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Investigating the Impacts of Land Use/Cover Changes on the Stream Flows of Muga Watershed

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ABSTRACT

Land use /land cover change have been responsible for altering the hydrological responses of watersheds leading to impact of the stream flows. Various water resource project planning and implementation will require knowledge of the extents of these changes on watershed hydrology. This study is mainly focusing on the investigation of the impacts of land use / land cover changes on the stream flow of Muga watershed which is located in the East Choke Mountains watersheds, Upper Blue Nile Basin, East Gojjam Zone, Amhara Region, Ethiopia. Soil and Water Assessment Tool (SWAT) model were used it investigate the impact of land cover change on the stream flow. For this study SWAT Simulation is used in identifying the most vulnerable sub basins to the stream flow and sediment load changes of Muga watershed. The model was calibrated and validated using historic Stream flow data. The model was calibrated using stream flow data from 1993 to1998, validated from 1999 to2002. The R2 and NSE values were used to examine model performance and the result indicates 0.81 and 0.87 to R2 and 0.80 and 0.86 to NSE during calibration and validation respectively. The result of this analysis indicated that the mean monthly stream flow for wet months had increased by 17.75 m3/s while the dry season decreased by 12.76m3/s during the 1995-2013 period due to the land use and land cover change. The highest annual surface runoff was attributed by sub basin 5 whereas sub basin 6 contributes the highest ground water respectively for 1995, 2003 and 2013 land cover maps. In terms of sediment yield, sub basin 1 contributes a maximum load for the study periods.

Keywords : *GIS, LULC Changes, Muga Watershed, SWAT Model.*

I. INTRODUCTION

Water is the most essential resources for living species. Since the available amount of water is limited, scarce, and not evenly distributed in relation to the population needs, proper management of water resources is very important to satisfy the current demands as well as to maintain sustainability. 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, LULC 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 (Walsh, Fletcher et al. 2005).

The LULC changes are caused by a number of natural and human driving forces (Meyer and Turner 1994). Natural effects are such as climate changes are only over a long period of time, whereas the human effects are immediate and often direct. Out of the human factors, population growth is the most important in Ethiopia (Tekle and Hedlund 2000), as it is common in developing countries.

Ethiopia is one of the most populous countries in Africa with over a population of 90 million people and an annual growth rate of 2.6 million people (CSA, 2008). 85 % of the population of lives in rural areas and directly depends on the land for its livelihood. This means the demands of lands are increasing as population increases. Agriculture, which depends on the availability of seasonal rainfall, is the main economy of the country.

People need land for the food production and for housing and it is common practice to clear the forest for the farming and housing activities. Therefore, the result of these activities is the LU/LC changes due to daily human intervention. Hence, understanding how the LC changes influence on the stream flow of the watershed is enable planners to formulate policies to minimize the undesirable effects of future LC changes. Providing a scientific understanding of the process of LULC change, the impacts of different LU decisions, and the ways that decisions are affected the hydrological cycle and increasing variability are priority areas of research (Abraha 2007).

The topography of the Blue Nile River basin in Ethiopia, in which the study area is allocated, is very rugged, dissected and mountainous which aggravates the problem of soil erosion and nutrient depletion. These are having a direct effect on the water that draws in the watershed. To visualize the future effects of LU change on the stream flow, it is very important to have an understanding of the effects of historic LU changes on the watershed hydrologic systems.

Land use change has an undeniable and significant global, ecological trend which in turn effects on the quantity of water (stream flow) (A.k., 2005). The topography of the Blue Nile River basin in Ethiopia, in which the study area is allocated, is very rugged, dissected and mountainous which aggravates the problem of soil erosion and nutrient depletion. These have a direct effect on the water that draws in the watershed. To visualize the future effects of land use change on river (stream) flow, it is important to have an Understanding of the effects of historic land use changes on the watershed hydrological system.

The dynamic nature of land use arising from an increasing population, expansion of the agriculture sector and climatic change is happening at an alarming rate in Ethiopia. expansion and intensification of agriculture, growth of urban areas and extraction of timber and other natural resources will likely accelerate over the coming decades to satisfy the demand of an increasing population. (Dereje,2010) the fast growing of population and the density of livestock in the basin resulted in forest clearing and overgrazing. In addition, more mountainous and steeper slopes are cultivated, in many cases without protective measures against land erosion and degradation. hence, outlining the relation between land use and hydrological condition of the area enables us know how the quantity of water flowing is changed with the change of land use. therefore, the need for scientific research that establishes the impact of land use changes on the stream flow is essential. The knowledge of influence of land use on the watershed hydrology will enable local governments and policy makers to formulate and implement effective and appropriate response strategies to minimize the undesirable effects of future land use and cover change or modifications. Hence, the general objective of this study is to quantify the impacts of land use and land cover (LULC) changes on the stream flow of Muga watershed. The specific objectives of this study are to (1) model the flow and sediment yield of Muga river, (2) estimate the simulated sediment yield of Muga watershed by using SWAT model and (3) estimate the surface runoff and ground water flow contribution to stream flow and simulated sediment yield from each sub basin of Muga watershed.

