool to assess the effect of land use land cover changes on runoff and soil erosion studies and, consequently in advancement of suitable soil and water conservation strategies.

SWAT is a basin-scale continuous-time model that operates on a daily time step and is designed to predict the impact of management on water, sediment and agricultural chemical yields in gauged watersheds. SWAT could accurately predict the relative impacts of hypothetical land use change in the sub watershed within the Lake Tana sub-basin. Stream flow Simulated response to historical land use shifts by using SWAT in the Megech watershed. Megech Dam is found at this outlet of Watershed and under construction for the purpose of water supply and irrigation for Gondar town and downstream farmer respectively.

Therefore, this study was utilized Arc SWAT model on ArcGIS to analysis the impact of Land use / land Cover changes on the stream flow of Megech water shaded in Ethiopia.

1.2 Statement of problem

Land-use and land cover change is an important characteristic in the runoff process that affects hydrology cycle such as infiltration, interception, erosion and evapotranspiration. These changes have caused severe stress on forest and water resources in watershed. Due to rapid development in the watershed, land-use/cover is subjected to changes causing the area to form impervious surfaces. Deforestation, urbanization, and other land-use activities can significantly alter the maximum and minimum flows of the river which mean increase impervious ground surfaces, decrease infiltration rate and increase runoff rate, hence causing low base flow during the dry seasons. Although land-use changes in the area are a current phenomenon, the severity of their effects on both forest cover and hydrology of Megech watershed might pose serious concern on the future functioning of this fragile resource if urgent action is not taken into consideration. Since Megech dam was designed for both water supply and irrigation propose, understanding how these activities influence stream flow will enable planners to formulate policies towards minimizing the undesirable effects of future land-use and land cover changes on the hydrology of the river is the most critical regarding the basin water balance, annual average discharges and how the discharge regime of Megach River reacts to the changing land-use/cover is a central question of interest. Therefore, the need for scientific research to establish the impact of land use Land cover change on Megach River stream flow is essential.

1.3 Objective

General objective

The main objective this study is to identify the impact of land use and land cover change on the hydrology of megach watershed by using soil water analysis tools (SWAT) Model.

Specific objective

- ✓ To asses land use and land cover change of megech watershed at 2000,2010 and 2018 years
- ✓ To analyze stream flow changes in response to land use/Land cover change.

1.4 Research Question

- ✓ What are the trends of land use/land cover change in the study area?
- ✓ How land cover changes significantly affect the stream flow?

1.5 Significance of the Study

The land use and land cover change has significantly impacts on natural resource, socio economic and environmental system. However, to assess the effect of land use land cover change on stream flow it is important to have an understanding of the land use land cover pattern and the hydrological process of the waterside. Understanding the types and impacts of land use land cover is essential indicator for resource base analysis and development of effective and appropriate response strategies for sustainable management of natural resources in the country in general and at the study area in particular. Moreover, the study presents a method to quantify land use and land cover change and their impact on stream flow. This was achieved through a method that combines the hydrological model (SWAT) to simulate the hydrological processes, GIS and remote sensing techniques to analysis the land use land cover change.

2. Literature Review

Land-use planning is an important part of integrated river basin management (IUCN, 2003) because so much of what happens to water concerns development on land. It is important that land-use is managed in such a way that water supply can be assured and that hydrological processes are not interrupted (IUCN, 2009). The effects of land-use and land cover changes on the hydrological system are considerable and deserve necessary pro-active planning for compensation of the negative effects. This section seeks to appraise the salient points of the literature review with a view to addressing the trends of land-use and land cover change, their driving forces and how they influence the hydrology of the sub-catchments. In conclusion, this section seeks to provide an overview of different techniques and methodologies put forward to overcome the problems of land-use and land cover change in water catchment in order to expose knowledge.

2.1Trends 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). Despite this complexity, little is known about how human and environmental factors operate and how they interact to affect land-use patterns and hydrological processes (LUCID, 2004). According to Lamb in et al. (2002), 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 et al. (2002) throughout the entire history of mankind, intense human utilization of land resources has resulted in significant changes on the land-use and land-cover.

2.2 Impact of Land Use/ Land Cover changes on hydrological cycle

It is obvious that land cover can affect both the degree of infiltration and runoff following rainfall events, while the degree of land cover can affect rates of evaporation. Land cover has various properties that help to regulate water flows both above and below ground. For example, tree canopy and leaf litter can help reduce the impact of raindrops on the ground, hence reduce soil erosion, while roots hold the soil in place and also absorb water. In the absence of vegetative cover, soil erosion and increasing runoff. Ethiopia is the water tower of northeastern Africa;

however, land cover change can affect the amount of runoff to the downstream of basin and Sub-basin, where every main rainy season big flood is reported. Low level vegetative cover could also affect infiltration and could lead to reduced groundwater levels and therefore the base flow of streams (Dagnachew et al, 2003). Specificity of characteristics of each catchment. Mach of the present understanding of land use effects on hydrology is derived from controlled experiments and manipulations of the land surface coupled with observations of hydrological processes, commonly precipitation inputs and stream discharge outputs (De Friesand Eshleman, 2004)

2.3 Effects of Afforestation and Deforestation on Hydrology

The magnitude of changes on the stream flow due to land use changes varies with catchments and other factors such as climate and human activities. Regarding the impact of deforestation and afforestation on the dry season flow in the tropics, there are conflicting statements and findings. Edwards (1999) in an experiment conducted in Mbeya, observed that the dry season flow was higher from a catchment with traditional small holder cultivation than with forest cover, even on steep slopes. Similar results were observed after deforestation of Brachystegia woodland in Zambia (Mumeka,1996) and Montane hard wood forest in Taiwan (Hsia and Koh, 1993). In South Africa, afforestation of dry grassland and land resulted in a highly significant decrease in low flows (Smith and Scott,1992).

2.4 Land Use and Land Cover Change Studies in Ethiopia

In Ethiopia, 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 and 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, (Abebe, 2005; Kidanu, 2004) in northern part of Ethiopia, (Zeleke, 2001) in north western part of Ethiopia, (Kassa, 2003) in north eastern part of Ethiopia. The changes of land use and 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); They identified that decrease of natural vegetation and expansion of agricultural land over a period of 41 years in Tigray, northern part of Ethiopia. They concluded that population pressure was an important deriver for expansion and intensification of agricultural land in recent periods.

To understand how LULC affects and interacts with global earth systems, information is Needed on what changes occur, where and when they occur, the rates at which they occur, and the social and physical forces that drive those changes. Human impact on global land cover change, especially in terms of change from forest cover to other land cover, has been one of the important issues on global change research. In the primitive times when there was little human population and low level of economic activity, deforestation was not a problem because the natural regeneration of forest was adequate to cover for any loss of forest by the human beings. However, with the advent of modern civilization and industrialization and the increase in population, the forest loss to meet the ever-growing needs of the population became so huge that it posed a problem for the global environment.

Operational definitions of key terms

Managing: In this context this term refers to organizing and monitoring of water catchments through proper land-use planning and development.

Land cover: -refers to the physical characteristic of the earth's surface, captured in distribute physical features of the land including those created solely by human activities such as mine exposures and settlement. According to Lambin et al. (2003)

Land use: - can also be defined in this study as the purposes for which humans exploit the land-cover

Remote Sensing: This is the practice of deriving information and water surfaces using images acquired from an overhead perspective, using electromagnetic radiation in one or more regions of the electromagnetic spectrum, reflected or emitted surface (Campbell, from1996) the earth.'

Hydrologic Regime: This refers to fluctuations (monthly, seasonal and long term) with time in the rates of rivers and in the levels and volumes of water (Tu_Min, 2006). These are known as high flow and low flow variations.

Rating Curve: rating curve is a relationship between stage and discharge at a cross section of a river. In most cases, data from stream gauges are collected as stage data.

Ground truth /Field survey: Ground truth or field survey is done in order to observe and collect information about the actual condition on the ground at a test site and determine the relationship between remotely sensed data and the object to be observed. GCPs were collected at the field which was used for further analysis, interpretation, and comparison and expressing of land cover by using GPS. These GCPs was used to produce signature for supervised classification and accuracy assessment of satellite images of the watershed. Stratified and random sampling method was used for the collection of the GCPs (Conglton, 1990).

Layer stacking images: In order to analyze remotely sensed images, the different images representing different bands must be stacked. This allows different combinations of RGB to be shown in the view. Therefore, layer stack is often used to combine separate image bands into a single multi spectral image file.

Sub setting: An image can be useful when working with large images. Sub setting is the process of "cropping" or cutting out a portion of an image for further processing.

Accuracy Assessment: Accuracy assessment is an important step in the process of analyzing remote sensing data. It determines the value of the resulting data to a particular user, i.e. the information value. The accuracy assessment is used to determine the degree of 'correctness' of a map or classified image. In essence, therefore, classification accuracy is typically taken to mean the degree to which the derived image classification agrees with reality or conforms to the 'truth' (Campbell, 1996; Janssen & Vander Wel, 1994). A classification error is, thus, some discrepancy between the situation depicted on the thematic map and reality.

The main technique for accuracy assessment is using change maps for evaluating each class and calculating the expected accuracy (Yuan et al., 1998). Another method leading to more exact results is by checking points accurately classified or not, after the selection of the points where changes are available or not upon the map. Many methods of accuracy assessment have been discussed in the remote sensing literature (e.g., Koukoulas& Blackburn, 2001; Piper, 1983; Rosen field &FitzpatrickLins, 1986). The most widely promoted and used, however, may be derived from a confusion or error matrix.

Application of Remote Sensing on LULCC: Remote Sensing (RS) is defined as the science of obtaining information about an object, area, or phenomenon through 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.

Most of data inputs to the hydrological (SWAT) model are directly or indirectly extracted from remotely sensed data. Some of the important data used in the hydrological modeling that are obtained from remote sensing data are digital elevation model (DEM), land cover map, land use map and soil map. Some of the application of remote sensing technology in mapping and studying of the land use and land cover changes are; map and classify the land use and land cover, assess the spatial arrangement of land use and land cover, allow analysis of time-series images used to analyze landscape history, report and analyze results of inventories including inputs to Geographic Information System (GIS), provide a basis for model building.

The importance of land cover mapping is to show the land cover changes in the watershed area and to divide the land use and land cover in different classes of land use and land cover. For this purpose, remotely sensed imagery plays 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, 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.

Image Classification: Image classification is perhaps the most important part of digital image analysis. It is very nice to have a "clear picture" or an image, showing a magnitude of colors illustrating various features of the underlying terrain, but it is quite useless unless to know what the colors mean.

Image processing takes a basic understanding of remote sensing and of digital images through the fundamental stages of image processing. It also provides a varied set of cases for application of image processing and introduces a wide range of processing techniques. These form the basis for continued development to advanced level. It is the process of assigning each pixel of an image to a particular group or class.

Supervised Classification: During supervised classification, the classifier/expertise identifies examples of the information classes (i.e., land cover type) of interest in the image which is called "training sites". The image processing software system is then used to develop a statistical characterization of the reflectance for each information class. This stage is often called "signature analysis" and may involve developing a characterization as simple as the mean or the average of reflectance on each band, or as complex as detailed analyses of the mean, variances and covariance over all bands.

Unsupervised Classification

Unsupervised classification is a method which examines a large number of unknown pixels and divides into a number of classed based on natural groupings present in the image values. Unlike supervised classification, unsupervised classification does not require analyst-specified training data.

The basic premise is that values within a given cover type should be close together in the measurement space (i.e. have similar gray levels), whereas data in different classes should be comparatively well separated (i.e. have very different gray levels) (Lillesand and Kiefer, 1994; Eastman, 1995)

Unsupervised classification is the simplest technique. Within the image data for the different wavelengths the computer is asked to determine a user-defined number of clusters. Each cluster represents a land cover class or sub-class. The mean digital value for each input band could be represented as a spectral reflectance profile. The cluster represents the spread of values around the mean for the land cover class. After the classification has been completed each class should be examined and assigned a name. It may also be necessary to merge a number of classes into a single category.

2.5 Hydrological Model

Hydrological models are mathematical descriptions components of the hydrologic cycle. They have been developed for many different reasons and therefore have many different forms. However, hydrological models are in general designed to meet one of the two primary objectives.

- To get a better understanding of the hydrologic processes in a watershed and of how changes in the watershed may these phenomena.
- For hydrologic prediction (Tadele, 2007). They are also providing valuable information for studying potential impacts of changes in land use and land cover or climate.

2.6 SWAT

2.6.1 Description of SWAT model

It is the acronym for Soil and Water Assessment Tool which is semi distributed, physically based, time continuous model designed to predict the impact of land management practices on water, sediment, and agricultural chemical yield in large river basins (Arnold et al., 2012) developed by Dr Jeff Arnold for the USDA Agricultural Research Service (ARS). The model is computationally efficient and capable of continuous simulation over long time periods. Major model components include weather, hydrology, soil temperature and properties, plant growth, nutrients, pesticides, bacteria and pathogens, and land management. Among the many advantages of this model are; it has incorporated several environmental processes, it uses readily available inputs, it is user friendly, it is physically based and distributed, and it is computationally efficient to operate on large basins in a reasonable time. Despite the strengths mentioned above SWAT model have some known weaknesses:

- ✓ No routines for concentrated animal feeding operation.
- ✓ Simplified stream channel degradation and sediment deposition routines
- ✓ The tile drainage routine of SWAT does not account for the drain spacing and depth of shallow water table.
- ✓ The spatial detail required to correctly simulate environmental processes. For example, it is difficult to capture the spatial variability associated with precipitation within watershed.
- ✓ Data files can be difficult to manipulate and can contain several missing records. The model simulations can only be as accurate as the input data.
- ✓ Model does not simulate detailed event-based flood and sediment routing.

Inputs entered into the SWAT model are organized to have spatial characteristics. The SWAT model provides three spatial levels: the watershed, the sub-basins, and the hydrologic response units (HRUs). Each level is characterized by a parameter set and input data. The largest spatial level, the watershed, refers to the entire area being represented by the model. The sub-basins refer to subdivisions of the watershed that are connected hydro logically. Sub-basins are then subdivided into HRUs. HRUs are areas within a sub-basin that have the same soil, land use and slope combination. Both sub-basins and HRUs are user defined, providing model users with some control over the resolution considered in the SWAT model (Neitsch et al., 2001a).

Although the SWAT model simulates on a daily time step, the model has options for the output that allow the user to define the output time step (daily, monthly, or annual). Output variables include flow volume, nutrient yields, sediment yield, plant biomass yields and etc. These variables are provided on the sub-basin or HRU spatial level depending on the output time step selected. The output files generated by the SWAT model are created in text and database file formats.

Generally, the model uses a digital elevation model (DEM) to delineate the watershed boundary and the watershed is divide into multiple sub water sheds, the sub water shade also subdivided in to hydrologic response units (HRUs) that consist of similar land use, slope, and soil characteristics (Arnold et al., 2012). The HRUs represent percentages of the sub watershed area and are not identified spatially within a SWAT simulation.

Alternatively, a watershed can be subdivided into only sub watersheds that are characterized by dominant land use, soil type, and management. Model outputs include surface runoff, evapotranspiration, groundwater, lateral flow, sediment nutrient, and pesticide yield.

Reasons of SWAT model selection are: -

1. Hydrologic processes that need to be modeled to estimate the desired outputs adequately.

2. They are freely available software's.

3. They have been used in wide geographical area including water balance

To simulate stream flow of watershed due to Land use/Land cover change using SWAT model are divided into six steps:

- Data preparation,
- Sub-basin discretization,
- HRU definition,
- Parameter sensitivity analysis,
- Calibration and validation,

- Uncertainty analysis

The key procedures SWAT modeling

- Create SWAT project
- Delineate the designated watershed for modeling,
- Define land use/soil/slope data grids,
- Determine the distribution of HRUs based on the land use and soil data,
- Define rainfall, temperature and other weather data,
- Write the SWAT input files- requires access to data on soil, weather, land cover, plant growth, fertilizer and pesticide use, tillage
- Edit the input files – if necessary, and
- Setup and run SWAT – requires information on simulation period, PET estimation method and other options view SWAT output.

The land phase of the hydrologic cycle is modeled in SWAT based on the water Balance equation (Neitsch, et al, 2005) as follow

2.7 Water Balance

The term ―water balance‖ is defined here as an accounting of the inflow to, outflow from, and storage in, a hydrologic unit, such as a reservoir (LangbeinandIseri, 1960).

- SWAT model is use to assess and predict the impact of land management practices on water in megach watershed with varying soils, land use and management conditions over long periods. This simulated runoff & inflow to the reservoirs in the megach watershed by SWAT will be used.

This is simplified as:

$$SW\ t = SW0 + \sum_{i=1}^{t}(R\ \text{day} - \text{Q surface} - \text{Ea} - \text{Wseep} - \text{Wgw})$$

Where, SWt is the final soil water content (mm),SWo is the initial water content (mm),tis the time (days),Rday is the amount of precipitation on day i (mm),Qsurf is the amount of surface runoff on day i (mm),Ea is the amount of evapotranspiration on day i (mm),Wseep is the amount of water entering the vadose zone from the soil profile on ,day i (mm), and Qgw is the amount of return flow on day i (mm)).

2.8 Hydrologic Cycle

Water on earth exists in space called the hydrosphere which extends about 15Km up in to the atmosphere and about 1 km down into the lithosphere, the crust of the earth (Chow, 1988). Water circulates in the hydrosphere through the maze of paths constituting the hydrologic cycle. As shown schematically in Fig. 1, water evaporates from the oceans and the land surface to become part of the atmosphere; water vapour is transported and lifted in the atmosphere until it condenses and precipitates on the land or the oceans; precipitated water may be intercepted by vegetation, become overland flow over the ground surface, infiltrate into the ground, flow through the soil as subsurface flow, and discharge into streams as surface runoff. Much of the intercepted water and surface runoff returns to the atmosphere through evaporation. The infiltrated water may percolate deeper to recharge groundwater, later emerging in springs or seeping into streams to form surface runoff, and finally flowing out to the sea or evaporating into the atmosphere as the hydrologic cycle continues

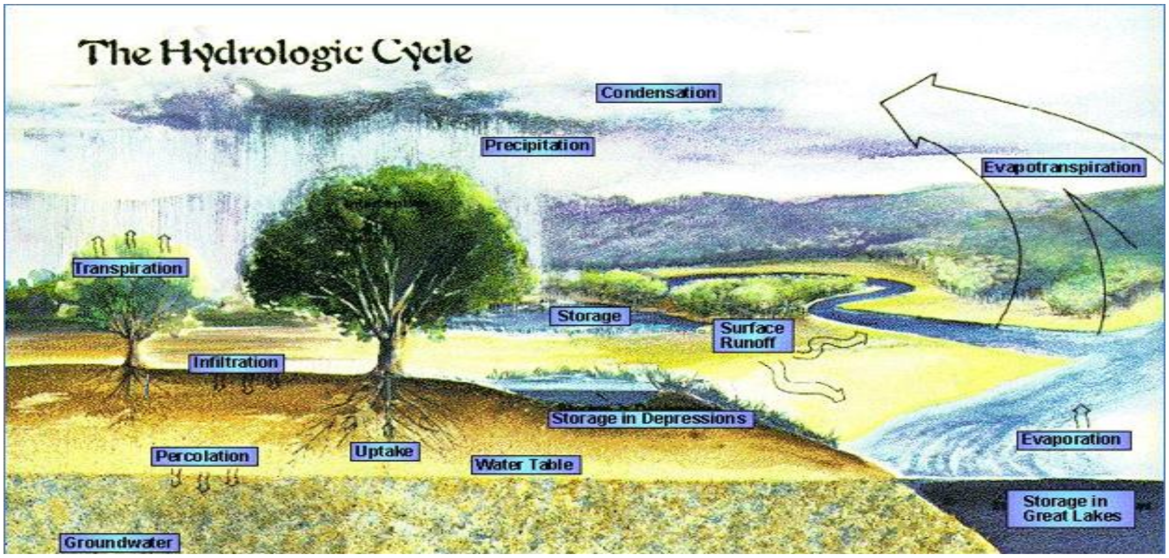

Figure. 1. Hydrological cycle component considered by SWAT model (Neitsch et al..,2005). [Source: Institute of Water Research, Michigan State University, 199

Surface runoff refers to the portion of rainwater that is not lost to interception, infiltration, and evapotranspiration (Solomon, 2005). Surface runoff occurs whenever the rate of precipitation exceeds the rate of infiltration. SWAT offers two methods for estimating the surface runoff: the Soil Conservation Service (SCS) curve number method (USDA-SCS, 1972) or the Green and Ampt infiltration method (Green and Ampt, 1911). The Green and Ampt method needs sub-daily time step rainfall which made it difficult to be used for this study due to unavailability of sub-daily rainfall data. Therefore, the SCS curve number method was adopted for this study.

The general equation for the SCS curve number method is expressed by equation

$$Q\ \text{surf} = \frac{(Rday\ \ +Ia)2}{(Rday - Ia + S)} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 1$$

Where, Qsurf is the accumulated runoff or rainfall excess (mm),

Rday is the rainfall depth for the day (mm water),

Ia is initial abstraction which includes surface storage, interception

and infiltration prior to runoff (mm water),

S is retention parameter (mm water).

The retention parameter varies spatially due to changes with land surface features such as soils, land use, slope and management practices. This parameter can also be affected temporally due to changes in soil water content. It is mathematically expressed as:

$$S = 24.5 * \left(\frac{100}{CN} - 10\right) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 2$$

Where, CN is the curve number for the day and its value is the function of land use practice, soil permeability and soil hydrologic group.

The initial abstraction, Ia, is commonly approximated as 0.2S and equation 2 becomes:

$$Q\ \text{surf} = \frac{(Rday\ \ +0.2S)2}{(Rday - 0.8S)} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 3$$

For the definition of hydrological groups, the model uses the U.S. Natural Resource Conservation Service (NRCS) classification. The classification defines a hydrological group as a group of soils having similar runoff potential under similar storm and land cover conditions. Thus, soils are classified in to four hydrologic groups (A, B, C, and D) based on infiltration which represent high, moderate, slow, and very slow infiltration rates, respectively and for my study the soil types are grouped in A, B and D.

The objective of hydrologic system analysis is to study the system operation and predict its output.

Generally, Input, transformation and output hydrology system respect to watershed parameter factors such as different of land use/land cover class, Soil type and slope are described as below diagram.

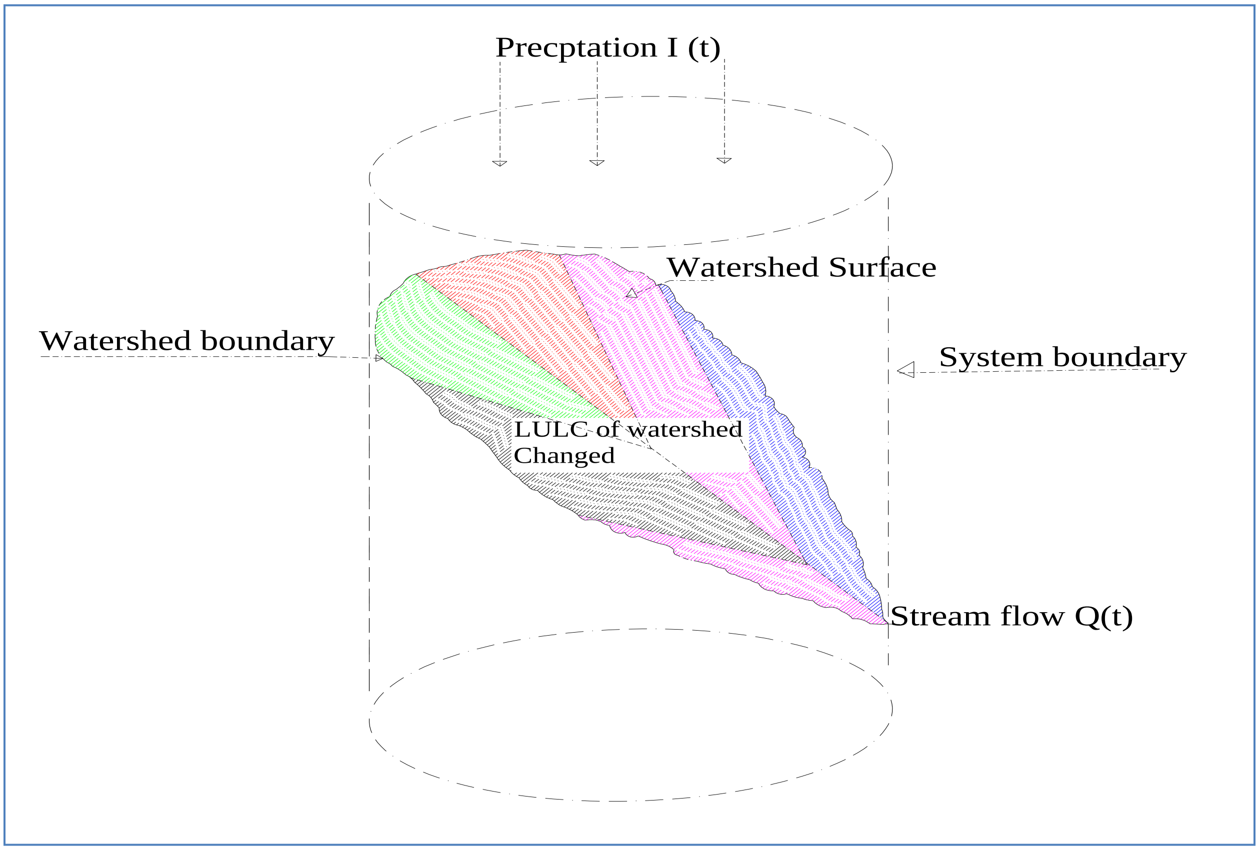

Figure. 2. The watershed as a hydrologic system.

