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Detailed Arable Land Soil Characterization of Kolasib District, Mizoram: An Insight

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Introduction

Soil characterization is a critical component of agricultural science as it provides a systematic framework for classifying and understanding soils. This knowledge is essential for optimizing agricultural practices, ensuring sustainable resource use, and supporting environmental conservation. Comprehensive scientific data on soil resources in diverse agroecological zones of India through Land Resource Inventorization (LRI) is essential. The Land Resources Inventory (LRI) utilizes geospatial methodologies to provide extensive spatial data, enabling the recognition of minor components such as landforms, soil classifications, soil-landform relationships, and more terrain-related details. This level of specificity improves decision-making and strategic planning. The overuse of fertilizers and their uneven application lead to soil pollution, threaten food security, degrade soil and water quality, and endanger human health. The northeastern hilly regions of India exhibit incredible biodiversity, substantial phyto-forest biomass, and varied climatic conditions marked by abundant rainfall and prolonged growing seasons. However, deforestation, agricultural alterations, soil erosion, nutrient depletion, water scarcity, soil acidity, micronutrient deficiencies, and an overall deterioration in soil quality negatively impact the region (Deb Roy *et al.*, 2024). Initiatives were undertaken to examine and characterize the soils of Mizoram at a scale of 1:2,50,000 by Maji *et al.* (2001). The map's limitations for delineating mapping units are particular, signifying the correlation of dominant and subdominant soils without explicit distribution boundaries. Nonetheless, comprehensive soil data is still lacking in substantial areas of the research region.

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Therefore, a land resource inventory at a 1:10,000 scale, employing geospatial approaches, is performed to characterize soil resources and establish the relationship with the landform in the Kolasib District, Mizoram.

Methodology

The study was conducted in the Kolasib district of Mizoram, which lies between 23°45′N to 24°50′N latitude and 92°28 ′E to 93°E longitude, covering an area of 1518.45 km^2. Elevations varied from 33 to 1410 m in the Kolasib district, mainly comprised of N–S trending steep, hilly ranges and narrow valleys in a few patches (Fig. 1). The prevailing climate is warm to hot and humid to perhumid, with an average annual precipitation of 2892 mm (Lalzarliana, 2014).

