Supplementary Materials:

Driver analysis

The random forest classifier works by constructing multiple decision trees during training and outputting the mode of the classes for classification tasks. For each decision tree in the forest, the prediction for an instance x is made by the tree's classification $h(x)$ that can be calculated as:

$$h(x) = argmax_{\mu} \sum_{t=1}^{T} I\left(h_t(x) = y\right) \quad \text{(S1)}$$

where T is the total number of trees, $h_t(x)$ is the prediction made by the t^{th} tree and I is an indicator function that equals 1 if the t^{th} tree predicts class y for instances x and 0 if that were false. The final prediction for classification classes tasks was determined by majority voting where:

$$H(x) = mode(h_1(x), h_2(x), \ldots, h_T(x)) \quad \text{(S2)}$$

The importance of each driver is then assessed based on the average reduction in impurity (Gini impurity) across all trees. First, the Gini impurity for a node is calculated as:

$$G = 1 - \sum_{i-1}^{nc} p_i^2 \quad \text{(S3)}$$

where p is the proportion of instances belonging to class i in the node, and nc is the number of classes. The total reduction in impurity (Gini impurity) across all trees or feature importance for a driver (Im) is measured as:

$$Im(f_j) = \sum_{t=1}^{T} \Delta G_{f_j}^t \quad \text{(S4)}$$

where $\Delta G_{f_j}^t$ is the reduction in Gini impurity caused by splitting on driver fj in tree

Table S1. Site description of Ramsar sites with available boundaries.

Province/ Administrative Region	Ramsar ID	Ramsar Site Name	Udvardy Biome	Udvardy Province	Unique LCCS Classes	Creation of Non-Ramsar Protected Area
Anhui	2248	Anhui Shengjin Lake National Nature Reserve	Temperate broad-leaf forests	Oriental Deciduous Forest	16	1986
Gansu	1975	Gansu Gahai Wetlands Nature Reserve	Temperate broad-leaf forests Cold-winter deserts	Oriental Deciduous Forest Takla-Makan-Gobi Desert	14 9	1982
	2246	Zhangye Heihe Wetland National Nature Reserve	Cold-winter deserts	Takla-Makan-Gobi Desert	13	1992
	2347	Gansu Yanchiwan Wetlands	Cold-winter deserts	Takla-Makan-Gobi Desert	12	1982
Guangdong	1157	Zhanjiang Mangrove National Nature Reserve	Tropical humid forests	South Chinese Rainforest	9	1990
	1727	Guangdong Haifeng Wetlands	Tropical humid forests	South Chinese Rainforest	14	1998
Guangxi	1153	Shankou Mangrove Nature Reserve	Tropical humid forests	South Chinese Rainforest	9	1990
	1728	Guangxi Beilun Estuary National Nature Reserve	Tropical humid forests	South Chinese Rainforest	9	1990
Heilongjiang	549	Zhalong	Temperate grasslands Temperate broad-leaf forests	Mongolian-Manchurian Steppe Manchu-Japanese Mixed Forest	16 12	1987
	1149	Honghe National Nature Reserve	Temperate broad-leaf forests	Manchu-Japanese Mixed Forest	11	1988
	1155	Xingkai Lake National Nature Reserve	Temperate broad-leaf forests	Manchu-Japanese Mixed Forest	20	1986
	1976	Heilongjiang Nanweng River National Nature Reserve	Temperate broad-leaf forests	Manchu-Japanese Mixed Forest	15	1999
	1977	Heilongjiang Qixing River National Nature Reserve	Temperate broad-leaf forests	Manchu-Japanese Mixed Forest	8	1991
	2185	Dongfanghong Wetland National Nature Reserve	Temperate broad-leaf forests	Manchu-Japanese Mixed Forest	14	2005
	2353	Heilongjiang Youhao Wetlands	Temperate broad-leaf forests	Manchu-Japanese Mixed Forest	11	2005
Hong Kong SAR	750	Mai Po Marshes and Inner Deep Bay	Tropical humid forests	South Chinese Rainforest	10	1983
Hubei	2184	Hubei Chen Lake Wetland Nature Reserve	Temperate broad-leaf forests	Oriental Deciduous Forest	12	1995
	2186	Hubei Dajiu Lake Wetland	Temperate broad-leaf forests	Oriental Deciduous Forest	10	2006
	2349	Hubei Wang Lake	Temperate broad-leaf forests	Oriental Deciduous Forest	15	2004
	551	Dong dongting hu	Temperate broad-leaf forests	Oriental Deciduous Forest	15	1984
	1151	Nan Dongting Wetland and Waterfowl Nature Reserve	Temperate broad-leaf forests	Oriental Deciduous Forest	16	1991

Table S1. Site description of Ramsar sites with available boundaries (Continued).

