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Original research

Assessment of Land Productivity Index Based on Parametric Approach Using GIS and Remote Sensing in Nubian Nasr Area, Aswan, Egypt

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Abstract:

The main objective of this research was to determine the land productivity index based on a parametric approach using geographic information systems (GIS) and Remote sensing (RS). This study was conducted in the Nubian Nasr Area, located between 24° 27' 30''N and 24° 35' 0''N latitude, and 33° 0' 0''E and 33° 6' 0''E longitude, in Aswan Governorate, Egypt. The study area covers about 107.51Km² (10750.64 hectare). To achieve this objective, 27 soil profiles were chosen to cover the study area, and 81 soil samples were collected. Soil samples were analyzed for their parameters using the standard methods of soil analysis. Accordingly, land productivity was calculated for all studied soil profiles, and a result map was generated for the land productivity index utilizing GIS. According to the results, it was found that most of the land productivity for field crops, forage crops, and fruit trees was concentrated in the Average (III) class with rates of 51.85% (5574.21 hectares), 48.15% (5176.43 hectares), and 37.04% (3982.04 hectares), respectively. The second class, good (II) for agricultural use, came in second place with the following order: 25.93% (2787.64 hectares), 22.22% (2388.79 hectares), and 33.34% (3584.26 hectares) for field crops, forage, and fruit trees, respectively. The poor class (IV) represented 18.52% (1991.02 hectares) of field crops, 29.63% (3185.41 hectares) for forage crops, and 25.93% (2786.56 hectares) for fruit trees. The excellent class (I) represented about 3.71% (397.77 hectares) for both field crops and fruit trees, while it was nil for forage crops.

Keywords: Land productivity, Nubian Nasr Area, Remote sensing and GIS, Require Land Productivity Index.

1- Introduction

Soil, the foundation of agriculture and a nation's most valuable resource, faces a significant threat. Over 75% of the Earth's land is already degraded, and projections suggest this could reach a staggering 90% by 2050 **(Charlet et al., 2018)**. Understanding soil properties is crucial for developing sustainable agricultural practices to address this crisis. For millennia, agriculture has been the cornerstone of human civilization. However, with a rapidly growing population, the land struggles to replenish itself at the same pace, creating an imbalance. To ensure long-term sustainability, we need to assess the potential of land for various uses. Land evaluation assesses land performance for specific uses.

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It interprets key inventories of soil properties, vegetation, environment, climate, and other factors. The escalating demand for food production underscores the critical role of efficient land evaluation systems in agriculture **(Yousif, 2024)**.

Over 90% of Egyptians reside in the narrow, fertile strip around the Nile River and Delta, encompassing just 4% of Egypt's total land area. This rich area is crucial to sustaining the bulk of the nation's agriculture **(CAPMAS, 2009)**. Egypt, which stretches vastly and covers over a million square kilometers, is largely dependent on irrigation; approximately 95% of its agricultural production comes from irrigated areas. Two-thirds of Egypt's arable land is found in the Nile Delta, which is essential to the country's food production, commerce, and economy as a whole **(Shehata, 2014)**. Soil scientists **(SSSA, 2008)** define soil productivity as how much a specific type of soil can produce under a particular management plan (e.g., fertilizer use, crop rotation). But for overall land productivity, we need to consider a bigger picture. This includes things like climate (temperature, rain), the original materials from which the soil was formed, the shape of the land (hills, flats), and of course, the soil properties themselves (texture, nutrients). In short, good soil is important, but it's not the only factor determining how productive land is. "The state and potential of land, encompassing its topography, soil, climate, biological characteristics, preservation, and environmental management" is another definition provided by **Dengiz et al. (2009)**.

The Food and Agriculture Organization **(FAO, 2018)** warns of a disturbing trend. Agricultural practices, while essential for feeding the world, are also contributing to greenhouse gas emissions. These emissions are creating a vicious cycle, harming agriculture itself. Crop yields are declining, leading to food shortages and negatively impacting the livelihoods of people in rural areas. Unsustainable land management is a major culprit, accelerating soil degradation and reducing the land's ability to produce food. Reduced food production is mostly the result of declining soil fertility, which is frequently brought on by human activity **(Debeljak et al., 2019)**. Long-term food security is seriously threatened by land degradation, which is the result of human activity out of balance with the land's natural capacity **(Kumar et al. 2019)**. Human activities can both enhance and degrade soil productivity. Each agricultural system has its distinct social structure **(Rashed et al., 2021)**. To assess the land's productive capacity, scientists use two main approaches: direct and indirect methods. Direct methods involve real-world experiments, either in fields, greenhouses, or labs. These experiments control factors like climate and management practices to see how well the land performs. Indirect methods, on the other hand, rely on creating models, ranging from simple to complex, to estimate land productivity based on various factors **(Dengiz, 2007).**

Land productivity is a comprehension and, at the same time, a precise concept in terms of agricultural activities. It is defined as a measure of the capability of land to perform specific functions **(Devi and Kumar, 2008).** Undoubtedly, one of the ways to provide food is to increase production in the area and to use the land with respect to its potentiality in an appropriate way. **Pieri et al. (1995) and Dengiz et al. (2009)** also reported that land productivity has been defined as "the condition and capacity of land, including its soil, climate, topography, and biological properties, for purpose of production, conservation, and environmental management." The productive capacity of land can be assessed through direct or indirect methods. Direct assessments occur in fields, greenhouses, or laboratories via specific experiments conducted under particular climatic and management conditions. Indirect assessments primarily involve the creation and application of models with different levels of complexity, aiming to estimate land productivity **(Delgado and Lopez, 1998).**

Researchers have explored how well land is suited for agriculture using land suitability indicators. Several methods have been developed to create productivity ratings, often using numerical or parametric approaches **(Ouyang et al., 2019)**. This study focuses on the Productivity Index (PI) model, which uses an algorithm based on the idea that root development and depth are influenced by soil conditions, ultimately affecting crop yields **(Lindstrom et al., 1992)**. The PI model provides a single scale for grading soils based on their suitability for crops **(Ziblim et al., 2012).**
The main objective of this study is to identify the productivity levels of the old agricultural lands in the Nasr al-Nuba area and produce maps of them using the applications of geographic information systems and remote sensing.

