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ANALYZING THE GEO-SPATIAL DISTRIBUTION OF SOIL TYPES AND MORPHOLOGY IN RELATION TO LAND SLOPE IN NANDURBAR DISTRICT, MAHARASHTRA (INDIA)

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Abstract

Present research paper examines study about geo-spatial distribution of soil types and morphology in respect of land slope in Nandurbar District, Maharashtra, India. Through application of GIS along with remote sensing techniques, the research evaluates spatial variability in soil characteristics across different topographies. The results indicate that there is a strong relationship between soil types and the land slope; this observation makes evident the fact that topographical factors really affect the entire processes of soil formation and its spatial distribution pattern.

This research determination contributes to the understanding of soil-environment interactions specific to the region and is useful for sustainable land management, agricultural practices, and environmental conservation strategies. In this way, the results become a vital resource for policymakers and land-use planners in efforts to improve land productivity while preserving ecological balance in the Nandurbar District.

Keywords: Geo-spatial distribution, Soil types, Soil Morphology, Land slope.

Introduction

Understanding the complexity of soil types, morphology and land slope is important in effective land use planning, agricultural productivity, and environmental sustainability. The Nandurbar District in Maharashtra, India, stands out as an example for this kind of study because of the diversity in its topography and the variability of its soils. This region with undulating landforms and complex landforms presents a good case to study how geological formations have interplayed in the distribution of soils.

Soils are essential natural resources in ecosystems and agriculture but remain degraded under anthropogenic pressure and climatic variability. Nandurbar has its soils influenced by the geomorphologic features, climate and hydrology that have created such a variety making it an area of investigation of spatial distribution of soil types relative to the slope of the land. The present study aims to map the distribution patterns of different soil types and correlate them with varying land slopes across the district by integrating geo-spatial technologies such as Geographic Information Systems (GIS) and remote sensing.

This research attempts to fill some existing facts gaps that concern the relations of soil morphology and its variations with topographic variance and offer useful inputs toward local agricultural strategy formulation, the design of effective conservation practice programs, and policymaking concerning the land-use aspects. At bottom, an appreciation of such inter-relationships could serve to aid sustainable development with environmental resilience. The

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findings of this study may thus be a foundation for other similar analyses in other regions and improve the general global understanding of soil-landform interactions.

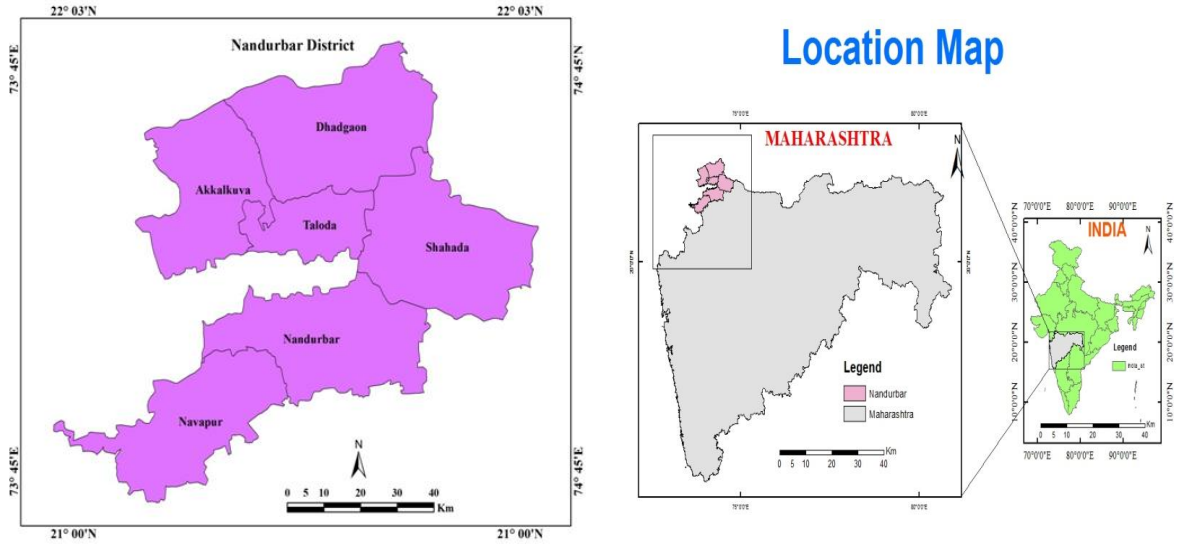
Location of Study Region

Nandurbar is located in North western tip of Maharashtra between Latitude 21°.00' North to 22°.03'North and Longitude 73°.34' East to 74°.47' East. Nandurbar district comprising of six tahsils viz. Akkalkuwa, Akrani,Talode Shahade, Nandurbar and Nawapur. The total geographical area of Nandurbar district is 5034 sq. kms. North western part Bounded by Gujarat state, North Eastern part bounded by Madhya Pradesh and South east by Dhule district.

