remote sensing

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Article

Estimation of Water Balance for Anticipated Land Use in the Potohar Plateau of the Indus Basin using SWAT

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Table S1. Description of satellite imagery acquisition.

Sr. No.	LULC Year	Source	Resolution	Acquisition Date	Cloud Cover
1	LULC 1990	Landsat-5	30 m	24-05-1990	1%
2	LULC 2000	Landsat-7	30 m	13-06-2000	1%
3	LULC 2010	Landsat-7	30 m	18-06-2010	2%
4	LULC 2020	Sentinel-2A	10 m	29-06-2020	0%

Table S2. Details of hydrometric data acquisition.

Sr. No.	Discharge Gauge	Year	Source
1	Soan at Dhoke Pathan	01-Jan-1991 to 31-Dec-2007	Surface Water Hydrology Project (WAPDA)
2	Kanshi River near Palote	01-Jan-1991 to 31-Dec-2007	
3	Haro River at Gurriala	01-Jan-1980 to 31-Dec-2007	

Table S3. Accuracy assessment of historical LULC's.

LULC	1990		2000		2010		2020	
	U%	P%	U%	P%	U%	P%	U%	P%
Water	97.00	100.00	95.00	100.00	96.00	100.00	98.00	100.00
Agriculture	82.00	82.00	79.00	84.04	85.00	80.95	89.00	84.76
Forest	92.00	92.93	98.00	80.99	94.00	94.95	100.00	93.46
Barren	85.00	69.11	74.00	68.52	85.00	64.89	96.00	78.69
Built-up	80.00	98.77	80.00	97.56	66.00	95.65	67.00	98.53
Overall Accuracy (%)	83.80		85.20		85.80		87.20	
Kappa Coefficient	0.7975		0.8150		0.8225		0.8475	

Table S4. Driving factors used to prepare the suitability matrix for LULC projection.

Sr. No.	Parameters Type	Parameter	Source
1	Socio-economic Parameters	Population Density	Diva.GIS
2		Gross Domestic Product (GDP)	Socioeconomic Data and Applications Center (SEDAC)
3	Spatial Parameters	Elevation Map	ALOS PALSAR
4		Slope Map	ALOS PALSAR
5		Aspect Ratio Map	USGS
6		Distance from Roads	Diva.GIS
7		Distance from Railways	Diva.GIS
8		Distance from Water Bodies	Diva.GIS

