Assessment of climate impact on meso-scale catchment hydrology considering land use projections

M. Haris Ali, Ioana Popescu, Andreja Jonoski
IHE Delft Institute for Water Education, the Netherlands.
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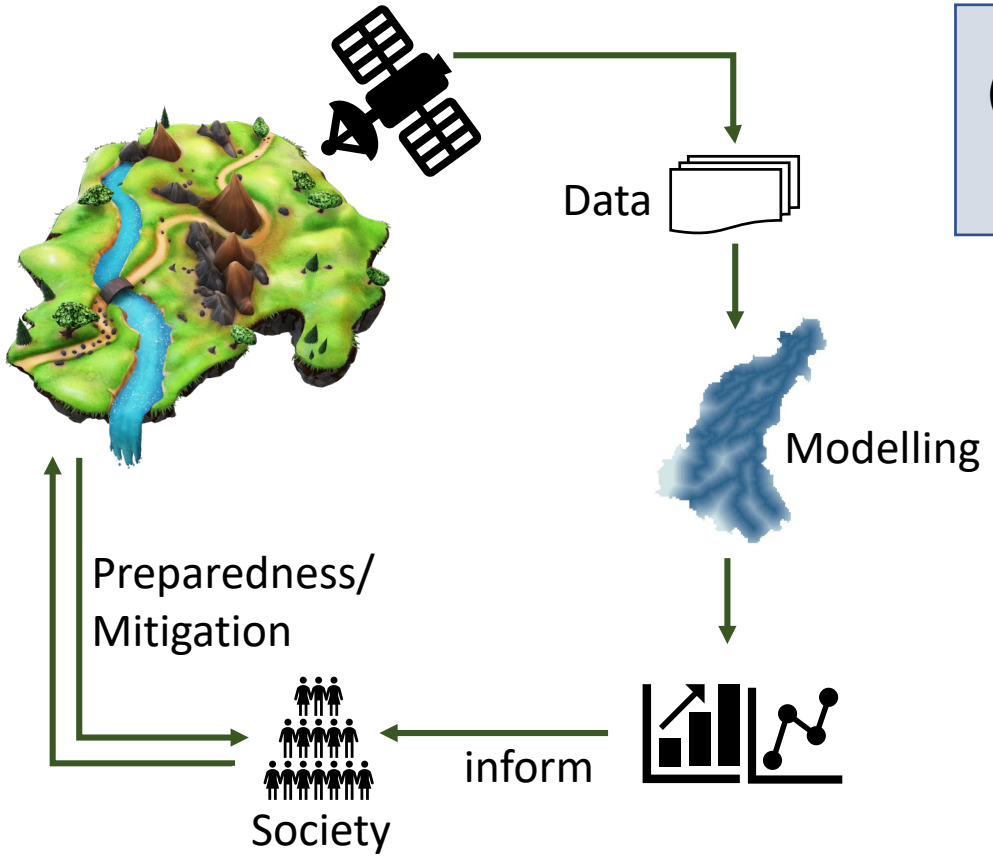
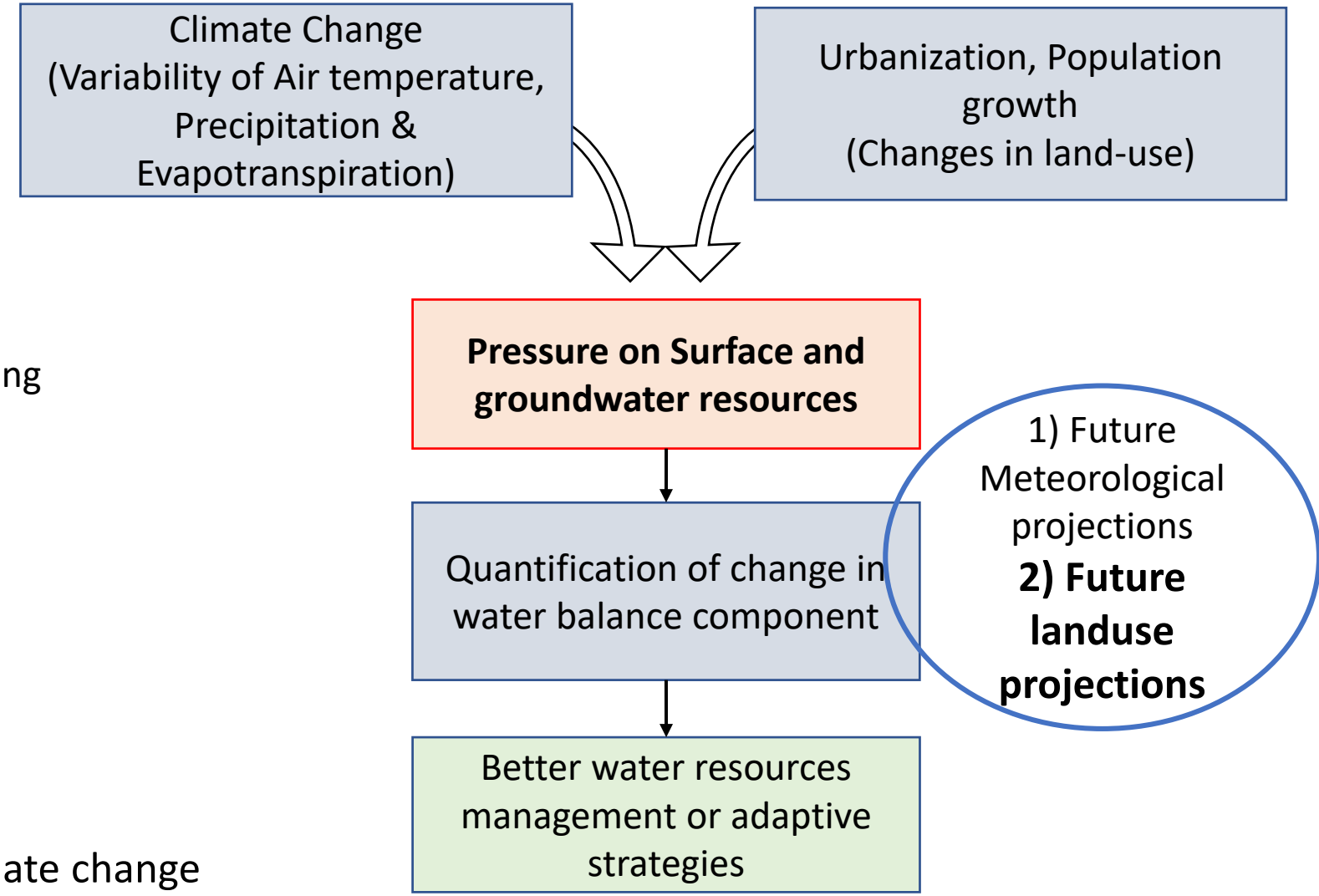
Motivation





Objective

- To analyse the combined impact of climate change and land use change on surface and sub-surface hydrology of study area

