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GEOGRAPHICAL NOTE

Landscape-Soil Relationship in Part of Bazargaon Plateau, Maharashtra

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ABSTRACT : A part of Bazargaon plateau under basaltic landscape in Nagpur district, Maharastra was surveyed at 1:50,000 scale to study the soil-physiographic relationship and land-use pattern. The study showed that the area comprised mainly of three micro-physiographic units, *viz*., dissected/denuded plateau, plateau-side drainage floor and entrenched valley floor. Ten soil series were identified in the area. A soil map was generated with seven mapping units at soil series association level. The study envisages that the different geomorphic features along with parent material and pedo-environment greatly influenced the type of soils formed and in turn the soil properties which affected the land use. An attempt has also been made to suggest proper land use.

Introduction

Geomorphological processes are generally complex reflecting inter-relationship among variable such as climate, geology, soils and vegetation (Buol, *et al* 1973). The Decean trap basaltic complex, which is presumed to have gone through various denudational processes causing the various physiographic entities are the remnants of the "landscape reduction process", retained after several erosional cycles (Subramanyan, 1981). The relationship between various physiographic positions and soils determine the pedological processes, which may have acted jointly to produce the present day landscpae. It is well known that different geomorphic features in conjunction with type of parent materials influence greatly the type of soils formed in topographic sequence under specific geo-pedological environmental conditions which is extensively documented (Kantor and Schwertmann, 1974, Beckmann *et al.*, 1974, Das and Roy, 1979). The changes in the characteristics of shrink-swell soils with variations in climatic conditions as well as physiographic positions in the Deccan basaltic terrain has been shown by Prasad *et al* (1989) and Bhattacharyya *et al* (1993). Similar type of soils may also be formed from different geological formations, however, with some minor dissimilarities in soil characteristics (Subramanian, 1993). In contrast, a parent material may give rise to different soil having variability in depth, texture, available water holding capacity, infiltration rate and also land use under different pedo-environments (Yadav *et al.*, 1998). This landscape soil relationship may be utilised for proper understanding of soil and other edaphic conditions of a region (Vink, 1975). Such relationship is known to be advantageous in terms of extrapolation of data and faster soil mapping (Pofali *et al.* 1979 ; Sharma *et al.* 1988). Many workers have shown that soils and landscapes are often good indicators of vegetation of region (Bhattacharyya *et al.*, 1992). However, landuse pattern of a particular region, especially

Vidharbha region, owes its uniqueness to non-soil factors. Therefore, this study is an attempt to understand the landscape-soil associations with landuse in this part of Bazargaon plateau.

