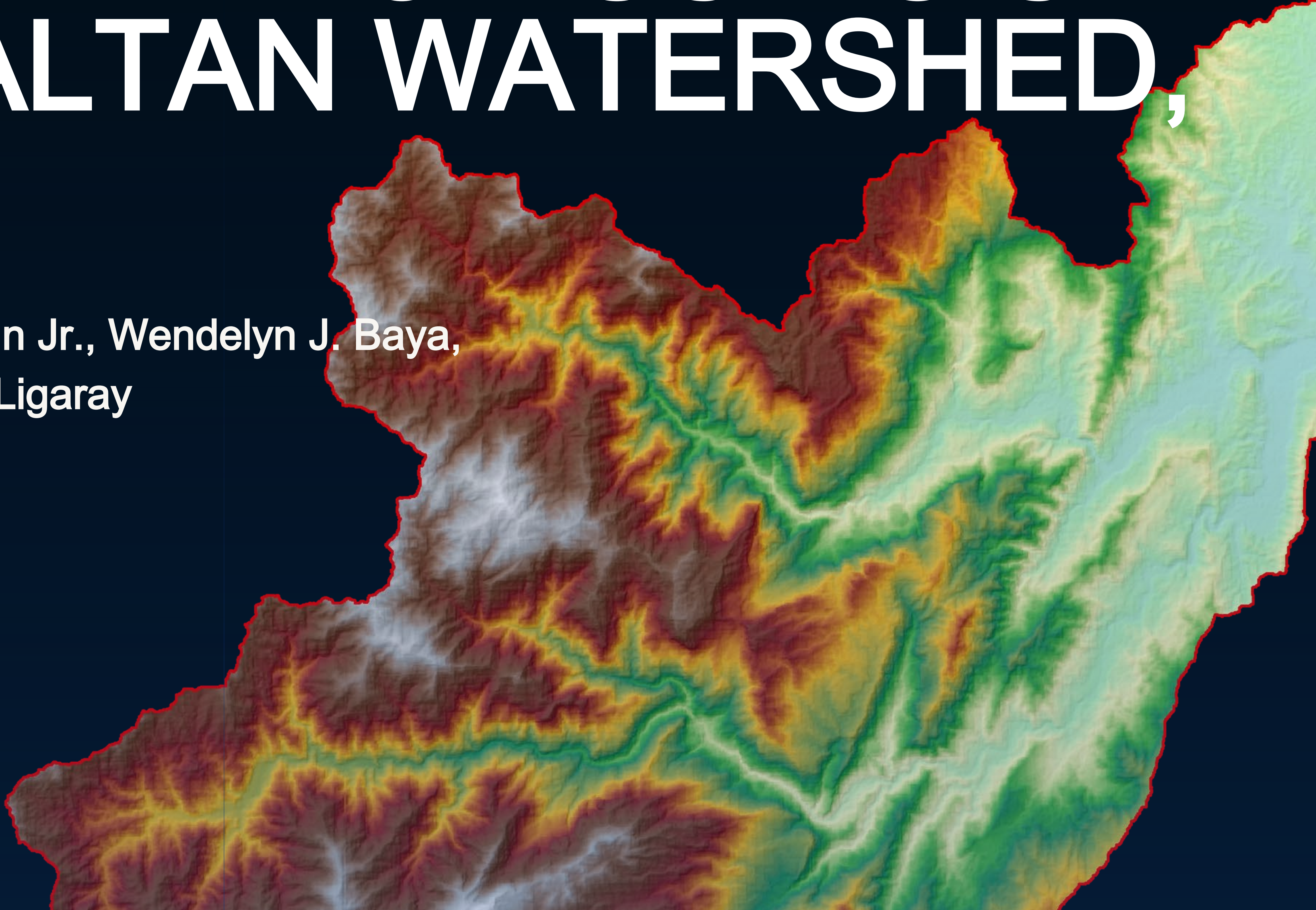
ASSESSMENT OF SURFACE RUNOFF AND SEDIMENTATION USING SWAT MODEL IN SALTAN WATERSHED, PHILIPPINES

Rena Christina C. Puno, Roger B. Dolguin Jr., Wendelyn J. Baya,
Kean Michael F. Cabigao, Mayzonee V. Ligaray



2025 SWAT International Conference
June 21–26, 2025 | Jeju, South Korea

INTRODUCTION

BACKGROUND OF THE STUDY

- Deforestation due agricultural expansion and urbanization
- River structures such as hydropower projects (micro to large dams)
- Hydrologic alterations (streamflow; sedimentation; flooding)

- Saltan Watershed in Kalinga Province is a key water source for irrigation, domestic use

OBJECTIVES

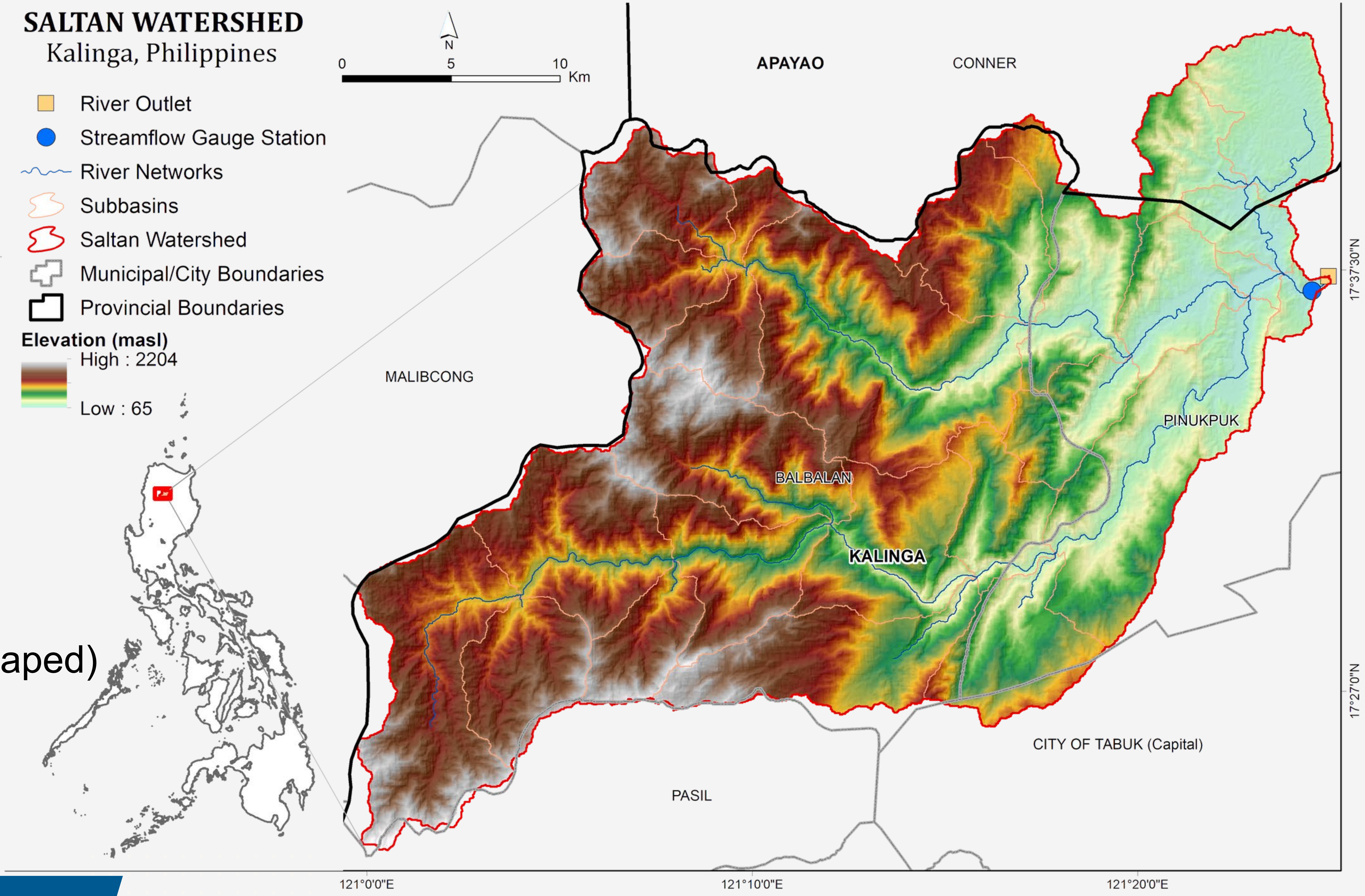
Simulate and calibrate the SWAT model of land cover data of 2000, 2010 and 2015 using streamflow data.

Analyze the sensitivity of SWAT model parameters.

Investigate surface runoff and sediment yield across subbasins and impacts of climate projections in Saltan Watershed.

