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Geospatial assessment of soil and land properties for mango suitability in Mustariwadi micro-watershed using geo-spatial techniques (AHP & Wao)

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Abstract

Sustainable enhancement of productivity of a land can be achieved by bringing together crops suitable to the potentials of that land. Land resource inventory (LRI) of Mustariwadi Micro- watershed (555.5ha) falling in Bidar District of North Karnataka, India was conducted on cadastral base map at 1:7920 scale. 107 surface and samples of 12 profiles were studied for physical and chemical properties like Depth, Texture, Slope, pH, EC and OC. As mango are major perennial fruit crops of the area assessment of surface and sub-surface properties of land were done with an objective to find out status of site specific suitability of land for Mango crop in the Mustariwadi micro-watershed. The data obtained through LRI was processed and interpreted through "Analytic Hierarchy Process (AHP)". The results revealed that among different properties of soil and land, the weights of the Organic carbon OC was highest (25.00%), soil depth (21.00%), slope (21.00%), followed by soil texture (11.00%), EC (6.00%) and pH (16%). Out of total area, 61 ha (10.93%) was found highly suitable (S1), 103 ha (18.46%) was judged as moderately suitable (S2), 248 ha (44.67%) area was found to be marginally suitable (S3) for cultivation of mango crop. An area of 133 ha (24.02%) was identified as not suitable (N). Findings of this research can be extrapolated to the sub watershed of similar conditions in developing a decision support system for assessing site specific crop suitability based on potentials and limitations of soil and land properties for enhancement of land productivity.

Keywords: Land resource inventory (LRI), analytic hierarchy process (AHP), geospatial, technique-weighted overlay analysis (WAO), soil site suitability, mango

Introduction

Soil and land resources are declining both in quantitative and qualitative terms at a rapid rate worldwide primarily due to anthropogenic activities and secondly because of depletion of natural reasons. The pressure of producing more and more food on these limited resources to satisfy the demands of increasing world population has further aggravated the situation at alarming speed. Impact of climate change has also imposed unpredictable conditions in soil and land for cultivation of crop. Interventions like suitable soil and water conservation methods, nutrient management practices and adoption of crops based on soil and land properties can bring major positive change in productive potential of land. Each parcel of land has got its own potentials and limitations with respect to their physical, chemical and biological properties to support crop growth. Therefore to strengthen the decision support system of sustainable enhancement of productivity, site specific crop suitability is an important pre-requisite. Intensive data on inherent properties of site specific of soil, land and crop, which influence on each other's potential and capabilities (Greenland *et al.*, 1998; Richardson *et al.*, 2023) in playing vital role in evaluating land suitability for different crops there by becomes critical inputs in making strategies for increasing productivity (Pramanik 2016) and making agriculture sustainable (El Baroudy 2016; Falascaet *al.*, 2012) [10, 16, 15, 6, 7, 13].

Mustariwadi micro watershed, covering an area of 555.5 ha, was identified as study area where, mango is one among the commonly cultivated fruit crop. With an objective to bring out site specific crop suitability plan for mango, a detailed Land Resource Inventory (LRI) was carried out to characterise surface and subsurface properties of soil and land. The outcomes of LRI were processed through AHP to develop site specific mango suitability map using GIS.

Highlights

- To characterize soil and land properties
- To identify potential and limiting factors of soil and land for mango cultivation
- To find out extent and distribution of mango suitable area

2. Materials and methods

2.1 Study Area: Mustariwadi micro-watershed is located between 18°9'10" to 18°10' 0" N latitude and 77°17'30" to 77°20'0" E longitude in Humnabad taluk of Bidar district, covering an area about 555.5 ha. (Figure 1). The micro-watersheds coming under north-eastern transition zone with average annual rainfall of 847 mm. Soils of Micro-watershed are lateritic with undulating physiographic.

