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Soil Quality Assessment Under Different Land-Use and Litter Conditions in Agrarian Landscape

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Abstract: Dayurejo Village, on the slopes of Mount Arjuno, is an agrarian landscape where diverse land uses—teak stands, agroforestry, banana and coffee plantations, and production forest—compete for space and shape soil conditions. This study assesses soil quality under different litter conditions and interprets the findings in relation to land functions and village-level spatial planning. Using a quantitative descriptive approach, soil samples were collected from topsoil (0–30 cm) and subsoil (30–60 cm) in five land-use types and analyzed for texture, porosity, pH, and organic matter. Rudi Hartono nic C, while litter thickness, pH, and moisture were also measured. Results indicate that all land uses are characterized by acidic soils with very low organic C (<0.60%) and litter layers that are generally dry, limiting decomposition. Agroforestry and forest land maintain relatively high porosity and thick litter, supporting their role as hydrological protection and buffer zones, whereas banana, coffee, and teak areas exhibit compaction and degradation, requiring targeted rehabilitation. The study concludes that integrating soil-quality indicators into village zoning and agrarian management is essential for sustainable land and spatial planning in Dayurejo Village.

Keywords: Agrarian landscape, Land Use, Soil quality, Spatial planning

INTRODUCTION

Land and agrarian systems in tropical regions are closely linked to soil conditions because soil quality underpins the productivity, stability, and sustainability of rural landscapes. In agrarian communities, access to land is not only a matter of ownership and tenure but also of the biophysical capacity of land to support crops, trees, and livestock on a sustainable basis. Where soil quality is low, farmers must invest more labor and capital to obtain the same yield, and the land itself becomes more vulnerable to erosion, degradation, and abandonment. Conversely, where soil quality is maintained or improved, land is more capable of providing secure livelihoods, buffering households from climatic shocks, and supporting long-term agrarian development pathways. Soil quality is therefore widely recognized as a key indicator for assessing the capacity of terrestrial ecosystems to support vegetation, maintain nutrient balance, and sustain hydrological and biological functions (Lal, 2015).

In many parts of Indonesia, pressures on land have increased due to the expansion of plantation commodities, infrastructure development, and demographic change. These pressures trigger land-use conversions from forest or mixed agroforestry systems into monoculture plantations or built-up areas, with important consequences for soil quality. Rarely are these changes neutral; they mirror wider agrarian discussions about land ownership, its use, and the distribution of benefits. As a result, soil quality becomes not only an ecological issue but also a political and spatial one, linked to decisions made in village development plans, spatial planning regulations, and corporate or state forest management schemes. In this context, understanding the drivers and spatial patterns of soil quality is central to formulating agrarian and land-use policies that are both socially and ecologically sustainable (Aji et al., 2016; Alfianto & Munir, 2023; Lal, 2015).

Among the various biophysical factors influencing soil quality, surface litter plays a particularly strategic role. Litter is defined as the layer of organic residues—leaves, twigs, branches, and other plant parts—that accumulates on the soil surface. This layer contributes to improved soil structure, increased water-holding capacity, and nutrient supply through decomposition processes. Litter also provides habitat and energy sources for soil microorganisms, which in turn regulate nutrient cycling, mineralization, and the formation of stable soil aggregates (Handayani et al., 2023). In this sense, litter functions not only as a source of organic matter and a carbon sequestration agent, but also as a protective cover that reduces erosion, moderates soil temperature and moisture, and buffers micro-climatic conditions at the soil surface (Hall et al., 2020; Prescott, 2010 in Handayani et al., 2023).

Land management, whether for natural forest, agroforestry, or intensive monoculture plantations, directly shapes the quantity, quality, and dynamics of litter. Land with dense, permanent vegetation cover such as natural forest or well-managed agroforestry systems typically accumulates thicker and more continuous litter layers than land under intensive cultivation, where frequent tillage and harvest disturb the soil surface. This contrast has direct implications for soil quality in both topsoil and subsoil, through differences in organic matter content, pore structure, and soil biotic activity (Handayani et al., 2023). Different plant communities also produce litter with distinct chemical and physical characteristics—including C/N ratio, lignin content, and inherent moisture—which affect decomposition rates and nutrient inputs to the soil. Litter from forest tree species tends to have higher lignin content and decomposes more slowly, whereas litter from annual crops such as bananas decomposes rapidly but contributes less long-term organic matter (Khotimah et al., 2022). These processes determine the extent to which different land-use systems contribute to or undermine soil fertility and are therefore critical for agrarian policy and spatial planning that aim to balance production and conservation.