Study Area

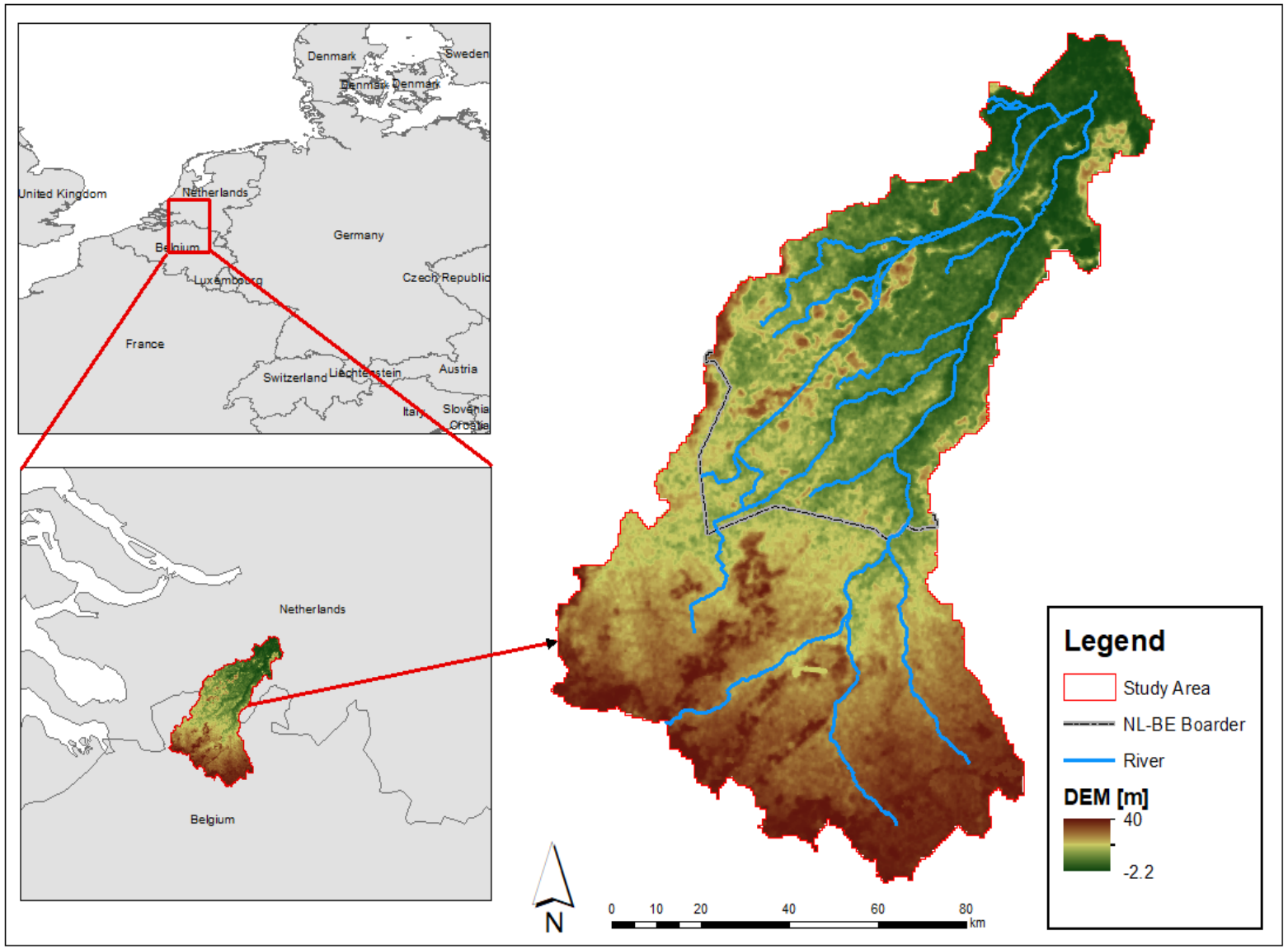
Source: Brecht, Flanders

Outlet: Breda

Total Area: 346 km^2
Netherlands: 147 km^2
Flanders: 199 km^2

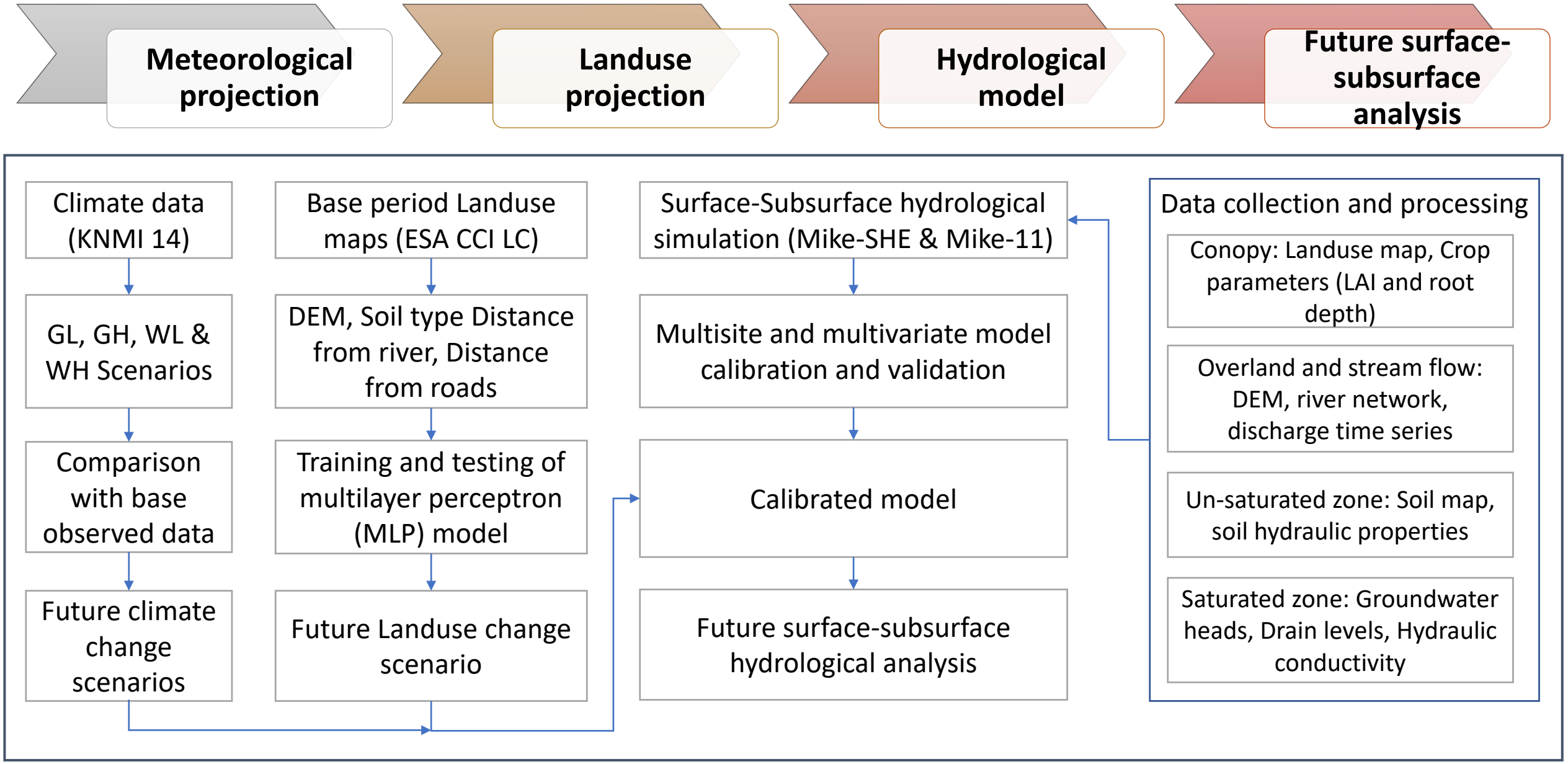
Originally a wetland but majorly the land use has changed due to agriculture.

Water stressed catchment in summers



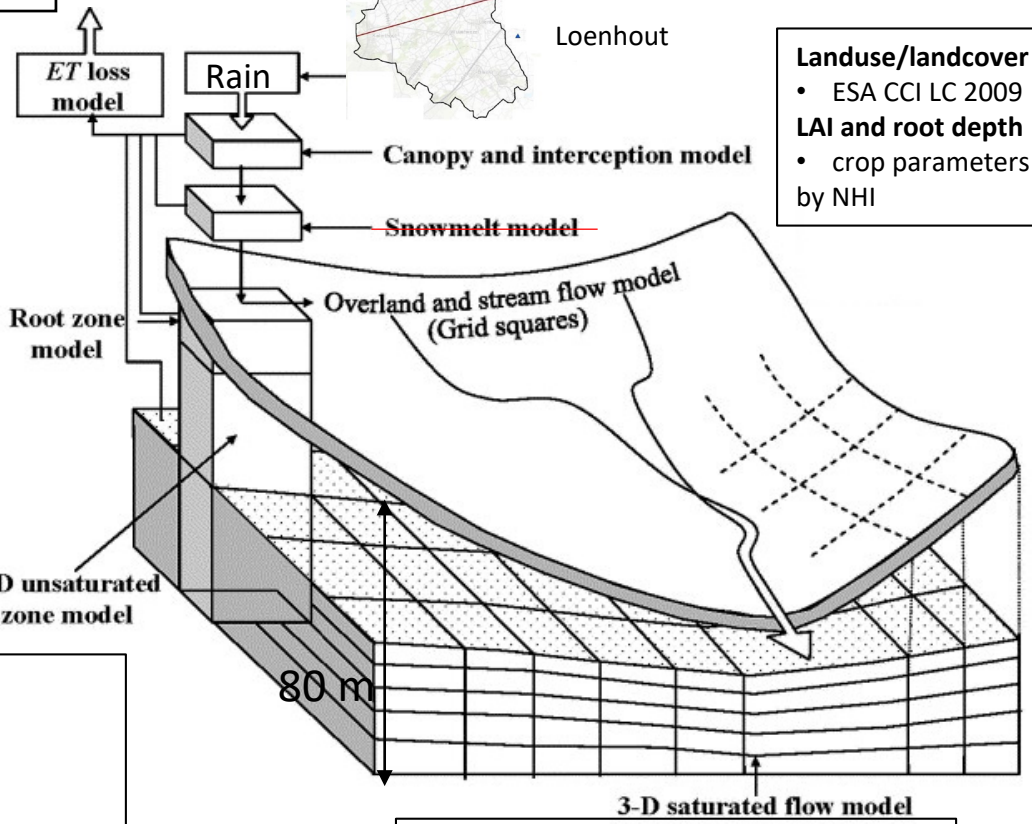
Location and DEM of study area [Source: EU-DEM V1.1, CLMS (n.d.-a)]

Methodology



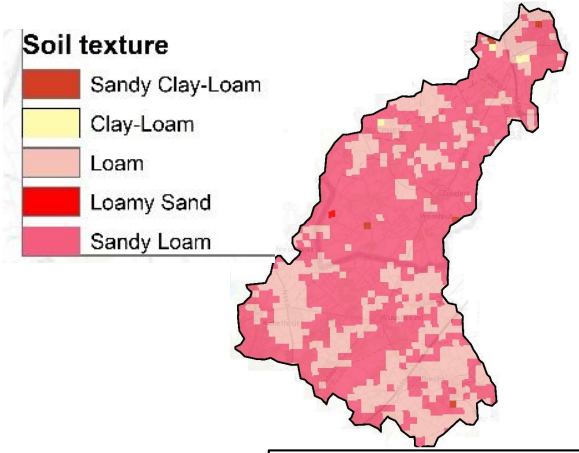
Model setup

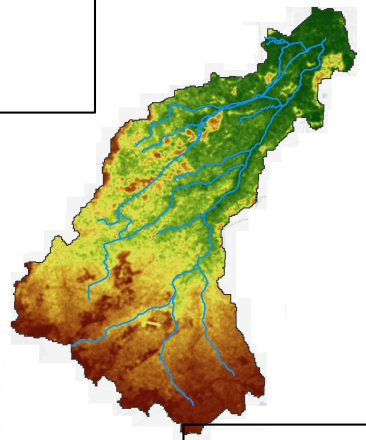
Potential ET
- Gilze-Rijen



Landuse/landcover
- ESA CCI LC 2009

LAI and root depth
- crop parameters by NHI





Soil Distribution Map
- ESDAC (LUCAS Top soil)

Richard's equation

Hydraulic soil properties
- Van Genuchten method

(Parameters by Rosetta program)

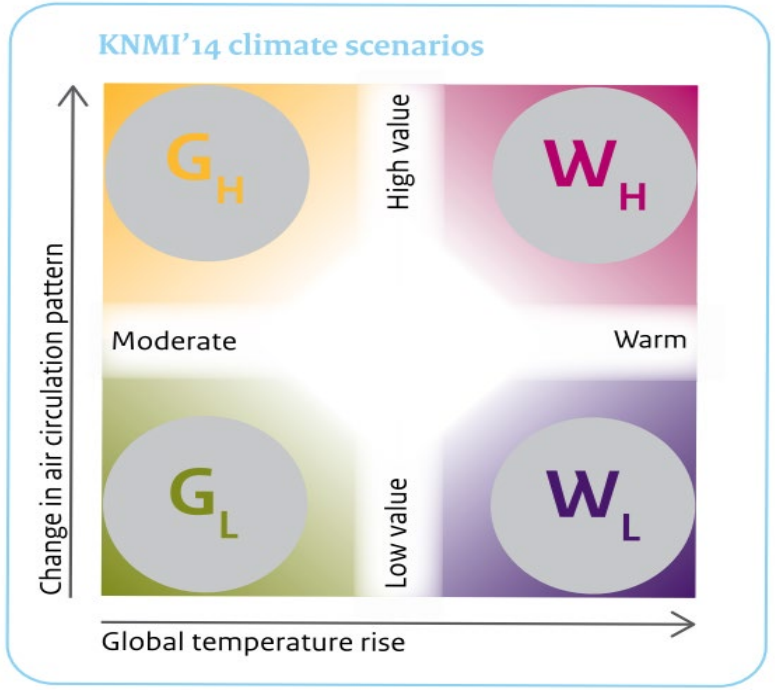
Finite Difference Equation
- Spatially distributed fixed head BC
- Drains: distributed
- Drain level = spatial distributed
- Hydraulic conductivity (spatially distributed based on Regis II model)

