

Supplementary Files:

Supplementary Tables:

Table S1. Details of data used in this study.

SL. No.	Satellite sensors	Year	Image acquisition time	Path/Row	Resolution (m)	Cloud Cover (%)	Image type
1	Landsat 5 TM	1989	04 November 1989	137/45	30	0.00	Level-1 GeoTIFF
2	Landsat 5 TM	1989	27 November 1989	138/45	30	0.00	Level-1 GeoTIFF
3	Landsat 7 ETM	1999	08 November 1999	137/45	30	0.00	Level-1 GeoTIFF
4	Landsat 7 ETM	1999	15 November 1999	138/45	30	0.00	Level-1 GeoTIFF
5	Landsat 5 TM	2009	11 November 2009	137/45	30	0.00	Level-1 GeoTIFF
6	Landsat 5 TM	2009	16 November 2009	138/45	30	0.00	Level-1 GeoTIFF
7	Landsat 8 OLI	2014	25 November 2014	137/45	30	0.02	Level-1 GeoTIFF
8	Landsat 8 OLI	2014	16 November 2014	138/45	30	0.03	Level-1 GeoTIFF
9	Landsat 8 OLI	2019	23 January 2019	137/45	30	0.00	Level-1 GeoTIFF
10	Landsat 8 OLI	2019	30 January 2019	138/45	30	0.27	Level-1 GeoTIFF

Note: In the 2nd column TM refer Thematic Mapper, ETM refer Enhanced Thematic Mapper and OLI refer Operation Land Imager. **Source:** USGS Earth Explorer Landsat archive (<https://earthexplorer.usgs.gov>) [66].

Table S2. Classification accuracy matrix and accuracy results for multiple classes from 2019 (Simulated) to 1989: (a-f) derived based on Maximum Likelihood classifier (MLC) of the multi-temporal Landsat derived classification images.

(a)

2019 (Simulated)		Accuracy Matrix					Classification Accuracy			
LC Classes	HE	TR	RI	BA	SA	Total	PA (%)	UA (%)	OA (%)	Kappa
HE	54	15	0	1	0	70	77.14	62.79	82.30	0.75
TR	23	77	0	0	0	100	77.00	83.70		
RI	3	0	65	2	0	70	92.86	97.01		
BA	5	0	2	38	0	45	84.44	88.37		
SA	1	0	0	2	17	20	85.00	100.00		
Total	86	92	67	43	17	305				

(b)

2019		Accuracy Matrix					Classification Accuracy			
LC Classes	HE	TR	RI	BA	SA	Total	PA (%)	UA (%)	OA (%)	Kappa
HE	60	8	0	2	0	70	85.71	81.08	90.49	0.87
TR	12	87	0	1	0	100	87.00	91.58		
RI	0	0	68	2	0	70	97.14	98.55		
BA	2	0	1	42	0	45	93.33	87.50		
SA	0	0	0	1	19	20	95.00	100.00		
Total	74	95	69	48	19	305				

(c)

2014		Accuracy Matrix					Classification Accuracy			
LC Classes	HE	TR	RI	BA	SA	Total	PA (%)	UA (%)	OA (%)	Kappa
HE	56	11	0	3	0	70	80.00	82.35	89.51	0.85
TR	9	91	0	0	0	100	91.00	89.22		
RI	0	0	69	1	0	70	98.57	97.18		
BA	3	0	2	40	0	45	88.89	85.11		
SA	0	0	0	3	17	20	85.00	100.00		
Total	68	102	71	47	17	305				

(d)

2009		Accuracy Matrix					Classification Accuracy			
LC Classes	HE	TR	RI	BA	SA	Total	PA (%)	UA (%)	OA (%)	Kappa
HE	58	10	0	2	0	70	82.86	77.33	87.87	0.83
TR	13	86	0	1	0	100	86.00	89.58		
RI	0	0	67	2	1	70	95.17	98.53		
BA	4	0	1	40	0	45	88.89	83.33		
SA	0	0	0	3	17	20	85.00	94.44		
Total	75	96	68	48	18	305				

(e)

