SWAT 2018 Conference

Modeling streamflow responses to changes in land cover in the Upper Ruvu watershed, Tanzania

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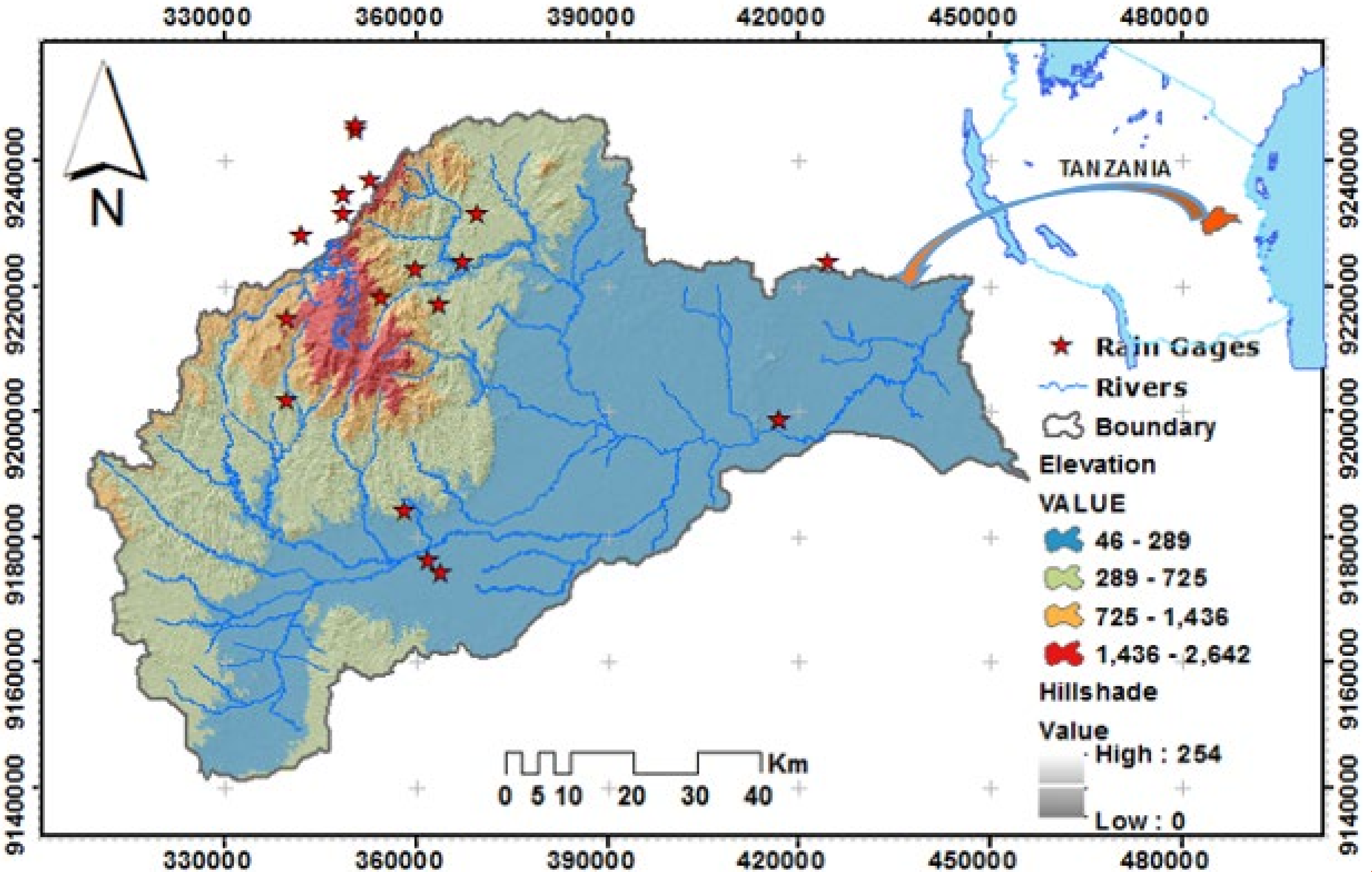
VUB, Belgium



N
TANZANIA
Rain Gages
Rivers
Boundary
Elevation
VALUE
46 - 289
289 - 725
725 - 1,436
1,436 - 2,642
Hillshade
Value
High : 254
Low : 0
0 5 10 20 30 40 Km
330000
360000
390000
420000
450000
480000
9140000
9160000
9180000
9200000
9220000
9240000

