

**Supplementary Table S1.** Description of soil quality indicators.

Name	Description	Units	Indicator source	Data source	Reference
Irrigation and drainage capacity	Irrigation water sources, water conservancy facilities, and drainage capacity.	-	Irrigation zoning map		
Parts of the terrain	Small and medium-sized geomorphic units with specific morphological characteristics and genesis.	-	Geomorphic map		
Effective soil thickness	The total thickness of soil above the parent material layer that can be used by crops.	cm	Distribution map of effective soil thickness	Summary and compilation of county survey results	
Plough layer texture	The size and combination of soil particles in the plough layer.	-	Plough layer texture map		
Soil texture profile	The arrangement of different texture levels in the soil profile.	-	Distribution map of soil profile configuration		
Soil salinization	The accumulation of salinity in the surface soil.	%	Distribution map of soil salinization		
Biodiversity	The ecological complex is formed by natural organisms and their environment and the synthesis of various ecological processes.	-	Field investigation and comprehensive discrimination of soil microorganisms or animals.		[29]
Farmland shelterbelt	The extent to which the forest belt around the farmland protects the farmland area.	%	Field investigation and comprehensive discrimination of forest belt protection around farmland.	Soil investigation	
Organic matter	It was determined by measuring soil organic carbon with quantitative potassium dichromate - sulfuric acid solution under the condition of sand bath heating.	g/kg	Laboratory analysis		
Available phosphorus	It was extracted with 0.5 mol/dm <sup>3</sup> sodium bicarbonate and then measured by using the molybdenum antimony colorimetric method (Olsen method).	mg/kg			

Name	Description	Units	Indicator source	Data source	Reference
Rapidly available potassium	It was extracted with 1 mol/dm <sup>3</sup> ammonium acetate and then measured by the flame photometric method.	mg/kg			
Total nitrogen	It was digested by concentrated sulfuric acid and then determined by the Kjeldahl digestion method.	g/kg	Laboratory analysis	Soil investigation	[29]
pH value	It was extracted with 1 mol/dm <sup>3</sup> KCl solution and then measured by the glass electrode method.	-			

**Supplementary Table S2.** Descriptive statistical and analysis table of soil quality evaluation indicators.

Indicators		Membership value statistics			Standard deviation	Factor weight
		Minimum value	Maximum value	Mean value		
Physical properties	Irrigation and drainage capacity	0.50	1.00	0.81	0.15	0.16
	Parts of the terrain	0.20	1.00	0.85	0.18	0.13
	Effective soil thickness	0.40	1.00	0.91	0.16	0.08
	Plough layer texture	0.40	1.00	0.88	0.12	0.10
	Soil texture profile	0.25	1.00	0.78	0.18	0.08
	Soil salinization	0.35	1.00	0.98	0.06	0.03
Chemical properties	Organic matter	0.10	1.00	0.47	0.15	0.12
	Available phosphorus	0.10	1.00	0.50	0.27	0.07
	Rapidly available potassium	0.10	1.00	0.73	0.24	0.06
	Total nitrogen	0.10	1.00	0.61	0.19	0.08
	pH value	0.50	1.00	0.86	0.08	0.05
Biological and environmental properties	Biodiversity	0.60	1.00	0.86	0.09	0.02
	Farmland shelterbelt	0.60	1.00	0.80	0.11	0.02

**Supplementary Table S3.** Descriptive statistical table of soil quality characteristic indicators.

Indicators		Category		Minimum value	Maximum value	Mean value	Standard deviation	Units
Production press indicators	Slope			0.00	36.43	1.36	2.03	degress
	Annual average precipitation		-	507.83	878.67	722.43	44.19	mm
	Annual average temperature			12.37	15.63	13.98	0.31	C°
Soil status indicators	Soil fertility indicator	Method A	-	0.00	1.00	0.74	0.12	-
		Method B		0.00	1.00	0.71	0.13	
				0.00	1.00	0.68	0.14	
		Method C		0.00	0.85	0.71	0.12	
				0.00	1.00	0.79	0.14	
		Method A	-	0.00	0.75	0.31	0.07	
	Soil moisture indicator	Method B		0.00	0.75	0.29	0.08	
			0.00	0.57	0.29	0.08		
			Method C		0.00	0.71	0.32	
				0.00	0.60	0.36	0.07	
	Soil degradation indicator	Method A	-	0.00	30.00	8.54	4.39	
		Method B		0.00	30.00	7.30	3.75	
				0.00	30.00	6.61	3.55	
		Method C		0.00	26.00	2.99	2.41	
				0.00	30.00	6.47	2.52	
Social action indicators	Agricultural labour indicator			0.00	87.56	47.59	14.11	%
	Agricultural mechanization indicator			0.00	84.47	14.34	7.00	kW/ha
	Agricultural irrigation indicator		-	0.00	100	62.64	27.51	%
	Agricultural fertilizer indicator			0.00	2393.02	653.14	334.48	kg NPK/ha

Note: Method A, Method B, and Method C are the no distinction between crop cover types, distinction between crop cover types, and fusion of multi-temporal data types, respectively. I and II are the one-season crop area and double-season crop area.

Supplementary Table S4. Principal component analysis results of soil state indicators.