The district has a tropical savanna climate with three distinct seasons: summer, winter, and monsoon. The average annual rainfall is around 700 mm.

The district is situated in the Satpura hill range, with an average elevation of 210 meters above sea level.

Map No.01: Location Map of the Nandurbar District.



Objectives of the Paper

The present paper's study objective is as follows:

1. To study the geo-spatial distribution of soil types and morphology and their relationship with land slope in the Nandurbar district, Maharashtra, India,

Study Methods and Material

Study Methods

Study the literature on soil types, morphological characteristics, and geographic information systems (GIS) to develop an understanding of context and current knowledge about the study area. GIS and Remote Sensing: Employ satellite imagery and GIS programs (e.g., Arc-GIS, QGIS) to develop a spatial database of the study area and examine the interaction between soil types and morphological characteristics.

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Statistical Analysis: Conduct statistical software (e.g., R, SPSS) analysis of data gathered in the field surveys and determine correlations between morphological features, soil types, and other environmental conditions.

Spatial Analysis: Apply spatial analysis methods (e.g., hot spot analysis, spatial autocorrelation) to examine the pattern of distribution of soil types and morphological features in the study area.

Data Sources and Materials

Utilize satellite images from sources like Landsat, MODIS, or Sentinel-2 to obtain information on land use/land cover patterns and soil moisture. Soil Sampling obtains soil samples from various locations within the study area for determining soil type and morphology. Obtain climate and topographic data e.g., precipitation, temperature, elevation from sources like the India Meteorological Department or the Survey of India. Gather data on environmental factors, including land use/land cover characteristics and soil morphology, through field observations.

DISCUSSION

The research article "Geo-spatial analysis of soil types and morphological features in Nandurbar district, Maharashtra" is an attempt to study the spatial pattern and morphological features of soil types in the Nandurbar district. The research use geo-spatial methods, such as remote sensing and Geographic Information Systems (GIS), to examine the soil attributes and their spatial relationships.

The Deccan Basalts traps are composed of plagioclase feldspar labrodorite as the prominent minerals. The alluvium of the Tapi and Narmada decreases in thickness in the westward direction. Black soil is formed from the trap soil, and it is highly fertile owing to its high content of plant nutrients like lime, magnesia, iron and alkalis. The traps, being large grained and fine, is not suitable for storage of ground water.

Map No.1, General soil Map of Nandurbar district.