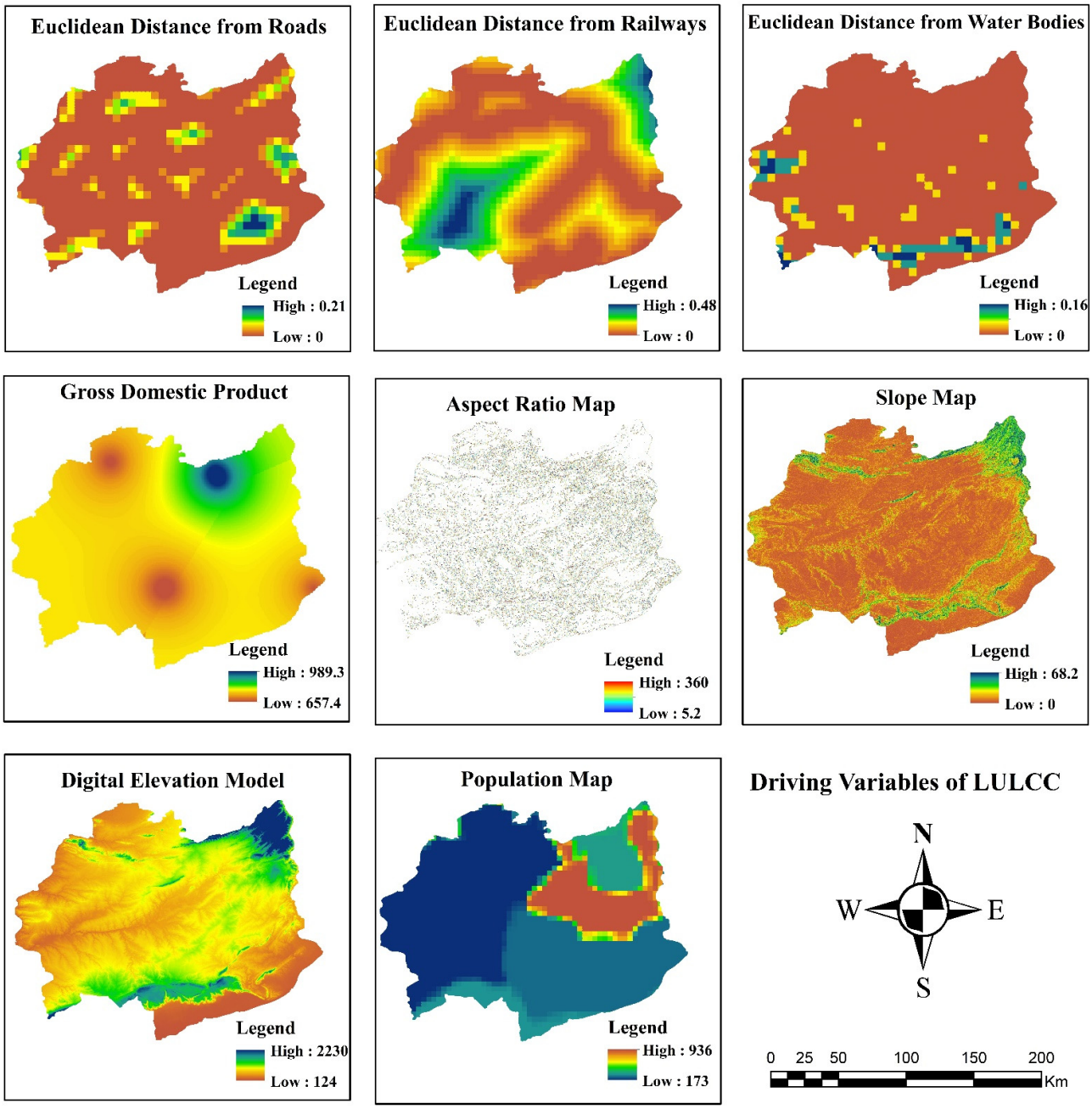


Figure S1. Spatial Maps of driving parameters of LULC change.

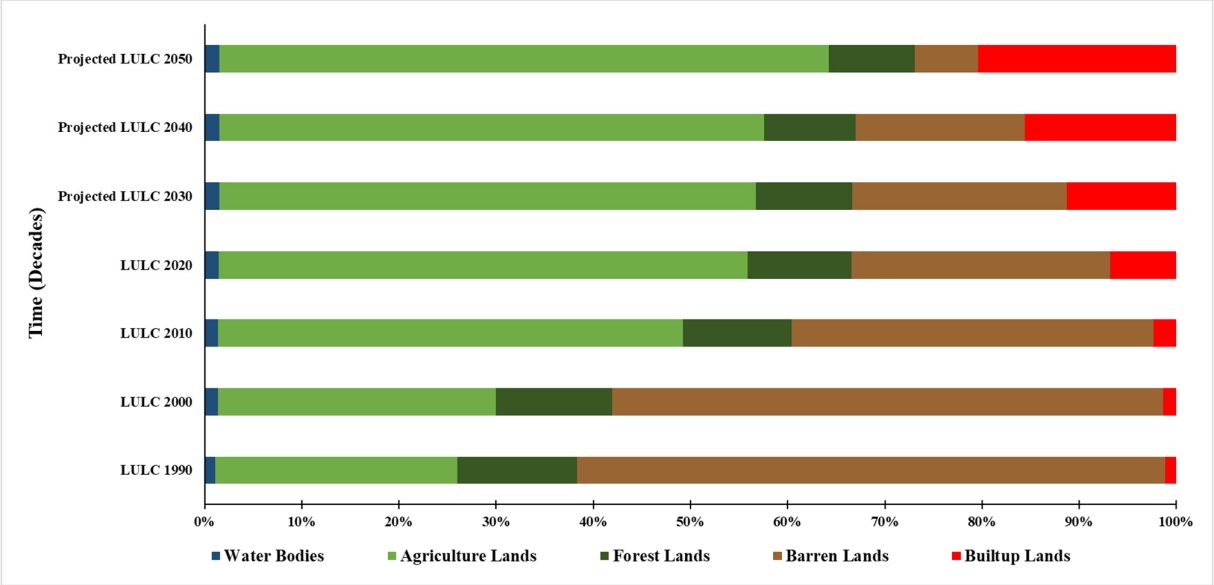


Figure S2. Temporal variance of LULC, historical and projected.

