Supplement of

PMF-LP: the first 10 m plastic-mulched farmland distribution map (2019-2021) in the Loess Plateau of China generated using training sample generation and classifier transfer method

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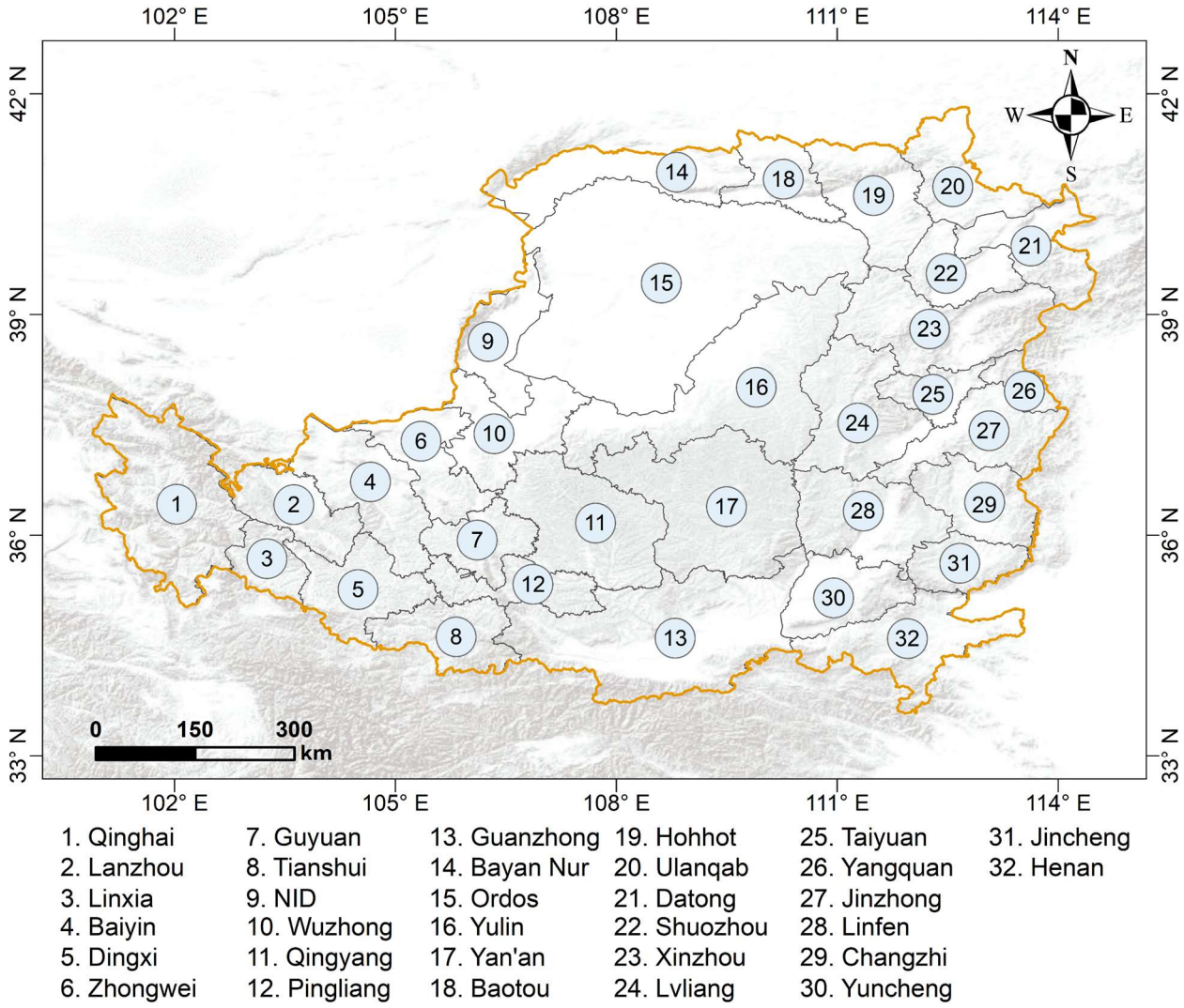

Figure. S1. Distributions of the 32 mapping units in the Loess Plateau of China. To ensure the integrity of two-class samples (i.e., plastic-mulched farmland and Non-plastic-mulched farmland samples), some cities were merged into a single mapping unit, such as “1. Qinghai”, “9. NID (the Ningxia Irrigation District)”, “13. Guanzhong”, and “32. Henan”.