Upper Ruvu and Uluguru Mts

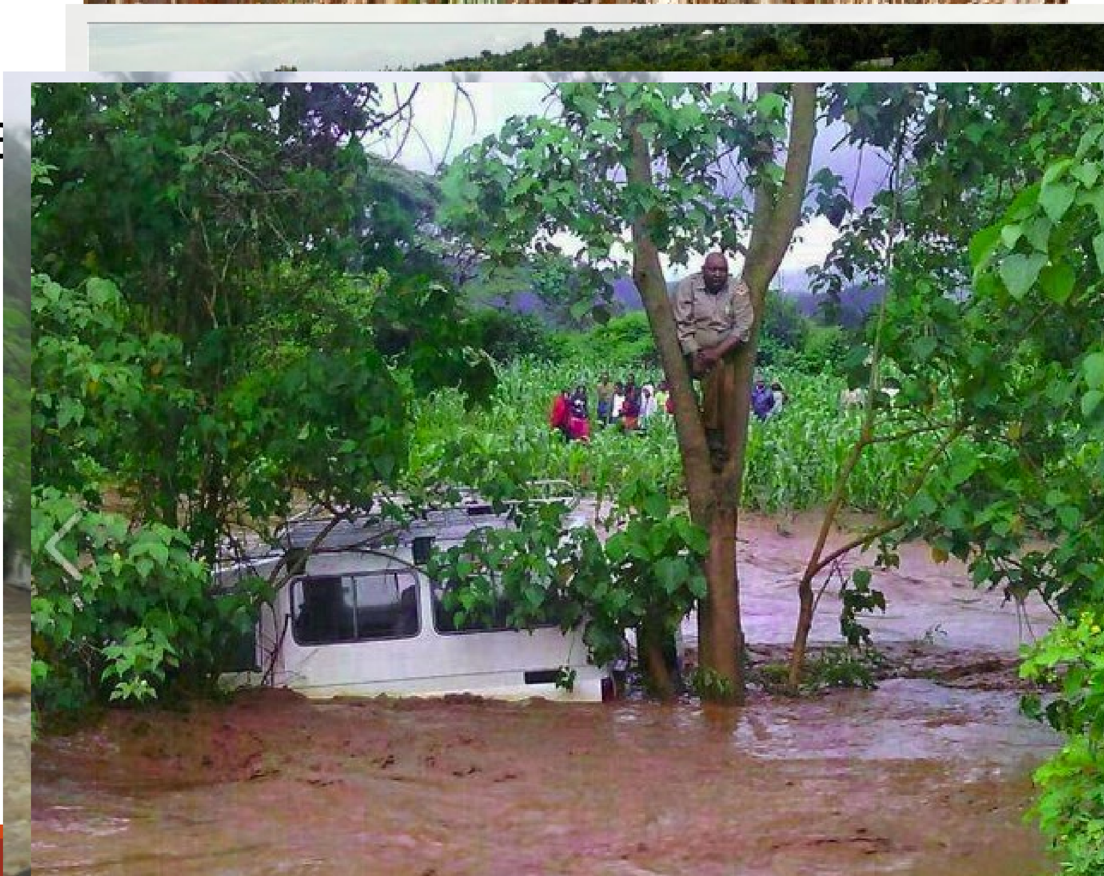
- Ranked 6th and 15th globally for vertebrates and birds
- High water potential with 44% and 37% -dry and wet – annual specific discharge
- Ruvu River is the major supplier of water to Dar Es Salaam

Challenges

- Landscapes occupy 60% - population (Upper Ruvu)
- Agricultural Expansion
- Deforestation (Charcoal, firewood, agriculture, timber and poles)
- Grazing
- Small scale mining-Gold
- Forest fires

Challenges

- Soil erosion and sedimentation
- Deteriorating water quality problems
- Water shortage in the dry season
- Flash floods
- Conflicts



Our objective

- Quantification of the impacts of land cover change on stream flow for the 25 years

SWAT Model and data

- DEM (30m resolution – SRTM – usgs.gov)
- Land use maps for 1991,2000,2015
- Soil Map – Soils and Physiography of Tanzania
- Soil samples collected from the field
- Rainfall data – 11 stations with daily rainfall data from 1971 to 2012
- Climate data– Morogoro Meteorological Station
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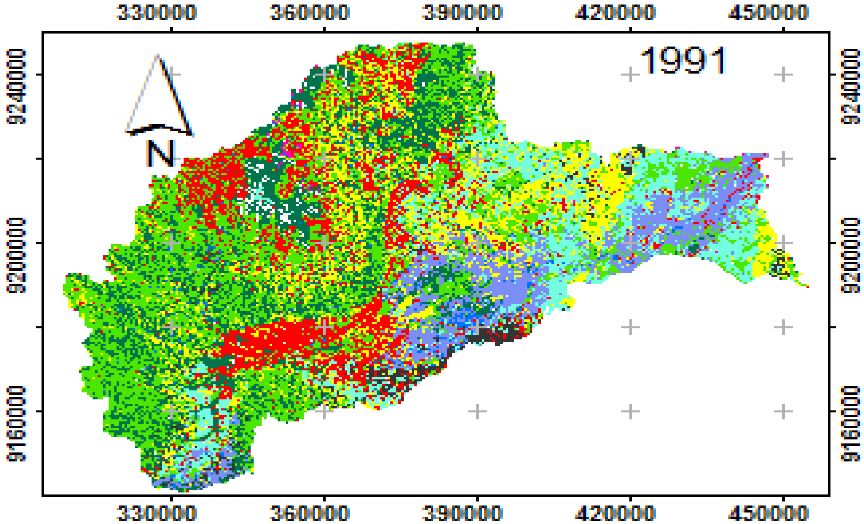
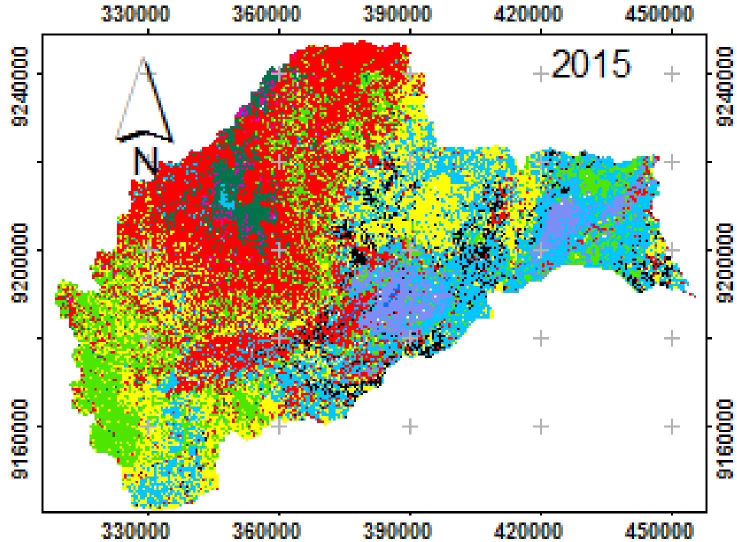
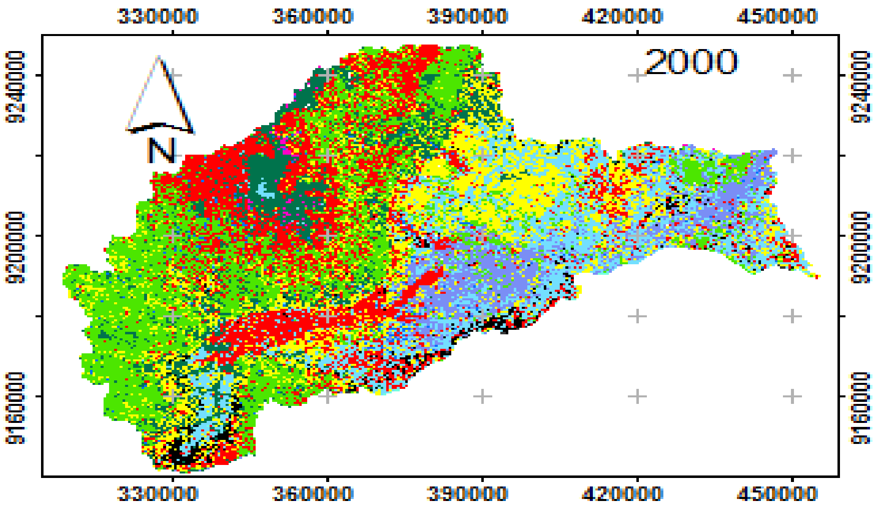
SWAT Model and data