II. STUDY AREA AND DATASET

2.1) Description of Study Area

The Muga watershed is located in the East Choke Mountains watersheds, Upper Blue Nile Basin, near Debre markos town in East Gojjam Zone, Amhara Region, Ethiopia. Geographically, it lies between10 ^{0}18’ N and 10 ^{0}39’ N latitude and 37 ^{0}44’E and 37 ^{0}53’E. The watershed has an area of 800 km^{2}. In terms of administrative boundaries, it covers the 3 Woredas of East Gojjam (DibayTilatgin, Enemay and Dejen Woredas). This study was conducted in the Muga Watershed (Figure 1). Locally, the climatic seasons are defined as: dry season (Bega) from October to the end of February; short rain period (Belg) from March to May and long rainy period (Kiremt) from June to September, with the greatest rainfall occurring in July and August. The year to year variation in monthly rainfall is most pronounced in the dry season, with the lowest annual variation occurring in the rainy season.

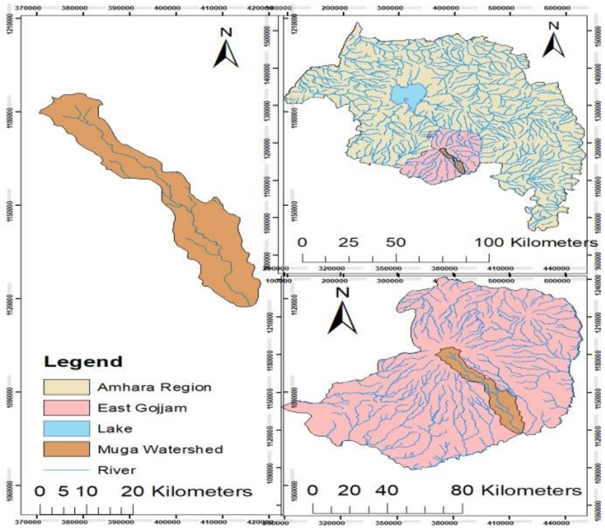


Figure 1 : Map of the study area

2.2) Data Set

SWAT is highly data intensive model that requires specific information about the watershed such as topography, land use and land cover, soil properties, weather data, and other land management practices. These data were collected from different sources and databases.

Topography is defined by a digital elevation model (DEM), which describes the elevation of any point in a given area at a specific spatial resolution as digital file. The digital elevation model is one of the essential inputs required by SWAT to delineate the watershed to a number of sub-watersheds. Digital Elevation Model (DEM) data are required to calculate the flow accumulation, stream networks, slope, stream length, and width of the channel within the watershed. For this study, Digital Elevation Model were collected from the Ministry of Water Resources, Irrigation and Electricity of Ethiopia with a spatial resolution of 30m. Meteorological data is needed by the SWAT model to simulate the hydrological conditions of the catchment. The meteorological data required for this study were collected from the Ethiopian National Meteorological Services (NMS). The meteorological data collected were precipitation, maximum and minimum temperature, relative humidity, and wind speed and sunshine hours. The weather input data required for SWAT simulation includes daily data of precipitation, maximum and minimum temperature, relative humidity, wind speed and solar radiation. The weather data used were represented from four stations in and around Muga watershed, such as Debre markos, Dejen, Motta and Yetnora stations as shown in figure 2.

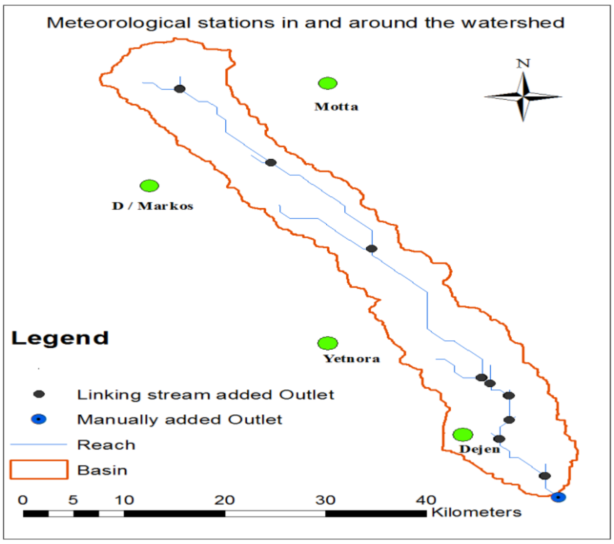


Figure 2 : Location of meteorological stations in and around the watershed.

Soil data is one of the major input data for the SWAT model with inclusive and chemical properties. The soil map of the study area was also obtained from Ministry of Water Resources, irrigation and electricity of Ethiopia. SWAT model requires soil physical and chemical properties such as soil texture, available water content, hydraulic conductivity, bulk density and organic carbon content for different layers of each soil type.

Land Use is one of the highly influencing the hydrological properties of the watersheds. It is one of the main input data of the SWAT model to describe the Hydrological Response Units (HRUs) of the watersheds. The land use map of the study area was also obtained from Ethiopian mapping agency.The stream flow data of the Muga watershed is needed for the calibration and validation of the model. The average monthly stream flow data (1990-2002) is quite sufficient and were collected from the Minister of Water Resources, irrigation and electricity of Ethiopia for the Muga watershed.

III. Methodology

3 .1) Data Processing and Analysis

The following chart shows the analysis of the study from the beginning (data collection) up to output (stream flow output).