Dayurejo Village, located in Prigen District, Pasuruan Regency, East Java, represents a typical agrarian landscape on the slopes of Mount Arjuno. The village has fertile soils derived from volcanic materials and abundant natural potential. The mountain environment has a positive impact on local livelihoods, as most households depend on plantation commodities such as coffee, bananas, and various timber species (Alfianto & Munir, 2023). Land use in Dayurejo consists of community forests, production forests, and protected forests managed by Perhutani, with coffee as a major crop for local farmers. Pine and mahogany are priority species in Perhutani's management schemes (Aji et al., 2016). The highland setting creates a relatively humid microclimate with high rainfall, conditions well suited to agroforestry practices and the cultivation of perennial crops. At the same time, the area is integrated into broader regional development agendas, including tourism and infrastructure, which further shape land-use decisions. The mosaic of land use in Dayurejo—ranging from teak stands and coffee plantations to agroforestry, banana plantations, and forest—makes the village an appropriate case study for examining the interactions between land use, litter conditions, and soil quality. This diversity allows comparative analysis of how different land-use types and land-cover configurations influence litter accumulation and soil characteristics in both surface (topsoil) and deeper (subsoil) layers.

Previous studies have highlighted the role of litter and vegetation in determining soil organic matter and soil physical and chemical properties (Bintoro et al., 2017; Handayani et al., 2023; Farrasati et al., 2019; Saputra et al., 2018). Nevertheless, most research has examined these relationships at the plot scale without explicitly linking them to the broader agrarian context, land-use decision-making, or spatial-planning frameworks, particularly in highland agroforestry landscapes such as Dayurejo. As a result, there is limited understanding of how variations in litter thickness and quality across multiple land-use types relate to soil quality in different soil layers and what such correlation means for land management, agrarian development, and spatial planning. This gap indicates that further research is needed to connect biophysical soil assessments with land-use planning and agrarian management. Existing works have not fully addressed how land-use change and the spatial distribution of forests, agroforestry, and monoculture plantations influence organic matter inputs and long-term soil dynamics in a way that can guide practical land-management strategies (Lal, 2015; Alfianto & Munir, 2023; Aji et al., 2016). In particular, there is still a lack of studies that compare different land-use systems within a single village landscape while simultaneously assessing litter conditions and soil quality in both topsoil and subsoil.

Based on these considerations, this study aims to evaluate soil quality under varying litter conditions across different land-use types in Dayurejo Village. The specific objectives are to: 1) Analyze the relationship between litter thickness and key soil quality indicators (texture, porosity, pH, and organic C) under different land uses; 2) Compare soil properties between topsoil (0–30 cm) and subsoil (30–60 cm) layers across teak, agroforestry, banana, coffee, and forest land; and 3) Examine how different land-cover types contribute to organic matter input and overall soil dynamics and how these biophysical patterns relate to agrarian functions and spatial-planning considerations in the village. By situating the biophysical findings within the context of local land management and the spatial arrangement of land uses, the study is expected to provide insights that can inform ecosystem-based land management, agrarian policy, and spatial planning for soil conservation in tropical highland regions.

METHODS

Study Area

The research was conducted on the slopes of Mount Ringgit within the administrative territory of Dayurejo Village, Prigen District, Pasuruan Regency, East Java. Geologically, this area belongs to the Middle Quaternary Volcanic Rocks of Mount Ringgit (Qpr), consisting of volcanic breccia, tuff, lava, agglomerate, and lahar deposits. Long-term weathering of these materials has produced soils that are predominantly classified as Andosols, which typically have dark colors, fine textures, and high organic matter content under undisturbed forest conditions (Fahmuddin Agus, 2021). The Andosols around Mount Ringgit are characterized by clay to silt textures and acidity levels that vary from slightly acidic to neutral, although intensive cultivation and erosion can cause further acidification and reduce organic matter.