METHODOLOGY

LOCALE OF THE STUDY



Area = 852.47 km2

Perimeter = 238.51 km

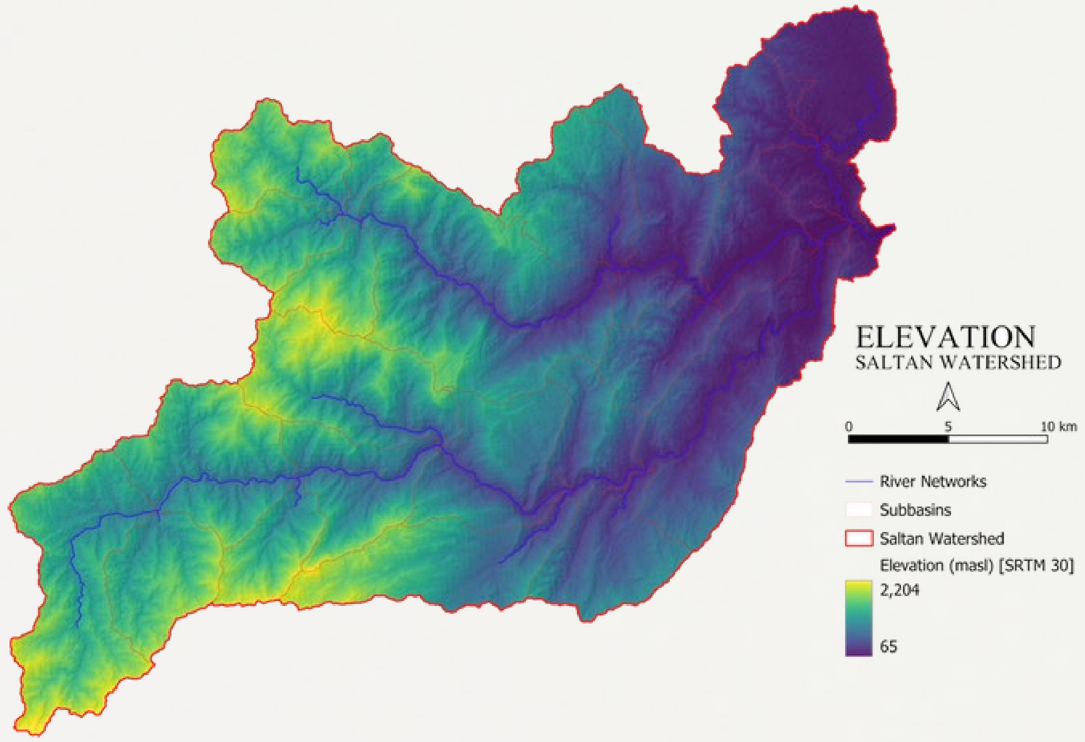
Basin Width = 22 km

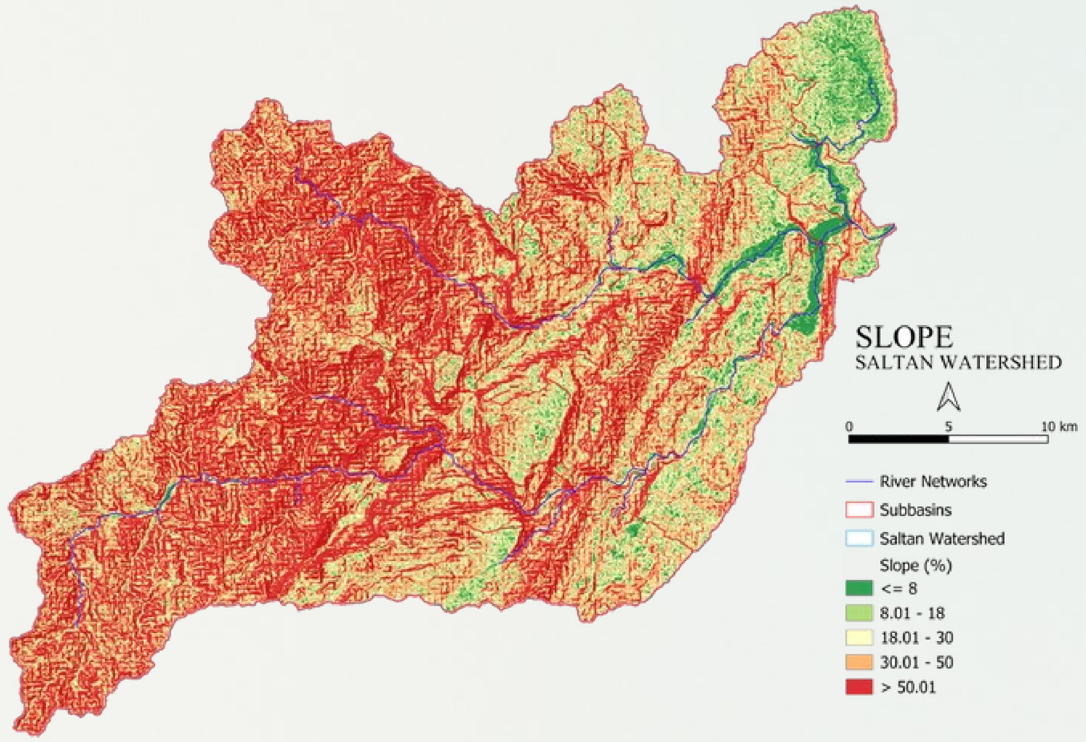
Basin Length = 56.76 km

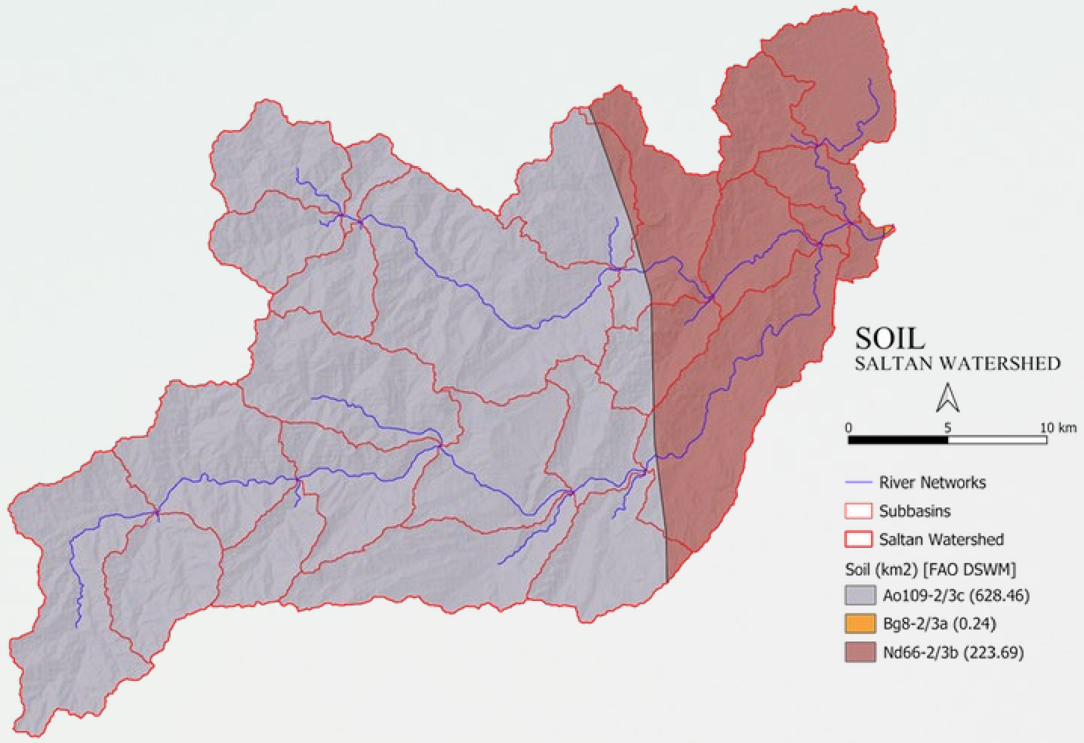
Circularity Ratio 0.188 Fern-shaped)