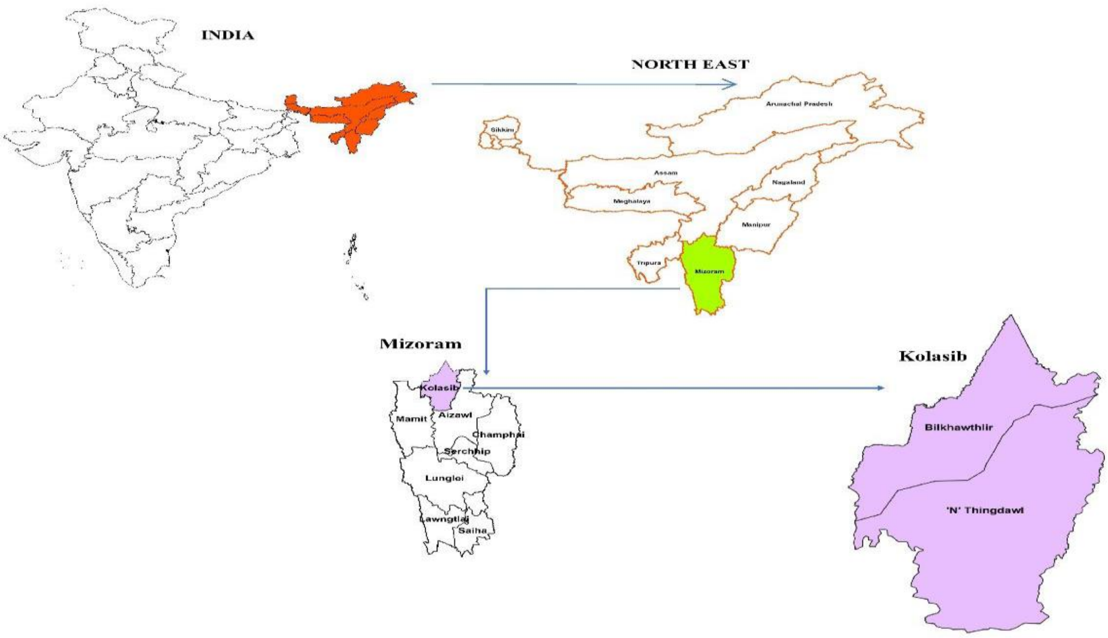

Fig. 1. Location map of the study area

A detailed soil survey (at 1:10,000 scale) was undertaken to characterize the Kolasib district's arable land soils. Before the soil survey fieldwork, a base map or landscape ecological unit (LEU) map was prepared, considering landform, land use/land cover, and slope. Landform analysis was carried out using elevation information available in the DEM (10 m) using ArcGIS software. The landform, slope and land use/land cover layer were overlaid in ArcGIS to generate landscape ecological units (LEU) map. A detailed soil survey was carried out to study the soil's field morphology. One hundred soil profiles and 250 auger observations were studied from selected transects (arable lands only). To study the soil-landform relationship transects from higher elevation to lower elevation representing all landforms and geological formations were selected. After field correlation, representative soil pedons from each landscape ecological unit falling under the arable lands category were selected and analyzed for important soil physical and chemical properties in the laboratory to establish the soil-landform relationship. Soils were classified according to Keys to Soil Taxonomy, Soil Survey Staff (2014), USDA.

Soil landform relationship

The soil landform relationship was identified during soil resource inventory generation in the arable land of Kolasib district, Mizoram (Fig. 2). The study area qualified for *udic* soil moisture as the soil control section is not dried in any part for as long as 90 cumulative days in normal years and *thermic* soil temperature regimes because the mean annual soil temperature is 15° C or higher but lower than 22° C, and the difference between mean summer and mean winter soil temperatures is 6° C or more either at a depth of 50 cm below the soil surface or at a densic, lithic, or paralithic contact, whichever is shallower. Hence, all the soils were classified under *udic* and *thermic* at suborder and family levels.

Bhuchang Series (BHG):

The Bhuchang *series* are found on the valley plains (40-60 m) with agricultural cropland. The soils have a 0 to 1% slope and are developed from shale, limestone, and sandstone parent material. The soils are very deep (> 150 cm), and the trend of clay content was irregular with an increase in soil depth. Soils of Bhuchang (*Endoaquepts*) vary from dark grey to grey on the surface horizon, whereas grey was observed in the subsurface horizons. These soils' base saturation (%) is moderate, ranging from 49 to 64% at the surface horizon and 48 to 82% at the subsurface horizons. The horizon sequence is of Apg-Bg1-Bg2-Bg3-Bg4 type.

Chempai Series (Chi):

The Chempai series are found on the valley plains (50-130 m) with agricultural cropland. The soils have a 0 to 1% slope and are developed from shale, limestone, and sandstone parent material. The soils are deep (100-150 cm), and the trend of clay content was irregular with an increase in soil depth. Soils (*Dystrudepts*) vary from brown to yellowish brown on the surface horizon, whereas brown to brownish yellow was observed in the subsurface horizons. These soils' base saturation (%) is moderate, ranging from 24 to 38% at the surface horizon and 22 to 51% at the subsurface horizons. The horizon sequence is of A1-Bw1-2Bw2-3Bw3 type (Lithological discontinuity).

Vengthar Series (VNR):

The Vengthar series are found on the ridge and rolling valley plains (75-250m) with plantation cropland and some areas under shifting cultivation. The soils have a 0 to 10% slope and are developed from the parent material of shale, limestone, and sandstone types. The soils are deep (100-150 cm), and the trend of clay content was moderate to high in content but irregular with an increase in soil depth. Soils of Vengthar (*Dystrudepts*) vary from dark brown to brown on the surface horizon, whereas reddish brown to yellowish brown was observed in the subsurface horizons. These soils' base saturation (%) is moderate, ranging from 32% to 46% at the surface horizon and 14% to 82% at the subsurface horizons. The horizon sequence is of A1-Bw1-Bw2-Bw3 type.