2.2 Criteria selection

Criteria considered for assessment of mango suitability in the study area was done by referring to manual on soil site

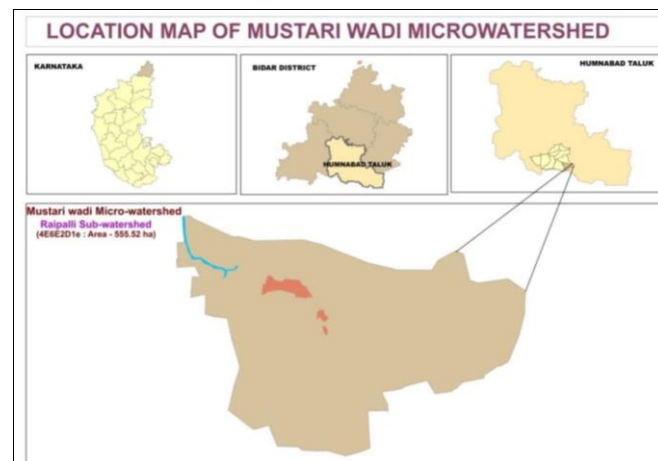


Fig 1: Location Map of Mustariwadi Micro- watershed.

suitability criteria for major crops (Naidu *et al.*, 2006, FAO 2015). The site specific physical and chemical properties like soil texture, depth, slope, pH, EC, and OC were recorded and used for assessing the land suitable for mango cultivation. The raster datasets developed using LRI and Lab studies along with the spatial data were processed on GIS Platform for selection of criteria as per the objectives of the study. (Table 1).

Table 1: Spatial Data sources

Sensor	Resolution (m)	Swath Width (km)	Spectral Bands(μm)
SOI (Toposheet)	1:50,000 scale	-	-
LISS-IV	5.8 m	24-50km	0.5-0.59(Green)
			0.62-0.68 (Red)
			0.77-0.86 (near IR)
Cartosat 1	2.5m	Pan-F 30 km	0.5-0.85(Panchromatic)
		Pan-A 25 km	

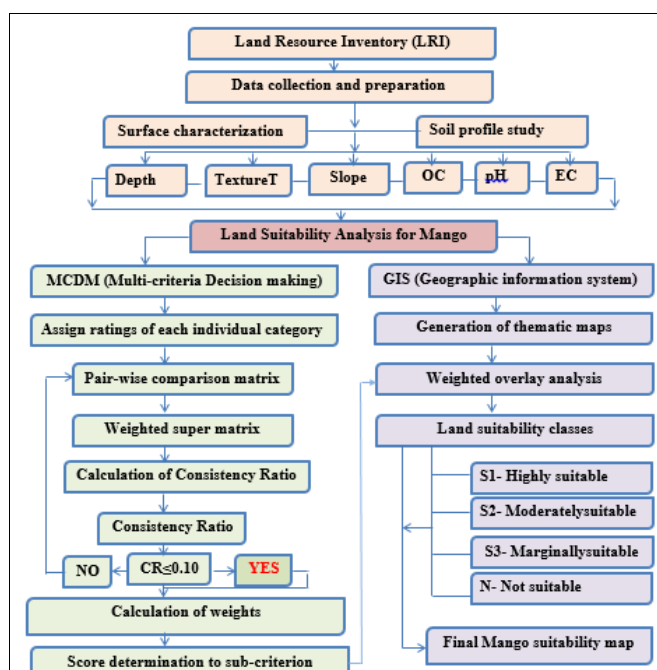


Fig 2: Flow chart of the methodology of integrated GIS-MCDA for Land suitability analysis for mango

2.3 Standardization of criteria layers

All the criteria considered for cropland suitability analysis were standardized based on the soil classification and characterization guide for agricultural suitability by FAO and other guidelines defining natural and artificial constraints for agriculture suitability (Naidu *et al.*, 2006). The crop requirements were matched with the soil and land characteristics to arrive at the crop suitability. The land suitability classification for different crops, viz., two orders were recognized, order S-Suitable and order N-Not suitable. Further, the orders have classes, sub-classes and units. Order-S has three classes, Class S1-Highly Suitable, Class S2-Moderately Suitable and Class S3-Marginally Suitable, N-Not suitable. There are no sub-classes within the class S1 as they will have very minor or no limitations for crop growth. Geostatistical interpolation technique kriging was applied to obtain the spatial layers of soil chemical properties. All these layers were classified and thematic maps were prepared as per the standards given by National Bureau of Soil Survey and Land Use Planning. These criteria maps are as shown in figure 3 and 4.