2. Materials and Methods

2.1. Location

Egypt is located on the Mediterranean Sea's northeastern coast of Africa. Aswan Governorate is bordered on the western side by the New Valley Governorate, on the eastern side by the Red Sea Governorate, on the northern side by Luxor Governorate, and on the southern side by the borders of the Republic of Sudan. It is located between latitude 22°:25° 41' N and longitude 30° 59':33° 30' E. The governorate is situated 880 kilometers from Cairo and stretches 258 kilometers to the Sudanese border. The investigation area is part of the Eastern Egyptian Desert and is located in Aswan Governorate in Upper Egypt. The investigation area is located between latitudes 24° 27' 30'' and 24° 35' 0'' N and longitudes 33° 0' 0'' and 33° 6' 0'' E (Figure 1) and covers an area of 107.51Km^2 (10750.64 hectare).

2.2 Climatic Conditions

The summers in the Aswan Governorate are often hot and dry, and the winters are chilly with little rain. Climate data were obtained from the Aswan meteorological station within the period of 2014–2023, which is presented in Table 1 and discussed in the flowing lines in Figure 2.

Table 1: The average of climate data for Aswan Governorate from 2014 to 2023

Month	Temperature (°C)			Relative moisture (%)	Rainfall (mm)	Wind speed (km/h $^{-1}$)
	Min.	Max.	Mean			
January	7.13	20.09	13.42	57.28	0.00	8.22
February	8.58	21.93	15.26	52.49	0.25	9.54
March	11.69	24.58	18.92	45.64	7.82	10.25
April	16.62	32.01	24.3	34.34	7.67	10.47
May	21.04	35.9	28.35	29.91	0.10	12.25
June	23.91	37.64	31.29	33.22	0.00	12.38
July	24.69	37.82	31.5	37.65	0.00	12.17
August	25	37.94	31.68	38.8	0.00	11.98
September	23.37	36.11	30.15	39.05	5.00	12.98
October	19.92	31.85	25.8	48.09	0.00	11.66
November	14.24	26.29	19.99	56.24	5.23	8.62
December	9.58	21.78	15.45	61.42	0.40	9.1
Mean	17.15	30.33	23.84	44.51	2.21	10.80

Source: https://fr.tutiempo.net/climat/ws-624140.html

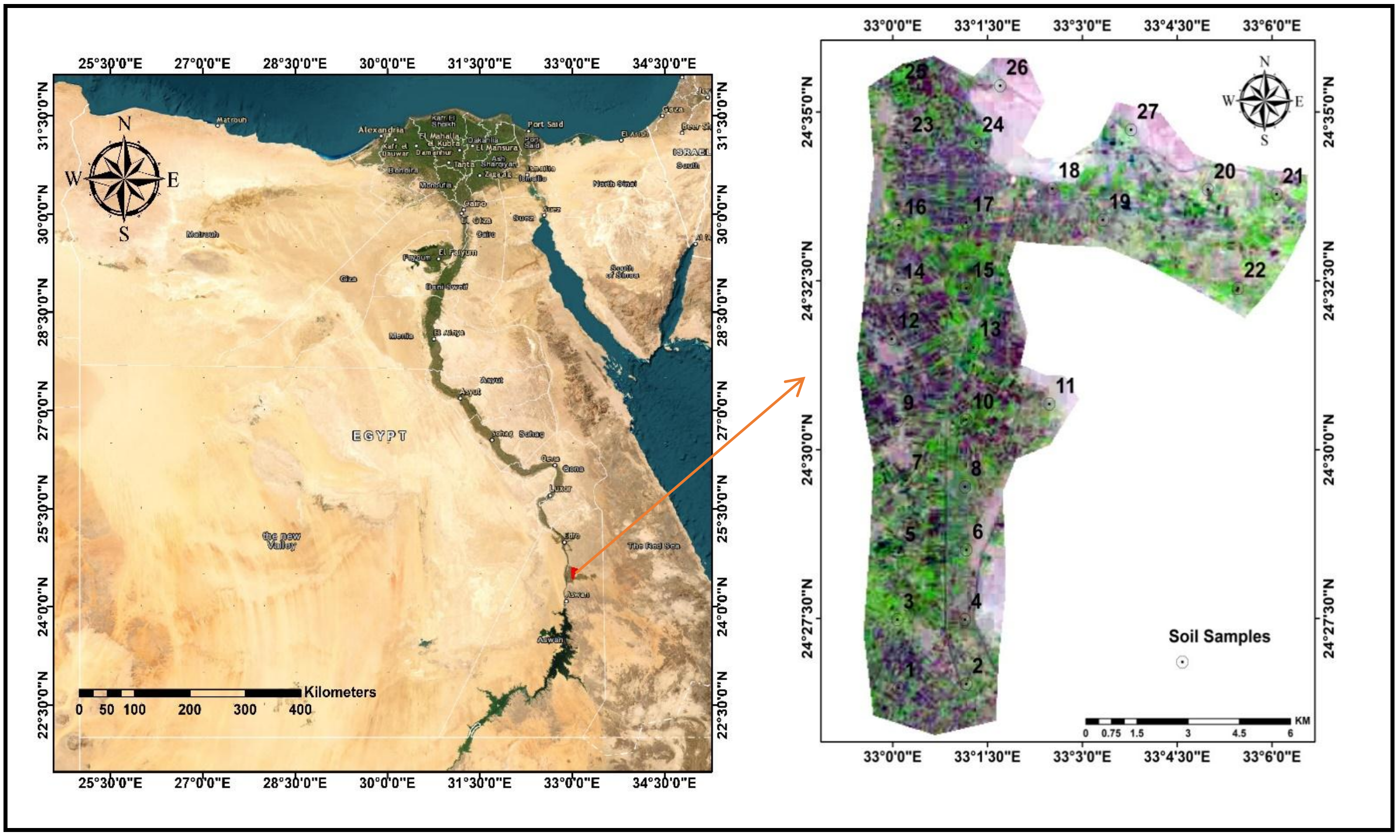

Figure 1: A map showing the study area location

2.2.1. Temperature

The data (Table 1, Figure 2) reveals distinct seasonal patterns. Temperatures follow a predictable curve, with highs occurring from May to October (dry season) and lows from December to March (rainy season). The coldest month is January (average minimum 7.13°C), while August is the hottest (average maximum 37.94°C). On average, summers are more than 8°C warmer than winters (average maximum 30.33°C, average minimum 17.15°C). This significant temperature difference classifies the soil temperature regime as "thermic" and the moisture regime as "torric" according to the Soil Survey Staff (2014) system. In simpler terms, Aswan experiences hot summers, cool winters, and dry soil conditions.

