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Impact of land use/land cover change on hydrologic processes in Dijo watershed, central rift valley, Ethiopia

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The aim of this study was to assess the impact of land use / land cover changes on the hydrological process in the central valley basin of Ethiopia, from 1985 to 2018 and evaluate historical land use/land cover change using satellite image. Satellite images were classified by supervised classification technique with maximum likelihood. SWAT model were used to simulate hydrological processes in the watershed. The result of the study shows that barren lands, agricultural and settlement lands were expanded by 7 and 64%; whereas, forestlands, water bodies, shrub and grasslands were declined by 13, 57 and 41% respectively over the past three decades. The calibrated and validated SWAT model used also showed that there has been good agreement between simulated and observed streamflow on monthly basis. Streamflow evaluation due to LULC change influence showed that mean monthly simulated streamflow was increased by 10.84% between the years 1985 and 2003, also increased from the year 2003 to 2018 by 9.3% in wet months; whereas, decreased by 8.23 and 11.4% between 1985-2003 and 2003-2018 in dry months. Therefore, hydrological process of the watershed was highly influenced by LULC changes and it requires integrated watershed management techniques.

Key words: Digital image processing, Gis, hydrologic process, landsat image.

INTRODUCTION

Improper agricultural based economy and the alarmingly increase in human population are the main cause of land Use/Land Cover (LULC) change in developing countries (Aman et al., 2014). Scarcity of resource is the root cause for LULC change and largely driven by the decision of the people, population growth, declining household farm size and income (Hamza and Iyela, 2012). It has significant influence on quantity or quality of stream flow (Aman et al., 2014; Bewket and Sterk, 2005). Several research that have been carried out in many parts of Ethiopia explore that agricultural land had expanded at the expense of natural vegetation, forest, shrub and grass lands for example (Tekleab and Kassew, 2019; Samuel et al., 2018; Megersa and Taffa, 2018; Kassa, 2009; Kassa and Förch, 2007; Kibret et al., 2016; Getachew and Melesse, 2012).

Rapid population growth, deforestation, traditional agriculture techniques, and improper land use have result to massive land degradation with water scarcity, decrease product availability and services of the livelihood

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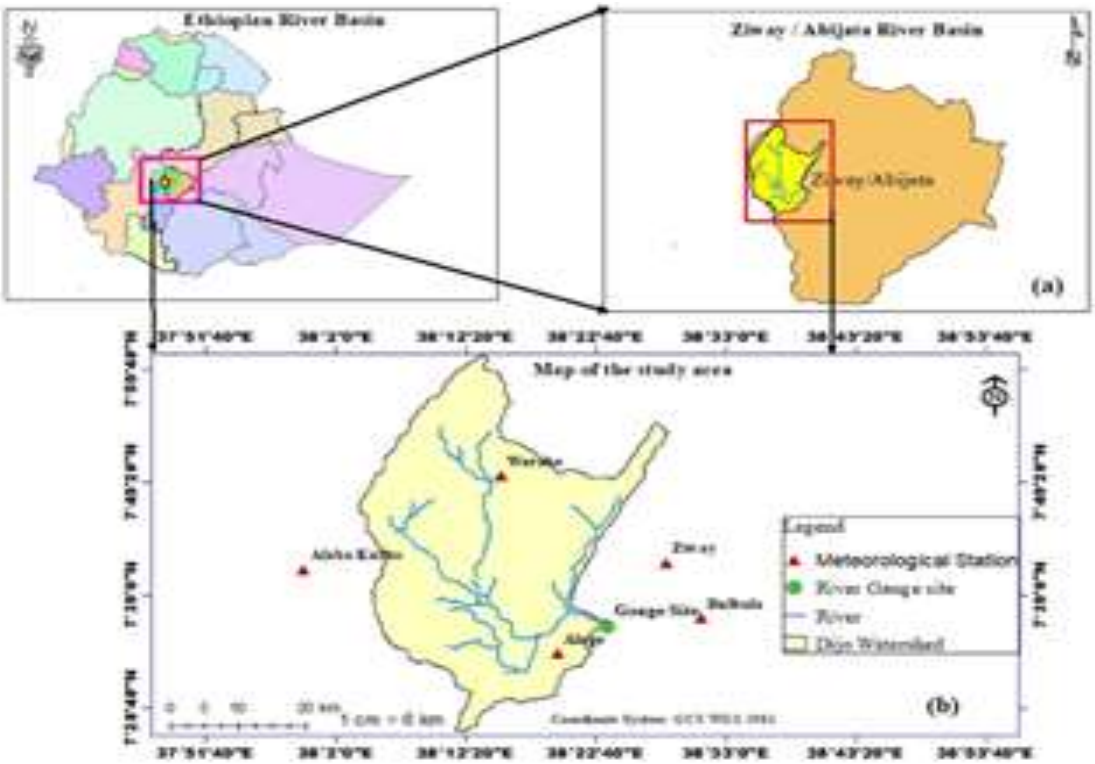

Figure 1. Location map of the study area.

(Takalaa et al., 2016; Badege, 2003). Under such circumstance, handling the land and water resources to achieve high productivity would be difficult to realize. Evaluating impact of LULC change on hydrological process is an essential task to predict reasonably the possible LULC changes at the watershed level considering the dominant land use practices of the area. However, the LULC change effect on hydrologic process at watershed scale is still an unresolved problem and is now a primary concern for most countries, which are commonly experiencing LULC change caused by increasing populations and demand for accommodations (Getachew and Melesse, 2012). Consequently, there is an increasing need in Ethiopia to identify land cover and water linkages that helps for optimal utilization and management of available water resources. This is especially true in areas where there is substantial LULC changes and high competition of water resources between upstream and downstream water users. Therefore, integrated research approach that focuses on solving these problems is essential for sustainable water resources development. However, effective utilization and management of the water resources require detecting and simulating impacts of LULC changes and management practices on hydrological regimes and its effect on water availability at down streams water users.

Simulation models are necessary instruments for studying responses of the hydrological regime to LULC change scenarios and land management options if they are built on a sound understanding of the hydrological processes (Singh and Woolhiser,2002). Recently there is a trend of coupling simulation models in such a way that outputs from a simulation model can be used as a policy maker. The outcome of simulation approach can significantly enhance the ability of practitioners, planners, and researchers to develop watershed management strategy. Moreover, this study was aimed to evaluate historical LULC change impact on hydrologic process of the watershed using the conceptual physical based hydrological model.