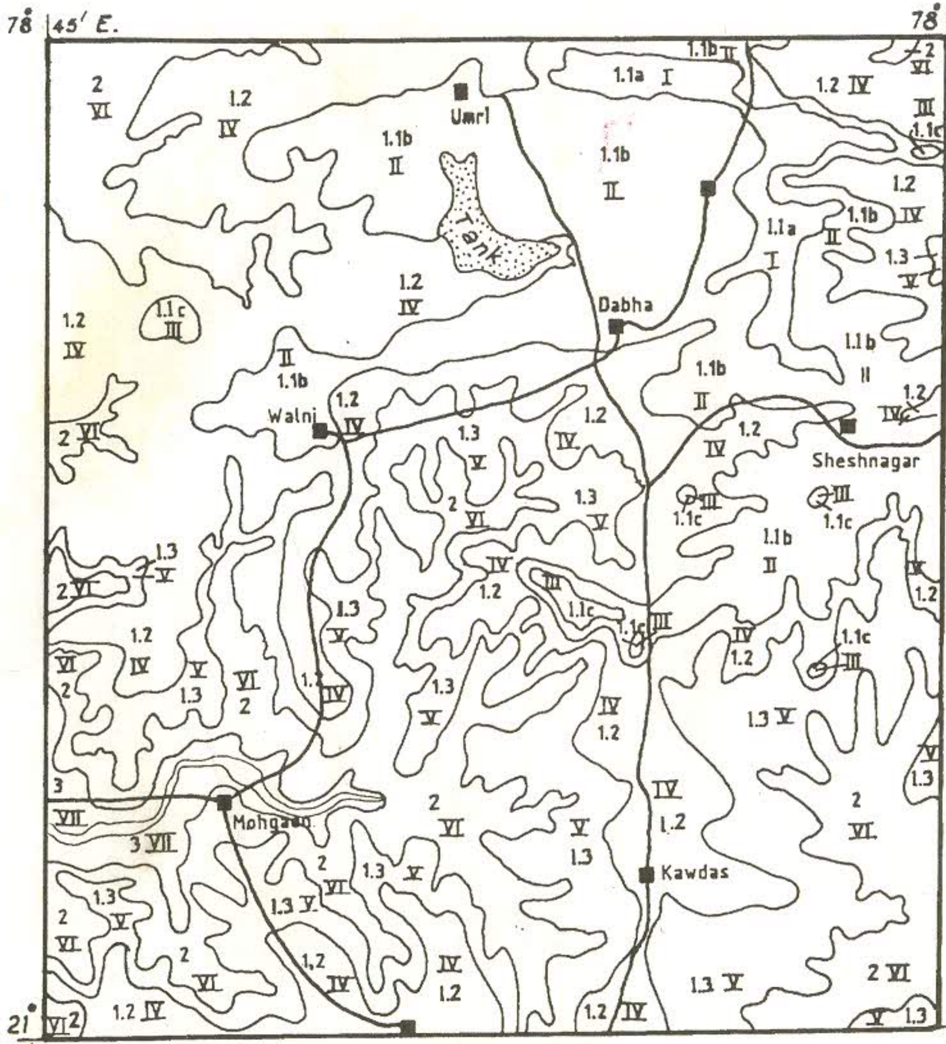
Materials and Methods

The study area lies between 78°45' and 78°50'E longitude and 21°00' and 21°05'N latitude (Fig. 1). The elevation ranges from 464 m above mean sea level at the summit crests to 360 m above mean sea level at the entrenched valley floor. Geologically the area is covered by basaltic lava flow of Lower Eocene to Upper Cretaceous, commonly known as "Traps". The area enjoys semi-arid moist sub-tropical type of climate with mean annual temperature of 27.2°C. The mean summer soil temperature is 30.9°C. The mean winter soil temperature is 24.1°C. The area comes under hyperthermic temperature regime. The mean annual rainfall is 1127 mm of which about 89 per cent is received during the south-west monsoon (June-Oct.). The natural flora of the area dominantly comprises of palas (*Butea frondosa*), teak (*Tectona grandis*), babul (*Acacia arabica*), ber (*Zizyphus jujuba*), kans (*Saccharum spontaneum*), kusal (*Heteropogan contratus*) etc.

The physiographic units were delineated using Survey of India toposheet of 1:50,000 scale. These physiographic units were checked by traversing on ground and then the final physiographic map was generated (Fig 1). A reconnaissance soil survey was carried out following standard methodology. Soil profiles were excavated in each physiographic unit and the soil morphological characteristics were studied systematically as enunciated by All Indian Soil and Land Use Survey Staff (1970) and Soil Survey Division Staff (1997). After correlation, soil series namely Dhaba-1 (P1), Dhaba-2, Sukli (P2), Yerangaon (P6), Agargaon (P10), Dhaba-3 (P12), Walni-1, Walni-2 (P9) and Mohegaon (P15) were identified and their association made for a particular physiographic unit and finally a soil map of the study area was prepared (Fig. 1). Soils were classified according to Keys to Soil Taxonomy (Soil Survey Staff, 1998). Present land use data for each landscape was also collected.