Topographically, Dayurejo Village occupies dissected volcanic slopes with an elevation gradient that generates a range of microclimatic conditions. The upper slopes are cooler and wetter and are dominated by forest and agroforestry land uses, while mid-slopes host coffee and banana plantations, and lower slopes accommodate settlements, mixed gardens, and supporting infrastructure. Drainage patterns follow natural ravines and small streams flowing from Mount Arjuno and Mount Ringgit, connecting the village landscape to downstream agricultural and urban areas.

From a land-tenure perspective, the study area contains a mix of state forest lands managed by Perhutani and community-managed lands under customary or formal tenure. Production forests of pine and mahogany, community agroforestry plots, and smallholder plantations of coffee, banana, and teak coexist in close proximity(Aji et al., 2016; Alfianto & Munir, 2023). This mosaic creates an ideal setting for analysing how land-use type and management practices influence soil quality under different institutional arrangements.

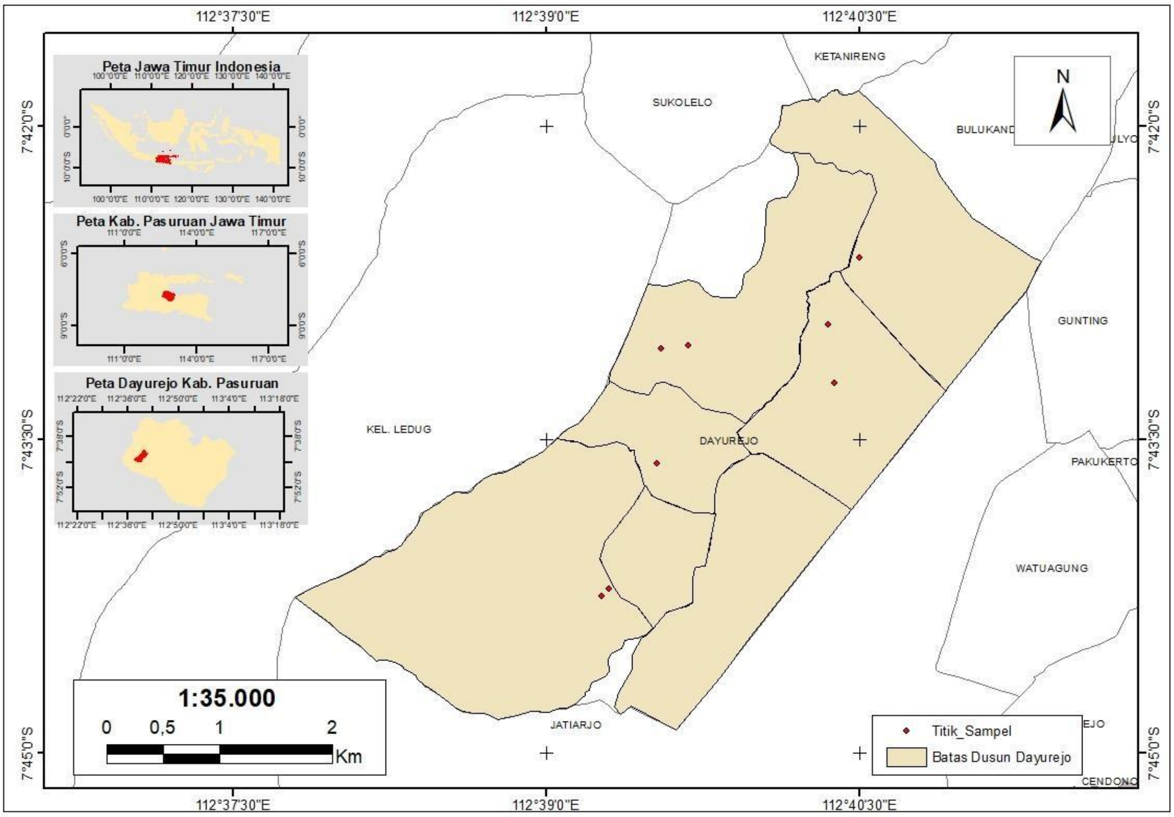

Figure 1. Administrative Map and Sample Poin
Source: Author, 2025

Research Design and Sampling Strategy

This study employed a quantitative descriptive approach to analyse soil quality based on litter conditions in various types of land use in Dayurejo Village. The approach is appropriate given the objective of characterising existing conditions rather than testing a specific experimental treatment. The quantitative data collected allow for systematic comparison of soil properties across land uses, while descriptive interpretation links the patterns to agrarian and spatial-planning contexts (Lal, 2015). Five representative land-use types were selected as research locations: 1) Teak land; 2) Agroforestry land (mixed systems dominated by sengon, elephant grass, and cassava); 3) Banana plantations, 4) Coffee plantations, and 5) Forest land managed as production forest. These categories capture the main forms of land use in Dayurejo and represent different combinations of vegetation structure, management intensity, and tenure arrangements

Sampling was carried out using the diagonal method at each land-use location. For each land-use type, a plot was delineated such that it represented typical conditions of that land unit in terms of slope, vegetation coverage, and management practices. Within each plot, a diagonal transect was drawn from one corner to the opposite corner. Five sampling points were then placed at roughly equal intervals along this transect. This design ensures that the spatial variability of field conditions—such as minor changes in micro-topography, shade, and ground cover—is reasonably captured (Bintoro et al., 2017; Nita et al., 2015).