Province/ Administrative Region	Ramsar ID	Ramsar Site Name	Udvardy Biome	Udvardy Province	Unique LCCS Classes	Creation of Non-Ramsar Protected Area
Inner Mongolia	1146	Dalai Lake National Nature Reserve, Inner Mongolia	Temperate grasslands	Mongolian-Manchurian Steppe	15	1986
	2351	Inner Mongolia Grand Khingan Hanma Wetlands	Temperate broad-leaf forests	Manchu-Japanese Mixed Forest	5	1979
Jiangsu	1145	Dafeng National Nature Reserve	Temperate broad-leaf forests	Oriental Deciduous Forest	7	1986
	1156	Yancheng National Nature Reserve	Temperate broad-leaf forests	Oriental Deciduous Forest	11	1983
Jilin	548	Xianghai	Temperate grasslands	Mongolian-Manchurian Steppe	12	1981
	2350	Jilin Hani Wetlands	Temperate broad-leaf forests	Manchu-Japanese Mixed Forest	7	1991
Liaoling	1147	Dalian National Spotted Seal Nature Reserve	Temperate broad-leaf forests	Oriental Deciduous Forest	7	1992
	1441	Shuangtai Estuary	Temperate broad-leaf forests	Oriental Deciduous Forest	15	1985
Qinghai	1436	Eling Lake	Temperate broad-leaf forests	Oriental Deciduous Forest	9	2000
	1442	Zhaling Lake	Temperate broad-leaf forests	Oriental Deciduous Forest	7	2000
Shandong	2187	Shandong Yellow River Delta Wetland	Temperate broad-leaf forests	Oriental Deciduous Forest	12	1990
	2346	Shandong Jining Nansi Lake	Temperate broad-leaf forests	Oriental Deciduous Forest	12	1994
Shanghai	1144	Chongming Dongtan Nature Reserve, Shanghai	Temperate broad-leaf forests	Oriental Deciduous Forest	3	1998
Sichuan	2348	Sichuan Changshagongma Wetlands	Cold-winter deserts Temperate broad-leaf forests	Tibetan Oriental Deciduous Forest	11 9	1997
Tibet	1438	Maidika	Cold-winter deserts	Tibetan	9	2008
	1439	Mapangyong Cuo	Cold-winter deserts Mixed mountain systems	Tibetan Himalayan Highlands	11 5	2008
	2352	Tibet Selincuo Wetlands	Cold-winter deserts	Tibetan	18	1993
Yunnan	1435	Dashanbao	Sub-tropical / Temperate rain forests / Woodlands	Chinese Subtropical Forest	9	1990
	1437	Lashihai Wetland	Mixed mountain systems	Szechwan Highlands	13	1997
	1440	Napahai Wetland	Mixed mountain systems	Szechwan Highlands	12	1985
Zhejiang	1867	Hangzhou Xixi Wetlands	Temperate broad-leaf forests	Oriental Deciduous Forest	7	2007

Table S2. LCCS legend and IPCC class.

IPCC Class		Value	LCCS Legend	Users Accuracy (%)
1. Agriculture		10	Cropland, rainfed	92
		20	Cropland, irrigated or post-flooding	83
		30	Mosaic cropland (>50%) / natural vegetation (tree, shrub, herbaceous cover) (<50%)	71
		40	Mosaic natural vegetation (tree, shrub, herbaceous cover) (>50%) / cropland (<50%)	39
2. Forest		50	Tree cover, broadleaved, evergreen, closed to open (>15%)	96
		60	Tree cover, broadleaved, deciduous, closed to open (>15%)	60
		70	Tree cover, needleleaved, evergreen, closed to open (>15%)	66
		80	Tree cover, needleleaved, deciduous, closed to open (>15%)	82
		90	Tree cover, mixed leaf type (broadleaved and needleleaved)	31
		100	Mosaic tree and shrub (>50%) / herbaceous cover (<50%)	35
		160	Tree cover, flooded, fresh or brakish water	36
		170	Tree cover, flooded, saline water	71
3. Grassland		110	Mosaic herbaceous cover (>50%) / tree and shrub (<50%)	22
		130	Grassland	46
4. Wetlands		180	Shrub or herbaceous cover, flooded, fresh/saline/brakish water	33
5. Settlement		190	Urban areas	86
6. Others	Shrubland	120	Shrubland	62
	Sparse vegetation	140	Lichens and mosses	33
		150	Sparse vegetation (tree, shrub, herbaceous cover) (<15%)	21
	Bare area	200	Bare areas	88
	Water	210	Water bodies	96
		220	Permanent snow and ice	96