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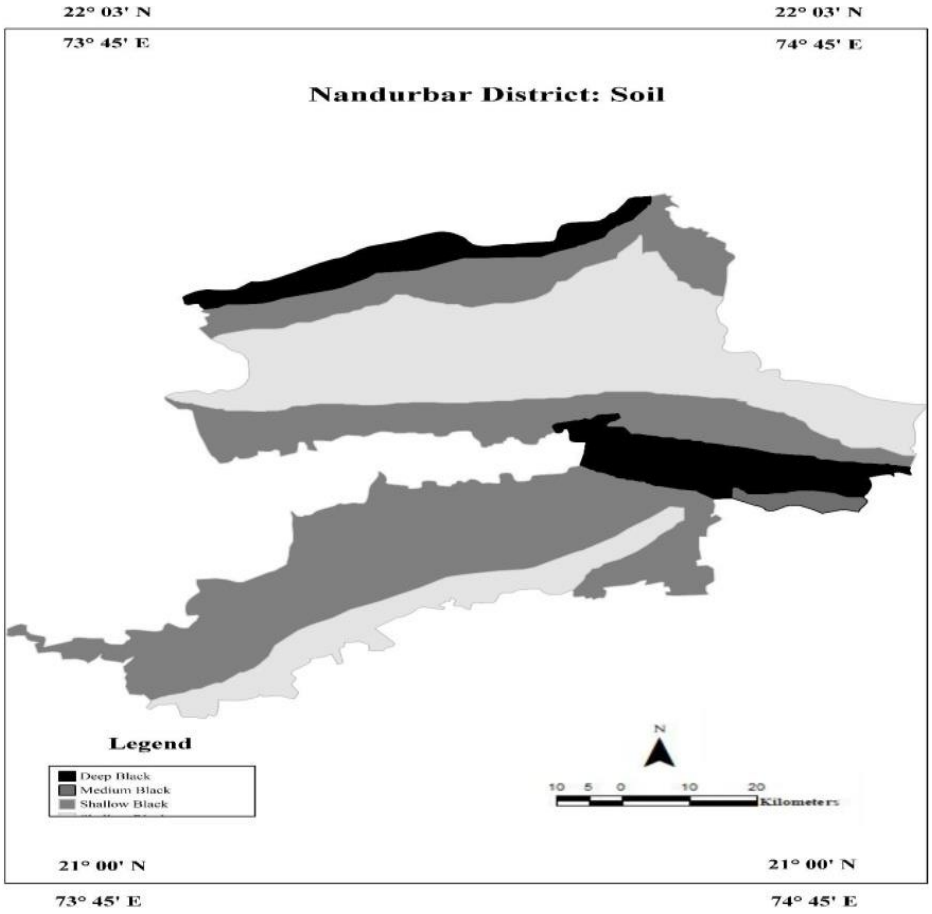

Rain water seeps and collects in the weathered parts which are the most dependable sources of groundwater in traps. No economically significant minerals are as yet reported in the area. Dense, hard and burble the trap is utilized reasonably extensively as building stone, road metal, railway ballast and as an aggregate in cement concrete.

Table No. 01. Nandurbar District Five Major Soils Categories-

Sr.	Tehsils	Very Shallow (0-7.5)		Shallow (7.5-25)		Medium Deep (25-50cm)		Deep (51-100cm)		very Deep (> 100 cm)		District Sum	
		Area	%	Area	%	Area	%	Area	%	Area	%	Area	%
1	Nandurbar	11028	3.17	111302	31.99	12375	3.56	7804	2.24	3356	0.96	145865	41.93
2	Navapur	22249	6.40	22463	6.46	22350	6.42	1847	0.53	270	0.08	69179	19.88
3	Akkalkuva	15419	4.43	17660	5.08	5398	1.55	3378	0.97	346	0.10	42201	12.13
4	Shahada	7638	2.20	5392	1.55	15559	4.47	23515	6.76	18158	5.22	70262	20.20
5	Taloda	779	0.22	2147	0.62	3774	1.08	4904	1.41	2855	0.82	14459	4.16
6	Akrani	1049	0.30	3551	1.02	1188	0.34	56	0.02	93	0.03	5937	1.71
	Total	**58162**	**16.72**	**162515**	**46.72**	**60644**	**17.42**	**41504**	**11.93**	**25078**	**7.21**	**347903**	**100**

Source: District Soil Survey and Soil testing Officer, Dhule

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Soil Categories in Nandurbar District:

The soil category evaluation throughout the distinct tehsils of Nandurbar District well-known shows a various distribution of soil sorts, every with various depths and implications for agriculture, urban making plans, and environmental management.

Overview of Soil Depth Categories:

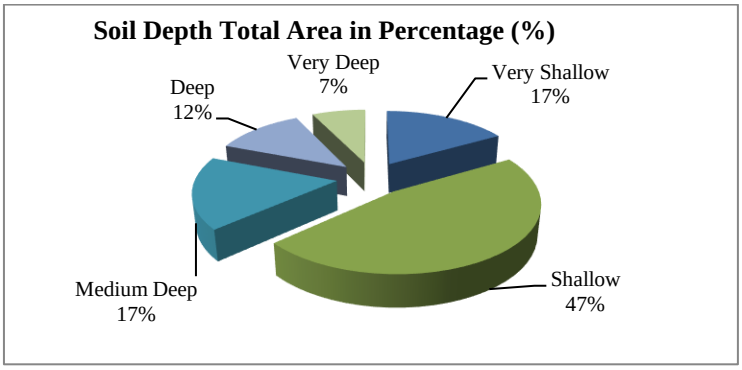
Across the full region of 347,903 hectares, the distribution of soil classes reveals the subsequent: There are five foremost classes of soils within the district. These categories consist of very shallow soils with soil intensity ranging among 0 cm to 7.5 cm, with shallow soils with depth of 7.5 to 25 cm, mild to medium soils 25 cm 50 cm, deep medium soils with 50 cm to 100 cm depth and deep block soils of more than 100 cm intensity. The soils within the districts as according to the Soil Survey Department are shown in (Table No.1& 2 fig.No.1)