1999		Accuracy Matrix					Classification Accuracy			
LC Classes	HE	TR	RI	BA	SA	Total	PA (%)	UA (%)	OA (%)	Kappa
HE	49	19	0	2	0	70	70.00	69.01	84.92	0.79
TR	19	81	0	0	0	100	81.00	81.00		
RI	0	0	69	1	0	70	98.57	98.57		
BA	3	0	1	41	0	45	91.11	91.11		
SA	0	0	0	1	19	20	95.00	100.00		
Total	71	100	70	45	19	305				

(f)

1989		Accuracy Matrix					Classification Accuracy			
LC Classes	HE	TR	RI	BA	SA	Total	PA (%)	UA (%)	OA (%)	Kappa
HE	51	15	0	4	0	70	72.86	77.27	86.89	0.82
TR	14	86	0	0	0	100	86.00	85.15		
RI	0	0	68	2	0	70	97.14	97.14		
BA	1	0	2	42	0	45	93.33	84.00		
SA	0	0	0	2	18	20	90.00	100.00		
Total	66	101	70	50	18	305				

Note: HE: light forest, TR: dense forest, RI: water bodies, BA: bare land and SA: sandy area; PA: Producer's accuracy, UA: User's accuracy, OA: Overall accuracy.

Table S3. Validation of the land cover change (LCC) prediction based on the actual and simulated 2019 LC image.

Chi-Square Test			
LC Classes	Simulated LC in 2019 (O)	Actual LC in 2019 (E)	(O – E) ² /E
HE	25.08	26.33	0.059
TR	36.68	34.31	0.164
RI	31.94	32.17	0.002
BA	6.24	7.12	0.109
SA	0.06	0.07	0.001
Total	100.00	100.00	0.335

Note: $\chi^2 = \Sigma(O - E)^2/E = 0.335$; df = 4 and $\chi^2_{0.975(4)} = 0.484$; Data shown in the 2nd and 3rd columns as in O and E represent the percentage share of individual LC classes used for model validation.

Table S4. Results of validation (agreement/disagreement components values) of two images and accuracy assessment of simulated LC images of 2019.

Agreement/Disagreement	Value	Value (%)	Index	Value
Agreement Chance	0.1667	16.67	Kno	0.76
Agreement Quantity	0.0784	7.84	Klocation	0.78
Agreement Strata	0.0000	0.00	Klocation Strata	0.78
Agreement Gridcell	0.5520	5.20	Kstandard	0.73
Disagreement Gridcell	0.1585	15.85		
Disagreement Strata	0.0000	0.00		
Disagreement Quantity	0.0444	4.44		

Source: Value calculated by the LCM module of TerrSet 18.21 version Software.

Table S5. Gain/Loss (%) estimation between different time periods and projected times based on LC area coverage (%) from 1989-2019 and FULC total area coverage (%) from 2019-2029.

Gain/Loss (%) between different years							
LC Classes	1989-1999	1999-2009	2009-2014	2014-2019	1989-2019	2019-2029	1989-2029
HE	3.12	11.51	4.51	0.65	19.79	1.59	21.33
TR	-2.87	-15.56	-3.81	-1.46	-23.80	-2.50	-26.30
RI	-0.69	0.69	-0.67	0.40	-0.27	-0.16	-0.43
BA	0.50	3.35	0.04	0.38	4.27	1.16	5.43
SA	-0.07	0.11	-0.08	0.03	-0.01	-0.03	-0.04

Note: HE- light forest; TR- dense forest; RI-water bodies; BA- bare land and SA- sandy area. The per year change is not displayed in this table, calculated result referred in the relevant text. The positive value refer projected Gain (%) and negative value refer projected Loss (%).

Table S6. Per year rate of change (%) calculation of LC classes between different times.

Per Year Rate of Change (%) of LC classes based on different time periods							
LC Classes	1989-1999	1999-2009	2009-2014	2014-2019	1989-2019	2019-2029	1989-2029
HE	0.31	1.15	0.90	0.13	0.66	0.16	0.53

TR	-0.29	-1.56	-0.76	-0.29	-0.79	-0.25	-0.66
RI	-0.07	0.07	-0.13	0.08	-0.01	-0.02	-0.01
BA	0.05	0.33	0.01	0.07	0.14	0.12	0.14
SA	-0.01	0.01	-0.02	0.01	-0.00	-0.00	-0.00

Note: data calculated based on the Table S7.