Result and Discussion

Physiographic analysis of the area showed three broad units, *viz.* (i) dissected/denuded plateau, (ii) plateau side drainage, and (iii) entrenched valley. The dissected/denuded plateau was further subdivided based on topographic position as (a) summit, (b) lower plateau, and (c) shoulder slope. The summit was further divided based on contour pattern and position in toposequence, gradient and length of slope into summit crest, table top summits and isolated mounds (Fairbridge, 1968). An empirical diagram depicts the major soils occurring on different physiographic unit (Fig. 2). The morphological properties of the soils and present and suggested land-use for dominant soil series are described (Table 1). The geomorphology, site and soil chararecteristics and social needs of the people influenced the land use of the area. Due to occurrence of the isolated mound (1.1c) in patches with small area and stoniness and stony shoulder slopes restricted the farmers to cultivate these lands and hence these are still under forests. In contrast, the comparable soils of other physiograpic units are being cultivated for different crops. This is possible because



INDEX

Physiography-Units	Soil Units	Physiography	Soil Series
1.1 a	I	Summit Crest	Sl-Db-2
1.1. b	II	Table top	Db-1-Db-2
1.1. c	III	Isolated mounds	Yg-Kd
1.2	IV	Lower slopes	Db-3-Wl-1 -Db-3
2	VI	Plateau side drainage	Wl-2 Db-3
3	VII	Entrenched valley	Mg-Wl-1

0 1 km

INDEX

Metalled road

Kachcha road

1.2 Soil Boundary

Village

Fig. 1. Physiographic and soil mapping units.