3. Materials and Methods

3.1Description of Study area

The Megech River, which is about 75 km long, has a drainage area of about 498 km^2 with average annual discharge of 9.6m^3/s. The river, which flows generally in a southern direction and empties into Lake Tana. The Megech Watershed covers parts of three Woredas in the Zone, including Gondar Zuria, Lay Gayint, Wegera and Gondar town and it is found on the northern side of Lake Tana Sub-Basin, in North Gondar Zone of Amhara region. Megech watershed is one of the major agricultural areas of the country. However, this potential area is under threat. The ever-increasing devastation of the natural vegetation, the steep slopes, and traditional land management practices, poorly adapted to land conservation under the prevailing conditions, have resulted in increasing both surface runoff and soil erosion which lead to decreasing stream flow in the watershed. The out let of megech watershed is located in between the geographic grid ref. UTM E 332995, N1382164 and E332492, N1382864. Both the left and right abutments rise to an elevation higher than 1965 m. The location of the river out let at the center of the dam axis is E = 332646 m and N= 1382648 m with an elevation of 1049.8m.

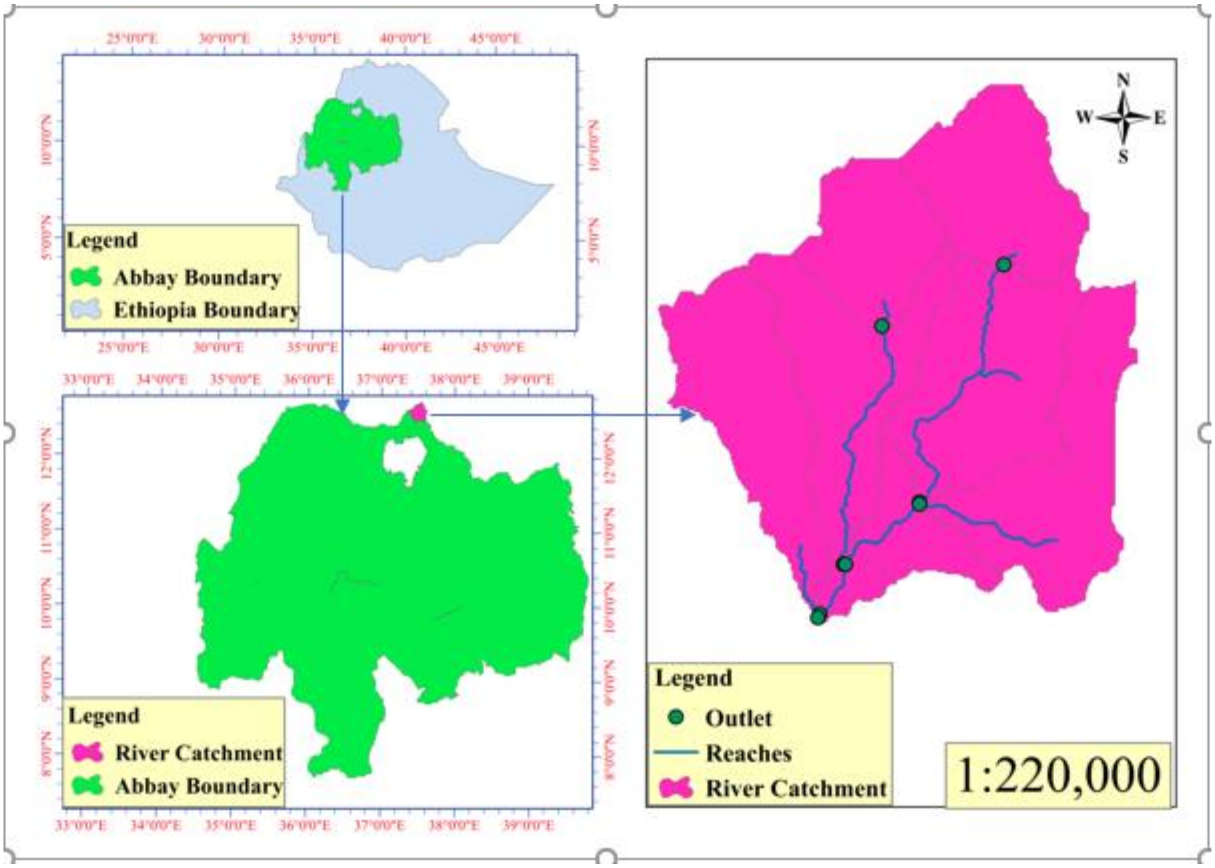

Figure. 3. Location of study area.

Climate of the study area

The climate of Ethiopia is mainly controlled by seasonal migration of Inter-tropical convergence zone (ITCZ) and its associated atmospheric circulation but the topography has also an effect on the local climate. The traditional climate classification of the country is based on altitude and temperature shows the presence of five climatic zones namely: Wurch (cold climate at more than 3000m altitude), Dega (temperate like climate-highland with 2500-3000 m altitude), Woina Dega (warm 1500-2500 multitude), Kola (hot and arid type, less than 1500 m in altitude), and Bereha (hot and hyper-arid type) climate (NMSA, 2001) and megech elevation is found between 2968 -1864m. Based on this climate of megech is classified as Inter-tropical Convergence Zone.

Rainfall: The climate of the megech catchment is marked by a rainy season from May to October, with monthly rainfall varying from 85.46 mm in October to 316.09mm in July. Mean annual precipitation is about 1198.37mm in the upper part and about 1056.47mm in the lower part. Rainfall over the megech watershed is mono-modal with nearly 83.71 % of the annual rainfall occurring in the period June – September. The dry season, from November to April, has a total rainfall about 7.24% of the mean annual rainfall and mean annual rainfall 1121.25mm

Temperature: Temperature variations throughout the year are minor. Maximum temperatures vary from 23 ºC in July to 30 ºC in March, whereas minimum temperatures range from 11.5 ºC in January to 15.6 ºC in April &May. Humidity varies between 39% in March and 79% in August. Wind speed is low, thus minimizing potential evapotranspiration values between 101 mm/month in July and 149 mm/month in March. Sunshine duration is to 4.2 – 4.9 hours during July and June, respectively.

Land use and Land Cover

Farming practices that can maintain soil, such as crop rotation and fallowing have almost vanished, mainly due to diminishing land-holding sizes. Most parts of the study area are intensively cultivated for centuries. The natural vegetation cover has become decreasing, town is increasing and some remnants of vegetation, such as scattered trees left in the farm fields, churchyards, and forest along the streams. As a result, the landscape over wide areas of the watershed is town, with some vegetation cover and cultivated land.

In the past natural forests covered most of the areas. Furthermore, they explained that the proportion of cultivated lands increases with time on account of grazing and forest lands because of high population growth and increased demand for food. Most of the steep slopes are used for cultivation beyond their capability and suitability. The sources of information for the present study for the interpretation of land use and land cover data were previous studies and field observations. It was important to re-assess the existing conditions to determine the actual land use and land cover types.

At present, cultivated lands cover most of the watershed area and even very steep slopes are cultivated for annual crops. In particular, the upper part of Gondar Town is highly degraded due to old-age and traditional agriculture practices. During field visits, it was observed that most of the land, including steep slope, is being used for cultivation beyond its capability. Large shrub land areas are found in and around the watershed. The shrub lands are used for livestock grazing and for production of wood for different purposes. The so-called grassland comprises very scattered shrubs, bush and weeds, used or grazing of livestock, including cattle, small ruminants and equines. Very limited grazing land is also found around settlement areas, swamps, hills and other spots.

Generally, cultivated lands cover most of the watershed, which accounts for 70.5% of the study area. The grasslands are accounts for about 0.53%; shrub lands 14.23%, Town 9.13%, Forest 1.45% and bare land 3.4% &Water body 0.78% total watershed in 2018year.

3.2 Materials Used

In the evaluation and identification of impact of land use/land cover change on the stream flow of Megech watershed of this sub-basin river, the following data and materials were used. The materials used for this research are:

- Hydrological data (monthly stream flow data).
- Meteorological data (daily Rainfall, Temperature, relative humidity, Sunshine hours, wind speed)
- Spatial data (Soil, slope land use and 30 by 30m DEM) map which were used for input data for SWAT model.
- Arc GIS 10.4 was used to obtain hydrological and physical parameters and spatial information, to locate geographical location of the study area, to reclassify land use land cover map etc.
- SWAT software was used to delineate the basin, sub basin and HRUs of the study area and estimate surface runoff.
- SWAT-CUP with SUFI-2 was used for sensitivity analysis, calibration and validation.
- Since the assessment was based on analytical basis, Excel spreadsheet was also used to observe and rearrange the output from the model
- USGS Earth explores to down load land use and land cover image.
- Google Earth was also used to check land cover and topography of the area.

3.3 Methodology

For different researches, there are different methods. In the case of this research, the following methodologies were used.

- Review of previous research that related to this study.

- Collection of data from Ministry of Water, Irrigation and Energy, Amehara Water Works Design and Supervision Enterprise and National Meteorological Service Agency.
- Checking the quality of data and filling of missed data.
- Arc GIS 10.4 was used to obtain hydrological and physical parameters and spatial information, to locate geographical location of the study area, to classify land use land cover map etc.
- Preparation of necessary input data (DEM, soil, Land use and climate data) for SWAT model.
- Then the SWAT model was used to delineate the watershed of the Sub-basin and simulate surface runoff.

Model Selection Criteria

Several lumped models exist and the following points guide the selection of models for use in this study. There are a number of criteria, which can be used for choosing the right model. These criteria are mainly dependent on the use of the model. Furthermore, some criteria are also user dependent such as personal preference; computer operation system; input/output management.

SWAT Model

The SWAT model is a complex physically-based, semi-distributed and process-based model. It was developed by the Agricultural Research Service of the United States Department of Agriculture and can model changes in hydrology processes, vegetation, erosion, and nutrient loadings at the catchment scale. It divides the catchment into sub catchments and subsequently into Hydrologic Response Units (HRUs). Different combinations of land use, soil types and slope in each sub catchment can be represented by the HRUs. The processes related to water, sediment and nutrient transport are modeled at the HRU scale. The hydrological processes are distributed in five compartments: the stream, the soil surface, the soil layers, the shallow unconfined aquifer, and the deep confined aquifer. With the daily time step, SWAT simulates water, nutrient transports and transformations in soil profiles, river network, various water bodies (e.g., pond, lakes, and wetland), and the interaction processes between different systems.

Cunderlik (2003) suggested four criteria for the selection of models. These are:

1. Required model outputs for the needed purpose.
2. Different hydrological processes that are required to be modeled for the desired purpose,
3. Availability of input data and.
4. Price of the software.

Based on the above selection criteria and comparisons of the models for this research Soil and Water Assessment Tool (SWAT) for impact of land use/land cover change on stream flow was selected. SWAT is a river basin scale, a continuous time, spatially distributed model developed to predict the impact of land management practice on water, sediment and agricultural chemical yields in large complex water sheds with varying soils, and land use and soil management over long period of time (Neitsch.et al 2005).

ArcGIS

Geographic information system (GIS) technology has not only made it easy to process, analyze, and combine spatial data, but it has also made it easy to organize and integrate spatial processes into larger systems that model the real world. However, the more complex a spatial model becomes, the more difficult it is to keep track of the various data sets, processing procedures, parameters, and assumptions that you have used.

3.3.1Data Collection and Analysis for the Model

Data availability is extremely important when one wants to tackle water related issue or problem. Without data, no model or study can be verified and hypotheses remain unproven. The continuous collection of data to support research and engineering question has been major task to identify the scale of impact of land use land cover on stream flow and estimating peak runoff using SWAT model.

The following datasets were collected for this study, daily river discharge data, metrological data, DEM, Soil and land use data were collected. The daily river discharge data was collected from the Ministry of Water, Irrigation and Electricity (MoWIE), daily metrological data such as rainfall, minimum and maximum temperature, relative humidity, wind speed and daily sunshine hours were collected from Metrological Agency of Ethiopia (EMA).

Meteorological Data: Availability of data on meteorological variables such as climate data are necessary for assessing, planning and management of resource. Daily meteorological data which includes precipitation, temperature, wind speed, solar radiation, and relative humidity of existing stations was collected from National meteorological service agency. Numerous ground observation stations of different classes are available in and around the study area. The time series data of all stations has got continuous missing values as indicated in the missing column of table.1. Hence, appropriate data quality checks have been conducted only focusing towards the objective of the hydrological analysis. In this study, four class stations were screened based on their location.

The definition of each class is given on the NMSA’s official website (www.ethiomet.gov.et/). Class 1 stations record all types of meteorological observations and those of class 4 stations record only rainfall. However, filling missing data values and quality controls were made based on the other surrounding stations. Table.1 provides summary information of the meteorological stations of the study area.

Table. 1 The list of meteorological stations of the study area.

S. No	Station Name	Latitude	Longitude	Elevation (m)	Rain fall Observation period
1	Gonder	12.52	37.43	1973.00	1998-2018
2	AmbaGorgies	12.77	37.60	2900.00	1998-2018
3	Makisegit	12.39	37.56	1912.00	1998-2018
4	Aykel	12.54	37.06	2254.00	1998-2018

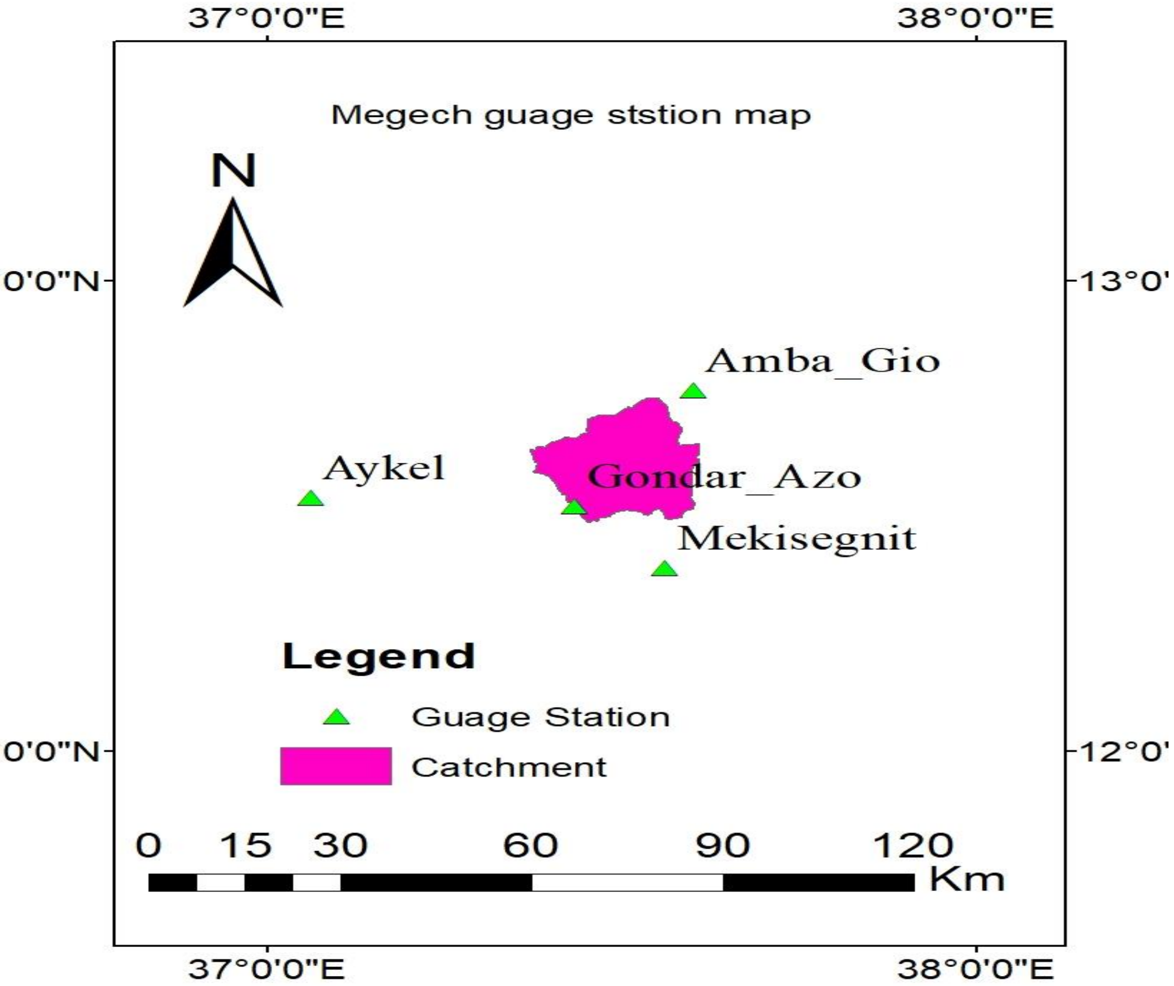

Figure. 4 Distribution of stations

River Flow Data: Availability of data on hydrologic variables such as river flow data are necessary for calibration and validation. The stream flow data collected from MoWIE has a longer time series data. Megech station Near Azezo (Station code111007) which is located at 12.48N and 37.45E has got time series data lasting from 1999 to 2019 years. These data are used to define hydrological model parameters of SWAT. Before the data was used, they had been checked visually to detect gross errors such as erroneous peak flow, missed recordings and flows of constant rate. These were followed by filling missing data using normal ratio methods. From the visual check it was identified that the time series data of stations have got continuous missing values and some values seem incorrect as shown in the analysis section. Hence, appropriate data quality checks have been conducted only focusing towards the objective of the hydrological analysis. This daily stream flow values were used for calibration and validation process at station.

Physiographical Data: A range of spatially distributed data such as topographic features, soil types, land use and the stream network (optional) are needed for the model.

The DEM used in this study was obtained from ASTRM with the resolution of 30*30. Digital elevation model is one of the essential inputs required by SWAT to delineate the watershed in to a number of sub watershed or sub basins. Generally, the DEM was used to delineate the watershed and the drainage patterns of the surface area analysis. Sub-basin parameters such as slope gradient, slope length of the terrain, and the stream network characteristics such as channel slope, length, and width were derived from DEM.

Spatial distribution and specific land use and soil parameters were required for modeling. Soils and land use/cove map are the most important input data for models used to estimation of water resource.

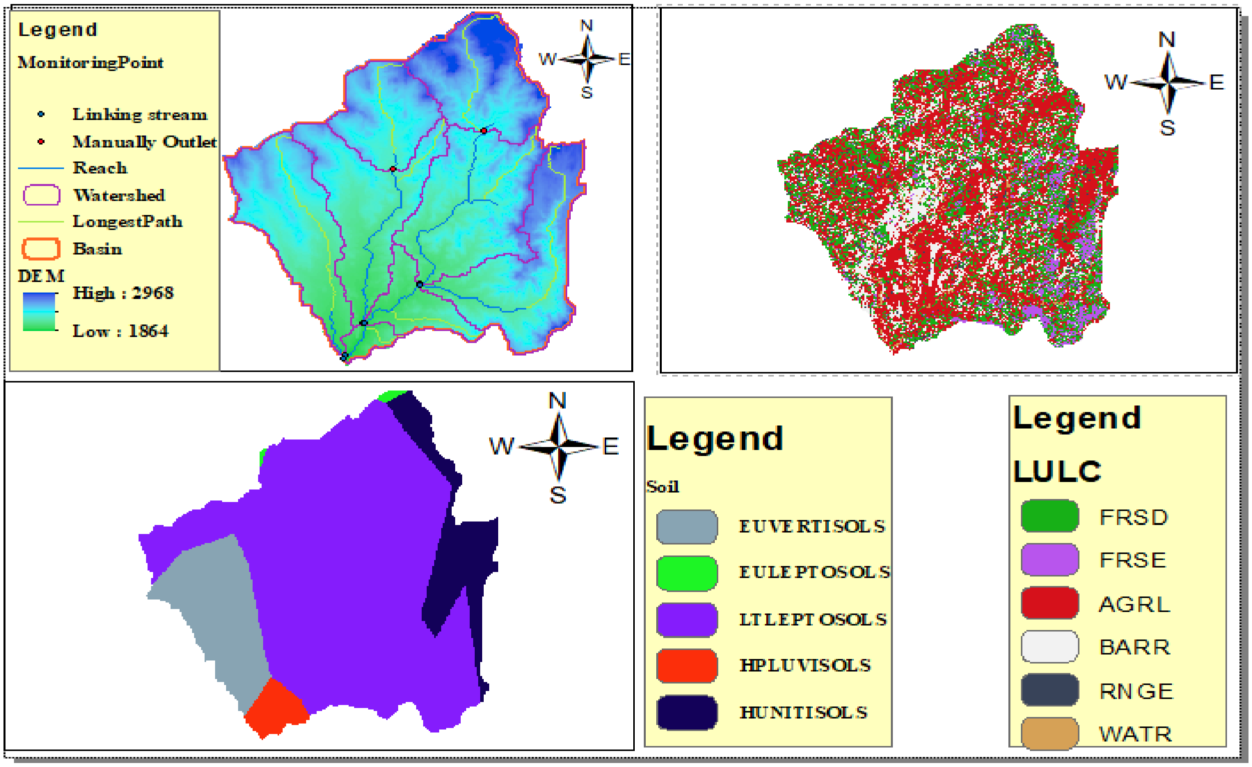

Figure. 5 Physiographic data like DEM, Land use/cover and major soil type

3.3.2Estimation of Surface runoff and peak flow

When the issue of surface runoff and peak flow for certain purposes is raised, the assessment of their conditions is inseparable considerations. The assessment of surface water conditions in a certain area may include the water discharge at outlet, the utilization and management of surface water, and other aspects. In the case of this study the assessment is for identification of scale of impact of land use land cover on the streams.

Testing of Dataset Quality: Hydrological model to a large extent depends on meteorological and hydrological data. Reliability of the collected raw meteorological and hydrological data significantly affects quality of the model input data and, consequently, the model simulation. This chapter sequentially presents, rough data screening of raw meteorological and hydrological data, completion of identified missing data for the study area and analysis done to check consistency and homogeneity of the estimated a real data set.

One of the challenges in assessing the hydrology a given study is the quality of the database. In most cases, datasets are reported with frequent missing values. Such values need to be thoroughly evaluated before using the data in detailed analysis and designs. The quality of the data leads to the accuracy and reliability of the particular model and is very important to run the model. Before conducting any climatic analysis, the homogeneity of the series confirmed. Any inhomogeneous series must be detected, adjusted or removed from the analysis. For this reason, the data should be tested for reliability and homogeneity prior to their implementation in this research studies. Therefore, check for consistency and continuity of the data was conducted. Check for continuity is used to detect missing data and check for consistency in order to detect any inconsistency to correct.

