



Figure S1: Location of study areas.

Table S1 Scores of chemical properties parameters

Indicator	Description	Threshold	Score
Chemical quality index (CQI) = $[\text{pH} \times \text{EC} \times \text{CaCO}_3 \times \text{ESP} \times \text{CEC} \times \text{Gypsum}]^{1/6}$			
pH¹	Neutral	6.6-7.3	1.0
	Slightly alkaline	7.3-7.8	0.8
	Moderately alkaline	7.8-8.4	0.6
	Strongly alkaline	8.4-9	0.4
	Very strongly alkaline	> 9	0.2
EC, dS/m²	Non-saline	< 2	1.0
	Very slightly saline	2-4	0.8
	Slightly saline	4-8	0.6
	Moderately saline	8-16	0.4
	Strongly saline	> 16	0.2
CaCO₃ , %³	Non-calcareous	0	0.2
	Slightly calcareous	0-2	1.0
	Moderately calcareous	2-10	0.8
	Strongly calcareous	10-25	0.6
	Extremely calcareous	> 25	0.4
ESP, %⁴	Non-sodic	< 10	1.0
	Slightly sodic	10-15	0.8
	Moderately sodic	15-30	0.6
	Strongly sodic	30-50	0.4
	Very strongly sodic	> 50	0.2
CEC, cmol_e/kg⁵	Very high	< 6	1.0
	High	6-12	0.8
	Moderate	12-25	0.6
	Low	25-40	0.4
	Very low	> 40	0.2
Gypsum %³	Non-gypsic	0	0.2
	Slightly gypsic	0-5	1.0
	Moderately gypsic	5-15	0.8
	Strongly gypsic	15-60	0.6
	Extremely gypsic	> 60	0.4

Table S2 Scores of physical properties parameters

Indicator	Description	Threshold	Score
Physical Quality Index (PQI) = [Depth × Slope × Texture × BD × WHC × HC]^{1/6}			
Depth, cm³	Very deep	> 150	1.0
	Deep	150-100	0.8
	Moderately deep	100-50	0.6
	Shallow	50-30	0.4
	Very shallow	< 30	0.2
Slope, %	Very gently sloping	< 2	1.0
	Gently sloping	2-5	0.8
	Sloping	5-10	0.6
	Strongly sloping	10-15	0.5
	Moderately steep	15-30	0.4
	Steep	> 30	0.2
Texture⁵	Clay loam		1.0
	Silty clay loam, loam, silty clay, silt		0.9
	Silt loam, clay < 60%		0.8
	Sandy clay, sandy clay loam, sandy loam		0.7
	Clay > 60%		0.6
	Loamy sand		0.4
Bulk Density (BD)⁵, g/cm³	Sand		0.2
	Very low	< 1.2	1.0
	Low	1.2-1.4	0.8
	Moderate	1.4-1.6	0.6
	High	1.6-1.8	0.4
	Very high	> 1.8	0.2
Water holding capacity (WHC)⁵	Very high	> 35	1.0
	High	35-30	0.8
	Moderate	30-20	0.6
	Low	20-15	0.4
	Very low	< 15	0.2
Hydraulic conductivity (HC)³, cm/hr	Low	1.0-2.0	1.0
	Moderate	2.0-6.0	0.8
	Very low	0.05-1.0	0.6
	High	6.0-12.0	0.4
	Extremely low – very high	< 0.05 or > 12.0	0.2

Table S3 Scores of fertility properties parameters

Indicator	Description	Threshold			Score
Fertility Quality Index (FQI) = [N × P × K × OM] ^{1/4}					
Available N ² , mg/kg	Very high		>120		1.0
	High		120-100		0.8
	Moderate		100-75		0.6
	Low		75-30		0.4
	Very low		<30		0.2
Available P ⁶ , mg/kg	Soil texture	Light	Medium	Heavy	
	Very high	>15	>8	>5	1.00
	High	15-10	8-5	5-3	0.75
	Medium	10-5	5-3	3-2	0.50
	Low	<5	<3	<2	0.25
Available K ⁶ , mg/kg	Very high		> 180		1.00
	High		180-120		0.75
	Medium		120-60		0.50
	Low		< 60		0.25
OM ⁷	Very high		> 2		1.00
	High		2-1		0.75
	Medium		1-0.5		0.50
	Low		< 0.5		0.25

¹Soil science division (2017); ²Yao et al. (2013); ³FAO (2006); ⁴FAO (1988); ⁵Hazelton and Murphy (2016); ⁶Soltanpour (1991); ⁷Mohamed et al. (2020).

Table S4 Final SQ range of study area

Index	Values	Symbol	Classes
Final SQ	≥ 0.61	C1	Highly (very high) quality
	0.53 – 0.60	C2	Moderately high (high) quality
	0.45 – 0.52	C3	Moderate quality
	0.37 – 0.44	C4	Moderately low quality
	≤ 0.36	C5	Low quality