2025 International SWAT Conference

THE COUPLED INFLUENCE OF LAND MANAGEMENT AND CLIMATE ON THE CROCODILE RIVER CATCHMENT, MPUMALANGA PROVINCE, SOUTH AFRICA

MARY NKOSI

DATE: 27 JUNE 2025

PRESENTATION OUTLINE

- Description of the study
- Adopted Methodology
- Results and Discussion
- Conclusion

DESCRIPTION OF THE STUDY

- The Crocodile River is a critical water source for Mpumalanga Province, vital for irrigation, domestic use, and ecological services that underpin the region's ecotourism industry
- Area: 10 450 km^2 and 320 km length
- The climate of the catchment is highly influenced by altitude resulting in climate variability and rainfall is highly seasonal
- The highveld: 730 mm/year rainfall,
- The escarpment region: 1600 mm/year
- The Lowveld region receives between 550–850 mm/year

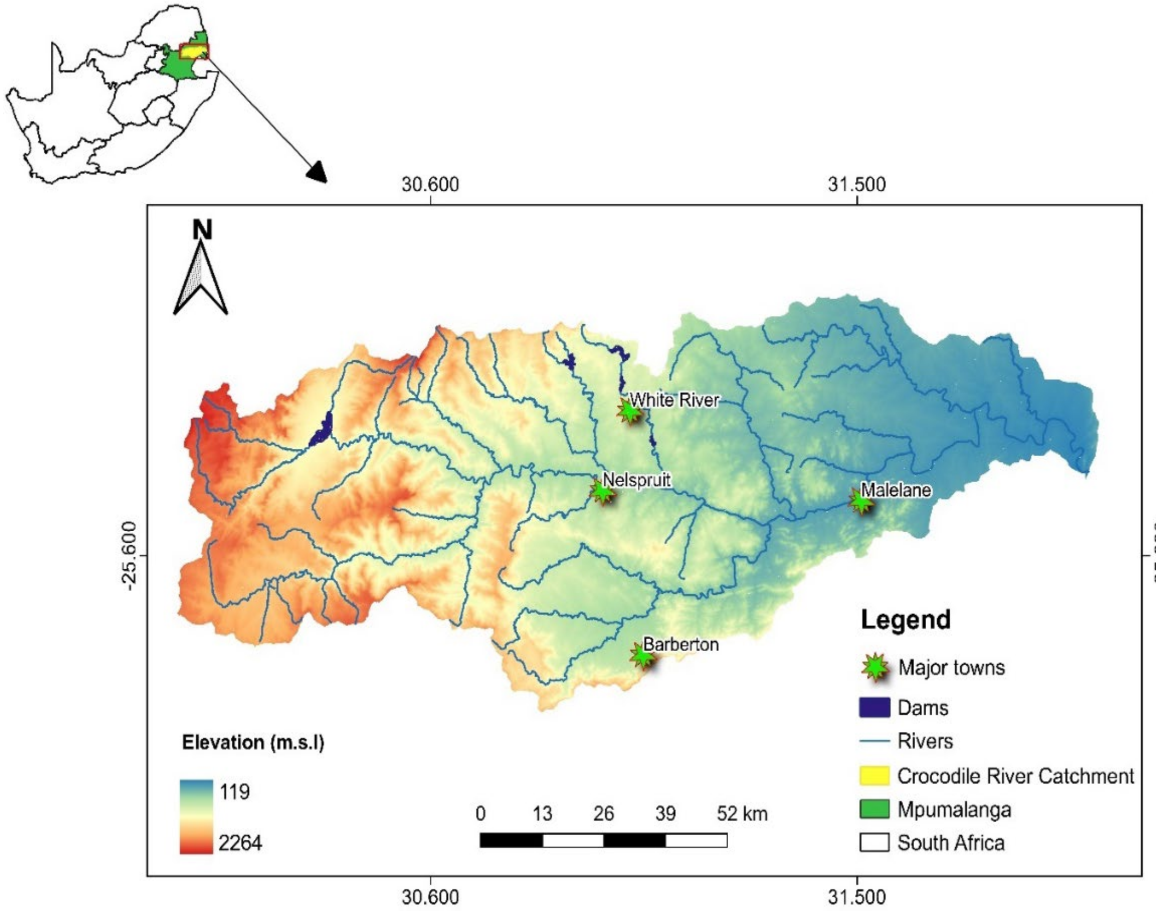
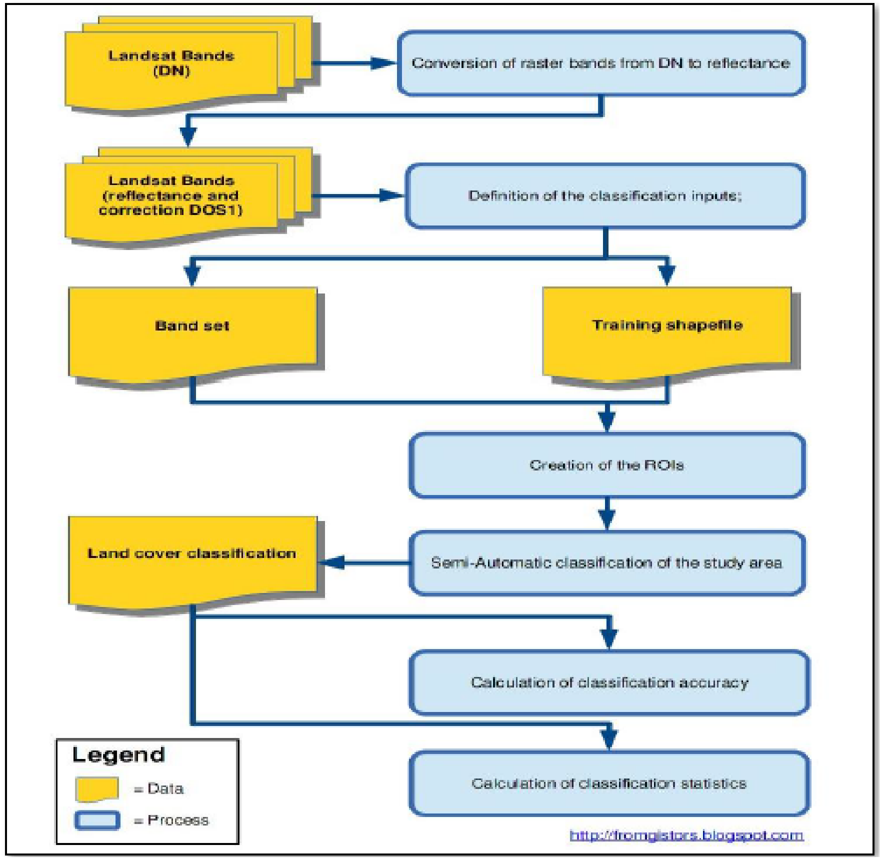