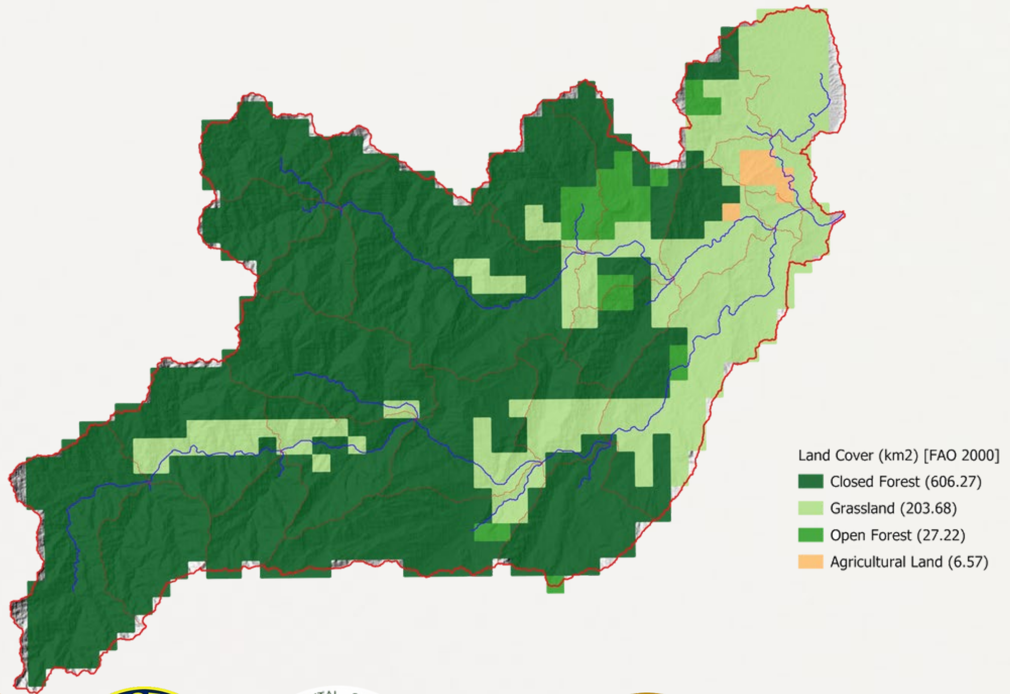
METHODOLOGY

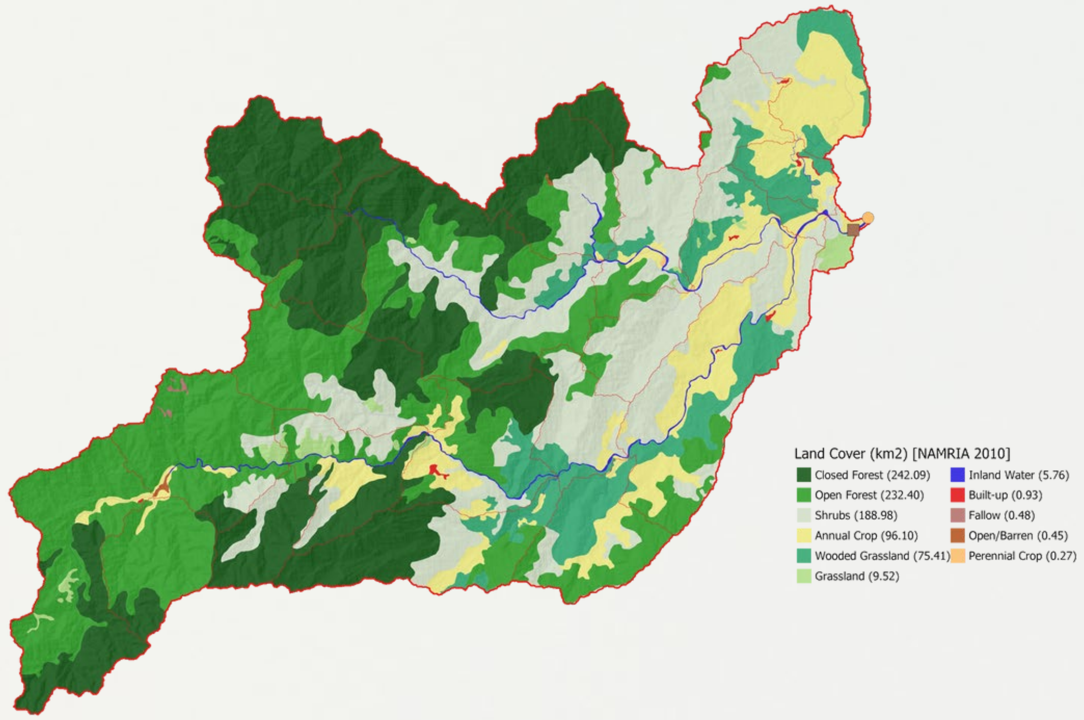
DATA INPUTS

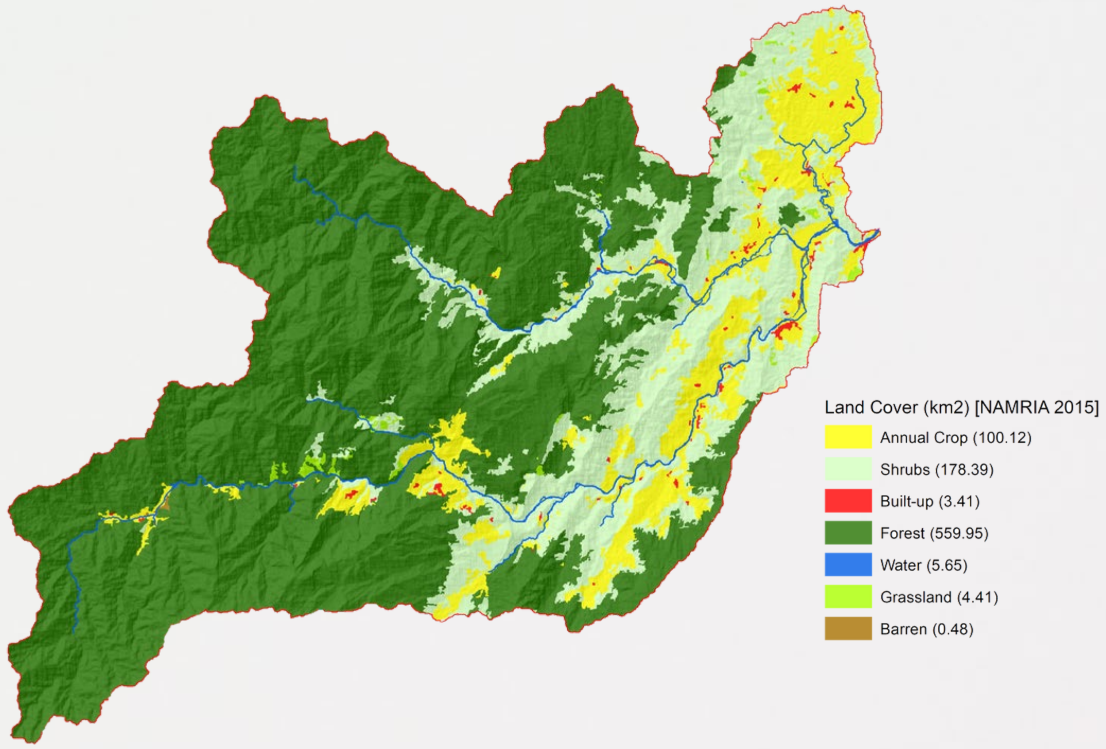




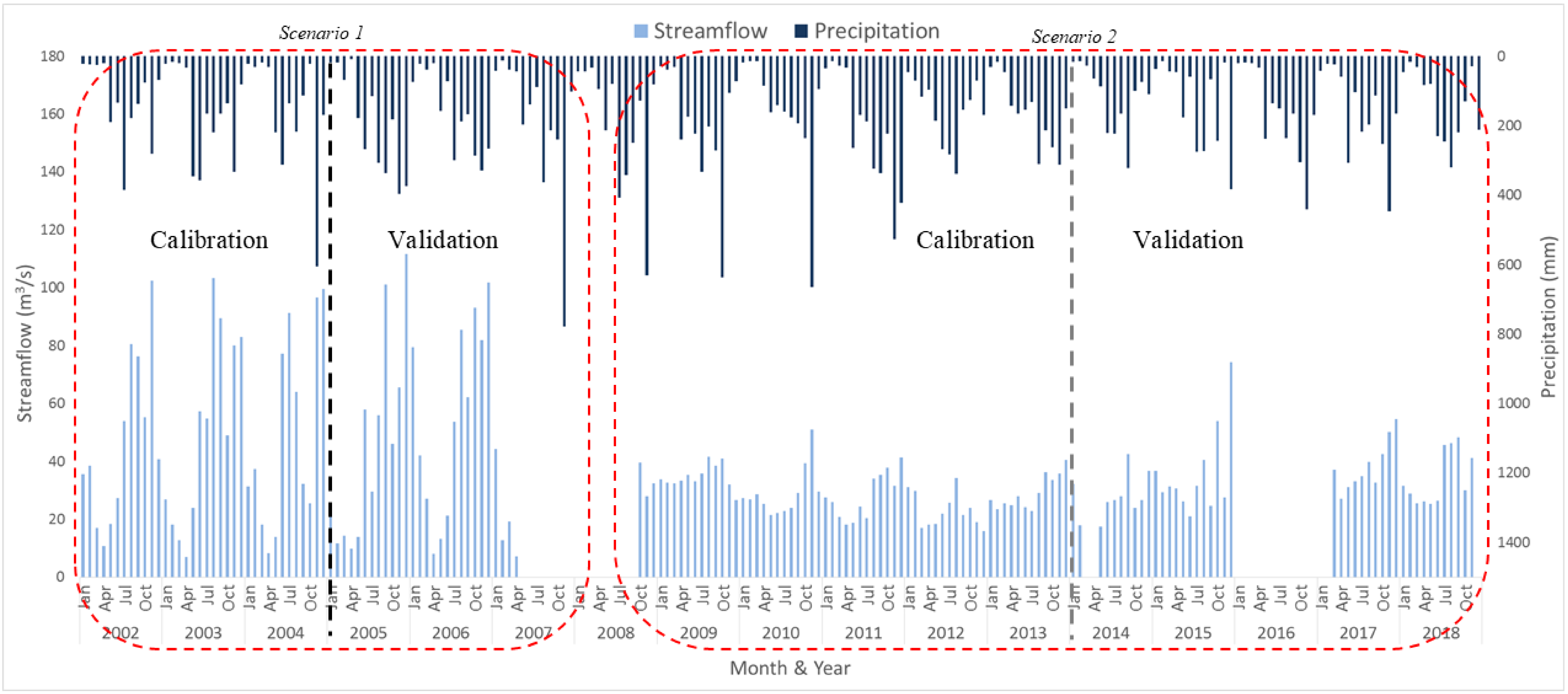




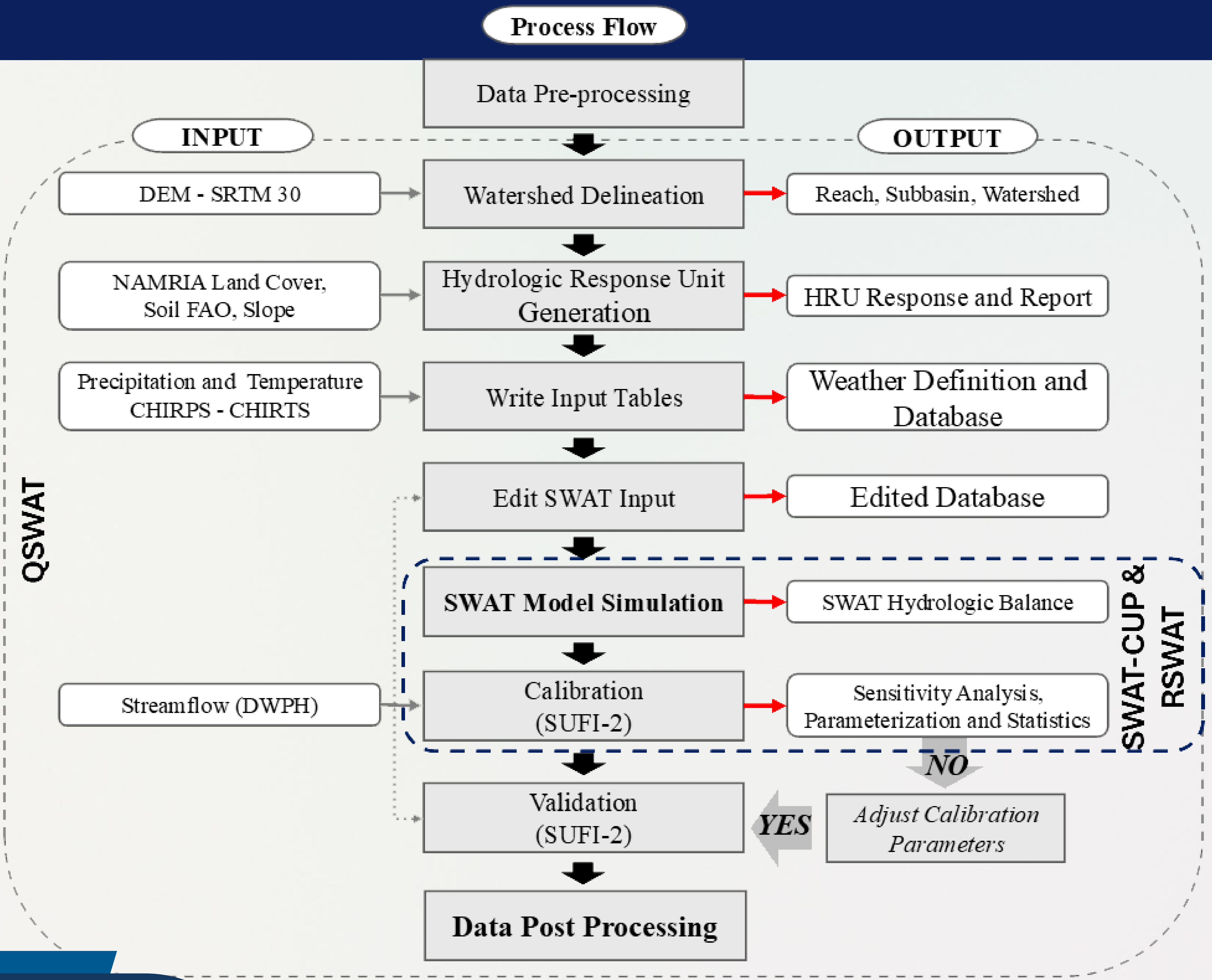




METHODOLOGY



METHODOLOGY



METHODOLOGY

Parameter Name	t-Stat	P-Value
11:V__SURLAG.bsn	0.078818762	0.937209089
2:V__ALPHA_BF.gw	0.323019868	0.746818557
9:V__CH_N2.rte	1.051476341	0.293560259
4:V__GWQMN.gw	1.529034737	0.126903744
5:V__REVAPMN.gw	2.184665465	0.029388422
8:V__EPCO.hru	-3.235262831	0.001297789
6:V__SLSUBBSN.hru	-6.220125653	0.000000001
3:V__GW_DELAY.gw	-7.49502463	0.000000000
10:V__SOL_AWC(..).sol	-9.134977953	0.000000000
1:R__CN2.mgt	-12.30562392	0.000000000
7:V__ESCO.hru	21.74961882	0.000000000

