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Assessment of the Impact of LULC Change on Water Resources: Tana sub-basin, Ethiopia

By Authors: Bewuketu Abebe
Dr. Bloodless Dzwairo
Dr. Dejene Sahlu

Outlines

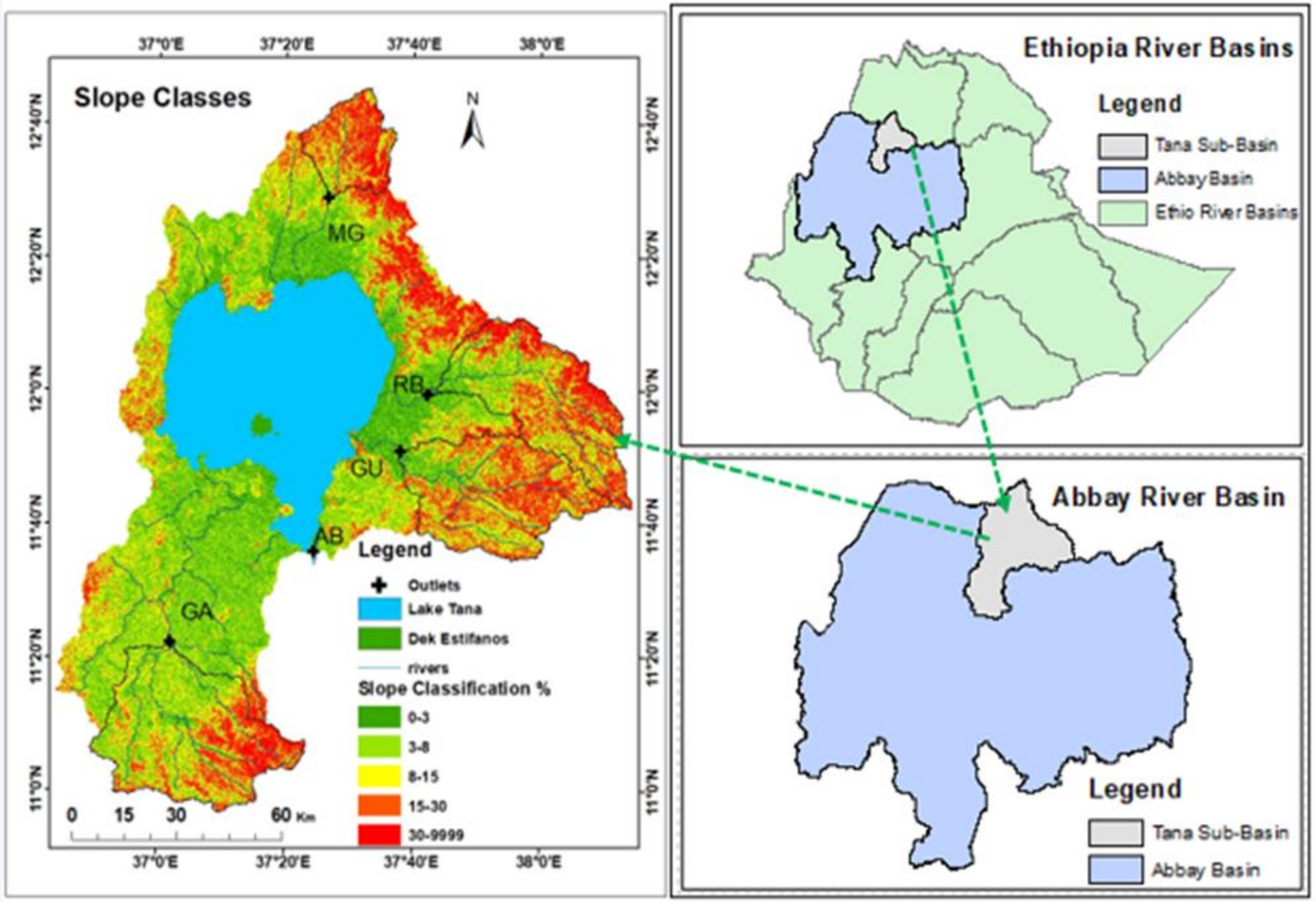
- ✓ Introduction
- ✓ Objectives
- ✓ Study area description
- ✓ Materials and Methods
- ✓ Result and discussion
- ✓ Conclusion & recommendation

