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Particle size distribution and hydraulic conductivity of soils under different land use systems in Nandurbar district

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Abstract

The climate of Nandurbar district is typically hot and dry, with an average annual rainfall of about 767 mm. In this region, agriculture, horticulture, forest, and pasture are the dominant land use systems; therefore, these four systems were selected for the study. Two representative sampling sites were chosen under each land use type from different locations across the district. Soil samples were collected at 20 cm depth intervals, starting from the surface and extending down to the bedrock. The soil profile depth reached up to 100 cm under agricultural, horticultural, and forest lands, whereas in pasture lands it extended up to 80 cm.

Soil physical properties such as bulk density, particle density, hydraulic conductivity, and particle size distribution play an important role in influencing plant growth. These characteristics directly or indirectly affect water movement, root penetration, aeration, and nutrient availability, and therefore must be carefully considered in land evaluation and planning for sustainable land use.

Analysis of particle size distribution provided an overall understanding of the soil's physical condition and offered insight into its potential chemical and biological behavior. The soils across most land use systems were predominantly clayey in texture. However, in pasture land, the lower soil layers exhibited a silty clay texture. Sand content across the different systems ranged from 1.5 to 12.5 percent, silt content from 21.5 to 42 percent, and clay content from 45.5 to 71 percent. The highest sand percentage was recorded at 60–80 cm depth under pasture land, while the lowest was found in the 0–20 cm layer of forest land. Similarly, maximum silt content occurred at 60–80 cm depth in pasture land, whereas the minimum was observed at the same depth under agricultural land. Clay content was highest at 60–80 cm depth in agricultural land and at 40–60 cm depth in forest land, while the lowest clay percentage was recorded at 60–80 cm depth under pasture land.

Hydraulic conductivity among the different land use systems ranged between 0.58 and 1.03 cm hr⁻¹ and generally decreased with increasing soil depth. In agricultural lands, values varied from 0.61 to 1.03 cm hr⁻¹; in horticultural lands from 0.63 to 0.86 cm hr⁻¹; in forest lands from 0.58 to 0.94 cm hr⁻¹; and in pasture lands from 0.62 to 0.81 cm hr⁻¹. The highest hydraulic conductivity was observed in the surface layer (0–20 cm) under agricultural land, whereas the lowest value was recorded at 80–100 cm depth under forest land.

Keywords: Particle size distribution, hydraulic conductivity, land use systems

Introduction

Soil is the most basic natural resource that determined the ultimate suitability and sustainability of any agricultural system. Soil plays a profound and vital role in influencing the crop productivity as well as cropping pattern of that region (Kasetiya *et al.*, 2022) [5]. Thus a good knowledge of the soil resources to any given territory is indispensable for planning it is agricultural development. Suitable management practices are urgently needed to preserve the production potential of agricultural lands. Efficient management and maintenance of soil health is the key to accomplish sustained high productivity, food security and environmental safety (Tripathi *et al.*, 2006 and Kasetiya *et al.*, 2022) [12, 5]. Therefore, characterization, classification and evaluation of soils for different land uses are most common to develop sustainable and eco-friendly land use model. Soil survey provides most useful information for planning proper soil and water management practices, which play important role in increasing crop production (Kasetiya *et al.*, 2022) [5].

The physico-chemical properties, fertility, and sustainability of soil have a direct relationship with ensuring food security for the world's ever-increasing population. The fertility and physico-chemical characteristics of soil resources have a significant impact on the overall production and sustainability of an agricultural sector (Wakene, 2001 and Kasetiya *et al.*, 2022) ^[5].

Materials and Methods

The present study titled “Soil Resource Appraisal under Different Land Use Systems in Nandurbar District” was conducted with the objective of characterizing and classifying soils across major land use systems and evaluating their fertility status. Nandurbar district covers a geographical area of approximately 5,955 km² (2,299 sq mi) and consists of six tehsils: Shahada, Nandurbar, Navapur, Taloda, Akkalkuwa, and Dhadgaon.

To ensure proper representation, two sampling sites were selected for each dominant land use system—agriculture, horticulture, forest, and pasture—at different locations within the district. Soil samples were collected at 20 cm depth intervals from the surface down to the bedrock in each land use system, allowing for a detailed assessment of soil

properties at varying depths.