Table S3. Land cover changes observed in Chinese Ramsar sites and their surrounding areas (Ext).

Land Cover Present	LCCS Class	Gains (km^2)		Loss (km^2)		Total Change (km^2)		Total Elimination or Addition (% of Total Change)		Overall Change (km^2)	
		Ramsar	Ext	Ramsar	Ext	Ramsar	Ext	Ramsar	Ext	Ramsar	Ext
Bare Area	200	337.41	309.51	273.69	257.22	611.10	566.73	7.42	8.02	63.72	52.29
Cropland	10	301.77	317.25	79.92	164.16	381.69	481.41	4.64	6.81	221.85	153.09
	20	231.57	251.01	84.06	118.89	315.63	369.90	3.83	5.24	147.51	132.12
Cropland, Trees, Shrubs, Herbaceous cover	30	95.40	95.85	119.43	160.29	214.83	256.14	1.15	1.85	-24.03	-64.44
	40	162.99	243.09	242.01	463.59	405.00	706.68	2.05	5.17	-79.02	-220.50
Grassland	130	973.53	1009.17	1266.84	1018.98	2240.37	2028.15	24.57	24.54	-293.31	-9.81
Shrubland	120	6.48	2.88	13.05	14.58	19.53	17.46	0.23	0.22	-6.57	-11.70
Tree cover	50	3.96	3.51	1.89	7.83	5.85	11.34	0.03	0.08	2.07	-4.32
	60	66.78	70.65	121.77	128.16	188.55	198.81	1.86	2.50	-54.99	-57.51
	70	15.75	16.20	363.15	185.49	378.90	201.69	2.97	2.36	-347.40	-169.29
	80	13.32	30.24	160.83	201.24	174.15	231.48	1.92	2.54	-147.51	-171.00
	90	0.00	0.09	9.45	2.61	9.45	2.70	0.11	0.04	-9.45	-2.52
Trees, Shrubs, Herbaceous cover	100	52.65	41.94	15.39	17.64	68.04	59.58	0.20	0.27	37.26	24.30
	110	21.60	17.10	31.59	21.42	53.19	38.52	0.24	0.12	-9.99	-4.32
	150	346.59	348.03	355.05	504.54	701.64	852.57	4.83	7.02	-8.46	-156.51
Urban Area	190	153.99	343.08	0.00	0.00	153.99	343.08	1.87	4.86	153.99	343.08
Permanent Snow & Ice	220	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wetlands (Flooded Vegetation & Water):		1331.91	432.72	977.58	265.68	2309.49	698.40			354.33	167.04
Water	210	950.58	314.28	922.86	217.08	1873.44	531.36	22.76	1.87	27.72	97.20
Flooded Vegetation:		381.33	118.44	54.72	48.60	436.05	167.04			326.61	69.84
Shrubs or Herbaceous cover (Flooded)	180	372.33	109.89	54.27	48.24	426.60	158.13	3.60	1.87	318.06	61.65
Tree cover (Fresh/Brackish)	160	0.00	0.09	0.09	0.18	0.09	0.27	0.00	0.00	-0.09	-0.09
Tree cover (Saline)	170	9.00	8.46	0.36	0.18	9.36	8.64	0.10	0.10	8.64	8.28

Table S4. Top ecoregions for land cover change experienced in Chinese Ramsar sites.