Table S7. TAM of LC change assessment of the SRF based on time frame data (1989 to 2019).

Time frame	LC classes	Expected to transition to					Probability of changing to				
		Class 1 (HE)	Class 2 (TR)	Class 3 (RI)	Class 4 (BA)	Class 5 (SA)	Class 1 (HE)	Class 2 (TR)	Class 3 (RI)	Class 4 (BA)	Class 5 (SA)
1989 to 1999	Class 1 (HE)	77864.0	374187.0	74491.0	16240.0	382.0	0.14	0.69	0.14	0.03	0.00
	Class 2 (TR)	512913.0	3199499.0	83652.0	62434.0	1511.0	0.13	0.83	0.02	0.02	0.00
	Class 3 (RI)	24164.0	115480.0	1905653.0	86847.0	1137.0	0.01	0.05	0.89	0.04	0.00
	Class 4 (BA)	18862.0	108521.0	13731.0	5239.0	133.0	0.13	0.74	0.09	0.04	0.00
	Class 5 (SA)	385.0	1696.0	396.0	139.0	4.0	0.15	0.65	0.15	0.05	0.00
1999 to 2009	Class 1 (HE)	621722.0	464112.0	106256.0	116265.0	4306.0	0.47	0.35	0.08	0.09	0.00
	Class 2 (TR)	911462.0	1498956.0	180641.0	216517.0	5770.0	0.32	0.53	0.06	0.08	0.00
	Class 3 (RI)	44621.0	61685.0	1996730.0	70058.0	6242.0	0.02	0.03	0.92	0.03	0.00
	Class 4 (BA)	41445.0	50811.0	237476.0	36953.0	3427.0	0.11	0.14	0.64	0.10	0.01
	Class 5 (SA)	1104.0	1368.0	5985.0	1470.0	176.0	0.11	0.13	0.59	0.15	0.02
2009 to 2014	Class 1 (HE)	572682.0	876561.0	68027.0	96285.0	535.0	0.36	0.54	0.04	0.06	0.00
	Class 2 (TR)	894392.0	1406618.0	101021.0	155811.0	845.0	0.35	0.55	0.04	0.06	0.00
	Class 3 (RI)	134226.0	121822.0	1788452.0	88530.0	1801.0	0.06	0.06	0.84	0.04	0.00
	Class 4 (BA)	120796.0	165238.0	58094.0	28695.0	342.0	0.32	0.44	0.16	0.08	0.00
	Class 5 (SA)	1069.0	1116.0	2026.0	537.0	37.0	0.22	0.23	0.42	0.11	0.01
2014 to 2019	Class 1 (HE)	651853.0	845748.0	19155.0	138838.0	1982.0	0.39	0.51	0.01	0.08	0.00
	Class 2 (TR)	896812.0	1395868.0	10864.0	155940.0	155940.0	0.36	0.57	0.00	0.06	0.00
	Class 3 (RI)	97.0	86.0	2161407.0	115.0	34.0	0.00	0.00	0.99	0.00	0.00
	Class 4 (BA)	90592.0	158091.0	25188.0	120990.0	3654.0	0.22	0.40	0.06	0.30	0.01
	Class 5 (SA)	401.0	629.0	3418.0	1497.0	714.0	0.06	0.09	0.51	0.22	0.11
1989 to 2019	Class 1 (HE)	1215619.0	251468.0	94525.0	95919.0	45.0	0.73	0.15	0.06	0.06	0.00
	Class 2 (TR)	592288.0	1797057.0	0.0	71725.0	0.0	0.24	0.73	0.03	0.03	0.00
	Class 3 (RI)	0.0	0.0	2138026.0	22150.0	1564.0	0.00	0.00	0.99	0.01	0.00
	Class 4 (BA)	52362.0	62381.0	1216.0	275708.0	6848.0	0.13	0.16	0.00	0.69	0.02
	Class 5 (SA)	1087.0	0.0	119.0	4536.0	916.0	0.16	0.00	0.02	0.68	0.14

Note: LC categorical meaning is available in section 3.2.2.

Table S8. Markov chain TPM of FULC classes for the period 2019-2029 by percentage.

