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DEPTH-WISE DYNAMICS OF SOIL CHEMICAL PROPERTIES ACROSS CONTRASTING LAND-USE SYSTEMS IN THE KASHMIR VALLEY

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ABSTRACT

Soil health assessment is essential for sustainable land management, particularly in sensitive ecosystems like the Kashmir Valley, where varied land-use practices impact soil properties. This study investigates the chemical characteristics of soils under different land uses: forest, agricultural (paddy), horticultural and pasture across three soil depths (0–20 cm, 20–40 cm, and 40–60 cm). Soil pH ranged from 6.33 in paddy fields to 7.76 in forest soils, generally decreasing with depth. Electrical conductivity (EC) was highest in paddy soils (0.77 dS/m) and lowest in forest soils (0.11 dS/m), with values increasing with depth. Available nitrogen, phosphorus, and potassium were significantly higher in forest soils (186.28, 8.24, and 96.16 mg/kg respectively) and lowest in paddy soils (119.05, 6.36, and 54.14 mg/kg), showing a consistent decrease with depth. Total NPK followed similar trends, except for total potassium, which increased with depth in all land-use types. The highest total potassium was recorded in forest soils, from 16,333.48 mg/kg at the surface to 16,529.91 mg/kg at 40–60 cm depth. Overall, nutrient levels were highest in the surface layer across all sites, following the order: Forest > Pasture > Horticulture > Agriculture. The findings will be of relevance not only to researchers and policymakers but also to extension workers and farmers striving to improve soil health and enhance crop productivity in the region.

Key words: Soil properties, Land use change, Kashmir Valley, Electrical conductivity, Total NPK

Introduction

Soil is one of the most fundamental components of the terrestrial ecosystem, playing a crucial role in supporting life by serving as a medium for plant growth, regulating water cycles, filtering pollutants, and recycling nutrients (Brady & Weil, 2017). It is a living and dynamic system that forms over time through complex interactions between parent material, climate, topography, biological organisms, and time (Jenny, 1941). The productivity and

sustainability of any agricultural system largely depend on the physical, chemical, and biological characteristics of soil (Lal, 2004). As the global population increases and pressure on natural resources intensifies, a comprehensive understanding of soil properties has become essential for ensuring food security, sustainable land use, and environmental conservation (FAO, 2015).

In the Himalayan region of Kashmir, soil assumes even greater significance due to the unique challenges

posed by its topography, climatic variability, and increasing anthropogenic pressure (Koul *et al.*, 2018). Agriculture is the backbone of Kashmir's economy, and a large proportion of the population is directly or indirectly dependent on farming for their livelihoods (Sheikh *et al.*, 2020). However, the region is witnessing a gradual decline in soil health, attributed to factors such as deforestation, unregulated land use, excessive tillage, and indiscriminate use of fertilizers and pesticides (Bhat *et al.*, 2017). These practices have led to nutrient depletion, loss of organic matter, soil compaction, erosion, and reduced biological activity (Shah & Wani, 2015). To reverse this trend and guide sustainable agricultural development, it is imperative to conduct detailed and location-specific soil characterization studies.

A robust soil assessment involves examining chemical properties, determine the soil's fertility status and its ability to sustain plant growth (Havlin *et al.*, 2014). Among chemical parameters, the most critical are the concentrations of macronutrients such as Nitrogen (N), Phosphorus (P), and Potassium (K) (Marschner, 2012). These nutrients are essential for plant physiological processes and are typically assessed in both available (immediately accessible to plants) and total (overall reserves in the soil) forms (U.S. Salinity Laboratory Staff, 1954). In the Kashmir Valley, soil pH can vary significantly due to variations in parent material, organic matter content, and rainfall patterns (Koul *et al.*, 2018). Similarly, electrical conductivity (EC) is an important measure of soil salinity. Elevated EC levels may indicate the presence of soluble salts that can impair plant water uptake, particularly in irrigated or poorly drained soils (U.S. Salinity Laboratory Staff, 1954). Monitoring soil EC is crucial for preventing salinity-related degradation, especially in areas where irrigation is practiced without proper drainage (Qadir *et al.*, 2014).