Particle size distribution of soil samples was determined by hydrometer method as described by Gee and Bauder (1986) ^[3] using 5% sodium hexameta phosphate as dispersing agent. The saturated hydraulic conductivity was determined by constant head method. The soil was first saturated for 24 hours and then leached with distilled water and a constant value of flow was taken, as described by Klute and Dirksen (1986) ^[6].

Results and Discussion

Particle size distribution

Particle size distribution analysis helps in understanding the overall physical characteristics of the soil and also provides an indication of its chemical and biological potential. Soil texture, determined by the proportion of sand, silt, and clay, plays an important role in influencing plant growth. It affects key soil properties such as water retention and availability, nutrient holding capacity, drainage conditions, ease of cultivation, and overall suitability for different crops. Therefore, studying particle size distribution is essential for evaluating soil productivity and management practices.

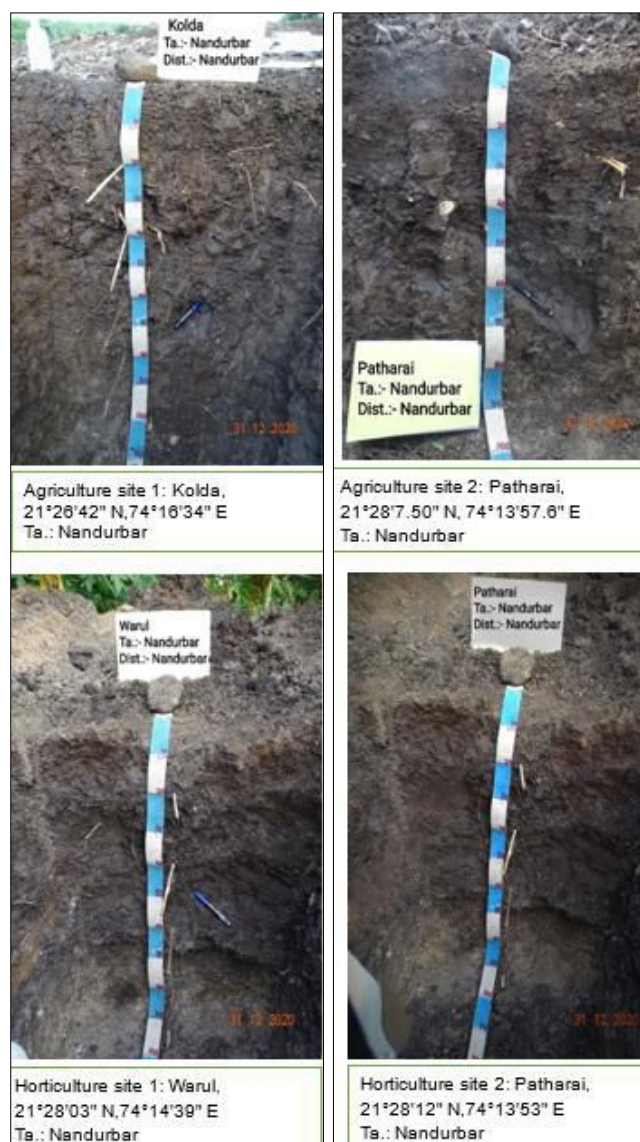


Plate 1: Sampling sites under Agriculture and Horticulture land use



Plate 2: Sampling sites under Forest and Pasture land use systems

The data presented in Table 1, shows that soils under most land use systems were predominantly clayey in texture. An exception was observed in pasture land, where the lower layers exhibited a silty clay texture. Across all systems, sand content ranged from 1.5 to 12.5 percent, silt from 21.5 to 42 percent, and clay from 45.5 to 71 percent.

In agricultural land, clay was the dominant fraction, followed by silt and sand. A similar pattern was observed in horticultural and forest lands. Pasture land, however, showed relatively higher sand and silt contents and comparatively lower clay in deeper layers.

The highest sand and silt contents were recorded at 60–80 cm depth under pasture land, whereas the lowest sand was found in the surface layer (0–20 cm) of forest land. Maximum clay content was observed at 60–80 cm depth in agricultural land and at 40–60 cm depth in forest land, while the lowest clay content occurred at 60–80 cm depth under pasture land. Comparable findings have also been reported by earlier researchers by Leelavathi *et al.*, (2009) [7], Devi *et al.*, (2015) [1] and Kasetiya *et al.*, (2022) [5].