Filling the Missing Data: Many developing countries experience missing data problem due to degradation of gauging stations couples with unsatisfactory data compilation and storage procedures. Different methods are available to fill missing data; however, these methods differ in performance depending on the characteristics of initial data points. This study was to fill the missing data by selection of suitable method.

Estimating Missing Rainfall Data: Measured precipitation data are vital to many problems in hydrologic analysis and design. Since there are costs related to data collection, it is imperative to have complete records at every station. However, the actual condition in most of the data records this is not satisfied for different reasons. For gauges that require periodic observation, the failure of the observer to make the necessary visit to the gauge may result in missing data. Vandalism of recording is another problem that results in incomplete data records, and instrument failure because of mechanical or electrical malfunctioning can result in missing data. Any such causes of instrument failure reduce the length and information content of the precipitation record (McCuen, 1989).

Observation from the data series show missing data ranging from one day to in some instances more than a month. It was necessary to fill the missing periods with synthetic values before using the rainfall data for analysis. The surrounding stations located within the basin help to fill the missing data on the assumption of hydro meteorological similarity of the group of stations. A number of methods have been proposed to estimate missing rainfall data. The most common methods are Simple arithmetic mean method, normal ratio method, regression method and inverse distance method

Normal ratio method: is used when the normal annual precipitation of the index stations differs by more than 10% of the missing station. The rainfall of the surrounding index stations is weighted by the ration of normal annual rainfalls using the following equation.

$$P_x = \frac{N_x}{N}\left[\sum_{i=1}^{N}\frac{P_i}{N_i}\right]$$

Where: Px - missing value of precipitation to be computed
Nx - average value of rainfall for the station in question for period
N1, N2, Nn- average value of rainfall for neighboring station
P1, p2, pn- rainfall of neighboring station during missing period
N- Number of the station used in the computation

The other climate data like sunshine hour, wind speed and humidity missed data were filled using a tool called weather generator (WGEN).

Test for Consistency and Adjustment of Rainfall Data: If the conditions relevant to the recording of a rain gauge station have undergone a significant change during the period of record, inconsistency would arise in the rainfall data of that station. Shifting of rain gauge station to a new location, the neighborhood of the station undergoing a marked change, change of ecosystem due to climates and occurrence of observational error from a certain date is some of the most common causes of inconsistency of records.

Inconsistency of the record was done by the double-mass curve technique. This technique is based on the principle that when each recorded data comes from the parent population, they are consistent (Subramanya, 1994).

A popular tool is a double mass curve which is obtained by plotting the cumulative amounts of the station under consideration against the cumulative amounts of a set of neighboring stations. In the double-mass curve analysis the graph is plotted between the cumulative rainfalls of a single Station as ordinate and the cumulative rainfall of the group of stations as abscissa. The data is arranged in the reverse order that is the latest record as the first entry and the oldest record as the last entry in the list. A change in the proportionality between the measurements at the suspect station and those in the region is reflected in a change in the scope of the trend of the plotted points. In this method a group of two adjoining stations are selected in the vicinity of suspicious station. The mean daily rainfall values are serially arranged in reverse chronological order to fix relative consistency. The observations from a certain station were compared with the mean of observations from numerous adjacent stations. In accepted double-mass computations, this testing involves removing from the arrangement the records from an uncertain station and comparing them with the remaining data. Since all the dataset were reliable with the accepted totalities in the area, they are re-combined into the base period station. After the data of each station are arranged in descending order, the accumulative sums, station to be investigated and base station; are plotted against each other and line of best fit were sketched in excel assignment sheet. The data series, which is inconsistent, adjusted to consistent values by proportionality.

$$P_{cx} = P_x * \frac{M_c}{M_a}$$

Where

P_{cx} is corrected precipitation at any time period,

P_x is original recoded precipitation at time period

M_c is corrected slope of double mass curve

M_a is original slope of the double mass curve

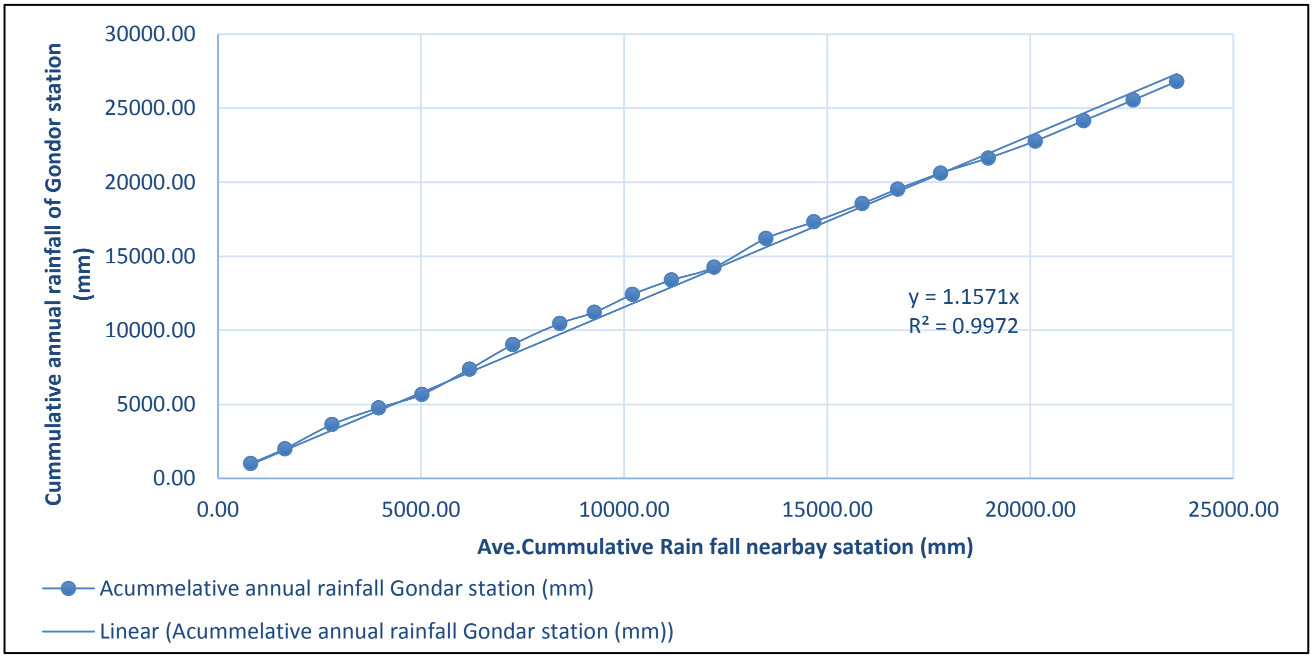

Figure. 6 Precipitation data consistency checked for meteorological stations

The mean annual cumulative rainfall of twenty years of each station was drawn in y-axis and the mean annual cumulative rainfall of surrounding stations was drawn in the x- axis to check the consistency of each rainfall stations using double mass curve.

The above graphs showed all points set on or form almost the straight lines, which was plotted for checking of consistency of rainfall, all stations were consistence and have more or less acceptable. Therefore, the stations did not need further adjustment. As the results of the test sample shown graphically in figure.6, the precipitation data is consistent with R^2=0. 9972.

Spatial Homogeneity of Selected Rainfall Station

Graphical comparison of the rainfall data done by creating time series plotting of monthly percentage of rainfall data (see figure.7) showed that the four stations show similar periodic pattern of records. Because of the uncertainty about possible changes, graphical methods are often used in climatology and hydrology to obtain some insight into the homogeneity of a record. The plotted points tend to fall along a straight line under conditions of homogeneity. In this study homogeneity is an important issue to indicate the trend of the rainfall data. One of the methods to check homogeneity of the selected stations in the watershed is the non-dimensional rainfall records and plotted to compare the stations with each other and the line of best fit were sketched.

$$\mathrm{P_i} = \frac{P_{i,avg}}{P_{avg}} * 100 \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots .3.1$$

Where

P_i - is non-dimensional value of precipitation for the month in station i.

$P_{i,avg}$ -is over years averaged monthly precipitation for the station i

P_{avg} - is over years averaged yearly precipitation of the station

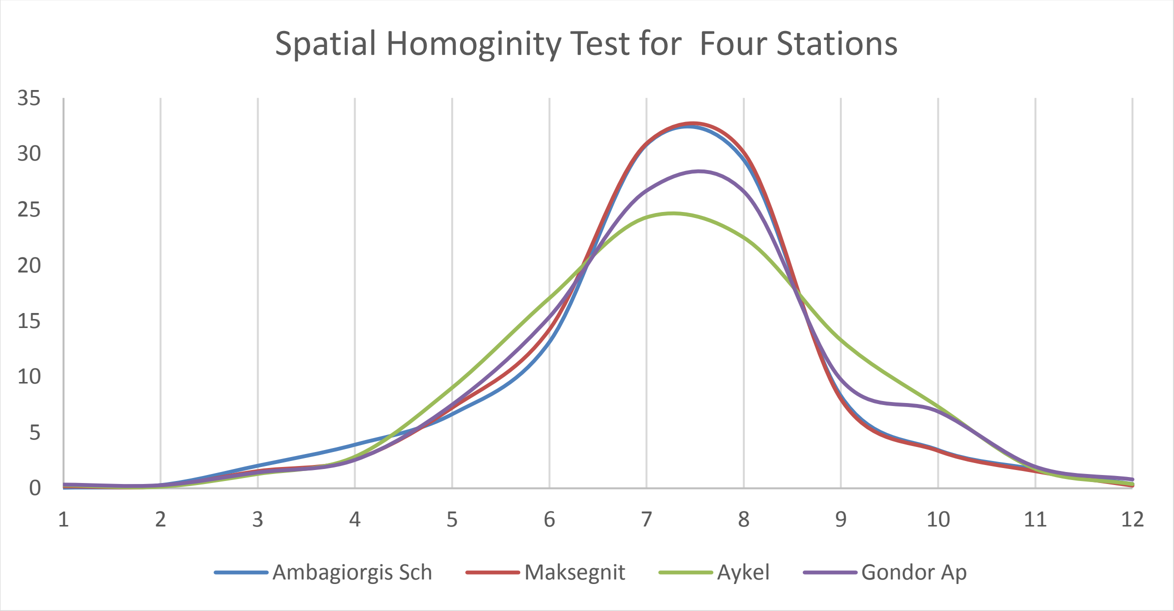

Figure. 7 Non-dimensional plot of selected stations within and around the study area

The percentage of rainfall of each station was drawn in y-axis and the months were drawn in the x- axis to check the homogeneity of each rainfall stations. When the rainfall patterns are spatially identical or vary with in a range, they could have considered as homogeneous. The above graphs showed all points set on or form almost the same pattern, which was plotted for checking of homogeneity of rainfall pattern, all stations were consistence and have acceptable homogeneity. (the same rainfall trend) and rainfall pattern of mono-modal with high rainfall season in June and September.

Average mean rainfall over the catchment was calculated by using thiessen polygon method of below formula

$$Pm = \sum_{n=1}^{n} \left(\frac{PiAi}{AT} \right)$$

Ai=Area of each station,

Pi= mean annual rain fall of each station,

AT= total area of each station

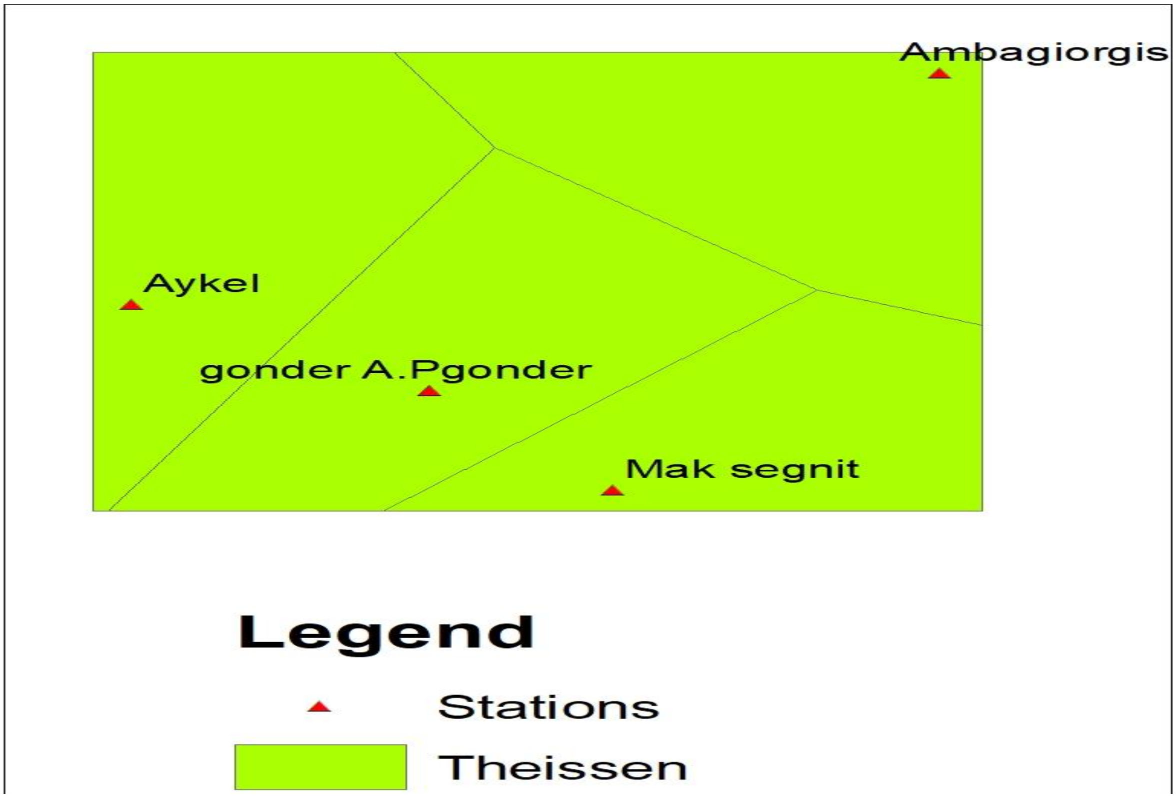

Figure 8 Area of station with Thiessen polygon.

Figure 9 Area of station, catchment and Thiessen polygon.

The annual rainfall of the study area ranges from 1056.41mm to 1198.37 mm with mean annual 1121.25mm. The graphs below indicate that most of rainfall occurs from June to September. Graphical comparison of the rainfall data done by creating time series plotting of monthly rainfall data (see figure.10) showed that the four stations show similar periodic pattern of records.

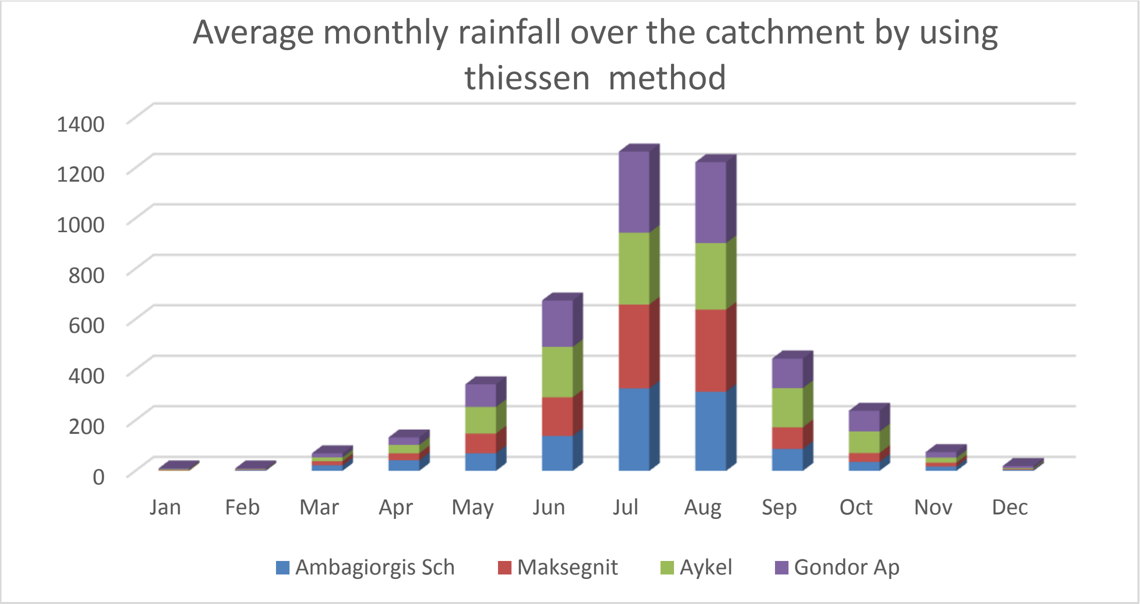

Figure. 10 Average monthly Rainfall Distribution over Megech Catchment.

Maximum and minimum temperature data representing the watershed was also collected for four stations and the average monthly value maximum and minimum temperature of each station with the study period presented in figure respectively.

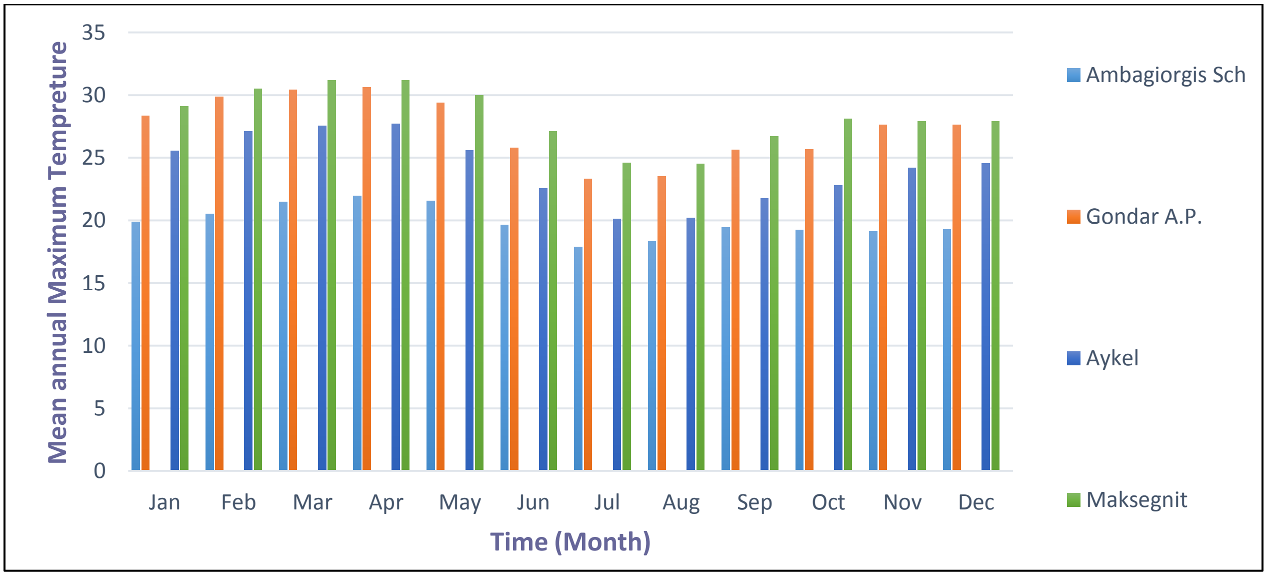

Figure. 11 Monthly average Maximum temperature of selected stations (0C/month)

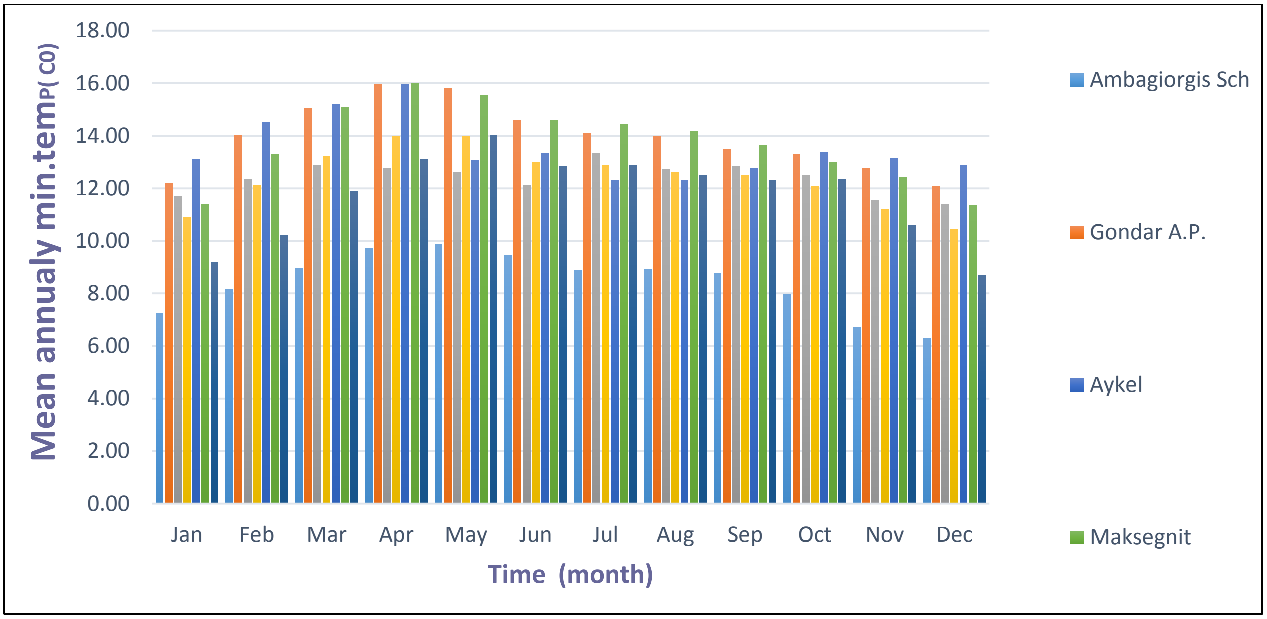

Figure. 12 Monthly average Minimum temperature of selected stations (0C/month)

SWAT Model

The hydrological components simulated in the SWAT model include: evapotranspiration, surface runoff, percolation, subsurface runoff (lateral runoff), and underground runoff (base runoff).

When simulating evapotranspiration, the model separately estimates the evaporation of water in the soil and plant transpiration. The evaporation of soil water is estimated using exponential functions of the water depth and content in the soil (Neitsch et al., 2005), while transpiration is estimated by correcting the potential evapotranspiration for conditions of vapour pressure deficit and soil water content deficit (Neitsch et al., 2005). The Penman-Monteith method (Jensen et al., 1990) was used to estimate potential evapotranspiration in this study. Surface runoff was estimated using the curve number method (USDA-SCS, 1972) with a change in the retention parameter, which varies according to the soil's water content (Neitsch et al., 2005). Percolation was estimated using a combination of a storage propagation technique and a crevice flow model (Arnold et al., 1998). Lateral runoff was estimated simultaneously with percolation using a kinetic storage model (Sloan et al., 1983). Underground runoff was determined based on the hydraulic conductivity of the free aquifer, on the distance travelled by the runoff until the main canal, and the depth of the water table (Neitsch et al., 2005). The hydrological components were simulated for each HRU and then aggregated to the sub-basin. The model simulates a basin by dividing it into sub-watersheds that account for differences in soils and land use.

The sub-basins are further divided into hydrologic response units (HRUs). These HRUs are the product of overlaying of slope, soils and land use.

Hydrological Modeling

Hydrological Component of SWAT

Generally, simulation of the hydrology of a watershed can be separated in two major components: Land phase and Routing phase of the hydrologic cycle. The Land phase of the hydrologic cycle is simulated based on the water balance equation (1) that controls the water movement in the land and determines the water, sediment, nutrient and pesticide amount that will be loaded into the main stream.

Hydrological components simulated in land phase of the Hydrological cycle are canopy storage, infiltration, redistribution, and evapotranspiration, lateral subsurface flow, surface runoff, ponds and tributary channels return flow. The routing phase of the hydrologic cycle that can be defined as the movement of water, sediments, nutrients, and organic chemicals through the channel network of the watershed to the outlet.