- **Quantified the change in land use for 1991, 2000 and 2015**

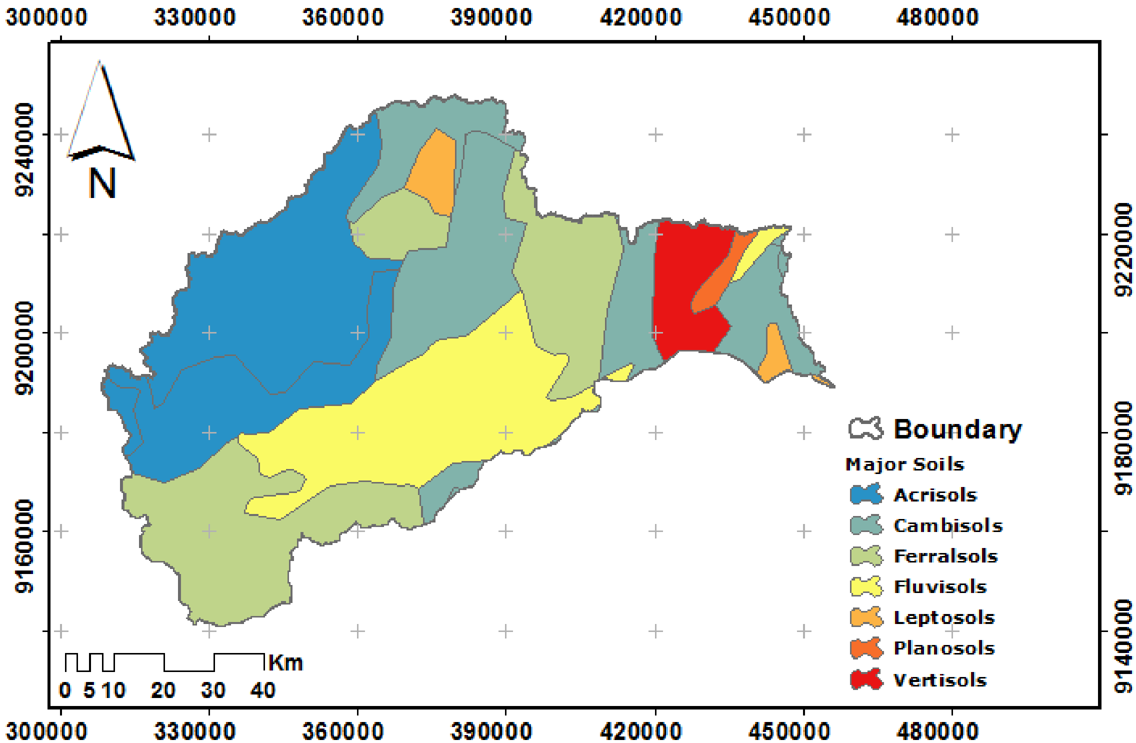






SWAT Model and data

- 7 major soils, dominated by Acrisol (28%) and cambisols (22%)



SWAT Model and data

- Discretized into 40 sub-basins and 1107 HRUS
- Model was set up with data from 1971 to 2012
- “Warm-up” period of 2 years 1971-1972
- Calibration period – 5 years (1973-1977)
- Two outlets:
    - 1H5 (Ruvu River at Kibungo Bridge)
    - 1H10 (Ruvu River at Mikula)
- Evaluation 5 –years
- Sensitivity analysis (manual) →SWAT-CUP one value at a time
- Calibration and evaluation – SWAT-CUP-SUFI2
- Objective function - NSE