2.4 Analytical Hierarchy Process (AHP)

The relative importance values were determined following Storrie index (O'geen, 2008), where a Saaty's scale score of 1 to 9 of the respective importance were obtained. A pair wise

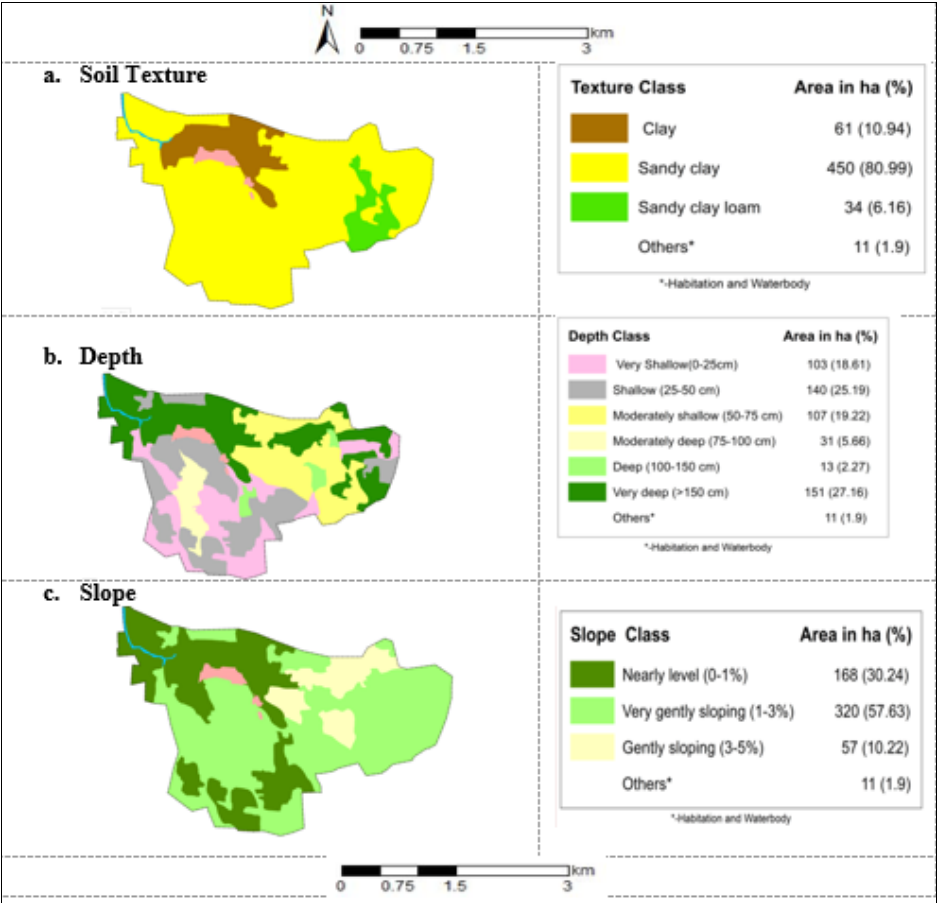


Fig 3: Criteria layers: Soil Texture, Depth and Slope

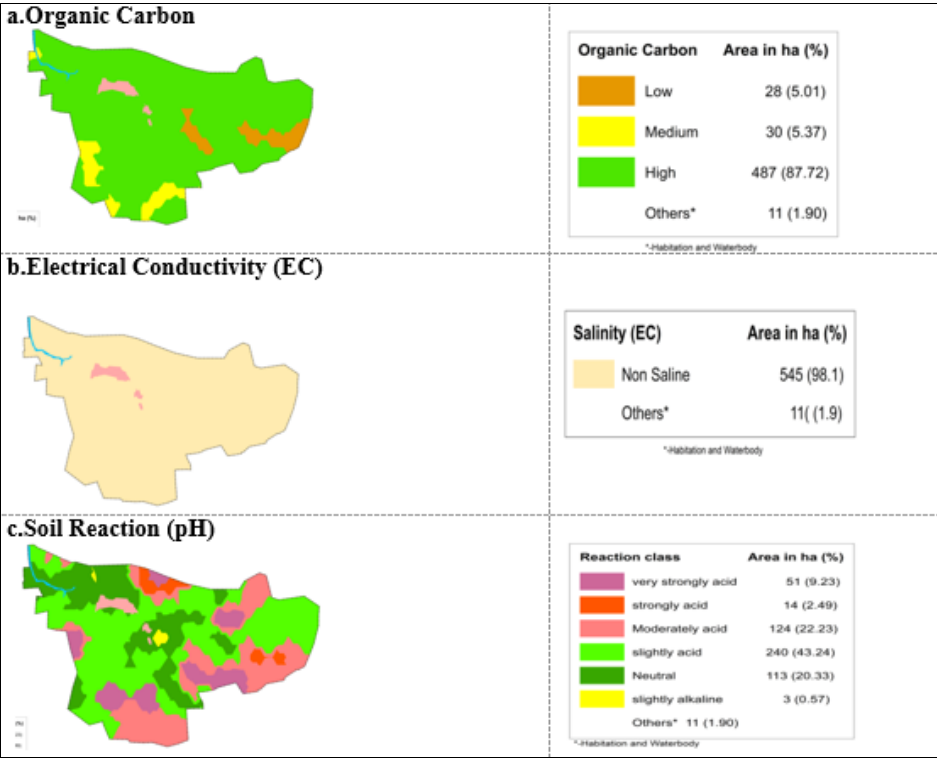


Fig 4: Criteria layers: Slope, Organic Carbon (OC), Electrical Conductivity (EC) and Soil Reaction pH

comparison matrix is derived using Storrie rating method of 9 point importance scale based on thematic and fertility layers used for soil and land suitability for mango. To obtain the weighted super matrix, each column of the super matrix is weighted by multiplying the corresponding weights and normalized. The AHP captures the idea of uncertainty in judgments through the principal Eigen value and the consistency index (CI) (Saaty,

2004)^[17]. Consistency Index (CI) as deviation or degree of consistency was derived using the following below equation,

$$CI = (\lambda_{max} - n) / (n - 1)$$

Where λ_{max} is the largest Eigen value of the pair-wise comparison matrix and n is the number of classes (Alonso *et al.*, 2006)

Consistency Ratio (CR) is a measure of consistency of pair wise comparison matrix and is given by equation, $CR = CI / RI$

Where, RI is the ratio Index. The value of RI for different n values is given in. When CR value is less than 0.10, the matrix indicates a reasonable consistency. The calculated results of weight would be accepted when the consistency ratio was satisfactory (Saaty 1980; 2003).

Table 2: Random inconsistency indices (RI) for N=18 (Alonso *et al.*, 2006)