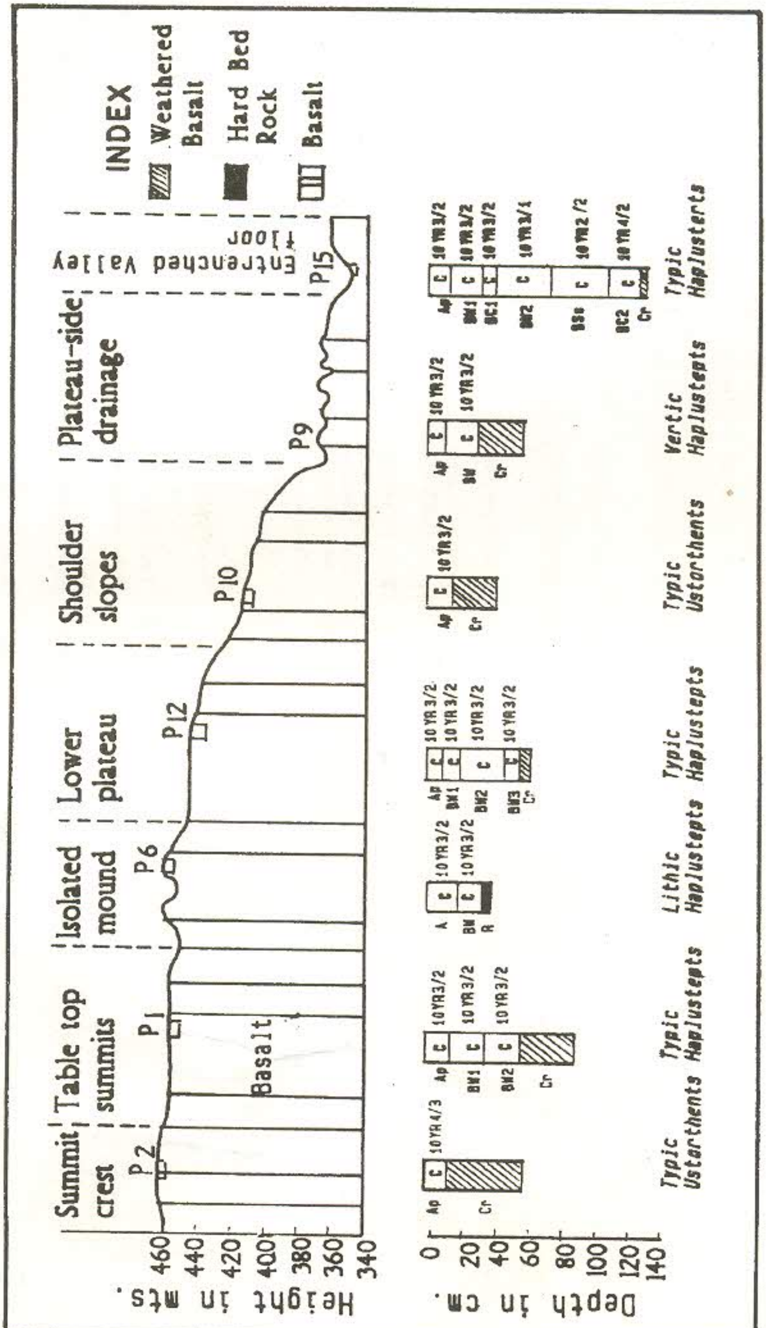


Fig. 2. Pedo-geomorphic Relationship.

TABLE 1. Morphologial properties ; present and suggested land use.

Physio-graphic Unit	Soil Series association	Elevation (m)	Slope per cent	Depth range (cm)	Tex-ture	Struc-ture*	Munsell Colour**	Soil taxonomy	Land capability sub-class	Present Landuse	Suggested Land Use
1.1.a	*Summit Crest* (Sl-Db-2)	460-465									
	Sl		1-3	11-15	clay loam	m2sbk	10YR 3/2	Typic Ustorthents	IVes	Cotton, pigeonpea	Agri-horti-silvicul-tural system
	Db-2		1-3	15-20	clay	m2sbk	10YR 3/2	Typic Ustorthents			
1.1.b	*Table top summit* (Db-1-Db-2)	455-460									
	Db-1		3-5	28-35	clay	m2sbk	10YR 2/2	Typic Haplustepts	IIIes to IVes	Cotton, pigeonpea, sorghum	Sorghum, pigeon-pea, bajra, sunflower safflower, sesamum
	Db-2		3-5	15-20	clay	m2sbk	10YR 3/2	Typic Ustorthents			
1.1.c	Isolated mounds (Yg-Kd)	450-465									
	Yg		1-3	30-37	clay	c3sbk	10YR 3/2	Lithic Haplustepts	VIes	Forest (Teak, palas)	Forestry development
	Kd		1-3	35-40	clay	m2sbk	5YR 4/4	Typic Haplustepts			
1.2	*Lower plateau* (Db-3-Wl-1-Db-2)	430-450									
	Db-3		1-3	40-52	clay	c3sbk-abk	10YR 3/2	Typic Haplustepts	IIIes-IVes	Cotton pigeonpea	Sorghum, bajra, sunflower, safflower
	Wl-1		3-5	10-12	clay	m2sbk	10YR 3/2	Lithic Ustorthents			
	Db-2		3-5	15-20	clay	m2sbk	10YR 3/2	Typic Ustorthents			
1.3	*Shoulder Slopes* (Ag-W1-1-Db-3)	380-430	3-5	10-15	clay	m2sbk	10YR 3/2	Typic Ustorthents	VIes	Thin decidu-ous forest	Afforestation, social forestry
	Wl-1		3-5	10-12	clay	m2sbk	10YR 3/3	Lithic Ustorthents			
	Db-3		3-5	40-52	clay	c3sbk-abk	10YR 3/2	Typic Haplustepts			
2	*Plateau side drainage* (Wl-2-Db-3)	370-380									
	Wl-2		3-5	58-60	clay	m2sbk-abk	10YR 3/2	Vertic Haplustepts	IIIes	Cotton, pigeonpea, sorghum	Sorghum, bajra, sunflower, safflower, pigeon-pea, vegetables, mustard, gram, wheat
	Db-3		3-5	40-52	clay	c3sbk-abk	10YR 3/2	Typic Haplustepts			
3	*Entrenched valley* (Mg-Wl-2)	350-370									
	Mg		1-3	130-135	clay	m3sbk-abk	10YR 3/2	Typic Haplusterts	IIIs	Cotton, pigeonpea, citrus	Cotton, pigeon-pea, citrus, vegetables, mustard, gram, wheat
	Wl-2		1-3	58-60	clay	m3sbk-abk	10YR 3/2	Vertic Haplustepts			

* Soil structure is designated in terms of type, grade and size. The sbk and abk refers to subangular and angular blocky type structure, respectively. The size of the individual peds is presented by m (medium 10 to 20 mm) or by c (coarse 20 to 50 mm) in present case. The numericals 2 and 3 represents grade of structure as moderate and strong respectively.