As the soils of the study area have developed on basaltic parent material, these soils have produced higher amount of clay. The results were in conformity with Eswaran *et al.*, (1988) [2], Kumar and Naidu (2012), Devi *et al.*, (2015) [1], Sashikala *et al.*, (2020) [10] and Kasetiya *et al.*, (2022) [5].

Saturated hydraulic conductivity

Saturated hydraulic conductivity refers to the rate at which water moves through soil when all the pores are completely filled with water and a hydraulic gradient is present. In simple terms, it indicates how easily water can pass through the pore spaces of a fully saturated soil. This property reflects the soil's permeability and plays a key role in determining drainage, infiltration, and overall water movement within the soil profile.

Hydraulic conductivity of the different land use systems varied from 0.58 to 1.03 cmhr⁻¹ and it decreases with depth of soil. Hydraulic conductivity of agriculture land use system varied from 0.61 to 1.03 cmhr⁻¹, horticulture land use system varied from 0.63 to 0.86 cmhr⁻¹, forest land use system varied from 0.58 to 0.94 cmhr⁻¹ and pasture land use system varied from 0.62 to 0.81 cmhr⁻¹.

Highest hydraulic conductivity was recorded at the depth of 0–20 cm under agriculture land use system and lowest was noticed at 80–100 cm depth under forest land use system. Similar results were reported by Kadu *et al.*, (1993) [4], Ommala *et al.*, (2017) [8] and Kasetiya *et al.*, (2022) [5].

Table 1 shows that the hydraulic conductivity was higher near the surface layers in all of the land use systems. This could be due to the porous character of the soil as a result of constant tillage operations and a greater organic matter status. Increasing soil compaction with depth resulted in an increase in bulk density, whereas decreasing pore density resulted in a decrease in hydraulic conductivity with depth. Similar results are reported by Ramprakash and Seshagiri Rao (2002) [9], Sashikalal *et al.*, (2020) [10] and Kasetiya *et al.*, (2022) [5].

Table 1: Physical characteristics of soil under different land use systems

Land use systems	Depth (cm)	Particle size distribution			HC (cmhr ⁻¹)
		Sand (%)	Silt (%)	Clay (%)	
Agriculture 1	0-20	6.5	25.0	68.5	0.87
	20-40	4.5	28.0	67.5	0.77
	40-60	7.5	33.0	59.5	0.73
	60-80	3.5	26.0	70.5	0.62
	80-100	9.0	32.5	58.5	0.95
Agriculture 2	0-20	4.5	26.5	69.0	0.83
	20-40	9.0	23.5	67.5	0.77
	40-60	8.0	28.5	63.5	0.67
	60-80	7.5	21.5	71.0	0.61
	80-100	10.5	27.0	62.5	0.86
Horticulture 1	0-20	8.5	33.0	58.5	0.82
	20-40	9.0	25.5	65.5	0.69
	40-60	4.5	26.0	69.5	0.67
	60-80	4.0	30.5	65.5	0.63
	80-100	6.5	33.0	60.5	0.82
Horticulture 2	0-20	5.5	27.0	67.5	0.69
	20-40	7.0	29.5	63.5	0.74
	40-60	4.5	29.0	66.5	0.67
	60-80	5.5	31.0	63.5	0.63
	80-100	10.0	33.5	56.5	0.89
Forest 1	0-20	1.5	35.0	63.5	0.81
	20-40	4.0	29.5	66.5	0.76
	40-60	6.5	32.5	61.0	0.62
	60-80	5.5	25.5	69.0	0.59
	80-100	9.0	32.5	58.5	0.94
Forest 2	0-20	6.5	30.5	63.0	0.81
	20-40	3.5	31.5	65.0	0.63
	40-60	2.5	26.5	71.0	0.61
	60-80	4.0	28.5	67.5	0.58
	80-100	7.5	26.0	66.5	0.79
Pasture 1	0-20	5.5	31.5	63.0	0.73
	20-40	6.5	27.5	66.0	0.62
	40-60	9.5	26.0	64.5	0.69
	60-80	11.0	41.5	47.5	0.81
Pasture 2	0-20	5.5	30.5	64.0	0.77
	20-40	6.0	28.5	65.5	0.66
	40-60	6.5	26.5	67.0	0.71
	60-80	12.5	42.0	45.5	1.03