Land Cover Changed	Udvardy Biome	Udvardy Province	Total Changed Area (km^2)	Percentage of Total Changed Area within China (%)	Percentage of Total Changed Area within Ecoregions (%)	Percentage of Specific Land Cover Changed Area within China (%)	Overall Land Cover Changed Area (km^2)
Land Covers:			5018.1				
Bare Area	Temperate grasslands	Mongolian-Manchurian Steppe	258.3	4.44	11.43	43.62	44.8
	Cold-winter deserts	Tibetan	242.2	4.16	12.78	40.90	41.5
Cropland	Temperate grasslands	Mongolian-Manchurian Steppe	209.2	3.60	9.26	31.46	164.0
	Temperate broad-leaf forests	Manchu-Japanese Mixed Forest	133.8	2.30	6.73	20.12	117.0
		Oriental Deciduous Forest	250.7	4.31	8.50	37.69	39.6
Grassland	Cold-winter deserts	Tibetan	935.5	16.09	49.35	47.37	-350.4
	Temperate broad-leaf forests	Manchu-Japanese Mixed Forest	393.0	6.76	19.76	19.90	204.7
	Temperate grasslands	Mongolian-Manchurian Steppe	341.8	5.88	15.12	17.31	117.7
Shrubland	Temperate broad-leaf forests	Oriental Deciduous Forest	5.2	0.09	0.18	28.36	-5.2
		Manchu-Japanese Mixed Forest	7.3	0.12	0.36	39.65	-1.3
	Cold-winter deserts	Tibetan	5.2	0.09	0.28	28.55	0.9
Tree cover	Temperate broad-leaf forests	Manchu-Japanese Mixed Forest	430.2	7.40	21.63	76.91	-297.0
	Temperate grasslands	Oriental Deciduous Forest	114.0	1.96	3.87	20.38	-96.1
Mosaic Tree, Shrub, Herbaceous cover	Temperate broad-leaf forests	Manchu-Japanese Mixed Forest	19.5	0.33	0.98	95.08	-19.5
Urban Area	Temperate broad-leaf forests	Oriental Deciduous Forest	122.6	2.11	4.16	85.18	122.6
Wetlands:			2267.5				
Flooded Vegetation	Temperate broad-leaf forests	Oriental Deciduous Forest	275.0	26.12	64.44	192.5	26.12
	Temperate grasslands	Mongolian-Manchurian Steppe	126.1	29.01	29.55	121.5	29.01
Water	Cold-winter deserts	Tibetan	695.4	30.67	37.78	444.0	99.24
	Temperate broad-leaf forests	Oriental Deciduous Forest	777.9	34.31	42.26	-199.5	73.88

Table S5. Top provinces for land cover change experienced in Chinese Ramsar sites.

Land Cover Change	Province Level Administrative Division	Total Changed Area (km^2)	Percentage of Total Change Area within Province (%)	Percentage of Total Change Area within China (%)	Percent of Land Cover Change Area within China (%)	Overall Land Cover Changed Area (km^2)
Land Covers:		5018.1				
Bare Area	Inner Mongolia	231.0	26.03	3.97	39.00	51.3
	Tibet	237.3	4.08	40.07	12.66	36.6
	Gansu	75.3	40.30	1.30	12.72	-26.0
Cropland	Heilongjiang	136.6	13.93	2.35	20.54	116.2
	Jilin	127.4	49.70	2.19	19.15	96.6
	Inner Mongolia	79.0	8.90	1.36	11.88	68.2
Grassland	Tibet	924.6	49.35	15.90	46.81	-339.5
	Heilongjiang	383.4	39.08	6.59	19.41	190.2
	Inner Mongolia	262.9	29.63	4.52	13.31	187.9
Shrubland	Hubei	5.2	0.74	0.09	28.36	-5.2
	Tibet	5.2	0.28	0.09	28.55	0.9
Tree cover	Heilongjiang	417.7	42.57	7.18	74.66	-283.2
Mosaic Tree, Shrub, Herbaceous cover	Heilongjiang	19.5	1.98	0.33	95.08	-19.5
Urban Area	Hubei	68.8	9.82	1.18	47.82	68.8
	Jiangsu	39.5	10.19	0.68	27.48	39.5
Wetlands:		2267.5				
Flooded Vegetation	Hubei	182.0	30.88	8.03	42.66	143.4
	Heilongjiang	120.2	94.75	5.30	28.15	110.9
Water	Tibet	695.4	37.11	11.96	37.78	444.0
	Hubei	407.5	58.13	7.01	22.14	-312.2

Table S6. Distribution of the largest concentration of land cover change (Complete Replacement) within internal buffers.