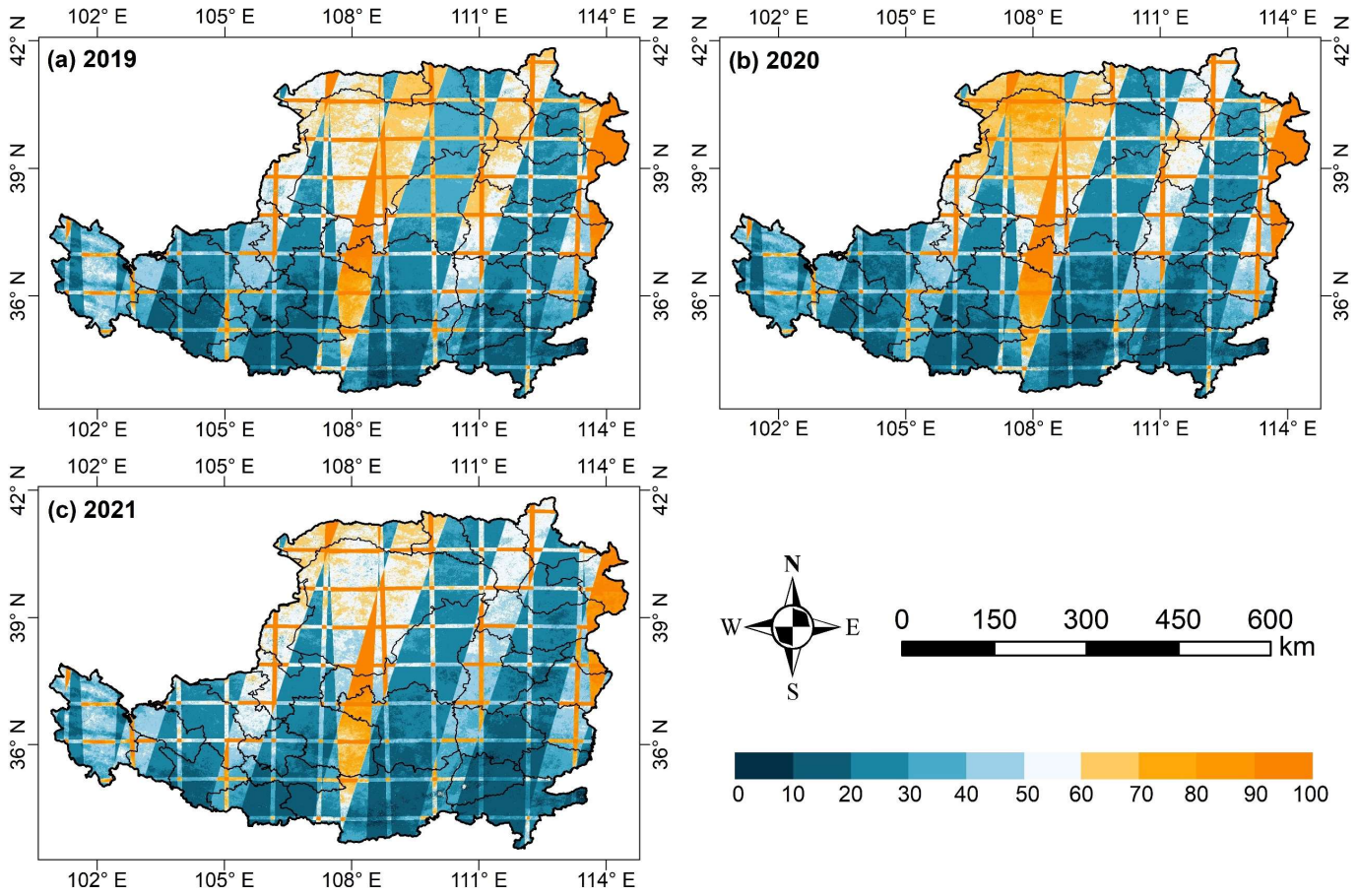

Figure. S2. Cloud-free Sentinel-2 observation counts at each pixel from March to October for the year 2019 (a), 2020 (b), and 2021 (c) in the Loess Plateau of China.

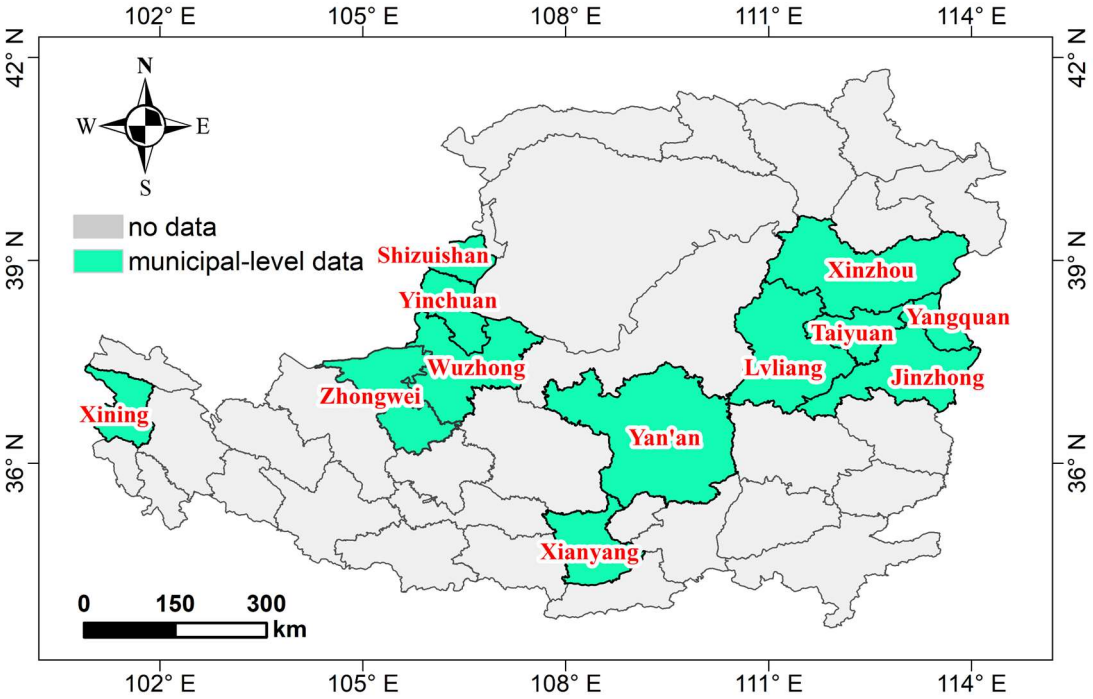

Figure. S3. Spatial distributions of the 12 cities with statistical data of plastic-mulched farmland areas in the Loess Plateau.