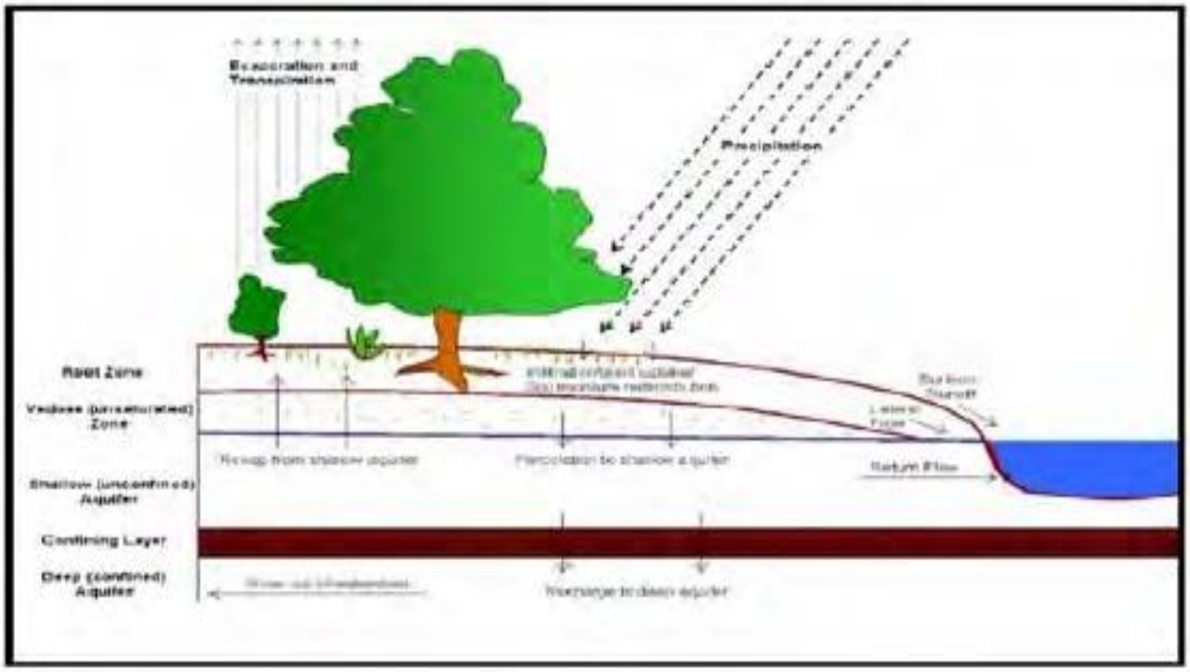

Figure. 13 Hydrological components of SWAT model

The hydrologic cycle of the SWAT model is based on the water balance equation, which considers the unsaturated zone and shallow aquifer above the impermeable layer as a unit. Eq. (1) is the important equation to predict the watershed of hydrology used by SWAT.

$$\mathbf{SW_t = SW_o + \sum_{i=1}^{t}(R_{day} - Q_{surf} - E_a - W_{seep} - Q_{gw})} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots . \mathbf{1}$$

Where $\boldsymbol{SW_t}$is the final soil water content, $\boldsymbol{SW_o}$is the initial soil water content on day $\boldsymbol{i}$,(mm) $\boldsymbol{t}$ is the time (days), $\boldsymbol{R_{day}}$is the amount of precipitation on day $\boldsymbol{i}$,(mm) $\boldsymbol{Q_{surf}}$is the amount of surface runoff on day (mm)$\boldsymbol{i}$,$\boldsymbol{E_a}$ is the amount of evapotranspiration on day *i*(mm) , $\boldsymbol{W_{seep}}$ is the amount of water entering the vadose zone from the soil profile on day $\boldsymbol{i}$, and $\boldsymbol{Q_{gw}}$is the amount of return/base flow on day $\boldsymbol{i}$ (mm)or daily lateral flow.

The estimation of surface runoff can be performed by the model using the Soil Conservation Service (SCS) curve number method, Arnold et al. This method is a widely used for the prediction of approximate amount of runoff from a given rainfall event. It is mainly based on the soil properties, land use and hydrologic conditions. The SCS curve number equation is

$$\mathbf{Q_s = \frac{(R_d - I_a)^2}{(R_d - I_a + S\,)} = \frac{(R_d - 0.2S)^2}{(R_d + 0.8S\,)}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots . \mathbf{2}$$

Q > 0 for $\boldsymbol{R_d}$>0.2S , Q=0 for $\boldsymbol{R_d} \leq$ 0.8S

Where $\boldsymbol{Q_s}$ is the accumulated runoff (mm), $\boldsymbol{R_d}$is the rainfall depth for the day (mm), $\boldsymbol{I_a}$is an initial abstraction which includes surface storage, canopy interception and infiltration prior to runoff (mm), $\boldsymbol{S}$ is the potential maximum moisture retention after runoiff begins (mm).

The retention parameter S and the prediction of lateral flow by SWAT model are defined in Eq. (3):

$$S = 25.4\left(\frac{1000}{CN} - 100\right) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots . \ldots\ldots\ldots\ldots\ldots 3$$

Where S= drainable volume of soil water per unit area of saturated thickness (mm/day); CN = curve number.

SCS defines three antecedent moisture conditions: I – dry (wilting point), II – average moisture and III – wet (field capacity). The moisture condition I curve number is the lowest value the daily curve number can assume in dry conditions. The curve numbers for moisture conditions I and III are calculated with the Eqs. (4) and (5), respectively.

$$\mathrm{CN}_1 = \mathrm{CN}_2 - \frac{20(100 - \mathrm{CN}_2)}{\left(100 - \mathrm{CN}_2 + \mathrm{e}^{\left(2.533 - 0.0636*(100 - \mathrm{CN}_2)\right)}\right)} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.4$$

$$CN_3 = CN_2 * e^{\left(0.00673(100 - CN_2)\right)} -5$$

Where CN1 is the moisture condition I curve number, CN2 is the moisture condition II curve number, and CN3 is the moisture condition III curve number

Lateral flow is predicted by

$$\mathrm{Q}_{\mathrm{Lat}} = 0.024 \frac{(2\mathrm{SSCsin}\alpha)}{\theta_{\mathrm{d}}\mathrm{L}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 6$$

Where Q_{Lat}= lateral flow (mm/day);S= drainable volume of soil water per unit area of saturated thickness (mm/day);SC = saturated hydraulic conductivity (mm/h); L= flow length (m), α= slope of the land,θ_d= drainable porosity.

The estimation of the base flow was done using Eq. (7):

$$\mathrm{Q}_{\mathrm{gwj}} = \mathrm{Q}_{\mathrm{gwj-1}}\mathrm{e}^{-\alpha\mathrm{gw}*\Delta\mathrm{t}} + \mathrm{W}_{\mathrm{rchrg}}\left(1 - \mathrm{e}^{(-\alpha\mathrm{gw}*\Delta\mathrm{t})}\right) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.7$$

Where Qgwj groundwater flow into the main channel on day j; αgw base flow recession constant; Δt time step; and Wrchrg the amount of recharge entering the aquifers (mm/day).

Creation of Database: The simulation of the water balance of an area by SWAT model requires a large amount of spatial and time series datasets in order to establish the water balance Eq. (1). The main sets of data used are briefly explained below.

Spatial Dataset: The topography, land use/land cover and soil characteristics are spatial datasets which defines the land system of any area and the most requirement of the hydrological model.

The input part of SWAT model includes a section from land system in the form of DEM, land use and soil.

The DEM of 30 x 30 m resolution was processed for the extraction of flow direction, flow accumulation, stream network generation and delineation of the watershed and sub-basins, Fig. 13. The topographic parameters such as terrain slope, channel slope or reach length were also derived from the DEM. From the present study SWAT model, the Simply watershed covers an area of 498km^2 with an elevation ranging from 1864m to 2968m. The whole Watershed is segmented in a total number of 8 sub-basins depending on topographic characteristics.

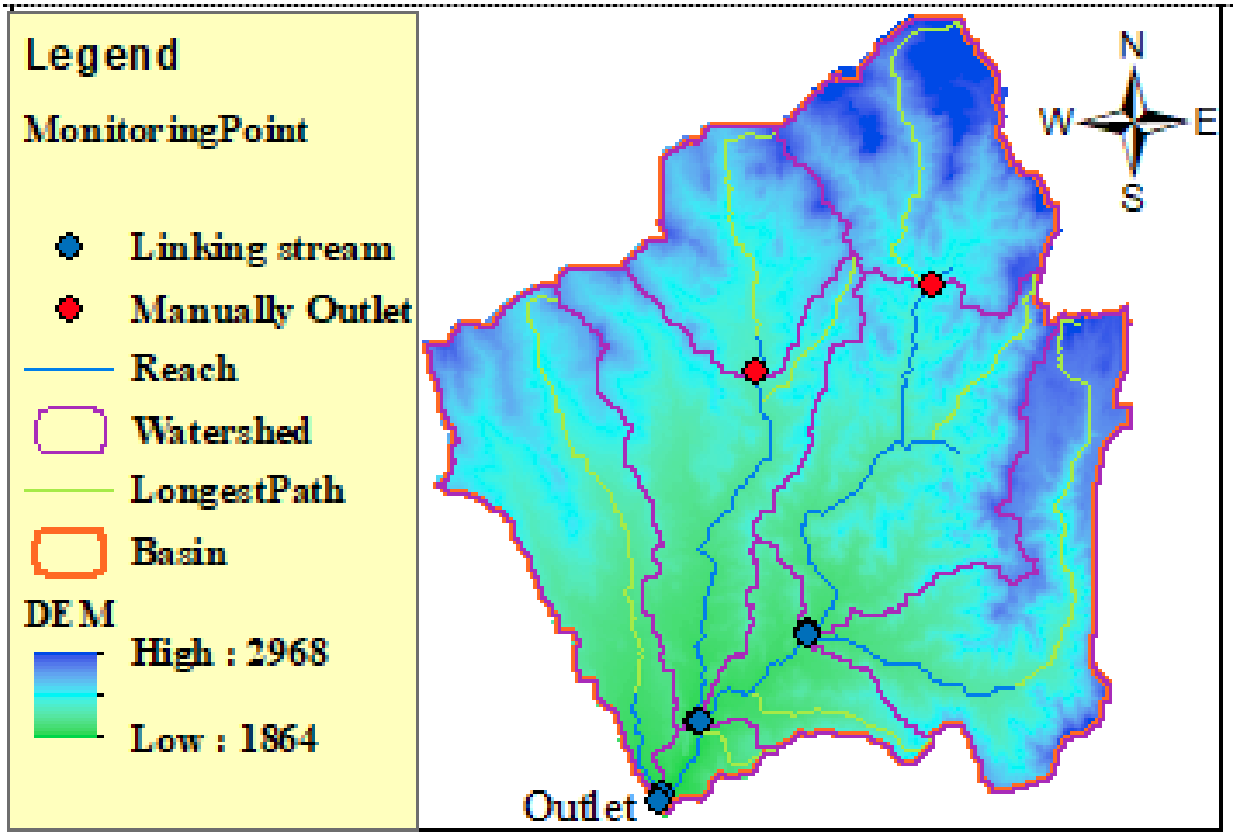

Figure. 14 Digital Elevation Model (DEM) of the watershed area

The Land use and soil map along with their respective look up tables prepared earlier were supplied to the model for reclassification according to SWAT coding convention. Further entire watershed was classified into five slope categories using the interface. All three maps were then overlaid to create HRU’s with unique land cover, soil and slope class. Subdividing the areas into hydrologic response units enables the model to reflect the evapotranspiration and other hydrologic conditions for different land cover/crops and soil. Land use/soil/slope of thresholds 5/10/10 (%) respectively, produces 114 HRUs and 8 sub-basins. The use of HRUs generally simplifies a simulation run because all similar soil and land use areas are lumped into a single response unit. The ArcGIS platform provides the user with a complete set of GIS tools for developing, running and editing hydrologic and management inputs and finally calibrating the model. The spatially distributed data required for Arc SWAT include the Digital Elevation Model (DEM), soil and land use data, either as shape files or grid data.

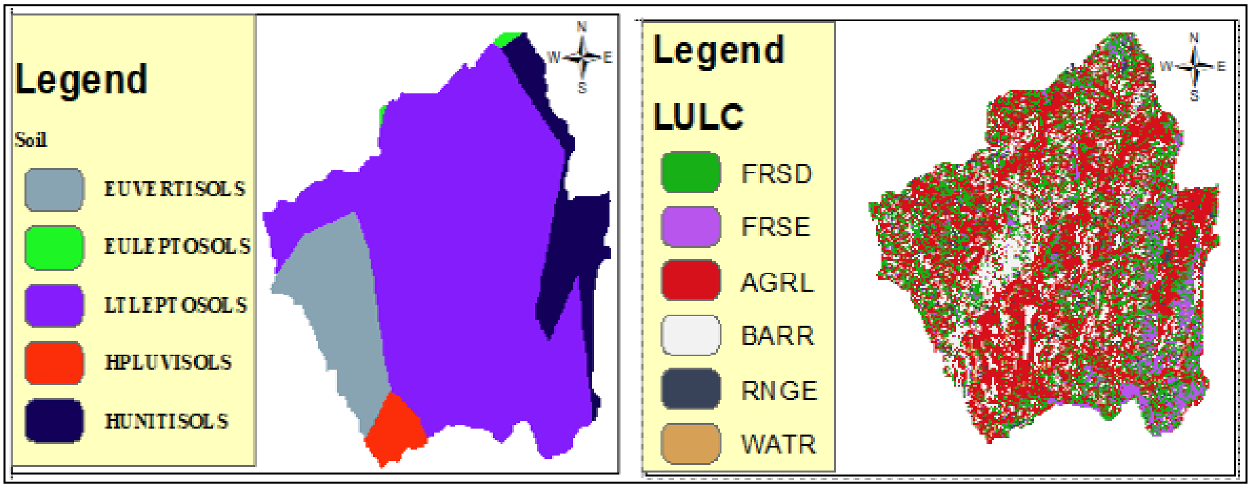

Figure. 15 Soil and land use data used in SWAT model for Megech Catchment

Land use land cover is one of the main input data of the SWAT model to describe the Hydrological Response Units (HRUs) of the watersheds which affect runoff, evapotranspiration and surface erosion in a watershed. It is also used for comparison of impacts on stream flow of the catchment with in time. The LULC map and all datasets for the years 2000, 2010 and 2018 were collected from USGS Earth Explore and USGS GLOVIS. A lookup table that identifies the SWAT land use code for the different categories of LULC was also prepared so as to relate the grid values to SWAT LULC class.

Spatial distribution and specific land use parameters were required for modeling. SWAT has predefined land uses identified by seven letter codes and it uses these codes to link land use maps to SWAT land use databases in the GIS interface. Hence, while preparing the lookup table, the land use types were made compatible with the input needs of the model. Hence the classified land use map and its attribute were adjusted to the SWAT model requirement format and database. Agricultural land use is the dominant land use in the megech River catchment.

Table. 2 Land use /Land cover according to SWAT database

Land use /Land cover according to SWAT database SWAT code		
Cultivated land	Agricultural land close to grown	AGRR
Dense Forest	Ever green Forest	FRSE
Shurb land	Range Bush	FRSD
Shurb land	Range Grass	RNGE
Settlement	Residential-High Density	URHD
Bare soil	Barren	BARR
Water	WATR	WATR

Soil Data: The soil textural and physicochemical properties required by the SWAT model include soil texture, available water content, hydraulic conductivity, bulk density and organic carbon content for each soil type. The shape file which describes the distribution of soil in the study area was obtained from the base line maps available at Ahimara Water Design of Tana Sub basin and it was observed that Euleptosol, Euvertisol, Hpluvisol, Hunitisol and Ltleptsol are the most dominant soils in the catchment. The value of different soil parameters (properties) for each soil which were collected from the above soil data sources are.

Table. 3 different soil property of watershed.

Object	Type of Soil	Area of Covered at watershed (km2)	In %
2	Euleptosol	211.40	0.42
3	Euvertisol	6896.34	13.84
4	Hpluvisol	1455.04	2.92
5	Hunitisol	5568.46	11.18
8	Ltleptosol	35698.16	71.64
Total		49829.4	100

Source: By Masked from Amara Water Design Supervision.

Temporal datasets: The climate data are required by SWAT to provide the moisture and energy inputs that control the water balance and determine the relative importance of the different component of the hydrology cycle. Rivers in the hydrological regimes may differ significantly in their runoff response to changes in the driving variables of temperature and precipitation.

Meteorological Data: The long-term meteorological datasets of precipitation, temperature, wind speed, solar radiation and relative humidity are required for the hydrological modeling. The model has the capability of weather generation to itself generate the data against these parameters. The observation data of four weather stations around the study area were collected. These stations which are listed in appendix gave the daily maximum and minimum temperature, precipitation for the studied calibration and validation periods.

SWAT Weather Database is designed to be a friendly tool to store and process daily weather data to be used with SWAT projects. It is capable of Storing relevant daily weather information; easily creating .txt files to be used as input information during an Arc SWAT project setup and efficiently calculating the WGEN statistics of several weather stations in one-step run. The climate datasets were store and processed into the model input format. A code was written for each climate data file for its conversion by SWAT Weather database to make them txt format files and calculate the WGEN statistics which are actually required for SWAT model. Table of weather data location (Daily Precipitation, Maximum and Minimum Temperatures, Wind Speed, solar radiation and Relative Humidity) were loaded to link them up with the required files already created for the purpose. After loading all the input data and generating the required database files, SWAT model was initially run on monthly basis using default parameter values.

The SWAT simulations were conducted on the catchments from 1998 to 2018 on a daily time step data. However, due to the complex nature of the flow processes in the catchment, a model warm-up period of 3 years (1998–2018) was considered to be sufficient to minimize the effects of the initial state of the SWAT variables on the river flow prediction (Sellami et al., 2013). The modified SCS curve number method is chosen for surface runoff volume computing. The variable storage coefficient method is selected for the flow routing through the channel and potential evapotranspiration is esti mated by the Penman–Monteith method.

River Flow Data: For calibration and validation, hydrological datasets of the River flow are required. The data have been collected from Ministry of Water, Irrigation and Energy. A long-term flow data of Megech River was gauged at Nr Azezo (located in 12.36N and 37.52E) which is a very close control point downstream the Outlet. The daily stream flow data from 1999 to 2019 years for the Megech watershed was used to assess the model prediction performances.

Model Simulation

Hydrologic modeling of Megech catchment was carried out using the ArcSWAT12. After preparing data files and completing all model inputs, the model is ready for simulation. The simulation is done for a period of 21 years which is the same period of availability of climate data. The hydrology simulation by SWAT is based on more than 19 parameters that have to be calibrated and adjusted. In such case, the calibration process becomes complex and computationally extensive. Hence, parameter reduction by filtering out the less influential ones is essential before calibration. The sensitivity analysis is so used to identify and rank the most responsive hydrological parameters that have significant impact on specific model output which is the outflow in this case, Saltelli et al. The sensitivity analysis was made using a SWAT-CUP.

SWAT-CUP

SWAT Calibration and Uncertainty Program (SWAT-CUP) is a computer program which provides the calibration, validation and sensitivity analysis of SWAT models. It involves several methods such as SUFI2, PSO, GLUE, ParaSol, and MCMC which can be chosen for the purpose of calibration and uncertainty analysis. This accesses the SWAT input files and runs the SWAT simulations by modifying the given parameters. The storage of the value of the objective function and the modification of parameters are the basis for comparison. The SWAT-CUP enables sensitivity analysis, calibration, validation, and uncertainty analysis of SWAT models.

For this study, various SWAT parameters related to discharge was estimated using the SUFI2 optimization technique. These optimization techniques use the range of the parameters as constraints and 7 of the model evaluation coefficients as Objective Functions (OF) during calibration, they are 1) A multiplicative form of the square error (mult); 2) A summation form of the square error (sum); 3) Coefficient of determination (r^2); 4) Nash-Sutcliffe (1970) efficiency (NSE); 5) Chi-squared $\chi2$(Chi2); 6) Coefficient of determination R^2 multiplied by the coefficient of the regression line (br^2); and 7) sum of square of residual (SSQR). Only one objective function is used at a time during calibration time. In SUFI2 all of the OF are exist, there is also a possibility to improve the model evaluation coefficients by using different Objective Functions.

SWAT- CUP is an interface that was developed for SWAT. Using this generic interface, any Calibration/uncertainty or sensitivity program can easily be linked to SWAT.

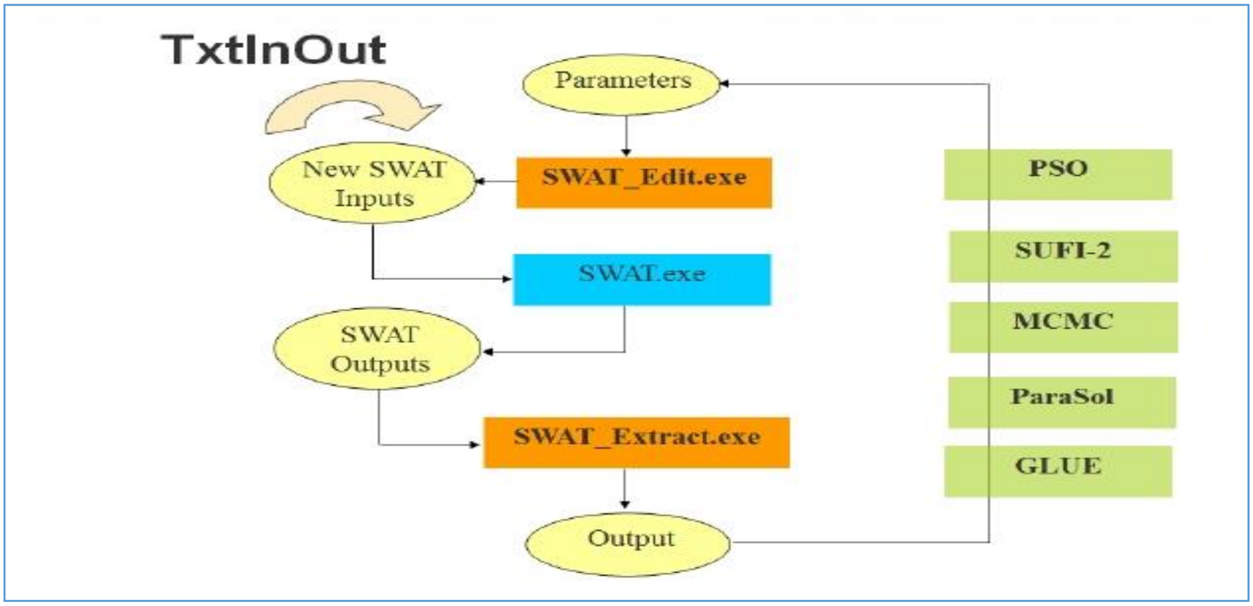

Figure. 16 schematic of the linkage between SWAT-CUP and five optimization programs

Sequential uncertainty fitting (SUFI-2)

The SUFI-2 algorithm (Abbaspour2008) has been selected as the most adapted algorithm for the calibration of the flow. The SUFI-2 algorithm is included in SWAT-CUP (SWAT Calibration Uncertainty Procedures) software and combines parameter calibration and uncertainty prediction. Figure.15 illustrates the coupling between SUFI-2 and SWAT. In SUFI-2, the uncertainty of input parameters is represented by uniform distributions, while model output uncertainty is quantified by the 95% prediction uncertainty (95PPU) calculated at the 2.5% and 97.5% levels of the cumulative distribution of output variables obtained through Latin hypercube sampling. The SUFI-2 algorithm introduces two efficiency criteria, P-factor and r-factor, that provide a measure of the model's ability to capture uncertainties and a measure of the quality of calibration, respectively. In particular, the P-factor is the percentage of the measured data bracketed by the 95PPU and ideally it should have a value of 1, indicating 100% bracketing of the measured data. The r-factor indicates the thickness of the 95PPU band and it is calculated as the average distance between the upper and lower 95PPU divided by standard deviation of the observed data. The r-factor should be ideally near zero, thus coinciding with the measured data. Evaluating these two factors, SUFI-2 quantifies the best parameter values through an interactive procedure, minimizing or maximizing a selected objective function.