Province Level Administrative Division	5% Buffer	10% Buffer	15% Buffer	20% Buffer	25% Buffer	Core Buffer
Anhui	Urban Area (73.79%)	Grassland (33.89%)	Water (38.11%) Cropland (35.74%)	Flooded Vegetation (41.46%)	Tree cover (33.88%)	
Gansu	Tree cover (48.59%) Bare Area (33.47%) Grassland (26.95%) Cropland (21.86%)	Urban Area (37.25%)		Water (44.76%)		
Guangdong	Urban Area (80.77%) Tree cover (36.89%) Flooded Vegetation (36.79%)				Tree, Shrub, Herbaceous cover (74.26%)	Grassland (47.99%) Water (37.50%) Cropland (32.65%)
Guangxi	Urban Area (86.39%) Cropland (82.69%)	Tree cover (33.17%)				Grassland (53.05%) Water (49.43%) Flooded Vegetation (39.61%)
Heilongjiang	Grassland (29.18%) Cropland (28.95%) Tree cover (27.78%)	Bare Area (51.11%) Shrubland (47.74%)	Tree, Shrub, Herbaceous cover (37.55%)		Water (76.83%) Urban Area (33.98%)	
Hong Kong SAR	Urban Area (100.00%)	Tree cover (55.40%) Cropland (52.71%)				
Hubei	Tree, Shrub, Herbaceous cover (100.00%) Urban Area (53.58%) Tree cover (30.57%) Cropland (25.93%)				Grassland (24.98%)	Shrubland (31.60%) Water (23.05%)
Inner Mongolia	Tree cover (29.83%)	Grassland (36.55%) Cropland (36.51%)	Tree, Shrub, Herbaceous cover (100.00%) Urban Area (90.00%) Water (28.47%)	Bare Area (32.56%) Flooded Vegetation (44.03%)		Shrubland (57.14%)
Jiangsu	Bare Area (100.00%) Cropland (41.68%)	Tree cover (100.00%) Grassland (27.42%)	Flooded Vegetation (33.69%) Water (32.43%) Urban Area (25.21%)			
Jilin	Grassland (35.23%) Cropland (34.25%)	Bare Area (27.39%)		Urban Area (54.55%) Water (31.50%)	Flooded Vegetation (24.43%)	

Table S6. Distribution of the largest concentration of land cover change (Complete Replacement) within internal buffers (Continues).

Province Level Administrative Division	5% Buffer	10% Buffer	15% Buffer	20% Buffer	25% Buffer	Core Buffer
Liaoling	Tree, Shrub, Herbaceous cover (100.00%) Cropland (86.20%) Urban Area (77.52%) Tree cover (76.51%) Bare Area (36.31%) Flooded Vegetation (35.12%) Water (28.50%)	Grassland (43.09%)				
Qinghai	Cropland (45.00%) Grassland (42.57%) Water (39.47%)	Flooded Vegetation (66.67%) Bare Area (50.00%)				
Shandong	Bare Area (100.00%) Urban Area (61.28%) Flooded Vegetation (52.71%) Cropland (40.31%) Water (27.04%) Tree cover (21.46%)		Grassland (31.65%)			
Shanghai	Urban Area (100.00%) Flooded Vegetation (74.19%) Cropland (59.72%) Water (55.09%)	Bare Area (100.00%) Tree cover (56.09%) Grassland (54.71%)				
Sichuan	Bare Area (79.79%)		Cropland (41.10%) Grassland (40.86%)			
Tibet	Cropland (65.29%) Urban Area (59.10%) Bare Area (57.16%) Flooded Vegetation (48.61%) Shrubland (33.56%)	Water (44.05%) Grassland (37.74%)	Tree, Shrub, Herbaceous cover (51.95%)			
Yunnan	Flooded Vegetation (100.00%) Tree, Shrub, Herbaceous cover (96.03%) Cropland (38.66%) Grassland (29.62%)	Water (48.65%) Tree cover (27.96%)	Urban Area (50.85%)			
Zhejiang	Tree cover (99.52%) Cropland (81.34%) Urban Area (76.89%) Flooded Vegetation (49.97%)					

Table S7. Mean effective mesh size (km²) and percentage of initial change (%) for flooded vegetation, water and urban areas in China.

Country	Flooded Vegetation	Water	Urban Areas
China 1992			
Ramsar	26.21	178.58	0.03
Surrounding areas	2.49	72.38	0.01
China 2020			
Ramsar	29.02	174.15	0.09
Surrounding areas	2.34	71.08	0.18
Total Change			
Ramsar	2.81 (10.7)	-4.43 (-2.5)	0.06 (200.0)
Surrounding areas	-0.15 (-6)	-1.30 (-1.8)	0.17 (1700.0)

Table S8. Total area (km²) and percentage of initial change (%) for flooded vegetation, water and urban areas in China.