MATERIALS AND METHODS

Description of the study area

Dijo watershed is located on the western part of Lake Ziway/Abijata sub-basin in central rift valley basin of Ethiopia. The total area of the watershed is 1426 km^2 and geographically it is located between 7° 28' 40" to 7° 59' 40" latitude in the north and 37° 51' 40" to 38° 53' 40" east longitude (Figure 1). The study area is located 65 km from Ziway town and 230 km from Addis Ababa to the south. The altitude of the watershed ranges from 1620 m. a. s. l at the river bed to 3180 m. a. s. l at the upper part of the watershed and covers slope range from flat 0° to steep 35° (Figure 2b and c). The topography of study area is extremely rugged. The major land forms range from moderate to high hills, dissected gully, an upland plateau, and escarpments, deep dissected gorges14. The dominant

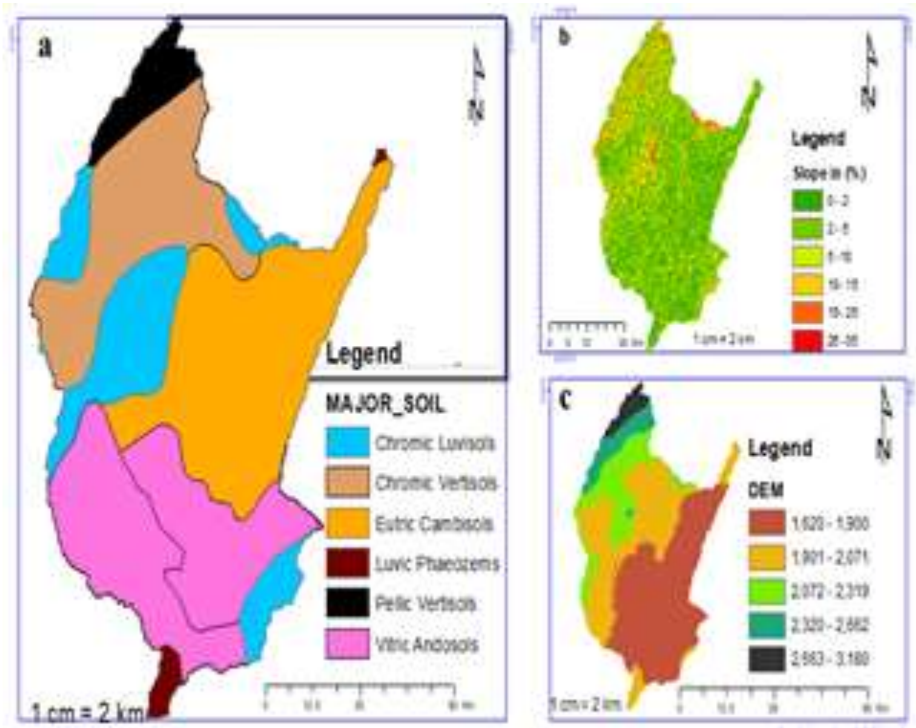

Figure 2. Spatial data of the study area: a) major soil, b) slope and c) DEM in (meter).

soil types of the watershed are Chromic Luvisols (60.11%) followed by Chromic Vertisols (15.1%), Chromic Vertisols (5.2%), Eutric Cambisols (16%), Luvic Phaeozems (4.5%), Pellic Vertisols (11%) and Vitric Andosols (48.1%)(Figure 2a). The watershed is characterized by a diverse land use land cover; includes forest, agriculture and settlement, shrub and grassland, barren land, settlement and water bodies, which comprises about 5.9, 60.1, 31.9, 1.8 and 0.3%, respectively, based on 2018 LULC.

Climate of the study area

The agro-climate of the watershed ranges from dry semi-arid in the lower part to wet sub humid in the upper part. In the watershed, there are two rainy seasons (bi-modal rainfall patterns) such as heavy rainfall from June to September and low rainfall from March to April. The watersheds receive its maximum rainfall during June to September (65 to 70% of the annual rainfall). The second rainy period covers the period from February to May (15 to 20%) of the annual rainfall (Figure 3). The long term mean maximum temperature over the period of 1985-2018 is about 26.9°C and the mean minimum temperature computed over the same period is 13.2°C. The mean annual potential evapo-transpiration (PET) 153.5 mm/yr was computed over the watershed from year 1985-2018 (Figure 3).

Data types and sources

Both primary and secondary types of data were used for analysis. It was collected from various sources. For example climatic data (that is daily rainfall, maximum and minimum temperature, relative humidity, wind speed and solar radiation) were collected from the National Meteorological Agency (NMA). The daily stream flow data from the year 1985 to 2018 at Jido and Furfuro station were collected from Ministry of Water, Irrigation and Energy (MoWIE). Landsat data were downloaded cloud free of charge from U.S Geological Survey website via (http://glovis.usgs.gov/). Digital Elevation Model (DEM) with 30 by 30 m cell size was obtained from high grid resolution raster data from the USGS databases of the SRTM (Shuttle Radar Topography Mission) website via (http://earthexplorer.usgs.gov/). Soil data were obtained from Digital Soil Map of the World (DSMW) website (http://fao.org/soils-portal/soil-survey/soil-maps/). A series of Landsat MSS of the year 1973-01- 02, TM of the year 1985-02-01, TM of the year 2003-02-01 and ETM+ 2018-01-01 with path 168 and row 055, path 168 and row 054 and path 169 and row 055 covering the watershed area were selected. Selections of these four different year satellite image were based on historical droughts, political, policy and social changes.

Hydro-meteorological data quality controls

Testing quality of hydro-meteorological data is an essential duty for reliable prediction of the model output. Basic data quality checks (that is the location of the station, homogeneity, consistency, persistence, filling missing data etc.) were done for selected stations. Different class (class I to class IV) meteorological station were located within and around the watershed (Figure 1). The missing records in climate data series were filled by the weather generator embedded in SWAT model. The missing data in stream flow records were filled by regressing the flow at Furfuro gauging station in the headwater within the watershed and the stream flow at Jido gauging station with a coefficient of determination (r^2=0.91). The upper and lower limit outlier test was compute for a sequential series of hydro-meteorological data. The Tukey fence methods were used to screen the outliers greater or less than a threshold value that can affect the detection of inhomogeneity. The outlier test was checked by micro- excels and the data array is characterized as Equation 1.

