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Impact of Climate Variability and Land use/Cover Change on Streamflow in Upper Rwizi Catchment, Uganda

Presenter:

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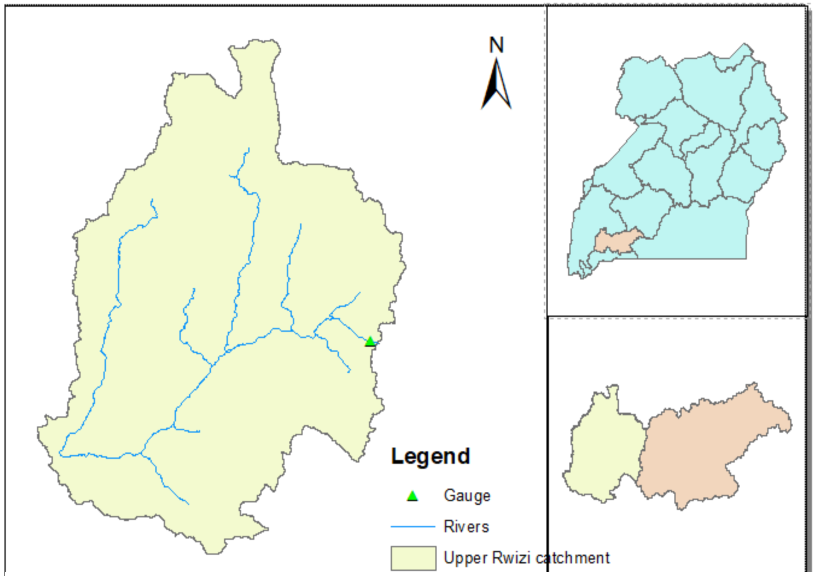
Introduction

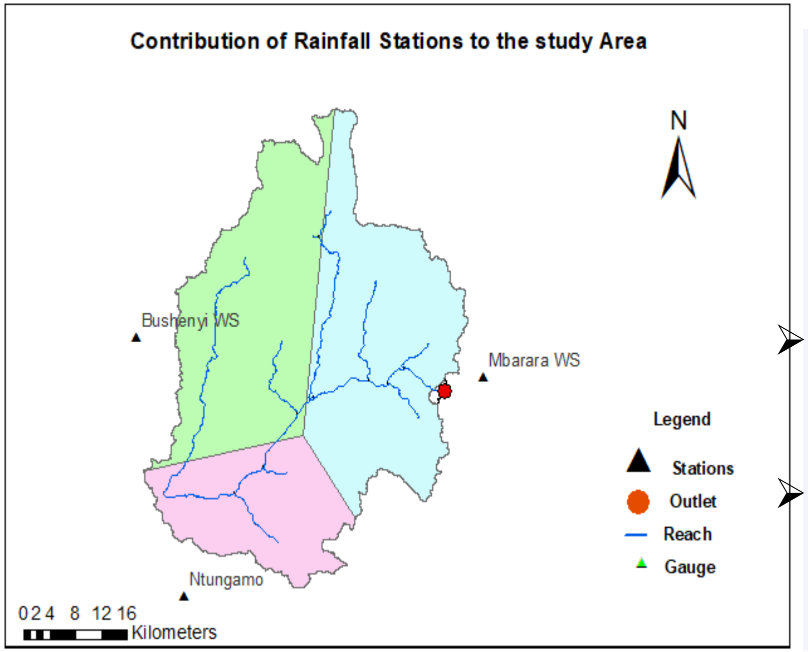
- Globally, Water resources face severe pressure from impacts of climate change and human activities, e.g land-use change, increasing population growth, and economic development (IPCC, 2013).

- Climate variability is the main contributor to changing streamflow volume, (IPCC, 2007) in addition to human activities that can also alter streamflow through land use and land cover changes, reservoir operation and direct abstraction of surface water or groundwater.

- Deforestation, expansion of agriculture and growth of urban centers are some of the most common and widespread land use/cover changes in Uganda (WB, 2015).