Fig 1. Location of the Crocodile River Catchment

ADOPTED METHODOLOGY

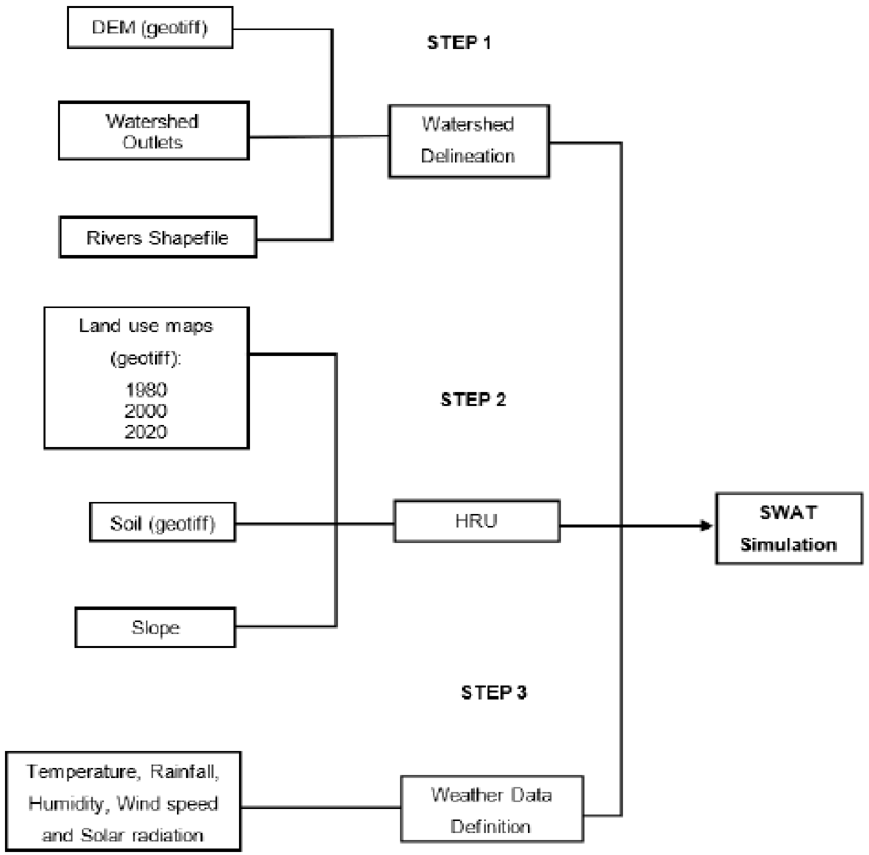
- LULC CLASSIFICATION – Semi-automatic Plug-in in QGIS
- SPI and SSI – were computed using R

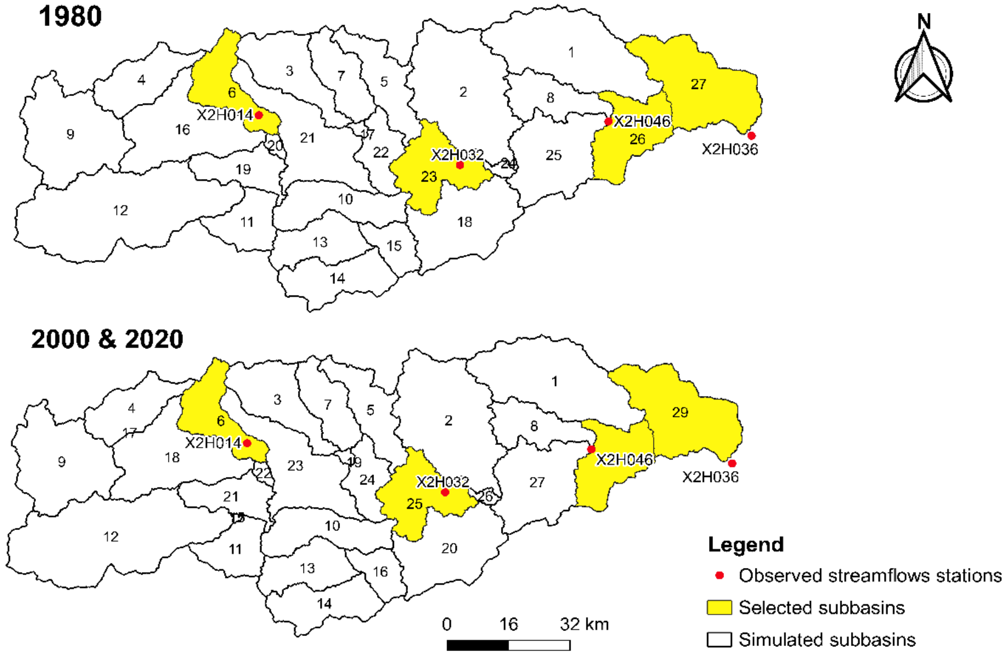
LULC	Description	SWAT Code
1. Cultivation	Crop lands, irrigated, dry crops, rotational crops, pastures	AGRR
2. Forest plantation	Alpines, evergreen, deciduous forests	FRSE
3. Waterbodies	Dams, ponds, rivers	WATR
4. Grassland	All grass range	GRAS
5. Built-up	All urban areas and settlements, commercial, mines, manmade structures	URBN
6. Bushland/Savanah	Bush, thickets, shrubs,	SAVA
7. Bare	No or little vegetation and exposed areas in cultivation areas, rocks, burnt areas, quarries areas	BSVR
8. Natural forest	Mixed indigenous forest and woodland	FRST