** The Munsell notation for colour consists of separate notations for hue *e.g.* (10YR), value (3), and chroma (2) which are combined in that order to form the colour designations. *e.g.* very dark reddish brown ; 10YR 3/3 (dark brown) ; 10YR 4/4 (reddish brown).

of the farmers access to these lands (to cultivate more area), irrigation facilities and intensive agromangement (seeds, fertilisers etc.), which further aggravate the problems of erosion, etc. in these marginal lands.

Execpt pedons of two soil series namely Walni-2 (Vertic Haplusteps) and Mohegaon (Typic Haplusterts) all are non-calcarious. The pH of the Kawdas soils varies from 6.6 to 6.8 (neutral) through depth. The other non-calcarious soils had pH varying from 7.4 to 7.8 (slightly alkaline). The pH range in calcareous soils is 8.5 to 8.7 (strongly alkaline). Hence when all the soils are developed over basalt or basaltic alluvium, the very first weathered basalt are expected to be clay. Expect Sukli soils which had clay loam texture (25-28 per cent clay) occurring on eroded surface, other soils are clayey. These soils are water retentive and available water holding capacity (AWC) is very low to high depending upon depth and clay content of the soils. The cation exchange capacity of soils ranged from 20-25 cmol (p+) per kg in Kawdas and Sukli soils and more than 40 in other soils.

Dissected/Denuded plateau

Summit crest

It occupies the top most portion of the landscape and are sinuous, narrow and constricted in nature. Though the surface of the crest area is extremely flat, its sides show sharp discontinuties with the surrounding units. This may be because of differeence in basaltic flow and the summit crest is occupied by the youngest basaltic flow.

In this physiographic unit, Sukli (Sl) soils are found in association with Dabha (Db-2) series ; the former being the dominant soil. Sl soils are very shallow, somewhat excessively drained, dark yellowish brown, loamy and has subangular blocky structure underlain by weathered basalt. These soils are classified as loamy, mixed, hyperthermic family of Typic Ustorthents. Db-2 soils are also very shallow but belong to the family of Clayey, smectitic (calcareous), hyperthermic Typic Ustorthents. The landscape soil relationship shows that being positioned at the highest point than the surroundings, soils are more prone to be eroded from site giving rise to very shallow soils.

Table top summits

This unit has extreme flatness and long slope length which favoured deep weathering due to relatively greater stability than summit crests. Numerous stones of varying dimensions indicate the haphazard joint patterns and fracture zones. Slope wash and sheet flow are predominant in this area, incipient gullies and shallow rills dominate this unit.

Dabha-1 (Db-1) soil are found in association with Dabha-2 (Db-2) soils. Db-1 soils are moderately deep, dark greyish brown with subangular blocky structure. With increasing depth, the soil structure tends towards angular blocky. It belongs to the family of fine, smectitic, hyperthermic Typic Haplustepts. The characteristics of Db-1 soils suggest that there is a greater degree of stability as shown by greater depth, higher degree of weathering and improved structure of table top summit soils.

Isolated Mounds

This unit is mostly circular and influenced by circumdenudation as the dominant geomorphic process. They are relict in nature and are remnants of erosion due to the parallel retreat of slope from all directions.