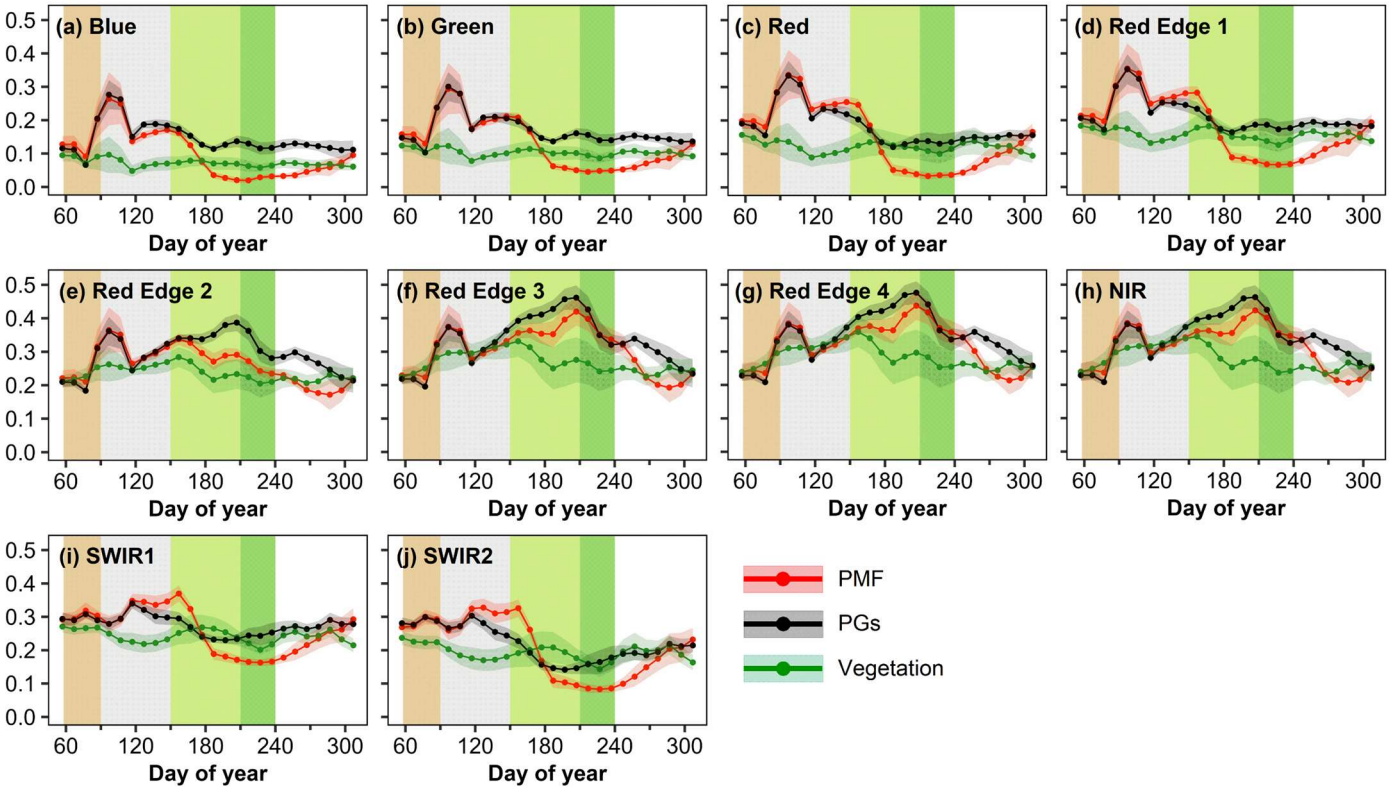

Figure. S4. Time series profiles of plastic-mulched farmland (PMF), plastic greenhouses (PGs), and vegetation in various spectral bands of Sentinel-2. The red, gray, and blue buffers indicate one standard deviation. The brown, gray, yellowish-green, and green rectangular areas denote the pre-mulching stage(PMS), mulching stage (MS), growth stage (GS), and flourishing stage (FS) as defined in Section 3.1.2 of the manuscript.