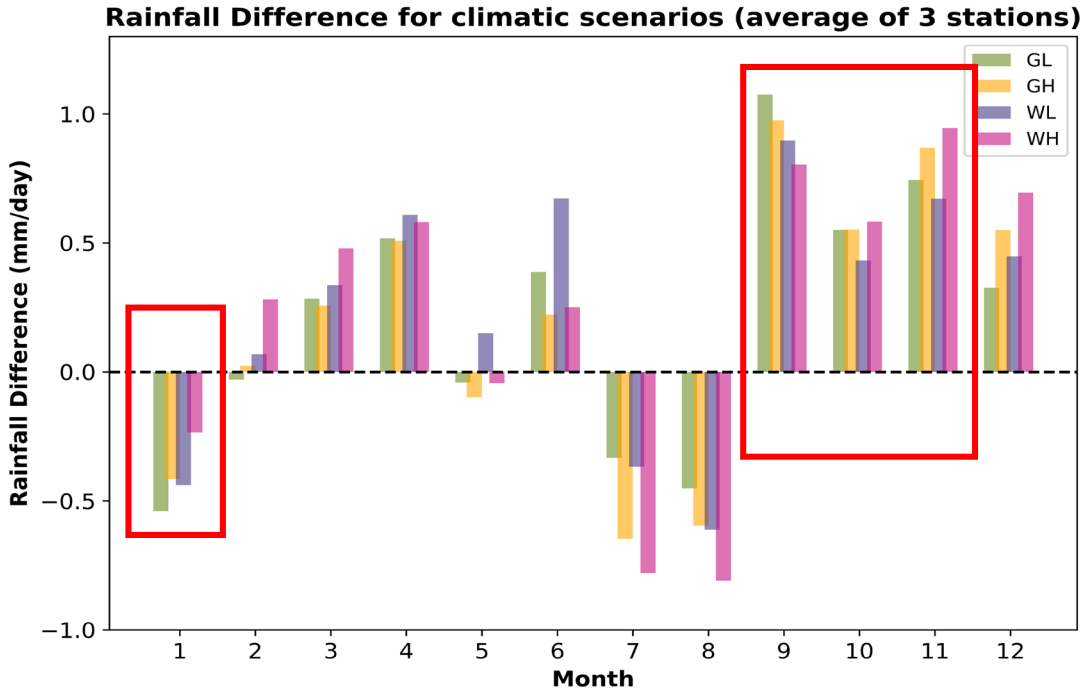
Topography
- EU DEM

River Network

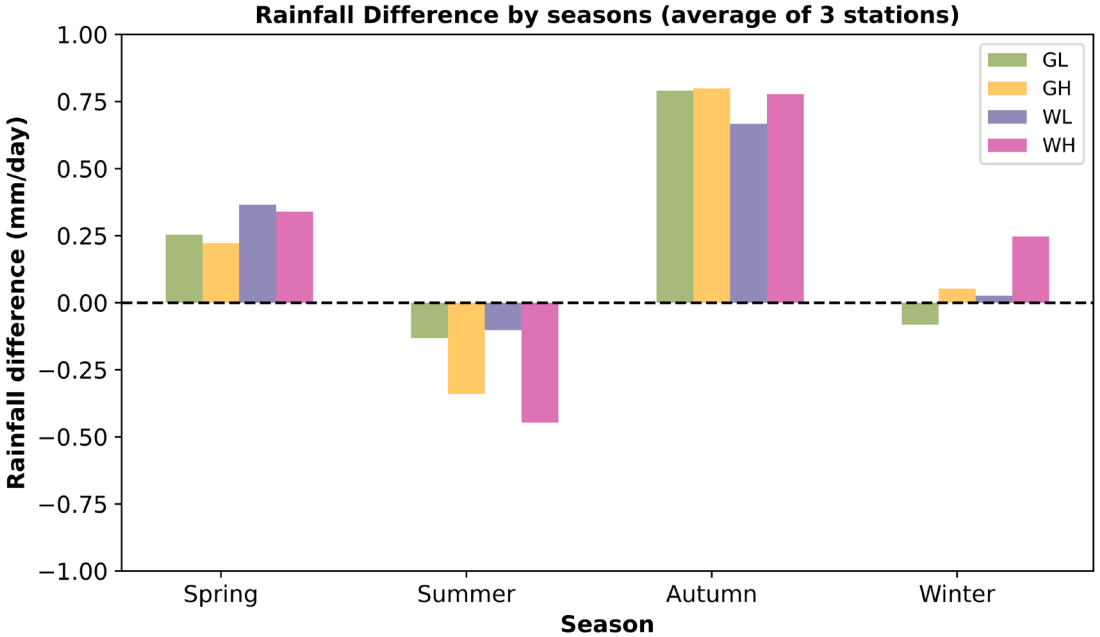
In Mike 11
- 7 automated weirs
- 22 fixed weirs

Future meteorological projection



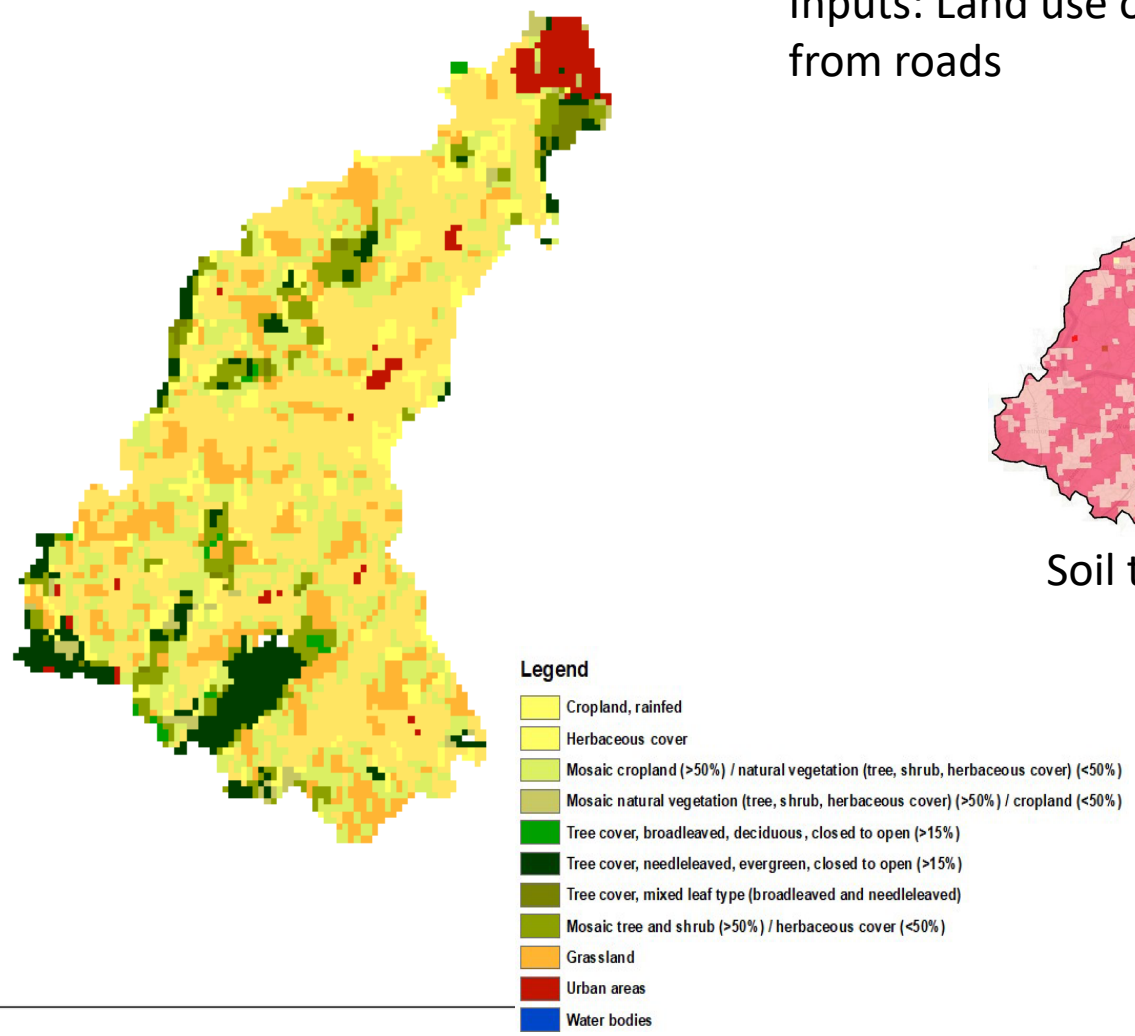


	2010-2019	2046 - 2055			
	Observed	GL	GH	WL	WH
mean rainfall (mm/day)	2.29	2.49	2.47	2.52	2.51



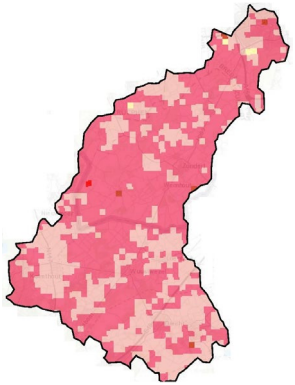
Future landuse projection

Land Use Map for Year =1992

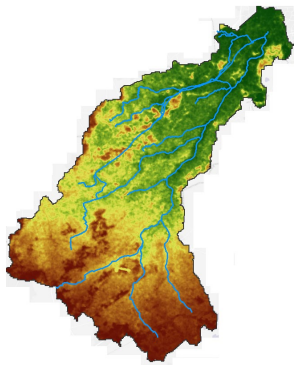


Trained an Artificial Neural Network (ANN) model using MOLUSCE plugin in QGIS.

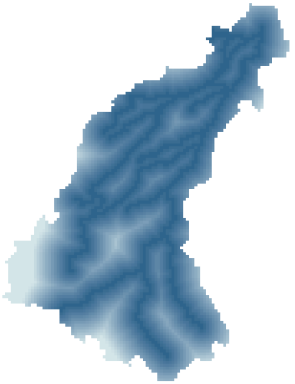
Inputs: Land use of two years, Elevations, Soil type, Distance from river, Distance from roads



Soil type



Elevation



Distance from river

Distance from roads

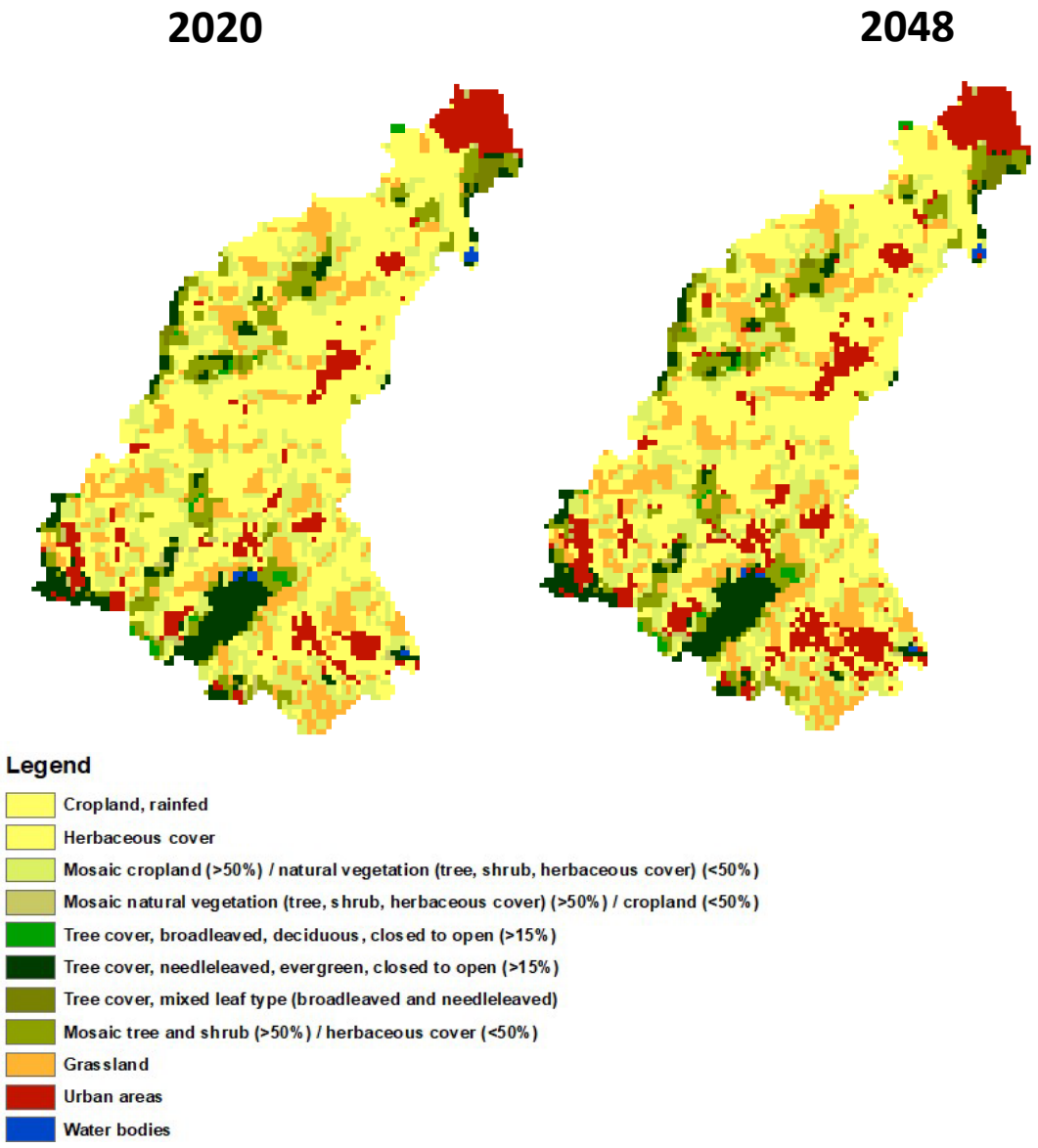
1st step: Used the Landuse map of 1992 and 2004 to predict map of 2016.

