Quantifying the Impacts of land cover change on hydrological responses under SSP-RCP Scenario

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Introduction

- Land use land cover (LULC) change induced by rapid anthropogenic activities is one of the major causes of change in hydrological and watershed processes (Rogger et al., 2016).

- For example, developing region like Ethiopia are facing rapid growth in population, which is having a significant impact on LULC dynamics through deforestation, rapid urbanization, and agricultural intensification, subsequently modifying the hydrological cycle in many river basins of Ethiopia, particularly the Upper Blue Nile basin (Abay).

Research Questions

We address the following scientific questions

1. What are the expected impacts of LULC changes on the water balance of the Upper Blue Nile basin?
2. How do these predicted impacts vary as a result of model parameter uncertainties?

Aim/purpose of the Research

The major objectives of this study are

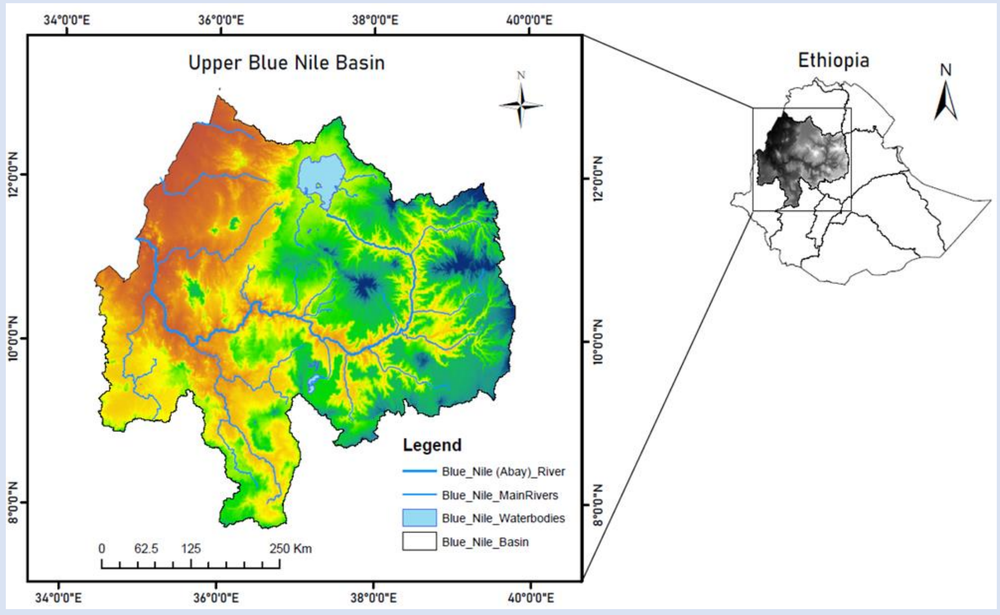
1. To predict the changes in hydrological processes owing to historical and future changes in LULC and
2. To understand the contribution of uncertainty from hydrologic parameterization to the hydrologic projections due to LULC change.

Material and Methodology

Research Site

Upper Blue Nile River (Abay) Basin

- This study will be conducted in the part of the Blue Nile Basin which is under Ethiopian territory, named Upper Blue Nile Basin (UBNB).



Two models were used in the current study, the hydrological model, and the land use change model.

- The Future Land Use Simulation (FLUS) model is used to simulate future land-use dynamics based on LUH2 under different SSP-RCP scenarios.

- The hydrological model, SWAT was used to assess the impact of LULC changes on water balance based on different SSP-RCP scenarios

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Land Use Scenario

Scenario Design

SSP1_RCP2.6, SSP2_RCP4.5, SSP5_RCP8.5

2020-2030, 2031-2040, 2041-2050

Land use change Projection

LULC dataset simulated by FLUS model based on LUH-2

2020s, 2030s, 2040s

Experimental Design

Spatial Data
- Digital Elevation Model
- Soil Information

Meteorological Data (1990-2015)
- Precipitation
- Temperature
- Wind Speed
- Solar Radiation
- Relative Humidity

Hydrological Data (1990-2014)
- River discharge

The hydrological model, SWAT is set up, calibrated, and validated for the upper Blue Nile (Abay) River Basin.
- ➡ LULC map (ESA_CCI-LU)-2015