N	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
RI	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.46	1.49	1.52	1.54	1.56	1.58	1.59	1.597	1.609	1.618

2.5 Weighted Overlay Analysis

Thematic layers of different surface and sub-surface characters with their respective ratings were analysed through AHP (Agarwalet *al.*, 2013)^[1] method to get their weightages. The analytical hierarchy process is a multi-attribute land evaluation technique which allows to determine the weights of these

multiple and heterogeneous criteria indicating relative importance. Different thematic layers identified in the study with their respective weightages were further integrated with each other in ArcGIS 10.6.1 software as per weighted overlay technique using the spatial analyst tool (Table 3).

Table 6: Criteria with their classes Ranks, Weightages

Criteria	Subclasses	Ratings	weightage	% of w
PH	Neutral (pH 6.5-7.3)	10	0.055	16
	Slightly acid (pH 6.0-6.5)	7.75	0.042	
	Moderately acid (pH 5.5-6.0)	4.5	0.025	
	Slightly alkaline (pH 7.3-7.9)	7.75	0.042	
Electrical conductivity	Non saline (<2 dsm)	10	0.055	6
Organic carbon	Very High (>1.00%)	10	0.055	25
	Low (<0.25-0.5%)	7.75	0.042	
	Medium (0.5-0.75%)	9.75	0.053	
	Very Low (<0.25%)	7.75	0.042	
	High (0.75-1.00%)	10	0.055	
Depth	Very deep (>150 cm)	10	0.055	21
	Shallow (25-50 cm)	4	0.022	
	Deep (100-150 cm)	9	0.049	
	Very shallow (0-25 cm)	2	0.011	
	Moderately deep (75-100 cm)	7.5	0.041	
	Moderately shallow (50-75 cm)	6	0.033	
Texture	Clay	6	0.033	11
	Sandy clay loam	5.5	0.03	
	Sandy clay	2.5	0.014	
Slope	Nearly level (0-1%)	10	0.055	21
	Very gently sloping (1-3%)	9.75	0.053	
	Gently sloping (3-5%)	9.5	0.052	