At each point, soil samples were collected from two depths: topsoil (0–30 cm) and subsoil (30–60 cm), using a hand auger. The chosen depths correspond to the root zone of most crops and trees in the area and allow the study to distinguish between surface processes (strongly influenced by litter and management) and deeper processes (reflecting longer-term soil development and vertical transport of organic matter). The auger was cleaned between depth intervals and between points to avoid contamination.

In addition to soil sampling, litter characteristics were assessed at every point. Litter thickness was measured using a ruler or caliper, from the soil surface to the top of the litter layer, at three micro-points around each sample point and averaged to reduce measurement error. Fresh litter samples were collected in plastic bags to be weighed and analysed in the laboratory for moisture content and pH.

RESULTS AND DISCUSSION

Teak Land

The teak site (Table 1) is characterised by a Sandy Clay Loam topsoil containing 54.9% sand, 22.5% silt, and 22.5% clay. Such a coarse-dominated texture generally favours rapid percolation of water but provides only limited water- and nutrient-holding capacity compared with finer textures. The measured topsoil porosity of 30.6% confirms that the pore network is relatively restricted, indicating a compacted condition with few macropores for air and water movement. With a pH of 5.3, the soil falls into the acidic category, and the organic-carbon content of 0.2% is very low. The overlying litter layer is 1.5 cm thick, has a slightly acidic reaction (pH 5.7), and extremely low moisture (0.001). Taken together, these indicators point to a land unit that is not functioning optimally as a biological medium. Low porosity, acidity, and very low C-organic limit root growth and constrain the activity of soil biota responsible for decomposition and nutrient cycling (Bachtiar, 2020). In such conditions, essential plant nutrients such as Ca, Mg, and P are less available, and microbial processes that build stable soil organic matter are suppressed. Recent syntheses on soil compaction similarly show that increased bulk density and reduced total porosity are closely linked with declines in infiltration capacity, increased surface runoff, and impaired root development (Shaheb et al., 2021).

In the subsoil, porosity rises sharply to 46.9%, while the textural class remains Sandy Clay Loam, dominated by 71.2% sand and 54.9% clay with no silt (Table 1). Soil pH is unchanged at 5.3, and organic C declines further to 0.1%. The higher porosity at depth most likely reflects the fact that these layers are less affected by surface compaction from human activities. Similar vertical profiles, where topsoil is more compact than subsoil, have been reported beneath skid trails and intensively used forest floors.