Baseline Scenario
- ➡ LULC map (Simulated LU)-2015

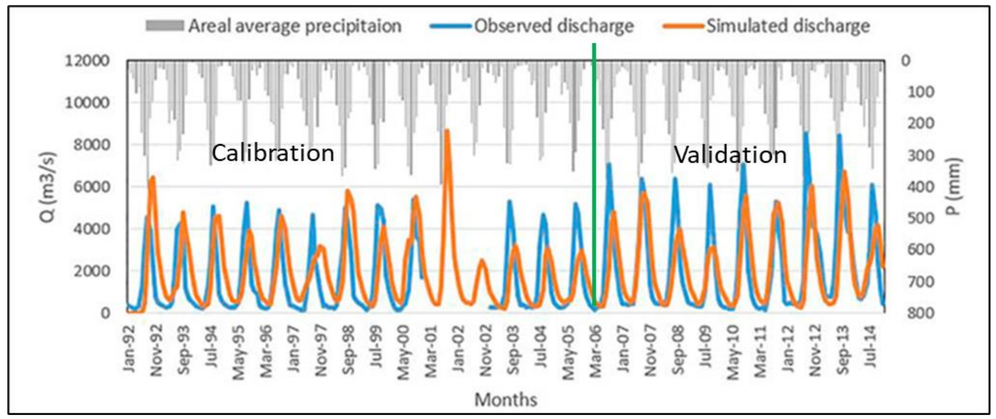
Future Scenario
- ➡ LULC map (SSP1_RCP2.6) - 2020, 2030, 2040 and 2050
- ➡ LULC map (SSP2_RCP4.5) - 2020, 2030, 2040 and 2050
- ➡ LULC map (SSP5_RCP8.5) - 2020, 2030, 2040 and 2050

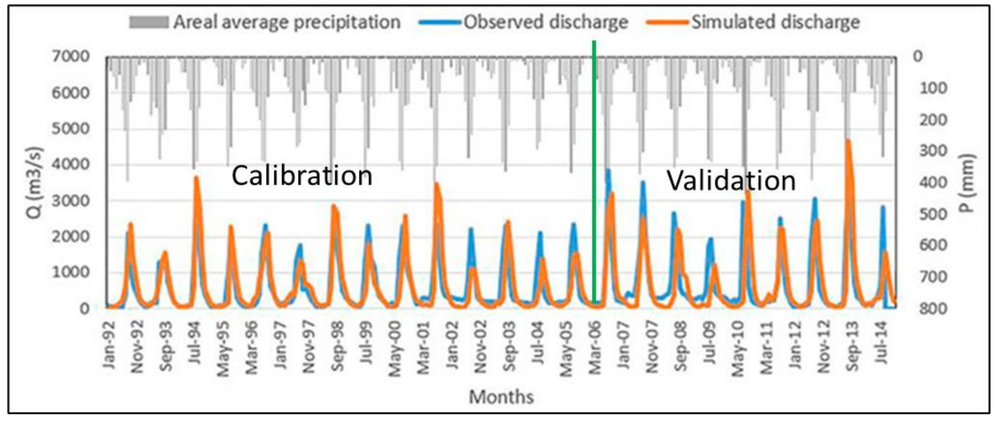
Hydrological model SWAT

Impact of Land Use Land Cover Change on Hydrological Components

Model Performance Evaluation

The performance of the model was evaluated at three ~~river~~ gauging stations
- Two stations on the mainstream of Abay (i.e., Kessie, and Ethio-Sudanese border)
- One station on the sub-basin (Rib station)





- ❑ At the sub-basin scale (at the outlet of the Kessie and Rib sub-basin), the simulation agrees with the observed flows for most of the simulation period.
- ❑ However, a slight shift of simulated discharge is apparent at the basin scale (at El Deim station).