Cogendo, 2014

ADOPTED METHODOLOGY

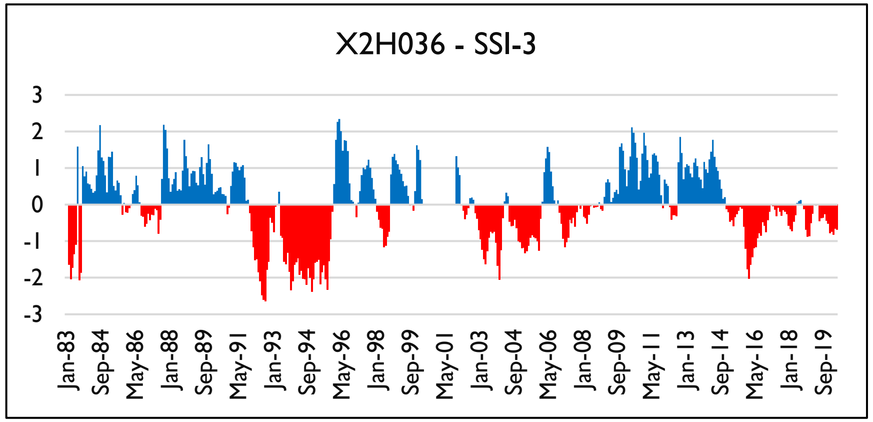


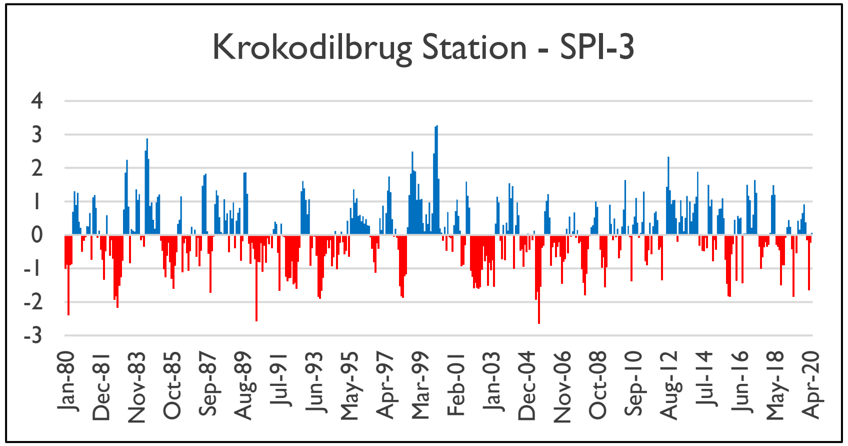


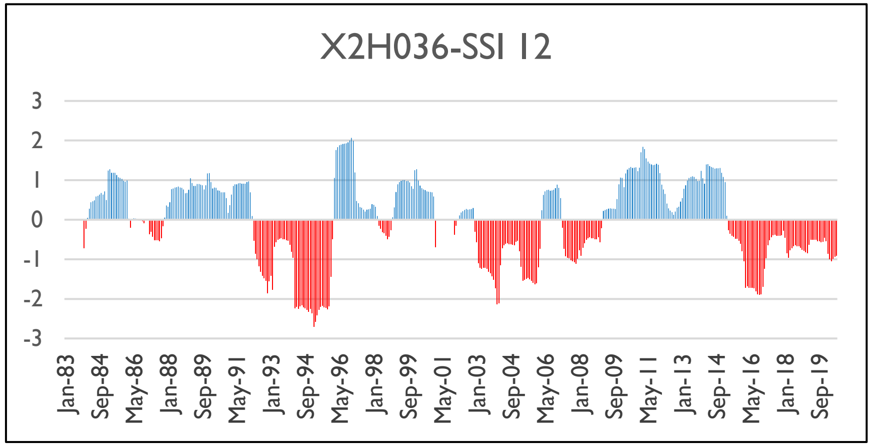
Adopted model performance Metrics: NSE, PBIAS and RSR