Country	Flooded Vegetation	Water	Urban Areas
China 1992			
Ramsar	2863.17	16272.27	55.26
Surrounding areas	1718.82	6657.03	78.39
China 2020			
Ramsar	3185.55	16305.48	204.93
Surrounding areas	1788.75	6753.96	417.78
Total Change			
Ramsar	322.38 (11.3)	33.21 (0.2)	149.67 (270.8)
Surrounding areas	69.93 (4.1)	96.93 (1.5)	339.39 (433.0)

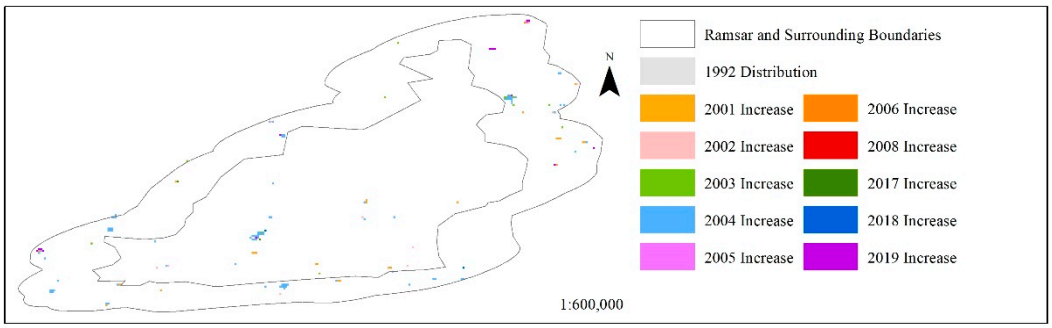


Figure S1. Changes in urban areas of Zhalong (Ris 549).

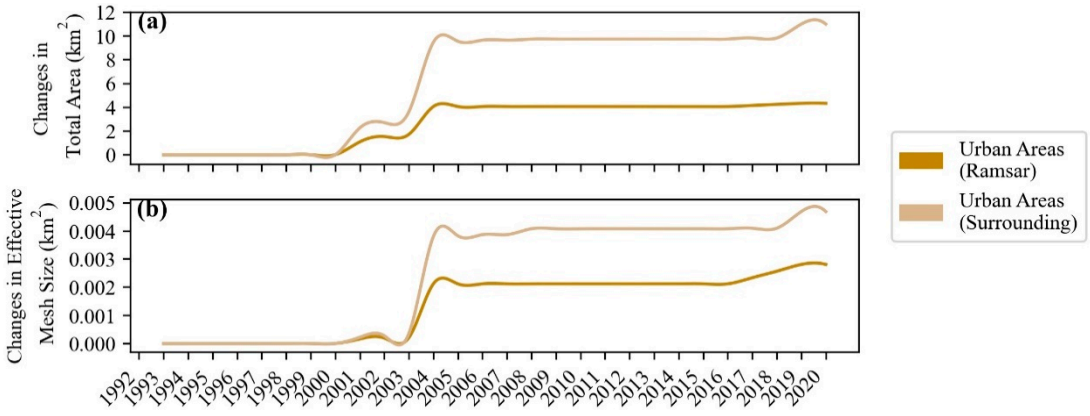


Figure S2. Changes in total area and effective mesh size of urban areas in Zhalong (Ris 549).

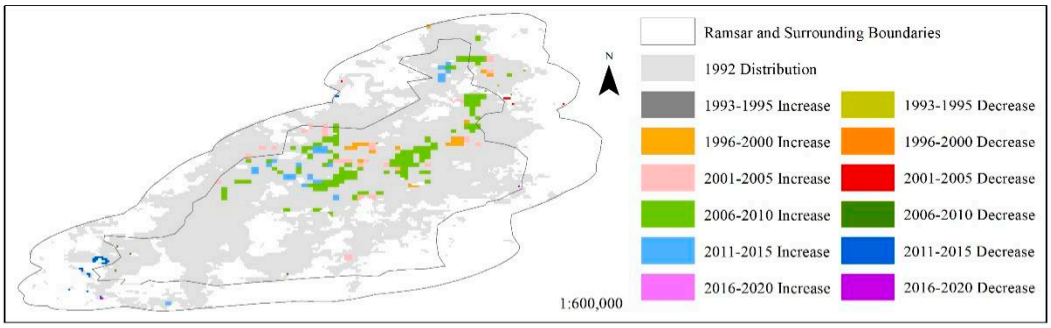


Figure S3. Changes in flooded vegetation of Zhalong (Ris 549).