Yerangaon (Yg) soils are found in association with Kawdaṣ (Kd) soils. Yg soils are shallow, clayey, well drained, very dark greyish brown in colour with subangular blocky structure. The cambic horizon is followed by lithic contact. It belongs to the family of clayey, smectitic, hyperthermic Lithic Haplustepts. Soils of Kd series are shallow, well to somewhat excessively drained, clayey in texture and reddish brown in colour. The structure is subangular blocky however, granular structure exists above the weathered basalt strate. It belongs to the family of clayey-skeletal, smectitic, hyperthermic Typic Haplustepts. The colour of the soils being an indicator of the degree of weathering may suggest that the soils of the mounds have undergone higher degree of weathering than the previous two geomorphic units (Beckmann *et al.*, 1974) due to the shape of the geomorphic unit.

Lower plateau

The gradient is slightly increased and the slope lengths are comparatively shorter. Severe sheet and slope wash are the dominant geomorphic processes operating in this unit. It has a shallow weathering zone due to excessive erosion.

Dabha (Db-3) soils are found in association with Walni (Wl-1) and Dabha-2 (Db-2). Db-3 soils are shallow, well drained, clayey, very dark greyish brown, subangular blocky structure and belonging to the family of clayey, smectitic, hyperthermic Typic Haplustepts. Weathered basalt *i.e.* saprolite is present underlying the Bw horizon. The soils of Wl-1 series are very shallow, well drained, clayey, very dark greyish brown in colour, with subangular blocky structure. The surface horizon is immediately followed by weathered basalt *i.e.* saprolite underlained by hard rock. It belongs to the family of clayey, smectitic, hyperthermic Lithic Ustorthents. Db-2 soils are inclusion (< 15 per cent coverage) in this association. From the description of the geomorphic unit, it is noticed that the soils are shallow due to increased gradient, shorter slopes and runoff lengths as shown by the soils of the unit, *viz.*, Db-2, Db-3 and Wl-1 all of which are shallow to very shallow with a shallow weathering front.

Shoulder slopes

Below the lower plateau, a restricted and elongated area is occupied by shoulder slopes. The slopes and the gradient are steeper with short slope length. The weathering products produced in this zone are immediately eroded down the slopes thereby rendering this area permanently skeletal.

Agargaon (Ag) soils are found in association with Walni (Wl-1) soils and Dabha (Db-3) soils in this physiographic unit. The soils of Agargaon series are very shallow, clayey, well drained, dark brown, subangular blocky structure and belonging to the family of clayey, smectitic, hyperthermic Typic Ustorthents. Being at the fringes of two broader physiographic units and higher gradient, this unti is more eroded than the lower plateau and suggests a good relationship between the two factors (Sharma and Roychoudhuri, 1988).

Plateau side drainage

This unit occurs below the shoulder slopes and is occupied by alternating spur slopes. Small tributaries originating from the edge of the plateau integrates into second and third order stream network forming plateau side drainage. This unit consists of areas having alternate wet and dry zones, due to which differential weathering occurs between these two contrasting zones.

Walni (Wl-2) soils are found in association with Dabha-3 (Db-3) soils. Wl-2 soils are moderately deep, clayey, moderately well drained, very dark greyish brown with subangular blocky structure. The Bw horizon is followed by a layer of weathered basalt belonging to the family of fine, smectitic, hyperthermic, Vertic Haplustepts. The soils observed in this geomorphic unit shows that due to better depositional environment, the soils are relatively deeper with high clay content and well developed soil structure.

Entrenched valley

This unit occurs as a narrow zone and occupies the lowest portion on the toposequence from the plateau summit. All the plateau side drainage valleys are further integrated, extended and abstracted to form a valley floor which is entrenching itself into the plateau side. This unit has got a very narrow flood plain. By virtue of its lowest location it is permanently moist both by the overland flow and seepage. This unit consists of colluval-alluvial fills at places.