Hortoki Series (HTK):

The Hortoki series are found on the valley plains (50-75 m) with agricultural cropland, and some areas are under fallow land. The soils have a slope of 0 to 1% and are developed from the parent material of shale, limestone, and sandstone types. The soils are deep (100-150 cm), and the trend of clay content was moderate to high in content but irregular with an increase in soil depth. Soils of Hortoki (*Endoaquepts*) vary from dark grey to grey on the surface horizon, whereas grey to greyish brown was observed in the subsurface horizons. The horizon sequence is of Apg-2Bg1-2Bg2-2Bg3-3Bg4 type with lithological discontinuity.

Nisapui Series (NSP):

The Nisapui soil series are found on the high structural hills (> 700 m) under shifting cultivation. The soils have a 10 to 25 % slope and are developed from shale, limestone and sandstone parent material. The soils are deep (100-150 cm), and the trend of clay content was moderate to high in content but increased along the soil depth. Soils of Nisapui (*Hapludults*) vary from dark brown to dark yellowish brown on the surface horizon, whereas yellowish red to yellowish brown colour was observed in the subsurface horizons. These soils' base saturation (%) is moderate, ranging from 19 to 44% at the surface horizon and 11 to 40% at the subsurface horizons. The horizon sequence is of the A1-Bt1-Bt2 type.

Lungmuat Series (LGT):

The Lungmuat soil series are found on the moderate structural hills (300-450 m) under shifting cultivation. The soils have a 10 to 15 % slope and are developed from shale, limestone and sandstone parent material. The soils are very deep (>150 cm), and the trend of clay content was moderate to high in content but increased along the soil depth. Soils of Lungmuat (*Kandiudults*) vary from brown to dark yellowish brown on the surface horizon, whereas yellowish red to strong brown colour was observed in the subsurface horizons. These soils' base saturation (%) is moderate, ranging from 34 to 65% at the surface horizon and 14 to 56% at the subsurface horizons. The horizon sequence is of the A1-Bt1-Bt2 type.

Zanlawn Series (ZWN):

The Zanlawn soil series are found on the low to high structural hills (450-700 m) under shifting cultivation, plantation and homestead plantation. The soils have a 10 to 25 % slope and are developed from shale, limestone and sandstone parent material. The soils are deep (100-150 cm), and the trend of clay content was moderate to high in content but increased along the soil depth. Soils of Zanlawn (*Haplohumults*) vary from brown to dark yellowish brown on the surface horizon, whereas yellowish red to strong brown colour was observed in the subsurface horizons. These soils' base saturation (%) is low to moderate, ranging from 24 to 55% at the surface horizon and 14 to 46 % at the subsurface horizons. The horizon sequence is of A1-Bw1-Bt1 type.

Saihapui Series (SHP):

The Saihapui soil series are found on the low structural hills (250-350 m) under shifting cultivation. The soils have a 10 to 15 % slope and are developed from shale, limestone and sandstone parent material. The soils are very deep (>150 cm), and the clay content trend was moderate but increased along the soil depth. Soils of Saihapui (*Hapludalfs*) vary from reddish brown to brown on the surface horizon, whereas strong brown to dark yellowish-brown colour was observed in the subsurface horizons. These soils' base saturation (%) is low to moderate, ranging from 25 to 65% at the surface horizon and 30 to 60% at the subsurface horizons. The horizon sequence is of the A1-Bt1-Bt2 type.

Eight soil series and thirty-five phases of soils (Fig. 3) were identified in the arable land of Kolasib district, Mizoram. Of the eight-soil series, the Chemapi series occupied 1.7 % of the district. This series occupied the north and northwestern part of the district and is found mainly on the ridge and rolling valleys. Surface textures identified in the soil series are clay loam, sandy clay loam, silty clay loam and clay. The second largest in terms of extent was the Zanlawn series, which occupied 1.1 % of the district area. The surface textures identified in the Zanlawn soil series were clay loam, silty clay loam and clay. About 0.9% of TGA was under Hortoki soil series. The surface textures of these soils were silty clay loam and clay. Vengthar and Lungmuat soil series occupied 1.98 % and 0.5 % of the area, respectively, and the surface textures identified in the Lungmuat series were clay loam, sandy clay loam and clay. In contrast, the surface texture for the Vengthar soil series was clay loam, silty clay loam and clay. The other three soil series *viz*. Nisapui, Saihapui and Bhuchang occupied only 0.4%, 0.2% and 0.2% of the area, respectively. The surface texture varied from clay loam to clay.