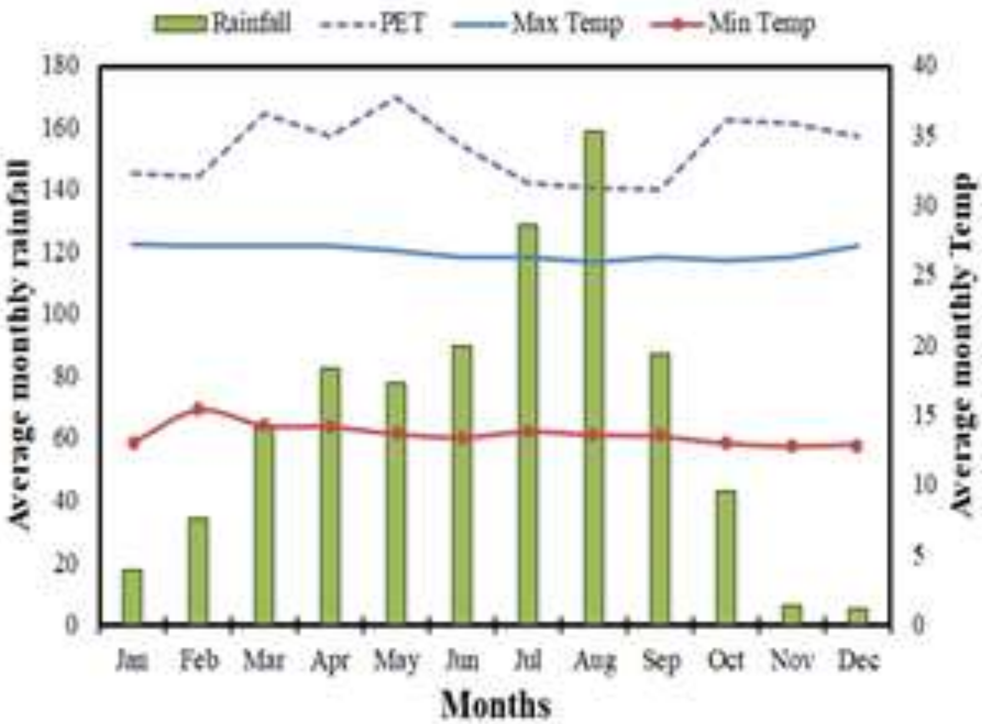

Figure 3. Long term mean monthly rainfall, PET, maximum and minimum temperature in Dijo watershed.

$$OT = [Q_1 - 1.5 * IQR \;\; and \;\; Q_3 + 1.5 * IQR] \quad (1)$$

Where: OT is outlier test, Q1 and Q3 are the lower and upper quartile points, respectively; 1.5 is standard deviations from the mean, and IQR is the inter-quartile range. The values outside the Tukey fence are considered as outliers. In this study, such outliers test was set to a limit value corresponding to 1.5 × IQR.

The homogeneity test for selected hydro-meteorological data time series was tested by evaluating the maximum and the range of the cumulative deviations from the mean. In this study, homogeneity test was done using RAINBOW software as Equation 2.

$$S_K = \sum_{i=1}^{k} (x_i - \bar{x}), \qquad \text{where } i = 1, 2, 3 \ldots\ldots n. \quad (2)$$

Where: xi is the records from the series x_1, x_2… x_n and $\bar{x}$ the mean. The initial values of SK=0 and last value SK=n are equal to zero. If there is no significant change among the mean, deviation of x_i and $\bar{x}$ will be fluctuate around zero.

METHODS OF DATA ANALYSIS

Image pre-processing technique

Different data pre-processing techniques were used such as; image enhancement, geometric and radiometric correction were implement to prepare land use map. Image enhancement techniques were used to contrast stretching at 2.5%, and false color composites to facilitate the identification of features. The accuracy of classified image was assessed by computing the error matrix (also known as confusion matrix or contingency table) that compares true world class result with ground truth information as suggested by DeFries and Chan (2000). The overall accuracy of classified image was computed based on Foody (2002) as Equation 3:

$$\mathrm{OA} = \left(\frac{\mathrm{x}}{\mathrm{y}}\right) * 100 \quad (3)$$

Where, OA is overall accuracy, x is number of correct values in the diagonals of the matrix, and y is total number of values taken as a reference point. Kappa is used to measure the agreement or accuracy between the remote sensing derived classification map and the reference data as indicated by the major diagonals and the chance agreement, which is indicated by the row and column totals (Jensen, 2005). Kappa coefficient can be calculated using Equation 4 according to Gwet (2002).

$$\mathrm{Kappa(K)} = \frac{\mathrm{p_o} - \mathrm{p_e}}{1 - \mathrm{p_e}} \quad (4)$$

Where: Po = is the proportion of correctly classified cases, Pe is the proportion of correctly classified cases expected by chance.