This study is therefore designed to address these gaps by conducting a detailed evaluation of the chemical and physical properties of soils from selected sites across the Kashmir Valley. Specifically, the research focuses on measuring available and total nitrogen (N), phosphorus (P), and potassium (K); soil pH; electrical conductivity (EC). By generating baseline data on these attributes, the study aims to provide actionable insights for soil fertility mapping, land capability assessment, and evidence-based nutrient and water management practices. Ultimately, this research will contribute to a better understanding of soil variability in Kashmir and support the development of sustainable agricultural systems that are resilient to environmental and socio-economic challenges. The findings will be of relevance not only to researchers and

Table 1: Different land-uses including Agriculture, Horticulture, Forest and Pasture.

S. No.	Site/ Land-Use	Longitude (°E)	Latitude (°N)
01.	Manigam (Agriculture)	34°.16'	74°.50'
02.	Baba Wayil (Horticulture)	34°.16'	74°.49'
03.	Gutli Bagh (Forest)	34°.16'	74°.48'
04.	Wangath (Pasture)	34°.31'	74°.93'

policymakers but also to extension workers and farmers striving to improve soil health and enhance crop productivity in the region. Aim of this research was to analyse the chemical properties of soils in selected agricultural sites of the Kashmir Valley, including available and total nitrogen (N), phosphorus (P), potassium (K), soil pH, and electrical conductivity (EC).

Materials and Methods

Study Area and Sampling Design

The study was carried out in District Ganderbal of Kashmir Valley. This region is characterized by diverse climatic conditions, topography ranging from plains to mountainous terrain, and varying land-use patterns. Different land-uses were selected including Agriculture (paddy), Horticulture (apple), Forest and Pasture (Table 1).

The experiment was conducted using four plots, each representing a different land use system, with a uniform plot size of 30 × 30 m. From each plot, five samples were collected, and the study was carried out with three replications to ensure reliability of results. In total, 60 soil samples and an equal number of 60 plant samples were collected and analyzed for the study.

Soil Samples shall be collected from these land uses at three depths (0-20, 20-40 and 40-60 cm). Composite samples shall be collected from 4 plots representing 4 land uses. The method of random sampling shall be followed for the collection of samples.

Soil Sample Preparation

Upon arrival at the laboratory, soil samples were air-dried at room temperature in the shade to minimize alterations in chemical properties. Coarse fragments including stones, roots, and other debris were carefully removed manually. The dried soils were gently crushed using a wooden pestle and subsequently passed through a 2 mm sieve to obtain homogenized samples for the determination of physical and chemical properties. For nitrogen analysis, a representative portion of each sample was further ground and sieved through a 0.5 mm mesh to ensure uniform particle size.

Chemical Analysis

The chemical properties analyzed included available

Table 2: Descriptive statistics of Available Nitrogen (mg/kg) in soil under different land uses.

	Agriculture			Horticulture			Forest			Pasture		
	0-20	20-40	40-60	0-20	20-40	40-60	0-20	20-40	40-60	0-20	20-40	40-60
Mean	119	110.46	95.14	131.46	123.94	118.14	186.84	170.18	163.32	163.6	154.62	145.62
Std. Dev	7.3	1.89	5.67	13.88	7.12	5.47	21.65	14.93	15.42	18.97	18.40	18.83
c.v. (%)	6.13	1.7	5.96	10.55	5.75	4.63	11.59	8.77	9.44	11.59	11.90	12.93
Min	112.1	10.1	88.7	120.4	117.3	113.9	158.5	154.3	150.3	145.2	138.5	133.1
Max	129.6	112.3	101.3	153.9	124.9	127.1	218.1	193.9	189.7	192.3	180.9	174.3

and total nitrogen (N), phosphorus (P), potassium (K), soil pH, and electrical conductivity (EC).

Available Nitrogen (N)

Available nitrogen was estimated using the alkaline permanganate method, which involves the oxidation of soil organic nitrogen by alkaline KMnO_4 . The amount of nitrogen released was then measured colorimetrically, providing an estimate of the mineralizable nitrogen available for plant uptake.