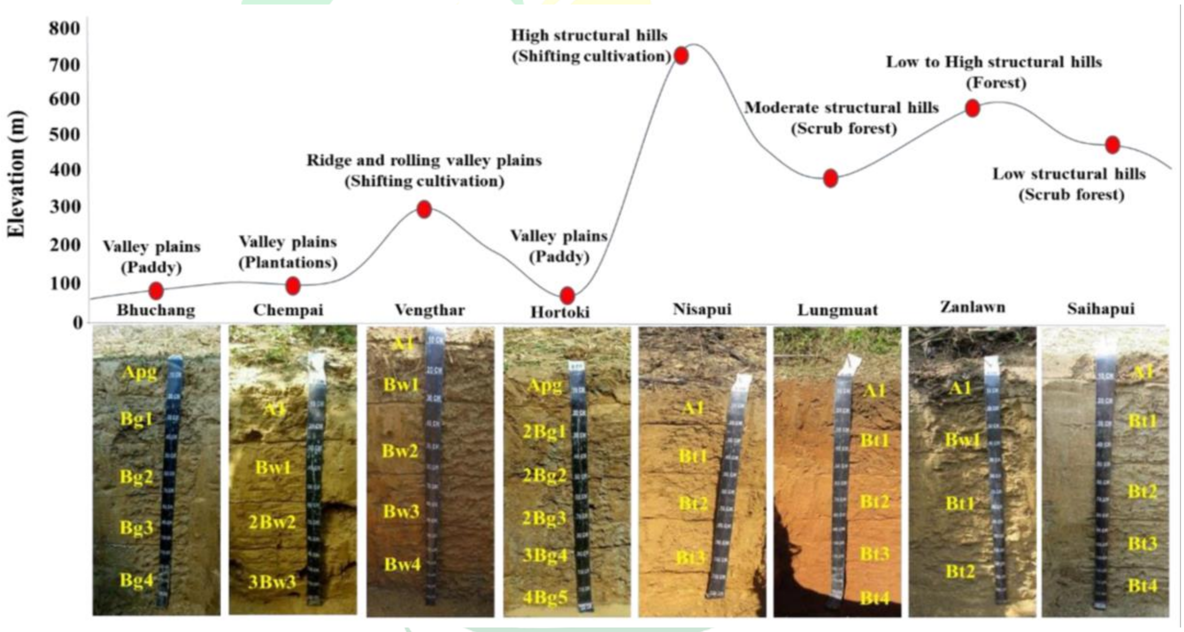

Fig. 2. Soil-landform relationship in Kolasib district, Mizoram

Generally, this region's soils are highly weathered due to high rainfall conditions. The lower values of clay CEC and clay ECEC substantiate these. Soils in the moderate structural hills are highly weathered due to very low apparent CEC and ECEC (<16 and <12 $cmol(p^+) kg^{-1}$ respectively) in the soil control section, which confirmed the criteria of *Kandic* horizon and with increasing depth did not have a clay decrease of 20 per cent or more (relative) from the maximum clay content and low organic carbon content owing to shifting cultivation. Thus, these soils are classified as *Kandiudults* (Bhattacharyya *et al*., 1994).