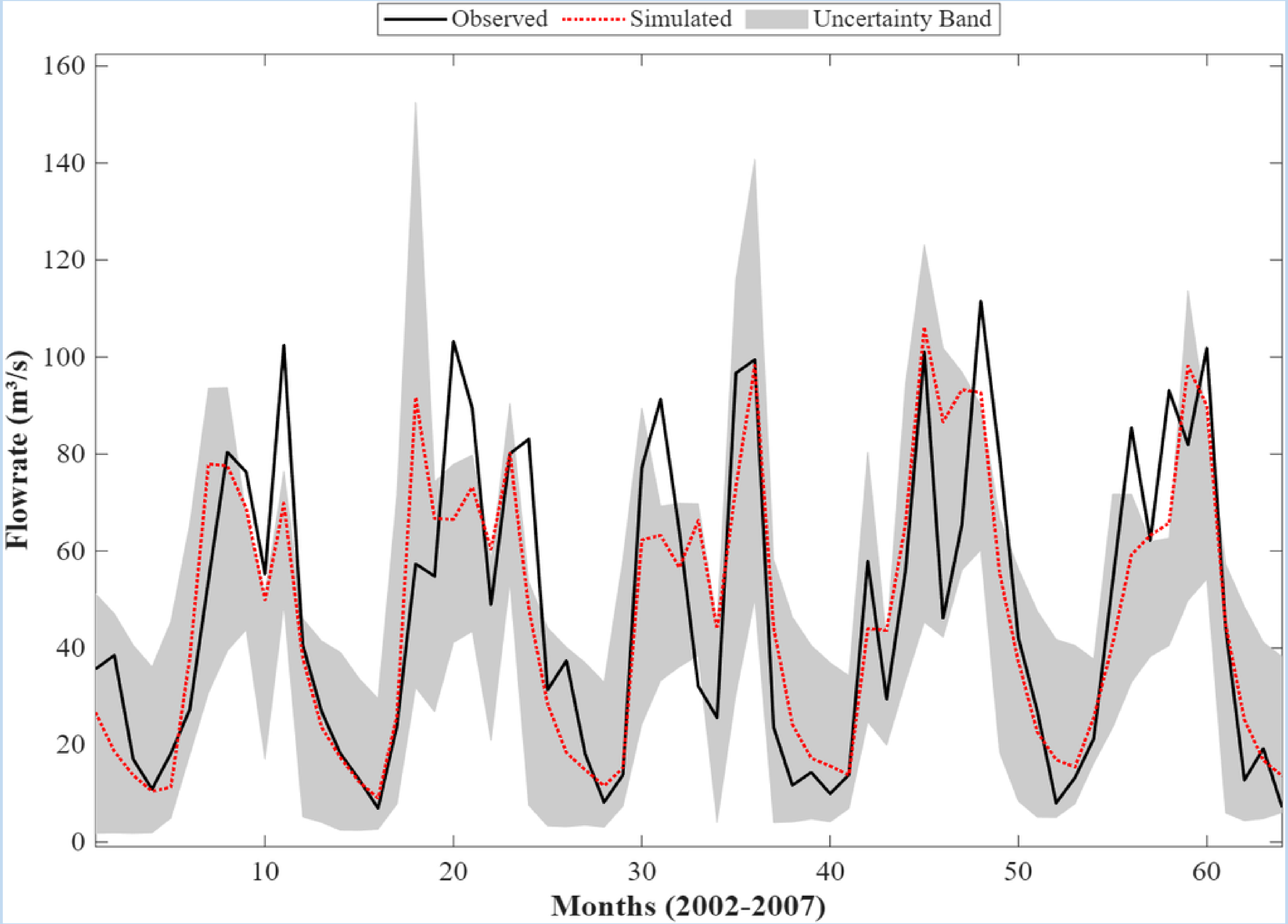
Scenario 1

Parameter Name	t-Stat	P-Value
7:V__SLSUBBSN.hru	0.004023627	0.996791277
4:V__GWQMN.gw	0.070379657	0.943920552
13:R__SOL_K(..).sol	-0.421373095	0.673669729
15:V__CH_N1.sub	-0.570501272	0.568602511
5:V__RCHRG_DP.gw	0.886952064	0.375545215
3:V__GW_DELAY.gw	-0.953870658	0.340625258
14:V__SURLAG.bsn	1.104311271	0.270006833
11:V__CH_K2.rte	1.188425886	0.235248460
9:V__EPCO.hru	1.400622571	0.161967735
6:V__REVAPMN.gw	-1.850653131	0.064828596
10:V__CH_N2.rte	2.689158778	0.007410467
12:R__SOL_AWC(..).sol	6.011422821	0.000000004
1:R__CN2.mgt	-10.645000427	0.000000000
8:V__ESCO.hru	-10.764535127	0.000000000
2:V__ALPHA_BF.gw	-19.375327763	0.000000000

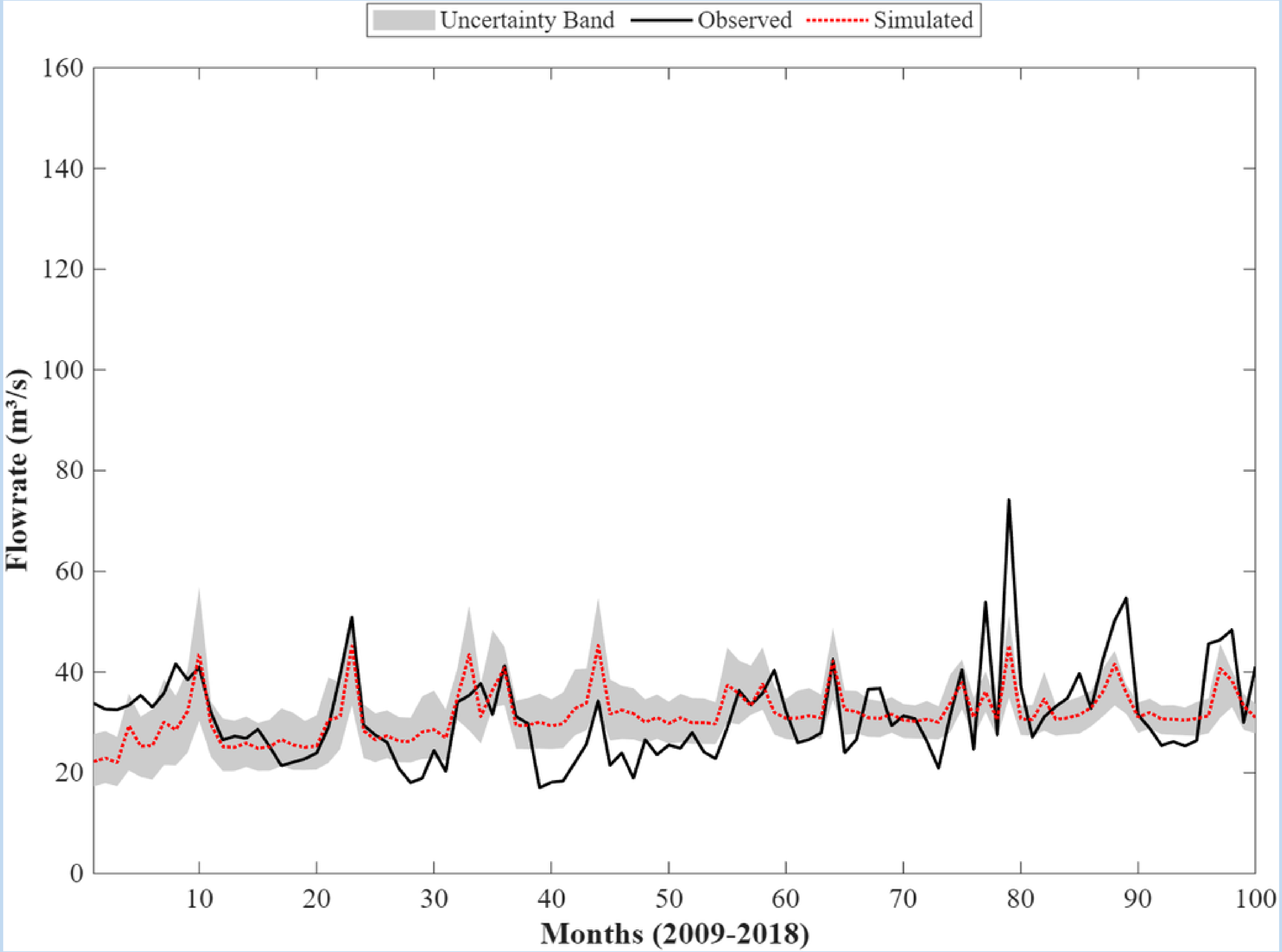
Scenario 2

Parameters	Initial Values	Change	Fitted Values (Scenario 1)	Fitted Values (Scenario 2)
CN2.mgt	35 - 98	relative	-0.207137	- 0.206644
ALPHA_BF.gw	0 - 1	replace	0.067933	0.000861
GW_DELAY.gw	0 - 500	replace	60.93351	399.994049
GWQMN.gw	0 - 5000	replace	1.786	72.183769
REVAPMN.gw	0 - 500	replace	342.099579	240.647522
RCHRG_DP.gw	0 - 1	replace	0.389	0.120093
SLSUBBSN.hru	10 - 150	replace	16.036104	143.874542
ESCO.hru	0 - 1	replace	0.949527	0.476936
EPCO.hru	0 - 1	replace	0.066019	0.280060
CH_N2.rte	-0.01 - 0.3	replace	0.025089	0.087231
CH_K2.rte	-0.01 - 500	replace	353.951599	139.534012
CH_N1.sub	0.01 - 30	replace	6.45785	4.887116
SOL_AWC().sol	0 - 1	relative	0.010641	0.400070
SOL_K().sol	0 - 2000	relative	8.073251	0.562749
SURLAG.bsn	0.05 - 24	replace	10.380334	14.76468

RESULTS AND DISCUSSIONS



Statistical Tools	Calibration 2002-2004	Validation 2005-2007	Full Simulation 2002-2007
p-factor	0.81	0.81	0.81
r-factor	1.48	1.30	1.39
R^2	0.71	0.78	0.73
NSE	0.70	0.77	0.73