Total Nitrogen

Total nitrogen content was determined by the Kjeldahl digestion and distillation method, which involves digesting the soil with concentrated sulfuric acid and catalysts to convert organic nitrogen into ammonium, followed by distillation and titration to quantify nitrogen.

Available Phosphorus (P)

Available phosphorus was extracted by Olsen's method using 0.5 M sodium bicarbonate (NaHCO_3) at pH 8.5, suitable for neutral to alkaline soils common in Kashmir. Phosphorus concentration in the extract was measured colorimetrically using the molybdenum blue method.

Total Phosphorus

Total phosphorus was determined by digesting soil samples with a mixture of perchloric acid (HClO_4) and nitric acid (HNO_3) followed by spectrophotometric measurement.

Available Potassium (K)

Available potassium was extracted using neutral 1N ammonium acetate (NH_4OAc) solution and quantified using flame photometry.

Total Potassium

Total potassium content was measured after acid digestion (HClO_4 - HNO_3) of soil samples, followed by flame photometry.

Soil pH

Soil pH was measured in a 1:2.5 soil-to-distilled water suspension using a glass electrode pH meter, calibrated with standard buffer solutions at pH 4.0 and 7.0.

Electrical Conductivity (EC)

Electrical conductivity was measured in the same soil-water suspension using an EC meter, indicating the soluble salt concentration and salinity status of the soil.

Results and Discussion

Soil chemical properties

Available Nitrogen

Soil analysis across different land-use systems in the Kashmir Valley showed clear variation in nitrogen concentrations with depth and land use (Table 2, Fig. 1). Agricultural soils (Manigam) had the lowest nutrient levels, decreasing from 119 mg/kg in the topsoil (0–20 cm) to 95.14 mg/kg at 40–60 cm. Horticultural soils (Baba Wail) showed slightly higher values, while pasture soils (Wangath) had even greater nutrient content, likely due to organic inputs from vegetation and grazing. Forest soils (Gutli Bagh) exhibited the highest nutrient concentrations across all depths (186.84, 170.18, and 163.32 mg/kg), attributed to undisturbed organic matter cycling and minimal human interference. Overall, nutrient levels were highest in the surface layer across all sites, following the order: Forest > Pasture > Horticulture > Agriculture. These findings align with previous research by Pal *et al.*, (2013), Sharma and Singh (2021), and Mir (2020), who also reported higher nutrient content and better soil quality in forested ecosystems compared to cultivated lands, with nutrient concentrations declining with depth due to reduced organic matter and microbial activity in deeper layers.

Available Phosphorus

The study revealed notable variations in available phosphorus (P) content across different land uses and

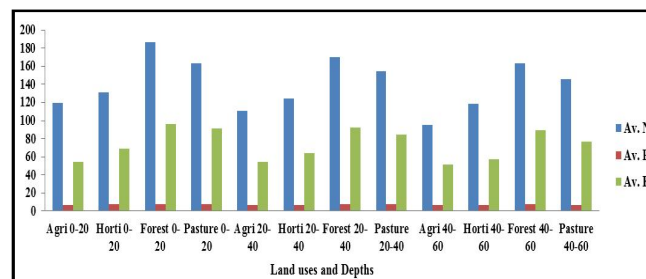


Fig. 1: Depth-wise distribution of available nutrients in soils under different land-uses.

Table 3: Descriptive statistics of Available Phosphorous (mg/kg) in soil under different land uses.

	Agriculture			Horticulture			Forest			Pasture		
	0-20	20-40	40-60	0-20	20-40	40-60	0-20	20-40	40-60	0-20	20-40	40-60
Mean	6.36	5.40	4.69	7.28	6.66	6.08	8.24	7.79	7.39	7.69	7.34	6.99
Std. Dev	0.493	0.522	0.34	0.41	0.55	0.70	0.47	0.42	0.25	0.30	0.28	0.39
c.v. (%)	7.75	9.66	7.33	5.64	8.33	11.63	5.81	5.41	3.45	3.88	3.90	5.60
Min	5.89	5.09	4.26	6.75	5.82	5.08	7.76	7.47	7.17	7.39	6.93	6.36
Max	7.75	6.03	5.08	7.79	7.28	6.84	8.83	8.52	7.74	8.16	7.63	7.29

Table 4: Descriptive statistics of Available Potassium (mg/kg) in soil under different land uses.