Viewed as a spatial unit, teak land situated on sloping terrain with compacted surface layers and limited organic inputs tends to enhance surface runoff rather than infiltration. Under intense rainfall, water cannot enter the soil quickly, leading to overland flow and increased erosion risk downslope. This runoff can carry fine particles and nutrients into adjacent agricultural plots and waterways, reducing fertility on-site and causing sedimentation off-site (Kaliraj et al., 2025). Within village-level spatial planning, teak compartments should be mapped as production forest blocks that require explicit soil- conservation measures, including the minimisation of heavy machinery traffic, the retention of understory vegetation, contour planting where appropriate, and the periodic addition of organic residues or compost (Setiawan et al., 2024).

Table 1. Results of Analysis of Teak Tree Soil Quality Characteristics

No	Characteristics	Topsoil	Subsoil
1	Soil Dust Fraction (%)	22.5	0
2	Soil Sand Fraction (%)	54.9	71.2
3	Soil Clay Fraction (%)	22.5	54.9
4	Porosity	30.6	46.9
5	Soil pH	5.3	5.3
6	Organic C (%)	0.2	0.1
7	Litter Thickness (cm)	1.5	
8	Litter pH	5.7	
9	Litter Moisture	0.001	

Source: Author's analysis results, 2025

Agroforestry Land

In agroforestry plots, the topsoil is classified as clay with 61.7% clay and 38.2% sand and no detectable silt (Table 2). Clayey soils generally have high cation exchange capacityand substantial water-holding capacity due to their large specific surface area and charged mineral surfaces. When well structured, such soils can be highly fertile; however, if structure collapses, they become dense and poorly aerated (Bintoro et al., 2017). The measured porosity of 52.35% the highest topsoil porosity among all land uses shows that the Dayurejo agroforestry soils are still relatively well aggregated and contain ample pore space. The mixture of tree, shrub, and herbaceous species in these systems likely promotes such structure by producing root channels, stabilising aggregates with root exudates, and supplying varied organic residues (Ramanda et al., 2025). Despite this favourable physical structure, the topsoil exhibits chemical limitations. Soil pH is 5.0 (strongly acidic) and C-organic is only 0.13%, falling in the very low category. Above the mineral soil, the litter layer is 2.34 cm thick the second thickest after forest land with a pH of 6.0 and low moisture content (0.00399). These data illustrate that substantial biomass is produced and accumulates on the surface, but conversion of this litter into stable soil organic matter is not yet effective. Acidic conditions and low moisture restrict the activity of decomposer microorganisms and slow mineralisation (Yanti & Kusuma, 2021; Farrasati et al., 2019).

In the subsoil, the textural class changes abruptly to silt loam, with 56.8% silt and 43.1% sand and no clay. Porosity remains relatively high at 46.01%, indicating a reasonably open structure, yet pH remains 5.0 and organic C only increases slightly to 0.20% (Table 2). This vertical differentiation could be the result of eluviation and illuviation processes or spatial variability in parent materials (Kamisah & Kartika, 2024). The silt-rich subsoil can store water and provide a favourable rooting environment, but the combination of persistent acidity and low C-organic suggests that biological activity is limited even at deeper horizons.

From an agrarian standpoint, agroforestry parcels provide multiple products—timber, fodder, food crops and may buffer households against market or climate shocks. Soil-quality data show that these systems maintain comparatively good physical properties but still suffer from chemical constraints. To realise their full potential, management should focus on improving pH and organic matter through liming and the strategic incorporation of high-quality organic residues (Hanuf et al., 2021). In terms of spatial planning, agroforestry land with high porosity and thick litter is well suited as a buffer zone separating protection forest from more intensive coffee or banana plantations. Its hydrological function enhancing infiltration and reducing runoff supports downstream agriculture and helps stabilise slopes.

Table 2. Results of Analysis of Agroforestry Soil Quality Characteristics

No	Characteristics	Topsoil	Subsoil
1	Soil Dust Fraction (%)	0	56.8
2	Soil Sand Fraction (%)	38.2	43.1
3	Soil Clay Fraction (%)	61.7	0
4	Porosity	52.35	46.01
5	Soil pH	5	5
6	Organic C (%)	0.13	0.20
7	Litter Thickness (cm)	2.34	
8	Litter pH	6	
9	Litter Moisture	0.00399	

Source: Author's analysis results, 2025

Banana Plantations

Banana plantation soils present a markedly different profile. The topsoil is a clayey material with 26.4% sand, 24.5% silt, and 49% clay, whereas the subsoil has an even higher clay fraction at 64.1%, with 16% silt and 19.8% sand (Table 3). Such dominance of clay typically confers high water-holding capacity but, when combined with low porosity, can lead to poor aeration and slow drainage. Indeed, porosity is low in both layers, falling from 23.82% in the topsoil to 20.88% in the subsoil. This indicates a compacted profile with few macropores, where water movement is restricted and root growth is physically constrained (Saputra et al., 2018).