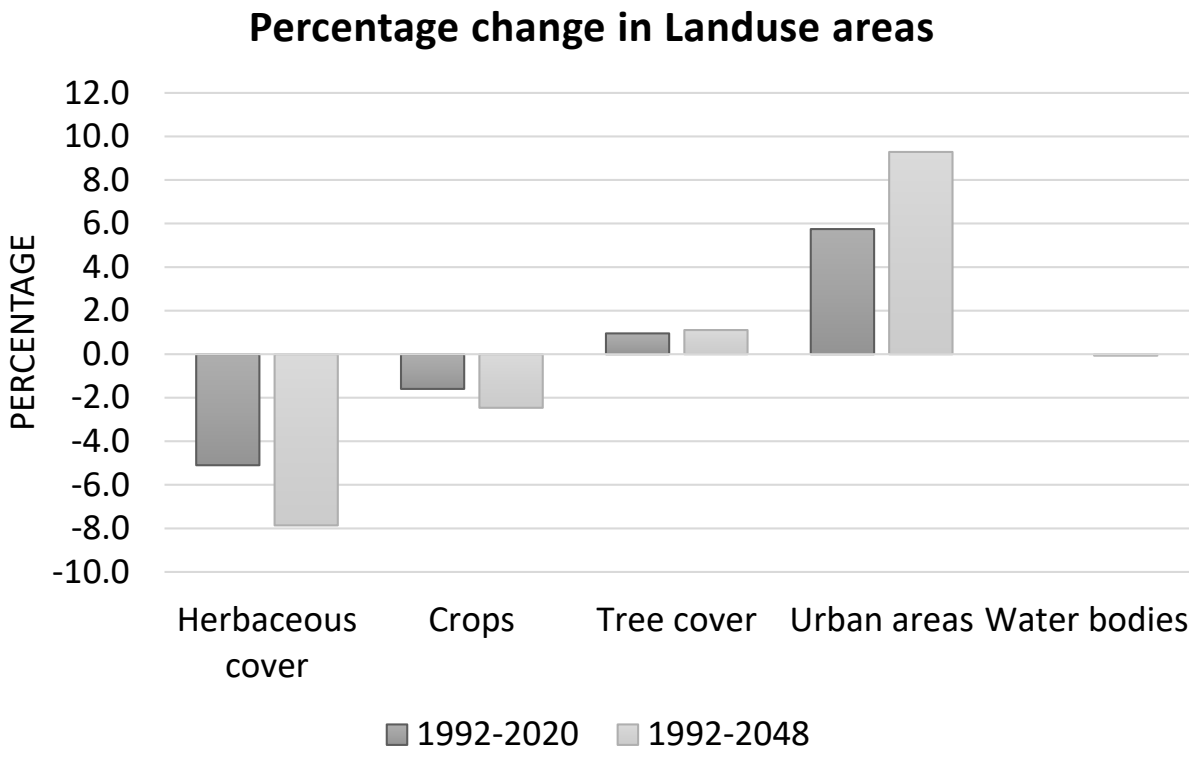
Validated with original map of 2016

Correctness : 99.14 % **Kappa = 0.98**

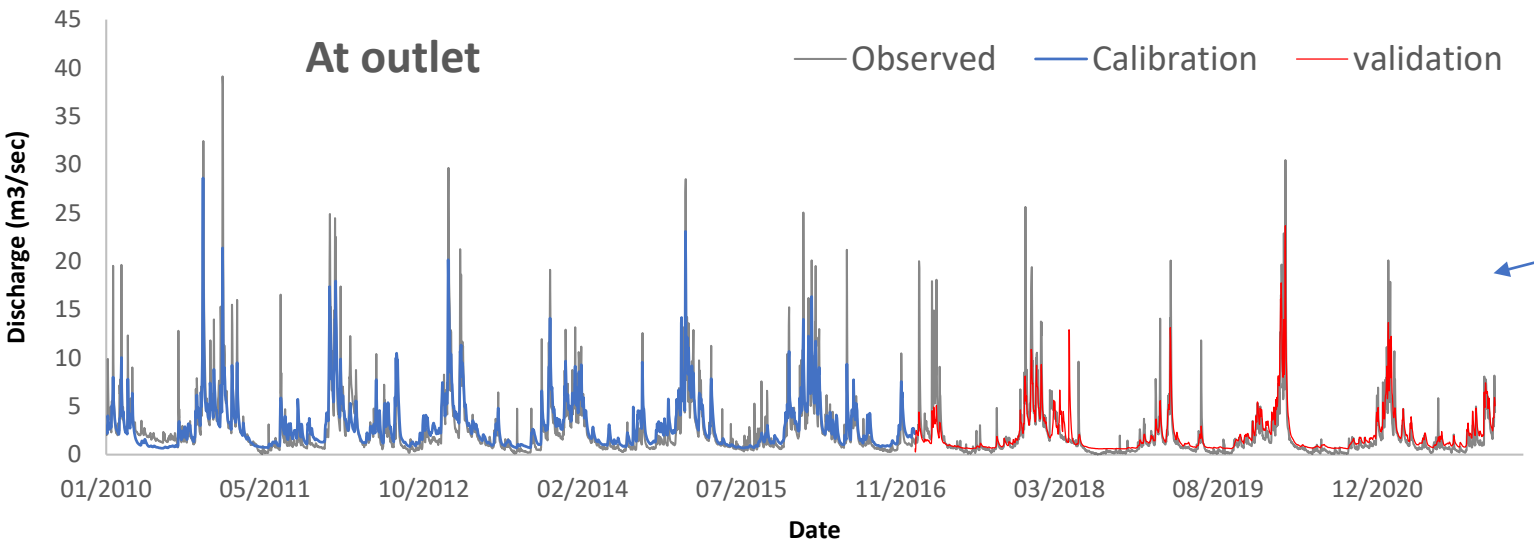
2nd step : Used the LU map of 1992 and 2020 to predict the map of 2048.

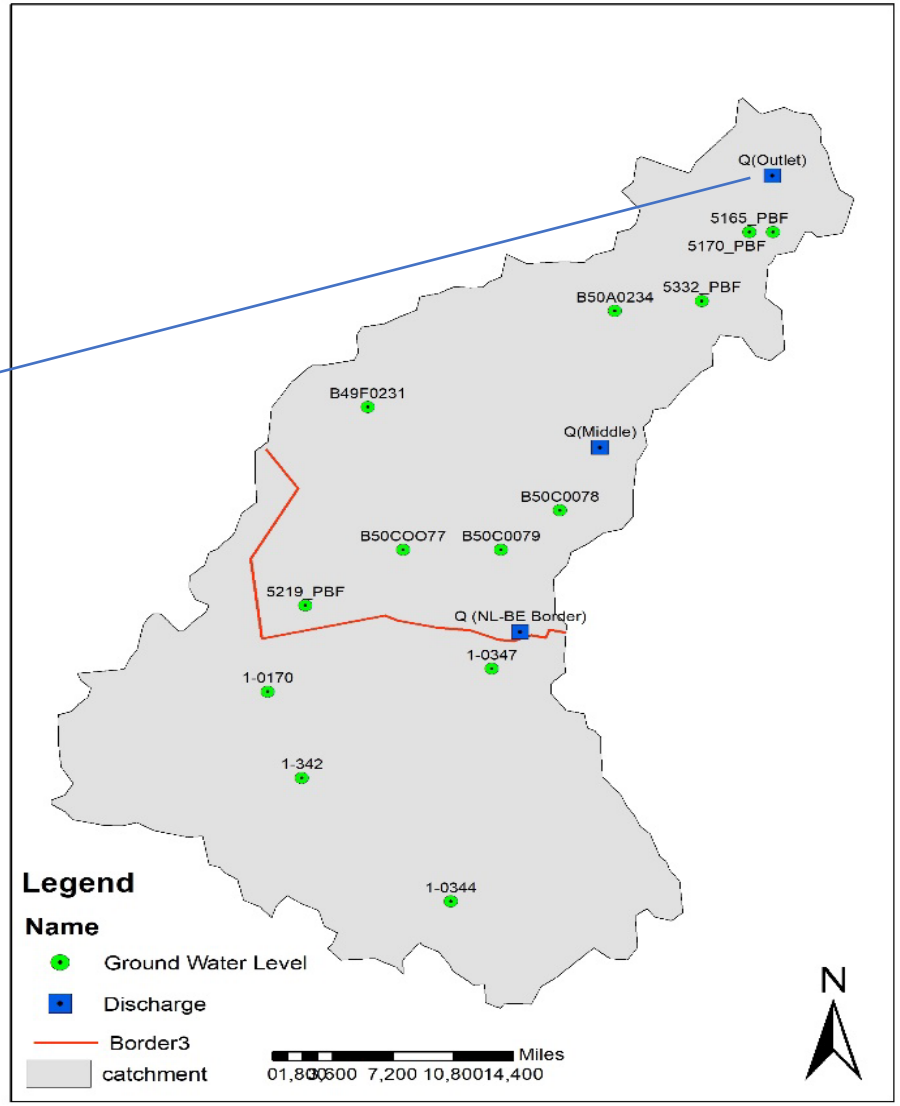
Future landuse projection





Results : Model Calibration and Validation

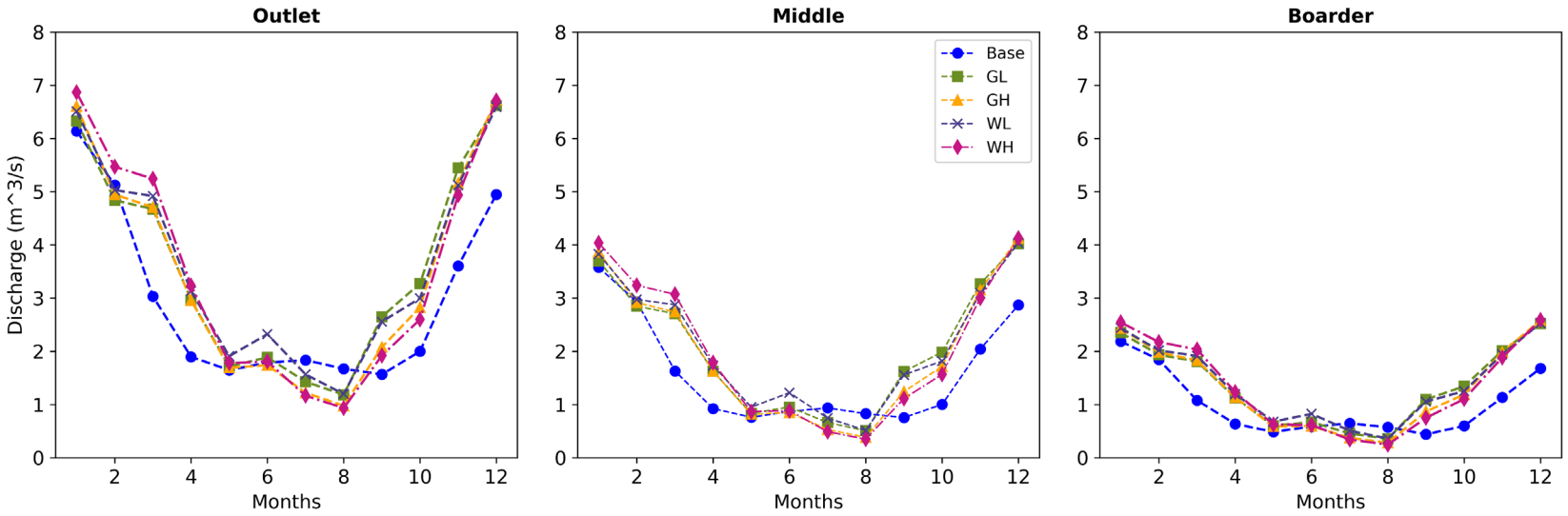


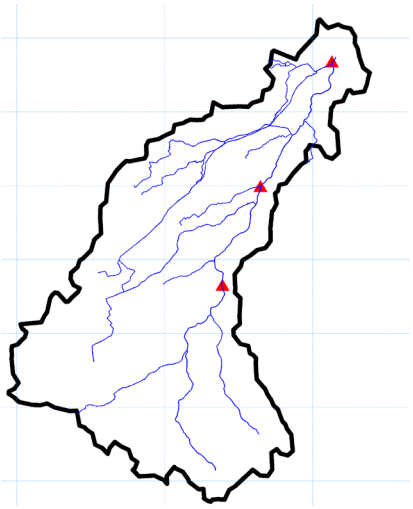


		Calibration (2010 – 2016)		Validation (2017 – 2021)	
	Name	**R**	**NSE**	**R**	**NSE**
Discharge	Outlet	0.90	0.78	0.84	0.70
	Middle	0.78	0.61	0.83	0.67
	Belgium Border	0.76	0.58	0.78	0.56
Groundwater Heads	5219_PBF	0.81	0.07	0.93	0.86
	5332_PBF	0.87	0.48	0.88	0.64
	5170_PBF	0.75	0.20	0.85	0.67
	5165_PBF	0.82	0.45	0.77	0.48
	B50COO77	0.88	0.53	0.84	0.38
	B50C0079	0.92	0.53	0.85	0.53
	B50C0078	0.80	0.54	0.86	0.57
	1-0344	0.69	0.29	0.78	0.34
	1-342	0.65	0.32	0.82	0.55