Evaluation of the hydrological process due to LULC change

To evaluate the variability of stream flow due to land use land cover

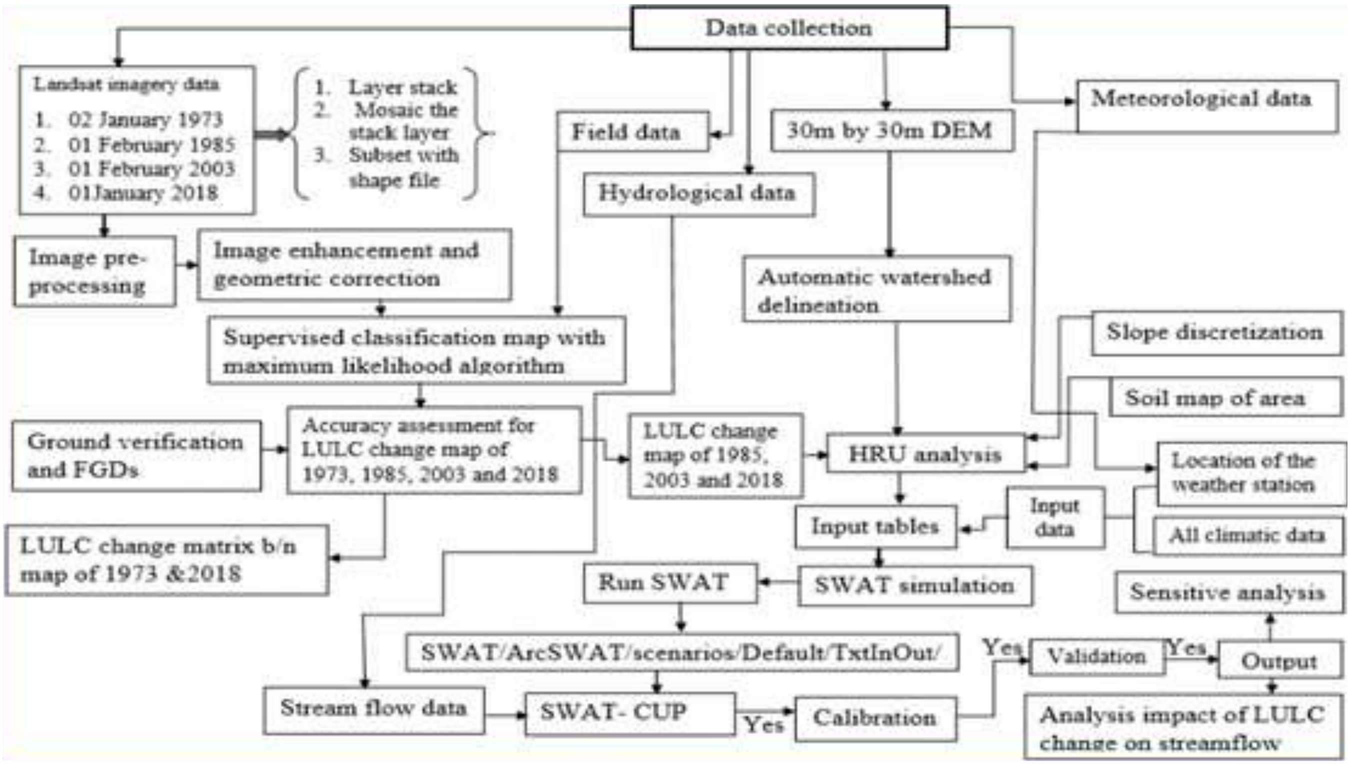

Figure 4. Conceptual framework for LULC changes analysis and ArcSWAT processing. Sensitivity analysis.

change from 1985 to 2018, three independent SWAT simulation runs were conducted on a monthly basis. Seasonal stream flow variability of 1985, 2003 and 2018 due to the land use land cover change was assessed based on simulation stream flow data. The comparison was made on surface runoff, base flow and ground water flow contributions to stream flows. Moreover, depending on the three simulation outputs, the periodic variability of the hydrological process due to the LULC changes were assessed certain sensitive parameters during calibration and validation. The overall LULC classification procedure and SWAT simulation was present in Figure 4.

Hydrological modeling inputs

ArcSWAT model requires an input to analysis HRU of the sub-basin and SWAT simulation. These inputs are Digital Elevation Model (DEM), land use map, soil map, all climatic parameters with their location and observed stream flow data. SWAT requires long-term daily records of meteorological data (that is, precipitation, relative humidity, minimum and maximum temperature, wind speed, solar radiation) and location of meteorological station were prepared by WGEN weather generator based on WGEN user table format.

Sensitivity analysis

Sensitivity analysis was carried out to identify the most sensitive parameters for the model calibration using One-factor-At-a-Time (LH-OAT), which is an automatic sensitivity analysis tool implemented in SWAT-CUP22. Upon the completion of sensitivity analysis, the relative sensitivity (RS) values of the parameters were used to rank the parameters, and their category of classification based on17. RS can be small to negligible (0 < RS < 0.05), medium (0.05 < RS < 0.2), high (0.2 < RS < 1) and very high (RS > 1).

Calibration and validation of the SWAT model

Calibration is correction of model parameters based on results against observations to ensure the same response over time. In this procedure, model parameters varied until recorded flow patterns are accurately simulated. For this study, Model calibration and validation analysis was done automatic which amalgamated in SWAT2012, using SWAT-CUP version 5.1.6.

Evaluating the performance of simulation model in relation to the measured coefficient of determination (R^2), the18 model efficiency coefficient (NSE), percentage bias (PBAIS) and observation standard ratio (RSR), determined accuracy of SWAT model simulation result. The value of R^2 is the indicator of strength of linearity relationship between actual and simulated values. The value of R^2 ranged between 0.0 to 1.0 and therefore, the higher the value, the better the agreement. The value of R^2 was obtained using Equation 5:

$$R^2 = \left(\frac{\Sigma_{i=1}^{n}(O_i-\bar{O})(P_i-\bar{P})}{\{\Sigma_{i=1}^{n}(O_i-\bar{O})^2]^{0.5}[\Sigma_{i=1}^{n}(P_i-\bar{P})^2]^{0.5}}\right)^2 \quad (5)$$

Based on 18, the value of NSE indicates that how well the predicted values and actual values fit the 1:1 line, the values ranged from infinite (∞) to one. The lower or closer values to zero indicating poor model performance, whereas, if the value is equals to one shows perfect model performance. According to 19 the general performance of NSE in SWAT is NSE>0.65 is very good, NSE