2.2.2. Rainfall

The mean value of the monthly rainfall is very low, the maximum monthly rainfall of 7.82mm was recorded in March . The period from June to October represented the dry season.

2.2.3. Relative humidity

"Humidity" refers to the amount of water vapor in the atmosphere, which is often correlated with air temperature. The quantity of moisture required to saturate the air is used to calculate relative humidity. In May, the relative humidity was 29.91%, and in December, it was 61.42%.

2.2.3 Wind speed

The surface wind velocity as evidenced in Table 1 and Figure 2 indicated that the maximum wind speed was 12.98 Km/h in September while the minimum wind speed reached 8.22 Km/h in January.

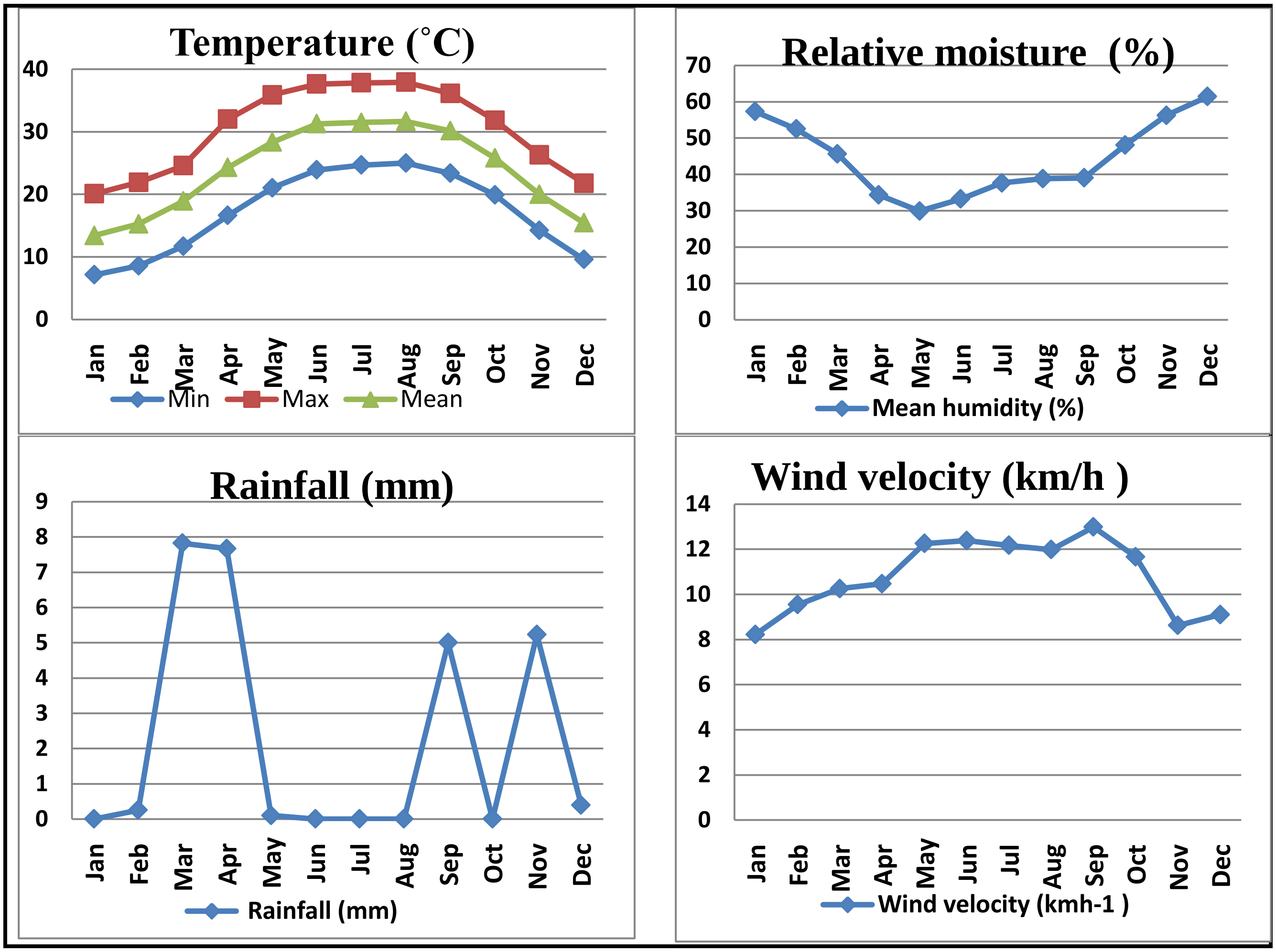

Fig. 2: Climatologically diagram of Aswan Governorate

2.3. Collecting soil samples and analyzing the soil's chemical and physical characteristics

To represent each type of land and different geographical features, field surveys were carried out to randomly excavate 27 soil profiles. From every soil profile, eighty-one representative soil samples were obtained. Soil profiles have a depth ranging from 120 to 150 cm. Air-dried soil samples were used, crushed, and sieved through a 2-mm sieve in preparation for physical and chemical testing. Electrical conductivity (EC) was measured by a EUTECH conductivity meter, and the pH was measured using a HANNA pH meter of the prepared 1:1 soil-water mixture. The percentages of clay were calculated using the pipette method, silt, and sand fractions (**Richards, 1954**); a calcimeter was used to calculate the lime contents (**Soil Survey, 1992); and** the Walkley-Black method, modified by Jackson (**Jackson, 1958**), was used to calculate the organic matter. Cation exchange capacity (CEC) was computed using the sodium acetate-ammonium acetate technique (**Richards, 1954**).