Calibration and Sensitivity Analysis

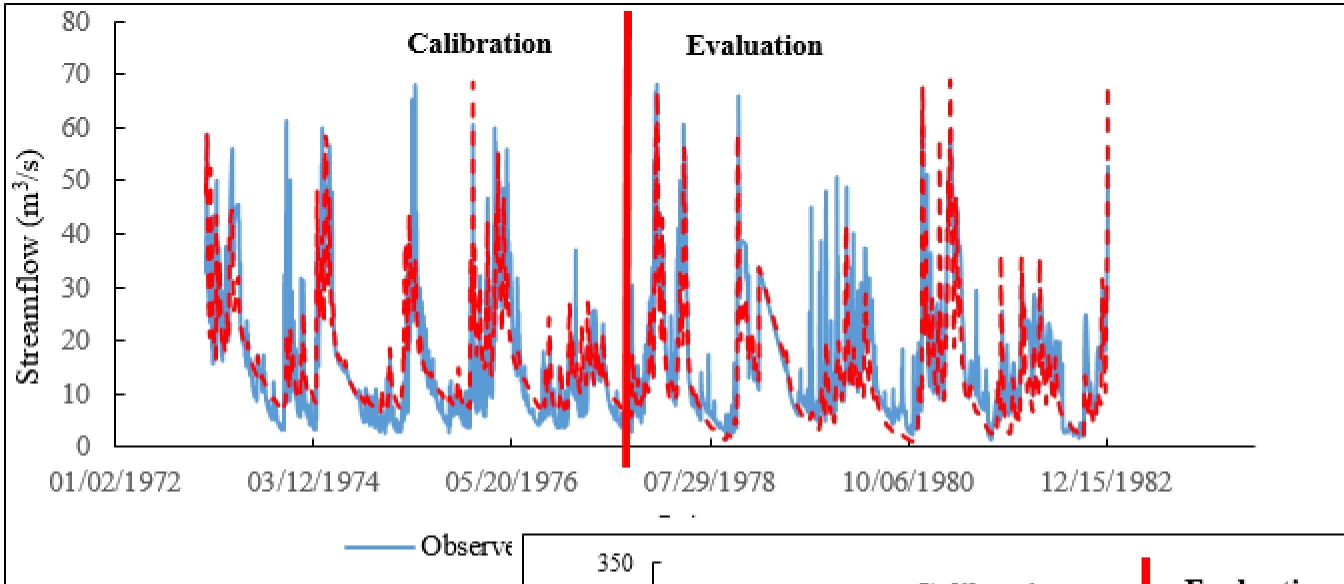
Rank	Parameter	Range	Fitted value
1	R_CN2.mgt	-0.4 - 0.31	-0.17
2	V_RCHRG_DP.gw	-0.15 - 0.53	0.36
3	V__ALPHA_BNK.rte	0.25 – 0.33	0.28
4	V_GW_DELAY.gw	48.26 - 94.77	49.19
5	V_GW_REVAP.gw	0.02 – 0.2	0.18
6	R_SOL_AWC.sol	0.39 – 0.71	0.56
7	R__HRU_SLP.hru	-0.18 - -0.02	-0.03
8	V_REVAPMN.gw	-2.22 – 6.56	3.58

Calibration and evaluation

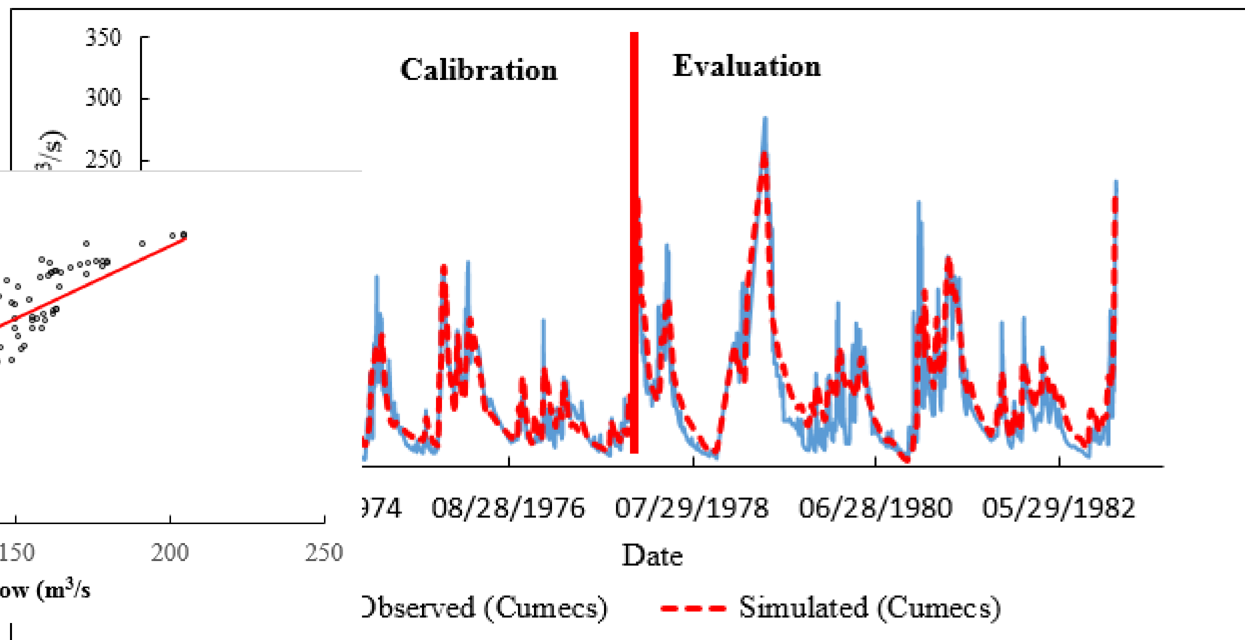
Station	NSE		PBIAS		RSR	
	Calibration	Evaluation	Calibration	Evaluation	Calibration	Evaluation
1H5*	0.69	0.68	-7.8	17.3	0.56	0.57
1H10**	0.84	0.67	-9.9	-21.6	0.40	0.42

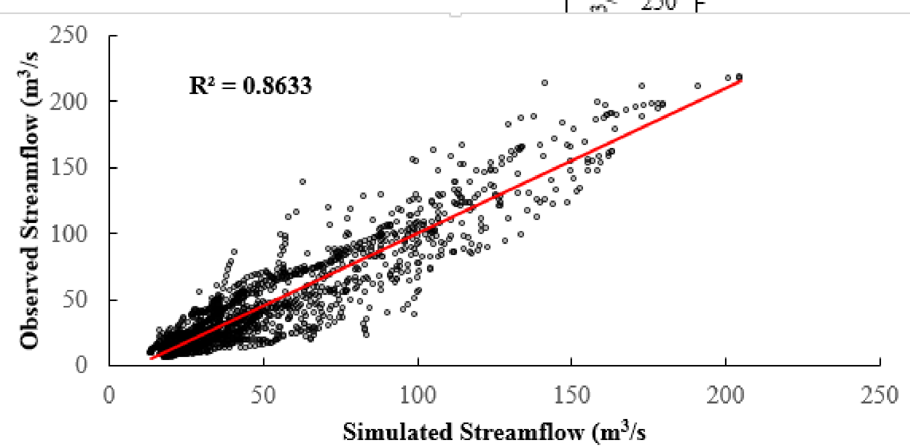
*1H5 – Ruvu at Kibungo Bridge, 1H10**--Ruvu at Mikula.