	Agriculture			Horticulture			Forest			Pasture		
	0-20	20-40	40-60	0-20	20-40	40-60	0-20	20-40	40-60	0-20	20-40	40-60
Mean	54.14	53.91	51.86	68.84	64.25	57.47	96.16	92.26	89.23	90.83	84.93	77.00
Std. Dev	5.26	5.67	5.01	1.06	4.35	3.76	11.26	11.29	11.22	12.41	10.98	11.87
c.v. (%)	9.71	10.52	9.67	1.53	6.77	6.54	11.71	12.23	12.57	13.66	12.93	15.41
Min	47.92	50.13	48.36	66.97	57.89	54.18	84.22	76.97	75.20	77.29	74.27	65.41
Max	62.06	63.69	60.07	69.48	68.04	63.72	114.35	107.96	105.37	105.04	94.52	90.24

soil depths in the Kashmir Valley (Table 3, Fig. 1). Forest soils exhibited the highest phosphorus levels, ranging from 8.24 mg/kg at the surface to 7.39 mg/kg at 40–60 cm depth, which can be attributed to abundant organic matter input and limited soil disturbance. Pasture soils also maintained relatively high phosphorus concentrations (7.69 to 6.99 mg/kg), likely due to continuous vegetative cover and organic inputs from grazing. In contrast, horticultural soils showed moderate phosphorus availability, while agricultural soils recorded the lowest values, with a clear decline from 6.36 mg/kg in the topsoil to 4.69 mg/kg in deeper layers. This reduction in agricultural soils is likely caused by intensive cultivation, nutrient mining, and inadequate replenishment of phosphorus. These findings are consistent with previous research indicating that natural ecosystems like forests and pastures retain phosphorus more effectively than cultivated lands, where nutrient depletion is common without proper management (Brady & Weil, 2017; Sharma *et al.*, 2017). The results highlight the need for improved nutrient management practices, such as organic amendments and balanced fertilization, especially in agricultural soils to maintain soil fertility and ensure sustainable crop production in the region.

Available Potassium

The experimental analysis of potassium content across

different land use types and soil depths revealed significant variations (Table 4, Fig. 1). The mean potassium levels were highest in forest soils (96.16 mg/kg at 0–20 cm depth) followed by pasture soils (90.83 mg/kg), with horticulture and agricultural soils showing comparatively lower concentrations, particularly at greater depths (e.g., 51.86 mg/kg at 40–60 cm in agricultural soils). This trend reflects the influence of vegetation cover and land management practices, where forest and pasture ecosystems maintain higher potassium reserves due to minimal soil disturbance and continuous organic matter input (Brady & Weil, 2017). The depletion of potassium in agricultural soils is commonly attributed to intensive cropping and inadequate replenishment (Singh *et al.*, 2016). Similar observations have been reported by Lal (2015), who highlighted nutrient depletion in cultivated lands compared to natural ecosystems, emphasizing the role of organic matter and soil biota in nutrient retention.

Total Nitrogen

The experimental data from different land use systems in the Kashmir Valley reveal significant variations in total nitrogen (Total N) content across both lands uses and soil depths (Table 5, Fig. 2). Forest soils (Gutli Bagh) recorded the highest mean nitrogen levels across all depth intervals (0–20 cm: 581.68 mg/kg), followed by pasture

Table 5: Descriptive statistics of Total Nitrogen (mg/kg) in soil under different land uses.