3. Results and Discussion

Physical and chemical properties of soil of an area are the important attributes which enable to assess the land suitability for different crops. To find out the site specific suitability for mango, soil and land properties criteria like soil depth, texture, slope, organic carbon, electrical conductivity (EC) and pH was processed through AHP and Weighted Overlay Analysis (Table 2 to 6). The results indicate that soil organic carbon with a weightage value above 25% is the most important factor in making land suitable for mango out of the six criteria (Bandyopadhyay *et al.*, 2009)^[4]. On the status of the remaining criteria of Soil depth and slope with weightage value of 21% each were found to be second most important factors in deciding

mango crop suitability in the study area. Whereas remaining properties like pH, Texture & EC with their weightage value of 16%, 11%, 6% respectively were found to be least influential on crop suitability as compared to soil organic carbon and depth, slope have proved their hierarchy in deciding mango suitability of the study area. As soil and land properties co-exist & highly interdependent in creating favorable or unfavorable conditions for crop growth, Status of soil and land characters have clearly proved their ability to become suitable or not suitable for mango crop (Sulankeet *al.*, 2023)^[19].

Thus, based on the outcomes of the weighted overlay evaluation, the study area of 555.5 ha falling under four different mango suitability categories were identified as mentioned in table 7.

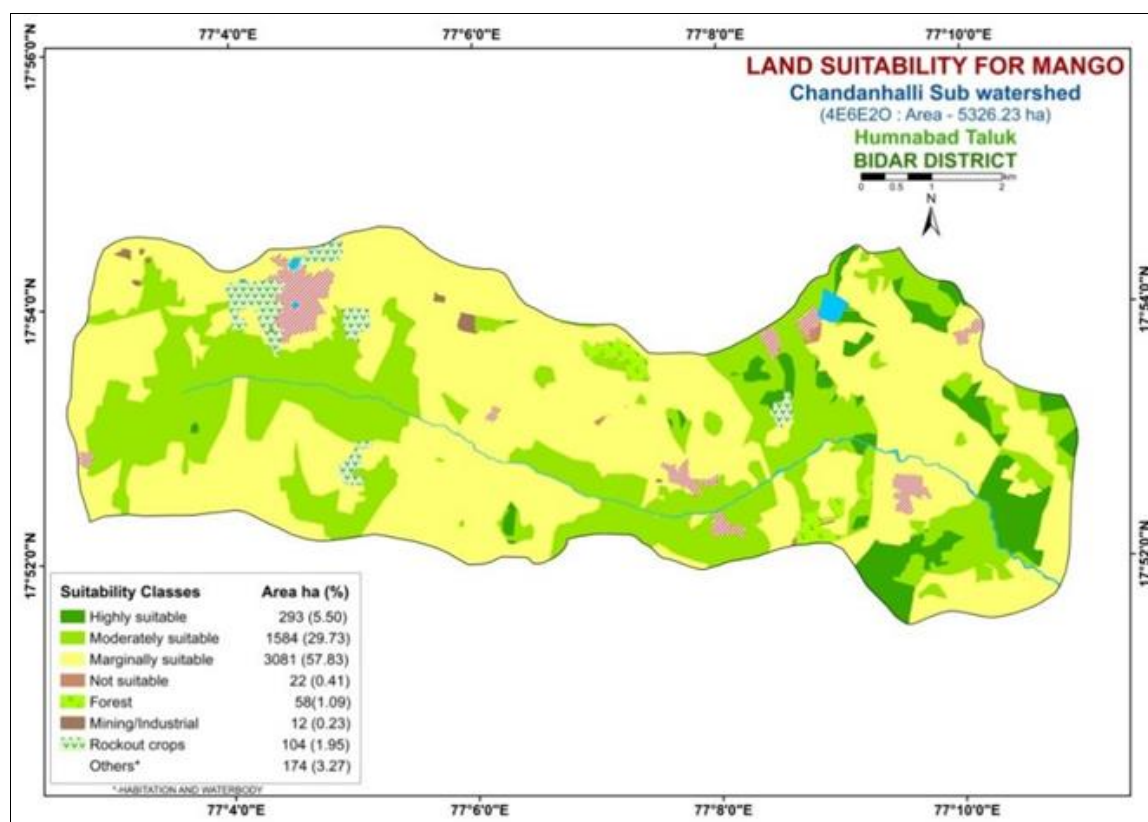
Table 7: Land suitability class for mango and its distribution in Mustariwadi mws