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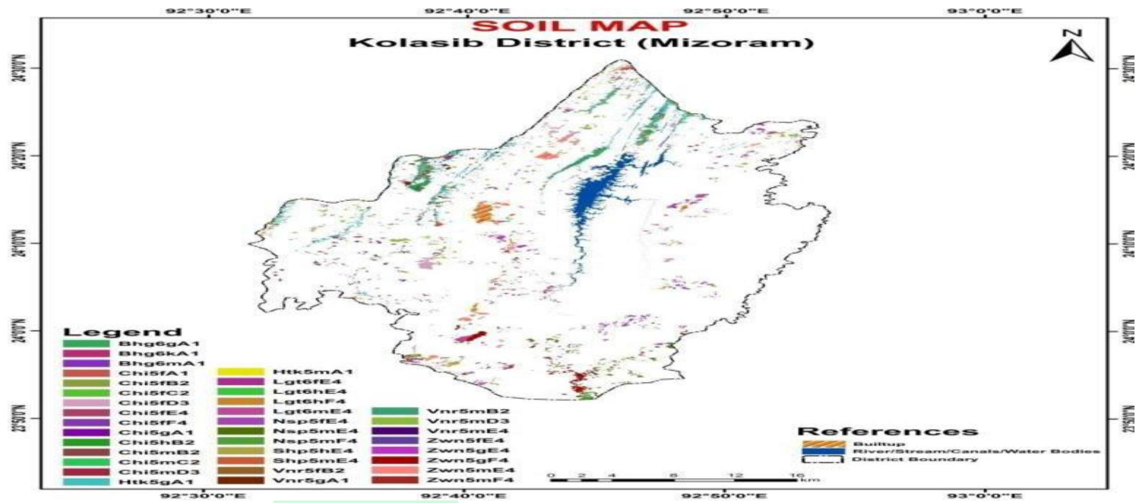

Fig. 3. Soils of Kolasib district, Mizoram

Soils of high and medium structural hills had clay CEC of more than 16 cmol (p^+) kg^{-1}, and although their clay ECEC was < 12 cmol (p^+) kg^{-1}, the soils could not qualify for a *Kandic* horizon, though it did qualify for *Hapludults*. The extensive occurrence of *Ultisols* may be due to the sandstones, siltstones, shales, and conglomerates rocks and high rainfall with sub-tropical conditions (Hikmatullah *et al*., 1999). Soils having argillic horizons with 0.9 per cent (by weighted average) or more organic carbon in the upper 15 cm of the *argillic* or *kandic* horizon qualified for *Haplohumults*. However, in the low structural hills, the soils are much less weathered as the base saturation is more than 35%, and the landscape and soils appear to be less stable for a higher degree of weathering. The clay content had an increasing trend with an increase in depth due to the illuviation of clay under the influence of a humid climate (Boul *et al.*, 2003). However, the degree of illuviation and leaching could not accentuate the removal of bases to the extent of <35 % and qualified for the presence of an argillic horizon. So, the soils were classified under *Hapludalfs* (Maniyunda *et al.*, 2019).

In ridge and rolling valleys and upper valley plains, the depositional landscapes produced weathering surfaces comparable to a "cambic" horizon and formed in highly weathered colluvium. The occurrence of deep soils belonging to *Ultisols*, *Alfisols* and *Inceptisols* on slopes of elevated landforms suggests that the materials displaced from the summits are not transported to long distances but deposited in the adjoining lowly elevated landscapes (Bhattachayya *et al*., 2002). The soils were classified as *Fluventic Dystrudepts* and *Typic Dystrudepts* at the sub-group level.

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However, it is interesting that in the lower valley region, the soils have a gleyed horizon, which may be due to the stability of the landscape with water stagnation and a uniform cropping system. The soils of the valley plain were classified as *Fluventic Endoaqudepts* and *Typic Endoaquepts*. The representative pedon (*Typic Endoaquepts*) of valley plains indicate no significant variation in clay content with depth. The increased water retention on the surface and restricted lateral movement due to the low slope gradient facilitate predominantly vertical water movement in the valley. This causes downward movement of clay throughout the depth, and the formation of distinct horizons is limited due to moisture for a relatively extended period than other landforms. An irregular decrease in organic carbon content between a depth of 25 to 125cm from the mineral soil surface and the organic carbon content of more than 0.2 per cent and more at a depth below 125 cm from the mineral soil surface may indicate its *Fluventic* nature. So, the soils in the ridge and rolling valleys and valley plains were classified into *Fluventic Endoaquepts* and *Fluventic Dystrudepts* at the group level (Soil Survey Staff, 2014). The decrease in organic carbon in an irregular pattern may be due to the irregular decrease in clay content of these soils in the subsurface horizon (Post *et al*., 1982). As a result of these studies, farmers, researchers, planners, and policymakers will have a better understanding of the properties of the soil, including its suitability for crops, irrigation and water management, nutrient management, soil conservation practices, alternative land use planning, climate change adaptation, policy, and research for improving livelihoods in the Kolasib district, Mizoram in particular, and the country in general, where such scenarios are present.

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