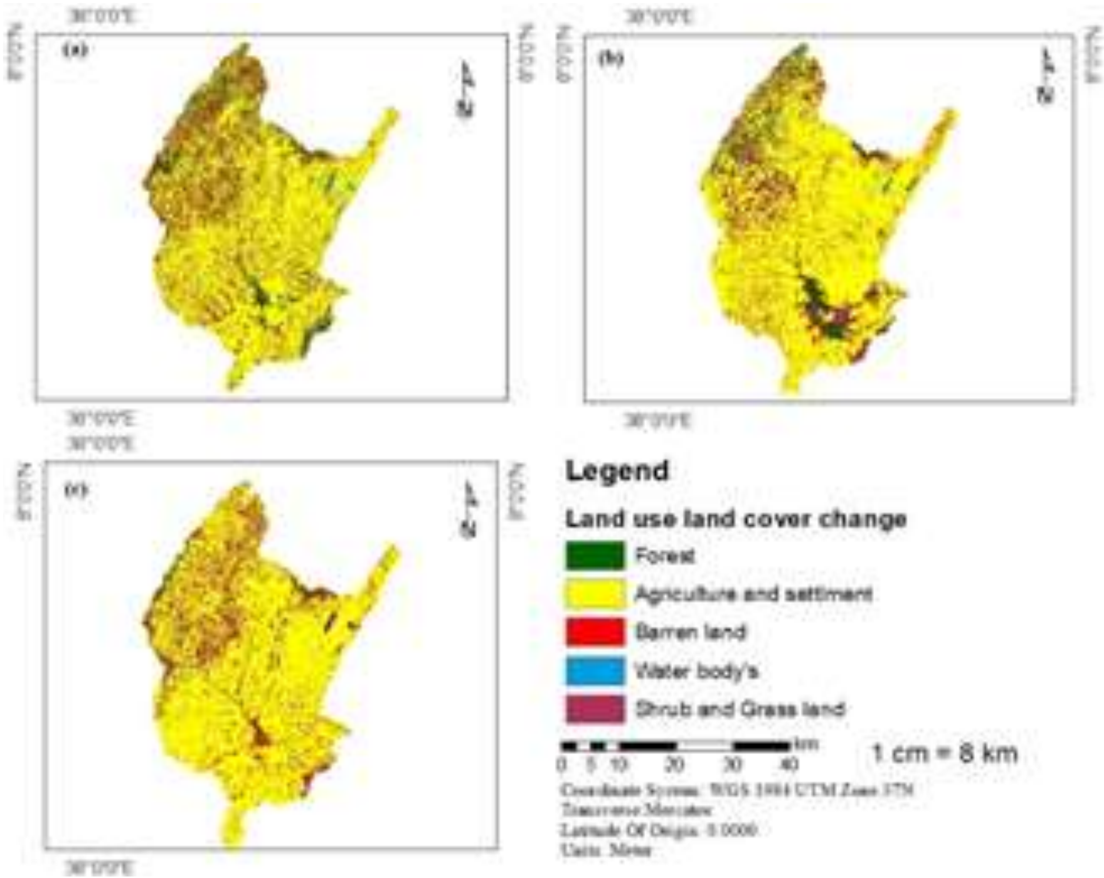

Figure 5. LULC map of Dijo watershed in the year a) 1985, b) 2003 and c) 2018.

between 0.5 and 0.65 is adequate, NSE >0.5 is satisfactory and NSE<0.5 is unsatisfactory both for calibration and validation. Using simulation coefficient NSE the SWAT model was calibrated on monthly basis using the following Equation 6:

$$\mathrm{NSE} = 1 - \left[\frac{(\Sigma_{\mathrm{i}=1}^{n}(\mathrm{O_i} - \mathrm{P_i})^2}{\Sigma_{\mathrm{i}=1}^{n}(\mathrm{O_i} - \bar{O})^2}\right] \tag{6}$$

The observation standard deviation ratio (RSR) standardizes RMSE using the observation standard deviations. It was used to combine an error index and the additional information suggested by RSR is calculated as the ratio of the RMSE and standard deviation of measured data, as given in Equation 7.

$$\mathrm{RSR} = \frac{RMSE}{SDEV_{obs}} = \frac{\sqrt{[\Sigma_{\mathrm{i}=1}^{n}(\mathrm{O_i} - \mathrm{P_i})]^2}}{\sqrt{[\Sigma_{\mathrm{i}=1}^{n}(\mathrm{O_i} - \bar{O}]^2}} \tag{7}$$

Where, RSR is ratio of standard deviation, RMSE is root mean square error; SDEobs is standard deviation of observed streamflow data.

Furthermore, according to20, Percent bias (PBIAS) measures the average tendency of predicted value to be the larger or smaller their actual counterparts. The value of PBIAS is 0.0, with smaller magnitude values showing exact model simulation 19. The positive value reflect model underestimation bias, and the negative values reflect model over estimation bias20. PBIAS is obtained by using Equations 8:

$$PBIAS = \frac{\Sigma_{\mathrm{i}=1}^{n}(\mathrm{O_i} - \mathrm{P_i})}{\Sigma_{\mathrm{i}=1}^{n}(\mathrm{O_i})} * 100\% \tag{8}$$

Where: PBIAS is a percent of biasness; O_i is the i^{th} observed value for the stream flow ($m^{3/s}$), and P_i is the i^{th} predicted value for the stream flow ($m^{3/s}$), $(\bar{O})$ is the mean of observed stream flow for the entire evaluation time period ($m^{3/s}$) and $(\bar{P})$ is the mean of model predicted stream flow for the entire evaluation time period ($m^{3/s}$), and n is the total number of observation.

RESULTS AND DISCUSSION

LULC dynamics analysis

The major types of LULC shown on the maps of 1985, 2003, and 2018 include barren land, agriculture and settlement, forest land, water body, shrub and grass land (Figure 5). In 1985, shrub and grass land were the dominant LULC types with the area of 773 km2 (54.3%); whereas, in 2018 these LULC types were highly

Table 1. Areas of LULC types in the study area from the year 1985 to 2018.

LULC type	LULC 985		LULC 2003		LULC 2018	
	Area (km^2)	%	Area (km^2)	%	Area (km^2)	%
FRST	96	6.7	81	5.7	84	5.9
AGRL	523	36.7	793	55.6	857	60.1
RNGE	773	54.3	511	35.8	455	31.9
BARR	24	1.7	35	2.5	25.7	1.8
WATR	10	0.7	6	0.4	4.3	0.3
Total	**1426**	**100**	**1426**	**100**	**1426**	**100**

Note: %=Percentage; FRST=forest land; AGRL=agriculture and settlement land; RNGE= shrub and grass land; BARR= barren land; and WATR= water body's

Table 2. Rate and percentage of LULC change in the study area.

LULC type	1985-2003		2003-2018		1985-2018	
	Rate (km^2/yr)	(%)	Rate (km^2/yr)	(%)	Rate (km^2/yr)	(%)
FRST	-0.83	-15.6	0.2	3.7	-0.36	-13
AGRL	15	51.6	4.3	8.1	10.12	64
RNGE	-14.6	-33.9	-3.7	-11	-9.64	-41
BARR	61.1	45.8	-0.62	-26.6	0.05	7
WATR	-0.22	-40	-0.11	-28.3	-0.17	-57

Note: Positive and negative signs indicate the increase and decrease of LULC class, respectively.

decreased to 455 km^2 (31.9%) (Table 1, Figure 5 a and c). However, from the year 1985 to 2018, agriculture and settlement land increased from 523 km^2 (36.7%) to 857 km2 (60.1%) (Table1). Water bodies accounted for 10 km2 (0.7%), 6 km^2 (0.4%) and 4.3 km^2 (0.3%) of the total area of the study watershed in the years 1985, 2003 and 2018 respectively (Table 1). On the map of 2003 agriculture and settlement land become the dominate land cover in the watershed with value of 793 km^2 (55.6%) and followed by shrub and grass land 476 km^2 (35.8%), forest land 81 km^2 (5.7%) and barren land 35 km^2 (2.5%) (Table 2). This shows there was expansion of agricultural land at the expense of shrub and grass land. Furthermore, in 2018, the map forest land and barren land cover an area about 84 km^2 (5.9%) and 25.7 km^2 (1.8%) (Table1). The barren land was also overspread following the similar trend as agriculture and settlement land, and its area became highest in 2018 compared with the land cover in 1985. On the contrary, the forest land, shrub and grass land and water bodies are reduced from 1985 in 2018 (Table 1).