Introduction

- ✓ The study area is one of the growth corridor of the country, Ethiopia (TaSBO, 2019).
- ✓ Natural resources are critically under pressure because of increasing demand from water competing sectors, climate change, booming population, livelihood improvement, and economic crises.
- ✓ The land cover continuously changing and these changes will have an impact on hydrological component and water resources in the study area.
- ✓ Therefore, it is very crucial to assess and update the impact of LULC change on the water resources in the Tana sub-basin.
- ✓ The study aimed to assess the impact of land use/land cover change on water resources in the Tana sub-basin using the Soil and Water Assessment Tool (SWAT).

Study area

- ✓ Area: 15,070.14 km2 and 20% of the sub-basin is the Lake Tana water body.
- ✓ Elevated region in Northern Ethiopia, situated in the headwaters of the Blue Nile Basin & $36^{0}45'$ - $38^{0}15'$ E long & $10^{0}57'$ - $12^{0}46'$ N lat
- ✓ 4,112 m.a.s.l. in the eastern part and 1,786 m.a.s.l at the point of outflow into the Blue Nile at Bahir Dar with mean elevation is 2,026.54 m.a.s.l
- ✓ Study area, 63.18% a slope of 0-8%, 36.82% a slope above 8%;
- ✓ Four major river watersheds: Gilgel Abbay (1,656.35 km2), Ribb (1318.01 km2), Gumara (1,354.35 km2), and Megech (515.06 km2)
- ✓ More than 80% of the subbasin water resources generated from the four major watersheds



Data source and used

Variable	Source	Spatial and temporal resolution	Site
DEM	NASA's	30m*30m SRTM	http://srtm.csi.cgiar.org/
Soil Data (Map)	Ministry of Water, Irrigation and Energy, Ethiopia	90m*90m	
Land use land cover	Amhara Design and Supervision Work Enterprise, Ethiopia	30m*30m 1986, 2000 and 2014	
Measured weather data (six variables)	Amhara Meteorology Agency, Ethiopia	1987-2013	
Rainfall (CFSR) for 42 stations	National Centers for Environmental Prediction (NCEP)	1987-2013	https://globalweather.tamu.edu/
Flow data (4 stations)	Abbay Basin Development Office, Ethiopia	1987-2013	

Material/tools used

Tools	Input variables	Purpose
Dew02.exe	Min and Max daily T and average daily humidity	used to compute daily dewpoint
WGNmaker and PCP stat	RF, Max and Min T, one-hour RF, solar radiation, wind speed and dew point temperature	used to compute statistical parameters for precipitation
ArcGIS10.3	LULC, Soil data, DEM, river and watershed shapefile	used for preparation an input for SWAT model and result visualization of model, and used to analyze the land use land cover change
SWAT-CUP	SWAT model output (simulated), flow data,	Used for calibration, validation, and uncertainty analysis of the SWAT model, and were also used to optimize the SWAT model parameters (monthly time)
SWAT2012	LULC, Soil data, DEM, Weather data,	used to assess the impact of LULC change on water resources in the study area