	Agriculture			Horticulture			Forest			Pasture		
	0-20	20-40	40-60	0-20	20-40	40-60	0-20	20-40	40-60	0-20	20-40	40-60
Mean	377.53	358.16	341.51	455.65	437.72	426.83	581.68	550.54	531.38	550.48	530.23	516.17
Std. Dev	16.62	17.06	16.69	21.4	15.18	12.85	22.39	15.57	11.75	24.49	20.37	26.89
c.v. (%)	4.40	4.76	4.88	4.69	3.46	3.01	3.84	2.82	2.21	4.44	3.84	5.20
Min	355.67	332.32	321.98	433.87	418.86	407.76	545.76	534.52	521.42	511.22	498.76	477.65
Max	398.87	378.23	367.76	486.34	459.96	443.28	601.12	576.56	550.65	576.98	550.87	545.43

Table 6: Descriptive statistics of Total Phosphorous (mg/kg) in soil under different land uses.

	Agriculture			Horticulture			Forest			Pasture		
	0-20	20-40	40-60	0-20	20-40	40-60	0-20	20-40	40-60	0-20	20-40	40-60
Mean	707.08	666.5	650.24	754.32	738.69	720.61	1044.3	1008.72	981.2	909.21	875.09	858.68
Std. Dev	61.92	32.23	30.41	37.37	35.15	36.64	77.19	56.62	29.47	47.06	17.82	17.59
c.v. (%)	8.75	4.83	4.67	4.95	4.74	5.08	7.39	5.61	3.00	5.17	2.07	2.04
Min	641.11	634.78	621.32	705.43	698.87	676.34	967.54	957.01	945.65	867.54	856.45	843.65
Max	776.65	703.54	687.72	801.12	788.42	776.11	1130.24	1099.65	1010.11	989.78	895.87	886.37

(Wangath), horticulture (Baba Wayil), and agriculture (Manigam), which showed the lowest total nitrogen content (e.g., 341.51 mg/kg at 40–60 cm). This trend reflects the influence of vegetation cover, litter input, and management intensity on nitrogen dynamics. Total N content declined consistently with increasing soil depth across all sites, which is expected due to reduced organic matter and biological activity in subsoil layers. These findings are consistent with regional studies in the Kashmir Himalayas (Dar *et al.*, 2018; Rather *et al.*, 2021), which have reported higher nitrogen levels in undisturbed forest and pasture soils compared to cultivated agricultural land. The depletion of nitrogen in agricultural soils highlights the need for integrated nutrient management practices, organic amendments, and conservation agriculture to restore soil fertility and ensure long-term productivity in Kashmir's fragile mountain ecosystems

Total Phosphorous

The analysis of total phosphorus across different land use systems in the Kashmir Valley reveals clear variations influenced by land management practices and soil depth (Table 6, Fig. 2). Forest soils (Gutli Bagh) exhibited the highest phosphorus levels at all depths (mean: 1044.3 mg/kg at 0–20 cm), followed by pasture (Wangath), horticulture (Baba Wayil), and agriculture (Manigam), which showed the lowest values (650.24 mg/kg at 40–60 cm). This trend reflects the role of organic matter inputs, minimal disturbance, and biological recycling in phosphorus retention under forest and pasture systems, in contrast to phosphorus depletion under intensive agriculture due to continuous cropping, erosion, and insufficient replenishment. Phosphorus content also decreased with depth across all land uses, consistent with its immobility in soil and surface accumulation. These findings align with regional studies (Dar *et al.*, 2018; Rather *et al.*, 2021; Sharma & Sharma, 2013), which report higher phosphorus levels under undisturbed ecosystems in the Himalayas. They emphasize the need for sustainable nutrient management such as organic amendments, reduced tillage, and integrated nutrient strategies to restore and maintain soil fertility in the agricultural landscapes of Kashmir.