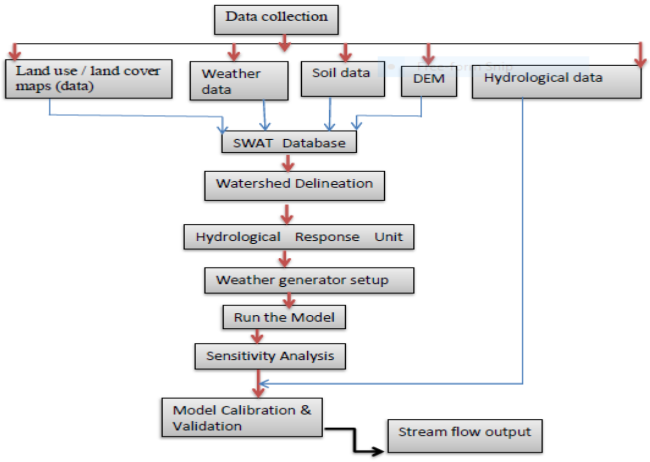


Figure 3. flow chart for data processing and analysis

3.2) Hydrological Model

Soil and Water Assessment Tool (SWAT) applied in the Muga watershed to assess the impacts of LULC changes on hydrological components. The criterion used to select this model is based on benefits it provides to meet the objectives of the study area. The SWAT model is embodied in ArcGIS that can integrate various readily available geospatial data to accurately represent the characteristics of the watershed.

The model is a physical based, semi-distributed, continuous time, and operating on daily time step (Neitsch, Arnold et al. 2005). As a physical based model, SWAT uses Hydrological Response Units (HRUs) to describe spatial heterogeneity in terms of land use, soil types and slope with in a watershed. In order to simulate hydrological processes in a watershed, SWAT divides the watershed in to sub watersheds based upon drainage areas of the tributaries.

The sub watersheds would have further divided in to smaller spatial modeling units known as HRUs, depending on LULC, soil and slope characteristics. One of the main advantages of SWAT is that it can be used to model watersheds with less monitoring data. For simulation, SWAT needs digital elevation model; LULC map, soil data and weather data of the study area. These data used as an input for the analysis of hydrological simulation of surface runoff and groundwater recharge.

SWAT splits hydrological simulations of a watershed in to two major phases: the land phase and the routing phase. The land phase of the hydrological cycle controls the amount of water, sediment, nutrient, and pesticide loadings to the main channel in each sub watershed. While the routing phase considers the movement of water, sediment and agricultural chemicals through the channel network to the watershed outlet. The land phase of the hydrologic cycle is modeled in SWAT based on the water balance equation (Neitsch, Arnold et al. 2005).

$$S_{wt} = S_{wo} + \sum_{i=1}^{t} (R_{day} - Q_{surf} - Ea. - W_{seep} - Q_{gw}). \ldots\ldots\ldots\ldots\ldots 1$$

Where,

S_{wt} is the final soil water content (mm)

S_{wo} is the initial water content (mm)

t is the time (days)

R_{day} is the amount of precipitation on day (mm)

Q_{surf} is the amount of surface runoff on day (mm)

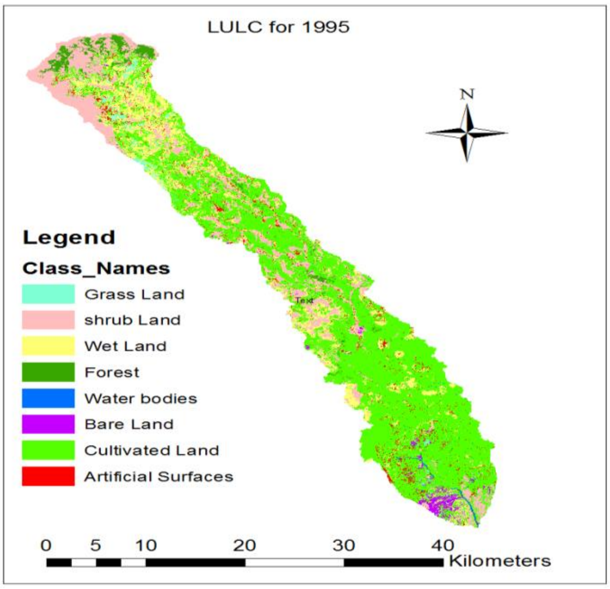
Ea is the amount of evapotranspiration on day (mm)

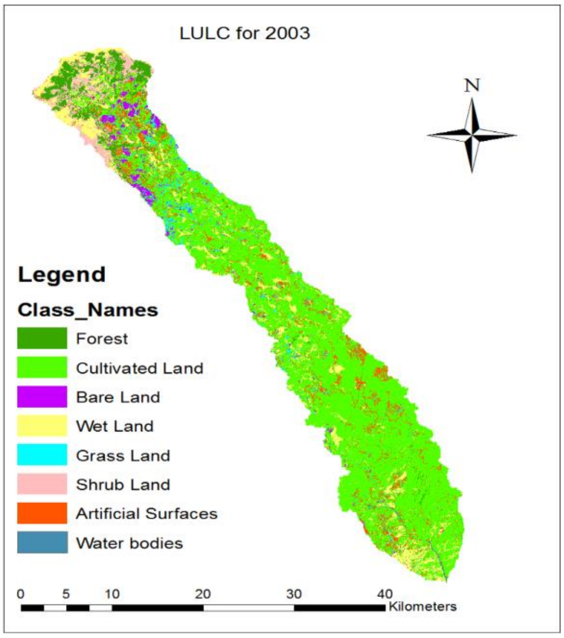
W_{seep} is the amount of water entering the vadose zone from the soil profile on day (mm),

Q_{gw} is the amount of return flow on day (mm).