Calibration and evaluation



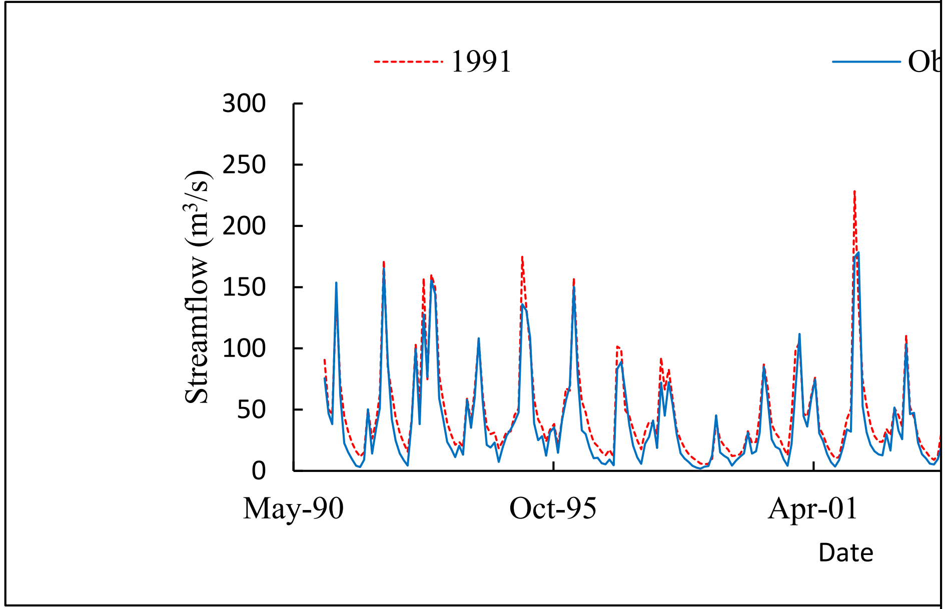
1H5

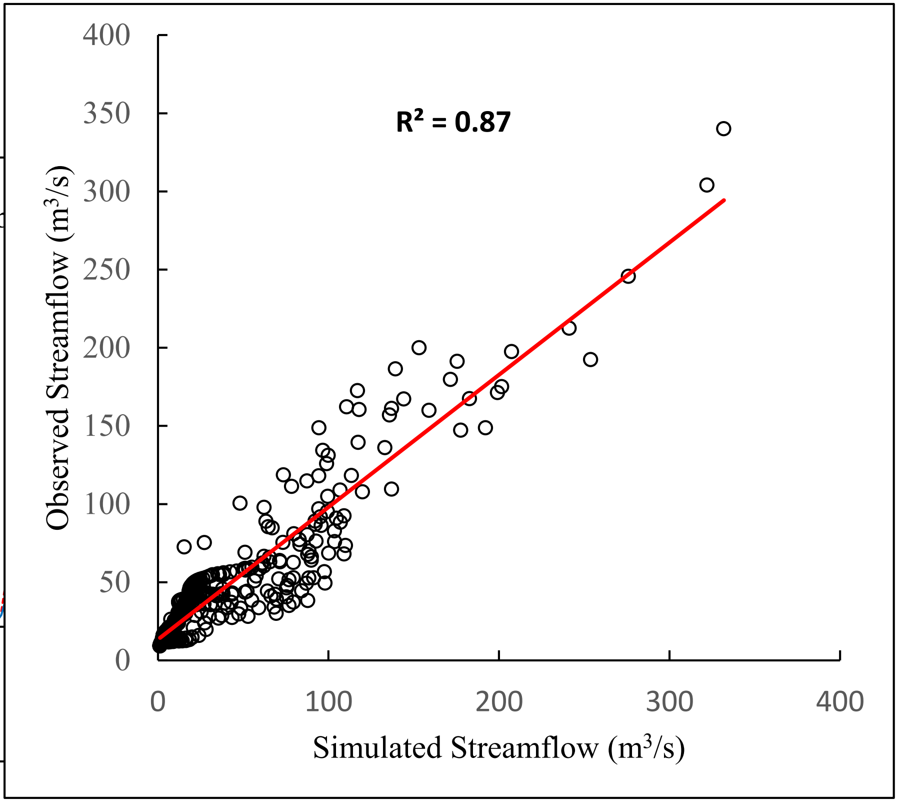




Simulating response to LULC

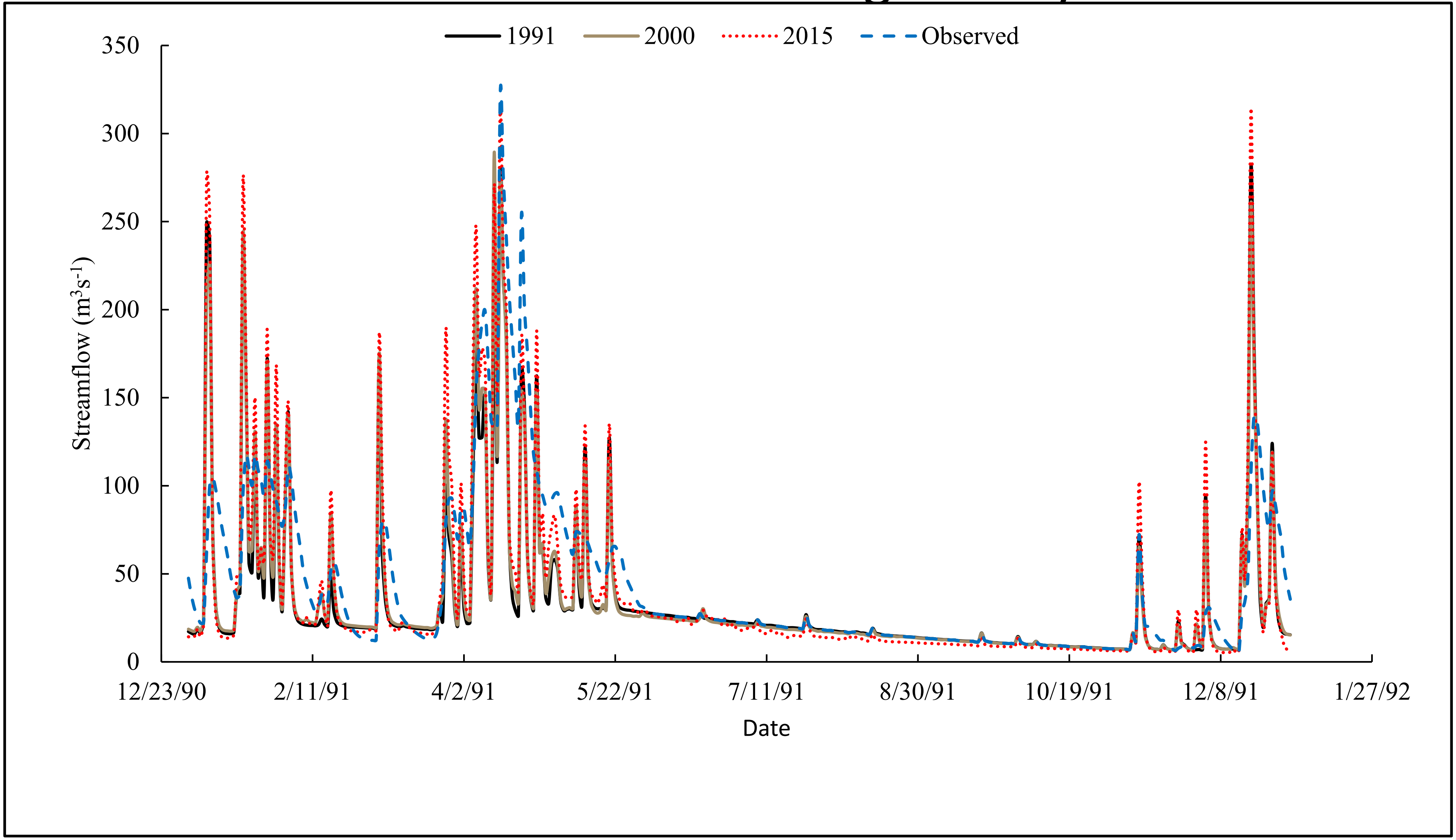
- Simulated 1991 LULC and compared with 1991 discharge
- Good agreement – $R^2 = 0.87$