Soil pH is 4.67 in both horizons, placing these soils in the very acidic range. The litter layer above the surface is 1.794 cm thick with pH 6.0 and moisture of 0.006, slightly higher than in other land uses (Table 3). Nevertheless, organic C remains very low, at 0.11% in the topsoil and 0.22% in the subsoil. The higher value at depth suggests some downward movement and stabilisation of organic compounds, but overall stocks remain depleted. Low C-organic levels of this magnitude are commonly associated with disturbed or eroding soils where organic inputs are insufficient to compensate for losses (Deepana et al., 2025).

Banana plantations are important cash-crop areas in many tropical highlands. However, the combination of low porosity, high acidity, and low organic matter observed here implies that such land is vulnerable to yield decline. Studies of banana systems elsewhere show that intensive management, including frequent weeding, inadequate mulching, and heavy fertiliser application, can accelerate soil erosion and organic-matter depletion, especially on steep slopes (Magalhaes et al., 2024; Pusponegoro et al, 2018).

Spatially, positioning banana plantations on steep, clay-rich slopes with compacted profiles is problematic. Under heavy rainfall, surface runoff from these areas can rapidly transport fine sediment downslope, clogging irrigation canals and degrading lowland fields (Lizaga et al, 2025). For village planning, it is therefore advisable to allocate banana cultivation to more moderate slopes or terrace systems and to integrate soil-conservation measures such as contour hedgerows, grass strips, and permanent ground cover.

Table 3. Results of Analysis of Soil Quality Characteristics of Banana Plantations

No	Characteristics	Topsoil	Subsoil
1	Soil Dust Fraction (%)	26.4	19.8
2	Soil Sand Fraction (%)	24.5	16
3	Soil Clay Fraction (%)	49	64.1
4	Porosity	23.82	20.88
5	Soil pH	4.67	4.67
6	Organic C (%)	0.11	0.22
7	Litter Thickness (cm)	1.794	
8	Litter pH	6	
9	Litter Moisture	0.006	

Source: Author's analysis results, 2025

Coffee Plantations

Coffee land represents another key agrarian space in Dayurejo. The topsoil texture is Clay Loam, with equal fractions of clay and silt (35.2% each) and 29.5% sand (Table 4). Porosity is 43.3%, which is higher than in banana and teak soils but still below the agroforestry topsoil. With a pH of 5.0 and organic C of 0.2%, this soil is moderately compact and chemically constrained. The litter layer is 1.86 cm thick, with pH 5.3 and moisture 0.005. These properties suggest that coffee trees produce abundant litter but that decomposition proceeds relatively slowly, consistent with the high lignin contents typical of coffee leaves and husks (Holisah & Prijono, 2022; Hall et al., 2020).

The subsoil shifts to a silt texture with 80.6% silt, 19.3% sand, and no clay. Porosity decreases to 30.9%, while pH and organic C remain unchanged (Table 4). This fine-textured subsoil with low porosity likely restricts vertical water movement and root penetration. As Satria (2016) notes, clay- or silt-dominated horizons with low macroporosity limit both aeration and water storage, especially when compacted by repeated foot traffic or tillage.

For farmers, coffee plantations are a major source of income, but the soil data show that many of these fields operate under conditions of gradual degradation. Root systems are concentrated in the upper, still-porous topsoil, making plants sensitive to drought, while the compact subsoil limits deeper rooting that could buffer moisture stress. the tropics demonstrate that management practices such as shade-tree integration, mulching, and reduced tillage can markedly improve soil quality in coffee systems, increasing organic C and enhancing biological activity (Rosalynda et al., 2025; Kiup et al., 2025). In spatial- planning terms, coffee plantations on mid- and upper slopes with such soil constraints may contribute to hillslope instability if not accompanied by soil-conserving practices. Recent research on agroforestry coffee systems in Central America shows that the combination of tree canopy, banana cover, and ground litter significantly reduces splash erosion and runoff compared with coffee monocultures (Blanco-Sepulveda et al., 2024).