Total Potassium

The analysis of total potassium content in soils under different land use systems in the Kashmir Valley reveals a distinct pattern shaped by land use intensity and organic matter dynamics (Table 7, Fig. 2). Forest soils (Gutli Bagh) recorded the highest potassium concentrations across all depths, with a mean of 16,333 mg/kg in the 0–20 cm layer, followed closely by pasture (Wangath), horticulture (Baba Wayil), and agriculture (Manigam), where the lowest mean potassium values were observed (13,454.93 mg/kg at 0–20 cm). These findings underline the positive influence of forest and pasture ecosystems, which contribute higher organic matter through litter fall, root biomass, and minimal disturbance, promoting better potassium retention and cycling. In contrast, the reduced potassium content in agricultural soils reflects continuous cropping, nutrient mining, and limited organic inputs, a trend commonly observed in intensively cultivated Himalayan regions. Notably, potassium levels showed less variation with depth compared to nitrogen and phosphorus, due to the relatively higher mobility of potassium and its release from weathering of parent materials. These trends are consistent with earlier studies in Kashmir and similar temperate regions (Dar *et al.*, 2018; Rather *et al.*, 2021; Sharma & Sharma, 2013), emphasizing the need for integrated potassium management using organic and mineral sources to sustain soil fertility in agricultural lands. The study reaffirms the ecological value of natural land covers in maintaining soil nutrient balance and the importance of sustainable land management in Himalayan agroecosystems.

pH

The evaluation of soil pH across diverse land use systems in the Kashmir Valley reveals significant

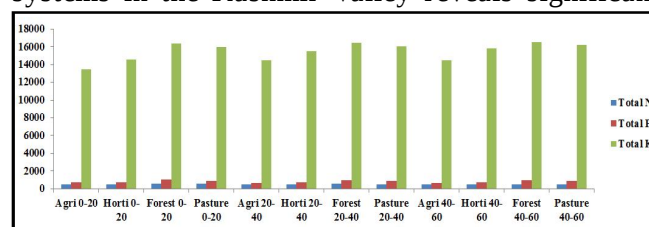
**Fig. 2:** Depth wise distribution of Total nutrients in different land-uses.

Table 7: Descriptive statistics of Total Potassium (mg/kg) in soil under different land uses.

	Agriculture			Horticulture			Forest			Pasture		
	0-20	20-40	40-60	0-20	20-40	40-60	0-20	20-40	40-60	0-20	20-40	40-60
Mean	13454.93	14485.9	14500.2	14558.13	15503.3	15773.7	16333	16431.76	16529.91	15960.81	16037.58	16189.79
Std. Dev	207.3	201.2	213.2	247.3	199.43	214.4	356.06	369.00	293.11	206.68	216.53	209.17
c.v. (%)	1.54	1.38	1.47	1.69	1.28	1.35	2.18	2.24	1.77	1.29	1.35	1.29
Min	13342.87	14340	14337.9	14356.54	15403.4	15778.9	16026.53	16123.3	16234.78	15678.64	15778.76	16001.57
Max	13601.78	14568	14587.8	14830.89	15608.88	15981	16780.55	16880.9	16887.34	16123.66	16226.62	16509.98

Table 8: Descriptive statistics of pH in soil under different land Uses.

	Agriculture			Horticulture			Forest			Pasture		
	0-20	20-40	40-60	0-20	20-40	40-60	0-20	20-40	40-60	0-20	20-40	40-60
Mean	7.2	7.29	7.61	7.03	7.17	7.29	6.48	6.54	6.76	7.48	7.65	7.79
Std. Dev	0.25	0.3	0.24	0.35	0.38	0.36	0.15	0.09	0.17	0.24	0.18	0.17
c.v. (%)	3.47	4.11	3.15	4.97	5.29	4.93	2.31	1.37	2.51	3.20	2.35	2.18
Min	6.87	7.62	7.84	6.51	6.61	6.77	6.31	6.41	6.53	7.11	7.34	7.48
Max	7.43	6.93	7.26	7.36	6.58	7.71	6.72	6.66	6.97	7.76	7.79	7.88