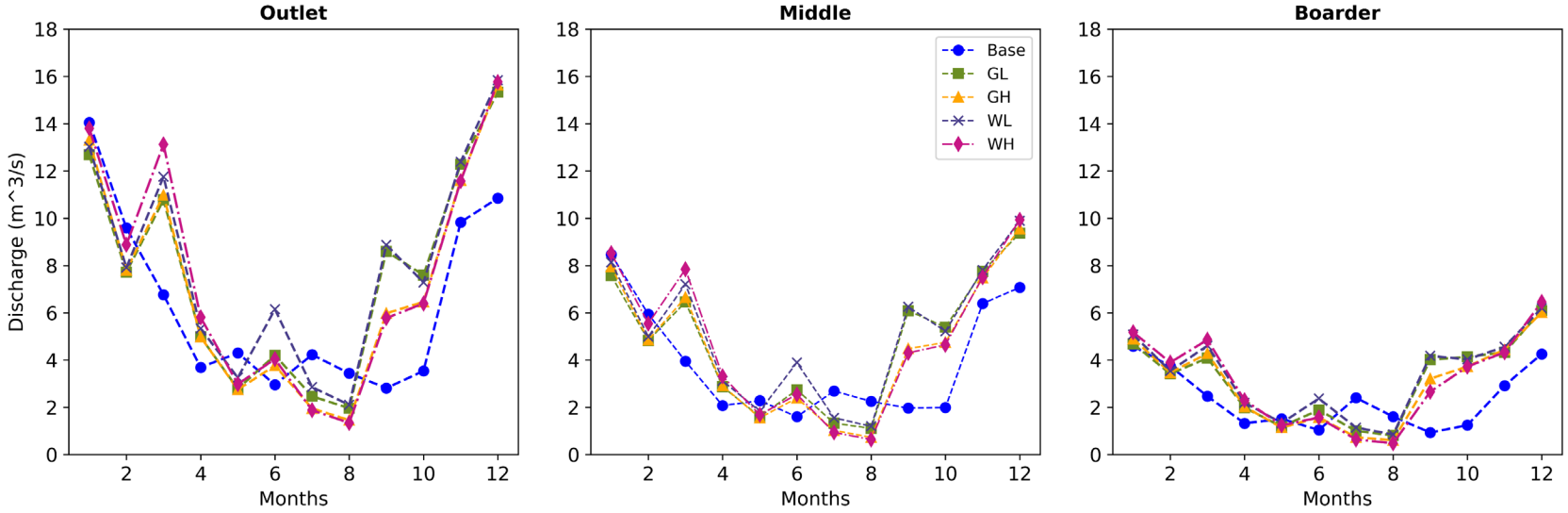
Results : Discharge

Base period vs Future scenarios (Annual mean monthly discharge)





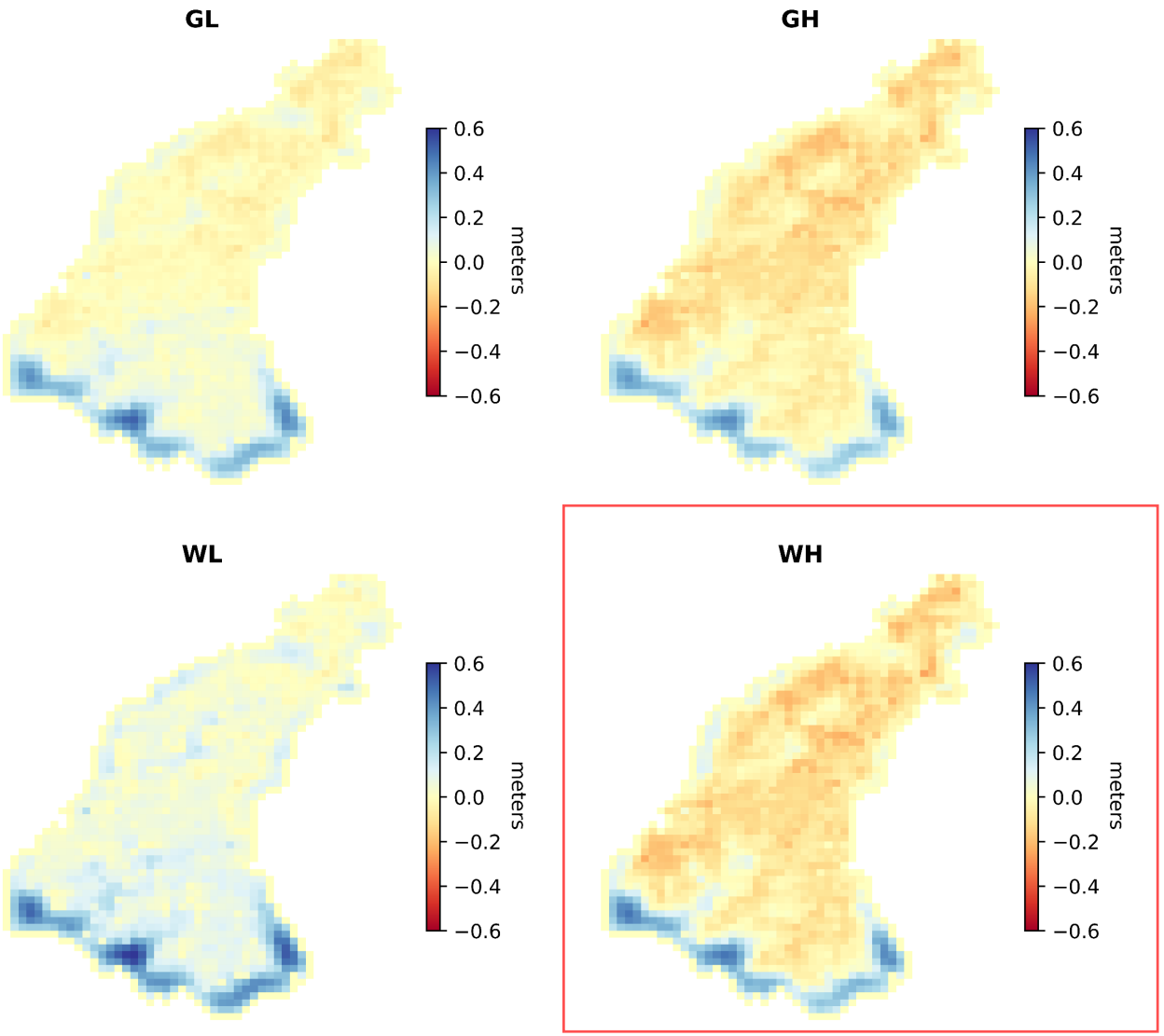
Base period vs Future scenarios (Annual maximum monthly discharge)



Results : Groundwater Levels

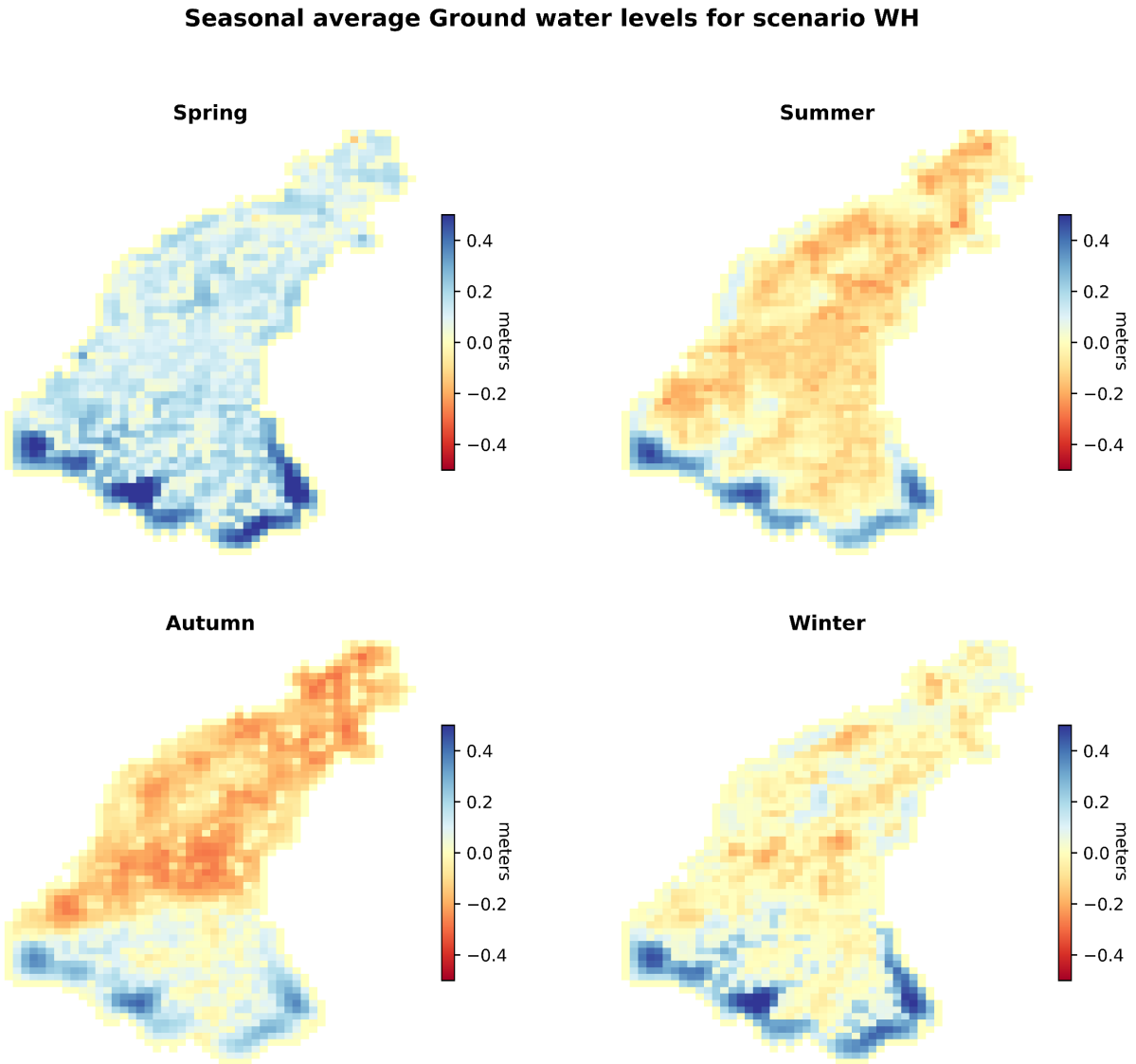
Difference of Base period and Future scenarios

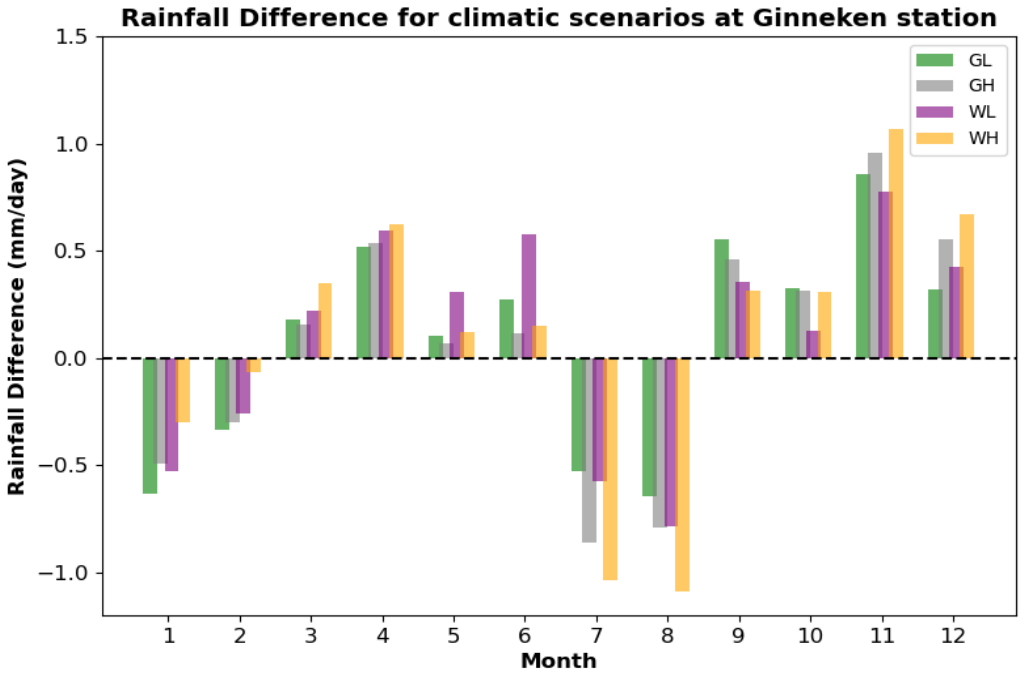
Average Ground water levels in Summer Months (JJA)