The mean weighted value of each determined soil characteristic (V), which was used to assess the soils, was obtained by multiplying the parameter value (Vi) of each horizon-by-horizon thickness (ti) and dividing by the total profile depth (T). The following equation was used to get this result:

$$\mathbf{V} = \sum_{n=1}^{\infty} \frac{(Vi \times ti)}{T}$$

3.4. RLPI calculation

In order to evaluate land in relation to productivity, **Require et al. (1970)** devised the parametric index known as the **RLPI**. The system doesn't take social or economic factors into account. Calculations for pH (N), soluble salts (S), texture (T), cation exchange capacity (A), organic matter (O), depth (P), slope (E), moisture (H), drainage (D), and mineral reserves (M) are suggested. The formula is as follows:

$$\text{The RLPI Equation} = (N/100) \times (S/100) \times (T/100) \times (A/100) \times (O/100) \times (P/100) \times (E/100) \times (H/100) \times (D/100) \times 100$$

Every factor is given a score between 0 and 100, and the resulting productivity index is compared to a scale that assigns the soil to one of the five productivity classes listed below (Table 2).

Table 2: RLPI Rating System.

No.	RLPI class	Scores	Symbol
1	Excellent	65 – 100	I
2	Good	35 – 64	II
3	Average	20 – 34	III
4	Poor	8 – 19	IV
5	Extremely poor or nil	0 – 7	V

3.5. RLPI assessment.

The productive potential of the modeled soil profiles was evaluated using the mathematical model **Require et al. (1970)** submitted. This approach recommends calculating the productivity index by taking into account nine factors affecting land production. A is the ability/nature of the clay to exchange minerals, M is mineral reserves, T is texture, S is soluble salt concentration, O is organic matter, D is drainage state, P is effective depth, N is base saturation, and H is the availability of moisture. Nine thematic layers are finally produced by digitally coding each geographic feature and related attribute data into a GIS database. Factor rating values identified in Tables 3, 4, 5, and 6 were assigned to the diagnostic factors for each subject stratum.

Table 3: Definition of soil moisture and organic matter

The amount of moisture of the soil (H)		**Horizontal organic matter content A1 (O)**	
(H1**)**	The rooting zone throughout the year is below the wilting point.	**(O**1**)**	Very little (less than 10 g/kg) organic matter
(H2**)**	The rooting zone throughout for 9 to 11 months of the year is below the wilting point H2a: 11, H2b: 10, H2c: 9 months.	**(O**2**)**	Little organic matter (10-20 g/kg)
(H3**)**	The rooting zone throughout for 6 to 8 months of the year is below the wilting point H3a:8, H3b: 7, H3c: 6 months.	**(O**3**)**	Average organic matter content (20-50 g/kg)
(H4**)**	The rooting zone throughout for 3to 5 months of the year is below the wilting point H4a:5, H4b: 4, H4c: 3 months,	**(O**4**)**	High organic matter content(over 50 g/kg)
(H5**)**	The rooting zone throughout for most of the year above wilting point and below field capacity	**(O**5**)**	A high content but a C/N ratio greater than 25

Table 4: Soil drainage definition and reserves of weatherable minerals

Condition of drainage (D)		Mineral reserves in the B horizon that are weatherable (M)	
D1a	Water table nearly touches the surface, with noticeable waterlogging year-round.	**M**1	Low to nonexistent reserves
		M2	Fair reserve levels
		M2a	minerals that come from sand, silica, or ironstone
D1b	2 to 4 months out of the year, the soil floods.	**M**2b	minerals that come from acidic rock
D2a	Waterlogging that is moderate with the water table being near enough to the surface to damage deeply rooted plants.	**M**2c	minerals derived from calcareous or basic rocks
		M3	significant reserves
D2b	Complete saturation of the profile ranging from 8 days to 2 months.	**M**3a	Sands, materials with sand, or ironstone
		M3b	Acid rock
D3a	Good drainage and a low enough water table to not obstruct agricultural growth.	**M**3c	calcareous or basic rocks
		pH (1:1) and Base saturation of A Horizon (N)	
D3b	Flooding or waterlogging that lasts for fewer than eight days each time.	**N**1	pH:3.5-4.5 BS:<15%
		N2	pH:4.5-5.0 BS:15 - 35%
D4	Deep water table, well-drained soil, and no soil profile wetness.	**N**3	pH:5.0-6.0 BS:35 - 50%
		N4	pH: 6.0- 7.0 BS: 50 - 75%
		N5	pH:7.0 – 8.5 BS:>75%
		N6	excessively calcareous soil (>30%)

Table 5: defines the soluble salt concentration, cation exchange capacity, soil depth, and root zone structure and texture.

Root zone structure and texture (T)		Depth of Soil (P)	
T1	Rocky, gravelly, or pebbly soil.	(**P**1)	Rock outcrops with very little or no soil cover
T1a	60% by weight of pebbly, stony, or gravelly material.	(**P**2)	Extremely shallow soil
T1b	40% to 60% of the surface is rocky, gravelly, or pebbly.	(**P**3)	30 to 60 cm (shallow soil)
T1c	From 20 to 40%, stony and pebbly	(**P**4)	60-90 cm (fairly deep soil)
T2	Very coarse soil texture	(**P**5)	90-120 cm (deep soil)
T2a	Pure sand, of particle structure	(**P**6)	soil >120 cm (very deep)
T2b	(more than 45% coarse sand)very coarse soil	**Soluble salt content (S)**	
T2c	(> 30% organic content) Raw humus that has not decomposed and fibrous structure in the soil	(**S**1)	< 0.2 %
T3	ESP > 15% in the scattered clay with an unstable structure	(**S**2)	0.2-0.4 %
T4	soil with light texture, fS, LS, SL, CS, and Si	(**S**3)	0.4- 0.6 %

Root zone structure and texture (T)		**Depth of Soil (P)**	
T4a	An unstable structure	(**S**4)	0.6- 0.8 %
T4b	Stable structure	(**S**5)	0.8- 1.0 %
T5	Heavy-textured soil: C or SiC	(**S**6)	> 1.0 %.
T5a	Massive to large prismatic structure	(**S**7)	Total salt that is soluble, including Na2CO3) 0.1-0.3%
T5b	Angular to crumb structure or massive however highly porous	(**S**8)	0.3-0.6%
T6	Heavy SL, SC, CL, SiCL, and Si in medium-heavy soil	(**S**9)	> 0.6%
T6a	A prismatic structure that is massive to large	**Cation Exchange Capacity (A)**	
T6b	Structure that is angular to crumbly (massive but porous)	(**A**0)	Clay exchange capacity < 5 cmolc/kg
		(**A**1)	Clay exchange capacity < 20 cmolc/kg (probably kaolinite and sesquioxides)
T7	average-textured, well-balanced soil: SiL, L, and SCL	(**A**2)	Clay exchange capacity from 20 to 40 cmolc/kg
		(**A**3)	Clay exchange capacity >40 cmolc/kg

Note that f S stands for fine sand, LS for loamy sand, SL for sandy loam, S for sand, C for clay, Si for silt, SiC for silty clay, and CS for course sand.