Seasonal response

- general increase of peak flows during the wet season and a decrease in baseflow during the dry season



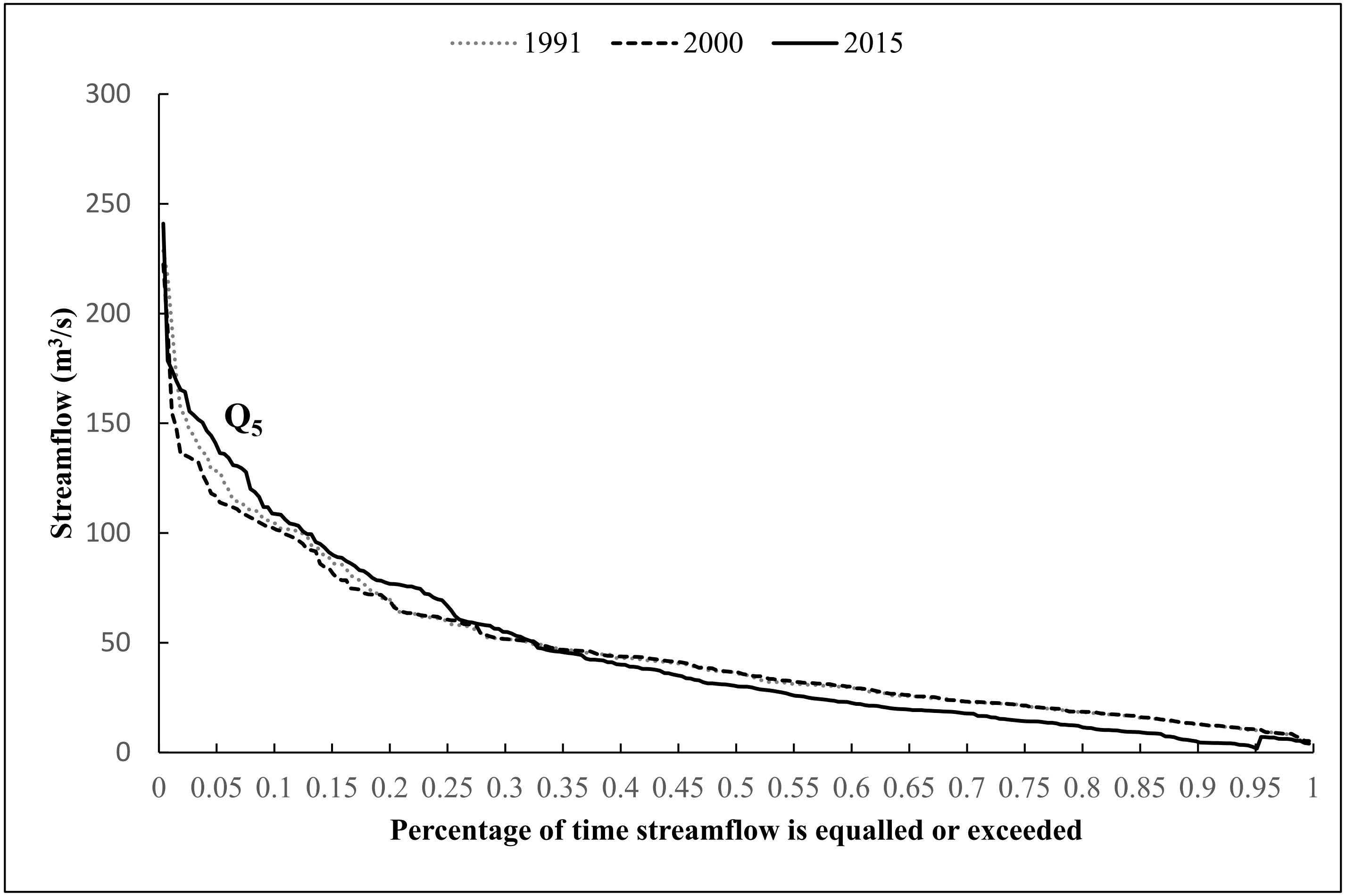
Seasonal response

- general increase of peak flows during the wet season and a decrease in baseflow during the dry season

