Table S1 Three sets of dual index systems and rationale for the selection of soil attributes.

"Three sets" (*i, j,* and *k*) index system			"Dual" (C-E) indicators		Respective functions in soil/ Rationale	References
First-level indicators	**Second-level indicators**	**Third-level indicators (i)**	**(Experimental group) index current value C_i**	**(Control group) index health value E_i**		
Function Index system (Indicators considered by experts)	Water and gas regulation	Bulk density			Porosity, Plant root penetration,	Moncada et al. [1], Xue et al. [2]
		Water holding capacity			Leaching, erosion potential, Runoff	Xue et al. [2], Mukhopadhyay et al. [3]
		Wilting coefficient			Available water to plant, moisture retention	Moebius-Clune et al. [4], Dai et al.[5], Fine et al.[6]
	Nutrient regulation	Cation exchange capacity (CEC)			Amount of exchangeable cations, nutrients retention capacity, protect underground water from cation contamination	Svoray et al. [7], Moncada et al. [1], Dai et al. [5]
		Organic matter			Maintain soil fertility and structure, water retention	Haney et al.[8], Mohanty et al. [9], Andrews et al.[10]
		C / N ratio			Nitrogen cycling and residual decomposition	Askari and Holden [11], Trivedi et al. [12]
	Comprehensive regulation	Soil thickness			The amount of soil available for crop root growth, type of crops to grow	Doran et al. [13]
		pH			Nutrients availability, absorption, and mobility of agrochemicals, amount of soil microorganisms	Biswas et al. [14], Arshad et al. [15]
		Microbial biomass			Nutrient cycling, ecosystem functioning, Plant nutrition, decomposition of organic pools.	Andrews et al. [16]
		Microbial main functional gene			Maintain Soil fertility, c cycling, degradation of complex polymers	Trivedi et al. [12]
		Microbial group/ communities			Soil productivity and drivers of ecological processes (disease suppression, degradation of contaminants, nutrient cycling, etc.)	Trivedi et al. [12], Doran et al. [17]
		Soil enzyme activity			Energy transfer, nutrient cycling, C oxidation, formation of humid substances, hydrolysis, and biodegradation	Igalavithana et al. [18]

First-level indicators	Second-level indicators	Third-level indicators (j)	Index current value C_j	Index health value E_j	Rationale	References
Nutrition index system (Indicators considered by managers)	Macro element	Total Nitrogen			Nutrient availability to crops, mineralization/ immobilization rates leaching potential, capacity to support plant growth, forecast environmental quality.	Zvomuya et.al. [19], Andrews et al. [10,23], Yu et al. [22], Moebius-Clune et al. [4], Andrea et al. [21]
		Total Phosphorus				
		Total Potassium				
		Available Nitrogen				
		Available Phosphorus				
		Available Potassium				
		Nitrogen-Phosphorus ratio (N/P)				
		Nitrogen-Potassium ratio (N/K)				
	Trace element	Available zinc				
		Available boron				
		Available molybdenum				
First-level indicators	**Second-level indicators**	**Third-level indicators (k)**	**Index current value C_k**	**Index expected value E_k**	**Rationale**	**References**
Output Index system (Indicators considered by owners or users)	Macro-view	Yield			Food security, the productivity of land, income indicator	Bagnall et al. [23], D'House et al. [24], Biswas et al. [14]
		Income			Earnings generated and possible investment, calculation of profit or lose	Bagnall et al. [23], Doran et al.[17]
	Micro-view	Product quality			Trust of the consumer,	

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