IV. RESULTS AND DISCUSSION

4.1. Land Use and Land Cover Maps





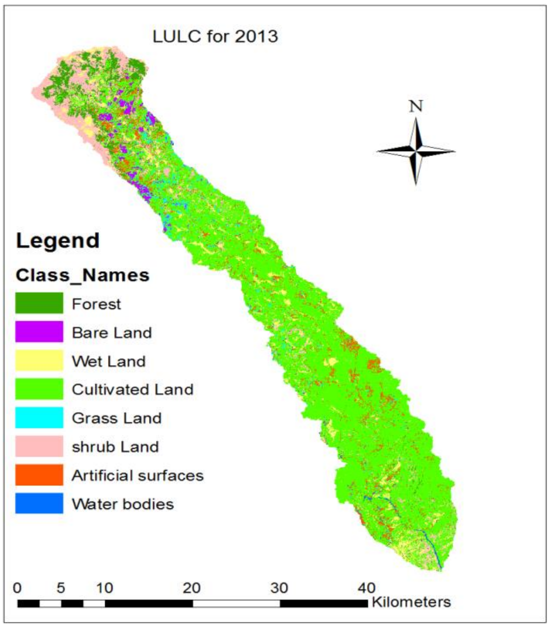


Figure 4 : Map of the Land use types of Muga watershed

The land use and land cover map of 1995 in the figure 4 shows that the total cultivated land coverage class was about 21 % of the total area of the watershed. It increased rapidly and became 55 % of the watershed in 2003 and 72% of the watershed in 2013. This is mainly because of the population growth that caused the increase in demand for new cultivation land and settlement which in turn resulted shrinking on other types of land use and land cover of the area.

On the land use and land cover map of the year 1995 in the figure 4 shows the total forest coverage was about 6 % of the total area of the watershed. On the land use and land cover map of the year 2003 it reduced to almost 5% of the total area and it reduced to almost 4% of the total area. These deforestation activities that have mostly takes place for the purpose of agriculture. In general, during the 18 years period the cultivated land increased almost 51 % whereas the forest land decreased 2 %. The individual class areas and change statistics for the two periods are summarized in table 1.

Table 1: Area of land covers types and change statistics of Muga watershed for the period of 1995 - 2013.

Land cover types	1995		2003		2013		2013-1995	
	Ha	%	Ha	%	Ha	%	Ha	%
Cultivated land	15227.3619	21.23	39571.0577	55.17	51651.9000	72.01	36422.3003	50.78
Forest	4375.2665	6.1	3514.5583	4.9	2840.2200	3.96	-1534.9296	-2.14
Shrub land	10170.701	14.18	6053.6474	8.44	560.7900	0.78	-9611.2411	-13.4
Grass land	44391.023	61.89	19946.9116	27.81	16905.449	16.3	-15485.574	-21.6
Artificial surfaces	5.7381	0.87	652.703688	0.91	687.3100	0.96	37.2974	0.52
Bare land	6168.40848	8.6	2632.33246	3.67	68.8500	0.10	-6096.683	-8.5
Water body	57.3805	0.08	25.5177	0.03	7.17257	0.01	-24.8628	-0.04
Wet land	208.004	0.29	71.7257	0.1	7.17257	0.01	-134.2783	-0.19

4.2) Sensitivity Analysis

Sensitivity analysis was performed on flow parameters of SWAT on monthly time steps with observed data of the Muga River gauge station. For this analysis, 26 parameters were considered and only 10 parameters were identified to have significant influence in controlling the stream flow in the watershed.

The result of the sensitivity analysis indicated that these 10 flow parameters are sensitive to the SWAT model i.e the hydrological process of the study watershed mainly depends on the action of these parameters. Curve number (CN2), ground water delay (GW_DELAY), soil available water capacity (SOL_AWC), soil evapotranspiration factor (ESCO), and Effective hydraulic conductivity of the main channel (CH_K2) are identified to be highly sensitive parameters and retained rank 1 to 5, respectively.

The other parameters such as, total soil depth (SOL_Z), Manning's roughness coefficient (CH_N2) Alpha factor (ALPHA_BF), threshold depth of water in the shallow aquifer required for return flow (GWQMN) and surface lag (SURLAG) are identified as slightly important parameters that were retained rank 6 to 10, respectively. The remaining parameters (16 parameters) were not considered during calibration process as the model simulation result was not sensitive to these parameters in the watershed.

These parameters are related to ground water, runoff and soil process and thus influence the stream flow in the watershed. The result of the analysis was found that Curve number (CN2) is the most important factor influencing stream flow in the Muga watershed. The Curve number (CN2) is a direct index of surface runoff response to changes in stream flow. The Muga watershed is characterized with tertiary basalt and volcanic regional geology that have good potential for ground water recharge. The other most influencing stream flow parameter in this analysis is the ground water delay (GW_DELAY).

4.3) Autocalibration Analysis

Calibration was done for sensitive flow parameters of SWAT with observed average monthly stream flow data. In this procedure, the values of the parameters were varied iteratively within the allowable ranges until the simulated flow as close as possible to observed stream flow. Then, auto calibration was run using sensitive parameters that were identified during sensitivity analysis.