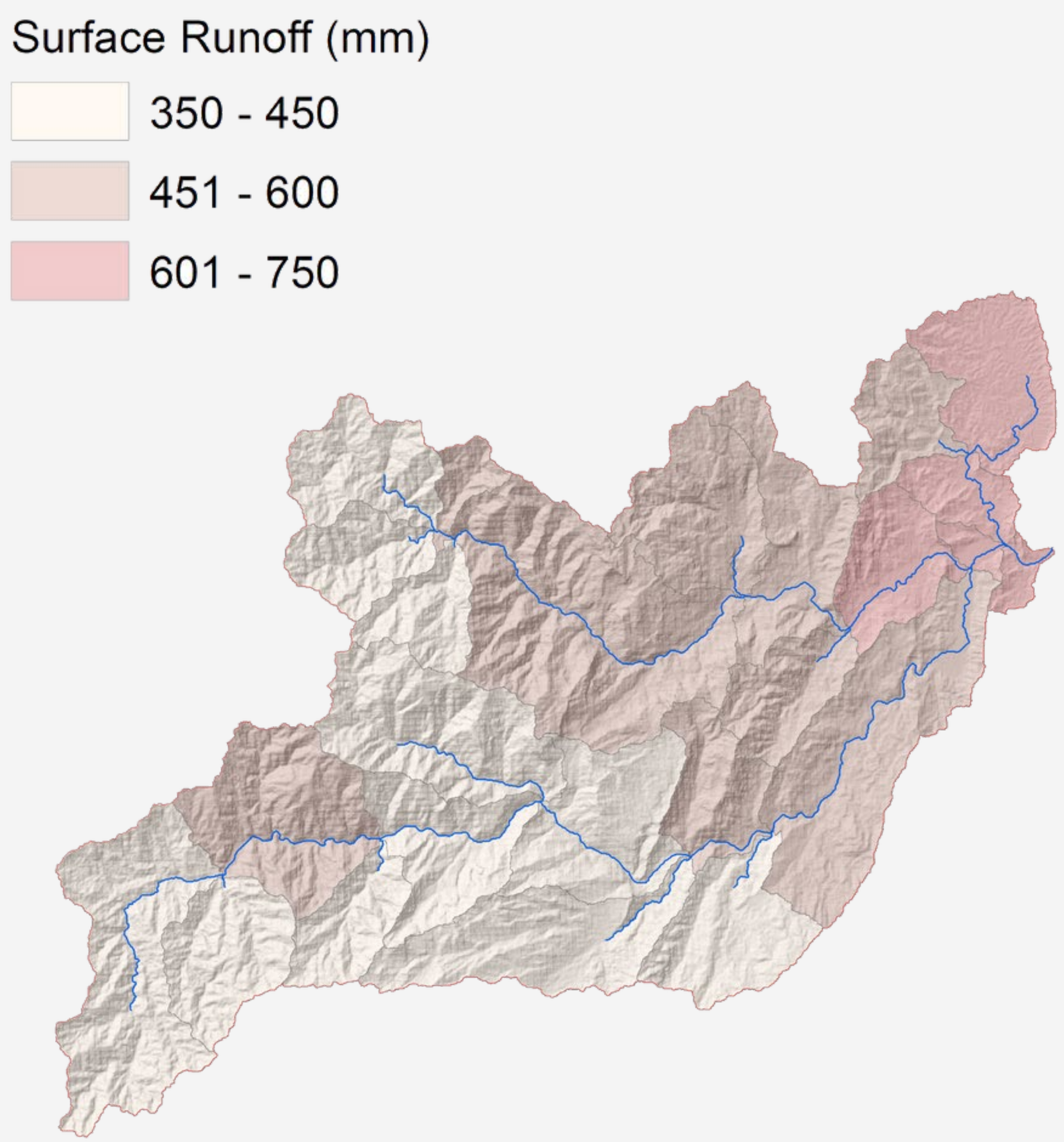


Statistical Tools	Calibration 2009-2013	Validation 2014-2018	Full Simulation 2009-2018
p-factor	0.69	0.61	0.71
r-factor	1.66	0.98	1.13
R^2	0.21	0.59	0.36
NSE	0.12	0.50	0.35