The result obtained is in close agreement with result obtained by24-25 forest land, shrub and grass land was shrinking, while barren land, agricultural and settlement land increased significantly; whereas 26-27 it found the opposite, in terms of magnitude for changes. 24 point out that the cultivated land and settlement land expanded by 67.38 and 53.2% respectively; whereas, forest land, respectively (1972-2017). Similarly, 25 reported that an increase in agricultural and barren land have expanded at an average rate of 2322.9 and 726.6 ha/yr; while, the wood land was decreasing at an average rate of 2833.8 ha/year in the past 25 years (1985-2010).

Trend of LULC change in Dijo watershed

The period between 1985-2003 years revealed that the land under forest, water bodies, shrub and grass land rate are continued to decrease by 0.83 km^2/yr (15.6%), 14.6 km^2/yr (33.9%) and 0.22 km^2/yr (40%) respectively (Table 2); whereas, the land cover under barren land, agriculture and settlement land rate are continued to increase by 61.1 km^2/yr (45.8%) and 15 km^2/yr (51.6%) respectively (Table 2). Besides, the result for the second period (2003-2018) showed that the rate of land under agricultural and settlement land increased by 4.3 km^2/yr (8.1%) and forest land increased by 0.2 km^2/yr (3.7%); while rate of, water bodies, barren land, shrub and grass land decreased by 0.11 km^2/yr (28.3%), 0.62 km^2/yr (26.6%) and 3.7 km^2/yr (11%) respectively (Table 2). During this period forest land, agriculture and settlement was increased at the expense of other LULC categories, mainly barren land, shrub and grass land decreased.

This is because after the high conversion of forest land into agriculture the land in second period becomes degraded and soil erosion occurred. Consequently, shrub land, and grass land declined by 66.35 and 18.36%

Table 3. Relative sensitivity of SWAT parameters for stream flow under different LULC changes maps.

SWAT code	AR	1985 LULC			2003 LULC			2018 LULC		
		Rs	Rk	Sc	Rs	Rk	Sc	Rs	Rk	Sc
CN2	0-100	0.45	1	H	0.52	1	H	0.542	1	H
ALPHA_BF	0 -1	0.428	2	H	0.334	2	H	0.312	2	H
GWQMN	0-5000	0.377	3	H	0.323	3	H	0.314	3	H
ESCO	0-1	0.15	5	M	0.17	5	M	0.181	5	M
SOL_AWC	0-1	0.22	4	M	0.21	4	M	0.231	4	M
CANMX	0-100	0.052	6	M	0.063	6	M	0.073	6	M
SOL_K	0-2000	0.017	7	S	0.016	8	S	0.015	8	S
GW_DELAY	0-500	0.011	8	S	0.017	9	S	0.018	7	S

Note: AR= Allowable Range; Sc= sensitivity class; Rk= Rank; H= High; M=Medium and S=Small; RS, is relative sensitivity; the small value to negligible 0 < RS < 0.05; Medium (0.05 < RS < 0.2; High 0.2 < RS < 1, very high RS > 1.0 (Lenhart et al., 2002).

EPRDF declares policy on integrated and participatory watershed management was implemented in the country since 2005/2006. This result is in agreement with finding of 28agriculture increased by 10.1%, settlement increased by 26.6%; while forest land decreased by 20.5% and grass land decreased by 53.2% in the year 1985-1995 at Somoda watershed. Moreover, (Arragaw and Bewket, 2017) obtained agriculture and human settlement increase while water body, forest and wood land are significantly decrease in CRV, of Ethiopia in year 1985 to 2015.

Stream flows sensitivity analysis

The sensitivity analyses were needed to determine the most sensitive parameters in the watershed for the calibration process, using simultaneous analysis method. In this analysis, varying and adjusting all parameter with allowable range at the same time before running model. After 150 to 500 iterations were done, eight most sensitive parameters were selected and used during the calibration as well as validation process including parameter sensitivity ranks (Table 3). Sensitivity analysis results of SWAT-CUP model stream flow parameters shows a range of small to high sensitivity class for 1985 LULC, 2003 LULC and 2018 respectively (Table 3). SCS runoff curve number (CN2), Base flow alpha factor (ALPHA_BF), and Threshold depth of water in the shallow aquifer required for return flow (GWQMN) were identified to be highly sensitive parameters and ranked 1 to 3, respectively.

Parameters like soil available water capacity (SOL_AWC), soil evaporation compensation factor (ESCO) and maximum canopy storage (CANMX) are identified as slightly important parameters that were retained rank medium sensitive, respectively. Ground water delay (GW_DELAY) and –Soil hydraulic conductivity (SOL_K) was found with small range of sensitive class (Table 3). The variation in sensitivity level of flow parameters for the three reference land uses occurs for those parameters which their sensitivity index laid in medium and low class. Similar results were obtained by (Abbaspour KC et al., 2017).

Calibration and validation of stream flows

The periods of 1990-1995, 2001-2006 and 2011-2015 were used for stream flow calibration of 1985 LULC, 2003 LULC and 2018 LULC; whereas, stream flow data used for validation of 1996-2000 with LULC of 1985, 2007 to 2010 using LULC of 2003 and 2016-2018 using LULC of 2018 (Figures 6, 7 and 8). These periods were selected for model calibration as meteorological and stream flow records during this period were complete and include both high and low flow conditions comparatively. The SWAT model during calibration and validation were done using observed stream flows in monthly time series at Jido gauging stations.

The result for the three land use maps indicated that the simulated and observed discharge indicates good efficiency both at calibration and validation periods (Table 4). During the calibration periods (1990-1995), the value of coefficient of determination R^2 was obtained as 0.91; whereas, NSE during calibration result was 0.86. The value of measured and observation standard ratio (RSR) is 0.95, the percentage bias (PBIAS) is -8.6% (Table 4). Conversely, during validation period from the year 1996-2000, the value of coefficient of determination (R^2) is 0.89. While, for the same times the value of Nash and Sutcliffe Efficiency (NSE) is 0.82, measured and observation standard ratio (RSR) is 0.81, and percentage bias (PBIAS) is 8.6% for 1985 LULC (Table 4).