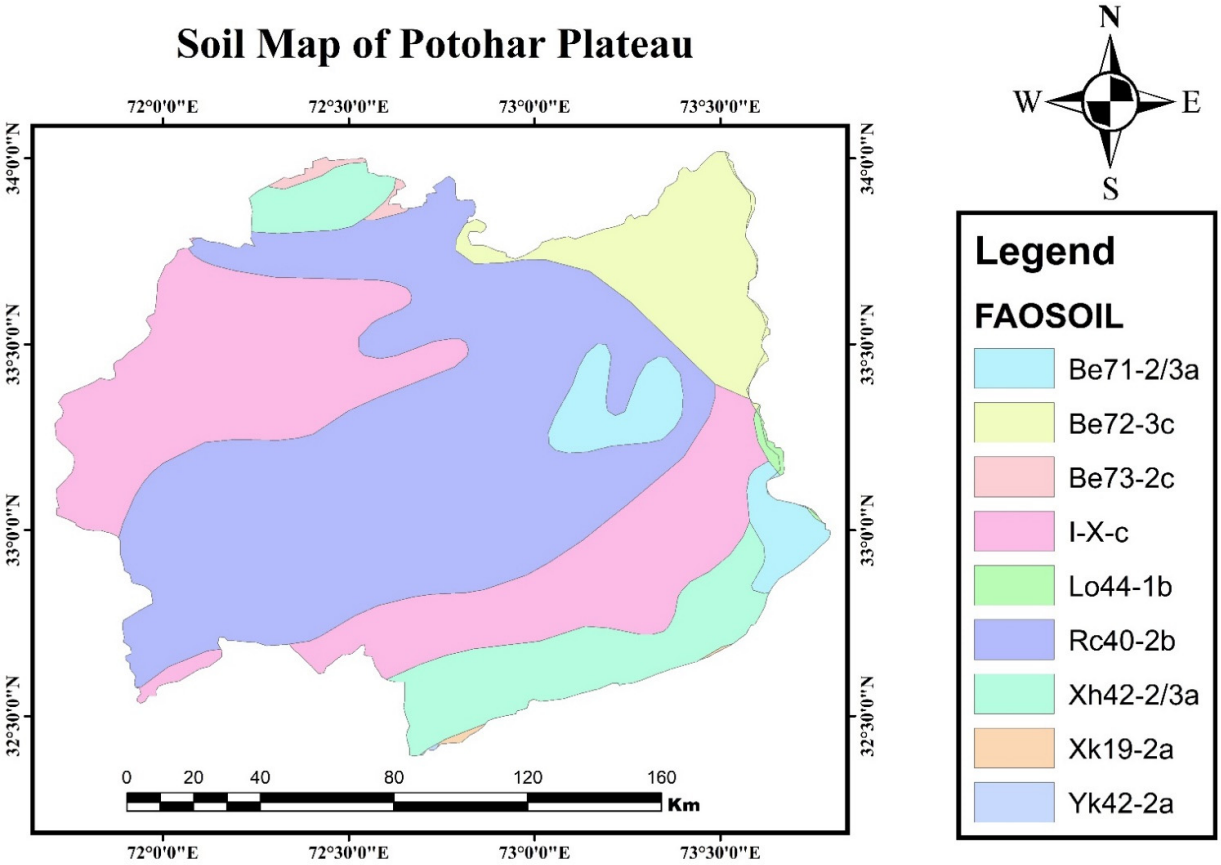


Figure S3. Soil map of Potohar Plateau.

Table S5. Global sensitivity values and ranks.

Parameters	Soan River Basin			Kanshi River Basin			Haro River Basin		
	Rank	t-stat	P-value	Rank	t-stat	P-value	Rank	t-stat	P-value
r__CN2.mgt	1	-23.53	0.00000	1	-16.86	0.00000	1	28.94	0.00000
v__ALPHA_BF.gw	2	6.71	0.00048	24	0.07	0.00039	29	-0.01	0.00500
v__GW_DELAY.gw	3	2.90	0.00032	3	3.68	0.00940	2	1.16	0.00025
v__GWQMN.gw	4	4.46	0.00015	4	2.91	0.00000	4	-4.39	0.00000
v__TIMP.bsn	24	1.07	0.00039	2	5.70	0.00100	3	-1.80	0.07295
v__SURLAG.bsn	21	-0.57	0.00057	21	0.33	0.00074	21	-0.39	0.00070
v__SHALLST.gw	5	-2.03	0.04300	5	-7.22	0.00000	5	6.67	0.00000
v__GW_REVAP.gw	6	1.02	0.00308	6	5.16	0.00000	6	-0.26	0.00798
v__RCHRG_DP.gw	7	-0.49	0.00623	7	-3.88	0.00013	7	4.59	0.00000
v__ALPHA_BNK.rte	8	8.04	0.00186	8	5.23	0.00000	8	3.18	0.00160
v__CANMX.hru	9	3.21	0.00100	9	1.95	0.05187	9	3.29	0.00112
v__CH_N2.rte	10	0.51	0.61600	10	0.58	0.00563	12	-1.69	0.00900
v__CH_K2.rte	11	-2.32	0.02100	12	-2.17	0.03074	10	-1.55	0.00122
v__ESCO.hru	12	-6.10	0.00196	11	-4.21	0.00004	11	7.20	0.00000
v__GW_SPYLD.gw	25	-0.52	0.04300	29	0.19	0.00390	13	-1.20	0.00231
v__GWHT.gw	26	0.84	0.04700	28	1.44	0.00470	22	-0.99	0.00323
v__OV_N.hru	13	0.60	0.55100	13	-1.59	0.00112	14	-1.67	0.00960
v__REVAPMN.gw	27	-0.43	0.03200	27	-0.13	0.00897	15	0.78	0.00434
v__SLSUBBSN.hru	14	1.70	0.09100	14	-0.17	0.00864	16	0.33	0.00742
v__HRU_SLP.hru	15	1.84	0.06700	15	1.75	0.08040	18	-1.12	0.00265
v__SNOCOVMX.bsn	29	-0.19	0.00470	25	0.63	0.04100	19	1.05	0.00294
v__CH_S1.sub	28	1.34	0.00370	26	0.94	0.03700	20	-0.03	0.00977
v__CH_K1.sub	16	-3.58	0.00052	16	1.63	0.00104	17	-0.10	0.00143
v__CH_N1.sub	23	1.14	0.00100	22	0.69	0.00385	24	2.07	0.00099
r__SOL_AWC(1).sol	17	-0.09	0.00926	17	-0.35	0.00726	25	0.86	0.03210
r__SOL_K(1).sol	18	-2.15	0.03200	18	-1.75	0.08099	26	0.84	0.04700
r__SOL_BD(1).sol	19	-0.20	0.00844	19	-0.88	0.00381	27	-0.13	0.00897
r__SOL_Z(1).sol	20	0.74	0.00478	20	0.62	0.00534	23	-0.23	0.00470
r__SOL_ALB(1).sol	22	0.89	0.00485	23	2.14	0.00200	28	0.34	0.00370