Upper Rwizi Catchment





Catchment Area

8,554.7

- Upper catchment

  3,252 km^2

- Study area

  2,028.4km^2

The Problem

High demand for charcoal, Fuel wood and timber resulting in forest and wetland degradation

- ➢ Increasing urbanization
- ➢ Population Increase

- ➢ Modifications of land cover & soils affect runoff and hence water availability

OBJECTIVES AND METHODS

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Objective by Objective

1. To assess variability of precipitation and temperature in the catchment
   - Non-parametric tests
   - Mann-Kendall trend test and Sens slope estimator

2. To determine Landuse/Cover changes in the catchment

   Classification of satellite images (Supervised classification in ArcGIS)
   - Toposheets
   - High Resolution Google Earth Satellite Imagery
   - Classification Accuracy Assessment (Kappa coefficient & Overall accuracy)
   - % Cover change

3. Assess Impact of climate variability and landuse/cover changes on streamflow
   - SWAT Model Setup
   - Sensitivity Analysis
   - Calibration and Validation (R^2& NSE)
   - Altering scenarios to determine the impact

Results and discussions

Objective 1:

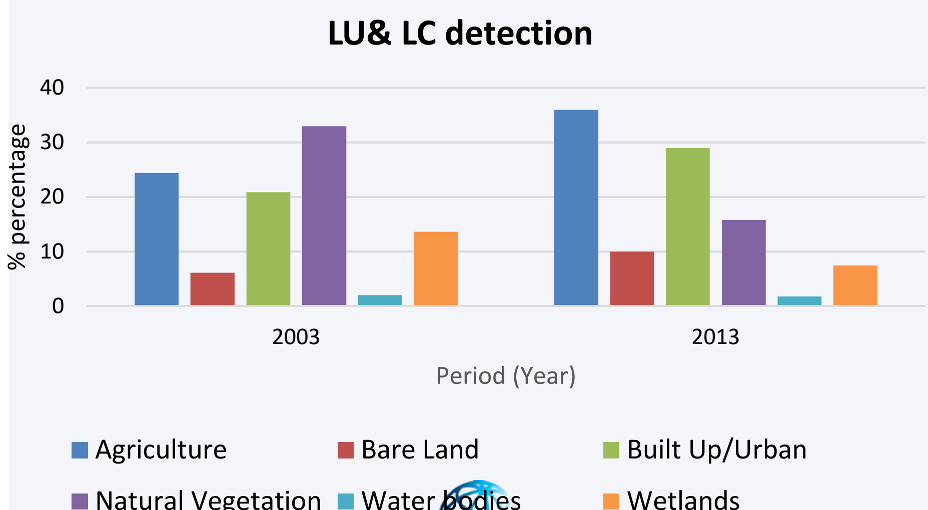
No.	Series Test	Score	P-value	Sen's Slope	Z
1	Temperature	117.000	0.016	0.033	0.0504
2	Evapotranspiration (ETo)	-68	- 0.118	-0.354	-0.03764
3	Precipitation	67.	0.169	11.833	0.028
4	Discharge (Q)	85.000	0.264	0.088	0.024

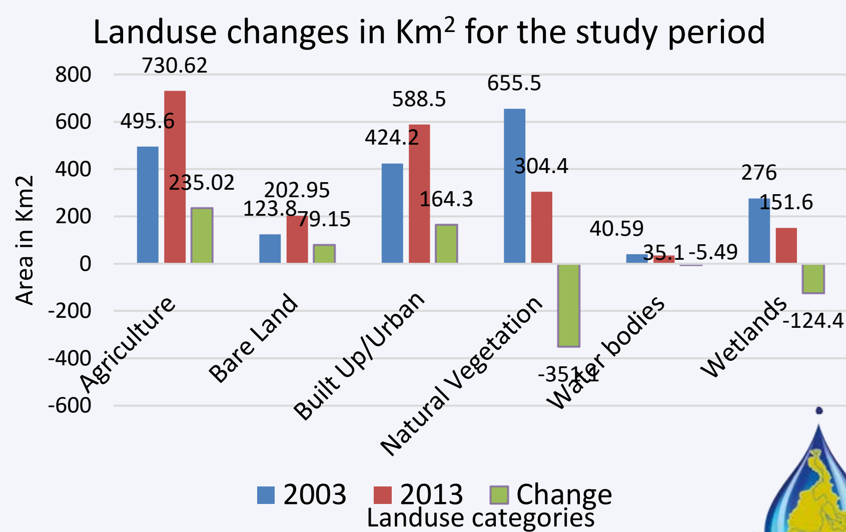
- According to the Mann Kendall trend test, these values were obtained. MK-score, Sens slope, p-values and Z values
- The results showed that three stations selected for trend analysis presented increasing trend in precipitation, Temperature and discharge but this was not the case with Evapotranspiration.
- However the trend is not statistically significance for the period analyzed .
- For Mann-Kendall statistics, for the trend to be statistically significant, Zs should be greater than 1.96 or less than -1.96. According to (Mann 1945, Kendall 1975, Gilbert 1987)