Important figures

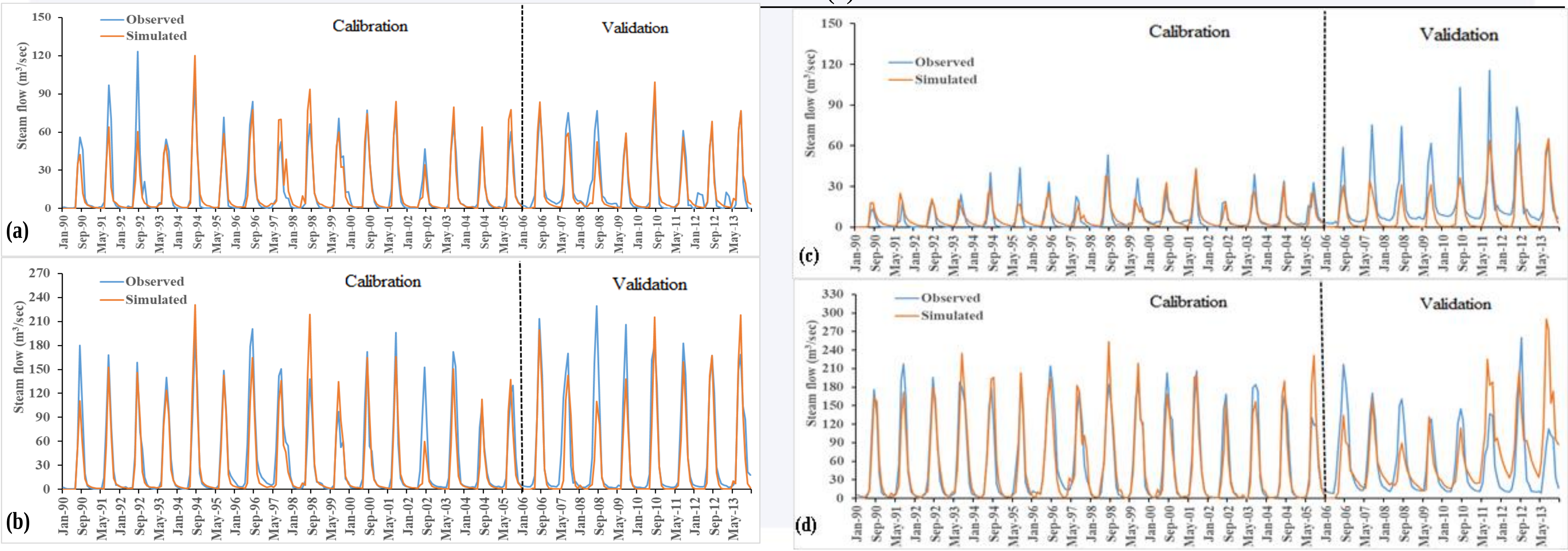
- ✓ Slope classified into flat to very gently sloping (<3%), gently to sloppy sloping (3–8%), strongly sloping (8–15%), moderately steep (15–30%), and steep to extremely steep (>30%).
- ✓ Land cover was categorized into eight: Cultivation land, Forest, Shrub/Bushland, Water bodies, Afroalpine, Grassland, and Settlement/Built-up area.
- ✓ 69 sub-basins were delineated.
- ✓ About 942, 886, and 869 HRUs were then created for 1986, 2000, and 2014 LULC respectively and 10% thresholds were used for LULC, soil, and slope.
- ✓ Simulation covered 27 years (from 1987-2013) where the first three years (1987-1989) were used as model warm-up periods, 16 years (1990-2005) for calibration, and the last 8 years (2006-2013) for validation.

Result and discussion

Model Calibration and Validation

SWAT model performed well in all watersheds for the calibration and validation periods

Sub-basin	Major watershed	Calibration				Validation			
		R2	NS	PBIAS	RSR	R2	NS	PBIAS	RSR
Tana	Gumara (b)	0.84	0.83	16.20	0.41	0.83	0.80	24.60	0.45
	Megech (c)	0.72	0.72	-9.4	0.53	0.74	0.57	44.1	0.65
	Gilgel Abbay	0.88	0.88	2.90	0.35	0.71	0.65	-4.3	0.93
	Rib (a)	0.83	0.82	4.10	0.42	0.90	0.89	11.60	0.33