	Indicator	Expression	Synthesis period (t)	Expression of principal components
One-season crop area	MT-NDVI	$0.553 \times PC_1 +$	177-192, 193-208, 209-224,	$PC_1 = 0.565 \times NDVI_{209-224} + 0.497 \times NDVI_{193-208} + 0.461 \times NDVI_{225-240} + 0.419 \times NDVI_{177-192} + 0.212 \times NDVI_{241-256}$
		$0.282 \times PC_2$	225-240, 241-256	$PC_2 = 0.055 \times NDVI_{209-224} - 0.261 \times NDVI_{193-208} + 0.359 \times NDVI_{225-240} - 0.526 \times NDVI_{177-192} + 0.724 \times NDVI_{241-256}$
	MT-DVI	$0.531 \times PC_1 +$	177-192, 193-208, 209-224,	$PC_1 = 0.500 \times DVI_{225-240} + 0.483 \times DVI_{209-224} + 0.406 \times DVI_{193-208} + 0.379 \times DVI_{257-272} + 0.329 \times DVI_{241-256} + 0.316 \times DVI_{177-192}$
		$0.298 \times PC_2$	225-240, 241-256, 257-272	$PC_2 = 0.112 \times DVI_{225-240} - 0.163 \times DVI_{209-224} - 0.442 \times DVI_{193-208} + 0.482 \times DVI_{257-272} + 0.536 \times DVI_{241-256} - 0.496 \times DVI_{177-192}$
	MT-RVI	$0.558 \times PC_1 +$	193-208, 209-224, 225-240,	$PC_1 = 0.509 \times RVI_{209-224} + 0.497 \times RVI_{225-240} + 0.431 \times RVI_{241-256} + 0.402 \times RVI_{257-272} + 0.383 \times RVI_{193-208}$
		$0.254 \times PC_2$	241-256, 257-272	$PC_2 = -0.393 \times RVI_{209-224} - 0.058 \times RVI_{225-240} + 0.534 \times RVI_{241-256} + 0.513 \times RVI_{257-272} - 0.542 \times RVI_{193-208}$
Double-season crop area	MT-NDVI			$PC_1 = 0.472 \times NDVI_{097-112} + 0.468 \times NDVI_{081-096} + 0.458 \times NDVI_{113-128} + 0.379 \times NDVI_{129-144} - 0.190 \times NDVI_{289-304} - 0.234 \times NDVI_{273-288} + 0.228 \times NDVI_{337-352} + 0.249 \times NDVI_{065-080}$
		$0.524 \times PC_1 +$	065-080, 081-096, 097-112,	
		$0.178 \times PC_2 +$	113-128, 129-144, 273-288,	$PC_2 = 0.013 \times NDVI_{097-112} - 0.097 \times NDVI_{081-096} + 0.086 \times NDVI_{113-128} + 0.324 \times NDVI_{129-144} + 0.713 \times NDVI_{289-304} + 0.444 \times NDVI_{273-288} + 0.402 \times NDVI_{337-352} + 0.100 \times NDVI_{065-080}$
	MT-DVI	$0.133 \times PC_3$	289-304, 337-352	$PC_3 = 0.138 \times NDVI_{097-112} - 0.004 \times NDVI_{081-096} + 0.284 \times NDVI_{113-128} + 0.379 \times NDVI_{129-144} - 0.088 \times NDVI_{289-304} + 0.428 \times NDVI_{273-288} - 0.562 \times NDVI_{337-352} - 0.501 \times NDVI_{065-080}$
				$PC_1 = 0.477 \times DVI_{097-112} + 0.435 \times DVI_{113-128} + 0.433 \times DVI_{129-144} + 0.428 \times DVI_{081-096} + 0.328 \times DVI_{065-080} + 0.235 \times DVI_{177-192} + 0.223 \times DVI_{145-160}$
		$0.143 \times PC_2$	113-128, 129-144, 145-160, 177-192	$PC_2 = -0.078 \times DVI_{097-112} - 0.032 \times DVI_{113-128} + 0.275 \times DVI_{129-144} - 0.363 \times DVI_{081-096} - 0.358 \times DVI_{065-080} + 0.112 \times DVI_{177-192} + 0.803 \times DVI_{145-160}$
Double-season crop area	MT-RVI			$PC_1 = 0.473 \times RVI_{097-112} + 0.472 \times RVI_{081-096} + 0.457 \times RVI_{113-128} + 0.371 \times RVI_{129-144} + 0.253 \times RVI_{065-080} - 0.213 \times RVI_{289-304} + 0.203 \times RVI_{337-352} - 0.236 \times RVI_{273-288}$
		$0.523 \times PC_1 +$	065-080, 081-096, 097-112,	
		$0.174 \times PC_2 +$	113-128, 129-144, 273-288,	$PC_2 = 0.001 \times RVI_{097-112} - 0.069 \times RVI_{081-096} + 0.039 \times RVI_{113-128} + 0.296 \times RVI_{129-144} + 0.201 \times RVI_{065-080} + 0.700 \times RVI_{289-304} + 0.469 \times RVI_{337-352} + 0.395 \times RVI_{273-288}$
	MT-DVI	$0.138 \times PC_3$	289-304, 337-352	$PC_3 = 0.146 \times RVI_{097-112} - 0.035 \times RVI_{081-096} + 0.293 \times RVI_{113-128} + 0.415 \times RVI_{129-144} - 0.453 \times RVI_{065-080} + 0.019 \times RVI_{289-304} - 0.531 \times RVI_{337-352} + 0.481 \times RVI_{273-288}$

Note: MT-NDVI, MT-DVI, and MT-RVI are the fusion of multi-temporal soil fertility indicator, soil moisture indicator, and soil degradation indicator, respectively.  $PC_1$ ,  $PC_2$ , and  $PC_3$  represent principal components 1, 2, and 3, respectively.  $NDVI_t$ ,  $DVI_t$ , and  $RVI_t$  represent the soil fertility indicator, soil moisture indicator, and soil degradation indicator of corresponding synthetic period of MODIS images, respectively.