Results cont'd, Objective 2:Landuse/Cover trend analysis

			Statistics for land-use changes				
Land-use types		**2003**		**2013**		**Change**	
	Km^2	%	Km^2	%	Km^2	%	
Agriculture	495.6	24.42	730.62	36	235.02	11.58	
Bare Land	123.8	6.1	202.95	10	79.15	3.89	
Built Up/Urban	424.2	20.9	588.5	29	164.3	8.09	
Natural Vegetation	655.5	32.3	304.4	15	-351.1	-17.3	
Water bodies	40.59	2	35.1	1.73	-5.49	-0.27	
Wetlands	276	13.6	151.6	7.47	-124.4	-6.13	
No Data	13.8	0.68	16	0.8			
Total	**2029.5**	**100**	**2029.5**	**100**			

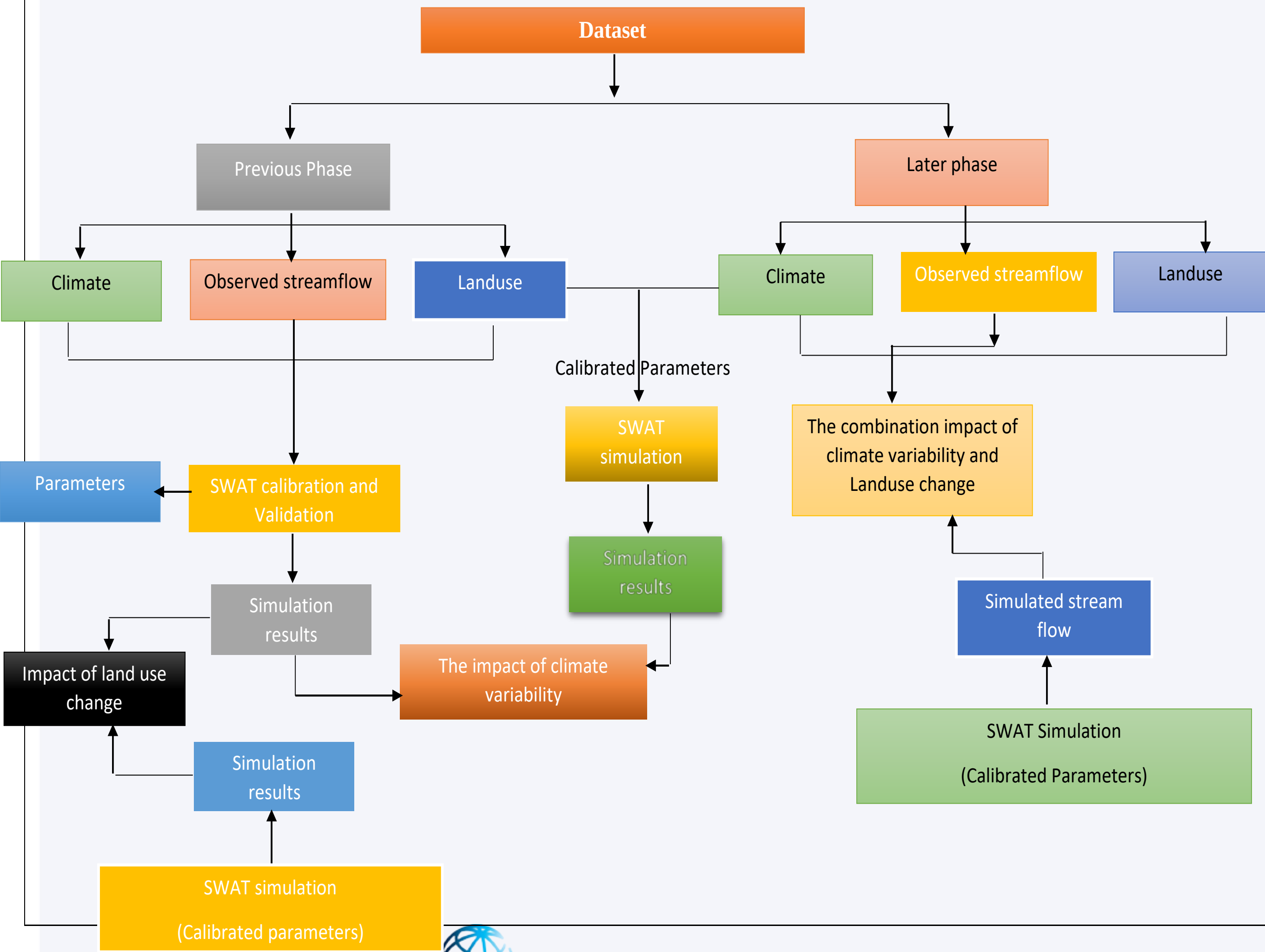
Overall Accuracy= 80%





Landuse/Cover trend analysis Cont'd

Results objective 3: Separate and combined impact factors



Four scenarios were established for analysis as follows