The goodness of fit and the degree to which the calibrated model accounts for the uncertainties are assessed by the above two measures. Theoretically, the value for P-factor ranges between 0 and 100%, while that of r-factor ranges between 0 and infinity. A P-factor of 1 and r-factor of zero is a simulation that exactly corresponds to measured data. The degree to which we are away from these numbers can be used to judge the strength of our calibration. A larger P-factor can be achieved at the expense of a larger r-factor. Hence, often a balance must be reached between the two. When acceptable values of r-factor and P-factor are reached, then the parameter uncertainties are the desired parameter ranges. Further goodness of fit can be quantified by the R^2 and/or Nash-Sutcliff (NS) coefficient between the observations and the final "best" simulation. It should be noted that we do not seek the "best simulation" as in such a stochastic procedure the "best solution" is actually the final parameter ranges. If initially we set parameter ranges equal to the maximum physically meaningful ranges and still cannot find a 95PPU that brackets any or most of the data.

Identification of most sensitive model parameters

Sensitivity analysis is a technique of identifying the responsiveness of different parameters involving in the simulation of a hydrological process. For large hydrological models like SWAT, which involves a wide range of data and parameters in the simulation process, calibration is quite a cumbersome task. Sensitivity analysis is a method of minimizing the number of parameters to be used in the calibration step by making use of the most sensitive parameters largely controlling the behavior of the simulated process. This appreciably eases the overall calibration and validation process as well as reduces the time required for it. Besides, as Neistch, et al. (2005) indicated, it increases the accuracy of calibration by reducing uncertainty.

After pre-processing of the data and SWAT model set up, simulation were done for the outlets. Sensitivity analysis ranks parameters from small to high values. Parameters with small sensitivity values do not significantly affect the model output; hence, they are neglected in calibration process. Only parameters with medium and high values which affect the model output significantly are used to calibrate the model.

Model performance Evaluation

Results of the calibration and validation were evaluated graphically and statistical procedures with that of quality criteria. The statistical parameters employed in measure of model quality are Root Mean square (RMS), Sum of square residual (SSQR), mean absolute error, Coefficient of determination (R^2), Nash-Sutcliffe Coefficient (NSE), PBIAS, p-factor and r-factor measure the model quantitatively. Model was desired to evaluate based quality criteria as it can give water balance error which can show that poor model performance. Some of the model performance coefficients this study frequently uses are described below.

Coefficient of determination (R^2) is the index of correlation of measured and simulated values. it provides a measure of how well observed outcomes are replicated by the model and for those extents of the discrepancy between observed and simulated with linear association using linear regression model. Coefficient of determination values found between zero and one, which the smaller figure demonstrating more error variation. The value of R^2 ranges from 0 to 1. The more the value of R^2 approaches 1, the better is the performance of the model and the values of R^2 less than 0.6 indicate a poor performance of the model. The figure value more than 0.6 found in satisfactory range for coefficient of determination a value of zero means no correlation at all; whereas one means that the desperation of the prediction is equal to that of the measured.

$$R^2 = \frac{\left[\sum_i (Q_{o,i} - \bar{Q}_m)(Q_{s,i} - \bar{Q}_s)\right]^2}{\sum_i (Q_{m,i} - \bar{Q}_m)^2 \sum_i (Q_{s,i} - \bar{Q}_s)^2} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots 1$$

Where, $\boldsymbol{i}$ is the i^{th} measured or simulated data, $Q_s$is simulated value, $\boldsymbol{Q_m}$is observed value, $\bar{Q}_m$is mean measured value and $\bar{Q}_s$ is mean simulated value.

Nash-Sutcliffe Efficiency (NSE): Nash-Sutcliffe defines the extents of variation between simulated to observed data discrepancy and Nash-Sutcliffe coefficient measures the efficiency of the model by relating the goodness-of- fit of the model to the variance of the measured data, which can range from −∞ to 1. An efficiency of 1 corresponds to a perfect match of simulated discharge to the observed data. An efficiency of 0 indicates that the model predictions are as accurate as the mean of the observed data, whereas an efficiency less than zero ($-\infty < \text{NSE} < 0$) occurs when the observed mean is a better predictor than the model. Besides, due to frequent use of this coefficient, it is known that when values between 0.6 and 0.8 are generated, the model performs reasonably. A value between 0.8 and 0.9 tells that the model performs well and a value between 0.9 and 1 indicates that the model performs extremely well [Nash and Sutcliffe, 1970].

The formula for Nash Sutcliffe (NSE) is the normalized statistics which measures the relative magnitude of the residual variance as compared to measured data variance. Similar to R^2, the more the NSE approaches 1, the better will be the model performance and vice versa.

$$NSE = 1 - \left[\frac{\sum_{i=1}^{n}\left(Q_{m,i}-Q_{s,i}\right)^2}{\sum_{i=1}^{n}\left(Q_{m,i}-\overline{Q}\right)^2}\right] \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 1$$

Global view of SWAT Model Components and Methodology

The methods to evaluate the impact of land use and land cover. change, on hydrological regimes can be achieved through integrating GIS, remote sensing, and hydrological models Satellite image have great contribution for preparation of land use land cover of the area.

LU/LC information is of critical importance in hydrologic modeling, as it helps determine model variables that account for the volume, timing, and quality of runoff. A Physically-based distributed hydrological (Arc SWAT) model that allows several different subunits or objects to be defined within a catchment is utilized. Details of the approach followed are given in figure.

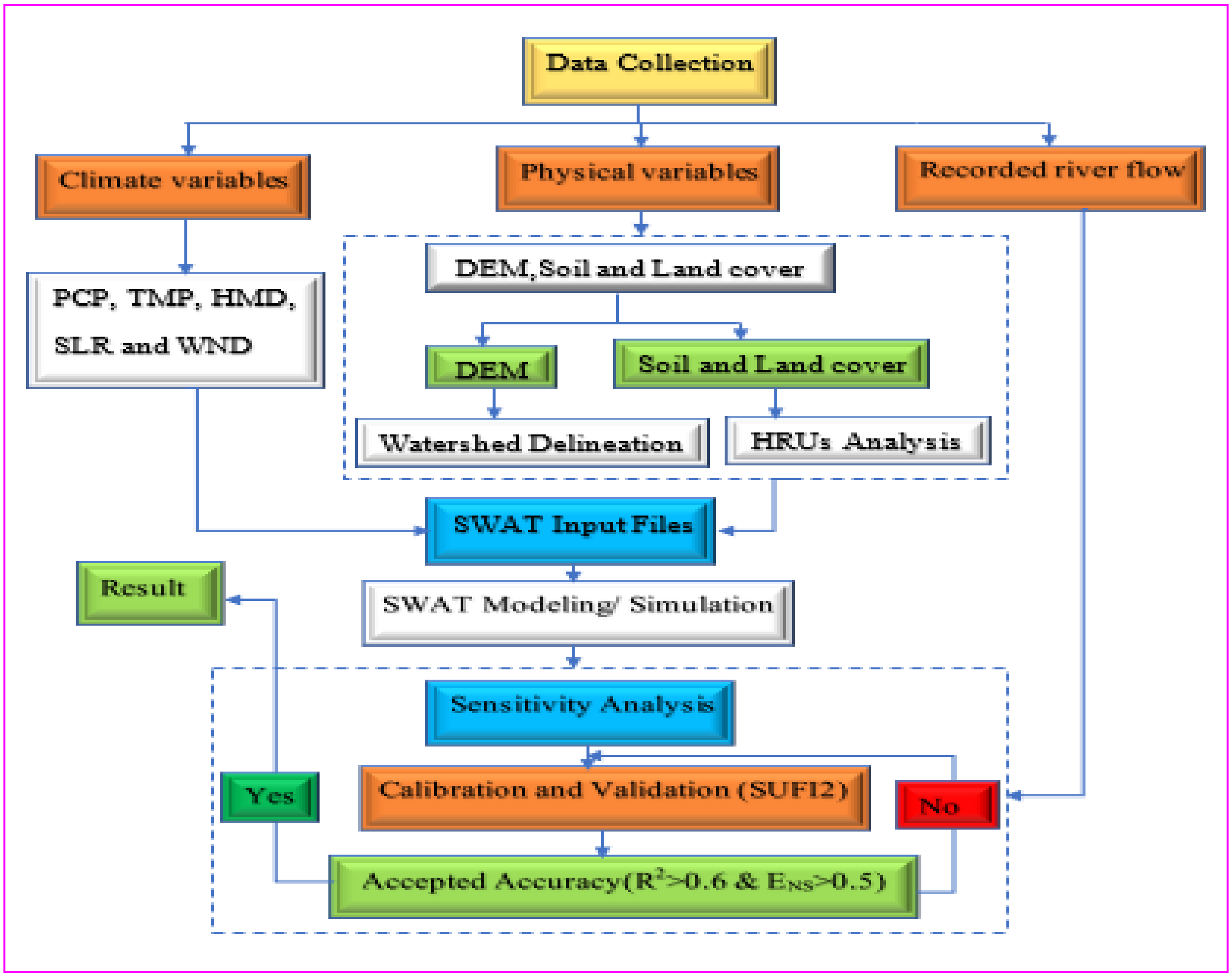

Figure. 17 Global views of SWAT Model Components and Methodology

P-factor and r-factor

The degree to which all uncertainties are accounted for is quantified by a measure referred to as the p-factor, which is the percentage of measured data bracketed by the 95% prediction uncertainty (95PPU). Another measure quantifying the strength of a calibration/uncertainty analysis is the r-factor, which is the average thickness of the 95PPU band divided by the standard deviation of the measured data. The goodness of fit and the degree to which the calibrated model accounts for the uncertainties are assessed by p-factor and r-factor. Theoretically, the value for p-factor ranges between 0 and 100%, while that of r-factor ranges between 0 and infinity. A p-factor of 1 and r-factor of zero is a simulation that exactly corresponds to measured data. The degree to which we are away from these numbers can be used to judge the strength of our calibration. A larger p-factor can be achieved at the expense of a larger r-factor. Hence, often a balance must be reached between the two. When acceptable values of r-factor and p-factor are reached, then the parameter uncertainties are the desired parameter ranges (SWAT-CUP 2012 user manual).

3.3.3 Land Use and Land Cover Analysis

The hydrological properties of the watersheds are highly influenced by Land use. It is one of the main input data of the SWAT model to describe the Hydrological Response Units (HRUs) of the watersheds (Kassa, 2009). The information contained in the land use/land cover shows how the different uses of the surface are distributed inside the study area. For this study three land uses/cover were obtained for the year 2000,2010 and 2018.Based on the study area land use/ land cover type the image classification was conducted and the land cover map was produced using both Google earth with supervised the site. Before starting classification of the imagery data land use and land cover classes have to be differentiated using the available data source such as previous research in study are a (Abraham et al., 2015). Seven different types of land use have been identified for Megech River Catchment. These are crop land (cultivated land), forest land, Grass land, settlement (impervious land), shrub-land, bare land and water body. Image classification is the process of assigning of pixels of continuous raster image to the predefined land cover classes. The result of the classifications is mostly affected by various factors such as classification methods, collecting of training sites etc. It must be kept in mind that maps are simple attempts to represent what actually exists in the area and are never completely accurate. Different classification techniques are presented in the literature.

For this study the supervised classification and unsupervised type was applied. It is the most common type of classification technique in which all pixels with similar spectral value are assigned in to land cover classes. For this study the land cover was produced based on supervised classification through the steps such as selecting of some point training sites which are representative for the land cover classes and using Goggle earth by performing the classification using the Maximum likelihood classifier.

SWAT has predefined land uses identified by four letter codes and it uses these codes to connect land use to SWAT land use databases in the GIS interfaces. When preparing the lookup table, the land use types were made compatible with the input needs of the model.

Land-use/Land-cover classification method

Land use/land cover data collection

Land use is one of the most important factors that affect runoff, evapotranspiration and surface erosion in a watershed. Moreover, Land use/land cover map is a very crucial input for SWAT for determining the impacts on surface runoff and sediment yield of the watershed. The satellite imagery for the years 2000 2010 and 2018 obtained from Landsat Thematic Mapper (TM) sensors at a spatial resolution of 30m by 30m and downloaded from in zipped files from the https://www.usgs.gov United State Geological Survey (USGS) website (USGS Earth Explore).

The LULC map of the area was reclassified based on the available topographic map (1: 50,000) and satellite images for the years 2000, 2010 and 2018 in combination with interviews of local residents. The reclassification of the land use map was prepared to represent the land use according to the specific land cover types such as type of Crop, Settlement, Grassland, Bare Soil, Water and forest. A look-up table that identifies the SWAT land use code for the above land cover classes also prepared so as to relate the grid values to SWAT LULC classes.

Mosaic an image (groping of multiple images to single imager)-since the study area is touch one image, i.e. path/rows 170/51 combining those images to single (tied) color balanced and compressed ortho- mosaic imagery was done.

Image Pre-processing

Landsat satellite images were used in this study to identify changes in land use land cover distribution in megech watershed of 18 years. For this time period three images were selected for land cover mapping of the study area. During this time period Landsat Thematic Mapper (TM) sensors at a spatial resolution of 30m by 30m were selected to represent the land cover conditions in the years 2000, 2010 and 2018.

Layer stacking images

In order to analyze remotely sensed images, the different images representing different bands must be stacked. This allows different combinations of RGB to be shown in the view. Therefore, layer stack is often used to combine separate image bands into a single multi spectral image file.

Sub setting

An image can be useful when working with large images. Sub setting is the process of "cropping" or cutting out a portion of an image for further processing. Sub setting of Megech watershed satellite image was performed using the layer stacked image by the delineated watershed shape file.

The images used in this research were obtained in different time scales; they have haze and dust in different proportions and these camouflages the real changes or may show the same kinds of land cover classes as different. To overcome these kinds of problems, atmospheric correction methods are used (Berberoglu& Akin, 2009). The radiometric enhancement of images is an important stage of pre-processing. The aim of image enhancement is to make the objects more prominent by raising the quality of images so as to differentiate between different objects or land cover classes. So, the techniques of haze reduction and noise reduction were applied on the images for a better understanding of the LULC classes (Lillesand& Kiefer, 1994).

The path and rows used for downloading megech watershed‘s satellite image was 170 and 51 respectively although the band compositions of the satellite images that were used for this study are 4, 3 and 2 and also it has 6 numbers of bands for each of satellites

Table. 4 Genera description of Land sat image.

Sensor (Instrument)	Satellite Name	Path	Raw	Date of acquisition	Spatial resolution	Producer
TM	Land sat 5	170	51	31/01/2000	30	USGS
ETM+	Land sat 7	170	51	31/01/2010	30	USGS
L$_S$8	Land sat 8	170	51	31/01/2018	30	USGS

Accuracy Assessment

Accuracy assessment is an important step in the process of analyzing remote sensing data. It determines the value of the resulting data to a particular user, i.e. the information value. The accuracy assessment is used to determine the degree of ‘correctness’ of a map or classified image. In essence, therefore, classification accuracy is typically taken to mean the degree to which the derived image classification agrees with reality or conforms to the ‘truth’ (Campbell, 1996; Janssen & Vander Wel, 1994). A classification error is, thus, some discrepancy between the situation depicted on the thematic map and reality.

The main technique for accuracy assessment is using change maps for evaluating each class and calculating the expected accuracy (Yuan et al., 1998). Another method leading to more exact results is by checking points accurately classified or not, after the selection of the points where changes are available or not upon the map. Many methods of accuracy assessment have been discussed in the remote sensing literature (e.g., Koukoulas& Blackburn, 2001; Piper, 1983; Rosen field &FitzpatrickLins, 1986). The most widely promoted and used, however, may be derived from a confusion or error matrix.

The confusion matrix is currently at the core of the accuracy assessment literature. As a simple cross-tabulation of the mapped class label against that observed in the ground or reference data for a sample of cases at specified locations, it provides an obvious foundation for accuracy assessment (Campbell, 1996 & Canters, 1997).

In general, for this study, the LULC map was produced based on the pixel based supervised classification through the steps such as: First, selecting of the training sample for signature which are typically representative for the land cover classes. Google earth and by interviewing the local people who live in that area by asking what was the land cover look like before 20 years ago, this was done during the collection of GCPs of the watershed. Second, perform the classification using the Maximum Likelihood Classifier and finally the accuracy assessment of the classified images was assessed by using the supervised image and Google earth as references.

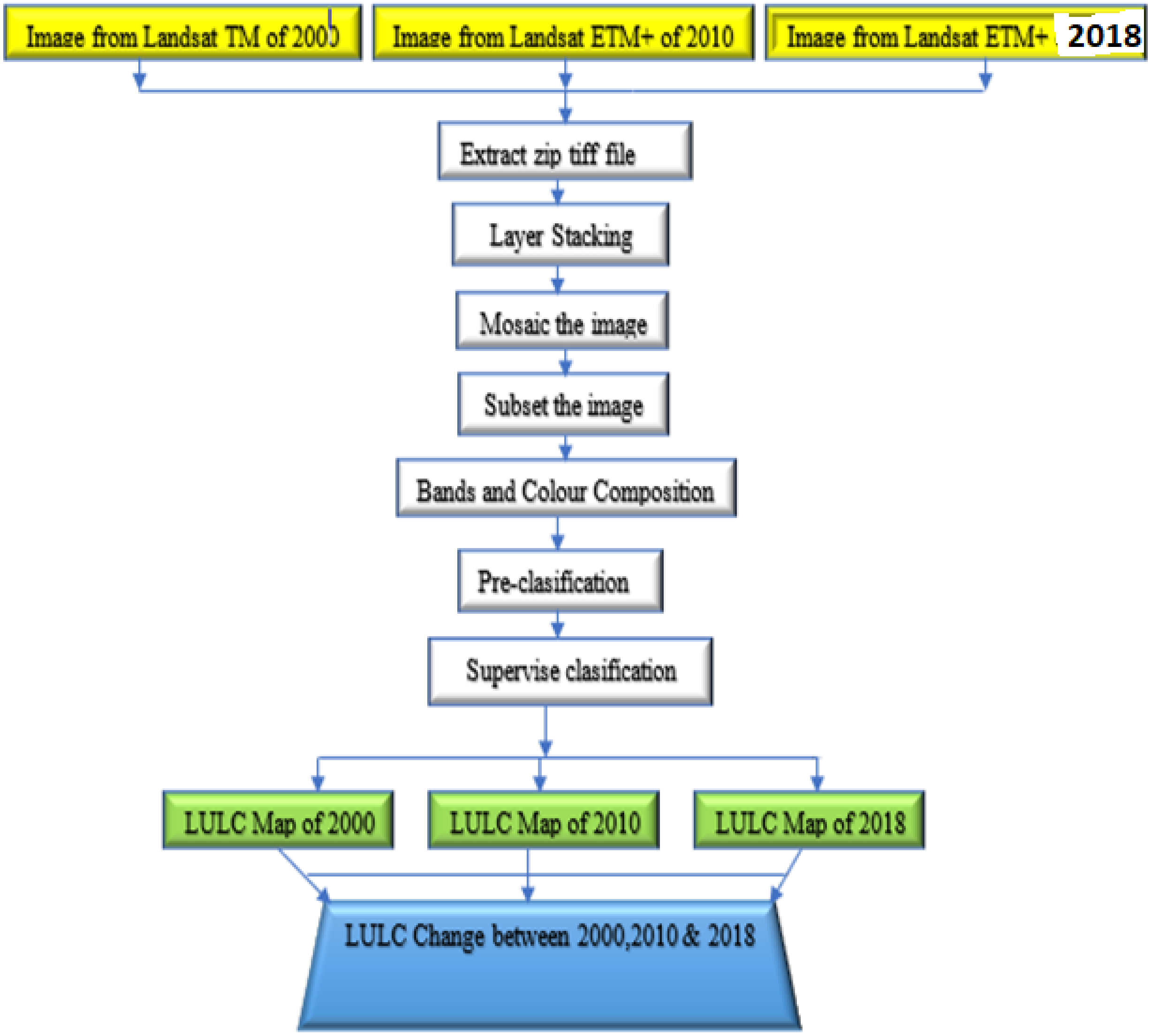

Figure. 18 Methodology of Land use map preparation

Evaluation of Stream Flow due to LULC

The impacts of land use/land cover change on stream flow were one of the most important parts of this study. Simulation of the impacts of land use and land cover change on stream flow was one of the most significant parts of this study and there was high expansion of agricultural lands in the expenses of other lands during the study periods considered. The study was carried out for three different years i.e. 2000, 2010 and 2018. The three generated land use and land cover maps, soil, climatic and stream flow data values were used to evaluate the impacts of land use and land cover change on stream flow.

To evaluate the variability of stream flow due to land use and land cover changes, three independent simulation runs were conducted on a monthly basis using land use and land cover maps of 2000,2010 and 2018 keeping other input parameters unchanged. Seasonal stream flow variability of the three-land use and land cover change was assessed and comparison was made on surface runoff to stream flow based on the three simulation outputs.