Result and discussion

LULC changes: 1986, 2000, 2014

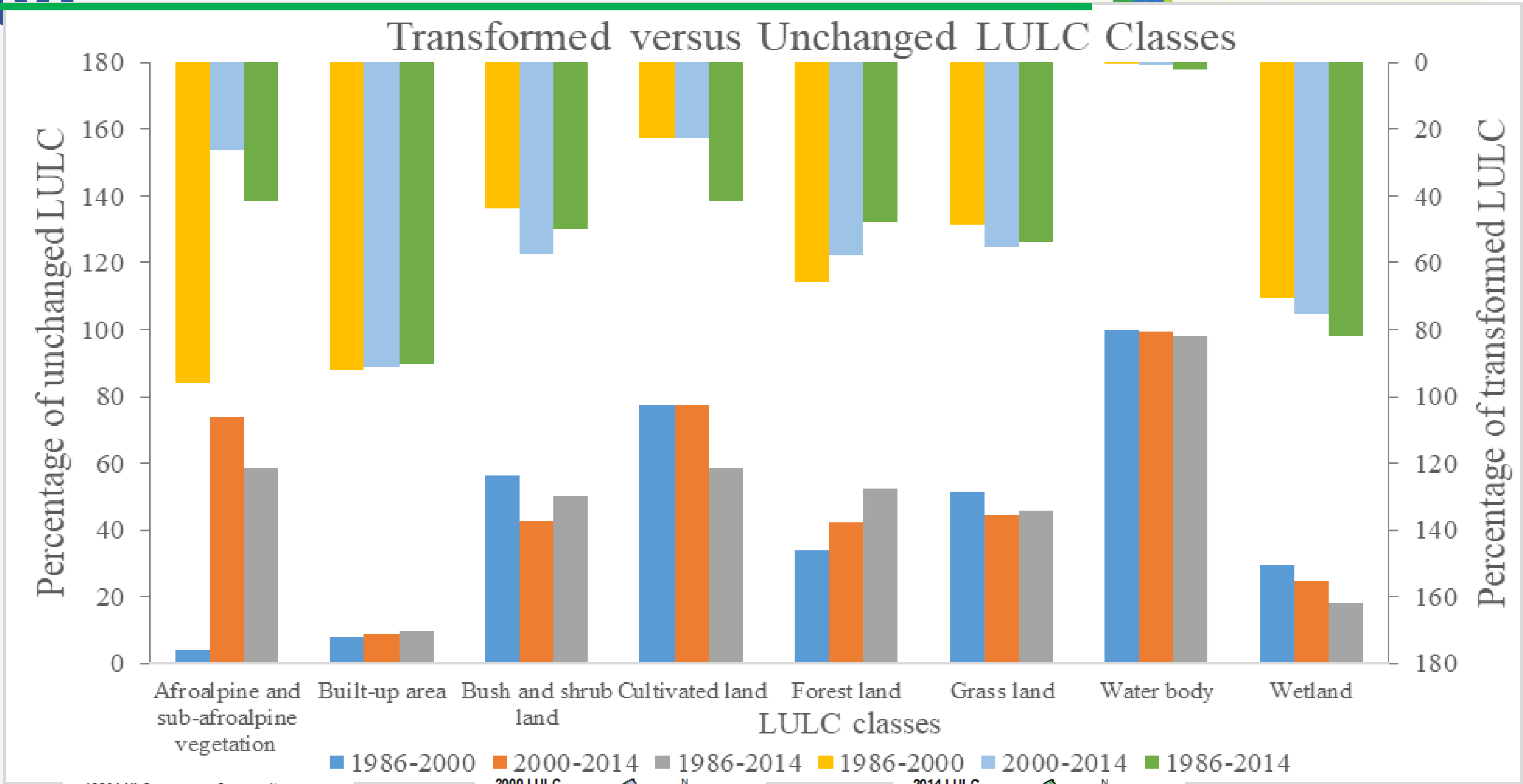
Forestland and grassland have decreased continuously in these years.

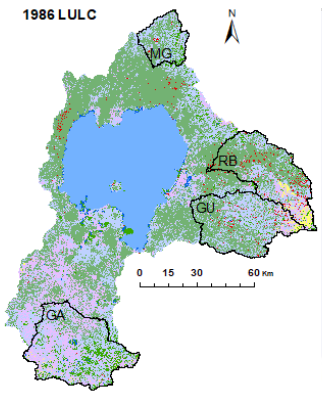
Sub-afro-alpine vegetation showed a dramatic decrease in the second period of assessment.

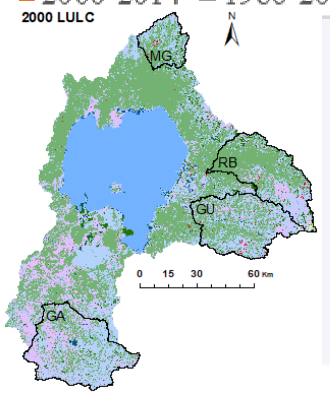
Bushes and shrubs recorded about a 1% increase in the total area and an unexpectedly fast decline in the second period.