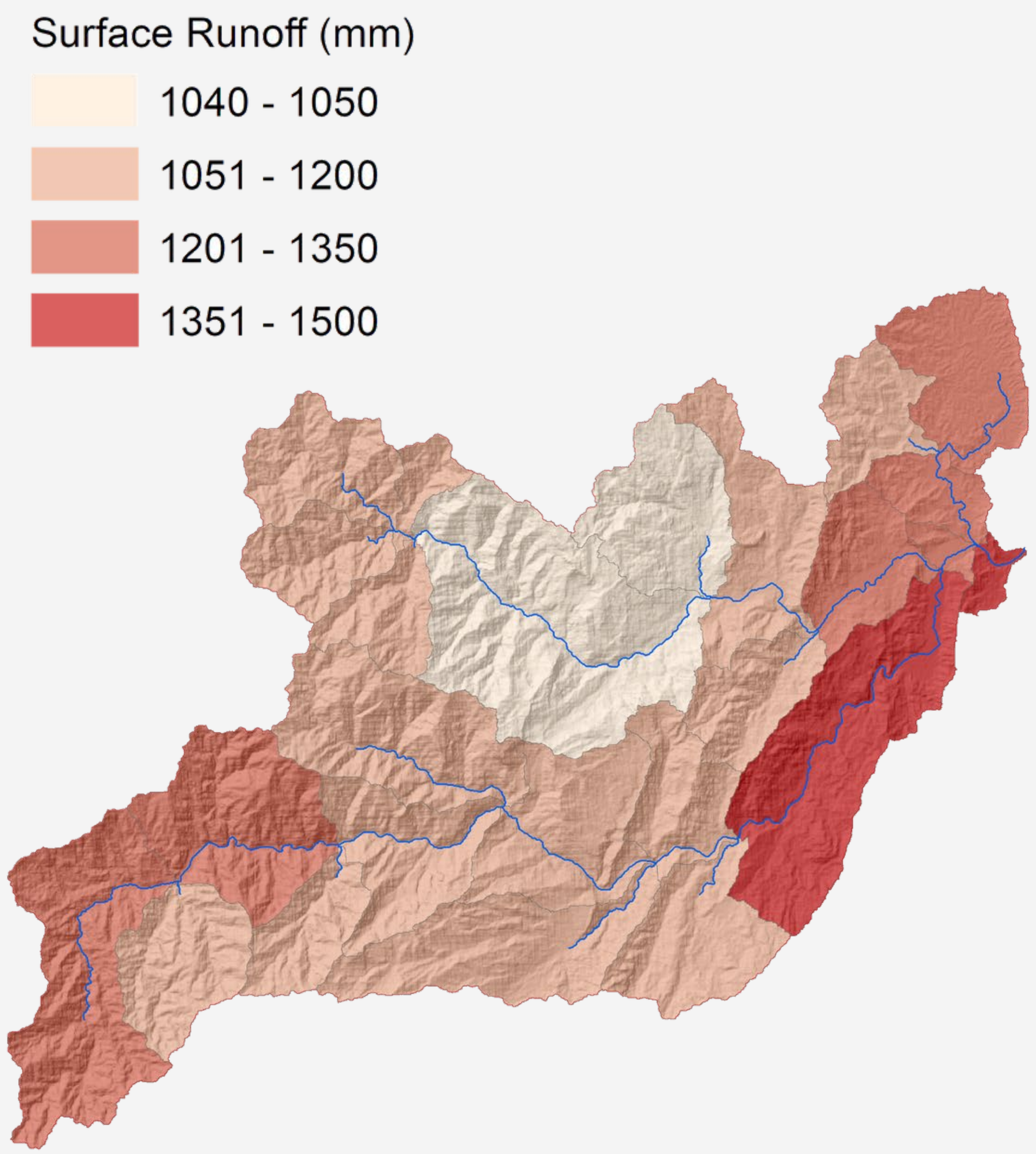
RESULTS AND DISCUSSIONS

Surface Runoff

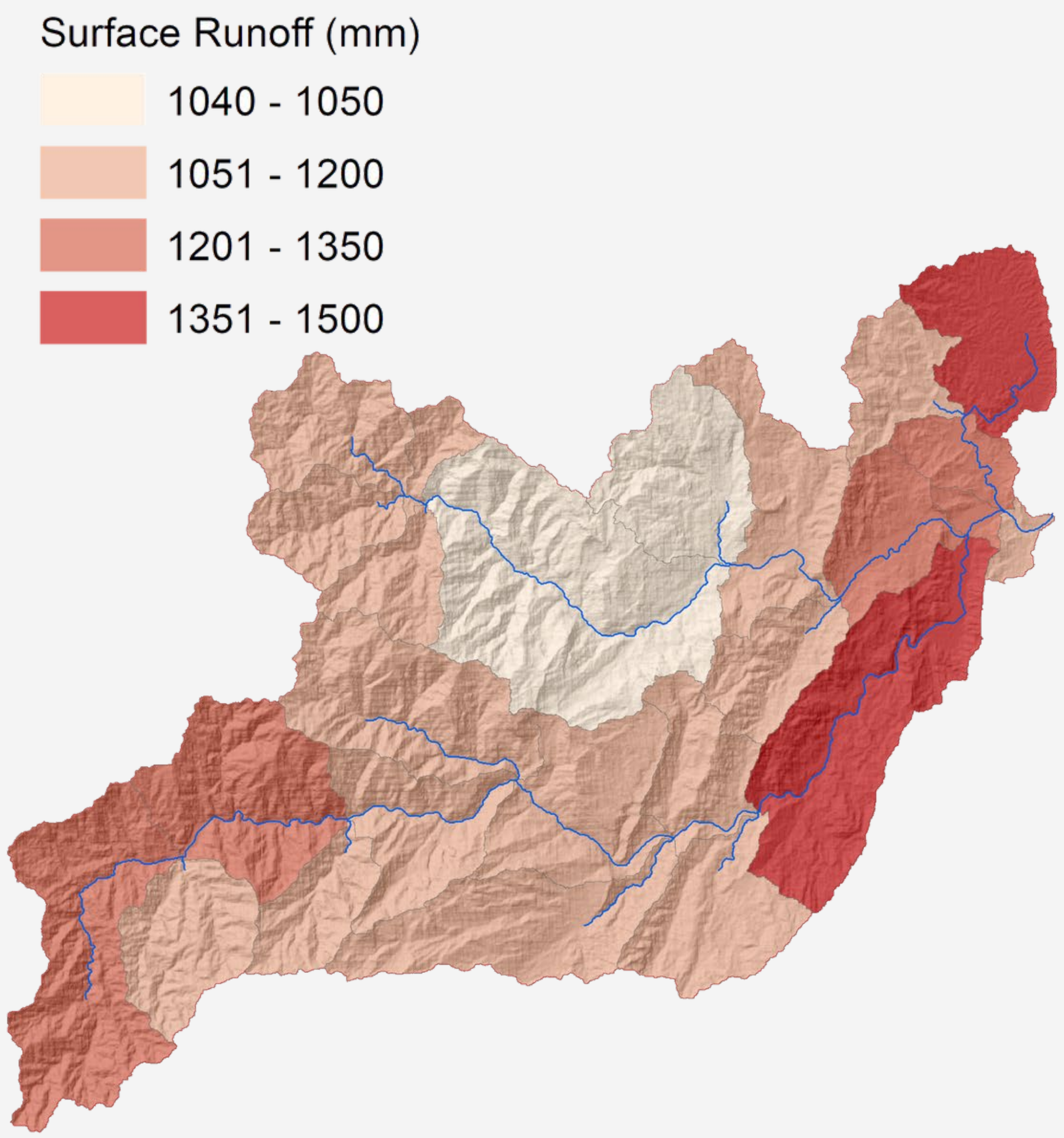
2000



2010



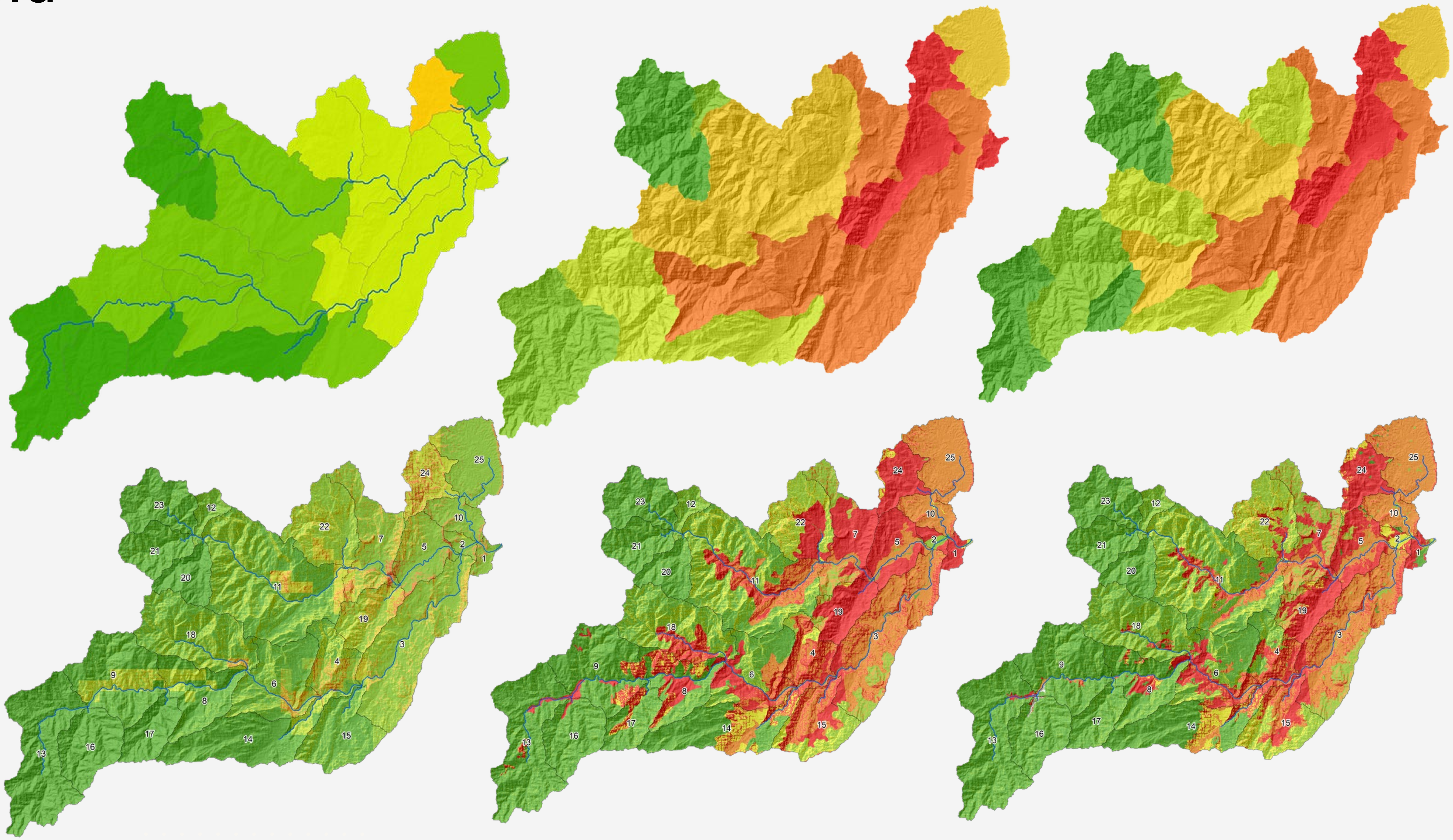
2015



RESULTS AND DISCUSSIONS

Sediment Yield

2000 **2010** **2015**



Sediment Yield (tons ha^{-1}·yr^{-1})

- < 50.00
- 50.01 - 200.00
- 200.01 - 500.00
- 500.01 - 1000.00
- 1000.01 - 2000.00
- > 2000.01

Different Soil Erosion Level (Hernando and Romana, 2015)