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Water Balance Components

Average annual Water balance components in the upper Blue Nile basin for a model setup period (table)

Water balance components (mm)	1990-2015
Precipitation: PREC	1547
Surface runoff: SUR_Q	159.8
Groundwater: GW_Q	302.35
Percolation out of soil: PERCO	203.2
Actual evapotranspiration: ET	575.3
Evapotranspiration: ET	960.2

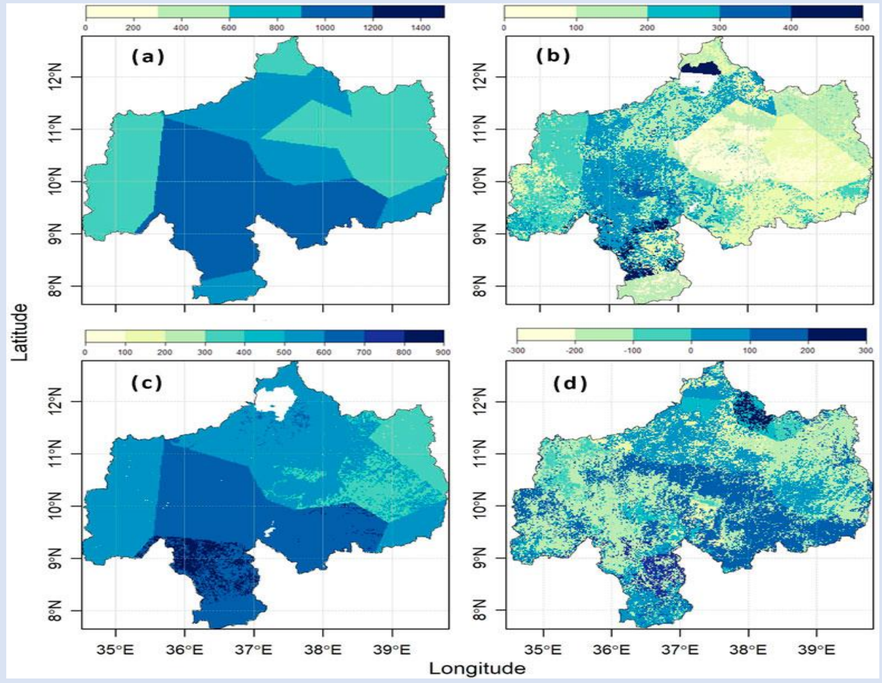
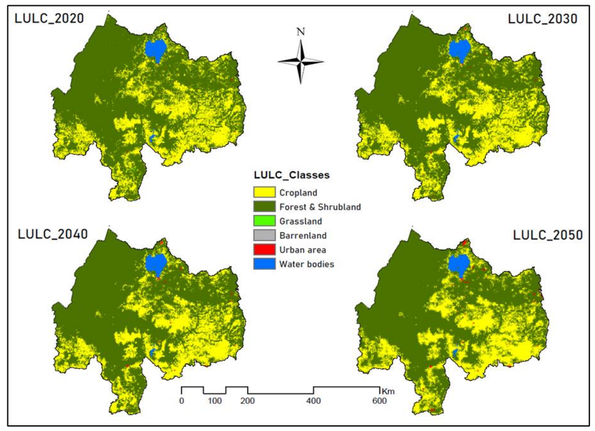


Figure: The spatial distributions of long-term mean annual water budget components: (a) precipitation, (b) runoff, (c) ET and (d) TWSC. All units are in mm.

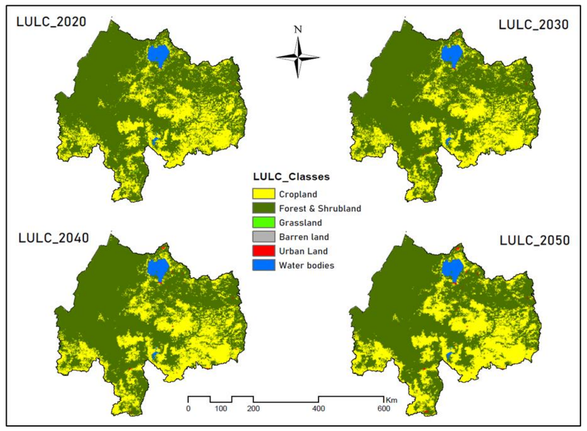
Conclusions

- In this study an attempt is made to quantify the hydrologic response of the upper Blue Nile Basin, owing to different land cover scenarios obtained from the LUH2 dataset, through the implementation of a sensitivity-based calibrated semi-distributed hydrological model.
- Our findings offer insights into the plausible hydrological scenarios in future at a river basin level,
- Overall, SWAT model captured the observed daily flows well in calibration, validation and baseline periods across sub catchments.
- Deforestation at the expense of cropland dominated the land cover change processes across all scenarios and sub-catchment, which has led to an increase in the extreme flows and mean annual flows

SSP1_RCP2.6



SSP5_RCP8.5



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