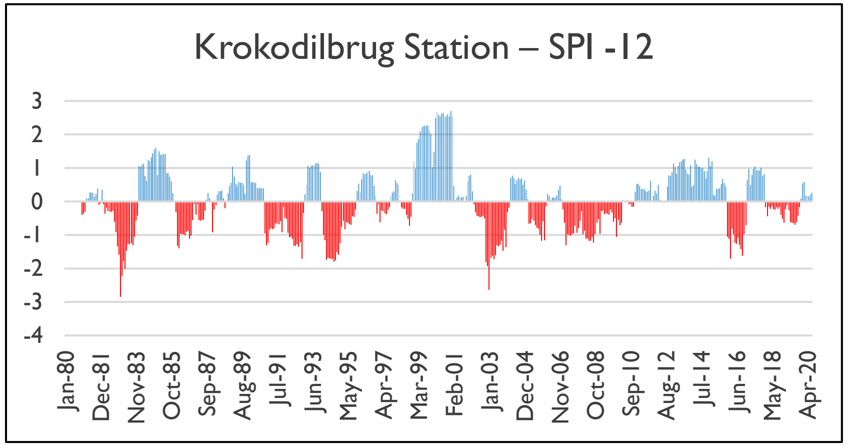
Results and Discussion

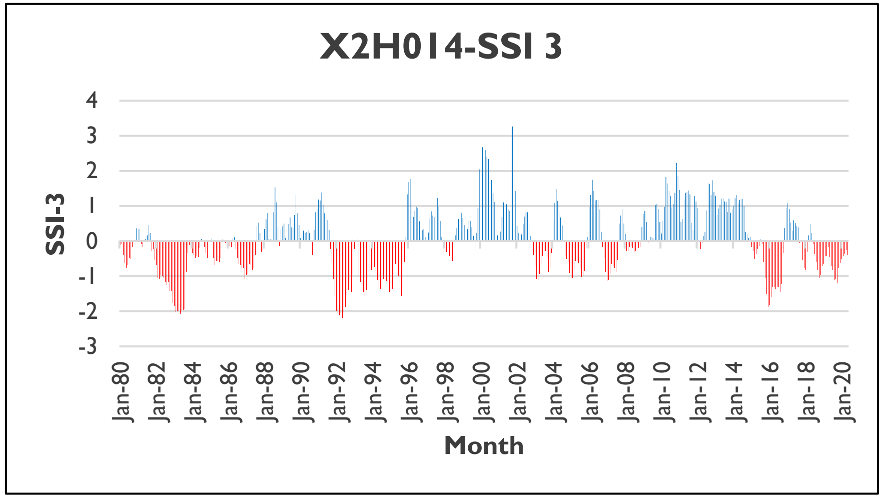
1. DROUGHT ANALYSIS







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SSI-3
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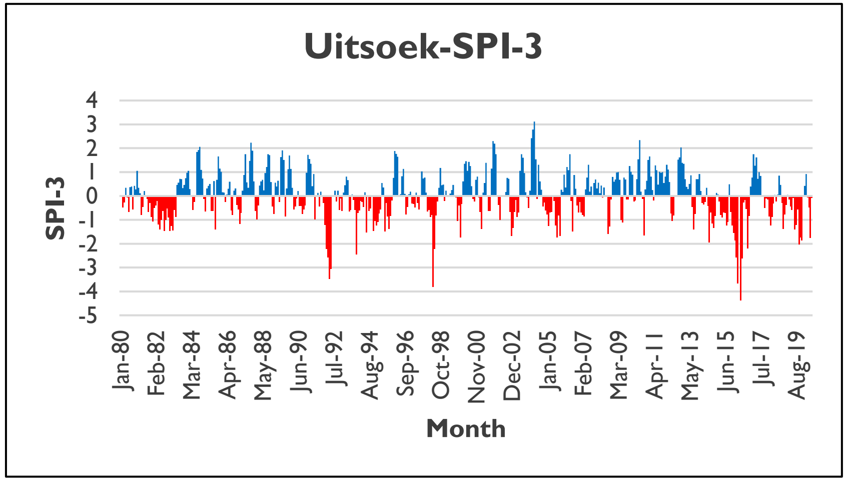
Jan-18
Jan-20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SPI-3
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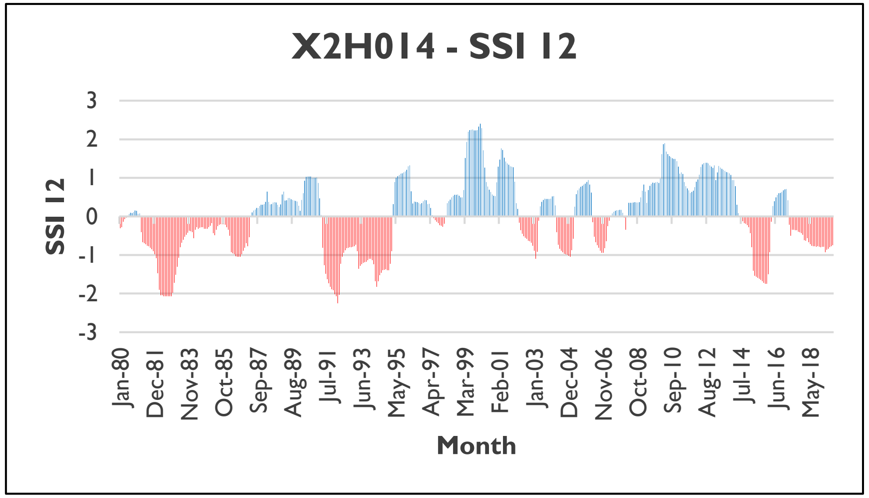
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SSI 12
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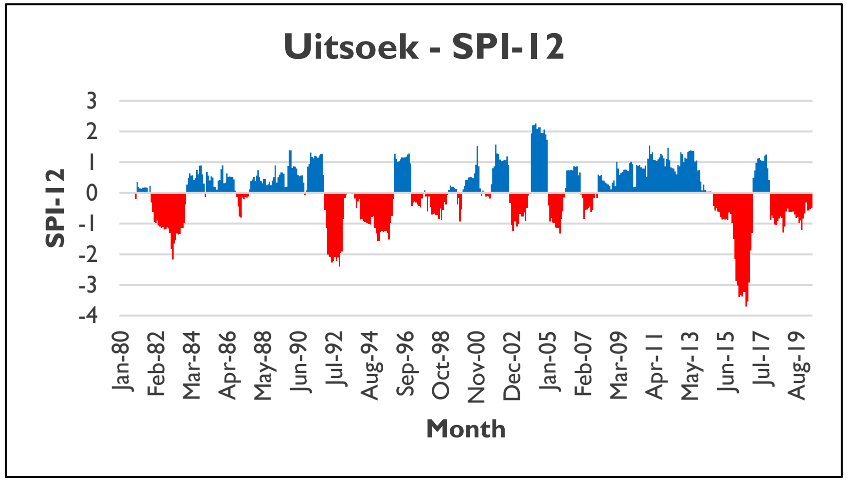
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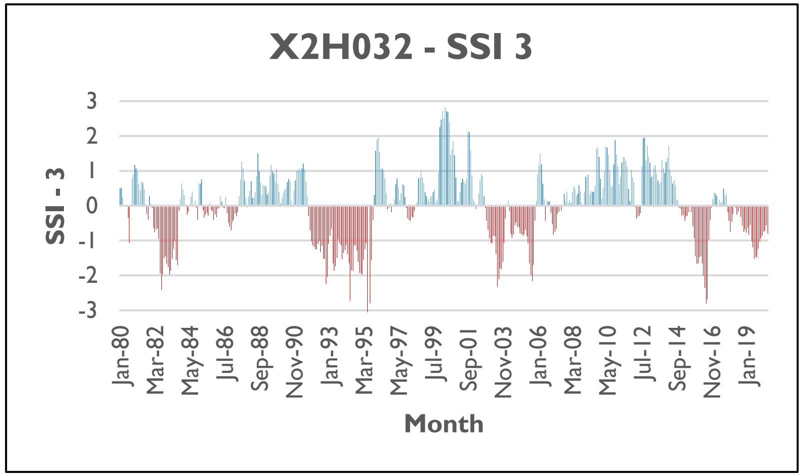
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SSI - 3
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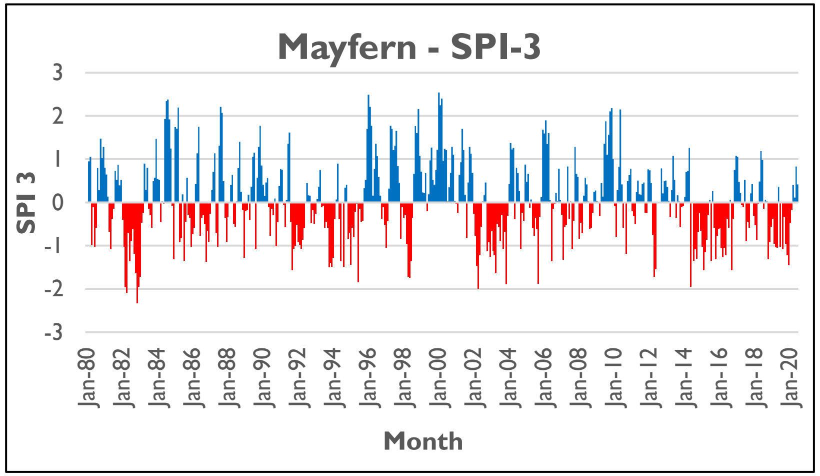
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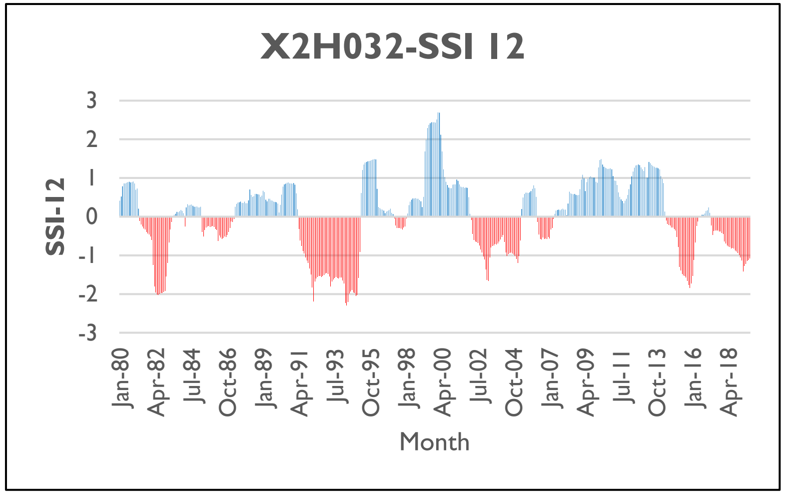
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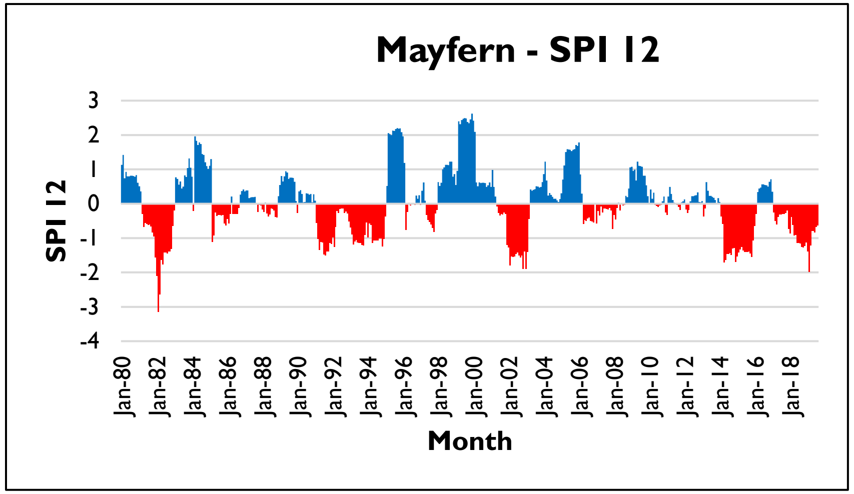
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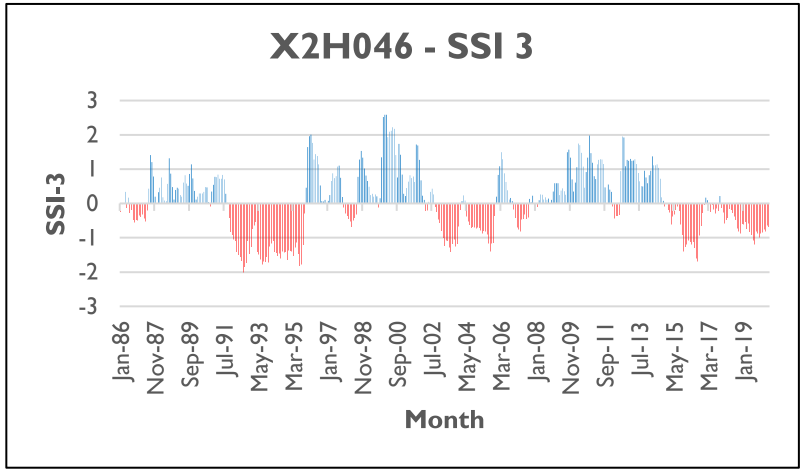
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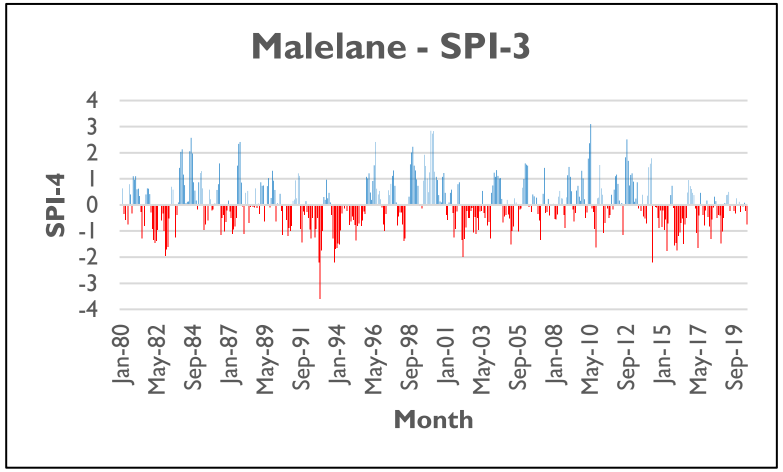
SSI-3
Month