O1: Climate 2000s and land use 2003 (baseline)

O2: Climate 2000s and land use 2013 (land-use change)

O3: Climate 2010s and land use 2003 (climate change)

O4: Climate 2010s and land use 2013 (land-use and climate change)

Objective 3 Results Cont'd

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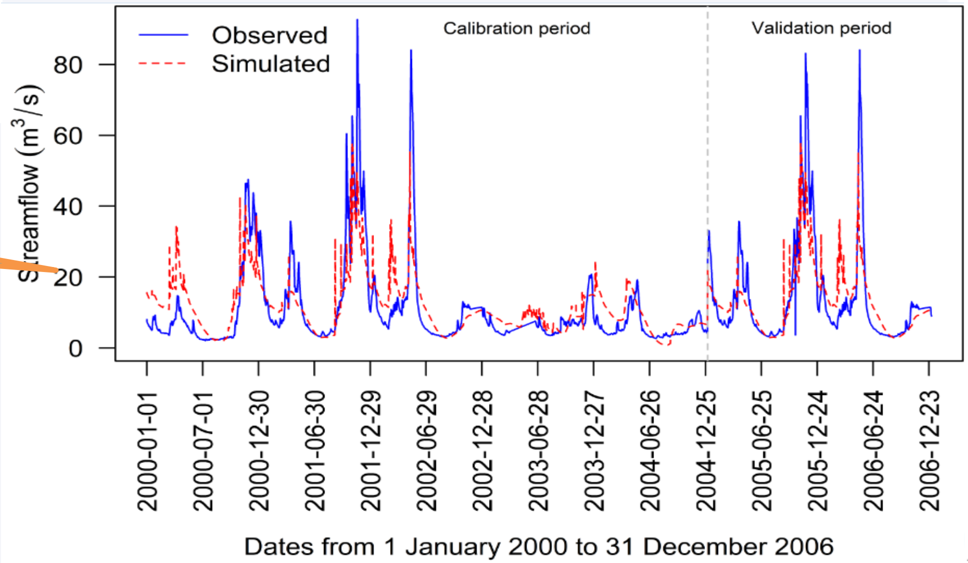
No.	Parameter Name	Fitted Value	Min-Value	Max-Value
1	R_CN2.mgt	-0.25	-0.47	-0.15
2	R_ESCO.bsn	0.088	0.0	1.5
3	V_CH_K2.rte	379.33	304.75	409.64
4	V_CH_N2.rte	0.22	0.16	0.25
5	V_CANMX.hru	44.85	27.1	56.43
6	V_ALPHA_BNK.rte	0.25	0.11	0.33
7	V__ALPHA_BF.gw	0.37	0.27	0.7
8	R_SOL_K.sol	-0.18	-0.2	0.1
	Meaning of V& R "V" Here default SWAT value is replaced by new value "R" refers to multiplying new value with default parameter value			