	1991 LULC	2000 LULC	Impact(1991-2000)	2015 LULC	Impact (1991-2015
Q_5 (m^3s^{-1})	128.85	151.6	5%	144.38	12%
$Q_{average}$ (m^3s^{-1})	47.41	46.32	-2%	41.50	-13%
Low Flow Duration (m^3s^{-1})	36.29	36.09	-0.5%	29.01	-25%

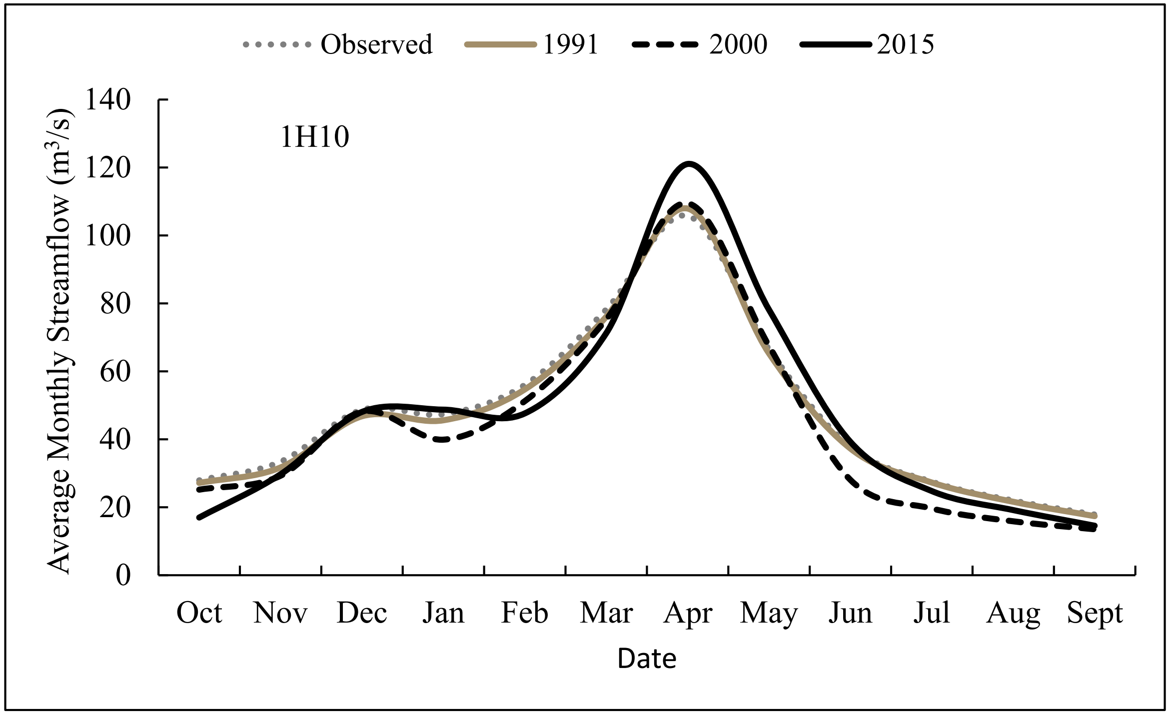
Streamflow response to LULC

- Baseflow was consistently lower for the year 2015, compared to the baseline year