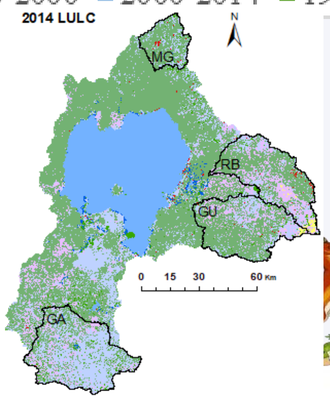
Forest land showed a continuous reduction while water bodies and wetlands showed a small variation as compared to the other

Continuous increment in cultivated land









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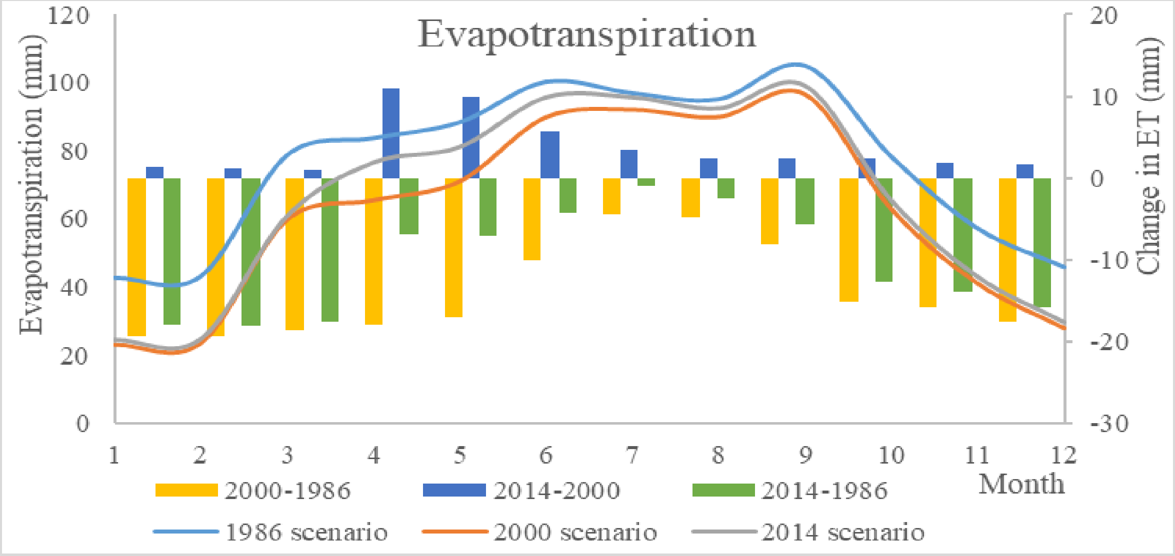
Result and discussion

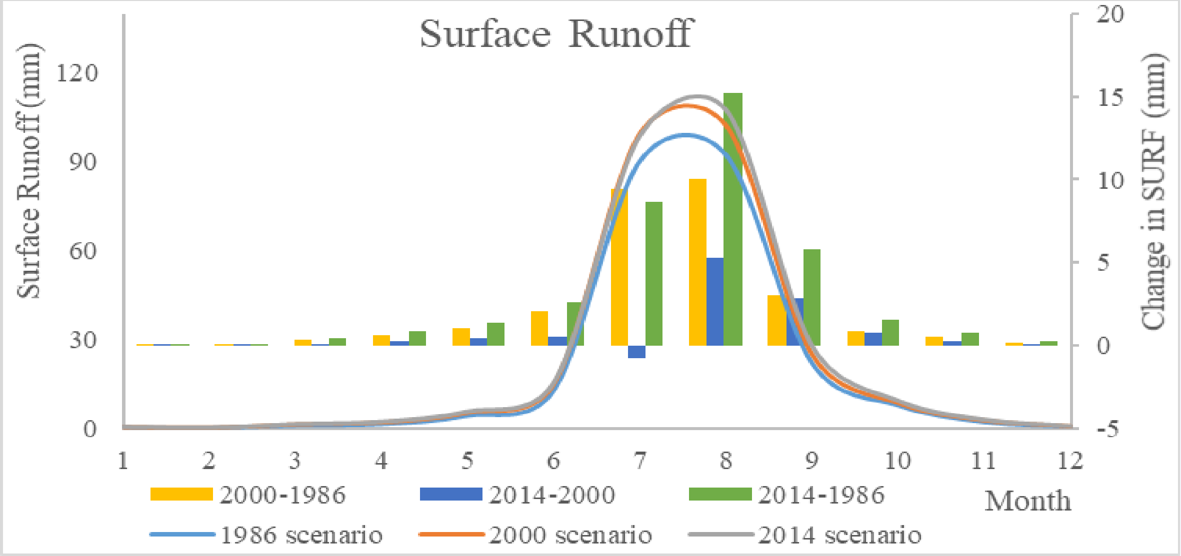
Impacts of LULC change on water resources