Table no.2, Soil Depth Categories:

Sr.	Soil Depth Categories	Soil Depth In Cm	Total Area in Hectares	Total Area in Percentage (%)
1.	Very Shallow	0-7.5 cm	58,162	16.72
2.	Shallow	7.5-25 cm	162,515	46.72
3.	Medium Deep	25-50 cm	60,644	17.42
4.	Deep	51-100 cm	41,504	11.93
5.	Very Deep	> 100 cm	25,078	7.21
6.	**Total**		**374903**	**100**

Source: District Soil Survey and Soil testing officer, Dhule

Figure No.1. Soil Depth Total Area in Percentage (%)



Source: Compiled by researcher

The Shallow category predominates the soil depth distribution and occupies nearly half (46.72%) of the area, which implies that the majority of soils are not suitable for deep rooting crops, and this might have an effect on farming activity in this area.

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Tehsil wise Insights Nandurbar Tehsil: Area: 11028 ha 3.17%, primarily Shallow 31.99%. The existence of 3.56% Medium Deep soils suggests some crop potential for crops with deeper roots.

Navapur Tehsil: Area: 69179 ha 19.88%, also dominated by Shallow soils 6.46%, but with a greater proportion of very shallow soils 6.40%. Implies restriction in soil depth for agriculture.

Akkalkuva Tehsil: Area: 42201 ha 12.13% Shallow soils 5.08% and a moderate occurrence of Middle Deep soils 1.55%. Implies some potential for deeper-rooted plants. **Shahada Tehsil:** Area: 70262 ha 20.20% Diverse having a substantial majority of Deep 6.76% and Very Deep 5.22% soils. Well adapted for use in several agri-practices over the other tehsils. **Taloda Tehsil:** Area: 14459 ha 4.16% extremely low percentages for every category, denoting a constrained agricultural capacity.

Akrani Tehsil: Area: 5937 ha 1.71%, extremely restricted depth over categories; bordering usefulness for agriculture.

Table No.2 Nandurbar districts soil types and land slope

Sr.	Tehsils	Geographical Area	Soil Types		Land Slope			
			Major Soil Classes	Area (ha)	0-3 % (ha)	3-8 % (ha)	3.25 % (ha)	> 25 % (ha)
	1		2	3	4	5	6	7
1	Nandurbar	108224	II,III,IV	108224	50865	41125	11904	4328
2	Navapur	97668	II,III,VI	97668	23440	62507	7813	3906
3	Akkalkuva	86837	II,III,IV,VII	86837	13025	15360	42550	15630
4	Shahada	99069	II,III,IV	99069	22785	62413	11888	1981
5	Taloda	34320	II,III,VII	34320	12355	16130	4804	1029
6	Akrani	77306	IV,VI,VII	77306	3865	12368	43291	17780
	Total	**503424**		**503424**	**126335**	**209903**	**122250**	**44654**

Source: District Soil Survey and Soil testing Officer, Dhule

Examining the table no. 2 data of different tehsils in Nandurbar districts in relation to geographical areas, soil types, and land slopes provides information regarding agricultural potential, land misuse, and management. Following is a categorized analysis of the data.

The table no. 2 shows a six tehsils with certain attributes, Tehsils names and administrative regions, Geographical Area total land area in terms of hectares (ha).

Soil Types: Principal categories of soil found, designated as II, III, IV, VI, VII, etc.

Land Slope: Land classification on the basis of slope percentage to realize its topographical heterogeneity: 0-3% slope, 3-8% slope, 3.25% slope, >25% slope. Important Observations the overall area in all tehsils is 503,424 ha, indicating a considerable agricultural area that further examined for productivity and land-use efficiency. Distribution of soil type most tehsils have a mix of soil classes, with dominance of soil classes II, III, and IV. There is variation in soil types between tehsils; for instance, Akkalkuva has an extra occurrence of soil type VII, which could reflect a more diverse agricultural potential. Facts of soil types are

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important since they influence crop selection, irrigation requirements, and fertilizer applications.