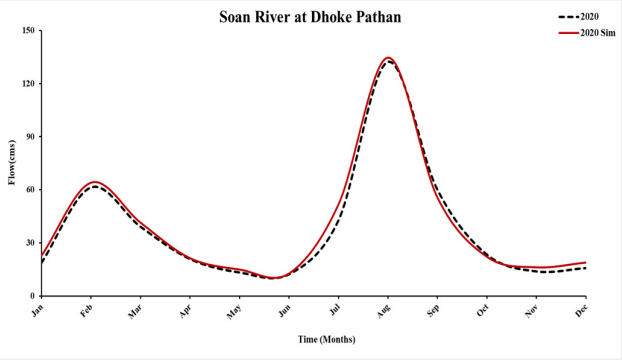
Table S6. List of most sensitive parameters with best-fitted values.

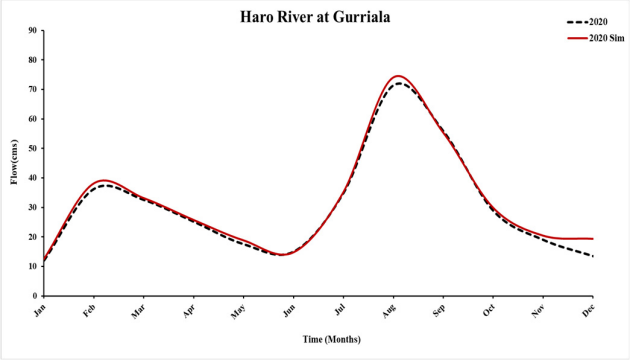
Parameter	Range		Soan Basin	Kanshi Basin	Haro Basin
	Initial	Final			
r__CN2.mgt	**-0.2**	**0.2**	-0.17	-0.13	-0.15
v__ALPHA_BF.gw	0	1	0.36	0.28	0.52
v__GW_DELAY.gw	100	500	259.74	244.98	347.6
v__GWQMN.gw	1000	5000	4337.71	3363.23	4469.02
v__SHALLST.gw	1000	5000	4125.89	4453.73	4801.43

v__GW_REVAP.gw	0.05	0.2	0.22	0.19	0.27016
v__RCHRG_DP.gw	0	1	-0.22	-0.41	-0.13
v__ALPHA_BNK.rte	0	1	0.91	0.83	1.06
v__CANMX.hru	0	150	101.20	77.56	136.84
v__CH_N2.rte	0.1	0.3	0.25	0.23	0.27
v__CH_K2.rte	0	500	-59.04	-77.85	23.12
v__ESCO.hru	0	1	0.54	0.34	0.74
v__OV_N.hru	0.1	1	1.27	1.02	1.32
v__SLSUBBSN.hru	10	150	66.76	66.19	101.07
v__HRU_SLP.hru	0	0.6	0.36	0.14	0.49
v__CH_K1.sub	50	300	250.45	162.27	290.77
r__SOL_AWC(1).sol	-0.1	0.1	-0.03	-0.07	0.01
r__SOL_K(1).sol	-0.1	0.1	-0.19	-0.24	-0.18
r__SOL_BD(1).sol	-0.1	0.2	0.40	0.21	0.46
r__SOL_Z(1).sol	-0.1	0.2	0.17	0.16	0.27
v__SURLAG.bsn	0	24	36.56	29.21	38.93
v__REVAPMN.gw	0	500	300.17	499.19	261.90

Table S7. Quantitative analysis of classified and simulated LULC 2020.

Class Name	2020 Classified	2020 Projected	2020 Classified (%)	2020 Projected (%)	Difference in Area	% Difference
Water Bodies	338.76	334.69	1.46	1.44	-4.07	-0.02
Agricultural Lands	12655.54	12439.41	54.43	53.63	-216.13	-0.8
Forest Area	2478.51	2335.59	10.66	10.07	-142.92	-0.59
Barren Lands	6190.87	6289.47	26.63	27.11	+98.6	+0.48
Built-up Area	1585.67	1800.17	6.82	7.75	+215.50	+0.93





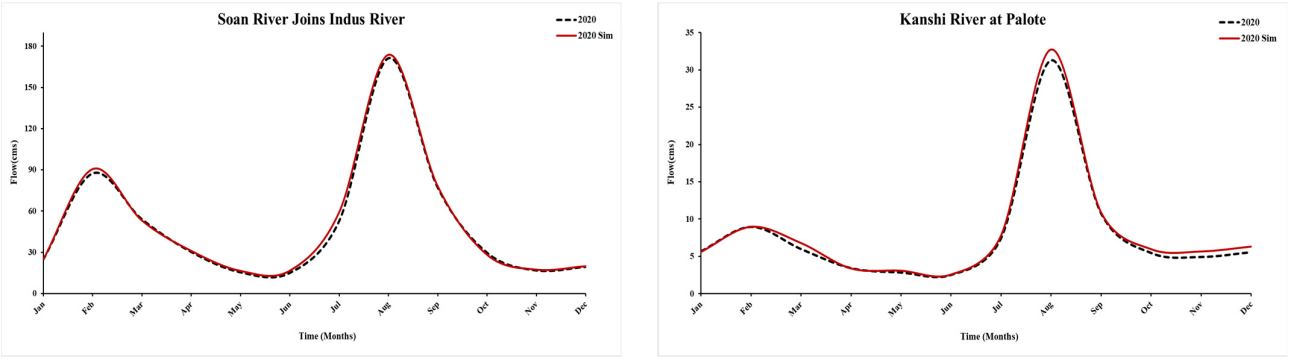


Figure S4. Streamflow evaluation of classified and simulated LULC 2020.