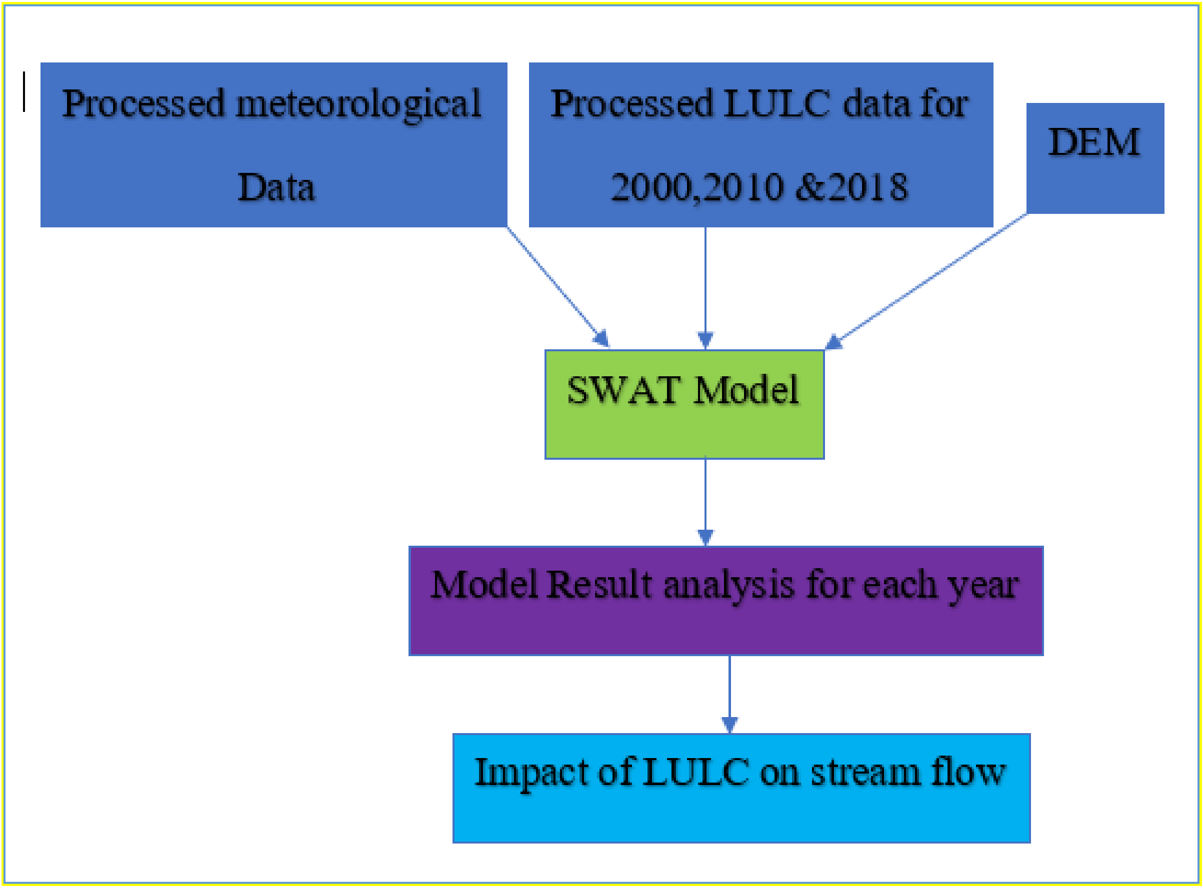

Figure. 19 Conceptual frame work of the study Area

4. Result and Discussion

4.1 Land Use Land Cover Map

Spatial analysis was carried out to describe land use land cover change pattern and overall land use changes with time. This was done after image classification of the three-land use land cover maps (2000 2010 and 2018) using the method maximum likelihood classification of land sat satellite image. The reason why the data of 2000, 2010 and 2018 used is the recent data gave the more accurate results. After referring previous documents, using different band combinations and contacting with persons who knows the study area the catchment dominant land use land cover is summarized to seven major classes namely cultivated (Agricultural) land, Forest, Bare land, Shrub-land, Grassland, and Town and water body. The area and percentage of each land cover class with referenced years (2000, 2010 and 2018) results are expressed as follows:

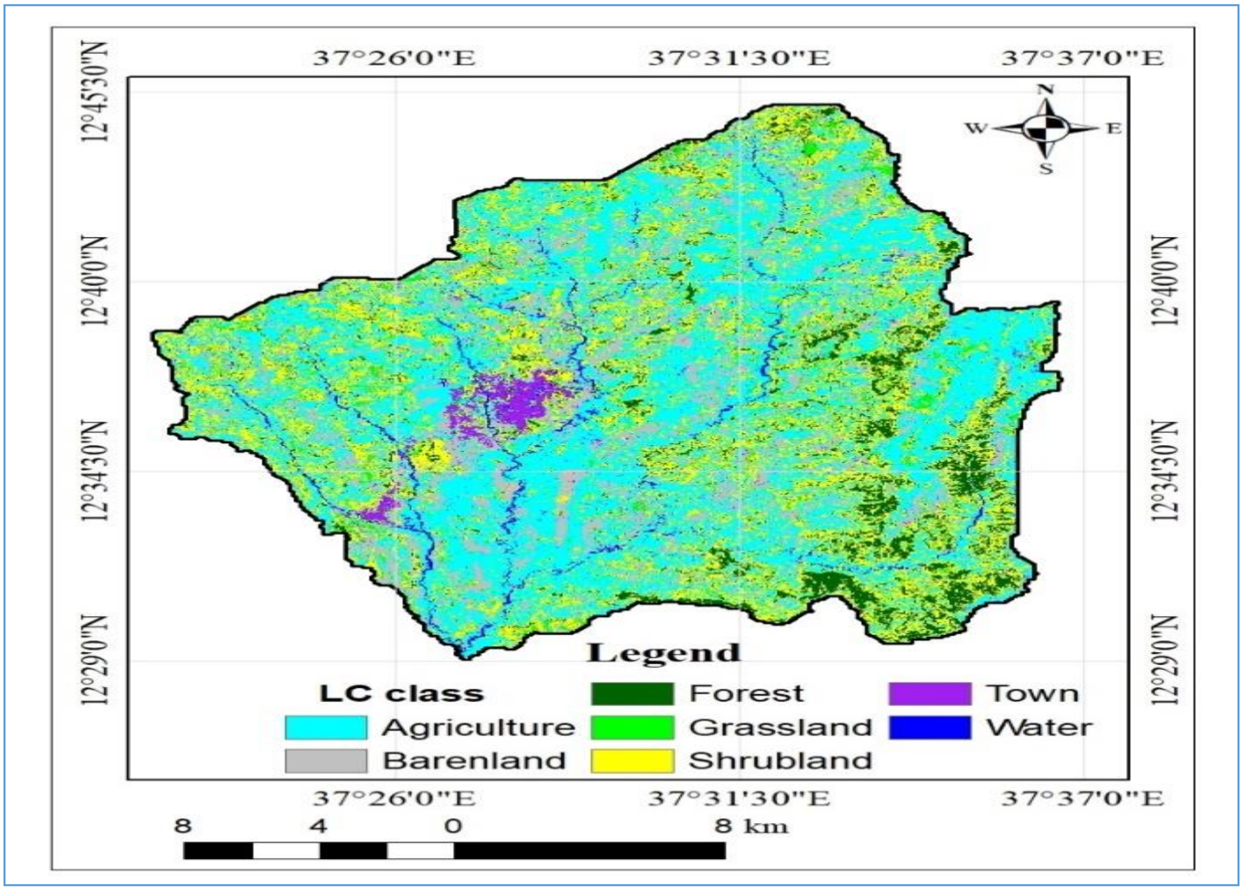

Figure. 20 The Land use and Land Cover map of 2000

The percentage of the land use Land cover of watershed at 2000 year are 46.3 % cultivated land, 26.16 % Shrub land, 14.3 % bare land, 6.43 % forest, 3.22 % Grass land, 2.21 % Town and 1.41 % water body.

Table. 5 Land use /land cover percentage of Megech Watershed in 2000 years

Megech LULC in 2000			
S.No	Land cover Class	Area(km^2)	Area (%)
1	Agriculture	230	46.30
2	shrub land	130	26.16
3	Bare land	71	14.30
4	Forest	32	6.43
5	Grass land	16	3.22
6	Town	11	2.21
7	Water	7	1.41
	Total	498	100

The percentage of the land use Land cover of watershed at 2000 year are 46.3 % cultivated land, 26.16 % Shrub land, 14.3 % bare land, 6.43 % forest, 3.22 % Grass land, 2.21 % Town and 1.41 % water body. The table 5 Show that Agricultural land in most part distribution of land cover whereas water body are the smallest portion of land.

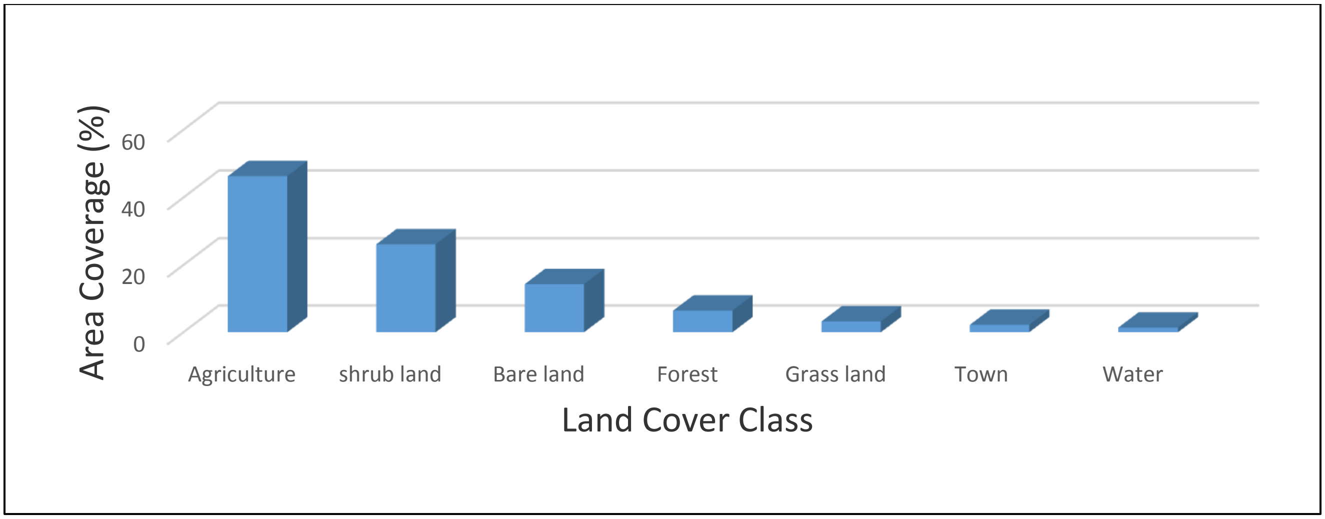

Figure. 21 Graphical Percentage of Land use Land cover of Megech Watershed in 2000

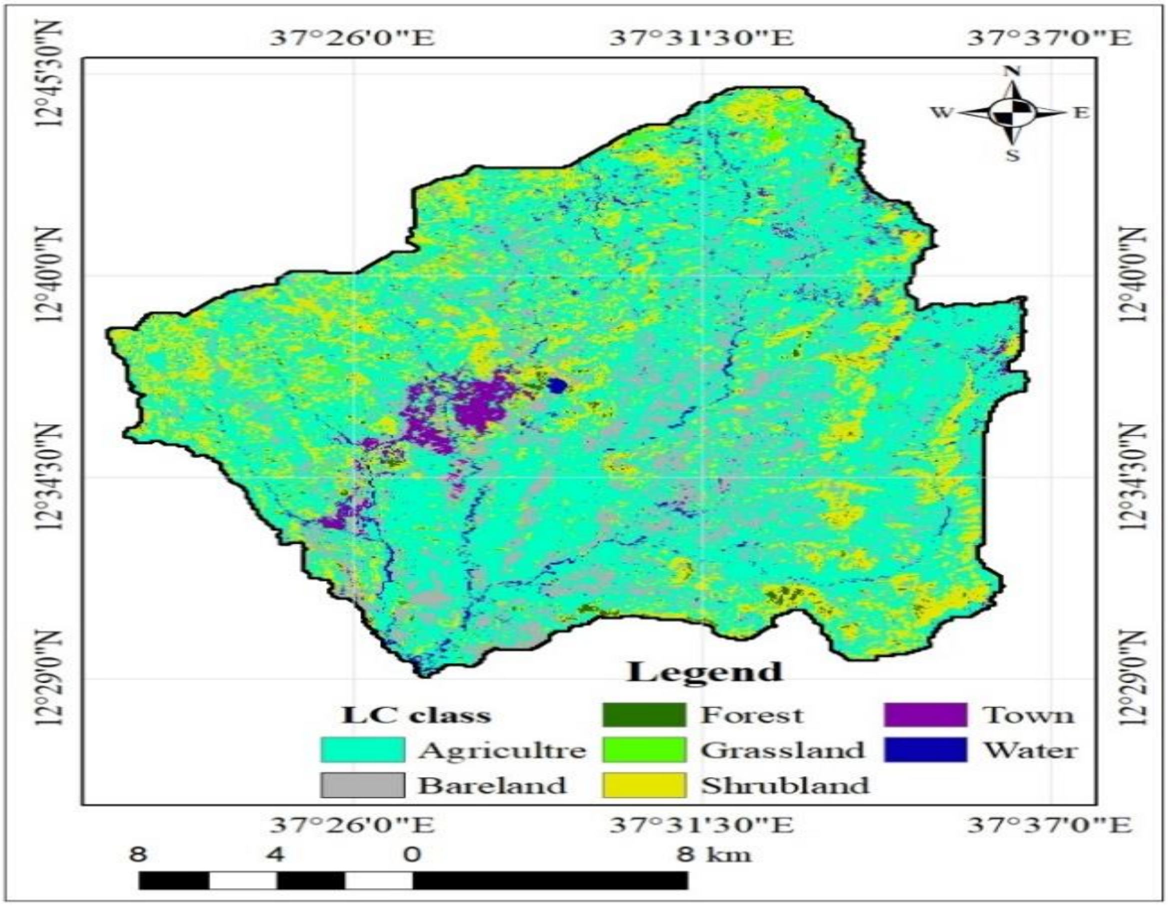

Figure. 22 Land use land Cover Map of 2010

The percentage of the land use Land cover watershed at 2010 year are 62.12 % Cultivated land, 19.64 % Shrub land, 12.82.3 % bare land, 0.8 % forest, 1.45 % Grass land, 2.81 % Town and 1.002 % water body.

Table. 6 Land use /land cover area of Megech Watershed in 2010 years

Megech LULC in 2010			
S.No	Class Name	Area(km^2)	Area (%)
1	Agriculture	310	62.12
2	shrub land	98	19.64
3	Bare land	64	12.82
4	Forest	4	0.8
5	Grass land	4	0.8
6	Town	14	2.81
7	Water	5	1.002
	Total	499	100.0

Table.6 show that cultivated land was increase from 46.3% to 62.12%, shrub land decrease from 26.16% to 19.64%, bare land decrease from14.3 % to 12.82%, forest decrease from 6.43% % to 1.45 %, Grass land decrease from 3.22 % to 0.8%, Town increased from 2.21 % to 2.81% and water body decreased from 1.41% to 1.002 from 2000 -2010 years.

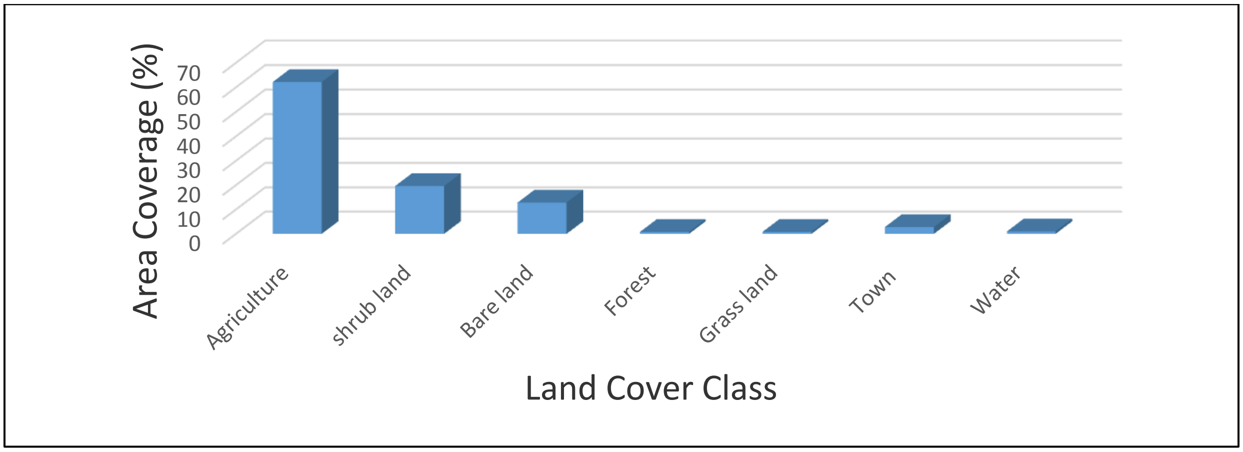

Figure. 23 Graphical percentage of Land use Land cover of Megech Watershed in 2010.

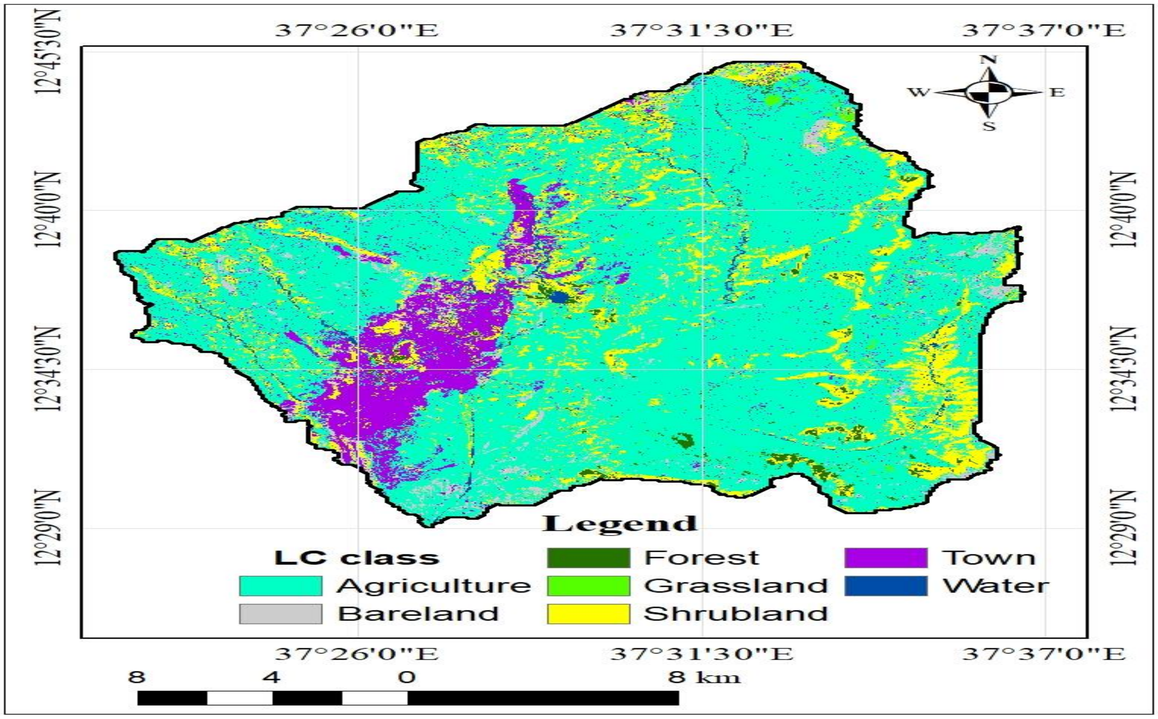

Figure. 24 Land use land Cover Map of 2018

The percentage of the land use Land cover watershed at 2018 year are 70.49 % Cultivated land, 14.24 % Shrub land, 3.4% bare land, 0.8% forest, 0.53 % Grass land, 9.13 % Town and 0.78% water body

Table. 7 Land use /land cover area of Megech Watershed in 2018 years

Megech LULC in 2018			
S. No	**Class Name**	**Area(km^2)**	Area (%)
1	Cultivated land	351.28	70.53
2	Bare land	16.9	3.4
3	Forest	7.21	1.45
4	Grassland	2.63	0.53
5	Shrubland	70.9	14.24
6	Town	45.52	9.13
7	Water	3.89	0.78
	Total	**498.33**	100

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Table.7 show that cultivated land were increase from 62.12% to 70.53%, shrub land were decrease from 19.64 % to 14.24% , bare land decrease from 12.82 % to 3.4% ,forest were decreased from 1.45 % to 0.8 %, Grass land 0.8 % to 0.53% , Town increased from 2.81 % to 9.13 % and water body decreased from 1.002 % to 0.78 % from 2010-2018 years.

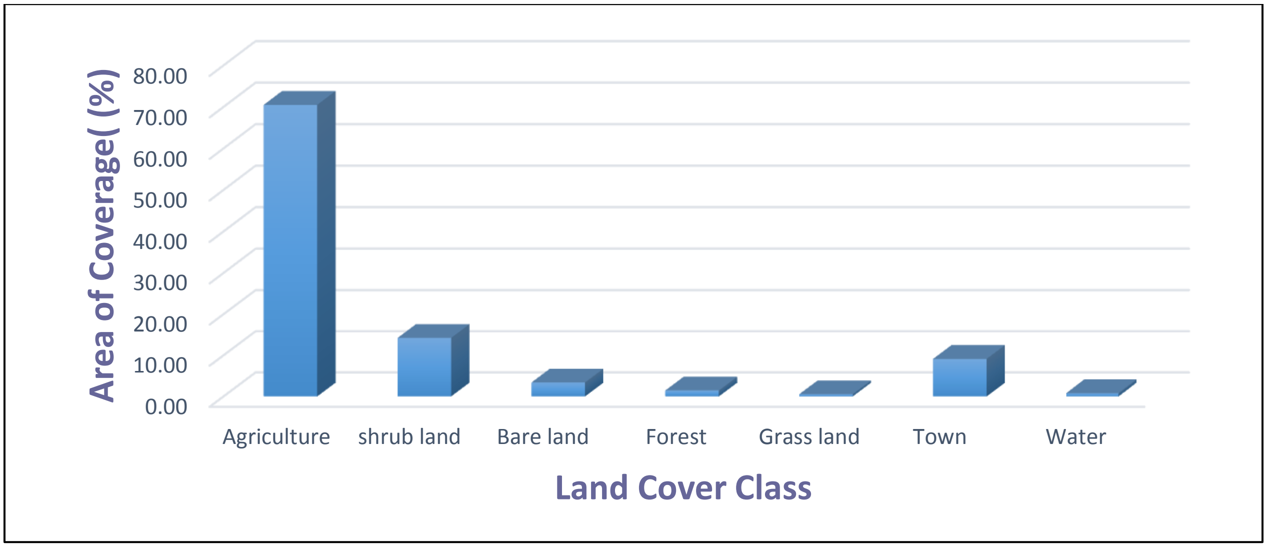


Figure. 25 Graphical percentage of Land use Land cover of Megech Watershed in 2018

Table. 8 Overall land use /cover changes at watershed level

Land use Land Cover Class	Over all land use land cover change at watershed								
	Years						Percentage(%) of Land use land cover detection		
	2000		2010		2018				
	Km^2	%	Km^2	%	Km^2	%	2010-2000	2018-2010	2018-2000
Agricutural land	230	46.33	310	62.12	351.28	70.49	15.79	8.37	24.16
Shurb land	130	26.16	98	19.64	70.9	14.23	-6.52	-5.41	-11.93
Bare land	71	14.3	64	12.82	16.9	3.39	-1.48	-9.43	-10.91
Forest	32	6.43	4	0.8	7.21	1.45	-5.63	0.65	-4.98
Grass land	16	3.22	4	0.8	2.63	0.53	-2.42	-0.27	-2.69
Twon	11	2.21	14	2.81	45.52	9.13	0.6	6.32	6.92
Water	7	1.41	5	1.002	3.89	0.78	-0.408	-0.222	-0.63

Generally, Agricultural land increased 46.3% to70.49%, shrub land decreased 26.16% to 14.23%, bare land decrease 14.3% to 3.39%, forest decreased 6.43 % to 1.45%, Grass Land decreased 3.22% to 0.53%, Town increased 2.21% to 9.13% at 2018 of megech watershed.

4.2. Stream flow modeling

4.2.1 Calibration of Model

Calibration is the process whereby model parameters are adjusted to make the model output match with observed data. There are three calibration approaches widely used by the scientific community. These are the manual calibration, automatic calibration and a combination of the two. Automated model calibration requires that the uncertain model parameters are systematically changed, the model is run, and the required outputs (corresponding to measured data) are extracted from the model output files. The main function of an interface is to provide a link between the input/output of a calibration program and the model. The simplest way of handling the file exchange is through text file formats.

Calibration and validation of a flow was conducted for 2000, 2010 and 2018 land use using different observed stream flows. SUFI-2 operates by performing several iterations usually at most <5 (Abbaspour, 2015). In the next iterations the parameter ranges get smaller zooming on a region of the parameter space which produces better results in the previous iteration (Abbaspour, 2015). As a parameter ranges get smaller the 95PPU (the model output) envelops gets smaller leading to small p-factor and smaller r-factor. When acceptable values of r-factor and p-factor are reached, then the parameter uncertainties are the desired parameter ranges (Abbaspour, 2015). These parameter ranges are accountable for all uncertainty and produce 95ppu which means our model output result. The 95ppu can be expressed as an envelope of good solutions generated by the parameter ranges. To quantify the fit between simulation results expressed as 95PPU and observation, p-factor and r-factor are used. Sensitivity analysis of simulated stream flow for the watershed was performed using monthly observed stream flow using SUFI2 program. Finally, based on the sensitive parameters, manual and SUFI2 program, calibration of this research was performed using 3 years from (1999-2001), (2008-2010) and (2014-2016) stream flow data for land use scenarios of 2000, 2010 &2018 years respectively.

4.2.2 Validation of Model

Validation model parameters can result in simulations that satisfy goodness-of fit criteria, but parameter values may not have any hydrological meaning. Values of model parameters will be a result of curve fitting. This is also reflected in having different sets of parameter values producing simulations, which satisfy these criteria. It is necessary to test if parameter values reflect the underlying hydrological processes, and are not a result of curve fitting. Therefore; to conduct appropriate model validation results, it is necessary to carry out split sample test. The split-sample test involves splitting the available time series into two parts. One part is used to calibrate the model, and the second part is used for testing (validating) if calibrated parameters can produce simulations, which satisfy goodness-of -fit tests.

Finally, Validation of this research was also conducted 3 years from(2002-2004),(2011-2013) and (2017-2019) using monthly observed stream flow data using SUFI2 program with Automated and manual for three land use scenarios of 2000, 2010 &2018 years respectively.