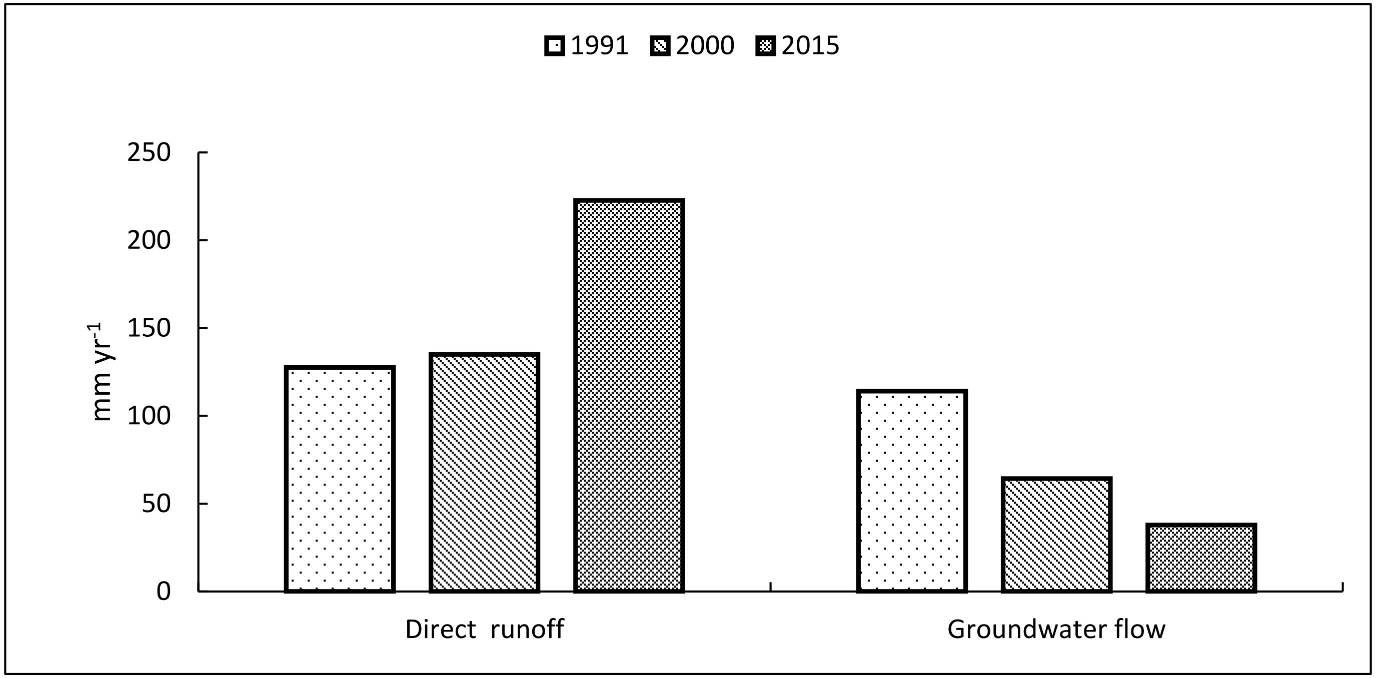
Streamflow response to LULC

- The mean monthly average in the short rainy season reaches approximately 50 m^3s^{-1} in December
- reaches approximately 121 m^3s^{-1} in April during the long rainy season and were high for the year 2015



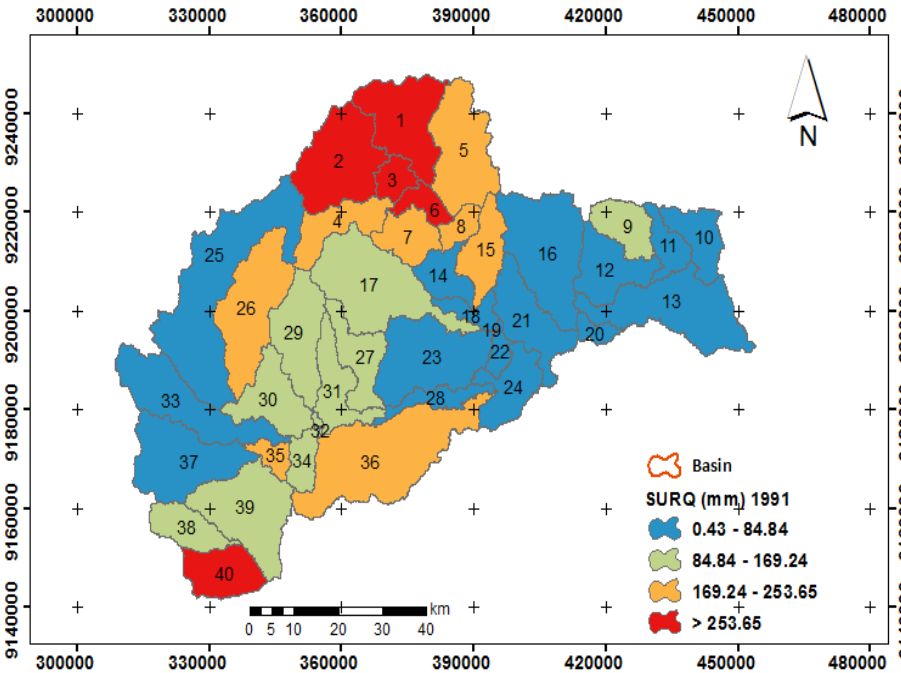
Streamflow response to LULC

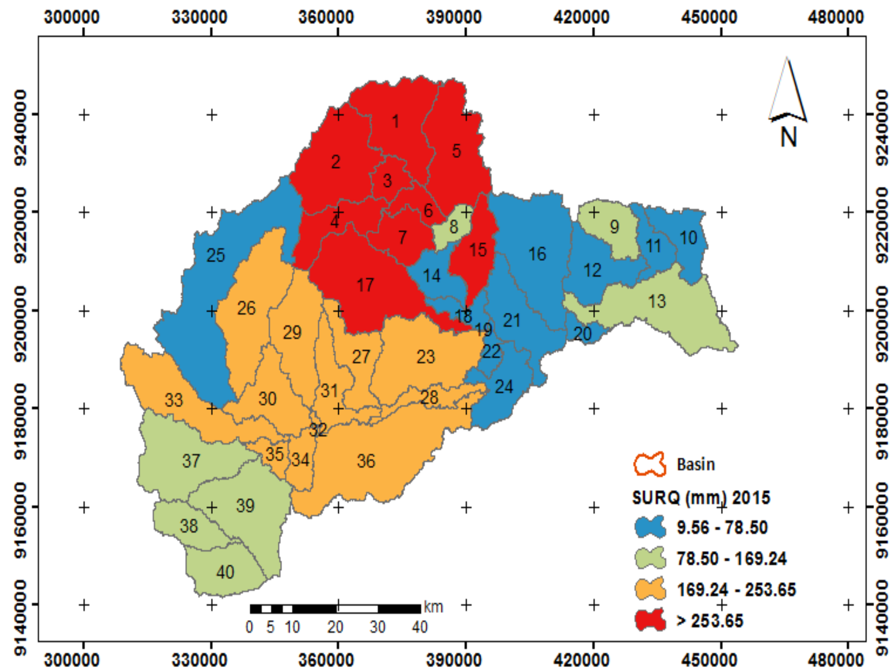
- increase in direct surface runoff from the baseline period to 2015
- Compared to the baseline scenario annual surface runoff was 10 mm and 95.2 mm higher in 2000 and 2015, respectively.
- The change was about 8% and 75% for 2000 and 2015, respectively



Impacts of LULC changes on hydrology at the sub-watershed scale.

- shows high variability of the contributing areas
- Surface runoff is generated from the sub-watersheds located in the uplands and mostly where human activities are dominant





Conclusions

- This study has shown that the SWAT model is quite useful in matching measured discharge
- Impacts of land cover change were quantified
- Results have shown a significant change of mostly forested areas into croplands
- The model has shown that a change in land use and land cover from the baseline scenario (1991) resulted in
  - a slight decrease of 2% in average streamflow by 2000,
  - decrease of up to 13% of average streamflow by 2015 from the baseline period.
- The study has shown that the change in land use from natural areas to cropland and grassland areas leads to an increase in the peak flows which have an implication in the magnitude of floods and water retention.
- The model can be used to investigate other scenarios

Thank You!!