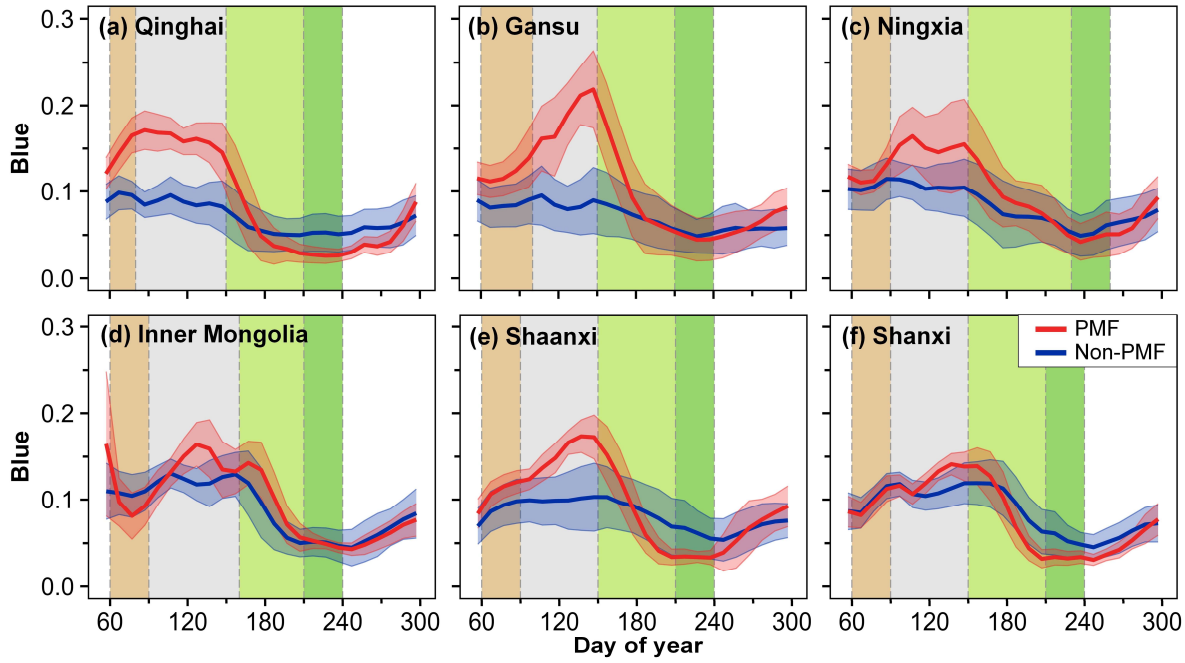

Figure. S5. Time series profiles of plastic-mulched farmland (PMF) and non-plastic-mulched farmland (Non-PMF) in the Sentinel-2 blue band across the six provinces (i.e., Qinghai (a), Gansu (b), Ningxia (c), Inner Mongolia (d), Shaanxi (e), Shanxi (f)) in the Loess Plateau of China. The red and blue buffers indicate one standard deviation. The brown, gray, yellowish-green, and green rectangular areas denote the pre-mulching stage (PMS), mulching stage (MS), growing stage (GS), and flourishing stage (FS) as defined in Section 3.1.2 of the manuscript, respectively.

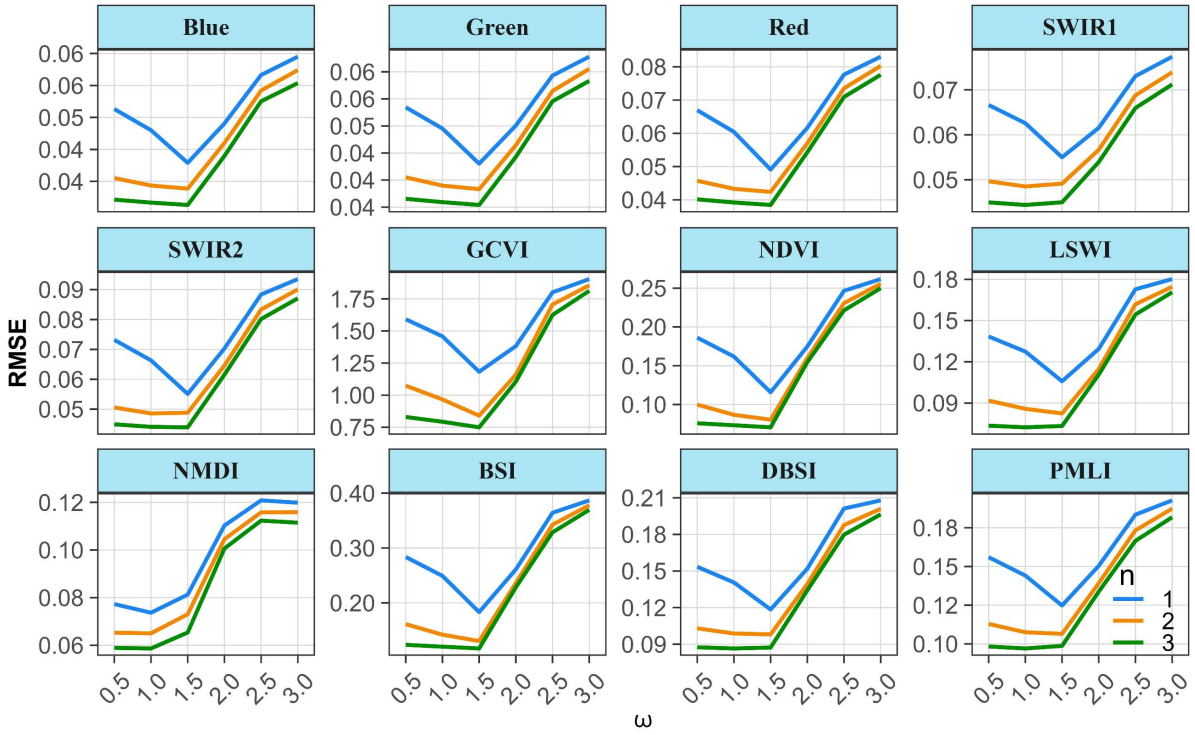

Figure. S6. Changes in the root mean square error (RMSE) across different spectral bands and vegetation indices as the number of harmonic components (n) and angular frequencies (ω) increases. The RMSE was calculated using the ground reference samples collected from the representative rectangular regions (Fig. 1 (a)) in each province.