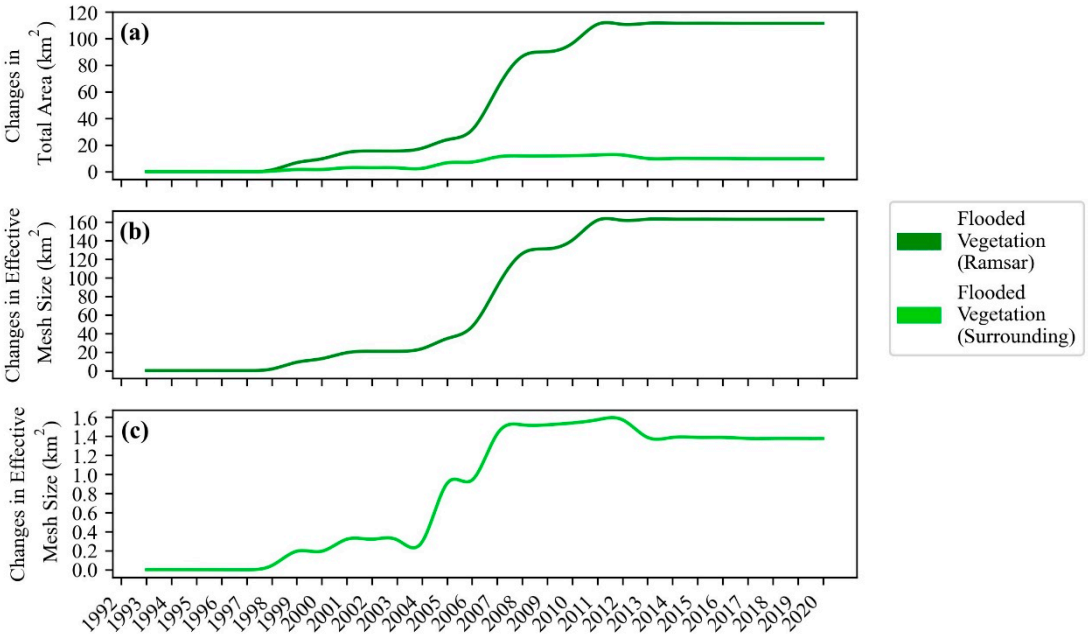


Figure S4. Changes in total area and effective mesh size of flooded vegetation in Zhalong (Ris 549).