Suitability zones	Area_Ha	Area_Per
Highly suitable (S1)	61	10.93
Moderately suitable (S2)	103	18.47
Marginally suitable (S3)	248	44.67
Not suitable (N)	133	24.02
Others	12	1.99
Total	555.5	100

The reasons for land parcels belonging to Highly suitable (S1) category which has spread across 61 ha(10.93%) are found strongly associated with deep to very deep soil depth where it allows the mango crop to have deeper and wider tap root system which enables to extract nutrient and moisture from deeper horizons. As these soils are belonging to very gently sloping lands, they become less prone to soil, nutrient and moisture loss. Therefore higher status of organic carbon is matching to the others conditions like neutral pH, Sandy clay loam texture. properties such as; clay soil texture influences the soil potential with its role in the retention of more SOC, faster decomposition and transformation process (Gami *et al.*, 2009)^[9]. In addition to that clay is known imparts good water holding capacity, reduced leaching loss, high nutrient retention, adsorption and exchange abilities due to its high surface area reflecting as higher fertility (Borchers *et al.*, 1992; Kome *et al.*,

2019). Moreover, land parcels on which very deep (>150 cm) soil have been identified, are existing in lowland and midland physiographic position which will have a positive influence on soil development through deposition as well as through in-situ process (Karaca *et al.*, 2018). Deeper rooting depth makes these soils harbor and nurture many annual and perennial crops with tap root system (Yüksek *et al.*, 2009)^[4, 19, 9, 5, 12, 11, 20, 22].

On the contrary lands identified as not suitable (N) category which are extended upto 133 ha (24.02%) can be confirmed by existence of severe limitation like very shallow to shallow depth and existence of lithic contact layer which blocks the root penetration. As most of the soils belongs to 3-5% slope and making them susceptible for erosion, runoff losses, resulting in low organic carbon, moderately alkaline pH, and dominance of weathered parent material which leads to increase in severity of limiting factors of mango crop

**Fig 5:** Land Suitability map for Mango of Mustariwadi mws

While an area of 103 ha (18.47%) found belonging to moderately suitable (S2) for mango in Mustariwadi micro watershed is in accordance with slight to moderate limitations in the form of moderately shallow soil depth leading to restrictive root penetration, drainage, moderate moisture and retention because of sandy clay texture. Large area of mws covering an area of 248 ha. (44.67%) has been categorised as marginally suitable (S3) with limitations like shallow soil depth which creates unfavourable conditions like restricted root penetrations,

low moisture retention and poor support of land for the crop growth with gently sloping lands susceptible for erosion and loss of nutrients (Ayehuand Besufekad2015). These facts also coincides with low organic carbon status, moderately alkaline pH, and sandy clay texture of soil (Liu *et al.*, 2020; Gorooei *et al.*, 2023)^[21].

Conclusions: By applying weighted overlay analysis, LRI data can be used to crop specific and site specific suitability

assessment. Such information can be an important input for developing decision support system model for judging crop suitability in a micro-watershed. Findings of such studies can be extrapolated and used in crop specific land-use planning for large area with similar land and soil characters.

Authors contribution

- Conceptualization, Investigation, Methodology -all authors
- Data curation: Praveenkumar B. Naikodi, Narayn Rao, Praveen. Jolgiker
- Formal analysis: Praveenkumar B. Naikodi
- Funding acquisition: Not applicable
- Project administration: Praveenkumar B. Naikodi,
- Resources: uhs bagalkot
- Software: ArcGIS 10.8 (Esri)
- Supervision, Validation, Visualization: all authors
- Writing draft - Praveenkumar B. Naikodi, Praveen B. Jolgike, Vijayshree
- Writing - review and editing: all authors except 3

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Table 3: Pair-wise comparison matrix