Table 9 shows the model performance during calibration period and validation (close agreement between the goodness-of- fit criteria of the simulated and observed flow). Coefficient of determination, which is best if R^2> 0.60 and Nash-Sutcliffe (1970) coefficient of efficiency, which is best if NS>0.5; the Megech catchment satisfies these criteria

Table. 9 Model efficiencies of parameters in calibration and validation periods.

Gauging station	Simulation period	Objective function	Period	Years		
				LULC 2000	LULC 2010	LULC 2018
Megech Near Azezo	1999-2001	R^2	Calibration	0.82		
		ENS	Calibration	0.82		
	2002-2004	R^2	Validation	0.71		
		ENS	Validation	0.66		
	2008-2010	R^2	Calibration		0.79	
		ENS	Calibration		0.63	
	2011-2013	R^2	Validation		0.84	
		ENS	Validation		0.78	
	2014-2016	R^2	Calibration			0.74
		ENS	Calibration			0.71
	2017-2019	R^2	Validation			0.78
		ENS	Validation			0.75

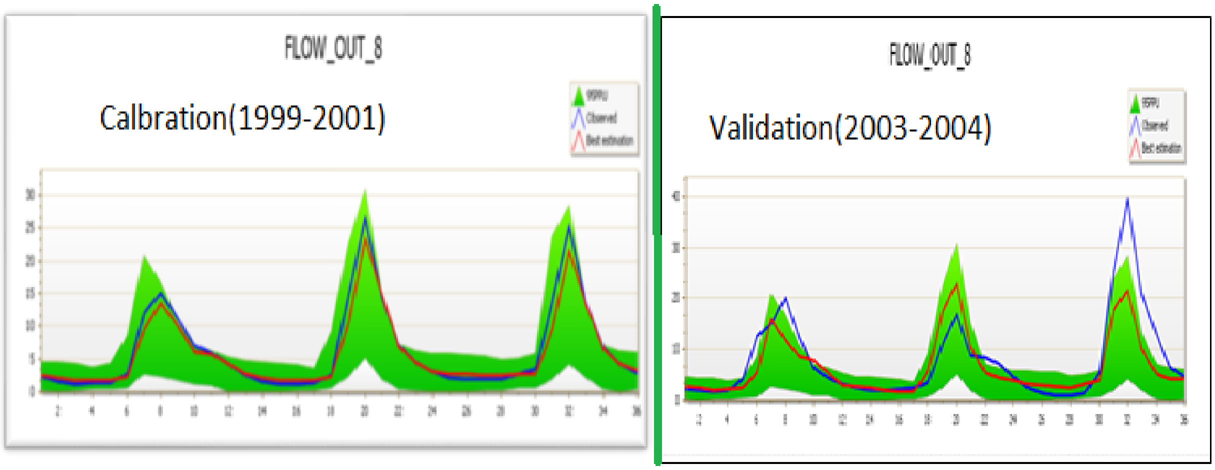


Figure. 26 Model Calibration and validation period for LULC2000

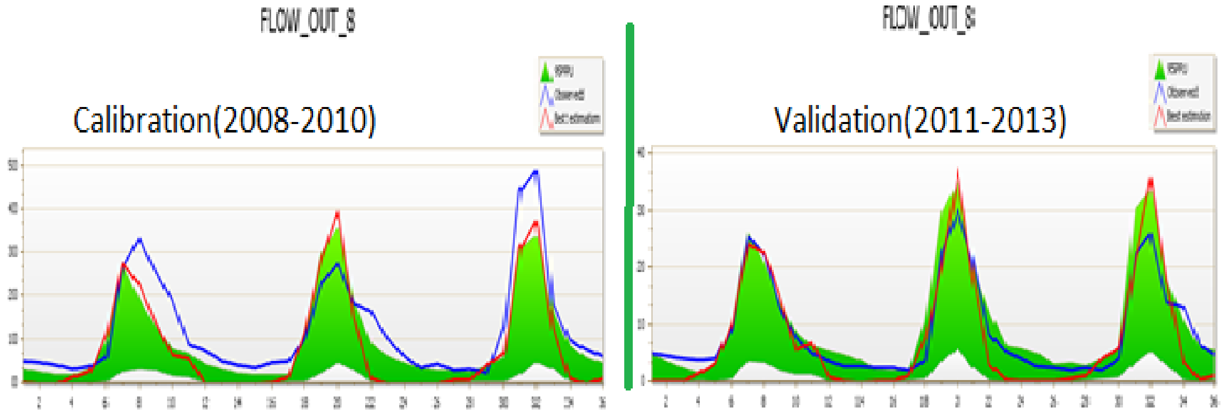


Figure. 27 Model Calibration and validation period for LULC2010

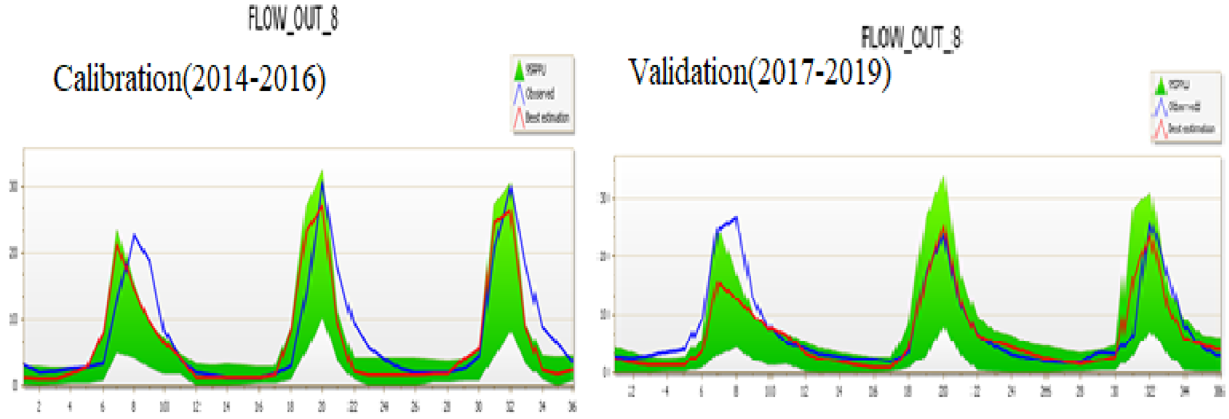


Figure. 28 Model Calibration and validation period for LULC2018

Sensitivity Analysis

The results of a sensitivity analysis can be used to eliminate non-sensitive parameters from the calibration process. First the initial range of parameters was assigned based on literature and SWAT absolute values. All results of the global sensitivity were using first iteration with 500 simulations

Selection of Parameters for Sensitivity Analysis

Before calibration to begin, Parameters those were used in SWAT model to other Abay basin's sub-basins were identified from previously published manuscript. Since this is not enough to get performance criteria, other parameters were gathered and added from SWAT-CUP manual. About nineteen parameters which are CANMX, CN2, ESCO, SOL_AWC, GW_DELAY, GW_REVAP, REVAPMN, GWQMN, ALPHA_BF,ALPHA_BNK,RCHRG_DP, SLSOIL, SOL_K, SOL_BD, SLSUBBSN, OV_N, PLAPS, TLAPS, EPCO and HRU_SLP were incorporated into SWAT-CUP algorithm (Sufi-2) to understand the level their sensitivity. For the reason that knowing of the more sensitive parameters could make ease the time required for calibration and validation. Furthermore, it is the technique to know the dominant parameters of the watershed those can influence the hydrological balance of the sub-basin.

The global sensitivity was determined depend on t-stat and P-value. The smaller the p-value and large absolute value of t-stat indicates the more sensitive parameter, whereas the larger p-vale and smaller t-stat point toward the less sensitive for the given watershed. The p-values close to zero has more significance. Accordingly, sensitivity analysis significantly eases relative sensitivity of parameters identification, rises the accurateness of calibration and lessen uncertainty and the time necessary for it.

In the current case study, a Sensitivity analysis was conducted using the SWAT-CUP method. Sensitivity analysis was performed on nineteen SWAT model parameters that may have the potential to influence the flow river. The parameters are Surface response, subsurface response and basin response. Sensitivity analysis was performed on nineteen SWAT parameters and the most sensitive parameters were identified using Global sensitivity analysis method in SWAT-CUP SUFI2.The sensitivity of parameters was computed to simplify the time consumed in model calibration and validation. Identification of sensitivity level of those parameters of the sub basin is also crucial to understand their effect on watershed to produce surface runoff.

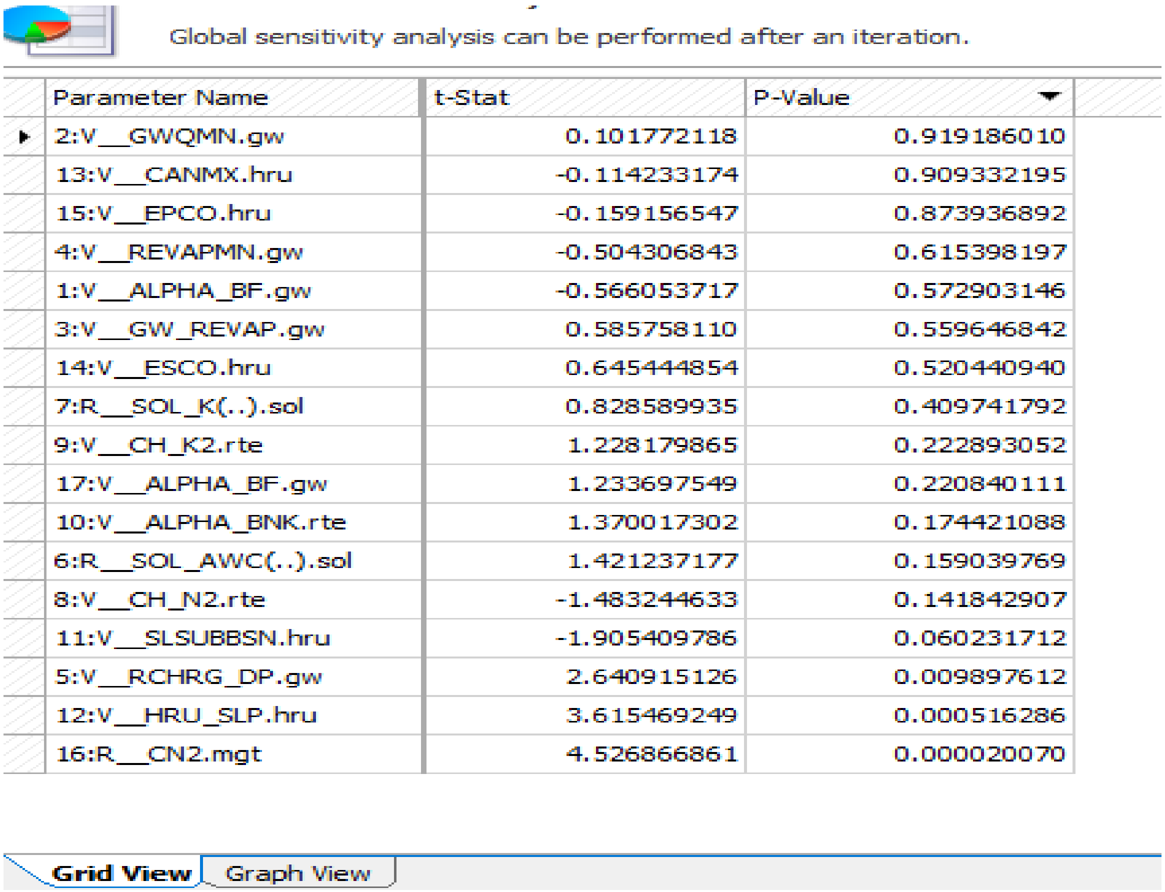
Table. 10 List of parameters used for calibration and validation

Parameters	Description
EPCO	Plant uptake compensation factor and expresses the amount of water needed to meet the plant uptake demand
ESCO	soil evaporation compensation factor which directly influences the evapotranspiration losses from the watershed
CANMX	Maximum canopy storage
SOL_AWC	available water capacity of the soil layer
CH_K	the hydraulic conductivity of the channel
CH_K2	Effective hydraulic conductivity in main channel
CH_N2	Manning’s value for the main channel
CN2	the initial SCS runoff curve number
SLSUBBSN	Average slope length
HRU_SLP	Average slope steepness
ALPHA_BF	Parameter that expresses the recession or the rate at which the groundwater is returned to the flow
ALPHA_BK	Base flow alpha factor for bank storage (days) contributes flow into the main channel or reach with the sub basin.
GWQMN	The threshold depth of water in the shallow aquifer required to return flow
GW_DELAY	The required time for water leaving the bottom of the root zone to reach the shallow aquifer where it can contribute to lateral groundwater flow
GW_REVAP	Groundwater "revap" coefficient, which is a dimensionless coefficient controlling the rate of water movement between the root zone and the shallow aquifer
REVAPMN	Threshold depth of water in the shallow aquifer for "revap" or percolation to the deep aquifer to occur (mmH2O).
RCHRG_DP	Deep aquifer percolation fraction which recharge deep aquifer

t -test and p-values

The t-stat is the coefficient of a parameter divided by its standard error. It is a measure of the precision with which the regression coefficient is measured. If a coefficient is “large” compared to its standard error, then it is probably different from 0 and the parameter is sensitive. A predictor that has a low p-value is likely to be a meaningful addition to your model because changes in the predictor's value are related to changes in the response variable. Conversely, a larger p-value suggests that changes in the predictor are not associated with changes in the response. So that parameter is not very sensitive. With a p-value of 0.05, there is only a 5% chance that results you are seeing would have come up in a random distribution, so you can say with a 95% probability of being correct that the variable is having some effect.

Table. 11 Most sensitive parameters for LULC 2000

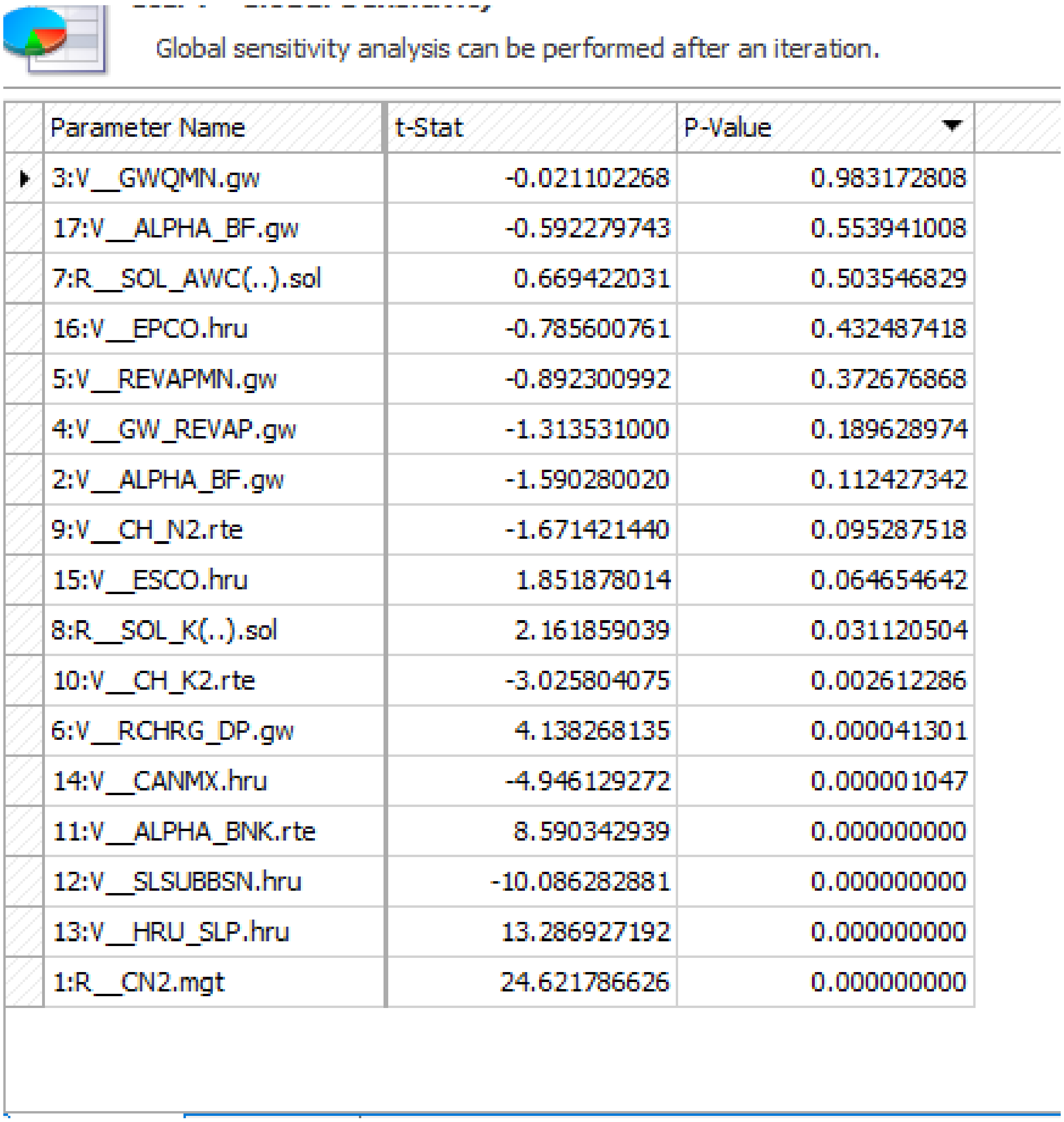


Global sensitivity analysis can be performed after an iteration.

Parameter Name	t-Stat	P-Value
2:V__GWQMN.gw	0.101772118	0.919186010
13:V__CANMX.hru	-0.114233174	0.909332195
15:V__EPCO.hru	-0.159156547	0.873936892
4:V__REVAPMN.gw	-0.504306843	0.615398197
1:V__ALPHA_BF.gw	-0.566053717	0.572903146
3:V__GW_REVAP.gw	0.585758110	0.559646842
14:V__ESCO.hru	0.645444854	0.520440940
7:R__SOL_K(..).sol	0.828589935	0.409741792
9:V__CH_K2.rte	1.228179865	0.222893052
17:V__ALPHA_BF.gw	1.233697549	0.220840111
10:V__ALPHA_BNK.rte	1.370017302	0.174421088
6:R__SOL_AWC(..).sol	1.421237177	0.159039769
8:V__CH_N2.rte	-1.483244633	0.141842907
11:V__SLSUBBSN.hru	-1.905409786	0.060231712
5:V__RCHRG_DP.gw	2.640915126	0.009897612
12:V__HRU_SLP.hru	3.615469249	0.000516286
16:R__CN2.mgt	4.526866861	0.000020070

From Table.11, R_CN2,mgt, V_HRU_SLP.hur and V_RCHRG._DP.gw are the most sensitive parameters respectively.

Table. 12 Most sensitive parameters for LULC 2010



Global sensitivity analysis can be performed after an iteration.

Parameter Name	t-Stat	P-Value
3:V__GWQMN.gw	-0.021102268	0.983172808
17:V__ALPHA_BF.gw	-0.592279743	0.553941008
7:R__SOL_AWC(..).sol	0.669422031	0.503546829
16:V__EPCO.hru	-0.785600761	0.432487418
5:V__REVAPMN.gw	-0.892300992	0.372676868
4:V__GW_REVAP.gw	-1.313531000	0.189628974
2:V__ALPHA_BF.gw	-1.590280020	0.112427342
9:V__CH_N2.rte	-1.671421440	0.095287518
15:V__ESCO.hru	1.851878014	0.064654642
8:R__SOL_K(..).sol	2.161859039	0.031120504
10:V__CH_K2.rte	-3.025804075	0.002612286
6:V__RCHRG_DP.gw	4.138268135	0.000041301
14:V__CANMX.hru	-4.946129272	0.000001047
11:V__ALPHA_BNK.rte	8.590342939	0.000000000
12:V__SLSUBBSN.hru	-10.086282881	0.000000000
13:V__HRU_SLP.hru	13.286927192	0.000000000
1:R__CN2.mgt	24.621786626	0.000000000

From Table.12 CN2. mgt, HRU_ SLP.hru, V_SLSUBBSN.hr are the most Sensitive parameters respectively.

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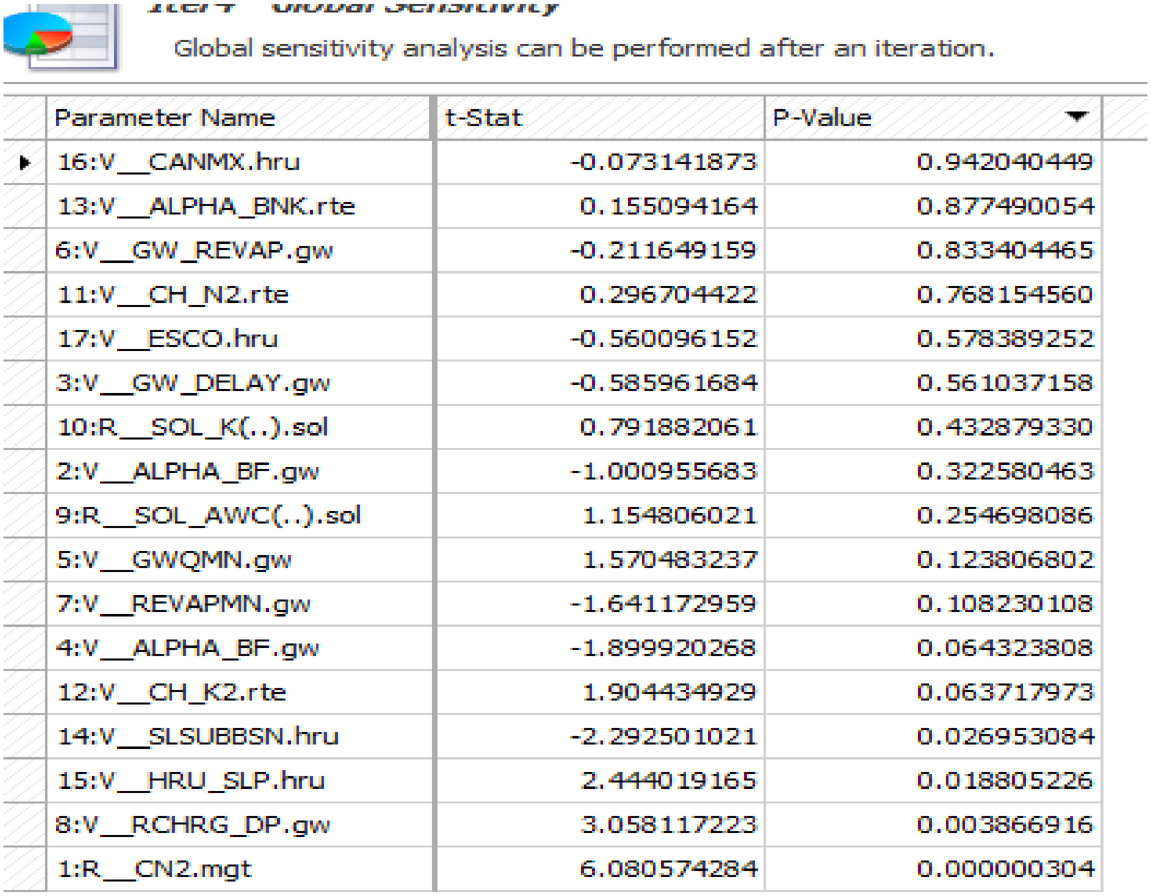
Table. 13 Most sensitive parameters for LULC 2018



Global sensitivity analysis can be performed after an iteration.