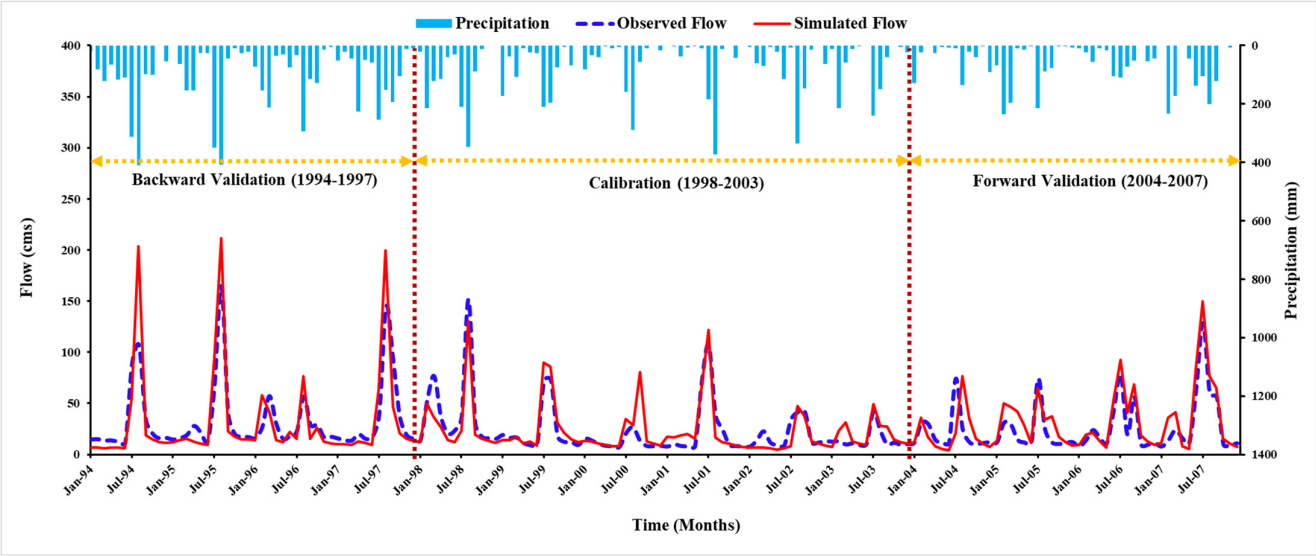


Figure S5. Calibration and validations of stream flows, Haro River Basin.

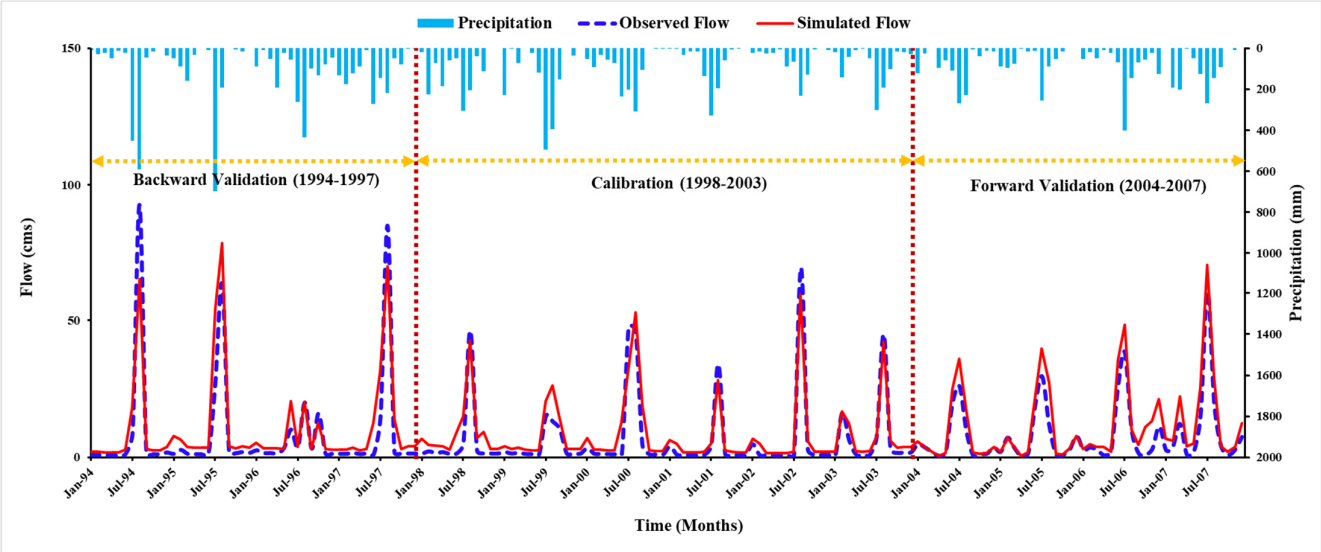


Figure S6. Calibration and validations of stream flows, Kanshi River Basin.