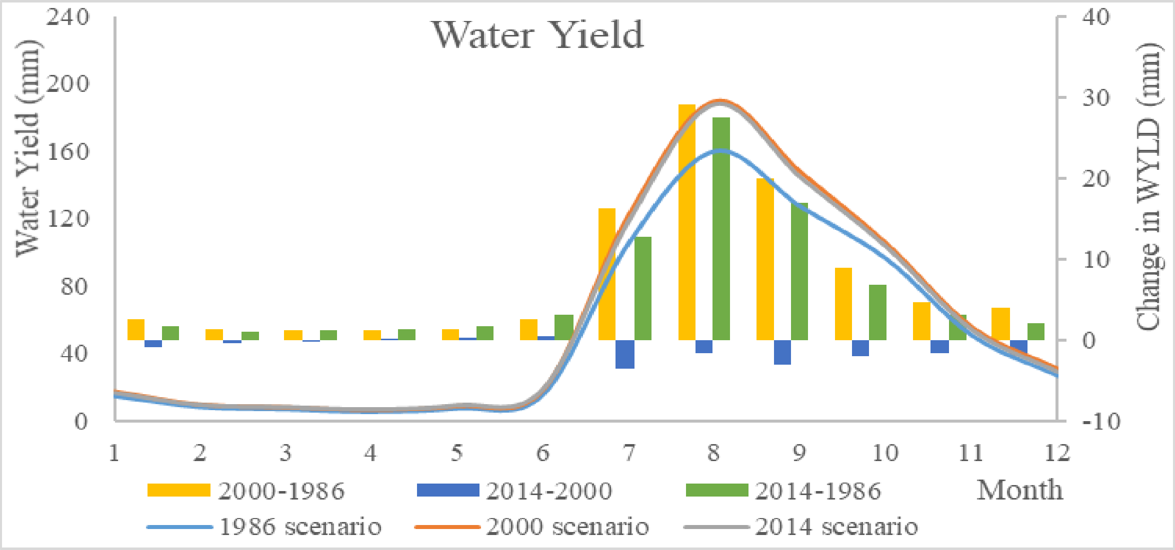
Period	LULC (%)								Water resources component (mm			
	Afroalpine and sub-Afroalpine vegetation	Built-up area	Bush and shrubland	Cultivated land	Forest land	Grass land	Water body	Wetland	ET	SURQ	WYLD	BF
1986	0.81	0.99	24.06	36.64	4.36	12.13	20.29	0.72	913.65	233.61	628.88	291.5
2000	0.07	0.28	25.09	40.71	2.33	10.49	20.37	0.67	745.62	261.65	722.45	345.1
2014	0.25	0.29	17.87	48.82	1.81	9.53	20.62	0.80	790.34	271.36	708.14	320.4
2000-1986	-0.74	-0.71	1.03	4.07	-2.03	-1.64	0.08	-0.06	-168.03	28.04	93.57	53.6
2014-2000	0.18	0.01	-7.22	8.12	-0.52	-0.96	0.25	0.13	44.72	9.71	-14.31	-24.7
2014-1986	-0.56	-0.70	-6.19	12.18	-2.55	-2.60	0.33	0.07	-123.31	37.75	79.26	28.9