Table 2 : flow sensitive parameters and their fitted value in SUFI_2

Parameters		Lower and upper bound	Fitted value
Name	Description		
CN2	SCS runoff curve number (%)	-0.2 to 0.4	0.09
GW_DELAY	Ground water delay (days)	46.4 to 458.12	447.41
SOL_AWC	Soil available water capacity (water/mm soil)	-0.35 to 0.48	0.05
ESCO	Soil evaporation compensation factor	0.03 to 1.83	1.73
CH_K2	Effective hydraulic conductivity of the main Channel (mm/hr.)	-11.35 to 113.25	52.2
SOL_Z	Total soil depth (mm)	-0.2 to 0.2	- 0.18
CH_N2	Manning's roughness coefficient	-0.12 to 0.14	-0.1
ALPHA_BF	Base flow alpha factor (days)	0.44 to 1.52	0.61
GWQMN	Threshold depth of water in the shallow aquifer required for return flow (mm)	0.08 to 2.56	1.97
SURLAG	Surface lag	0.04 to 1.06	0.96

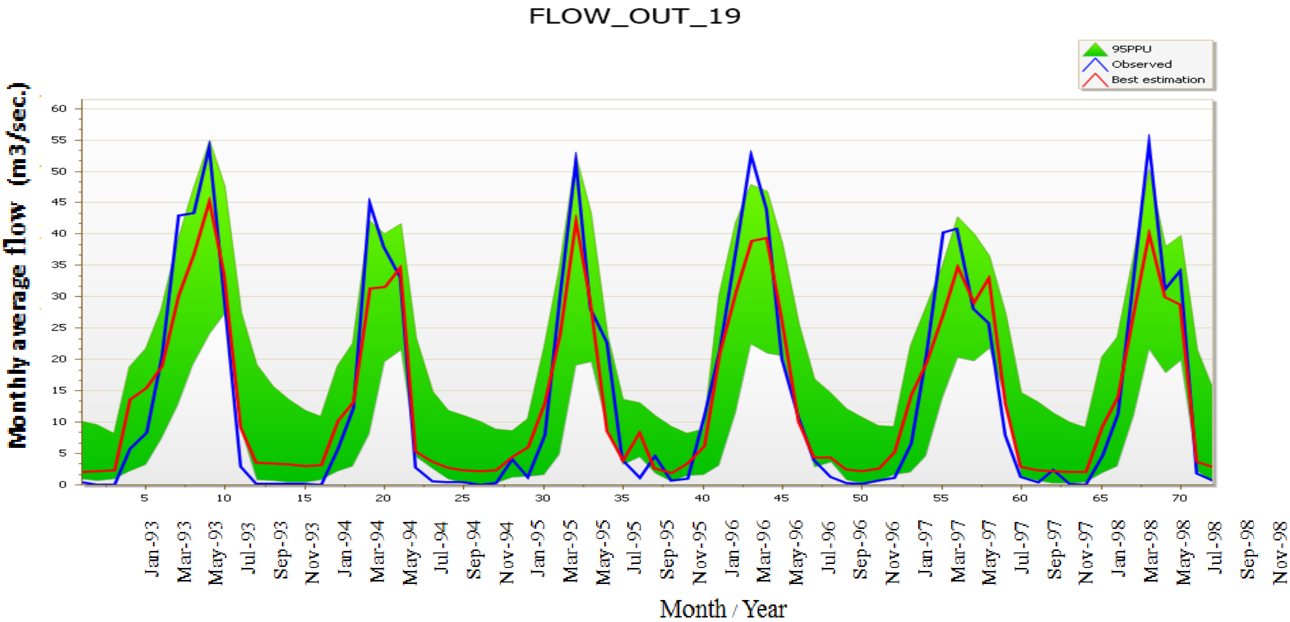


Figure 5 : The result of calibration for average monthly stream flows.

4.4) Model Validation and Evaluation

The model validation was also performed for 4 years from 1999 to 2002 without further adjustment of the calibrated parameters. The validation result for monthly flow is shown in the figure 6. The validation simulation also showed a good agreement between the simulated and measured monthly flow with the ENS value of 0.89 and R^2 of 0.90 as shown in Table 3.