Mohegaon (Mg) soils are found in association with Walni (Wl)-2 soils in this physiographic unit. The Mohegaon soils are deep, clayey, moderately well drained, very dark greyish brown with structure varying from subangular to angular blocky. Slickensides which are indicative of shrink-swell phenomenon in deep black soils are present in these soils (Soil Survey Staff, 1975). These soils are underlain by basaltic saprolite at a depth of 130 cm suggesting that the weathering is very active. On the other hand, deposition of alluvium as well as colluvium is continuing in an irregular fashion as shown by the horizon sequence of Mg soils. The Mg series soils belongs to the family of fine, smectitic (calcareous), hyperthermic, Typic Haplusterts.

Land Capability and Land use

The land capability classification (Klingebiel and Montgomery, 1961) is an interpretative grouping made primarily for agricultural purposes. Depending on effects of combinations of climate and permanent soil charecteristics on risks of soil damage, limitation in use, productive capacity and management requirement, the study area has been classified under arable class (III to IV) and non-arable class VI with sub-classes IIIsw, IIIes and IVes associated with limitations, e(water erosion), s(soil depth), w(drainage) and accordingly control measures and an appropriate land use have been suggested (fig. 3).

The soils of summit crest with land capability class IVes are under cultivation. Cotton, which is a deep rooted crop is grown here under rainfed conditions leads to low productivity because of intermittent dry spells and moisture stress during the growth phases. Pigeonpea is also intercropped with cotton with a similar fate. The prevailing cropping system is very risky under rainfed condition and need to be discouraged. However, plantation of custard apple is recommended (Jagdish Prasad *et al* 1995) or it can be put under permanent cover of grasses like sedwa or sheda (*Sehima nervosum*), anjan or kusa (*Cenchrus ciliaris*), etc.

The soils of table top summits having the land capability class IIIes-IVes are under sorghum, cotton and pigeonpea cultivation. The lack of enough solum depth is a deterrent for high production of cotton and pigeonpea. Wheat and gram are cultivated during *rabi* in small pockets under irrigation with low productivity. These crops can be grown under intensive soil and water conservation like bunding, and mulching, etc.. The inclusion of multipurpose trees preferably legumes may prove to be advantageous under agro-forestry.

The lands in isolated mounds are put under land capability sub-class (VIes) due to the limitations of water erosion and associated with stoniness. The land is presently under forest mostly of teak (*Tectona grandis*) and palas (*Butea monosperma*) These lands can be put under fast growing species of teak and other multi-purpose trees. Uncontrolled grazing is to be restricted.

These arable lands of lower plateau are classified under land capability sub class (IIIes-IVes) which are moderate to good lands but pose limitations of water erosion and soil characteristics. The climatically and adapted crops like cotton, pigeonpea can be grown under proper agro-management, however these lands are better suited for agro-forestry.

The lands on shoulder slopes fall under non-arable land capability class (VIes) with thin deciduous forest. The slope gradient being steeper, erosion would be more pronounced leading to further degradation of the soil present. Therefore, the development of the forest cover and or grasses are the need of the hour to stabilise the terrain and eco-restoration for sustained production.

The lands on plateau side drainage floor with land capability class IIIes are mostly cultivated lands. The crops grown are cotton, pigeonpea, sorghum with low to medium productivity. However, the productivity of these crops can be enhanced through appropriate agro-management and water conservation measures.

The lands on entrenched valley floor is grouped under IIIs land capability class and cultivated to cotton, pigeonpea and irrigated citrus. These are productive soils but under continuous downpour or flood irrigation pose problems of drainage which restrict the choice of crops. The drainage of the soils can be improved through different practices otherwise in course of time these may develop sodicity.