The calibration and validation result indicates that the model achieved a relatively good fit between predictions and observations for 2003 LULC. The value of R^2, NSE, PBIAS and RSR is 0.93, 0.81. -11.6% and 0.89 respectively during calibration periods from 2001-2006

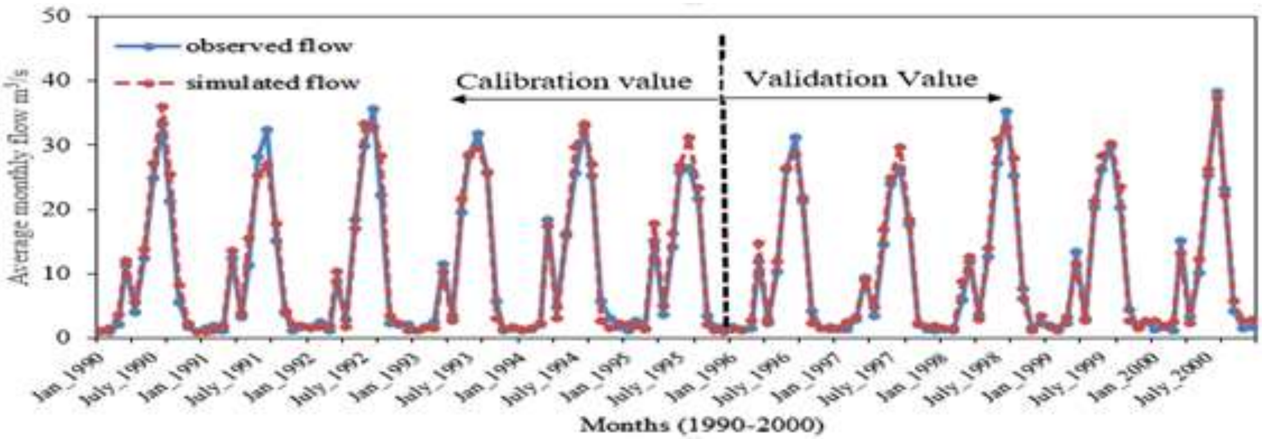

Figure 6. Observed and simulated monthly flow hydrograph of calibration and validation for 1985 LULC map.

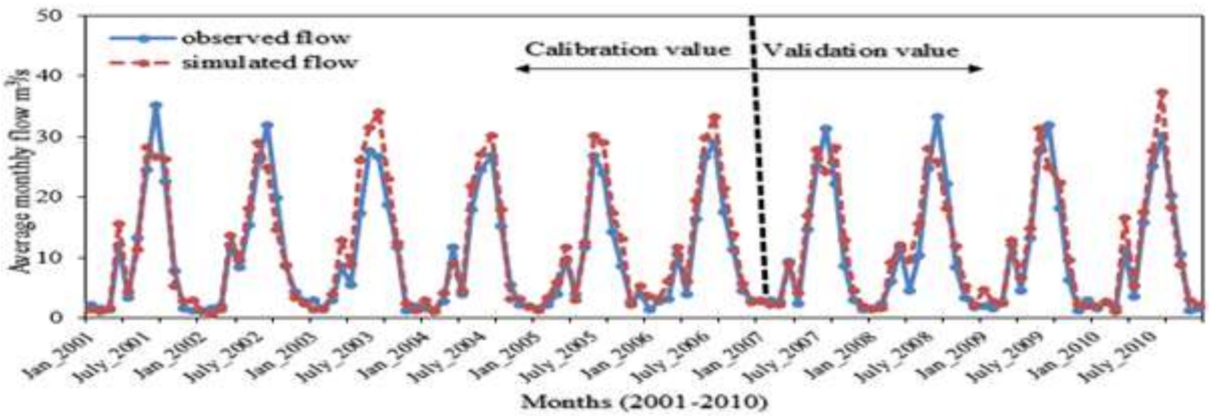

Figure 7. Observed and simulated monthly flow hydrograph of calibration and validation for 2003 LULC map.

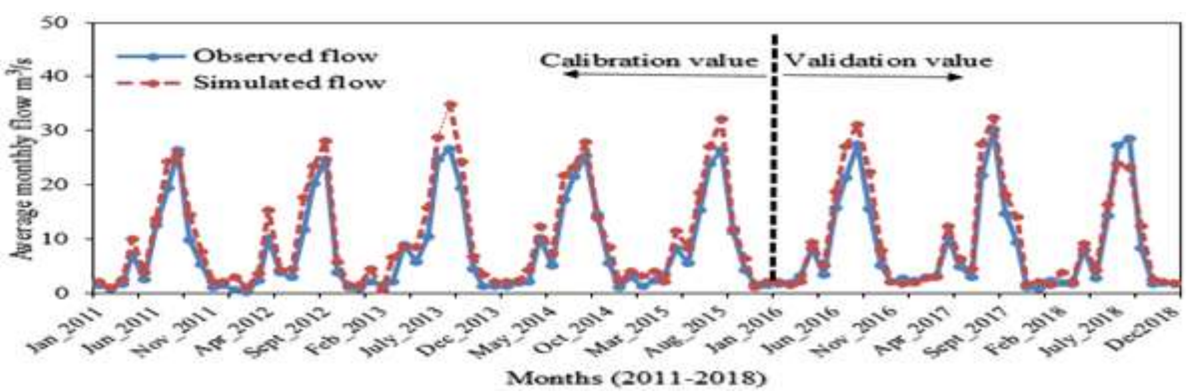

Figure 8. Observed and simulated monthly flow hydrograph of calibration and validation for 2018 LULC map.

(Table 4). Whereas, the result during validation process for the period 2007-2010, R^2, NSE, PBIAS and RSR is 0.91, 0.88, -10.8% and 0.76 respectively (Table 4). Moreover, for 2018 LULC map the value of R^2, NSE, PBIAS and RSR is 0.89, 0.84, -7.2, and 0.78 respectively during calibration process from 2011-2015 (Table 3).

Table 4. Model performance for calibration and validation on stream flow.

Performance criteria		LULC of 1985		LULC of 2003		LULC of 2018	
		Calibration	Validation	Calibration	Validation	Calibration	Validation
1	R^2	0.91	0.89	0.93	0.91	0.89	0.86
2	NSE	0. 86	0.82	0.81	0.89	0.84	0.79
3	PBIAS	-8.6	-4.3	-11.6	-10.8	-7.2	-10.4
4	RSR	0.95	0.81	0.89	0.76	0.78	0.81

While, during the validation period, 2016-2018, the value of R^2, NSE, PBIAS and RSR were 0.86, 0.79, -10.4% and 0.81 respectively (Table 4). Moreover, according to the studies carried out by Moriasi et al. (2007) and Santhi et al. (2001), if the value of coefficient of determination Nash and Sutcliff (1970) Efficiency are getter than 0.5 and the PBIAS is within the range of 15%, it is inferred as the model calibration and validation result is a very good performance.