Parameter Name	t-Stat	P-Value
16:V__CANMX.hru	-0.073141873	0.942040449
13:V__ALPHA_BNK.rte	0.155094164	0.877490054
6:V__GW_REVAP.gw	-0.211649159	0.833404465
11:V__CH_N2.rte	0.296704422	0.768154560
17:V__ESCO.hru	-0.560096152	0.578389252
3:V__GW_DELAY.gw	-0.585961684	0.561037158
10:R__SOL_K(..).sol	0.791882061	0.432879330
2:V__ALPHA_BF.gw	-1.000955683	0.322580463
9:R__SOL_AWC(..).sol	1.154806021	0.254698086
5:V__GWQMN.gw	1.570483237	0.123806802
7:V__REVAPMN.gw	-1.641172959	0.108230108
4:V__ALPHA_BF.gw	-1.899920268	0.064323808
12:V__CH_K2.rte	1.904434929	0.063717973
14:V__SLSUBBSN.hru	-2.292501021	0.026953084
15:V__HRU_SLP.hru	2.444019165	0.018805226
8:V__RCHRG_DP.gw	3.058117223	0.003866916
1:R__CN2.mgt	6.080574284	0.000000304

From Table.13, R_CN_2, V_RCHRG_DP,gw., and HRU_SLP.hru are the most Sensitive parameters.

Based on a t -test that was used to identify the relative significance of each parameter that was a value larger in absolute value was most significant and p-value the significance of the sensitivity, the value close to zero is more significant.as the graphs indicates some parameters are the most sensitive parameters. The graphical view of these parameters is shown below in figure, which is produced by the model itself.

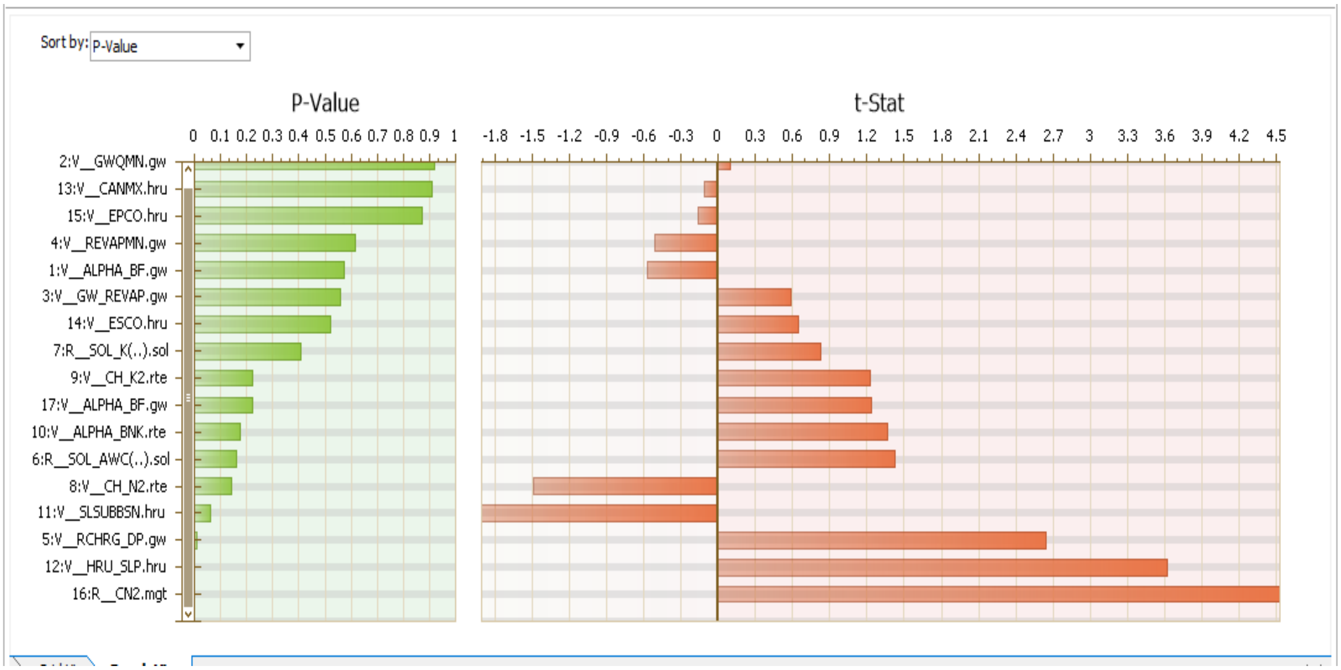


Figure. 29 Graphical views of sensitive parameters generated from SWAT-CUP for LULC 2000

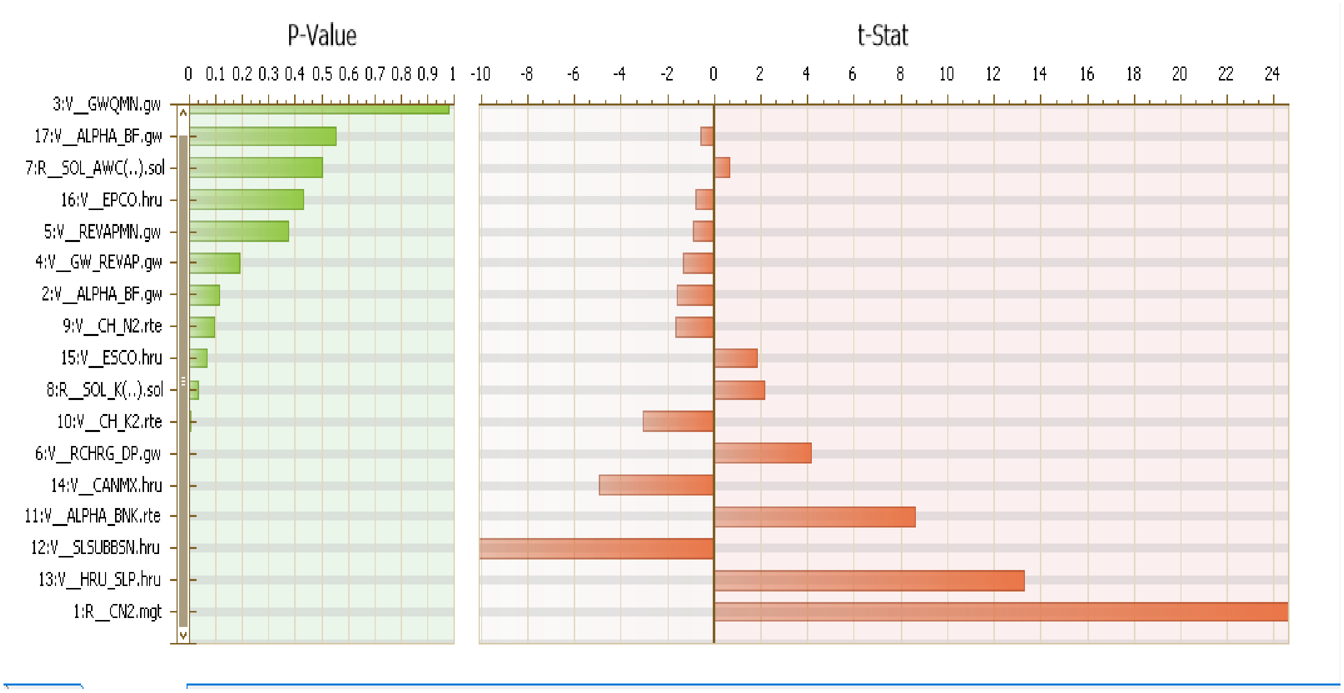


Figure. 30 Graphical views of sensitive parameters generated from SWAT-CUP for LULC 2010.

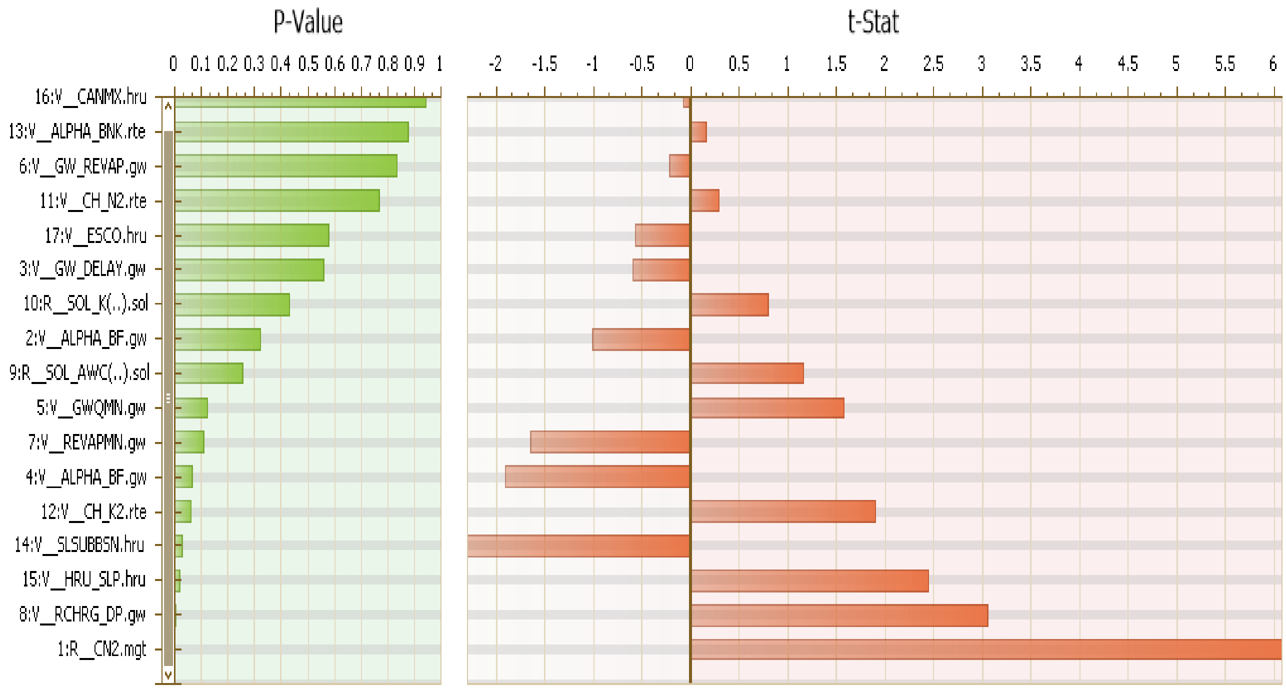


Figure. 31 Graphical views of sensitive parameters generated from SWAT-CUP for LULC 2018.

4.3. Effect of land use and land cover change on stream flow.

Effects on stream flow

Scenarios for Land use/Land cover changed at 2000, 2010 and 2018 years, stream flow were generated by SWAT software. SWAT-CUP model was run minimums three times for three land uses using the calibrated and validated parameters. After models were simulated stream flow at megech river watershed are listed blow table by using pivot method.

Table. 13 Average monthly stream flow (m^3/s) due to changed land use/land cover.

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Avg.Monthly flow (in 2000)	2.90	2.16	1.62	1.96	2.46	5.40	25.60	43.60	26.25	7.93	6.23	3.72
Avg.Monthly flow (in 2010)	1.87	1.31	1.43	1.87	2.51	7.43	22.81	45.34	23.23	6.47	3.06	1.61
Avg.Monthly flow (in 2018)	1.20	0.83	1.04	1.51	2.38	7.62	23.11	49.66	18.40	5.95	2.53	1.01

Table. 14 Mean monthly Dry and Wet stream flow (m^3/s) Changed with Scenario of LULC

Mean monthly Dry and Wet stream flow changed with scenario of LULC megech watershed.							
Mean monthly flow (m^3/s)						Mean monthly flow changed 2018-2000 year	
Land use /Cover 2000 year		Land use /Cover 2010 year		Land use /Cover 2018 year			
Dry months	Wet months	Dry months	Wet months	Dry months	Wet months	Dry	Wet
(Jan,Feb,Dec)	(May,Sep,Oct)	(Jan,Feb,Dec)	(May,Sep,Oct)	(Jan,Feb,Dec)	(May,Sep,Oct)		
2.93	12.21	1.60	10.74	1.05	8.90	-1.88	-3.31

As indicate in Table.15 above the mean monthly stream flow for both dry and wet months were decreased by 1.88m^3/s and 3.31m^3/s due to land use / cover change in the catchment.

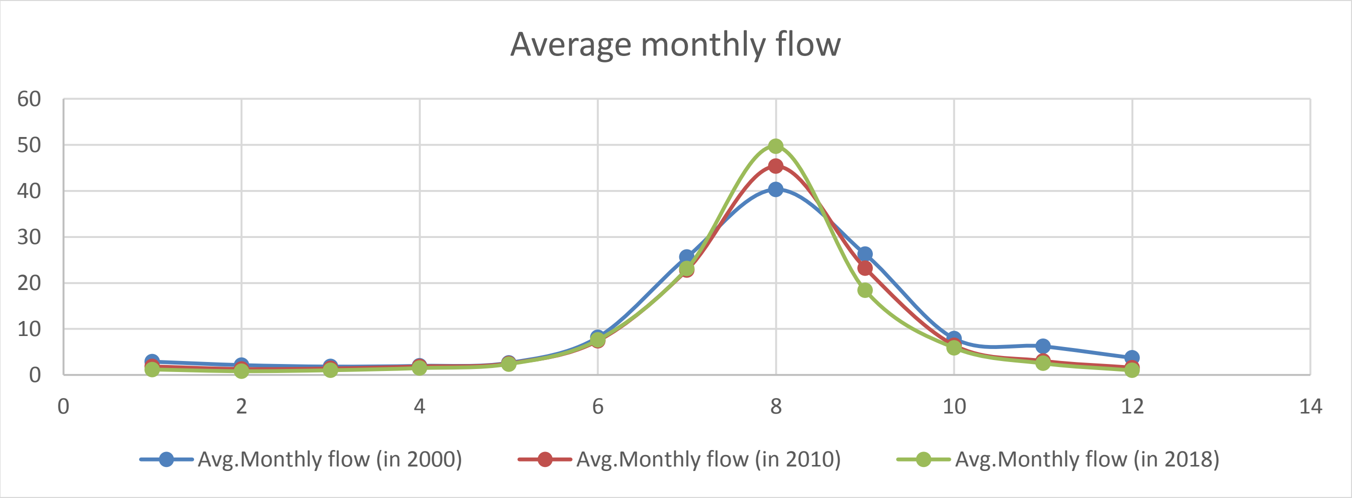


Figure. 32 Average monthly stream flow for different scenario of LULC

Figure.30 shows that stream flow was changed from 2000-2018 year because of land use and cover changed through year sat the catchment. Flow is decrease at dry season and increased at summer season through 18years of land use land cover change.

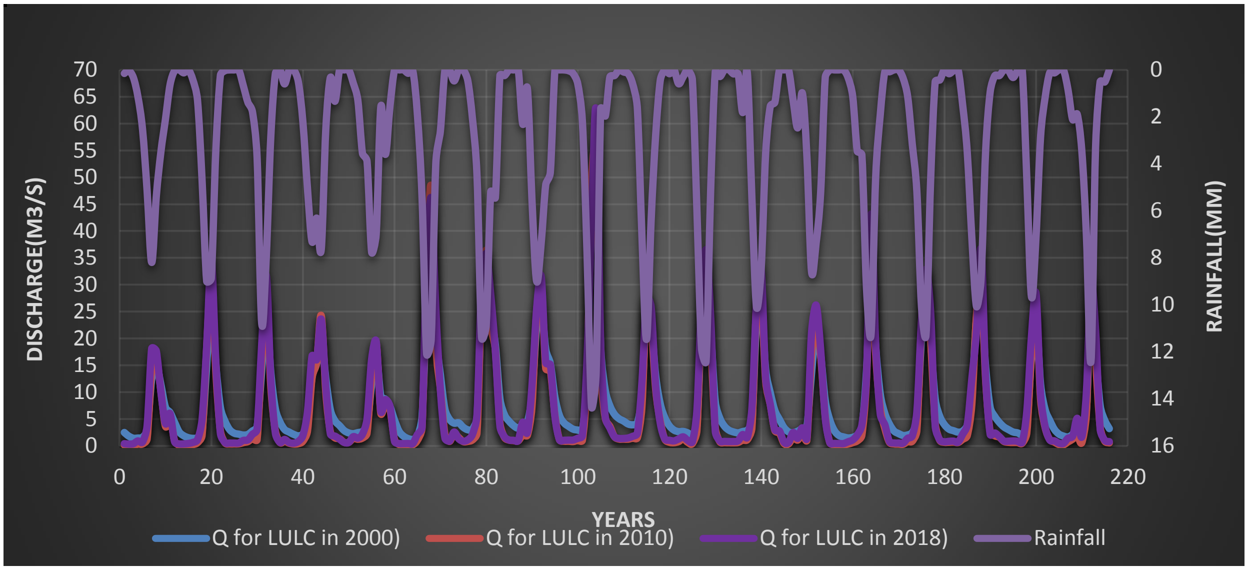


Figure. 33 Comparison of average stream flow of different years and Rain fall at watershed.

It’s clear that when rain fall of each year are increased/decreased, discharge at watershed of each year also increased/decreased through the year.

5. Conclusions and Recommendation

5.1. Conclusion

The main goal of this study is to assess the past potential land use /land cove changes, and their impact on the hydrology of the Megech catchment which is located in upper-Abbay basin with a total area of 498 km2. Specifically, the study analyzed the historical LULC changes (2000 to 20018) that have taken place in the catchment and its effect on the hydrology of the catchment. Population growth, deforestation and higher demand for farm lands have effect on natural resource of the Megech River Catchment, Abbay River Basin. Assessing the problem and finding solution at catchment level is use full to minimize the effect of the problem. Land use /Land cover change analysis has shown that the Settlement (town) area has increased from 2.21% to 9.13%, Agricultural land from 46.3% to 70.49%, Forest area decreased from 6.43% to 0.8% and shrub-land area has decreases 26.16% to 14.23% between 2000 and 2018years.

There is heterogeneity in the magnitudes of the changes in hydrological fluxes with LULC. This heterogeneity presents a challenge to water resources managers and therefore point to the need for increased local scale research to understand better the effects of land cover transitions on hydrological fluxes. Understanding future LULC and mitigating their impacts on water resources in specific watersheds will require integration of results from regional scale analyses and those from local scale studies.

This review is based on a relatively limited body of applicable research undertaken in the megech river catchment and to better understand the impacts of LULCC on hydrological fluxes in megech catchment requires holistic studies that place emphasis on both time and spatial scales and consider ecological scope and climate variability.

Model calibration and validation was conducted for three land use using measured data near to gauge station and by using multi gauge calibration using SWAT-CUP. For 2000, 2010 and 2018 land use, calibration from 1999-2001 and validation from 2002-2004, calibration from 2008-2010 & validation from 2011-2013, calibration from 2014-2016 & validation from 2017-2019 years was respectively conducted. The Results from calibration for three land use show acceptable range (0.82, 0.63 and 0.71 for NSE and 0.82, 0.79 and 0.74 for R2) between observed and simulated stream flow respectively. The results of validation were also acceptable range (0.66, 0.78 and 0.75 for NSE and 0.71, 0.84 and 0.78 for R2) respectively.

Generally, Land use/Land cover change analysis has shown that the Settlement (town) area has increased from 2.21% to 9.13%, shrub land decreased 26.16% to 14.23%, Agricultural land from 46.3% to 70.49% and Forest area has decreased from 6.43 to 0.8 between 2000 and 2018years.Amounig of land use /land cover change agricultural is the most changed in percent at watershed as the result stream flows of mean monthly and annually also changed. The mean monthly flows are decreased by 3.31m^3/se in wet season at (May, Sep, Oct) and decreased by 1.88m^3/se in dry season at (Jan, Feb, Dec).

Finally, recommendation of the land use and land cover changes on stream flow in the study area and the country are general mainly cause by increasing population. Nowadays, household family size and its annual crop production method are not proportional. Moreover, the farmers are unable to improve the amount of the production by the existing farming practices. For this reason, improve of household knowledge with the impact of population growth on their living status has paramount importance. Therefore, family planning which aware to decreasing expansion of agricultural by 26.19% and decreasing expansion Tow by 6.92% should be given widely and continuously through formal and informal education in school and some other social gathering area at upstream population in order to increasing stream flow of river watershed.

5.2 Recommendation

Generally, from this specific study the following recommendations could improve similar Research for future work.

- ✓ The research was conducted using three land use data of the study area. It can be applied to variety of watershed, where time sequence land use and land cover data is available to predict the hydrological and downstream sedimentation consequence to LULC.
- ✓ The research is limited in conducting practical land use scenarios. Another volume of research can be conducted by developing scenarios based on next strategies like growth and transformation plan of Ethiopia land use policies, catchment-based population and economic projection and master plan.
- ✓ The research was conducted by evaluating the effects of land use and land cover changes on stream flow. However, the effects of LULC also have impact on the component of stream flow of the catchment by changing the magnitude of surface runoff and ground water flow. So, further research of this kind can be computed on the assessment of the impacts of LULC on stream flow components (water quality, surface run-off, bas flow and ground water) analysis for the wet and dry months.
- ✓ The weather stations should be improved both in quality and quantity in order to improve the performance of the model. For this reason, it is highly recommended to establish good meteorological stations.
- ✓ Integrating land use change models with hydro logic models could be applied to predict the impacts of land use changes on the stream flow in the watershed and the country in general. This helps for stakeholders and decision makers to make better choices for land and water resource planning and management.
- ✓ Therefore, an overall conclusion is that there is still need for more field studies, at longer time scales and variable spatial scales, and integrate these with modeling studies that takes full consideration of parameter uncertainty. For increased clarity, model inter-comparison studies are also recommended to verify their predictive power in relation to spatio-temporal changes in hydrological fluxes, using long term field data for improved model calibration and validation.

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7. Appendices

Annex A Average Annual rainfall at watershed area

Year	Ambagiorgis Sch	Maksegnit	Aykel	Gondor Ap
1998	72.34	53.13	91.89	81.21
1999	74.05	52.16	95.04	80.12
2000	82.53	120.84	92.36	96.52
2001	80.44	122.90	107.47	92.58
2002	78.62	113.39	102.34	124.30
2003	87.50	134.32	111.16	147.32
2004	65.40	111.89	107.24	144.69
2005	93.32	139.12	104.25	155.40
2006	72.62	63.87	90.03	80.74
2007	108.61	76.88	75.69	86.02
2008	79.61	78.96	83.21	96.24
2009	93.02	75.75	80.45	85.11
2010	88.30	97.69	115.41	101.20
2011	109.23	82.69	102.72	96.32
2012	89.12	89.46	103.78	102.30
2013	53.63	63.54	103.99	81.56
2014	87.18	75.68	84.12	88.12
2015	138.20	93.89	94.01	85.53
2016	99.21	76.98	107.05	95.56
2017	107.39	76.89	89.85	79.80
2018	88.32	78.90	104.70	96.43

Annex B Average annual R.F, Annual mean (max, min, STDEV and CV)

Annual	1056.41	1073.59	1169.50	1198.37
Anual mean	88.03	89.47	97.46	99.86
MAX	325.97	332.44	284.54	321.39
MIN	0.43	1.73	1.53	3.19
STDEV	115.41	120.25	104.67	116.99
CV	131.09	134.41	107.40	117.15

Annex C Average Maximum Temperature of Watershed

Month	AmbagiorgisSch	Gondar A.P.	Aykel	Maksegnit
Jan	19.89	28.36	25.57	29.10
Feb	20.54	29.88	27.13	30.50
Mar	21.47	30.44	27.57	31.20
Apr	21.96	30.63	27.73	31.20
May	21.58	29.38	25.60	30.00
Jun	19.64	25.79	22.55	27.10
Jul	17.89	23.31	20.14	24.60
Aug	18.34	23.53	20.21	24.50
Sep	19.44	25.65	21.75	26.70
Oct	19.26	25.67	22.79	28.10
Nov	19.12	27.63	24.19	27.90
Dec	19.29	27.62	24.56	27.90

Annex D Average Minimum Temperature of Watershed

Month	AmbagiorgisSch	Gondar A.P.	Aykel	Maksegnit
Jan	7.23	12.18	13.10	11.40
Feb	8.16	14.01	14.50	13.30
Mar	8.97	15.03	15.22	15.08
Apr	9.73	15.95	15.98	16.00
May	9.87	15.82	13.05	15.55
Jun	9.44	14.60	13.34	14.58
Jul	8.88	14.11	12.32	14.43
Aug	8.90	14.00	12.30	14.18
Sep	8.77	13.48	12.75	13.65
Oct	7.98	13.28	13.37	13.01
Nov	6.70	12.75	13.16	12.41
Dec	6.31	12.08	12.87	11.35