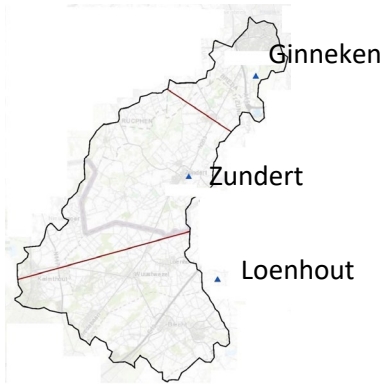


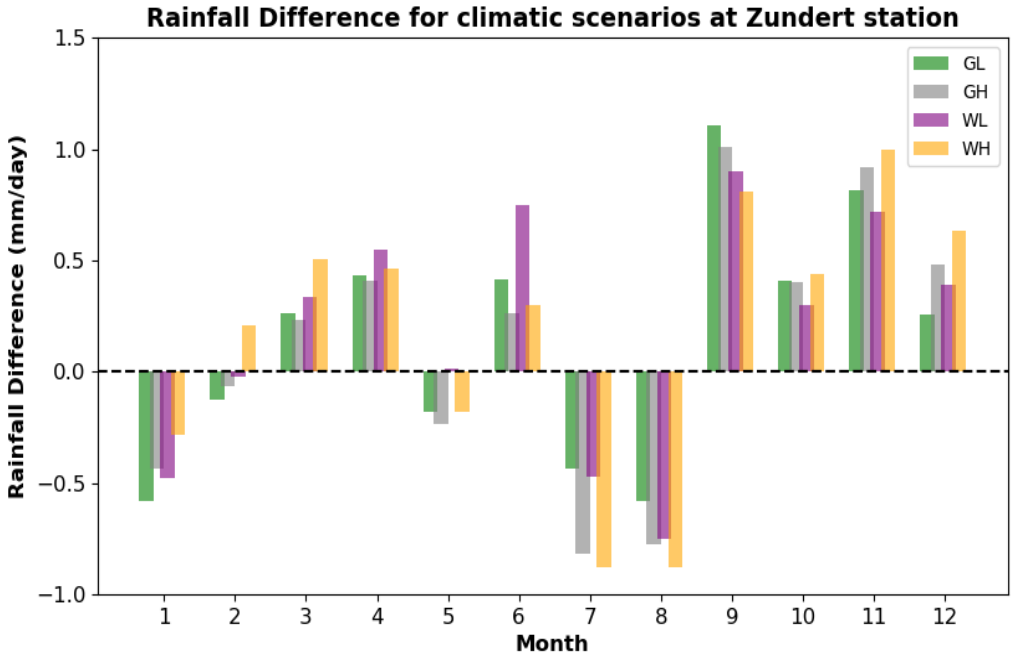
Results : Groundwater Levels

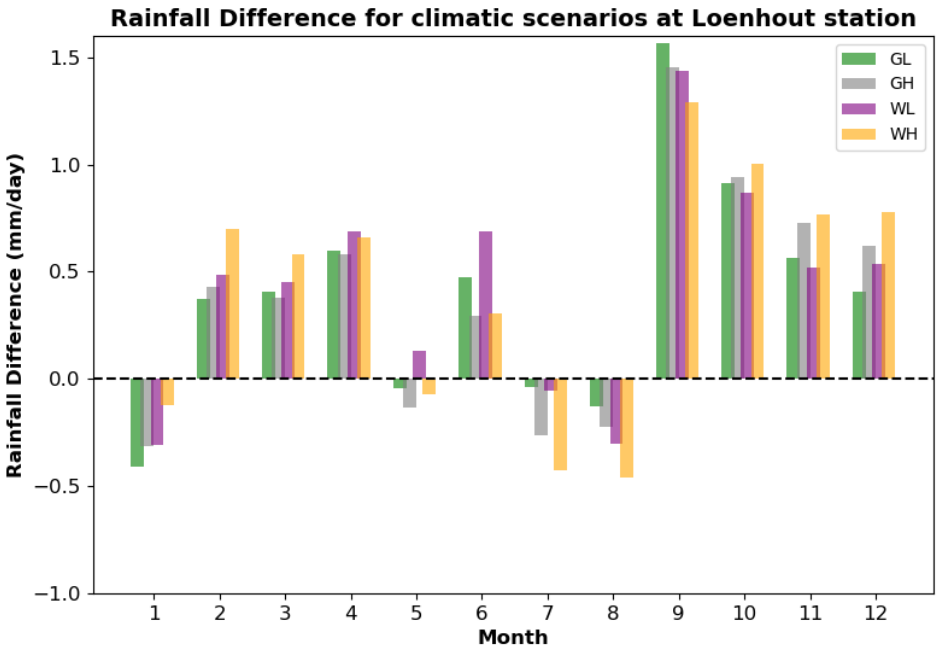
Difference of Base period and Future scenariosc




Rainfall Difference for climatic scenarios at Ginneken station
Rainfall Difference (mm/day)
Month
GL
GH
WL
WH


Ginneken
Zundert
Loenhout

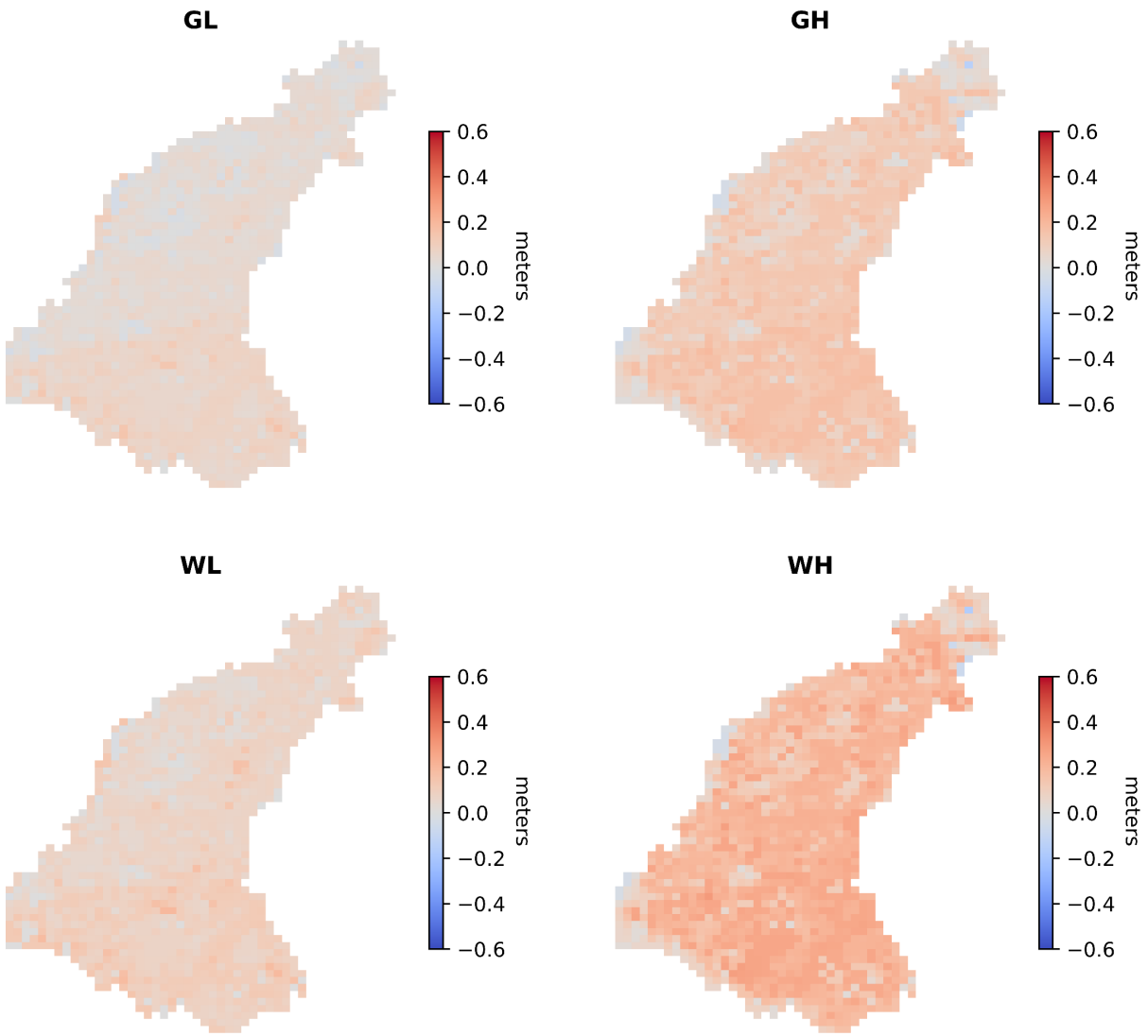

Rainfall Difference for climatic scenarios at Zundert station
Rainfall Difference (mm/day)
Month
GL
GH
WL
WH


Rainfall Difference for climatic scenarios at Loenhout station
Rainfall Difference (mm/day)
Month
GL
GH
WL
WH

Results : Actual ET

Difference of Base period and Future scenarios

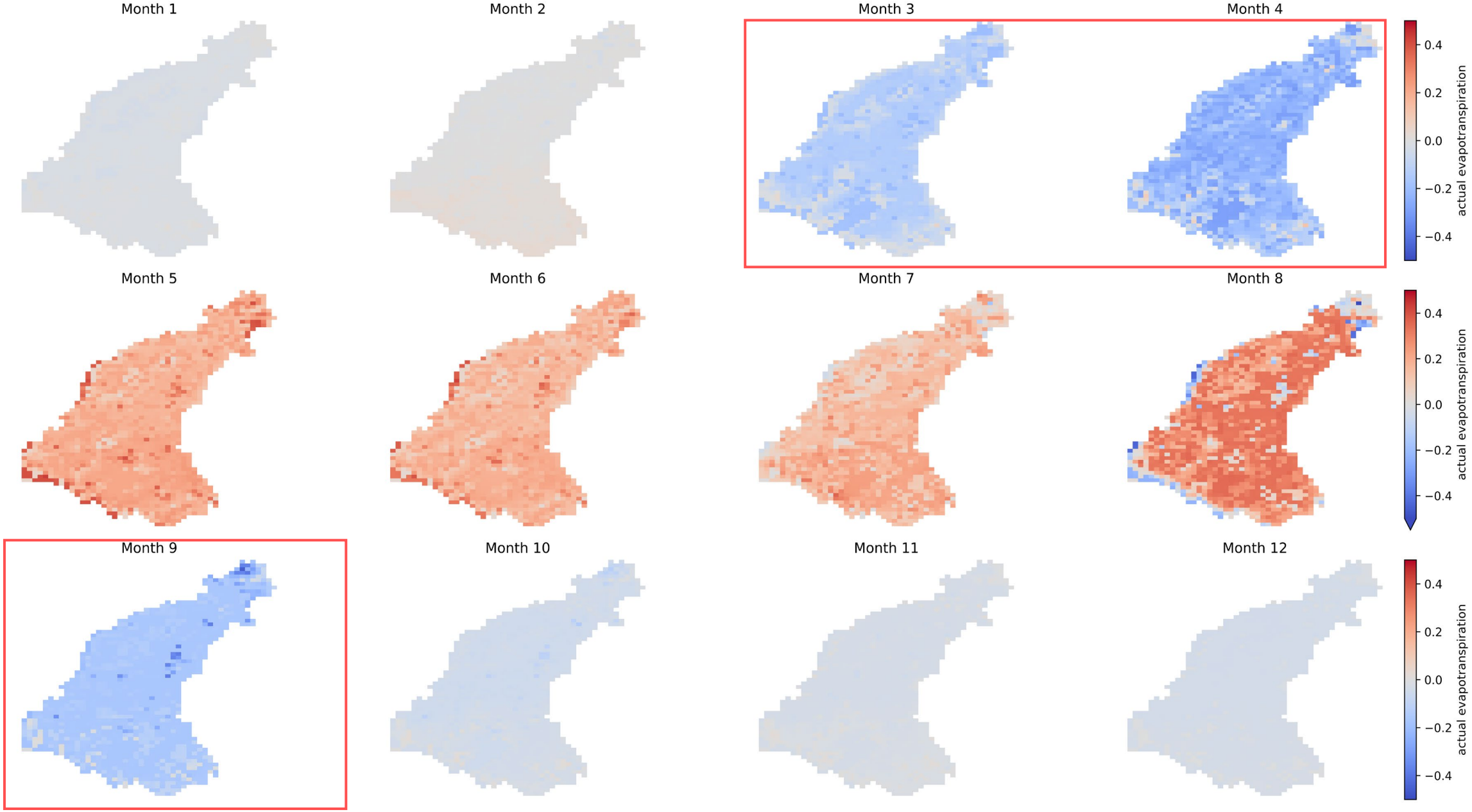
Average Actual ET in Summer (JJA)