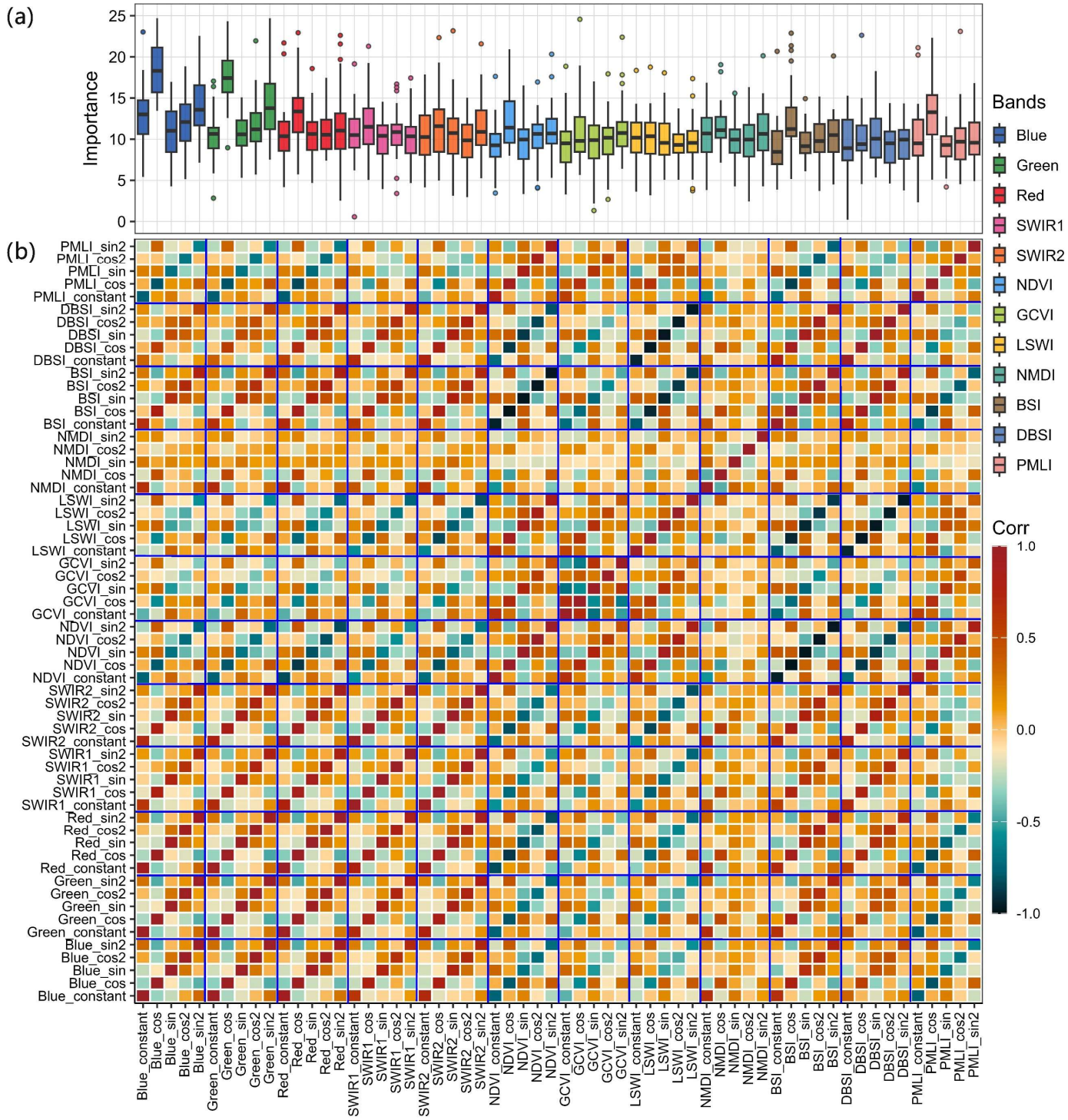

Figure. S7. Feature dimension reduction by combining feature correlation analysis and feature importance evaluation. (a) Feature importance values based on the Gini impurity reduction calculated by the random forest classifiers trained in each city in the Loess Plateau. Since the feature importance in each city is not comparable, we normalized the individual value by dividing the total reduction in impurity over all features within each city and scaled them by multiplying 1000. (b) Correlation matrix of 60 harmonic regression coefficients across the Loess Plateau in the year of 2020.

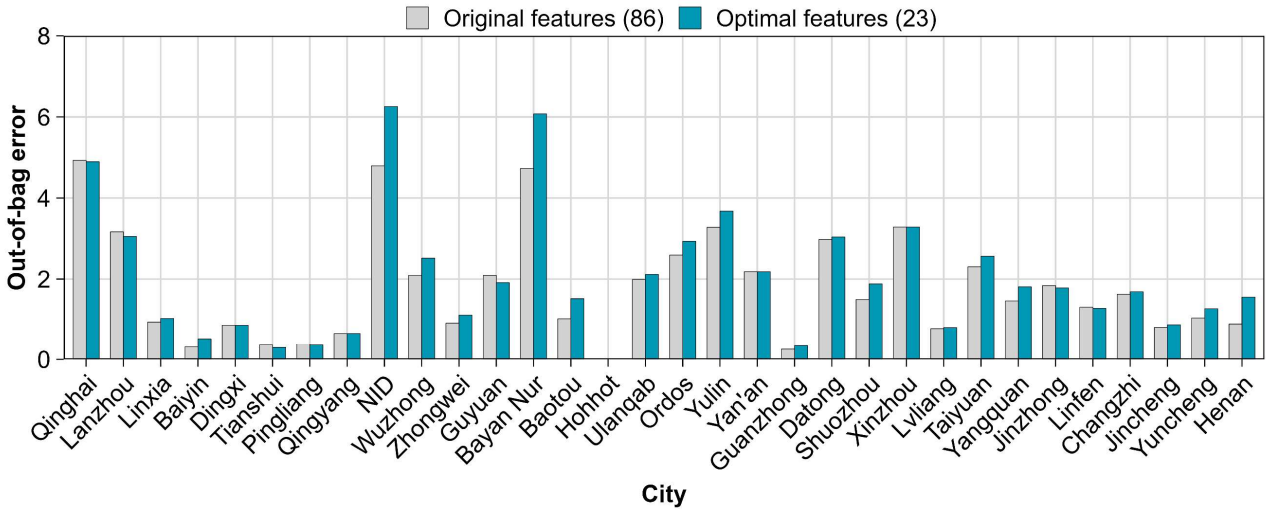

Figure. S8. Accuracy comparison between the random forest classifiers trained on the 86 features (original features) and the 28 features (optimal features)