Land Slope Analysis

Gentle Slopes (0-3% and 3-8%): Nandurbar contains a high percentage of land on gentle slopes (50,865 ha in 0-3%, and 41,125 ha in 3-8%), which is generally favorable for agriculture. Shahada reveals a high extent (62,413 ha) in the 3-8% slope category, indicating good scope for sustainable agriculture but potentially also subject to erosion hazards.

Steep Slopes (>25% slope): Akrani possesses the largest extent (17,780 ha) with slopes over 25%, which may restrict agricultural use due to erosion hazard, requiring soil conservation measures. Taloda's steep portions (1,029 ha) also deserve concentration for sustainable land management practices.

Comparative Analysis

Akkalkuva has a substantial area under steep slopes (15,630 ha >25%). This contrasts with tehsils like Nandurbar and Shahada, which have lower land areas with steep slopes.

Navapur and Taloda show a more significant distribution of land in the gentler slope categories, which may indicate an advantage in supporting agriculture.

Land Use and Management Implications

The data recommend the necessity for tailored agricultural strategies based on the soil and slope characteristics of each tehsil.

Areas with steeper slopes may require specialized soil conservation practices, agro-forestry, or terracing to mitigate erosion and sustain agricultural productivity.

Gentle slope areas are prime entrant for conventional agricultural practices, while those with varied soil types should be studied for specific crop suitability.

Summary and Implications

Agricultural Planning

The predominance of shallow and very shallow soils indicates a need for development strategies focusing on shallow-rooted crops, improved irrigation practices, and soil management to enhance productivity. The regions with deeper soils (especially Shahada) could focus on deeper-rooted crops.

Environmental Concerns

The shallow soil depth limits nutrient-holding capacity, impacting agricultural sustainability. Conservation efforts should prioritize soil preservation and restoration practices in regions with high percentages of shallow soils.

Resource Management

Accessibility to irrigation and inputs for nutrient retention in shallower soils is crucial. Crop rotation and the use of organic matter could be effective strategies to improve soil health.

Conclusion

The analysis gives a detailed insight into the land characteristics of the tehsils, showing areas where there are possibilities for agricultural development and areas that could

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be under careful management to avoid land degradation. This information can be critical for policymakers and agronomists when planning for sustainability and food security programs.

This soil categorization analysis in the Nandurbar district serves as a foundation for making sound agricultural, land use planning, resource management, and environmental conservation. Additional research on the particular attributes of each kind of soil and how they react to varying agriculture is an important addition that would further enrich understanding of sustainable development in the region.

Recommendations

1. The farmer's should an adopt soil conservation techniques like contour farming and terracing to minimize soil erosion and encourage sustainable land use practices.
2. The farmer's should accept crop selection and management practices be made suitable to the individual level of soil types and morphology in the district.
3. The necessity of effective irrigation management practices, considering the soil water-holding capacity and infiltration rates.
4. Government should guidance to the farmers of taking into account the geo-spatial variation of soil morphology and types while planning land use, to take on sustainable and environmentally sound land use practices.

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Other sources

1. National Bureau of Soil Survey and Land Use Planning (NBSS&LUP) - A government organization that provides information on soil science and land use planning in India.
2. Soil Survey of India - A government organization that provides information on soil survey and classification in India.
3. Indian Space Research Organisation (ISRO) - A government organization that provides satellite data and remote sensing services for various applications, including soil science and land use/land cover analysis.

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4. These references should provide a good starting point for your research paper on the geo-spatial distribution of soil types and morphology in relation to land slope in Nandurbar District, Maharashtra (India).
5. District Soil Survey and Soil testing Officer, Dhule.

Journals

1. Indian Journal of Soil Conservation - A peer-reviewed journal that publishes research articles on soil science, conservation, and management.
2. Journal of the Indian Society of Soil Science - A journal that publishes research articles on soil science, including soil morphology and classification.
3. Geoderma - An international journal that publishes research articles on soil science, including geo-spatial analysis and soil morphology.
4. Catena - An international journal that publishes research articles on soil science, including soil morphology and landform analysis.
5. Transactions of the Indian National Society of Agricultural Statistics - A journal that publishes research articles on agricultural statistics, including spatial analysis and land use/land cover studies.