Results : Actual ET

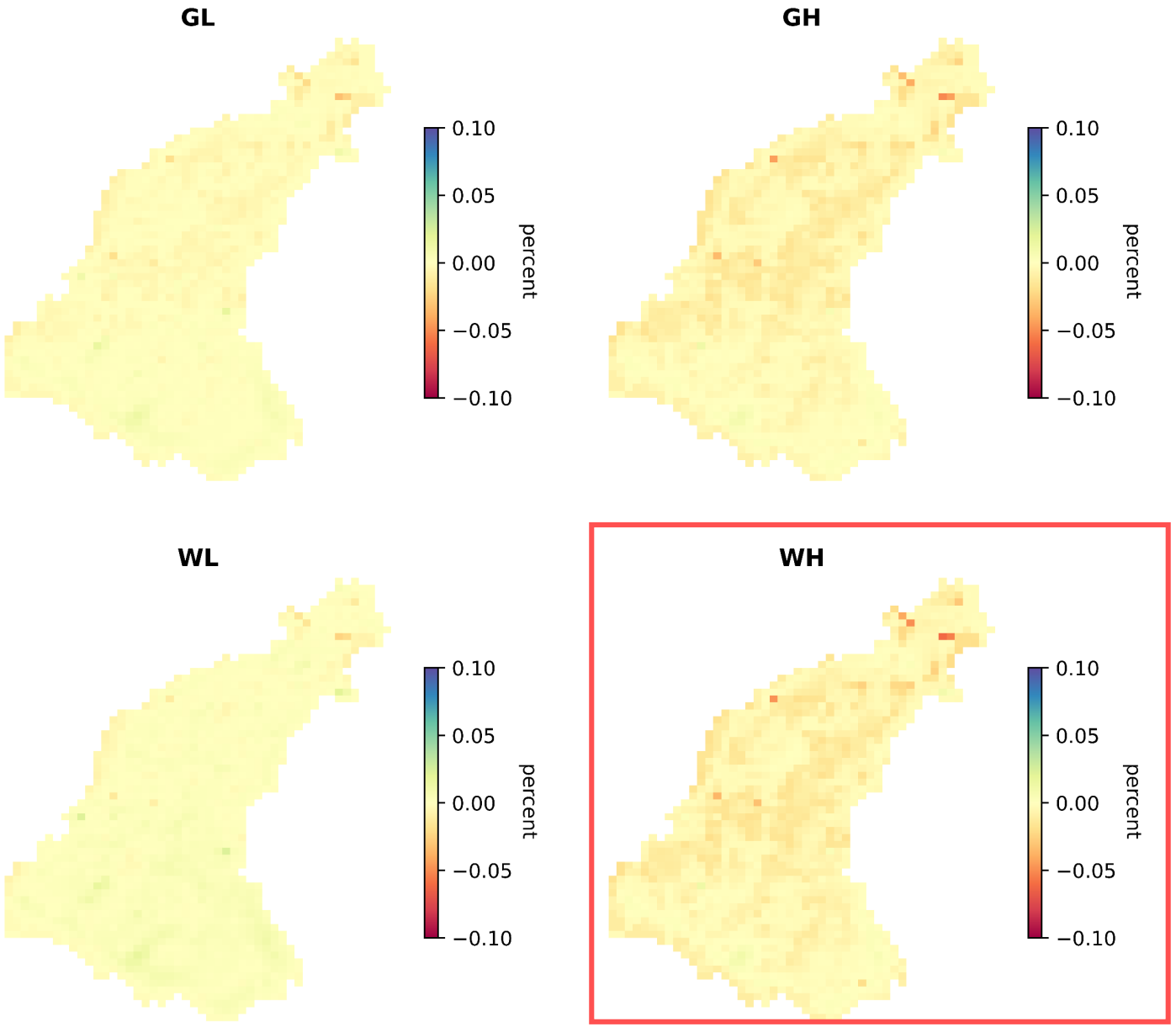
Difference of Base period and Future scenarios

Monthly average actual ET for scenario WH

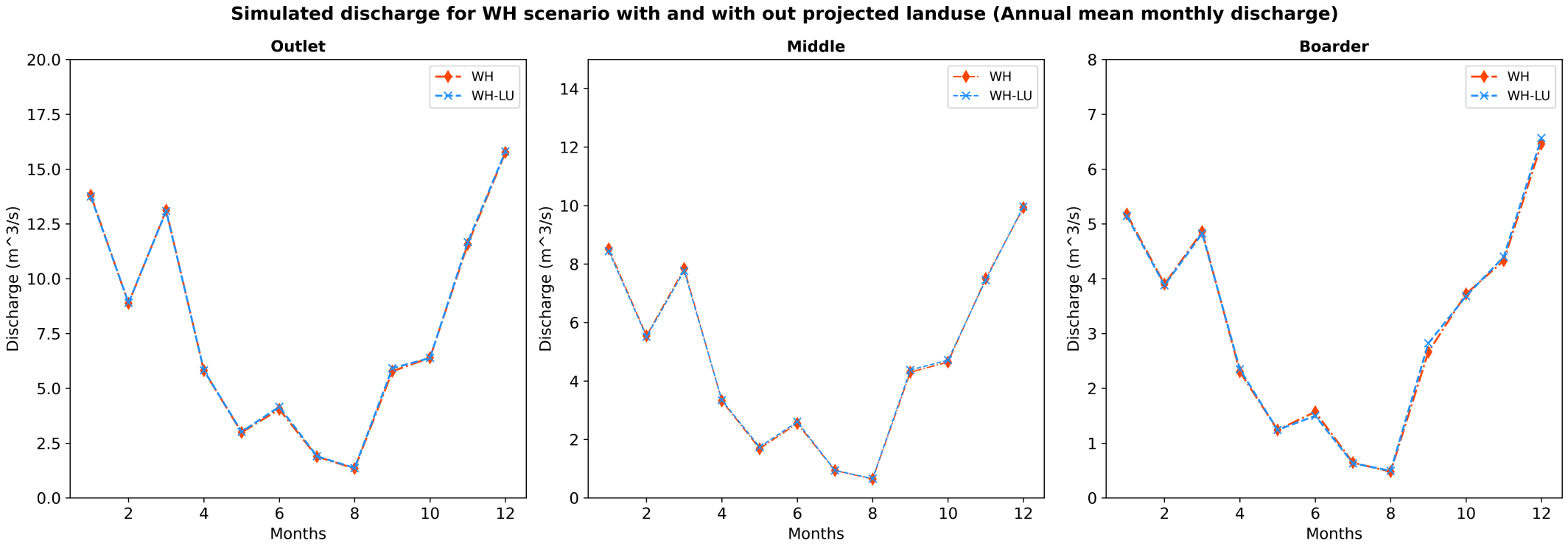


Results : Soil moisture

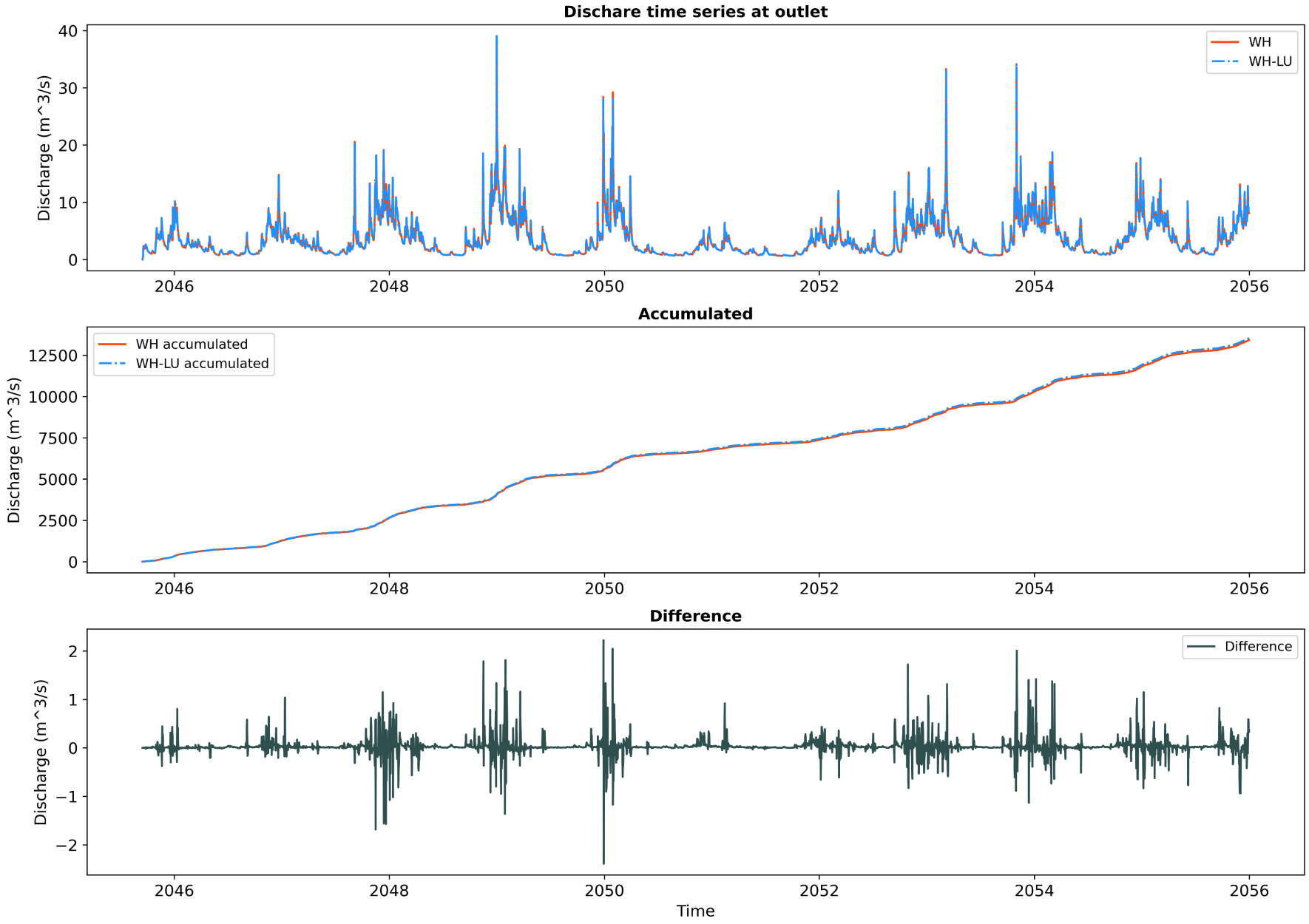
Difference of Base period and Future scenarios soil moisture for summer months (JJA)