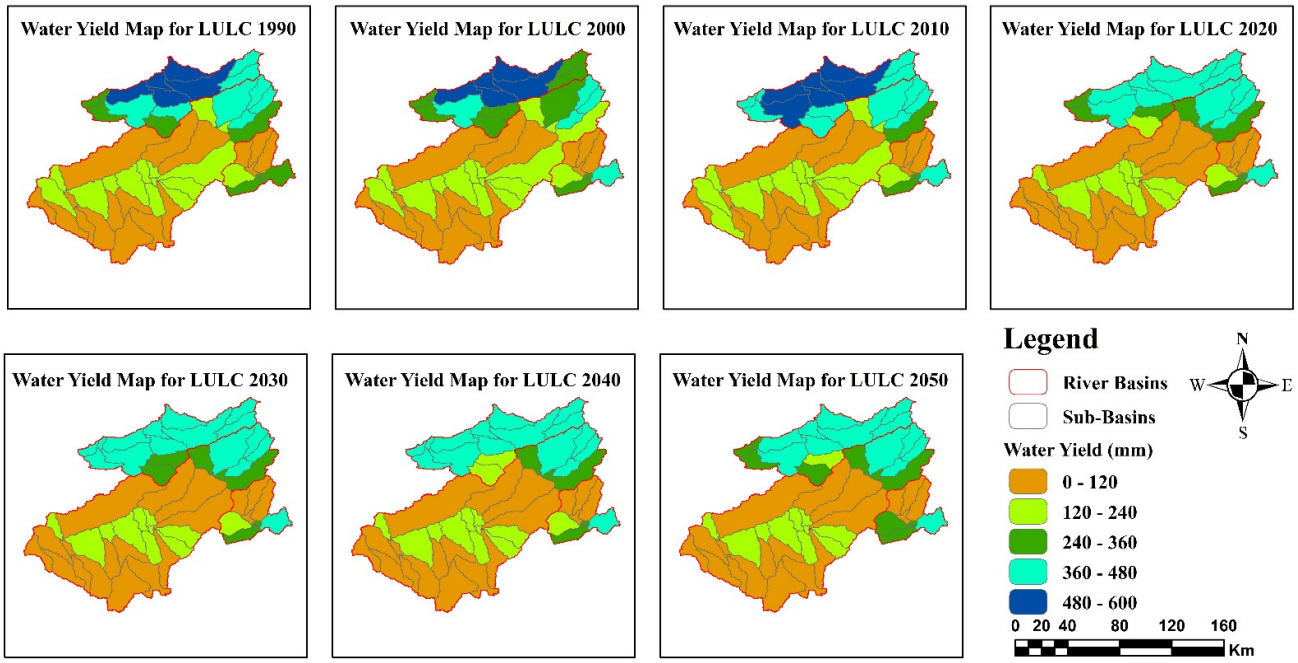


Figure S7. Spatial and temporal distribution of variations in simulated in water yield.