Table 4. Results of analysis of soil quality characteristics of coffee plantations.

No	Characteristics	Topsoil	Subsoil
1	Soil Dust Fraction (%)	35.2	80.6
2	Soil Sand Fraction (%)	29.5	19.3
3	Soil Clay Fraction (%)	35.2	0
4	Porosity	43.3	30.9
5	Soil pH	5	5
6	Organic C (%)	0.2	0.2
7	Litter Thickness (cm)	1.86	
8	Litter pH	5.3	
9	Litter Moisture	0.005	

Source: Author's analysis results, 2025

Forest Land

The forest plots, classified as production forest, exhibit some of the most extreme chemical conditions among the land uses. Both topsoil and subsoil have a pH of 4.0, indicating strong acidity that can increase the solubility of aluminium and iron to levels toxic for many plant roots (Harahap et al., 2021; Malesi et al., 2023). Topsoil porosity is 35.18%, while subsoil porosity is slightly higher at 38.40% (Table 5). Texturally, both horizons are silty clay, with the topsoil containing 64.1% silt, 21.3% clay, and 14.5% sand, and the subsoil 65.2% silt, 21.7% clay, and 13% sand. This fine texture provides a good inherent capacity for water storage and nutrient retention, provided soil structure is not degraded.

The forest litter layer is the thickest observed in the study, at 2.9 cm, with a pH of 5.0 and moisture of 0.005. Such a litter mantle is typical of humid tropical forests and plays a fundamental role in nutrient cycling and hydrological regulation (Giweta, 2020). However, despite the substantial litter stock, soil organic C remains low (0.25% in topsoil and 0.28% in subsoil). This suggests that strong acidity and limited moisture during the sampling period slow down decomposition and the incorporation of organic matter into the mineral soil (Hu et al., 2025).

Functionally, forest parcels are critical for maintaining hydrological and ecological stability within the Dayurejo landscape. Thick litter cover and fine-textured soils work together to intercept rainfall, reduce kinetic energy at the soil surface, and encourage gradual infiltration rather than rapid runoff. Because these forests are also designated as production forests, there is potential tension between timber extraction and conservation functions. Therefore, forest management in Dayurejo should adopt reduced-impact logging practices, restrict road construction on steep slopes, and maintain buffer strips along streams. Within spatial planning, these forest blocks should form the core of protection zones, surrounding and supporting more intensive land uses.

Table 5. Results of analysis of forest soil quality characteristics

No	Characteristics	Topsoil	Subsoil
1	Soil Dust Fraction (%)	64.1	65.2
2	Soil Sand Fraction (%)	14.5	13
3	Soil Clay Fraction (%)	21.3	21.7
4	Porosity	35.18	38.4
5	Soil pH	4	4
6	Organic C (%)	0.25	0.28
7	Litter Thickness (cm)	2.9	
8	Litter pH	5	
9	Litter Moisture	0.005	

Source: Author's analysis results, 2025

Cross-Land-Use Comparison and Spatial Implications Key soil quality indicators porosity, litter thickness, litter pH, and litter moisture across the five land-use types. Agroforestry has the highest topsoil porosity (52.35%), followed by coffee (43.30%), forest (35.18%), teak (30.60%), and banana (23.82%) (Table 6). Subsoil porosity shows a different pattern: teak (46.90%) and agroforestry (46.01%) remain relatively high, while coffee (30.90%), banana (20.88%), and forest (18.40%) show marked declines (Table 6). Litter thickness is greatest in forest (2.90 cm) and agroforestry (2.34 cm), intermediate in coffee (1.86 cm) and banana (1.794 cm), and lowest in teak (1.50 cm), although litter moisture is low in all land uses (Table 6).