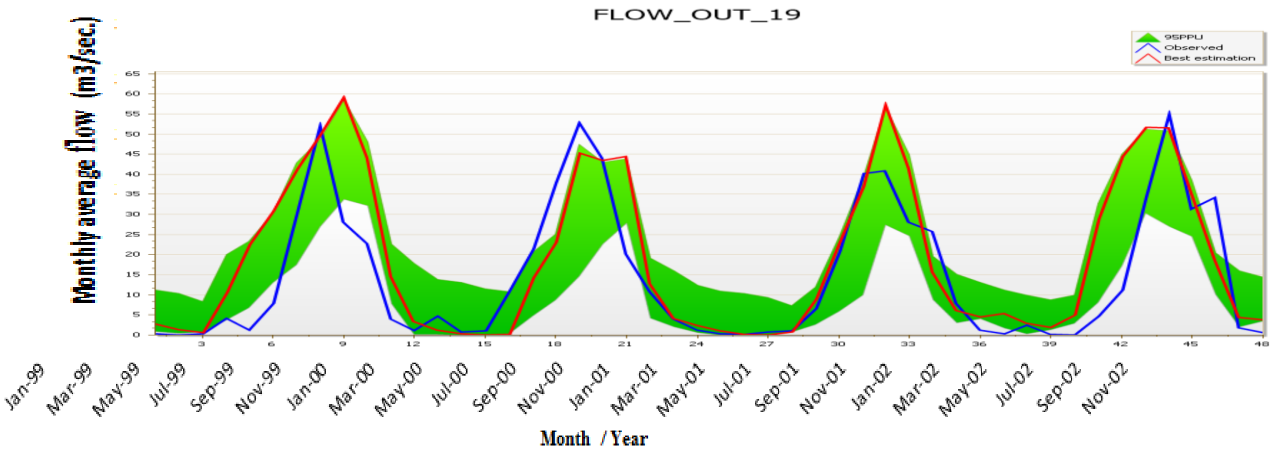


Figure 6 : The result of Validation for average monthly stream flows.

The measured and simulated average monthly flow for Muga was obtained, during the calibration period; they were 18.334 and 16.780 m^3/s, respectively. The measured and simulated average monthly flow for the validation period was 14.714 and 17.814m^3/s, respectively. These indicate that there is a reasonable agreement between the measured and the simulated values in both calibration and validation periods (Table 3).

Table 3 : Comparison of Measured and simulated monthly flow for calibration and validation simulations

Period	Average monthly flow (m^3/s)		ENS	R^2
	Measured	Simulated		
Calibration (1993-1998) Period	18.334	16.780	0.86	0.88
Validation (1999 - 2002) Period	14.714	17.814	0.89	0.90

As indicated in the Table 3, the model performance values for calibration and validation of the flow simulations are adequately satisfactory. This indicates that the physically processes involved in the generation of stream flows in the watershed were adequately captured by the model. Hence, the model simulations can be used for various water resource management and development aspects.

4.5) Effects of LULCC on stream flow and simulated sediment load of the Study area

After calibrating and validating of the model using the Three land use and land cover data for their respective periods of 1993 to 1998 and 1999 to 2002 respectively, SWAT was run using the three land cover data (1995, 2003 and 2013) for the period of 1993.

This process gave the discharge outputs for all land use and land cover patterns. Then, these outputs were compared and the discharge change during the wettest months of stream flow taken as June, July and August and driest stream flow are considered in the months of January, February and March were calculated and used as indicators to estimate the effect of land use and land cover change on the stream flow.

Table 4. presents the mean monthly wet and dry month's stream flow for 1995, 2003 and 2013 land use and land cover maps and its variability (1995 -2013).

Mean monthly flow (m^3/s)						Mean monthly flow change	
LULC data of 1995		LULC data of 2003		LULC data of 2013			
Wet months (Jun, Jul, Aug)	Dry months (Jan, Feb, Mar)	Wet months (Jun, Jul, Aug)	Dry months (Jan, Feb, Mar)	Wet months (Jun, Jul, Aug)	Dry months (Jan, Feb, Mar)	Wet	Dry
35	15.71	42.31	10.21	52.75	2.95	+ 17.75	-12.76

The mean monthly stream flow for wet months had increased by 17.75 m^3/s while the dry season decreased by 12.76m^3/s during the 1995-2013 period due to the land use and land cover change.

To assess the change in the contribution of the components of the stream flow due to the land use and land cover change and the simulated sediment yield, analysis was made on the surface runoff (SURQ) and ground water flow (GWQ). Table 4.6 presents the SURQ and GWQ of the stream simulated using 1993 and 2002 land use and land cover map for the same period.

Table 5 : Annual average Surface runoff, Ground water flow and sediment load of the stream simulated using 1995, 2003 and 2013 LULC map

Item	LULC 1995	LULC 2003	LULC 2013
Surface Runoff, mm	309.37	316.21	329.37
Groundwater (Deep Aq), mm	25.32	20.24	17.24
Groundwater (Shal Aq), mm	380.21	348.41	345.14
Total Aq Recharge mm	414.71	399.31	379.01
Total Water Yld, mm	736.21	716.64	707.36
total sediment loading, t/ha	11.124	27.431	43.515

As the table 5 showed as the SURQ and GWQ components of the stream simulated using the 1995 land use and land cover map for the period of 1993 to 2002 were 309.37 mm and 380.21mm, using 2003 land use and land cover map were 316.21 mm and 348.41mm while using 2013 land use and land cover map were 329.37 mm and 345.14, respectively. The contribution of surface runoff has increased from 309.37 mm to 329.37 mm whereas the ground water flow has decreased from 380.21 mm to 345.14 mm due to the land use and land cover change occurred between the periods of 1990 to 2015. This is because of the expansion of agricultural land over forest that results in the increase of surface runoff following rainfall events. Researcher can explain this in terms of the crop soil moisture demands.

Crops need less soil moisture than forests; therefore, the rainfall satisfies the soil moisture deficit in agricultural lands more quickly than in forests there by generating more surface runoff where the area under agricultural land is extensive. And this causes variation in soil moisture and groundwater storage. This expansion also results in the reduction of water infiltrating in to the ground. Therefore, discharge during dry months (which mostly comes from base flow) decreases, whereas the discharge during the wet months increases. These results demonstrate that the land use and land cover change have a significant effect on infiltration rates, on the runoff production, and on the water retention capacity of the soil.