Criteria	Subclasses	Ratings	10	7.75	7.75	10	10	7.75	9.75	7.75	10	10	4	9	2	7.5	6	6	5.5	2.5	7	10	9.75	9.5	8.75
PH	Neutral (pH 6.5-7.3)	10	1.00	1.29	1.29	1.00	1.00	1.29	1.03	1.29	1.00	1.00	2.50	1.11	5.00	1.33	1.67	1.67	1.82	4.00	1.43	1.00	1.03	1.05	1.14
	Slightly acid (pH 6.0-6.5)	7.75	0.78	1.00	1.00	0.78	0.78	1.00	0.79	1.00	0.78	0.78	1.94	0.86	3.88	1.03	1.29	1.29	1.41	3.10	1.11	0.78	0.79	0.82	0.89
	Moderately acid (pH 5.5-6.0)	4.5	0.45	0.58	0.58	0.45	0.45	0.58	0.46	0.58	0.45	0.45	1.13	0.50	2.25	0.60	0.75	0.75	0.82	1.80	0.64	0.45	0.46	0.47	0.51
	Slightly alkaline (pH 7.3-7.9)	7.75	0.78	1.00	1.00	0.78	0.78	1.00	0.79	1.00	0.78	0.78	1.94	0.86	3.88	1.03	1.29	1.29	1.41	3.10	1.11	0.78	0.79	0.82	0.89
EC	Non saline (<2 dsm)	10	1.00	1.29	1.29	1.00	1.00	1.29	1.03	1.29	1.00	1.00	2.50	1.11	5.00	1.33	1.67	1.67	1.82	4.00	1.43	1.00	1.03	1.05	1.14
Organic carbon	Very High (>1.00%)	10	1.00	1.29	1.29	1.00	1.00	1.29	1.03	1.29	1.00	1.00	2.50	1.11	5.00	1.33	1.67	1.67	1.82	4.00	1.43	1.00	1.03	1.05	1.14
	Low (<0.25-0.5%)	7.75	0.78	1.00	1.00	0.78	0.78	1.00	0.79	1.00	0.78	0.78	1.94	0.86	3.88	1.03	1.29	1.29	1.41	3.10	1.11	0.78	0.79	0.82	0.89
	Medium (0.5-0.75%)	9.75	0.98	1.26	1.26	0.98	0.98	1.26	1.00	1.26	0.98	0.98	2.44	1.08	4.88	1.30	1.63	1.63	1.77	3.90	1.39	0.98	1.00	1.03	1.11
	Very Low (<0.25%)	7.75	0.78	1.00	1.00	0.78	0.78	1.00	0.79	1.00	0.78	0.78	1.94	0.86	3.88	1.03	1.29	1.29	1.41	3.10	1.11	0.78	0.79	0.82	0.89
	High (0.75-1.00%)	10	1.00	1.29	1.29	1.00	1.00	1.29	1.03	1.29	1.00	1.00	2.50	1.11	5.00	1.33	1.67	1.67	1.82	4.00	1.43	1.00	1.03	1.05	1.14
Depth	Very deep (>150 cm)	10	1.00	1.29	1.29	1.00	1.00	1.29	1.03	1.29	1.00	1.00	2.50	1.11	5.00	1.33	1.67	1.67	1.82	4.00	1.43	1.00	1.03	1.05	1.14
	Shallow (25-50 cm)	4	0.40	0.52	0.52	0.40	0.40	0.52	0.41	0.52	0.40	0.40	1.00	0.44	2.00	0.53	0.67	0.67	0.73	1.60	0.57	0.40	0.41	0.42	0.46
	Deep (100-150 cm)	9	0.90	1.16	1.16	0.90	0.90	1.16	0.92	1.16	0.90	0.90	2.25	1.00	4.50	1.20	1.50	1.50	1.64	3.60	1.29	0.90	0.92	0.95	1.03
	Very shallow (0-25 cm)	2	0.20	0.26	0.26	0.20	0.20	0.26	0.21	0.26	0.20	0.20	0.50	0.22	1.00	0.27	0.33	0.33	0.36	0.80	0.29	0.20	0.21	0.21	0.23
	Moderately deep (75-100 cm)	7.5	0.75	0.97	0.97	0.75	0.75	0.97	0.77	0.97	0.75	0.75	1.88	0.83	3.75	1.00	1.25	1.25	1.36	3.00	1.07	0.75	0.77	0.79	0.86
	Moderately shallow (50-75 cm)	6	0.60	0.77	0.77	0.60	0.60	0.77	0.62	0.77	0.60	0.60	1.50	0.67	3.00	0.80	1.00	1.00	1.09	2.40	0.86	0.60	0.62	0.63	0.69
Texture	Clay	6	0.60	0.77	0.77	0.60	0.60	0.77	0.62	0.77	0.60	0.60	1.50	0.67	3.00	0.80	1.00	1.00	1.09	2.40	0.86	0.60	0.62	0.63	0.69
	Sandy clay loam	5.5	0.55	0.71	0.71	0.55	0.55	0.71	0.56	0.71	0.55	0.55	1.38	0.61	2.75	0.73	0.92	0.92	1.00	2.20	0.79	0.55	0.56	0.58	0.63
	Sandy clay	2.5	0.25	0.32	0.32	0.25	0.25	0.32	0.26	0.32	0.25	0.25	0.63	0.28	1.25	0.33	0.42	0.42	0.45	1.00	0.36	0.25	0.26	0.26	0.29
	Sandy loam	7	0.70	0.90	0.90	0.70	0.70	0.90	0.72	0.90	0.70	0.70	1.75	0.78	3.50	0.93	1.17	1.17	1.27	2.80	1.00	0.70	0.72	0.74	0.80
Slope	Nearly level (0-1%)	10	1.00	1.29	1.29	1.00	1.00	1.29	1.03	1.29	1.00	1.00	2.50	1.11	5.00	1.33	1.67	1.67	1.82	4.00	1.43	1.00	1.03	1.05	1.14
	Very gently sloping (1-3%)	9.75	0.98	1.26	1.26	0.98	0.98	1.26	1.00	1.26	0.98	0.98	2.44	1.08	4.88	1.30	1.63	1.63	1.77	3.90	1.39	0.98	1.00	1.03	1.11
	Gently sloping (3-5%)	9.5	0.95	1.23	1.23	0.95	0.95	1.23	0.97	1.23	0.95	0.95	2.38	1.06	4.75	1.27	1.58	1.58	1.73	3.80	1.36	0.95	0.97	1.00	1.09
	Moderately sloping (5-10%)	8.75	0.88	1.13	1.13	0.88	0.88	1.13	0.90	1.13	0.88	0.88	2.19	0.97	4.38	1.17	1.46	1.46	1.59	3.50	1.25	0.88	0.90	0.92	1.00
		SUM	18.28	23.58	23.58	18.28	18.28	23.58	18.74	23.58	18.28	18.28	45.69	20.31	91.38	24.37	30.46	30.46	33.23	73.10	26.11	18.28	18.74	19.24	20.89