RESULTS AND DISCUSSIONS

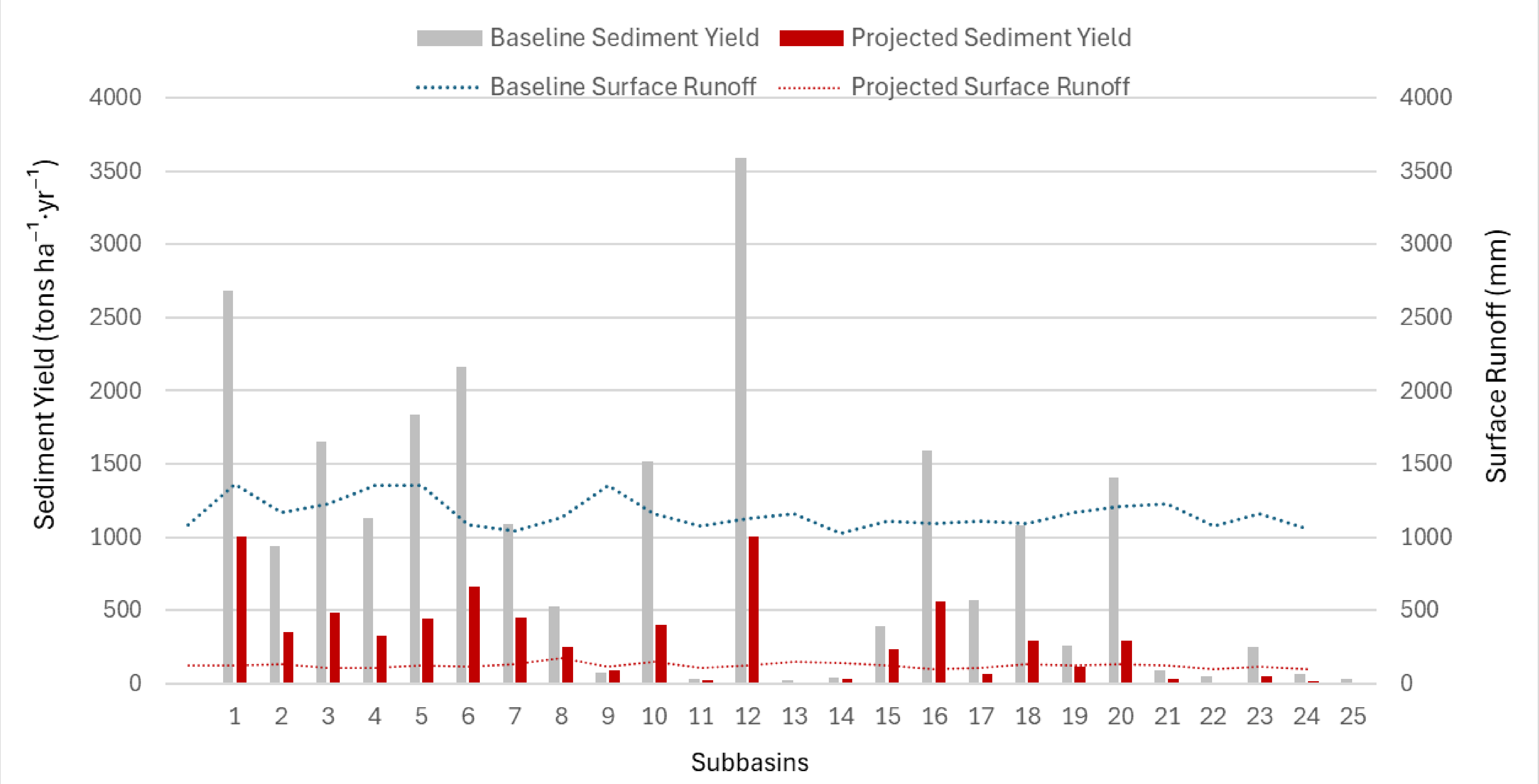
Baseline

Soil Loss Rate (tons ha^{-1}·yr^{-1})	Area Affected by Soil Erosion (%)		
	2000	2010	2015
< 50	44.95	35.31	39.48
50.01 - 200	36.61	16.11	20.90
200. 01 - 500	11.01	5.99	5.84
500.01 - 1000	4.99	18.43	17.19
1000.01 - 2000	2.36	12.11	8.51
> 2000.01	0.08	12.04	8.08
	100.00	100.00	100.00

Surface runoff: **+864.43%; −1.28%**

Sediment yield: +**302.79%; −20.26%**

Climate Projection



Surface runoff: **−89.42%**

Sediment yield: **−60.74%**

CONCLUSIONS AND LIMITATIONS

- The calibration and validation of the model demonstrated acceptable agreement with observed streamflows , though limitations included underestimating peak flows and overestimating low flows, largely due to the quality of streamflow data and other external factors not accounted for in the model.

- Sensitivity analysis identified key parameters: CN2, ALPHA_BF, SOL_K, and ESCO.

  - Enhance ground data collection for calibration and validation (sediments).

  - Assess the impact of proposed dam or weir structures (dimensions) on the hydrologic behavior of the Saltan River Watershed.

  - Assess updated land cover and considering land management practices (reforestation or contour farming) on sediment generation to support accurate sediment modeling and effective watershed management.

REFERENCES

Abbaspour K. C., M. Vejdani, and S. Haghighat. 2007. SWATCUP calibration and uncertainty programs for SWAT. In Proc. Intl. Congress on Modelling and Simulation (MODSIM'07), 1603-1609. L. Oxley and D. Kulasiri, eds. Melbourne, Australia: Modelling and Simulation Society of Australia and New Zealand.

Abbaspour, K. C. (2015). SWAT-CUP: SWAT Calibration and Uncertainty Programs – A User Manual. Swiss Federal Institute of Aquatic Science and Technology, Eawag, Dübendorf

Abbaspour, K. C., Rouholahnejad, E., Vaghefi, S., Srinivasan, R., Yang, H., & Kløve, B. (2015). A continental-scale hydrology and water quality model for Europe: Calibration and uncertainty of a high-resolution large-scale SWAT model. Journal of Hydrology, 524, 733-752. https://doi.org/10.1016/j.jhydrol.2015.03.027

Alibuyog, N. R., & Pastor, F. C. (2009). Predicting the hydrologic response of the Laoag River basin to climate change using SWAT Model. ILAARRDEC, 109–119.

Arceo, M. G. A. S., Cruz, R. V. O., Tiburan, C. L. Jr., & Balatibat, J. B. (2018). Modeling the hydrologic responses to land cover and climate changes of selected watersheds in the Philippines using the Soil and Water Assessment Tool (SWAT) model. DLSU Business & Economics Review, 28(3), 84–101.

Asian Development Bank. (2019). Initial Environmental Examination: Rehabilitation of Pingi-Codcodwe Water Work System, Gawa-an, Balbalan, Kalinga. Philippines: Integrated Natural Resources and Environmental Management Project.

Briones, R. U., Ella, V. B., & Bantayan, N. C. (2016). Hydrologic impact evaluation of land use and land cover change in Palico Watershed, Batangas, Philippines using the SWAT model. Journal of Environmental Science and Managementral, 19(1), 96–107.

Cai, T., Li, Q., Yu, M., Lu, G., Cheng, L. & Wei, X. (2012). Investigation into the impacts of land-use change on sediment yield characteristics in the upper Huaihe River basin, China. Physics and Chemistry of the Earth, Parts, (53-54), 1-9. doi: 10.1016/j.pce.2011.08.023

Climate Hazards Center. (2023). Climate Hazards Group InfraRed Precipitation with Stations (CHIRPS). Retrieved from https://www.chc.ucsb.edu/data/chirps

Combalicer, E. A., Cruz, R. V. O., Lee, S. H., &Im, S. (2010). Modelling hydrologic processes distribution in a tropical forest watershed in the Philippines. Journal of Tropical Forest Science, 22(2), 155–169.

Ely, P., Fantin-Cruz, I., Tritico, H. M., Girard, P., & Kaplan, D. (2020). Dam-induced hydrologic alterations in the rivers feeding the Pantanal. Frontiers in Environmental Science, 8, Article 579031.

FAO-UNESCO. (1974). FAO-Unesco soil map of the world, 1:5,000,000: Vol. 1, Legend. Food and Agriculture Organization of the United Nations and United Nations Educational, Scientific and Cultural Organization.

Food and Agriculture Organization of the United Nations. (2023). FAO Global Soil Database. Retrieved from https://www.fao.org/soils-portal

Gassman, P. P. W., Reyes, M. M. R., Green, C. C. H., & Arnold, J. J. G. (2007). The Soil and Water Assessment Tool : historical development, applications, and future research directions. Transactions of the ASABE, 50(4), 1211–1250. doi: 10.13031/2013.23637

Kim, H. W., Li, M.-H., Kim, J.-H., & Jaber, F. (2016). Examining the Impact of Suburbanization on Surface Runoff using the SWAT. International Journal of Environmental Research,10(3), 379–390. doi: 10.22059/IJER.2016.58757

Lee, J., Kim, J., Jang, W.S., Lim, K.J. & Engel, B. (2018). Assessment of Baseflow Estimates Considering Recession Characteristics in SWAT. Water, 10(4), 2-14. doi: 10.3390/w10040371

Li, Z., Deng, X., Wu, F., & Hasan, S. S. (2015). Scenario analysis for water resources in response to land use change in the middle and upper reaches of the Heihe River Basin. Sustainability, 7(3), 3086–3108. doi: 10.3390/su7033086

Moriasi, D.N., Arnold, J.G., Van Liew, M.W., Bingner, R.L., Harmel, R.D., & Veith, T.L. (2017). Model evaluation guidelines for systematic quantification of accuracy in watershed simulations. American Society of Agricultural and Biological Engineers, 50(3), 885–900.

Oduor, B. O., Campo-Bescós, M. Á., Lana-Renault, N., & Casalí, J. (2023). Effects of climate change on streamflow and nitrate pollution in an agricultural Mediterranean watershed in Northern Spain. Agricultural Water Management, 285, 108378. https://doi.org/10.1016/j.agwat.2023.108378

Rumsey, C.A., Miller, M.P., Susong, D.D., Tillman, F.D., & Anning, D.W. (2015). Regional scale estimates of baseflow and factors influencing baseflow in the upper Colorado iver basin. Jouanl of Hydrology: Regional Stududies, 4(B), 91–107. doi: 10.1016/j.ejrh.2015.04.008

Singson, C. L., Alejo, L. A., Balderama, O. F., Bareng, J. L. R., & Kantoush, S. A. (2023). Modeling climate change impact on the inflow of the Magat reservoir using the Soil and Water Assessment Tool (SWAT) model for dam management. Journal of Water and Climate Change, 14(3), 633–646.

Wang, H., Sun, F., Xia, J., & Liu, W. (2017). Impact of LUCC on streamflow based on the SWAT model over the Wei River basin on the Loess Plateau in China. Hydrology and Earth System Sciences, 21, 1929-1945. doi: 10.5194/hess-2016-332

THANK YOU!