Sediment yield has increased from 1995 to 2003 and from 2003 to 2013. As a result of continuous agricultural land increment, sediment loadings of the area are increasing contributing maximum sediment rate. The study also revealed that, the expansion of farm land has attributed to the increased sediment load.

Different studies have been conducted in different parts of the country to evaluate the effects of land use and land cover changes on stream flow. A modelling study of Anger watershed, in Ethiopia, (Brook *et al*, 2011) introduced that the surface runoff increased and the base flow decreased due to the expansion of agricultural land and declined of forest land. Study on a Hare watershed, in Southern Ethiopia, (Tadele, 2007) reported that due to the replacement of natural forest in to farmland and settlements, the mean monthly discharge for wet months had increased while in the dry season decreased. In the study of Chemoga watershed, in Blue Nile basin, (Abebe, 2005) reported that large volume of surface runoff occurs during the storm events since the area under forest cover decreased.

Generally, the hydrological investigation with respect to the land use and land cover change within Muga watershed showed that the flow characteristics have changed, with increase in surface flow and reduction of base flows through the selected period of study.

4.6) Contribution of Sub Basins to the stream flow and simulated sediment yield.

Table 6: Maximum and minimum surface runoff, Groundwater, sediment load contributed by each sub basin for period of 1995

No. sub basin	Surface runoff, Groundwater, sediment load contributed by each sub basin.					
	Surface runoff, mm		Groundwater, mm		Sediment yield, t/h	
	maximum	minimum	Maximum	Minimum	Maximum	Minimum
1	391.26	156.16	562.12	360.52	48.20	0.01
2	358.15	147.45	420.01	244.86	0.52	0.001
3	387.16	150.05	575.90	378.80	0.90	0.04
4	382.59	150.26	581.49	360.23	8.15	0.01
5	408.19	160.68	687.56	433.58	0.55	0.01
6	390.93	155.81	690.58	370.95	1.39	0.01
7	340.63	108.06	549.81	316.68	0.60	0.01
8	340.59	113.44	549.42	316.28	0.70	0.01
9	340.79	115.78	549.09	318.08	0.52	0.30
10	340.64	110.55	549.95	310.83	0.62	0.02
11	340.69	140.22	549.28	330.90	0.51	0.35
12	341.64	115.98	549.97	380.71	0.31	0.30
13	340.65	130.26	549.97	398.77	0.30	0.30
14	340.59	134.16	549.59	398.56	0.33	0.30
15	340.61	130.27.27	545.51	257.79	0.60	0.36
16	348.37	90.96	570.43	280.81	1.96	0.34
17	330.14	130.48	510.97	280.01	0.76	0.01
18	346.84	107.23	460.99	275.97	1.90	0.31
19	327.19	110.04	495.61	285.58	2.09	0.01

Table 7 : Maximum and minimum surface runoff, Groundwater, sediment load contributed by each sub basin for period of 2003

No. sub basin	Surface runoff, Groundwater, sediment load contributed by each sub basin.					
	Surface runoff, mm		Groundwater, mm		Sediment yield, t/h	
	maximum	minimum	Maximum	Minimum	Maximum	Minimum

1	393.24	155.59	559.19	350.52	50.37	0.02
2	353.25	152.45	413.01	235.86	0.51	0.01
3	396.19	158.05	571.91	371.80	0.90	0.04
4	395.59	157.26	580.49	362.23	10.15	0.01
5	410.17	158.68	679.46	434.58	0.55	0.01
6	395.97	159.81	686.59	377.95	1.49	0.01
7	344.63	110.06	548.81	317.68	0.64	0.01
8	345.59	117.44	548.42	318.28	0.74	0.01
9	345.79	117.78	548.09	320.08	0.53	0.32
10	345.64	117.55	546.95	318.83	0.62	0.02
11	344.69	144.22	540.28	338.90	0.53	0.35
12	345.64	129.98	550.97	388.71	0.33	0.38
13	345.65	139.26	550.97	398.77	0.35	0.35
14	344.59	144.16	550.59	398.56	0.39	0.39
15	344.61	130.27.27	540.51	255.79	0.85	0.36
16	350.37	109.96	563.43	276.81	1.96	0.34
17	330.14	132.48	509.87	278.01	0.76	0.01
18	348.84	111.23	491.98	265.96	1.95	0.31
19	330.17	111.04	489.61	285.58	2.09	0.01

Table 9 : Maximum and minimum surface runoff, Groundwater, sediment load contributed by each sub basin for period of 2013

No. sub basin	Surface runoff, Groundwater, sediment load contributed by each sub basin.					
	Surface runoff, mm		Groundwater, mm		Sediment yield, t/h	
	maximum	minimum	Maximum	Minimum	Maximum	Minimum
1	398.26	159.56	557.11	350.52	55.27	0.02
2	357.25	154.45	411.01	235.86	0.55	0.01
3	399.13	160.05	569.90	371.80	0.94	0.04
4	399.59	160.26	573.49	360.23	11.15	0.01
5	414.15	165.68	681.46	433.58	0.55	0.01
6	400.93	160.81	682.58	378.95	1.49	0.01
7	349.63	112.06	546.81	316.68	0.66	0.01
8	349.59	118.44	546.42	316.28	0.76	0.01
9	349.79	118.78	548.09	318.08	0.58	0.32