Malelane - SPI-3
SPI-4
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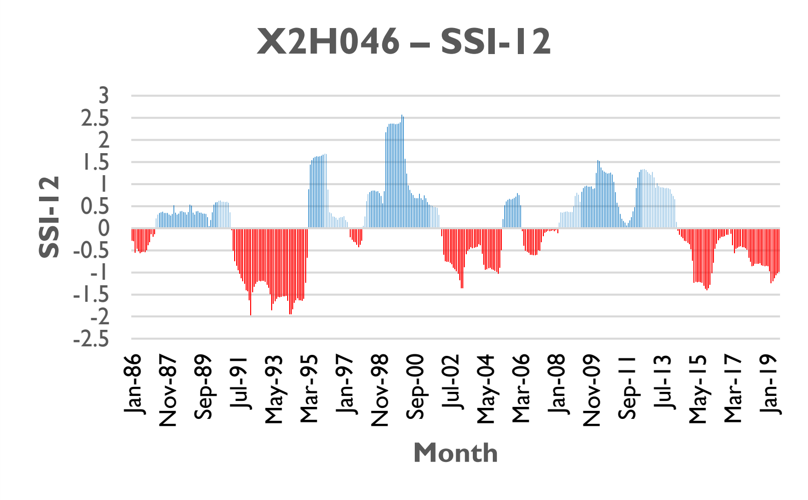
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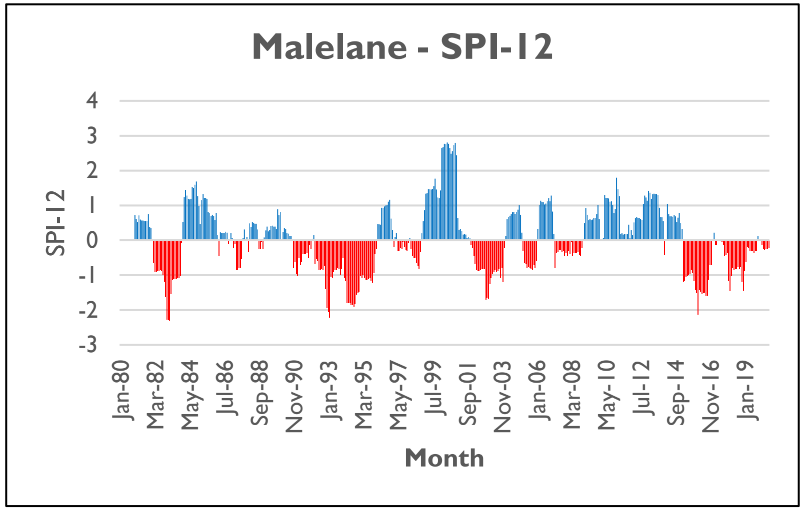
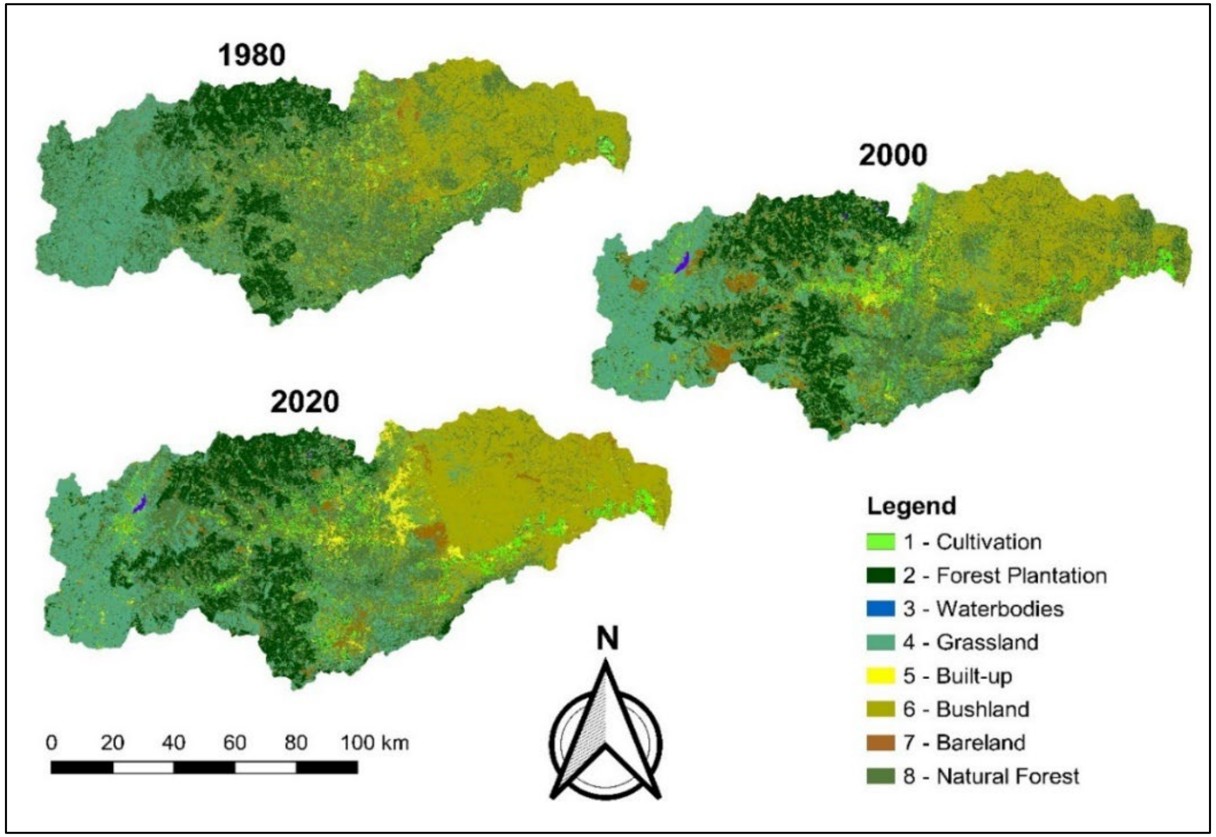