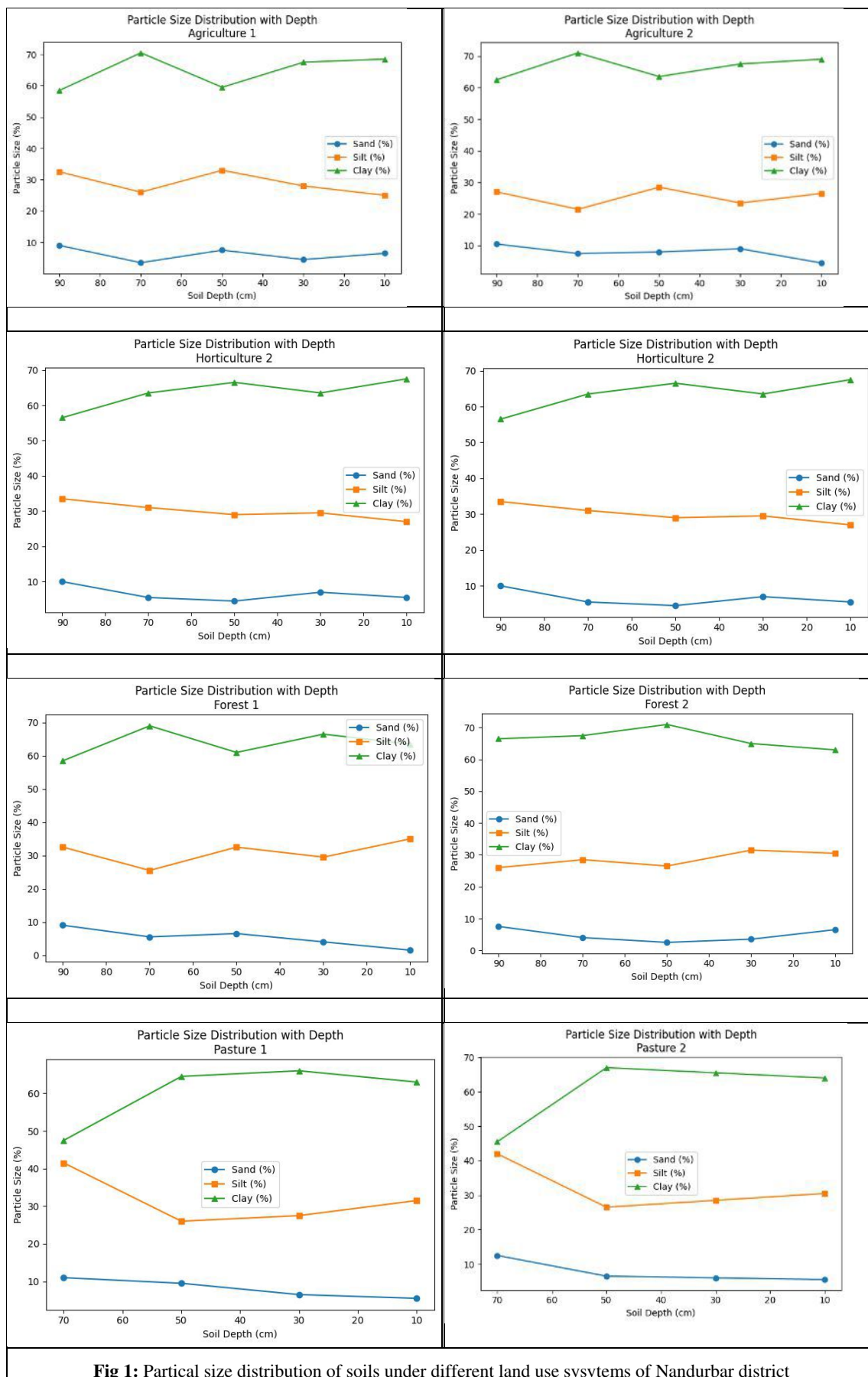


Fig 1: Partical size distribution of soils under different land use sysytems of Nandurbar district