10	349.64	118.55	546.95	316.83	0.65	0.02
11	349.69	145.22	547.28	335.90	0.58	0.35
12	349.64	128.98	546.97	382.71	0.38	0.38
13	349.65	140.26	546.97	392.77	0.35	0.35
14	349.59	145.16	546.59	392.56	0.39	0.39
15	349.61	133.27.27	537.51	255.79	1	0.36
16	351.37	109.96	563.43	272.81	1.96	0.34
17	334.14	133.48	504.97	276.01	0.76	0.01
18	350.84	114.23	491.98	263.96	1.95	0.31
19	335.19	117.04	489.61	282.58	2.09	0.01

Table 10 : Summary of surface run off, groundwater and sediment load contributed by the sub basins

Item	Sub basins		Average annual Surface runoff, mm		Simulation period
	Sub basin for maximum	Sub basin for minimum	Maximum (Q_{surf}> 400 mm)	Minimum (Q_{surf}< 115)	
1	5 and 6	7,10,16,18 and 19	408.19,410.17,414.15 and 400.93	108.66,110.55,90.96,107.23,110,109.96,111.23,111.04,112.06,109.96 and114.23	1995, 2003, 2013
Item	Sub basins		Average annual Groundwater flow, mm		Simulation period
	Sub basin for maximum	Sub basin for minimum	Maximum (Q_{gw}> 600mm)	Minimum (Q_{gw}< 275)	
2	5, and 6	16,17,18 and 19	687.56,690.58,679.46,686.59,681.46 and 682.58	280.81,280.01,275.97,288.59,276.91278.01285.5,276.01 and 282.58	1995, 2003, 2013
Item	Sub basins		sediment loading, t/ha		Simulation period
	Sub basin for maximum	Sub basin for minimum	Maximum (>1)	Minimum (< 0.03)	
3	1,4 and 6	1,3,4,5,6,7,8,10,17 and 19	48.20,8.15,1.39,50.37,10.15,1.4,52.27,11.15 and1.49	0.02,0.01,0.01,0.01,0.01,0.01,0.01,0.02,0.01 and 0.01	1995, 2003, 2013

The examinations of different sub basins on their percentage contribution to the changes of the stream flow and simulated sediment were evaluated to get the prominent sub basin contributor of the catchment. The highest annual surface runoff was attributed by sub basin, 5 and 6, respectively for 1995, 2003 and 2013 and the minimum from sub basin 7, 10 and 16, for 1995, 2003 and 2013 respectively.

The contribution of ground water flow is maximum for sub basin, 5 and 6 respectively for 1995, 2003 and 2013 and minimum from sub basin, 16, 17, 18 and 19 for the period of 1995, 2003 and 2013 respectively.
In terms of sediment yield, sub basins1,4,6,15,16,18 and 19 contributes a maximum load whereas sub basins1,3,4,5,6,7,8,10,17 and 19contributes a minimum sediment load for the study periods. 5)

V. Conclusions and Recommendations

Conclusions

The impact of the land cover change on stream flow was analyzed statistically using the hydrological model, SWAT. To do this analysis, first land use and land cover change during the past 18 years (1995 – 2013) was analyzed; then SWAT model were tested for its performance at the Muga watershed in order to examining the hydrological response of the watershed to changes in land use and land cover.

The ArcGIS uses for the processing of DEM, land use and land cover, soil data layers and displaying model results. From the land use and land cover change analysis, it can be concluded that the land use and land cover of the Muga watershed for the period of 1995 to 2013 showed significantly changed. Cultivated land was drastically changed from 21 % in 1995 to 55 % in 2003 to 72% in 2013 the expenses of the other classes.

The sensitivity analysis using SWAT model has pointed out ten most important parameters that control the stream flow of the studied watershed. On the other hand, model calibration and validation have showed that the SWAT model simulated the flow adequate satisfactorily. Performance of the model for both the calibration and validation watershed were found to be reasonably good with Nash-Sutcliffe coefficients (ENS) values of 0.86 and 0.89 and coefficient of determination (R^2) values of 0.88 and 0.90 for the calibration and validation respectively. Following calibration and validation of the model, impacts of the land use and land cover change on stream flow was carried out. Land use and land cover changes recognized to have major impacts on hydrological processes, such as runoff and groundwater flow.

The result of model for all periods of land use and land cover (1995, 2003 and 2013) indicated that during the wet season, the mean monthly flow for 2013 land cover was increased by 17.75 m^3/s relative to that of 1995 land cover period while the mean monthly flow decreased by 12.76 m^3/s during the dry season. The surface runoff increased from 309.37mm to 329.37 mm, while the ground water decreased from 380.37 mm to 345.14 mm from the 1995 up to 2013 land cover data's respectively.

Recommendations

Generally, from this specific study the following recommendations could improve similar research for future work: Further research activities should be consider using different hydrological models in the region for the sake of further investigation of the impact of land use-cover change on the hydrology of sub basin.

Land use-cover change problems awareness at all levels (community, local, regional and national levels) and appropriate response techniques. It is recommendable to have more hydro meteorological data measurement instruments in and around the sub basin that could provide adequate data with better quality. Better data gathering techniques and dissemination process should be foreseen so that local and regional authorities can be involved in integrated and coordinated manner.

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