Given:		Transition Probabilities of Changing to:				
FULC Classes	Year	HE	TR	RI	BA	SA
HE	2019-2029	0.6557	0.3303	0.0000	0.0140	0.0000
TR	2019-2029	0.2387	0.7016	0.0000	0.0598	0.0000
RI	2019-2029	0.0630	0.0243	0.7172	0.1939	0.0016
BA	2019-2029	0.2959	0.0804	0.0000	0.6236	0.0001
SA	2019-2029	0.0237	0.0034	0.0000	0.0202	0.7709

Note: LC categorical meaning is available in section 3.2.2.

Table S9. LC change transformation of the SRF based on time frame data (1989 to 2029) (unit in ha).

Time Frame	LC Class	Transformation To				
		Class 1 (HE)	Class 2 (TR)	Class 3 (RI)	Class 4 (BA)	Class 5 (SA)
1989-1999	Class 1 (HE)	11461.32	14279.49	2647.44	1639.53	41.49
	Class 2 (TR)	35714.79	326375.82	162.9	2382.12	51.3
	Class 3 (RI)	331.47	877.59	188553.51	6318.09	52.11
	Class 4 (BA)	1147.59	5753.16	580.68	2621.25	65.79
	Class 5 (SA)	229.59	114.75	50.76	222.66	25.02
1999-2009	Class 1 (HE)	31026.6	12795.12	1047.06	3926.43	89.55
	Class 2 (TR)	84148.65	236208.33	5767.38	21201.66	74.79
	Class 3 (RI)	1786.05	2697.57	182347.83	4743.72	420.12
	Class 4 (BA)	1161.45	1478.43	6887.25	3352.95	303.57
	Class 5 (SA)	16.74	21.69	90.72	85.32	21.24
2009-2014	Class 1 (HE)	56161.98	55596.78	1553.58	4806.54	20.61
	Class 2 (TR)	72838.53	165600.81	2463.75	12291.75	6.3
	Class 3 (RI)	4288.59	1725.03	184256.55	5746.77	123.3
	Class 4 (BA)	11934.9	7346.43	3568.86	10348.65	111.24
	Class 5 (SA)	44.1	12.78	292.14	391.05	169.2
2014-2019	Class 1 (HE)	72845.01	61919.55	823.86	9599.49	80.19
	Class 2 (TR)	71853.66	149909.85	172.35	8325.09	20.88
	Class 3 (RI)	4.68	2.34	192119.58	6.03	2.25
	Class 4 (BA)	4466.43	9661.23	1276.92	17823.42	356.76
	Class 5 (SA)	12.06	3.33	163.8	112.32	139.14
1989-2019	Class 1 (HE)	17711.73	6530.85	3274.83	2521.98	29.88
	Class 2 (TR)	128131.65	211386.78	1238.67	23756.13	173.70
	Class 3 (RI)	751.59	1118.88	189737.46	4300.74	224.10
	Class 4 (BA)	2428.20	2376.63	275.67	4961.34	126.63
	Class 5 (SA)	158.67	83.16	29.88	326.16	44.91
2019-2029	Class 1 (HE)	84553.29	51948.63	330.3	12332.07	17.55
	Class 2 (TR)	62797.41	141719.13	496.08	16480.62	3.06
	Class 3 (RI)	1189.53	366.84	192195.54	720.09	84.51
	Class 4 (BA)	9601.2	12348.00	559.35	13101.66	256.14
	Class 5 (SA)	283.23	28.35	10.44	201.06	76.14
1989-2029	Class 1 (HE)	17567.01	6505.47	3329.55	2666.61	0.63
	Class 2 (TR)	136449.54	196987.32	686.34	30550.14	13.59
	Class 3 (RI)	1772.01	758.61	189353.70	3952.26	296.19
	Class 4 (BA)	2550.24	2121.66	222.12	5253.12	21.33
	Class 5 (SA)	85.86	37.89	0.00	413.37	105.66

Supplementary Figures:

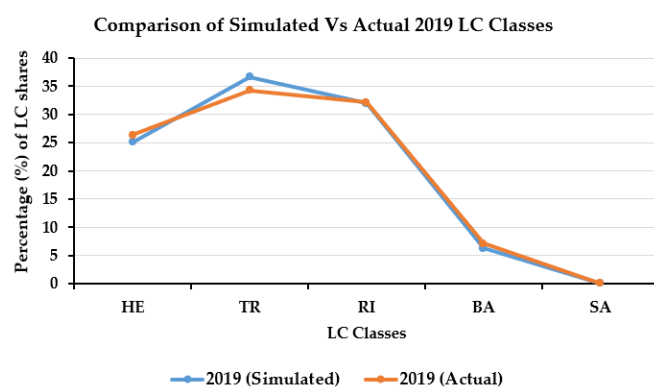
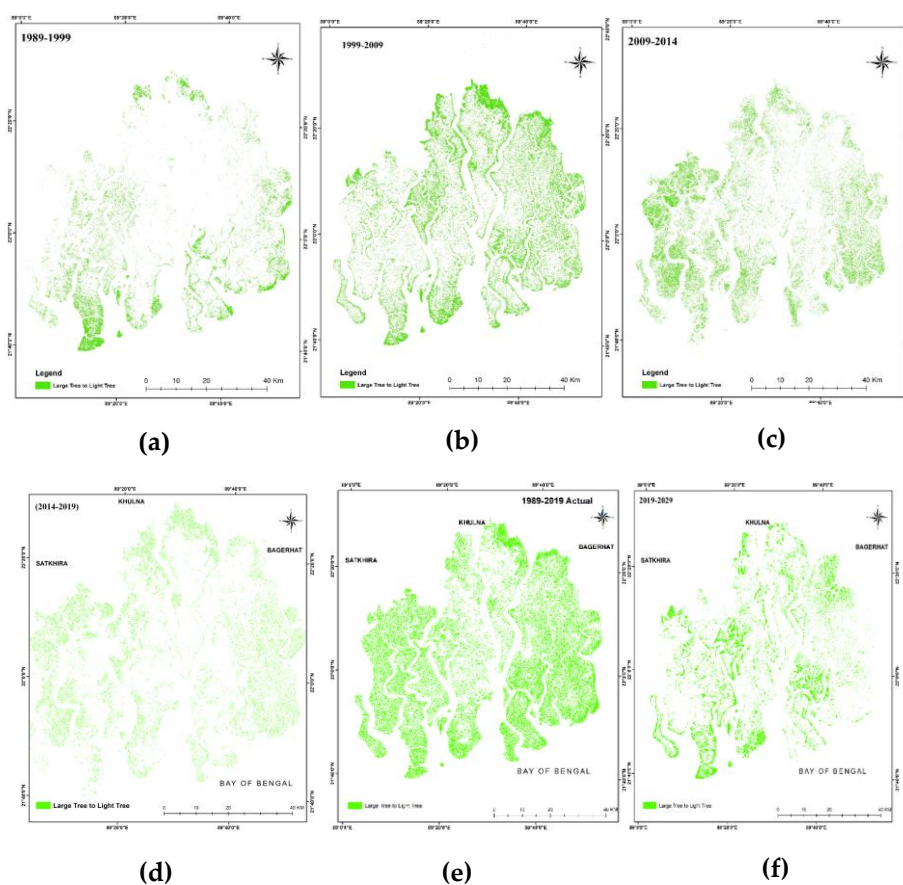
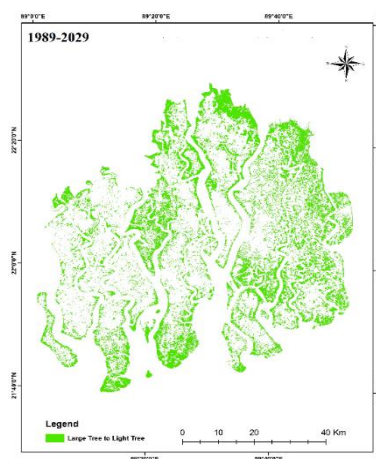


Figure S1. Comparison of simulated Vs actual 2019 LC classes. Note: LC classes categorical meaning are available in section 3.2.2).





(g)

Figure S2. FCC visualization specially TR to HE conversion in different time periods. (a) SRF change (TR Table 1989. (b) SRF change (TR to HE) 1999-2009, (c) SRF change (TR to HE) 2009-2014, (d) SRF change (TR to HE) 2014-2019, (e) SRF change in future (TR to HE) 2019-2029, (f) Overall SRF change (TR to HE) 1989-2019, and (g) Overall SRF change towards future (TR to HE) 1989-2029.