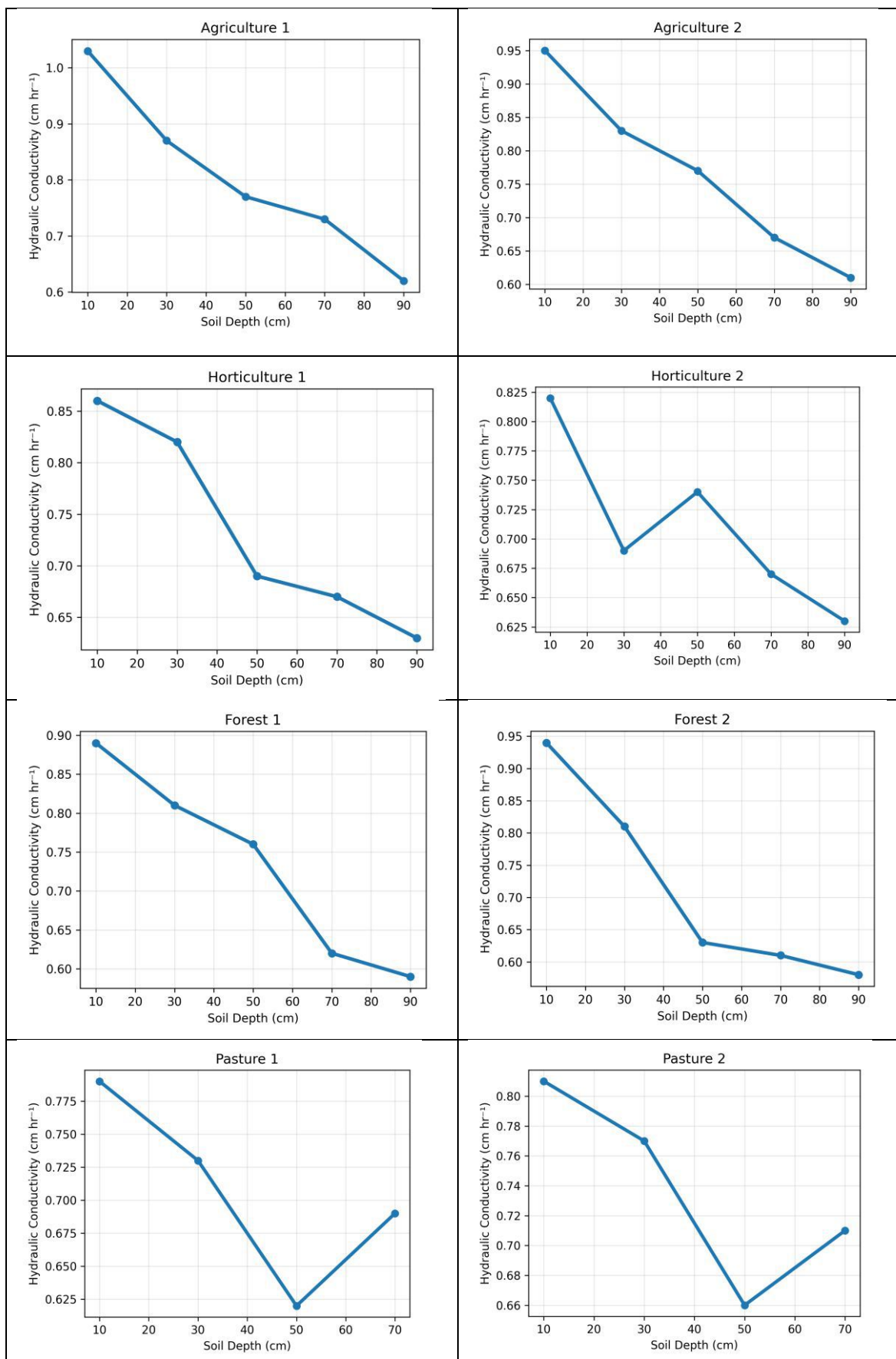


Fig 2: Hydraulic conductivity of soils under different land use systems of Nandurbar district

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