Malelane - SPI-12
SPI-12
Month

Subbasin –5					
Mayfern			XH032		
Drought year	SSPI-12	Drought Classification		SSI	Classification
Feb – Nov 95	-1.1	Moderate Dry	Aug – Dec 1995	-1.7	Severe Dry
Nov 2002 -Jan 2004	-1.5	Severe Dry	October 2003 – Mar 2004	-1.3	Moderate Dry
Mar 2015 – Nov 2016	-1.4	Moderate Dry	Feb 2016 -Jan 2017	-1.9	Severe Dry
May 2019 -Feb 2020	-1.3	Moderate Dry	Dec 2019 – Jan 2020	-1.2	Moderate Dry
Subbasin-3					
Malelane			XH046		
Nov 92 – Oct 95	-1.3	Moderate Dry	Jul 92 – Dec 95	-1.5	Severe Dry
Nov 2002 – Dec 2003	-1.1	Moderate Dry	Nov 2003 – Feb 2004	-1.2	Moderate Dry
Mar 2015-Oct 2016	-1.3	Moderate Dry	Feb 2016 – Jan 2017	-1.3	Moderate Dry
Jan 2018- Dec 2018	-1	Moderate Dry	Feb 2020 – Jun 2020	-1.1	Moderate Dry
Subbasin - 1					
Krokodilbrug			X2H036		
Dec 1993 – Marc 1995	-1.3	Moderate Dry	Jun 1992 – Jan 1995	-1.6	Severe Dry
Nov 2002 – Dec 2003	-1.6	Severe Dry	Feb 2003 -Mar 2004	-1.4	Moderate Dry
Dec 2015 – Oct 2016	-1.3	Moderate Dry	Mar 2005 – Jun 2006	-1.5	Severe Dry
			Jan 2016 – Jan 2017	-1.7	Severe Dry
Subbasin 23					
Uitsoek			X2H014		
Jun 94 – Nov 95	-1.2	Moderate Dry	Mar 1994 – Dec 1995	-1.3	Moderate Dry
Nov 2015 – Jan - 2017	-2.7	Extreme Dry	Feb 2016 – Jan 2017	-1.6	Severe Dry

2. Land Use/Land Cover Changes



Period	Overall accuracy	Kappa statistics
1980	77.4	0,71
2000	82.3	0.78
2020	77.2	0.72

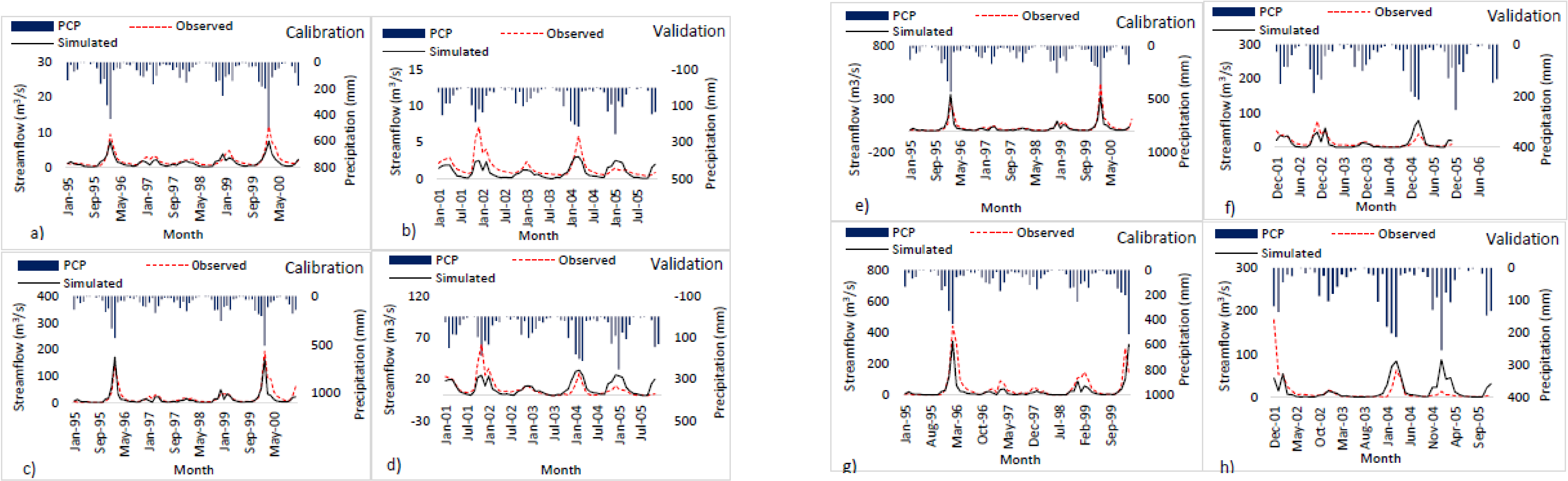
Land-use	1980	2000	2020	% of Change from 1980-2020
1. Cultivation	2.6	5.1	5.1	2.5
2. Forest plantation	12.3	14.4	15.4	3,1
3. Water	0.04	0.3	0.1	0.06
4. Grassland	27	27	26.	-1
5. Built-up	0.5	1.3	2.8	2.3
6. Bushland/Savana	23.8	23	25.9	2.1
7. Bareland	1.3	5.6	5	3.7
8. Natural Forest	32.5	23.3	19.7	-12.8