Efficiency criterion	Performance Range	Calibration Daily	Validation Daily	Calibration Monthly	Performance rating
NSE	0.5<NSE<0.65	0.60	0.51	0.65	Satisfactory
PBIAS	1-25%	11%	18%	24%	Satisfactory
R^2	0 .5– 1	0.63	0.54	0.68	Satisfactory
RSR	0.60<RSR< 0.70	0.68	0.65	0.68	Satisfactory

Calibrated SWAT is obtained for Scenario Analysis



SWAT model gave good model results at Mbarara New water works gauging station for Rwizi upper catchment

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Objective 3 Results Cont'd

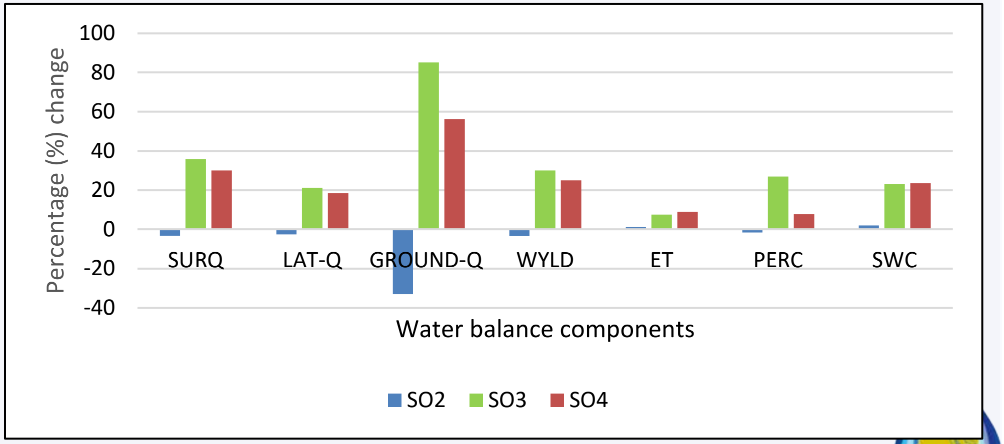
No.	Water Balance components	Percentage differences in water balance components (%)		
		Landuse/cover SO2-SO1	Climate SO3-SO1	Combined SO4-SO1
1	Surface runoff	-3.24	36	30
2	Lateral Flow	-2.5	21.2	18.5
3	Ground water	-33	85.2	56.3
4	Water yield	-3.3	30	25
5	Evapotranspiration	1.4	7.5	9.1
6	Percolation	-1.5	27	7.8
7	Soil water content	1.95	23.2	23.6

Percentage difference in water balance components under SO2, SO3 and SO4

No.	Water Balance components	Model scenarios results			
		SO1	SO2	SO3	SO4
1	Surface runoff (mm)	90.63	87.39	123.4	117.98
2	Lateral flow(mm)	81.54	79.5	98.9	96.65
3	Ground water (mm)	1.42	0.95	2.63	2.22
4	Water yield (mm)	173.59	167.84	224.93	216.85
5	Evapotranspiration (mm)	624.7	633.3	672	682
6	Percolation (mm)	203.69	200.67	260.24	219.68
7	Soil water content (mm)	195.06	191.24	241.16	240.33

Scenario results from the model

- ✓ Under the impact of combined land-use and climate changes, the streamflow and surface runoff increased in the 2010s compared with those in the 2000s.



Percentage differences in water balance components analysed

Conclusion and Recommendations

- In general, climate variability influenced hydrological processes more strongly than the land-use change in the catchment during the period 2000-2014.
- Climate variability and change Interventions/measures like Rain water harvesting should be emphasized when planning for future water resources to supplement on river flows during dry seasons
- More efforts in gathering good and enough data (rehabilitating rainfall stations) to improve performance of hydrological models

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THANK YOU!