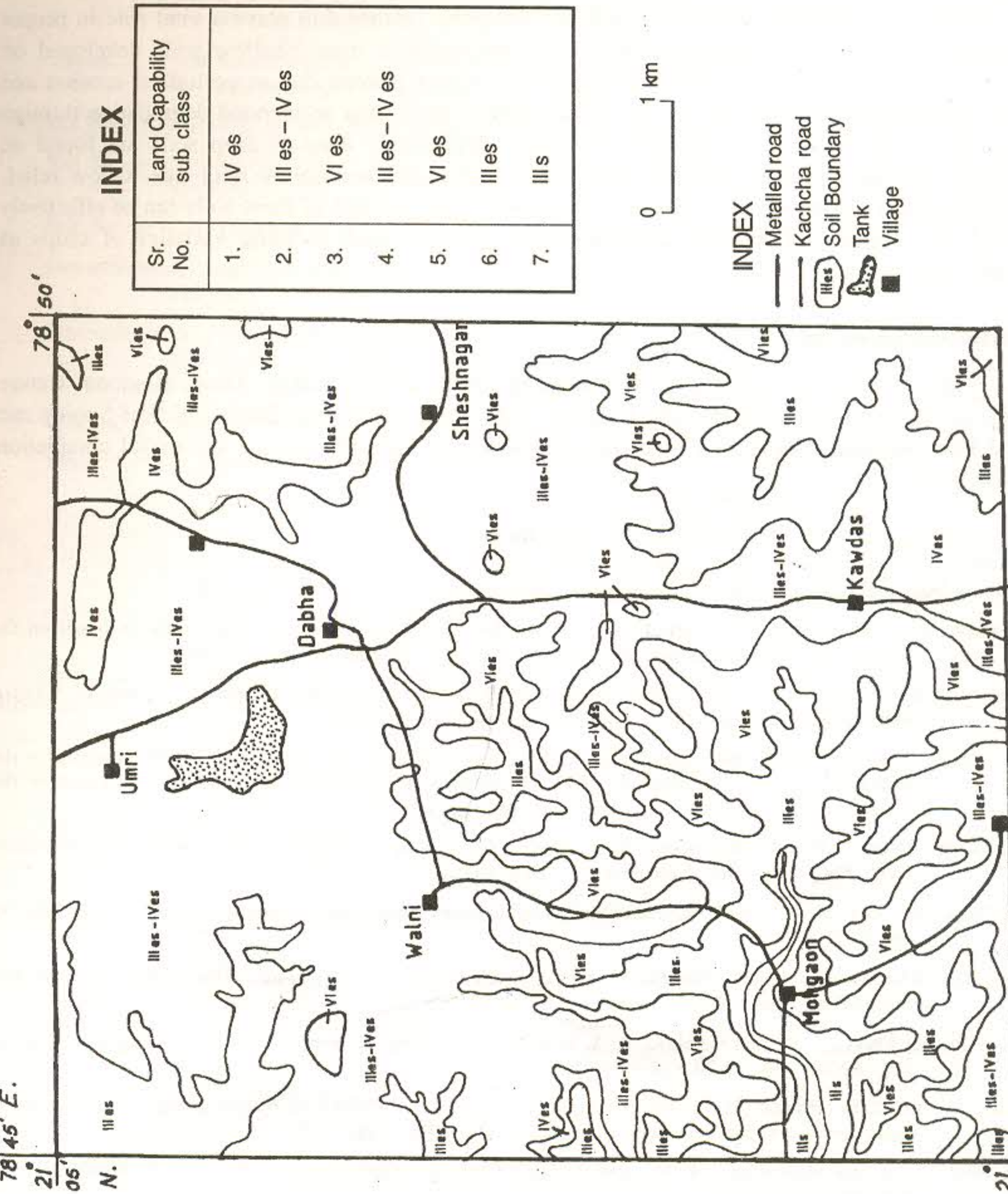


Fig. 3. Land Capability map of Part of Bazargaon Plateau.

Conclusion

The present study reveals that soil-physiography relationship plays a vital role in proper understanding of soil and its potential for various kinds of uses. Shallow soils developed on sumit crest, isolated mounds, shoulder slopes and lower plateau due to periodical erosion and slow weathering processes require special attention to check the accelerated degradation through afforestation and run-off management structures. Moderately deep to deep soils are found on table top summits, plateau side drainage slopes and entrenched valley floor due to low relief, high infiltration rate and active weathering processes. The potential of these soils can be effectively tapped by adoption of modern techniques and growing high yielding varieties of crops as suggested.

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