3. Hydrological Simulations

2.1. Calibration and Validation

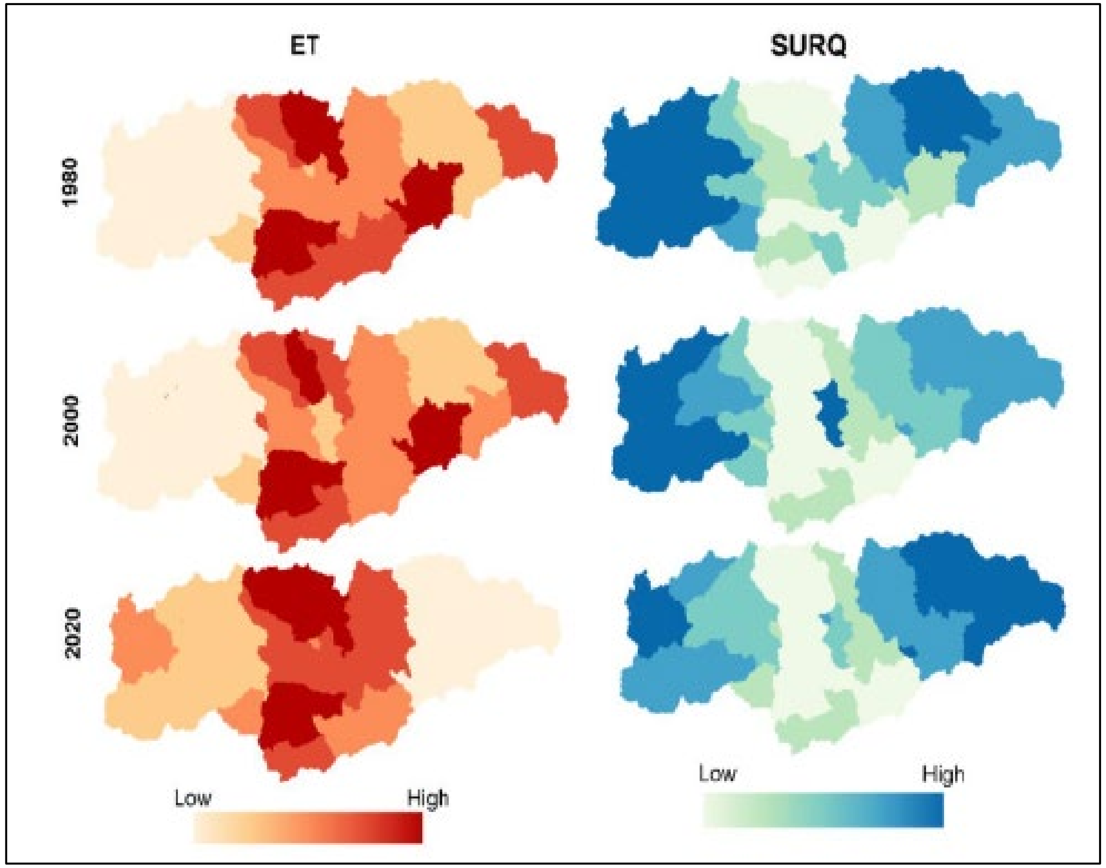
Parameters	Description	Fitted value		
		1980-1990	1995-2005	2010-2020
1. CN2.mgt	Initial SCS runoff curve number for moisture condition II	0.1	0.5	0.5
2. ALPHA_BF	Baseflow alpha factor (days)	0.01	0.01	0.01
3. GW_DELAY	Groundwater delay time (days)	500	1000	100
4. GWQMN	The threshold depth of water in the shallow aquifer required for return flow (mm)	4000	3000	5000
5. GW_REVAP	Groundwater revap (percolation) coefficient	0.02	0.02	0.02
6. SURLAG	Surface Runoff lag coefficient (mm H2O).	4	4	4
7. SHALLST	Initial depth of water in the shallow aquifer (mm).	1000	1000	1000
8. REVAPMN	The threshold depth of water in the shallow aquifer for "revap" to occur (mm)	750	750	750
9. ESCO	Soil evaporation compensation factor	0.95	0.95	0.95
10. RCHRG_DP	Deep aquifer percolation fraction	0.05	0.05	0.05

X2H014 Model performance		1980	2000	2020
NSE	Calibration	0.59	0.68	0.2
	Validation	-0.1	0.31	0.5
PBIAS	Calibration	-2.6	32	38.07
	Validation	53	37.9	33
RSR	Calibration	0.47	0.57	0.9
	Validation	1	0.8	0.7
X2H032 Model performance		**1980**	**2000**	**2020**
NSE	Calibration	0.78	0.76	0.63
	Validation	0.57	0.41	0.73
PBIAS	Calibration	-2.6	27.9	22.3
	Validation	12	-5.9	5.7
RSR	Calibration	0.47	0.49	0.60
	Validation	0.66	0.76	0.52
X2H046 Model performance		**1980**	**2000**	**2020**
NSE	Calibration	-1.4	0.83	0.4
	Validation	0.56	-1.3	0.3
PBIAS	Calibration	-49	-23.7	29
	Validation	3.4	-90	-2.8
RSR	Calibration	1.6	0.41	0.76
	Validation	0.66	1.5	0.83
X2H036 Model performance		**1980**	**2000**	**2020**
NSE	Calibration	0.80	0.51	0.5
	Validation	0.4	0.10	0.5
PBIAS	Calibration	23.6	40.6	-22.3
	Validation	36	-24	20.3
RSR	Calibration	0.43	0.7	0.72
	Validation	0.75	0.9	0.70