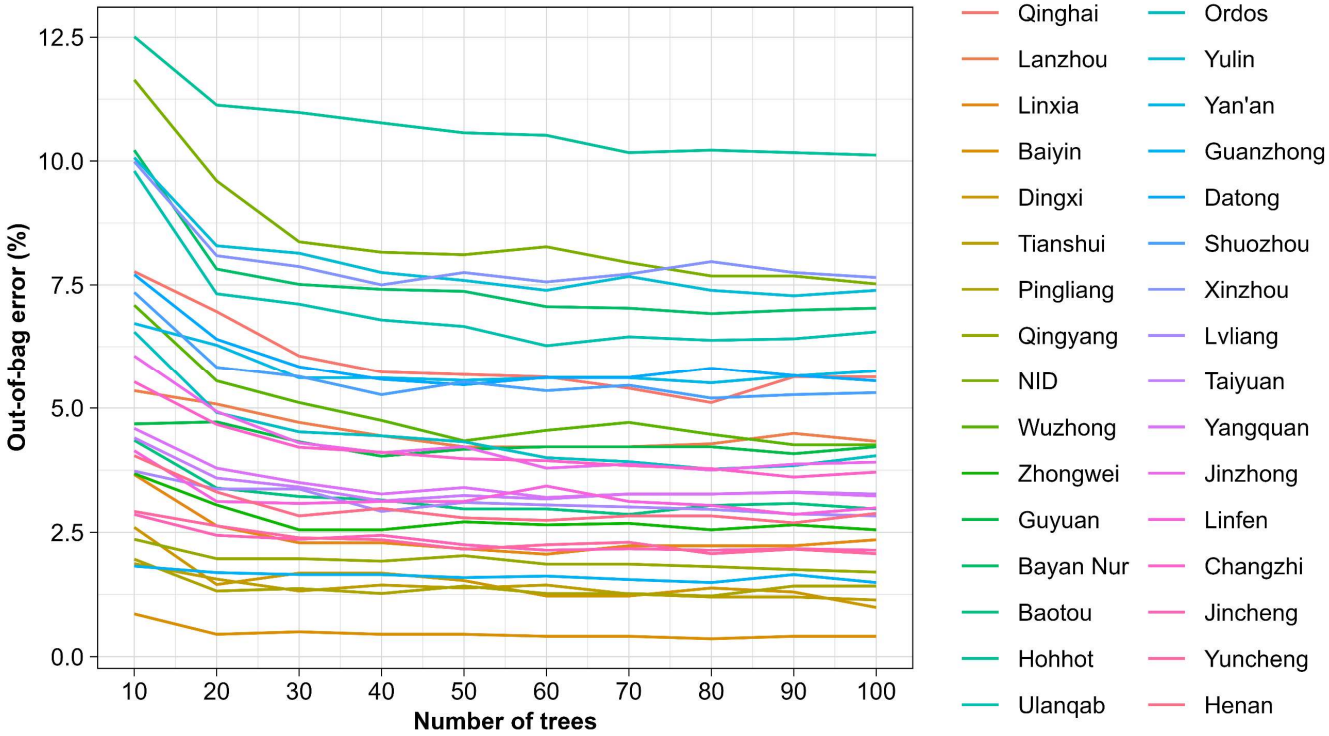

Figure. S9. Changes in the out-of-bag errors calculated by the random forest classifiers trained in each mapping unit as the number of trees increases.