Impact of LULC change on stream flows

This study investigates the impact of LULC change on stream flow in Dijo watershed. Also, seasonal variability of stream flow was evaluated on wet (Jun, Jul, Aug, and Sep) and dry (Dec, Jan, Feb, and Mar) months. The wet mean monthly stream flow between the year 1985 to 2003 increased by 10.83%; while, dry season mean monthly stream flow was decreased by 8.22% (Table 5). However, stream flow was increased in 2018 in wet season by 9.25% and reduced in dry season by 11.39% as compared to 2003 due to LULC alteration (Table 5). This was attributed due to expansion of the barren lands, agriculture and settlement lands; but with significant declining of forest land, shrub and grass lands in the watershed. The result showed that mean monthly stream flow and surface runoff simulation was increased from the 1985 to 2003 and further stream flow and surface runoff was also increased between the years 2003 to 2018 (Table 5). While mean monthly ground water and base flow simulation was decreased from the years 1985 to 2003 and also decrease from the years 2003 to 2018 (Table 5). Agriculture and settlement land was the major cover in the year 2003 which expanded at the expense of other land use from the year 1985 to 2003. Therefore, high runoff was generated during this period; this increased stream flow of 2003 as compared to 1985. Moreover, in the year 2018, land area under agriculture and settlement was also increased at expense of the shrub and grass land was decreased.

Consequently, for the same reason, the stream flow was increased in 2018 as compared to 2003. Widely, during the study period, Dijo watershed experienced an increase of stream flow due to radical LULC alteration. Change in monthly surface runoff, ground water and base flow because of LULC alteration was evaluated for year 1985, 2003 and 2018. It was obtained that the mean monthly surface runoff was increased from 1.62 to 1.76 mm; whereas, ground water decreased from 3.5 to 3.1 mm from 1985 to 2003 (Table 5). So, high surface runoff was generated in the year 2003 as compared to 1985; while ground water store declined due to expansion in the area under agriculture and settlement with declining of forest land, shrub and grass land.

Furthermore, in the year 2018, there was an increment of agriculture and settlement at the expense of other land covers, this leads to increase of surface runoff and decreasing ground water compared to year 2003. Besides, base flow was decreased from 4.1 to 2.5 mm in 1985 as compared to 2003 because of LULC dynamics (Table 5). This was attributed due to the decline of forest, shrub and grass land because forest, shrub and grass increases base flow by infiltrating the rainfall and sinking surface runoff.

Almost similar results were obtained, in Ethiopia, at different area to assess the impact of LULC change on stream flow. For example, 5 reported that the mean dry monthly flow decreased by 5.82% and average wet monthly streamflow was increased by 0.92% from the year 2000 to 2009 in Upper Awash Watershed. 4also revealed that the mean monthly stream flow for wet months had increased by 36.4%; while, the flow during the dry season decreased by 33.6% for the years 1995 to 2005 in Kesem Watershed, Awash basin, Ethiopia. Furthermore, 10 showed that the mean wet monthly stream flow was increased by 39% and dry average monthly flow decreased by 46% for the year 1985 to 2011 in Angereb Watershed. In addition, 33 revealed that mean wet monthly flow was increased by 3.8% and average monthly flow in dry season is decreased by 12.3% for the years 1986 to 2010 in the Ketar Watershed, Lake Ziway Catchment, Ethiopia.

The study concludes that flow during wet season increased; while it decreased during dry season due to LULC change. Therefore, changes in LULC are expected to have a great influence on watershed hydrology. LULC change alters the hydrologic cycle which has direct effects on hydrological processes such as evapotranspiration regime, precipitation, surface runoff, infiltration rates, and water retention capacity of the soil etc. (Takalaa et al., 2016); in Gilgel Gibe, Omo Gibe

Table 5. Mean monthly surface runoff, ground water, base flow, wet and dry monthly stream flow.

S/N	Wet and dry mean monthly stream flow simulation				% of mean monthly stream flow change	
	LULC map 1985		LULC map 2003	LULC map 2018	1985 to 2003	2003 to 2018
1	Wet	27.94	31.34	34.24	10.84	9.3
	Dry	3.04	2.81	2.49	-8.23	-11.4
Mean monthly stream flow simulation (m^3/s)					% of mean monthly stream flow change	
	LULC map 1985		LULC map 2003	LULC map 2018	1985 to 2003	2003 to 2018
2	13.15		14.43	15. 15	9.48	3.81
	Mean simulated surface runoff				% simulated surface runoff change	
	LULC map1985		LULC map 2003	LULC map 2018	1985 to 2003	2003 to 2018
3	1.62		1.76	2.12	8.42	13.43
	Mean simulated ground water				% of simulated ground water change	
	LULC map1985		LULC map 2003	LULC map 2018	1985 to 2003	2003 to 2018
4	3.5		3.1	1.3	-11.39	-58.1
	Mean simulated base flow				% of simulated base flow change	
	LULC map1985		LULC map 2003	LULC map 2018	1985 to 2003	2003 to 2018
5	4.1		2.5	1.1	-39	-56

Basin, Ethiopia. It further indicates that the surface runoff increased by 195.35 mm (44.7%), whereas groundwater flow decreased by 195.35 mm (44.7%) from the year 1984- 2016.

Conclusions

From the study, it concluded that a significant LULC change was observed. The most important changes were substantial expansion of barren lands, agriculture and settlement lands; whereas, significant shrinking of water body's, forest, shrub and grass lands during the analysis period. For the whole study period (1985-2018), forest lands, water body's, shrub and grass lands were declined by 0.6, 0.3 and 8.3 km^2/yr; whereas, barren lands, agriculture and settlement lands increased by 0.1 and 8.9 km^2/yr respectively. PBIAS range from -10.8 to -4.3% during validation. The SWAT model was calibrated and validated using long term records and resulted good model efficiency. The model efficiency result showed that the value R^2 range between 0.89 to 0.93, the NSE range between 0.81 to 0.86, the RSR range between 0.78 to 0.95, the PBIAS range between -11.6 to -7.2% during calibration period. Whereas, the R^2 range from 0.88 to 0.931, the NSE range from 0.81 to 0.9, the RSR range from 0.65 to 0.86, the mean monthly stream flow simulations increased during wet months and decreased in dry months. The base flow and ground water simulations declined. However, mean monthly simulations surface runoff increased at wet seasons and decreased during dry seasons between the years 1985 to 2018 due to substantial LULC dynamics.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests

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