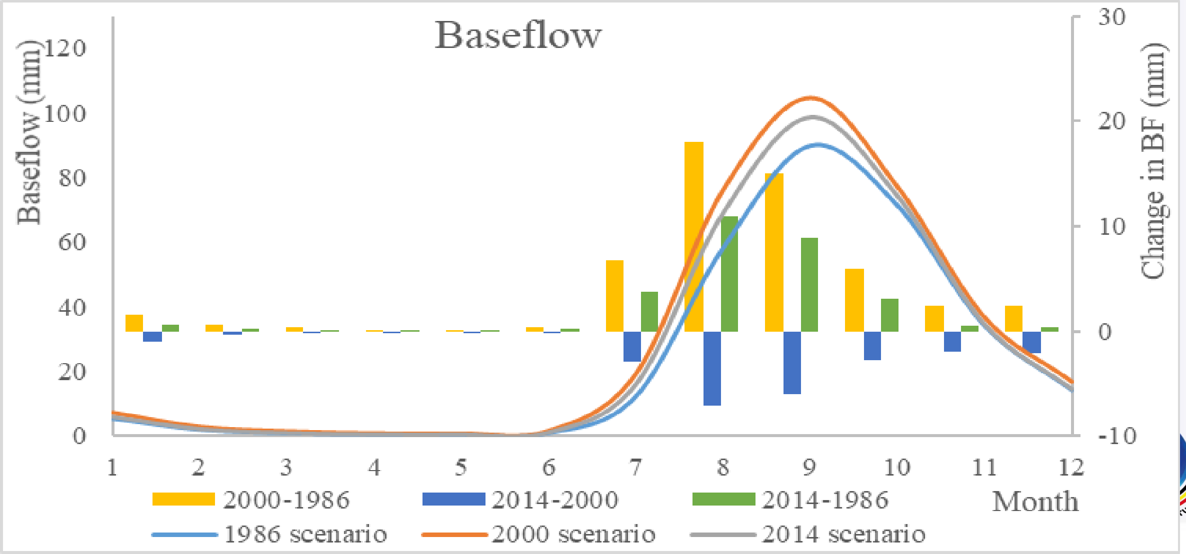
Result and discussion

Impact of LULC Change on hydrological components on monthly scale









Result and discussion

- ✓ Average annual water yield increased by 14.88% and 12.6%, baseflow increased by 18.4% and decreased by 7.16%, surface runoff increased by 12% and 16.16%, evapotranspiration decreased by 18.39% and 13.49%, for 2000 and 2014 respectively, compared to baseline 1986.
- ✓ Expansion of cultivation land and reduction of bush and shrubland, grassland and forest help increase surface runoff, and water yield, and reduce evapotranspiration and baseflow in this study
- ✓ Increase in surface runoff and water yield in the study area corresponds to sub-basins with a reduction in forest cover and shows an effect on evapotranspiration.
- ✓ High forest cover will respond to a high rate of transpiration, and this will increase the value of evapotranspiration.
- ✓ ET depends on forest and other cover than waterbodies bodies in the study area
- ✓ Cultivation land decreases soil infiltration rate/percolation/baseflow and increases surface runoff compared to grassland and shrubland.
- ✓ LULC change has significant impacts on infiltration rates, runoff production, total simulation flow, interflow, base flow, water yield, evapotranspiration, and water retention capacity of the soil or change in storage of the soil; hence, it affects the water balance of the study area.

Conclusion and recommendation

- ✓ SWAT model applicable and performed well in the study area and LULC change is one factor that has significant impacts on the hydrology component of the study area. This will continue to have consequences on natural resources management and development.
- ✓ Expected reduction of surface runoff during the dry season may affect agriculture/irrigation and water-oriented activities while its increments during the wet/rainy season may lead to flooding.
- ✓ The approach used in this study has accredited contributions of changes in LULCs to water resources, providing perceptible information that will allow stakeholders and decision-makers to make prominent choices regarding natural resource planning and management.
- ✓ Establishing land use policy, ensuring and enforcing land use plan
- ✓ Research methods used can serve as a guide for other similar studies and be applied to a variety of river basins to predict the consequences of LULC changes on water resources

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THANK YOU!