Table 6: Rating of different soil and land characteristics

Factors	**Field crops**	**Forage crops**	**Fruit trees**	**Factors**	**Field crops**			**Forage crops**	**Fruit trees**
		H		**D**	**H**4,**H**5	**H**2,**H**3			
H1	5	5	5	**D**1	10	40		60	5
H2a*	10	20	10	**D**2	40	80		100	10
H2b	20	20	10	**D**3	80	90		90	40
H2c	40	30	10	**D**4	100	100		80	100
H3a	50	30	10	**P**					
H3b	60	40	20	**P**1	5			20	5
H3c	70	60	40	**P**2	20			60	5
H4a	80	70	70	**P**3	50			80	20
H4b	90	80	90	**P**4	80			90	60
H4c	100	90	100	**P**5	100			100	80
H5	100	100	100	**P**6	100			100	100
N				**T**					
N1	40	60	80	**T**1a	10			30	50
N2	50	70	80	**T**1b	30			50	80
N3	60	80	90	**T**1c	60			90	100
N4	80	90	100		**H**4,5,6	**H**3	**H**1,2		
N5	100	100	100	**T**2a	10	10	10	The same rating as for	The same rating as for fruit trees
N6	80	90	100	**T**2b	30	20	10		
O	**H**1**H**2**H**3 **D**3**D**4	**H**4**H**5**D**1**D**2		**T**2c	30	30	30		

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Factors	Field crops	Forage crops	Fruit trees	Factors	Field crops			Forage crops	Fruit trees
O1	85	70		**T**3	30	20	10	forage crops	
O2	90	80		**T**4a	40	30	30		
O3	100	90		**T**4b	50	50	60		
O4	100	100		**T**5a	50	60	20		
O5	70	70		**T**5b	80	80	60		
	A			**T**6a	80	80	60		
A0		85		**T**6b	90	90	90		
A1		90		**T**7	100	100	100		
A2		95		**S**	**T**1,2,4	**T**5,6,7			
A3		100		**S**1	100	100			
M	**H**1**H**2**H**3	**H4 H5**		**S**2	70	90			
M1	85	85		**S**3	50	80			
M2a	85	90		**S**4	25	40			
M2b	90	95		**S**5	15	25			
M2c	95	100		**S**6	5	15			
M3a	90	95		**S**7	60	90			
M3b	95	100		**S**8	15	60			
M3c	100	100		**S**9	5	15			

*__H__2a has a value of 10, and when the soil is watered, the rating rises to 100

3. Results and Discussion

3.1. Characterization of soil

Descriptive statistical values for the soil properties under investigation are given in Table 7. In addition, the basic soil characteristics of the studied area are tabulated in Table 8. The pH values ranged from 7.53 to 8.16, indicating that these soils fall into the slightly and moderately alkaline categories. Furthermore, all values indicate that these soils are fairly non-saline with profile weighted mean EC values ranging between 0.90 and 10.19 dSm^{-1}. The predominant soil texture classifications were sandy loam and sandy clay loam, with clay, loamy sand and silt loam textured soils occurring in only a few soil profiles. The cation exchange capacity of these soils ranged from 12.09 to 41.30 $cmol^{+}/kg$. The ESP values ranged from 1.81 to 56.56 %. Soil organic matter was low to moderate. Calcium carbonate content was low and ranged from 3.39% to 22.21%.

Table 7: Descriptive statistics values for the examined soil parameters

property	Mean	Minimum	Maximum	Standard Deviation	Standard Error
slope %	4.05	0.60	10.23	2.63	0.51
Depth	142.59	120.00	150.00	11.96	2.30
EC (dS/m)1:1	3.11	0.90	10.19	2.44	0.47
pH (1:1)	8.16	7.53	8.70	0.34	0.06
CEC $cmol^{+}/kg$	24.23	12.09	41.30	8.76	1.69
ESP %	16.99	1.81	56.56	13.84	2.66
O.M %	2.69	1.42	3.95	0.87	0.17
Ca Co3 %	10.35	3.39	22.21	4.60	0.89
drainage			GD,WD		

property	Mean	Minimum	Maximum	Standard Deviation	Standard Error
soil texture			SL,LS,SCL,C,SiL		

SL:sandy loam, L: loam, SCL:sandy clay loam, C: clay, SC: sandy clay, CL: clay loam, SiL: Silt loam, S: sandy, GD: Good drained, WD: Well drained.

Table 8: The major soil characteristics of the studied area:

Profile No.	slope %	Depth (cm)	Drainage	Soil texture	EC (dS/m) (1:1)	pH (1:1)	CEC $cmol^{(+)}/kg$	ESP %	O.M %	$CaCo_3$ %
1	1.65	150	Well	Sandy Clay loam	1.51	7.83	31.51	7.81	3.44	9.76
2	2.71	120	Well	sandy loam	1.24	7.72	17.08	6.34	1.68	5.21
3	5.11	150	Well	sandy loam	0.93	7.79	22.21	1.81	2.78	6.13
4	4.51	130	Well	Sandy Clay loam	3.01	7.62	33.95	7.89	3.39	7.21
5	1.65	150	Good	sandy loam	1.09	8.28	26.44	7.42	3.05	10.83
6	6.02	150	Good	sandy loam	1.29	7.53	34.44	5.61	2.37	14.83
7	2.71	150	Well	Sandy Clay loam	2.45	8.64	41.30	8.65	1.42	13.56
8	1.65	150	Well	silt loam	3.55	8.32	20.57	15.06	1.67	7.72
9	0.60	150	Well	sandy loam	2.43	8.02	15.03	18.73	2.31	9.93
10	1.65	150	Well	Clay	4.03	8.43	38.87	9.80	1.73	8.62
11	2.71	150	Well	sandy loam	2.55	8.41	19.79	19.26	1.46	6.29
12	3.61	120	Well	sandy loam	2.79	8.33	33.96	12.31	2.08	7.51
13	2.71	150	Good	sandy loam	1.12	7.62	22.03	3.42	2.08	14.09
14	3.61	130	Well	sandy loam	0.90	8.26	17.93	8.61	1.63	3.39
15	2.71	150	Well	sandy loam	0.97	8.17	13.64	10.93	1.87	4.08
16	4.81	150	Good	sandy loam	1.15	8.15	13.09	17.67	1.87	12.25
17	6.77	150	Well	sandy loam	4.49	8.70	20.59	35.19	3.55	11.27
18	4.81	150	Well	Sandy Clay loam	2.61	7.70	31.32	9.21	3.14	9.68
19	3.61	150	Well	sandy loam	6.80	8.40	12.86	56.56	3.71	11.23
20	9.92	120	Good	sandy loam	7.95	8.47	20.51	43.21	2.93	22.21
21	2.71	150	Well	Sandy Clay loam	10.19	8.11	33.36	35.33	3.42	13.93
22	3.61	130	Well	loamy sand	1.54	7.95	17.97	5.46	2.12	4.76
23	0.60	150	Well	sandy loam	1.51	8.52	14.47	14.73	3.93	10.05
24	2.71	120	Good	Sandy Clay loam	5.23	8.23	33.51	19.54	3.60	17.92
25	7.37	150	Well	sandy loam	1.05	8.44	12.09	10.31	3.76	12.05
26	8.72	130	Good	sandy loam	5.42	8.16	27.88	28.35	3.95	18.38
27	10.23	150	Well	sandy loam	6.12	8.53	27.88	39.46	3.61	6.66