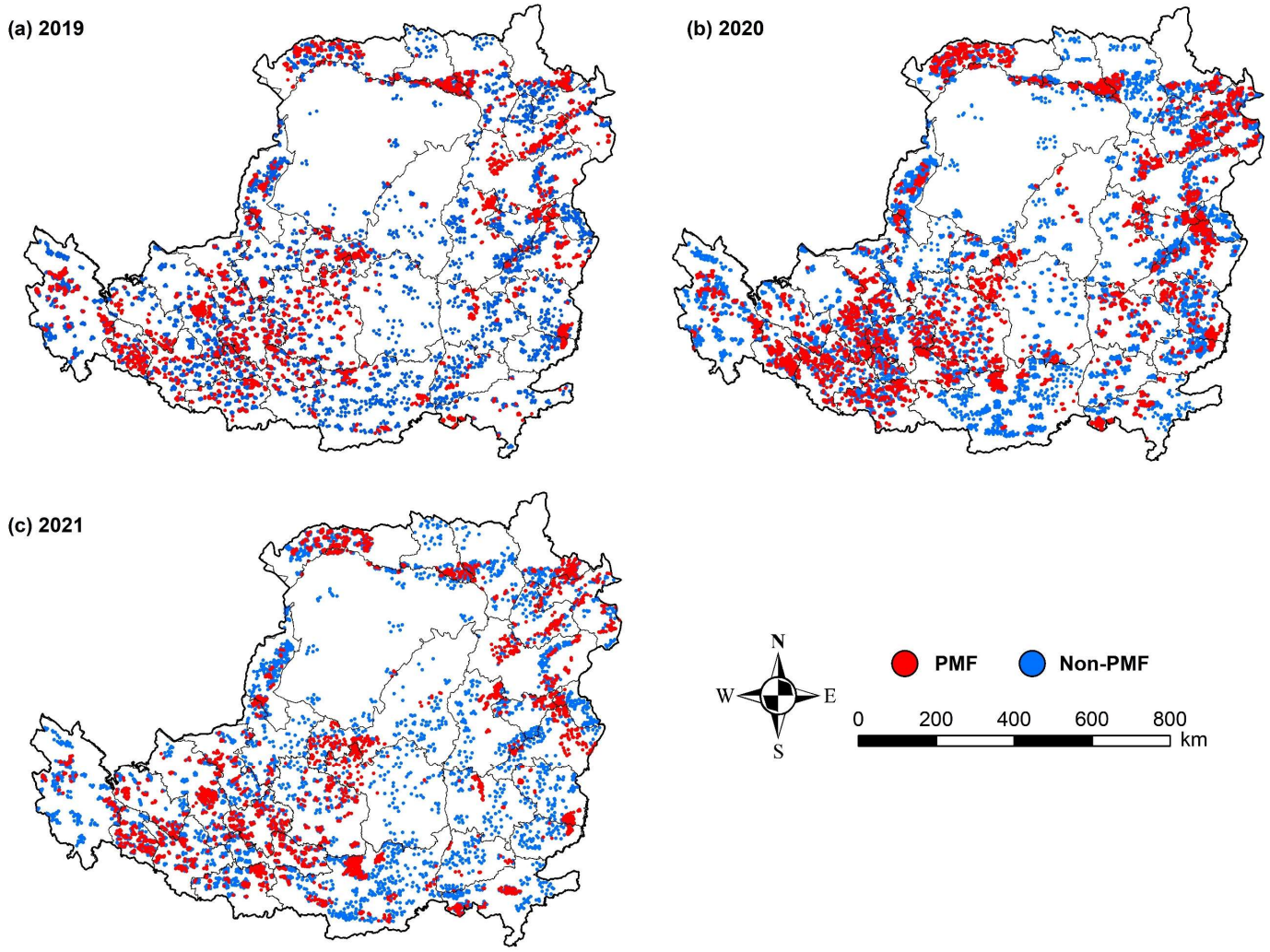

Figure. S10. Distributions of the validation samples for the year 2019 (a), 2020 (b), and 2021(c) in the Loess Plateau.

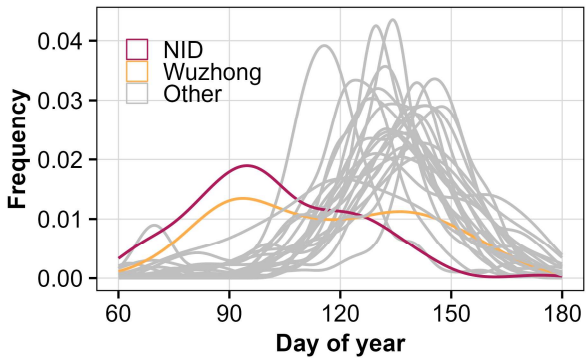

Figure. S11. Sowing date distributions in cities across the Loess Plateau. The sowing dates were derived from the dates corresponding to the peak values of the harmonic regression curves in the Sentinel-2 blue band. The NID refers to the Ninxia Irrigation District as illustrate in Fig. S1.

Table S1

Statistical analysis results of the MBPMFI and BPMFI indices for plastic-mulched farmland (PMF) and non-plastic-mulched farmland (Non-PMF). Note that the PMF and Non-PMF samples for each province were collected from the rectangular regions in Fig. 1 (a) of the manuscript. Student's *t* test (two-tailed, unpaired) was used for the comparison between PMF and Non-PMF. $^{*}p < 0.05$; $^{**}p < 0.01$; and $^{***}p < 0.001$.

Location	Metrics	*t*	*p-value*
Qinghai	MBPMFI	-38.51	0.00^{***}
	BPMFI	-28.92	0.00^{***}
Gansu	MBPMFI	-66.53	0.00^{***}
	BPMFI	-49.00	0.00^{***}
Ningxia	MBPMFI	-50.85	0.00^{***}
	BPMFI	-40.30	0.00^{***}
Inner Mongolia	MBPMFI	-53.88	0.00^{***}
	BPMFI	-55.32	0.00^{***}
Shaanxi	MBPMFI	-40.80	0.00^{***}
	BPMFI	-43.99	0.00^{***}
Shanxi	MBPMFI	-46.45	0.00^{***}
	BPMFI	-52.14	0.00^{***}

Table S2

Summary of the vegetation indices used for plastic-mulched farmland recognition in this study.

Name	Equation*
NDVI (Normalized Difference Vegetation Index)	$\frac{\rho_{NIR}-\rho_{Red}}{\rho_{NIR}+\rho_{Red}}$
GCVI (Green Chlorophyll Vegetation Index)	$\frac{\rho_{NIR}}{\rho_{Green}}-1$
LSWI (Land Surface Water Index)	$\frac{\rho_{NIR}-\rho_{SWIR1}}{\rho_{NIR}+\rho_{SWIR1}}$
NMDI (Normalized Multi-band Drought Index)	$\frac{\rho_{RE4}-(\rho_{SWIR1}-\rho_{SWIR2})}{\rho_{RE4}+(\rho_{SWIR1}-\rho_{SWIR2})}$
BSI (Bare Soil Index)	$\frac{(\rho_{SWIR2}+\rho_{Red})-(\rho_{NIR}-\rho_{Blue})}{(\rho_{SWIR2}+\rho_{Red})+(\rho_{NIR}-\rho_{Blue})}$
DBSI (Dry Bareness Soil Index)	$\frac{(\rho_{SWIR1}-\rho_{Green})}{(\rho_{SWIR1}+\rho_{Green})}-\frac{(\rho_{NIR}-\rho_{Red})}{(\rho_{NIR}+\rho_{Red})}$
PMLI (Plastic-mulched Landcover Index)	$\frac{\rho_{SWIR1}-\rho_{Red}}{\rho_{SWIR1}+\rho_{Red}}$

* ρ_{blue}, ρ_{green}, ρ_{red}, ρ_{nir}, ρ_{RE4}, ρ_{SWIR1}, and ρ_{SWIR2} represent the Sentinel-2 reflectance in the blue band (496 nm), green band (560 nm), red band (665 nm), near-infrared band (833 nm), red-edge 4 band (864 mm), shortwave-infrared band 1 (1610 mm), and shortwave-infrared band 2 (2185 mm), respectively.

Table S3

Number of ground truth samples collected from visual interpretation of Sentinel-2 true-color composite images and Google Earth high-resolution images in the years of 2019, 2020, and 2021. PMF: Plastic-mulched Farmland; Non-PMF: Non-plastic-mulched Farmland.

Year	PMF	Non-PMF
2019	3099	3992
2020	5342	6798
2021	2923	3791

Table S4

Accuracy assessment of the plastic-mulched farmland map for each city in the Loess Plateau in 2019 based on the validation samples. The PA, UA, F1, and OA are abbreviations of the producer accuracy, user accuracy, F1-score, and overall accuracy, respectively.