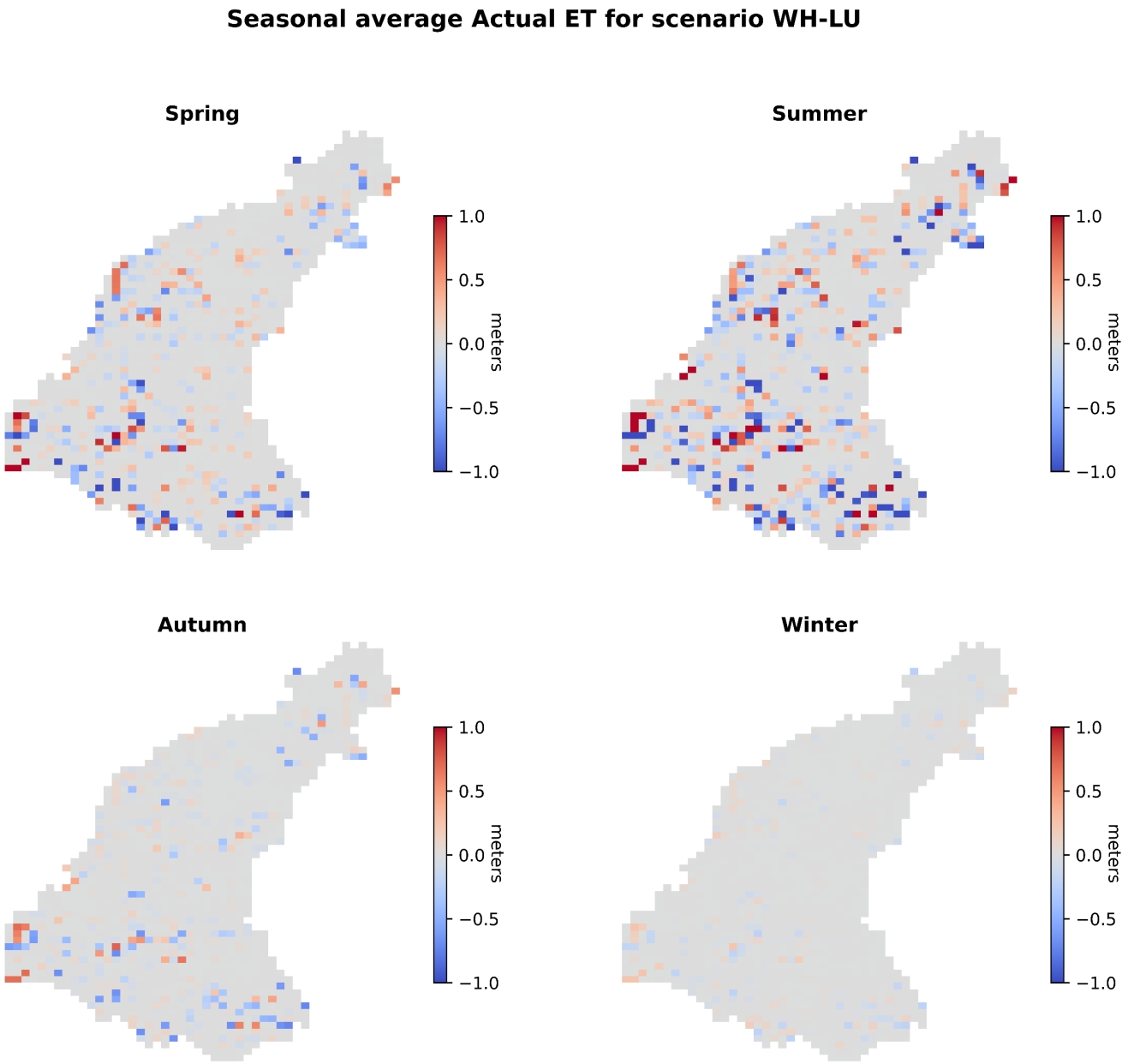
Results (WH scenario with Future Landuse Map)



Results (Impact of future landuse consideration)

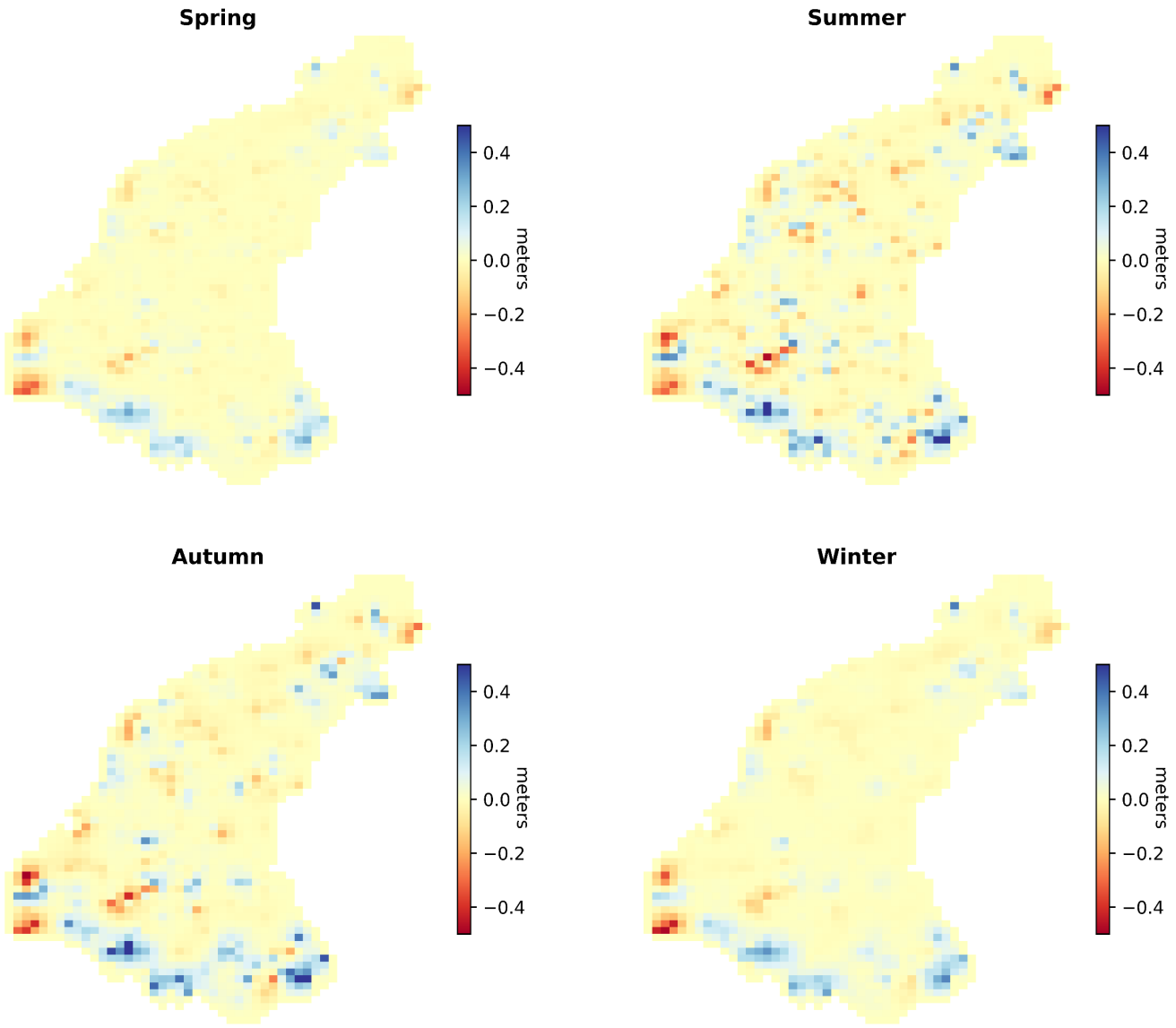


Results (Impact of future landuse consideration)



Results (Impact of future landuse consideration)

Seasonal average Ground water levels for scenario WH-LU

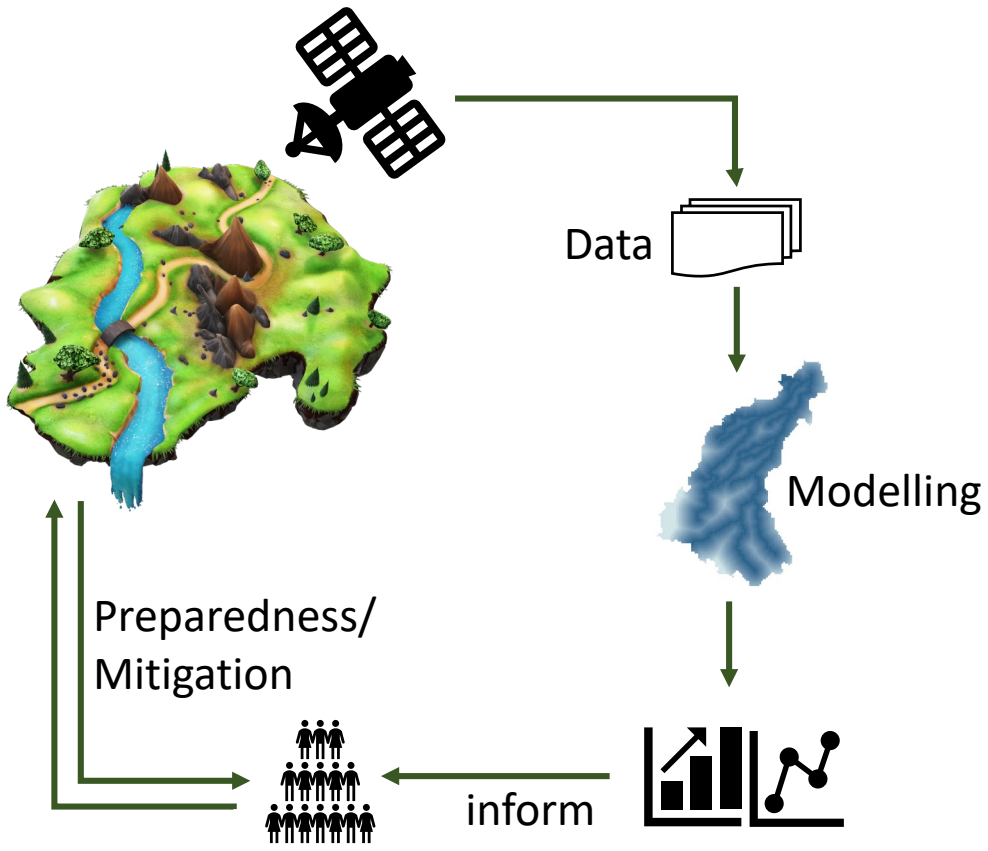


Results: (Yearly water balance)

Components	Base Case (mm)	Scenario WH (mm)	Scenario WH + LU (mm)
Precipitation	891	959	959
ET	521	523	519
Overland flow to river	37	53	53
UZ-storage change	-16	-8	-8
Infiltation to SZ	364	406	410
SZ-storage change	34	30	30
SZ drain to river	186	226	229
Base flow to river	22	22	22
SZ BF out	108	113	114
SZ BF in	1.0	1.3	1.3

Recommendation and conclusions

- Used KNMI 14 scenarios for future meteorological data.
- In Spring and Autumn season the average rise in rainfall is upto 0.25 mm/day and 0.75 mm/day. While in summer the average fall in rainfall is upto 0.30 mm/day.
- Used **ANN based MOLUSCE** plugin for preparing future projection map for year 2048.
- According to future landuse map urban area will increase by 3.6% of catchment area while herbaceous cover will reduce by 2.8 % as compared to 2020 LU map.
- The average discharge at outlet will increase in Spring and Autumn seasons will it will reduce in summer.
- The consideration of future landuse map in simulation has minor effect on the discharge while the impact of GWL and AET at local points is considerable.
- The understanding of combined impact of meteorological and landuse change on hydrology of catchment is important for better preparedness and water management.



THANK YOU