$$W_{yield} = Q_{surface} + Q_{gw} + Q_{lat} - T_{losses}\,. \quad \text{(S1)}$$

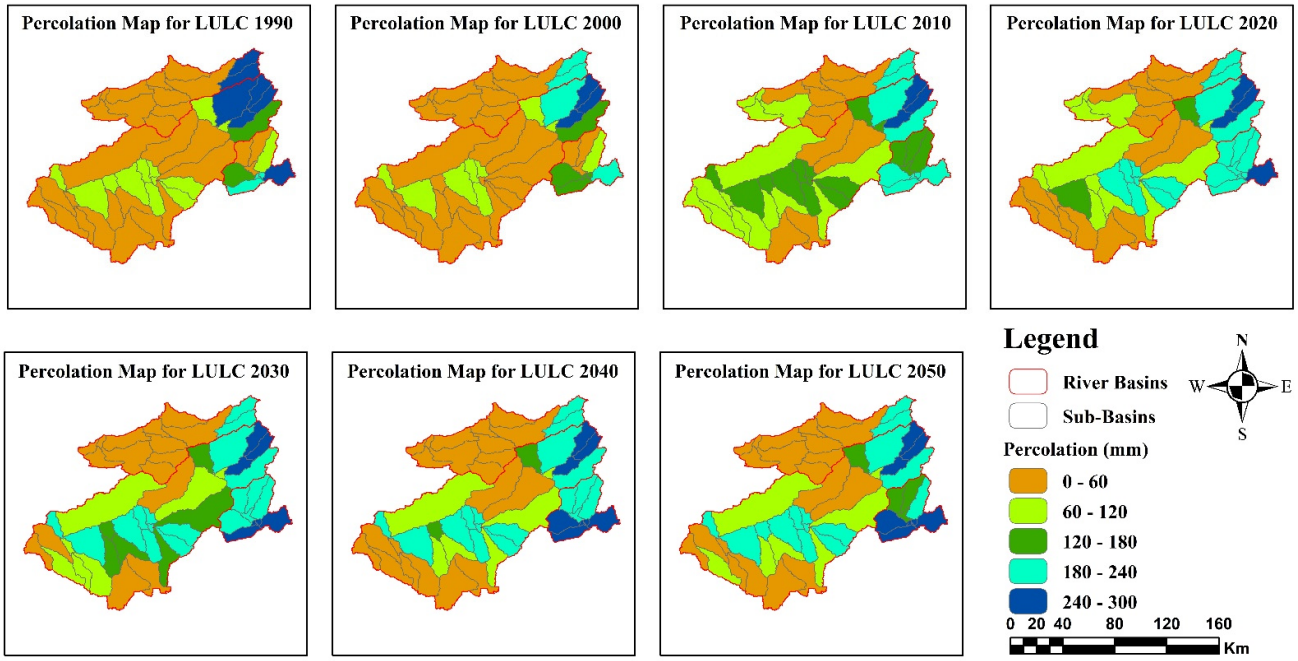


Figure S8. Spatiotemporal patterns of percolation under LULC scenarios.

$$pe_i = (\Theta_i - FC_i) * [1 - e^{\frac{-\Delta t}{t_i}}] \quad \text{(S2)}$$

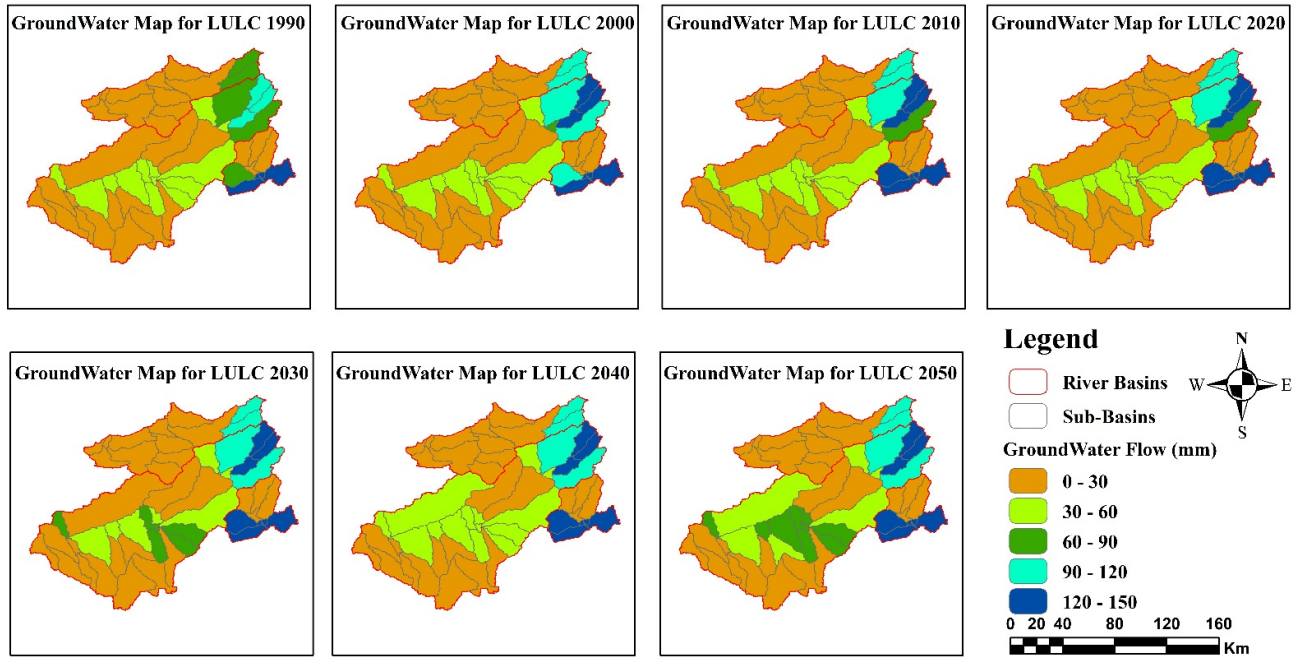


Figure S9. Spatiotemporal patterns of groundwater flow under LULC scenarios.

$$(Q_{gw})_j = (Q_{gw})_{j-1} * e^{(-\alpha gw.\Delta t)} + W_{recharge}(1 - e^{(-\alpha gw.\Delta t)}) \quad \text{(S3)}$$