variations that are influenced by land cover type, anthropogenic activity, and soil depth (Table 8). The pasture soils (Wangath) exhibited the highest pH values, with a mean ranging from 7.48 to 7.79, indicating slightly alkaline conditions, likely due to continuous organic matter return, low disturbance, and nutrient cycling within a stable vegetative cover. In contrast, forest soils (Gutli Bagh) recorded the lowest mean pH values (6.48 to 6.76), reflecting slightly acidic conditions attributed to organic acid accumulation from litter decomposition, high microbial activity, and minimal external input trends widely reported in Himalayan ecosystems (Dar *et al.*, 2018; Wani & Bhat, 2020). Agricultural (Manigam) and horticultural (Baba Wayil) soils showed moderately high pH values, increasing slightly with depth, suggesting the influence of base-forming cations and long-term liming or fertilizer application, which are common in cultivated systems (Sharma & Sharma, 2013; Lal, 2006). These findings are consistent with the work of Rather *et al.*, (2021), who reported pH elevation under intensive cultivation in Kashmir, and Bhattacharyya *et al.*, (2000), who linked soil alkalinity in Indian uplands to reduced organic carbon and microbial respiration. This highlights the critical role of land management in determining soil reaction, which directly affects nutrient availability, microbial activity, and long-term soil health across Kashmir's agro-ecological zone.

Electrical Conductivity

The assessment of electrical conductivity (EC) in soils across different land use systems of Kashmir reveals distinct patterns associated with management intensity, organic input, and leaching potential (Table 9). The highest EC values were recorded under agricultural land (Manigam), with means increasing from 0.77 dS/m (0–20 cm) to 1.11 dS/m (40–60 cm), suggesting accumulation of soluble salts, possibly due to fertilizer application and reduced leaching under tillage (Lal, 2006; Sharma *et al.*, 2018). Similarly, horticultural soils (Baba Wayil) exhibited moderate EC levels (mean 0.12–0.19 dS/m), reflecting controlled organic inputs and irrigation practices. In contrast, forest soils (Gutli Bagh) showed the lowest EC levels (0.10–0.13 dS/m), indicating minimal anthropogenic influence and high organic matter buffering, consistent with natural forest systems (Wani & Bhat, 2020). Pasture soils (Wangath) maintained slightly higher EC than forest (0.19–0.22 dS/m), potentially due to livestock excreta and moderate biological cycling, which adds ions to the surface layer (Dar *et al.*, 2018). These findings align with studies showing that EC increases in disturbed or fertilized lands due to ion accumulation, whereas natural ecosystems tend to exhibit stable, low EC due to balanced biogeochemical cycles (Bhattacharyya *et al.*, 2000; Singh & Singh, 2006).

Table 9: Descriptive statistics of EC (ds/m) in soil under different land Uses.

	Agriculture			Horticulture			Forest			Pasture		
	0-20	20-40	40-60	0-20	20-40	40-60	0-20	20-40	40-60	0-20	20-40	40-60
Mean	0.77	0.87	1.11	0.12	0.15	0.19	0.1	0.11	0.13	0.19	0.2	0.22
Std. Dev	0.14	0.1	0.12	0.05	0.05	0.06	0.01	0.01	0.01	0.02	0.02	0.03
c.v. (%)	18.1	11.4	10.8	43.63	33.30	31.57	10	9.09	7.69	10.52	10	13.63
Min	0.63	0.76	0.98	0.09	0.11	0.13	0.08	0.1	0.12	0.16	0.17	0.18
Max	0.97	1.03	1.23	0.22	0.24	0.28	0.12	0.13	0.16	0.22	0.23	0.27

Thus, EC serves as a reliable indicator of land use intensity and soil health in the temperate zones of Kashmir.

Conclusion

The study clearly demonstrates that land-use practices and soil depth significantly influence the chemical characteristics of soils in the Kashmir Valley. Forest soils consistently maintained superior fertility status, with higher levels of available and total N, P, and K, alongside more favourable pH and EC values compared to other land-use systems. In contrast, paddy soils exhibited the lowest nutrient availability and less favourable chemical conditions, reflecting nutrient depletion and soil degradation under continuous cultivation. Depth-wise analysis revealed a general decline in available nutrients with increasing depth, while total potassium showed a contrasting trend of accumulation in deeper layers. Across all land uses, nutrient concentrations were highest in surface soils, following the order Forest > Pasture > Horticulture > Agriculture. These findings underscore the need for sustainable land management strategies that conserve soil fertility, particularly in sensitive ecosystems such as the Kashmir Valley, to ensure long-term productivity, ecological stability, and agricultural resilience.

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