3.2. Soil productivity potentials:

In order to make agricultural policy decisions, accurate forecasts of future soil productivity are required. The RLPI of (**Require et al. 1970)**, is a reliable system of land productivity assessment. After the final data preparation, the physical and chemical properties were applied to RLPI model to calculate the land productivity evaluation. The spatial analysis function in ArcGIS 10.8 was used to create thematic layers of the most constrained factors. The diagnostic factors of each thematic layer were assigned values of factor rating identified in Tables 9, 10, 11and 12.

Table 9: The region under investigation's soil properties.

Profile	Soil moisture (H)	Mineral reserve in B horizon(M)	Texture (T)	Drainage (D)	Depth (P)	EC (S)	OM (O)	CEC (A)	BS/ pH (N)
1	H4a	M2a	T7	D4	P6	S1	O3	A2	N5
2	H4a	M3a	T4	D4	P5	S1	O2	A1	N5
3	H4a	M3a	T4	D4	P6	S1	O2	A2	N5
4	H4a	M2a	T7	D4	P6	S1	O3	A2	N5
5	H4a	M3a	T4	D3a	P6	S1	O3	A2	N5
6	H4a	M3a	T4	D3a	P6	S1	O3	A2	N5
7	H4a	M2a	T7	D4	P6	S1	O2	A3	N6
8	H2a	M2a	T7	D4	P6	S2	O2	A2	N5
9	H4a	M3a	T4	D4	P6	S1	O3	A1	N5
10	H4a	M3a	T5	D4	P6	S2	O2	A2	N5
11	H4c	M3a	T4	D4	P6	S1	O2	A1	N5
12	H4a	M3a	T4	D4	P5	S1	O3	A2	N5
13	H4a	M3a	T4	D3a	P6	S1	O3	A2	N5
14	H4a	M3a	T4	D4	P6	S1	O3	A1	N5
15	H4a	M3a	T4	D4	P6	S1	O2	A1	N5
16	H4a	M3a	T4	D3a	P6	S1	O2	A1	N5
17	H4a	M3a	T4	D4	P6	S2	O3	A2	N5
18	H4c	M2a	T7	D4	P6	S1	O3	A2	N5
19	H4c	M3a	T4	D4	P6	S3	O3	A1	N5
20	H4c	M3a	T4	D3a	P5	S3	O3	A2	N5
21	H4c	M2a	T7	D4	P6	S3	O3	A2	N5
22	H4c	M3a	T4	D4	P6	S1	O3	A1	N5
23	H4a	M3a	T4	D4	P6	S1	O3	A1	N6
24	H4a	M2a	T7	D3a	P5	S2	O3	A2	N5
25	H4a	M3a	T4	D4	P6	S1	O3	A1	N5
26	H4c	M3a	T4	D3a	P6	S2	O3	A2	N5
27	H4c	M3a	T4	D4	P6	S2	O3	A1	N6

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Table 10: RLPI assessment for the study area's field crops.

Profile	Soil moisture (H)	Mineral reserve in B horizon(M)	Texture (T)	Drainage (D)	Depth (P)	EC (S)	OM (O)	CEC (A)	BS/ pH (N)	LPI %	Definition / symbol
1	80	85	100	100	100	100	100	95	100	64.60	Good II
2	80	90	50	80	100	100	90	90	100	23.33	Average III
3	80	90	50	80	100	100	90	95	100	24.62	Average III
4	80	85	100	100	100	100	100	95	100	64.60	Good II
5	80	90	50	100	100	100	100	95	100	34.20	Average III
6	80	90	50	100	100	100	100	95	100	34.20	Average III
7	80	85	100	100	100	100	90	100	80	48.96	Good II
8	60	85	100	80	100	50	90	95	100	17.44	Poor IV
9	80	90	50	100	100	100	100	90	100	32.40	Average III
10	80	90	50	100	100	50	90	95	100	15.39	Poor IV
11	100	90	50	100	100	100	90	90	100	36.45	Good II
12	80	90	50	100	100	100	100	95	100	34.20	Average III
13	80	90	50	100	100	100	100	95	100	34.20	Average III
14	80	90	50	80	100	100	100	90	100	25.92	Average III
15	80	90	50	100	100	100	90	90	100	29.16	Average III
16	80	90	50	100	100	100	90	90	100	29.16	Average III
17	80	90	50	100	100	100	100	95	100	34.20	Average III
18	100	85	100	100	100	100	100	95	100	80.75	Excellent I
19	100	90	50	100	100	100	100	90	100	40.50	Good II
20	100	90	50	80	100	70	100	95	100	23.94	Average III
21	100	85	100	80	100	100	100	95	100	64.60	Good II
22	100	90	50	100	100	100	100	90	80	32.40	Average III
23	80	90	40	100	100	100	100	90	80	20.74	Average III
24	80	85	100	100	100	100	100	95	100	64.60	Good II
25	80	90	40	100	100	70	100	90	100	18.14	Poor IV
26	100	90	40	80	100	70	100	95	100	19.15	Poor IV
27	100	90	40	100	100	70	100	90	80	18.14	Poor IV

Table 11: RLPI assessment for the study area's forage crops.