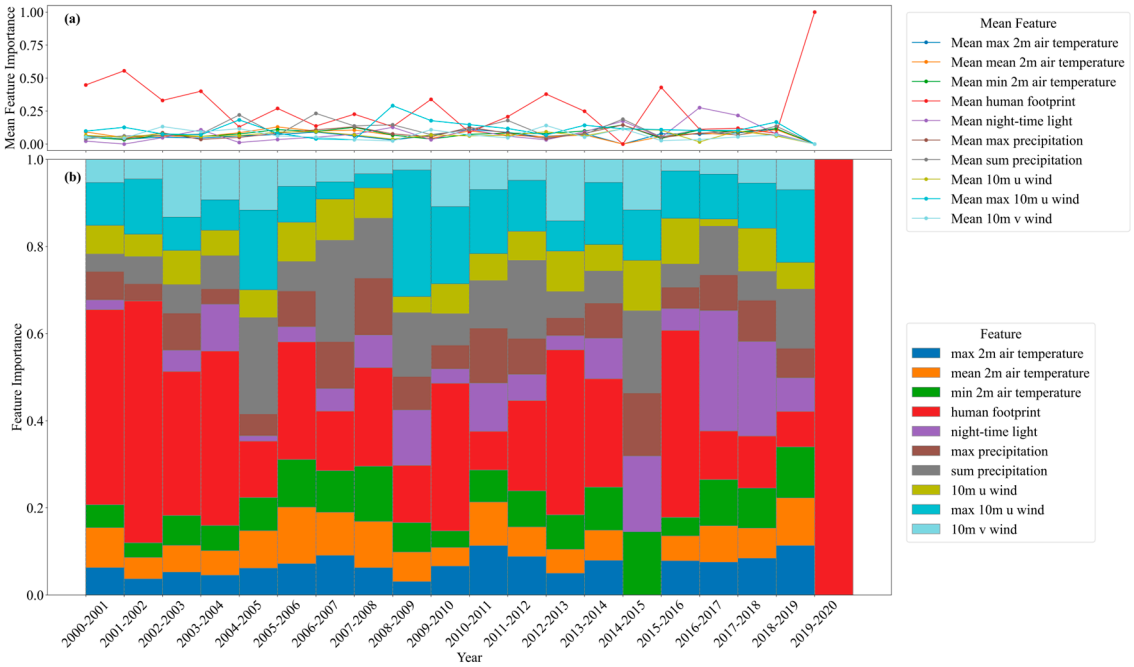


Figure S5. Temporal trends of feature importance in land cover lost or gained (Surrounding Areas). Figure (a) shows the annual importance of various drivers over the 2000-2020 period. Figure (b) depicts the stacked bar charts of the importance of drivers for each year from 2000 to 2020. X-axis represents the year and Y-axis represents the feature importance.



Figure S6. Temporal trends of feature importance in wetland lost or gained (Chinese Ramsar Areas). Figure (a) shows the annual importance of various drivers over the 2000-2020 period. Figure (b) depicts the stacked bar charts of the importance of drivers for each year from 2000 to 2020. X-axis represents the year and Y-axis represents the feature importance.

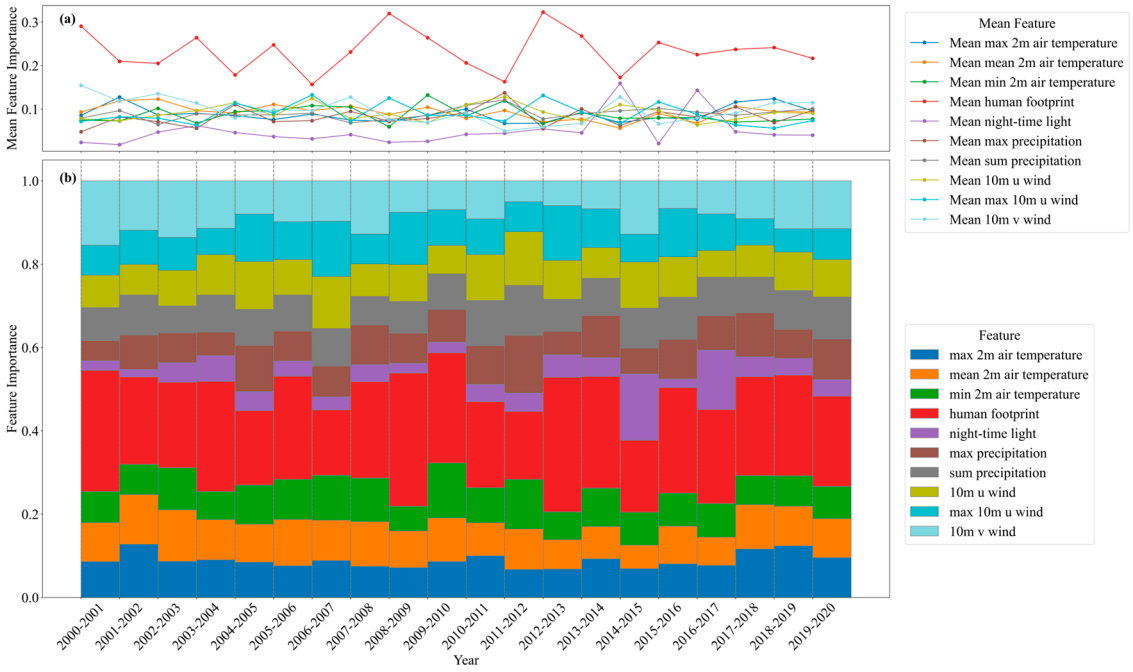


Figure S7. Temporal trends of feature importance in wetland lost or gained (Surrounding Areas). Figure (a) shows the annual importance of various drivers over the 2000-2020 period. Figure (b) depicts the stacked bar charts of the importance of drivers for each year from 2000 to 2020. X-axis represents the year and Y-axis represents the feature importance.