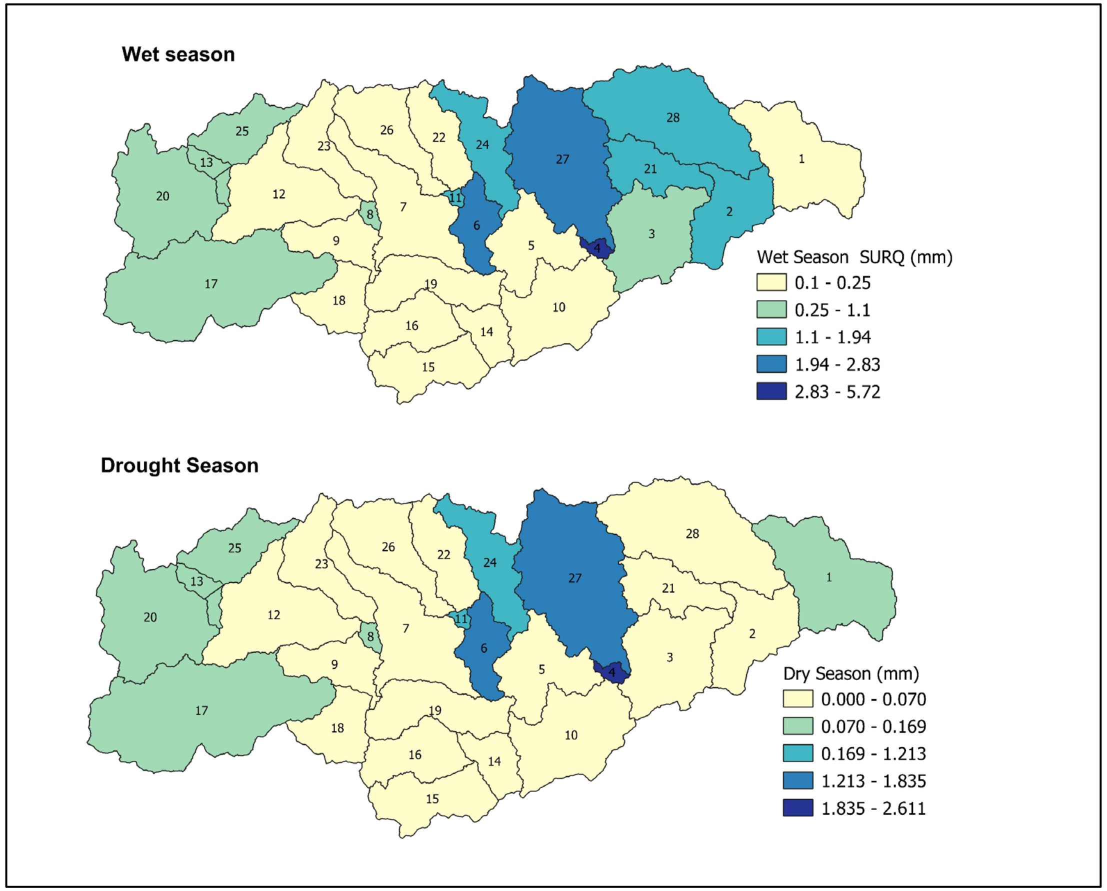


Simulated and observation streamflow for **X2H014 (a and b), X2H032 (c and d), X2H046 (e and f)** and **X2H036 (g and h)** streamflow stations.

4. HYDROLOGICAL RESPONSE TO LULC

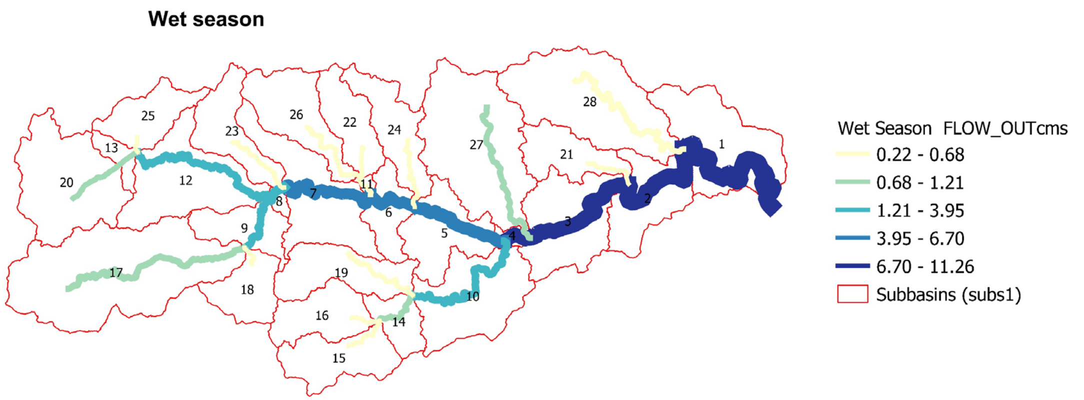


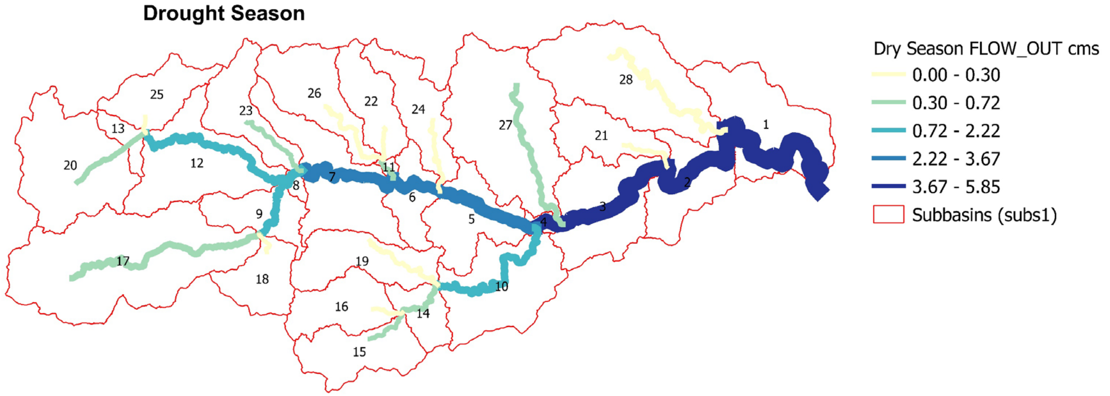
Evapotranspiration and Surface runoff Distribution between 1980 - 2020



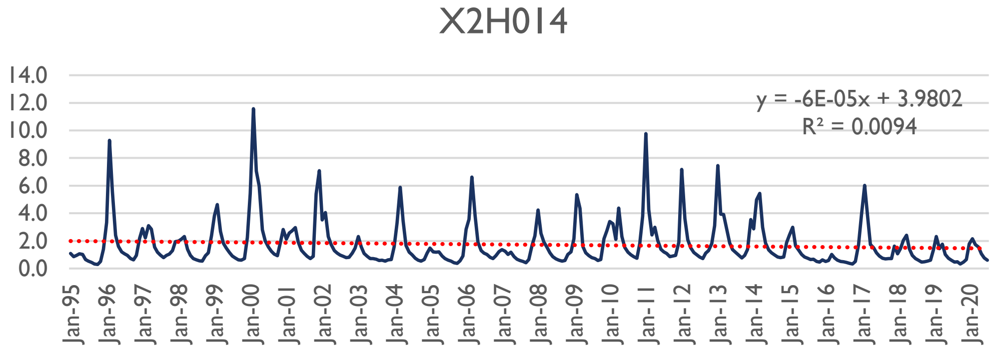
Distribution of Surface Runoff during the wet and dry season

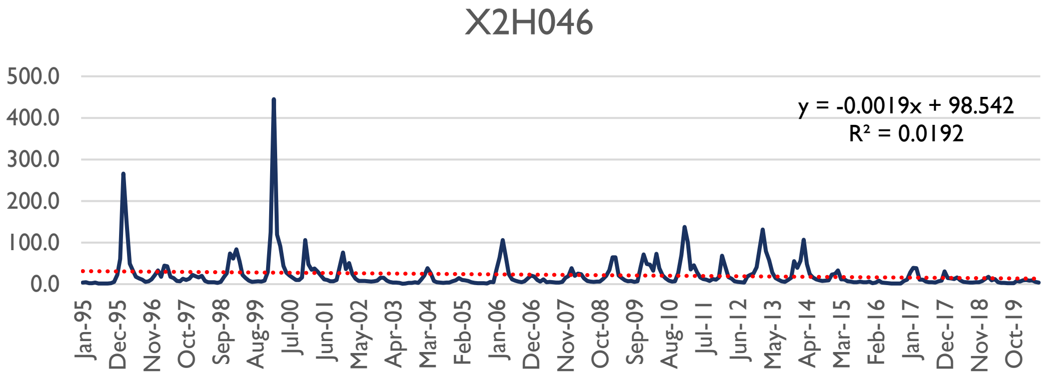
4. HYDROLOGICAL RESPONSE TO LULC





Streamflow variation during the wet and dry season





Overall streamflow trend downstream between 1995 - 2020

CONCLUSION

- Observed increase in built-up area and forest plantation leading to increase surface runoff in urbanised subbasin
- Overall decreasing streamflow trend
- Streamflow fluctuations varied with dry and wet conditions identified through SPI and SSI indices

THANK YOU