Profile	Soil moisture (H)	Mineral reserve in B horizon(M)	Texture (T)	Drainage (D)	Depth (P)	EC (S)	OM (O)	CEC (A)	BS/ pH (N)	LPI %	Definition / symbol
1	70	90	100	80	100	100	90	95	100	43.09	Good II
2	70	95	50	80	80	100	80	90	100	15.32	Poor IV
3	70	95	50	80	100	100	80	95	100	20.22	Average III
4	70	90	100	80	100	100	90	95	100	43.09	Good II
5	70	95	50	80	100	100	90	95	100	22.74	Average III
6	70	95	50	80	100	100	90	95	100	22.74	Average III
7	70	90	100	80	100	100	80	100	90	36.29	Good II
8	90	90	100	80	100	90	80	95	100	44.32	Good II
9	70	95	50	80	100	100	90	90	100	21.55	Average III

Profile	Soil moisture (H)	Mineral reserve in B horizon(M)	Texture (T)	Drainage (D)	Depth (P)	EC (S)	OM (O)	CEC (A)	BS/ pH (N)	LPI %	Definition / symbol
10	70	95	50	90	100	90	80	95	100	20.47	Average III
11	90	95	50	80	100	100	80	90	100	24.62	Average III
12	70	95	50	80	80	100	90	95	100	18.19	Poor IV
13	70	95	50	90	100	100	90	95	100	25.59	Average III
14	70	95	50	80	100	100	90	90	100	21.55	Average III
15	70	95	50	80	100	100	80	90	100	19.15	Poor IV
16	70	95	50	80	100	100	80	90	100	19.15	Poor IV
17	70	95	50	80	100	90	90	95	100	20.47	Average III
18	90	90	100	90	100	100	90	95	100	62.33	Good II
19	90	95	50	80	100	80	90	90	100	22.16	Average III
20	90	95	50	90	80	80	90	95	100	21.05	Average III
21	90	90	100	90	100	80	90	95	100	49.86	Good II
22	90	95	50	80	100	100	90	90	100	27.70	Average III
23	70	95	30	90	100	100	90	90	90	13.09	Poor IV
24	70	90	100	80	80	90	90	95	100	31.03	Average III
25	70	95	30	80	100	100	90	90	100	12.93	Poor IV
26	90	95	30	90	100	90	90	95	100	17.76	Poor IV
27	90	95	30	80	100	90	90	90	90	13.46	Poor IV

Table 12: RLPI assessment for the study area's fruit trees.

Profile	Soil moisture (H)	Mineral reserve in B horizon(M)	Texture (T)	Drainage (D)	Depth (P)	EC (S)	OM (O)	CEC (A)	BS/ pH (N)	LPI %	Definition / Symbol
1	70	90	100	100	100	100	90	95	100	53.87	Good II
2	70	95	60	100	100	100	80	90	100	28.73	Average III
3	70	95	60	100	100	100	80	95	100	30.32	Average III
4	70	90	100	100	100	100	90	95	100	53.87	Good II
5	70	95	60	40	100	100	90	95	100	13.65	Poor IV
6	70	95	60	40	100	100	90	95	100	13.65	Poor IV
7	70	90	100	100	100	100	80	100	100	50.40	Good II
8	100	90	100	100	100	90	80	95	100	61.56	Good II
9	70	95	60	100	100	100	90	90	100	32.32	Average III
10	70	95	60	100	100	90	80	95	100	27.29	Average III
11	100	95	60	100	100	100	80	90	100	41.04	Good II
12	70	95	60	100	100	100	90	95	100	34.11	Average III
13	70	95	60	40	100	100	90	95	100	13.65	Poor IV
14	70	95	60	100	100	100	90	90	100	32.32	Average III
15	70	95	60	100	100	100	80	90	100	28.73	Average III
16	70	95	60	40	100	100	80	90	100	11.49	Poor IV
17	70	95	60	100	100	90	90	95	100	30.70	Average III
18	100	90	100	100	100	100	90	95	100	76.95	Excellent I
19	100	95	60	100	100	80	90	90	100	36.94	Good II

Profile	Soil moisture (H)	Mineral reserve in B horizon(M)	Texture (T)	Drainage (D)	Depth (P)	EC (S)	OM (O)	CEC (A)	BS/ pH (N)	LPI %	Definition / Symbol
20	100	95	60	40	100	80	90	95	100	15.60	Poor IV
21	100	90	100	100	100	80	90	95	100	61.56	Good II
22	100	95	60	100	100	100	90	90	100	46.17	Good II
23	70	95	60	100	100	100	90	90	100	32.32	Average III
24	70	90	100	40	100	90	90	95	100	19.39	Poor IV
25	70	95	60	100	100	100	90	90	100	32.32	Average III
26	100	95	60	40	100	90	90	95	100	17.54	Poor IV
27	100	95	60	100	100	90	90	90	100	41.55	Good II

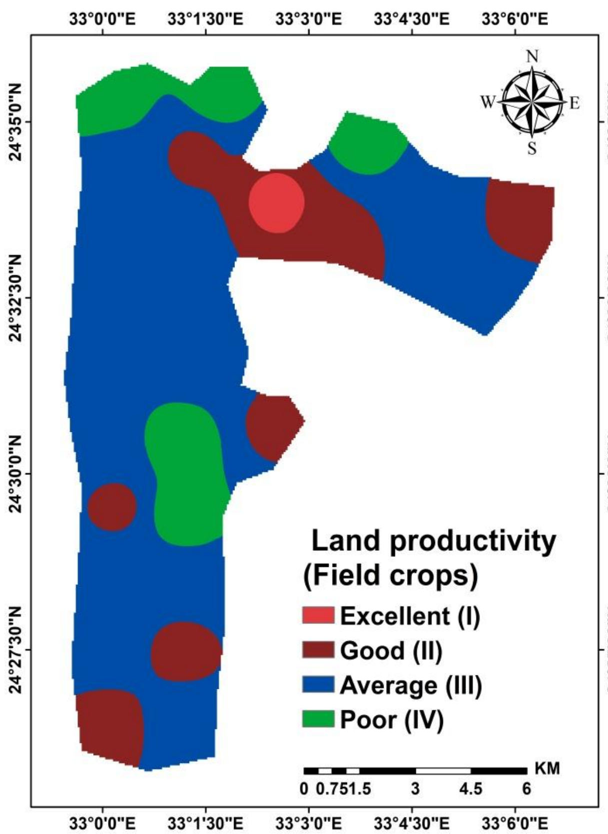

Fig. 3: Land productivity map for field crops in the study area.