Table 4: Weighted Super matrix

Criteria		Subclasses			Ratings		10		7.75	7.75	10	10	7.75	9.75	7.75	10	10	4	9	2	7.5	6	6	5.5	2.5	7	10	9.75	9.5	8.75	SUM	Weights			
PH	Neutral (pH 6.5-7.3)	10	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	1.258549932	0.05244			
	Slightly acid (pH 6.0-6.5)	7.75	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.975376197	0.040641			
	Moderately acid (pH 5.5-6.0)	4.5	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.566347469	0.02359		
	Slightly alkaline (pH 7.3-7.9)	7.75	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.975376197	0.040641		
Electrical conductivity	Non saline (<2 dsm)	10	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	1.258549932	0.05244		
Organic carbon	Very High (>1.00%)	10	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	1.258549932	0.05244		
	Low (<0.25-0.5%)	7.75	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.975376197	0.040641		
	Medium (0.5-0.75%)	9.75	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	1.227086183	0.051129		
	Very Low (<0.25%)	7.75	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.975376197	0.040641		
	High (0.75-1.00%)	10	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	1.258549932	0.05244		
Depth	Very deep (>150 cm)	10	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	1.258549932	0.05244		
	Shallow (25-50 cm)	4	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.503419973	0.020976		
	Deep (100-150 cm)	9	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	1.132694938	0.047196		
	Very shallow (0-25 cm)	2	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.251709986	0.010488		
	Moderately deep (75-100 cm)	7.5	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.943912449	0.03933		
	Moderately shallow (50-75 cm)	6	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.755129959	0.031464	
Texture	Clay	6	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.755129959	0.031464	
	Sandy clay loam	5.5	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.692202462	0.028842		
	Sandy clay	2.5	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.314637483	0.01311		
	Sandy loam	7	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.880984952	0.036708		

[illegible]**Table 5: Consistency Calculation**[illegible]