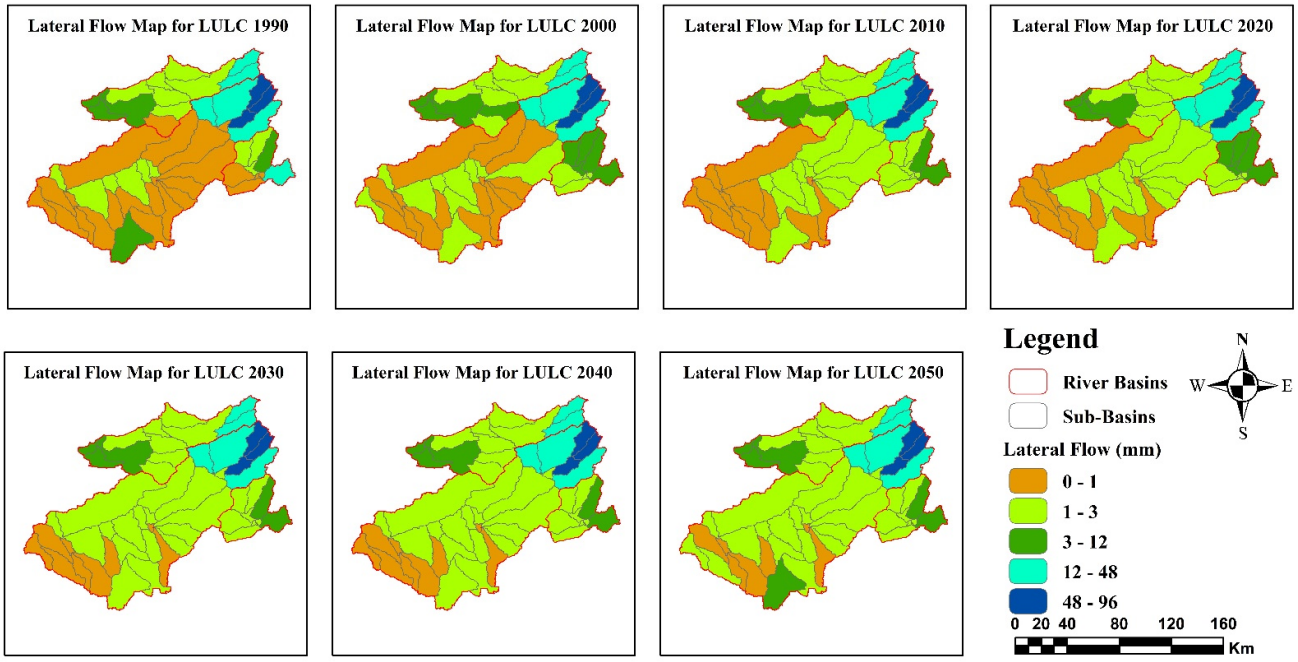


Figure S10. Spatiotemporal patterns of lateral flow under LULC scenarios.

$$Q_{lat} = 0.024 * \frac{2SSC \sin \alpha}{\theta_d L} \quad \text{(S4)}$$

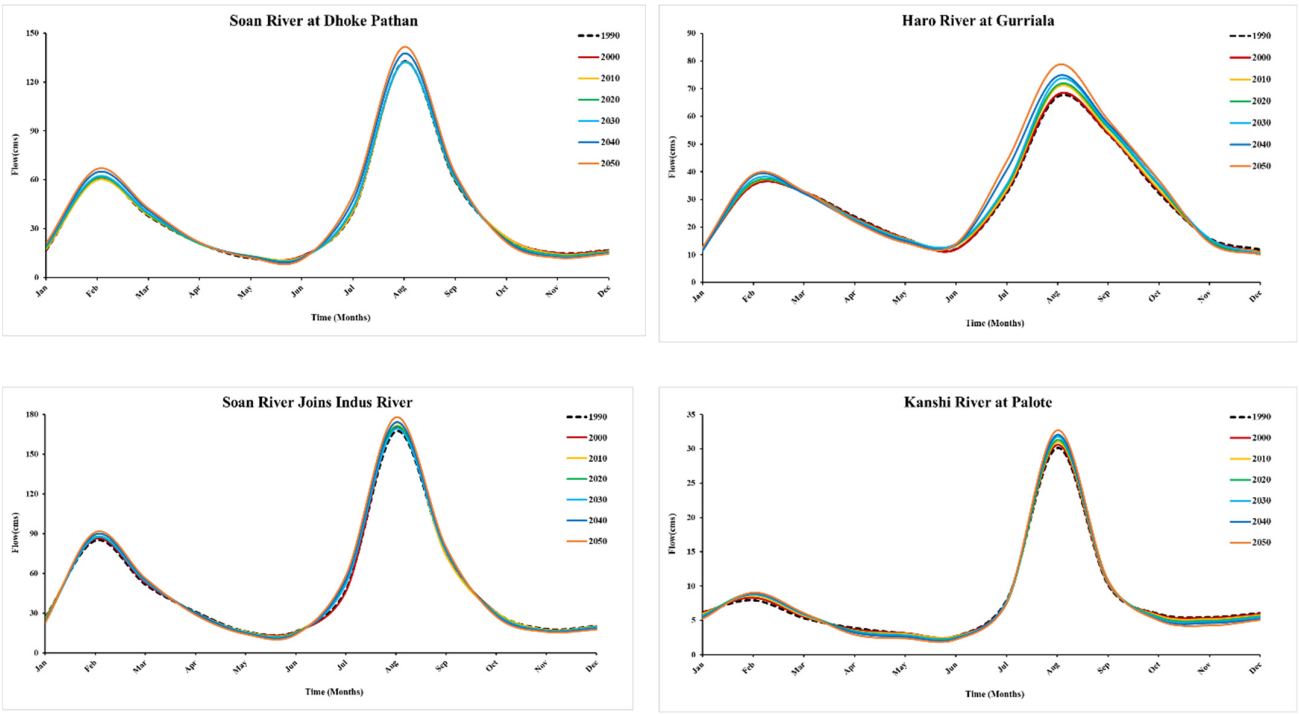


Figure S11. Seasonal variation of flow regime under LULC scenarios at different hydrometric stations.