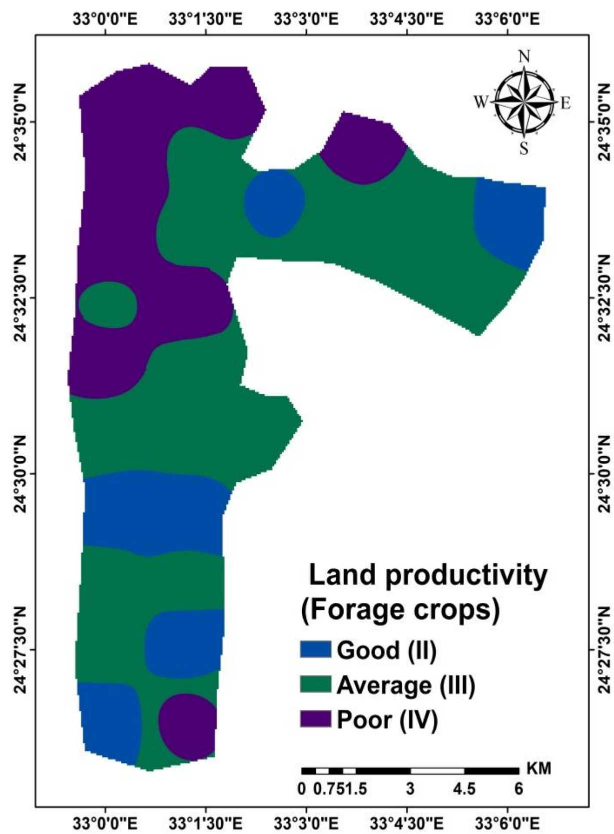

Fig. 4: Land productivity map in forage crops of study area.

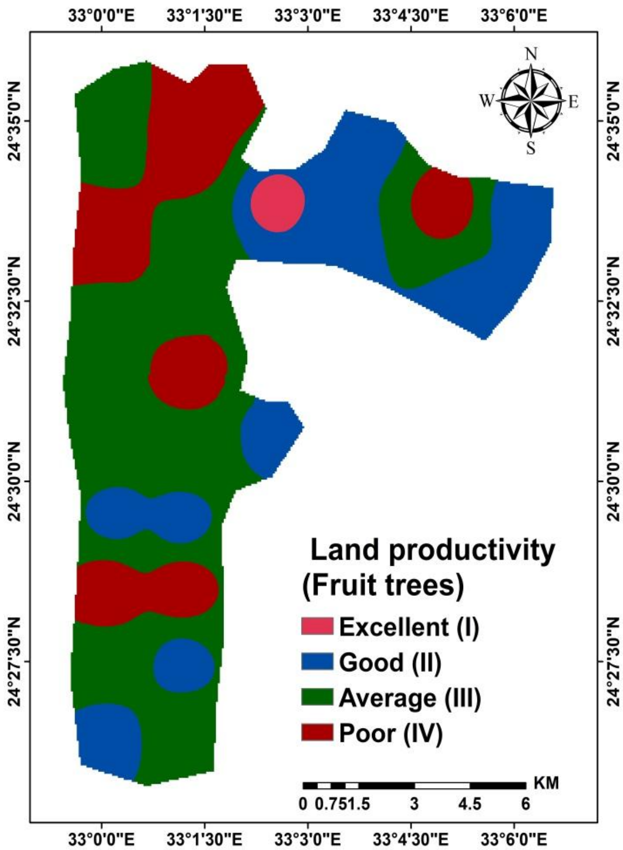

Fig. 5: Land productivity map for fruit trees in study area.

3.3. Determination of RLPI:

Table 13 and Figures 3, 4, and 5 show the classes and the area of land productivity in the study area for field crops, forage crops, and fruit trees. The area's land productivity classes range from "excellent" to "poor " due to various limiting factors. 3.70% of the area was identified as excellent for both field crops and fruit trees. Field crops were classified as good in 25.93% of the area, average in 51.85%, and poor in 18.52%. For forage crops, 22.22% of the area was classified as good, 48.15% as average, and 29.63% as poor. When it comes to fruit trees, 33.34% of the area was rated as good, 37.04% as average, and 25.93% as poor.

Table (13): Land productivity for field crops, forage crops, and fruit trees of the study area.

LSPI	Definition	field crops		forage crops		fruit trees	
		Area (hectare)	Area (%)	Area (hectare)	Area (%)	Area (hectare)	Area (%)
66-100	Excellent (I)	397.77	3.71	0	0	397.77	3.71
35-64	Good (II)	2787.64	25.93	2388.79	22.22	3584.26	33.34
20-34	Average (III)	5574.21	51.85	5176.43	48.15	3982.04	37.04
8-19	Poor (IV)	1991.02	18.52	3185.41	29.63	2786.56	25.93
0-7	Extremely Poor or nil(V)	0	0	0	0	0	0

4. Conclusion

Evaluation of the productivity of old agricultural lands is of utmost importance to maintain land productivity and achieve sustainable agricultural production in an economically viable and environmentally safe manner. It is also necessary to use modern surveying techniques and analysis tools in this field. For this reason, GIS, with its ability to collect and analyze data, is now seen as an effective and efficient tool for soil management. The study shows the effectiveness of this tool in analyzing information about land evaluation in different fields in an integrated way to understand the system. It is also very easy to update the data shared in the GIS database with greater accuracy and reliability.

Soil Limitations: Some limitations for low-grade land (Classes IV and V) can be improved. These include factors like salinity and cation exchange capacity, which can be addressed through proper soil management practices. Unfortunately, other limitations, like soil depth and texture, are permanent and cannot be corrected. These factors inherently restrict the land's potential for some uses, particularly tree growth. The study area is generally well-suited for field crops, forage crops, and fruit trees. Some of the limitations can be overcome through management, while others are inherent in the soil.

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