City	PA	UA	F1	OA
Qinghai	0.77	0.82	0.80	0.86
Lanzhou	0.86	0.94	0.90	0.90
Linxia	0.94	0.90	0.92	0.92
Baiyin	0.97	0.76	0.85	0.83
Dingxi	1.00	0.76	0.86	0.84
Tianshui	0.78	0.92	0.86	0.89
Pingliang	0.98	0.89	0.94	0.93
Qingyang	0.99	0.80	0.89	0.87
NID	0.65	0.63	0.64	0.73
Wuzhong	0.77	0.75	0.76	0.86
Zhongwei	0.93	0.70	0.80	0.79
Guyuan	0.95	0.81	0.87	0.86
Bayan Nur	0.76	0.77	0.77	0.75
Baotou	0.78	0.84	0.81	0.82
Hohhot	0.43	0.92	0.58	0.74
Ulanqab	0.95	0.89	0.92	0.92
Ordos	0.77	0.74	0.75	0.80
Yulin	0.98	0.76	0.86	0.84
Yan'an	0.99	0.61	0.75	0.77
Guanzhong	0.65	0.65	0.65	0.80
Datong	0.88	0.82	0.85	0.86
Shuozhou	0.72	0.85	0.78	0.81
Xinzhou	0.91	0.85	0.88	0.88
Lvliang	0.91	0.82	0.86	0.88
Taiyuan	0.95	0.80	0.87	0.85
Yangquan	1.00	0.74	0.85	0.86
Jinzhong	0.90	0.86	0.88	0.88
Linfen	0.84	0.75	0.79	0.84
Changzhi	0.96	0.74	0.83	0.79
Jincheng	0.90	0.73	0.81	0.85
Yuncheng	0.83	0.93	0.87	0.92
Henan	0.84	0.84	0.84	0.86

Table S5

Accuracy assessment of the plastic-mulched farmland map for each city in the Loess Plateau in 2020 based on the validation samples. The PA, UA, F1, and OA are abbreviations of the producer accuracy, user accuracy, F1-score, and overall accuracy, respectively.

City	PA	UA	F1	OA
Qinghai	0.88	0.79	0.84	0.88
Lanzhou	0.94	0.94	0.94	0.94
Linxia	0.91	0.92	0.92	0.92
Baiyin	0.96	0.89	0.92	0.92
Dingxi	0.94	0.78	0.85	0.85
Tianshui	0.75	0.97	0.84	0.86
Pingliang	0.97	0.87	0.92	0.91
Qingyang	0.98	0.77	0.86	0.84
NID	0.69	0.81	0.75	0.86
Wuzhong	0.93	0.84	0.88	0.92
Zhongwei	0.89	0.91	0.90	0.91
Guyuan	1.00	0.68	0.81	0.81
Bayan Nur	0.80	0.99	0.88	0.90
Baotou	0.83	0.68	0.75	0.81
Hohhot	0.55	0.74	0.63	0.80
Ulanqab	0.83	0.89	0.86	0.89
Ordos	0.90	0.61	0.73	0.78
Yulin	0.99	0.80	0.89	0.88
Yan'an	0.83	0.92	0.87	0.88
Guanzhong	0.78	0.78	0.78	0.85
Datong	0.91	0.83	0.87	0.86
Shuozhou	0.82	0.94	0.88	0.88
Xinzhou	0.91	0.78	0.84	0.83
Lvliang	0.83	0.96	0.89	0.91
Taiyuan	0.86	0.80	0.83	0.82
Yangquan	0.98	0.80	0.88	0.92
Jinzhong	0.88	0.96	0.92	0.92
Linfen	0.68	0.89	0.77	0.81
Changzhi	0.93	0.92	0.92	0.92
Jincheng	0.84	0.96	0.89	0.93
Yuncheng	0.74	0.78	0.76	0.87
Henan	0.87	0.86	0.87	0.87

Table S6

Accuracy assessment of the plastic-mulched farmland map for each city in the Loess Plateau in 2021 based on the validation samples. The PA, UA, F1, and OA are abbreviations of the producer accuracy, user accuracy, F1-score, and overall accuracy, respectively.

City	PA	UA	F1	OA
Qinghai	0.66	0.56	0.60	0.79
Lanzhou	0.93	0.94	0.93	0.94
Linxia	0.83	0.91	0.87	0.88
Baiyin	0.98	0.76	0.86	0.84
Dingxi	0.89	0.74	0.81	0.81
Tianshui	0.70	0.89	0.78	0.83
Pingliang	0.95	0.78	0.86	0.85
Qingyang	0.98	0.76	0.85	0.85
NID	0.75	0.81	0.78	0.86
Wuzhong	0.78	0.87	0.82	0.89
Zhongwei	0.95	0.84	0.89	0.88
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Baotou	0.81	0.67	0.73	0.74
Hohhot	0.57	0.74	0.64	0.81
Ulanqab	0.81	0.87	0.84	0.85
Ordos	0.91	0.70	0.79	0.86
Yulin	0.86	0.70	0.77	0.76
Yan'an	0.92	0.71	0.80	0.79
Guanzhong	0.77	0.80	0.78	0.84
Datong	0.43	0.94	0.60	0.69
Shuozhou	0.87	0.87	0.87	0.87
Xinzhou	0.90	0.67	0.77	0.72
Lvliang	0.95	0.74	0.83	0.84
Taiyuan	0.99	0.65	0.78	0.72
Yangquan	1.00	0.54	0.70	0.66
Jinzhong	0.97	0.77	0.86	0.81
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Yuncheng	0.70	0.61	0.65	0.84
Henan	0.95	0.84	0.89	0.91