These cross-land-use patterns clarify how each land unit performs spatial functions in the village landscape. Agroforestry combines high porosity with relatively thick litter, enabling it to act as a buffer zone that moderates runoff and supports organic matter cycling. Forest land provides the thickest litter cover and serves as a hydrological regulator, even though its subsoil porosity is low. Teak compartments, with low topsoil porosity but higher values at depth, behave as compacted production stands where surface runoff and erosion may be significant unless managed carefully. Banana and coffee plantations, characterized by low porosity and very low organic C, represent intensively used agrarian spaces that depend on external inputs and are vulnerable to degradation.

Interpreted through the lens of spatial planning, Table 6 supports a zoning approach in which forest and agroforestry areas are prioritized as protection and buffer zones, coffee and banana plantations are concentrated on suitable slopes with strong soil-improvement programs, and teak stands are managed with explicit soil-conservation measures. In this way, the numerical indicators of soil quality and litter conditions are directly linked to the spatial organization of land uses, ensuring that land is treated not merely as a physical medium but as a multifunctional space within the agrarian landscape of Dayurejo Village.

Table 6. Compilation of Five Land Use Types Based on Key Soil Quality Indicators

Land Use	Topsoil Porosity (%)	Subsoil Porosity (%)	Litter Thickness (cm)	Litter pH	Litter Moisture
Teak	30.60	46.90	1.50	5.7	0.001
agroforestry	52.35	46.01	2.34	6	0.0039
Banana	23.82	20.88	1.794	6	0.006
Coffee	43.30	30.90	1.86	5.3	0.005
Forest	35.18	18.40	2.90	5	0.005

Source: Author's analysis results, 2025.

In considering the cross-land-use patterns, the study reveals that each land-use type in Dayurejo Village uniquely influences the overall soil functions and thus must be viewed within the broader spatial and agrarian context. Agroforestry and forest areas, with their relatively high porosity and thicker litter layers, function as essential buffer zones. They not only support water infiltration and reduce surface runoff but also help maintain the ecological stability of the landscape. This makes them ideal candidates for designation as protection and hydrological regulation zones within village-level spatial plans. Teak lands, with their compacted topsoil but higher subsoil porosity, present a different challenge. These areas need specific soil conservation practices to reduce surface compaction and enhance organic matter content, thereby improving topsoil structure. Similarly, banana and coffee plantations, which are more intensively cultivated and exhibit lower porosity and organic C, are identified as the most vulnerable to soil degradation. These lands require targeted interventions, such as the introduction of cover crops, contour. planting, and organic amendments, to build soil organic carbon and improve soil structure. By linking these findings to spatial planning, the study suggests a zoning approach that prioritizes forest and agroforestry areas as core protection zones. Coffee and banana plantations should be located on moderate slopes and managed with strong soil- improvement programs, while teak stands need explicit soil conservation measures to reduce compaction.

CONCLUSIONS

This study demonstrates that soil quality in Dayurejo Village is significantly influenced by land use and litter conditions. Across teak, agroforestry, banana, coffee, and forest lands, the soils were found to be consistently acidic and low in organic carbon, with litter layers that, while present, were often too dry and acidic to effectively improve soil quality during the sampling period. As a result, litter alone is not sufficient to enhance soil fertility unless accompanied by favorable physical and chemical conditions that promote decomposition and nutrient cycling.

The vertical differences in porosity between topsoil and subsoil provide insights into how each land unit functions. Agroforestry emerges as the land use with the most favorable soil structure, maintaining high porosity throughout the profile. In contrast, banana and coffee plantations show signs of compaction and degradation, particularly in the subsoil. Teak and forest lands exhibit higher porosity in the subsoil than in the topsoil, reflecting surface compaction from human activities and natural processes.

From a spatial-planning perspective, these findings underscore the need to treat different land uses as distinct functional zones within the village territory. Forest and agroforestry areas should be prioritized as hydrological protection and buffer zones, while coffee, banana, and teak parcels should be managed as intensive production spaces that require targeted soil-improvement interventions. By integrating soil-quality indicators into spatial planning, Dayurejo Village can move towards.

RECOMMENDATIONS

Based on research findings, the condition of the soil in the topsoil and subsoil in the coffee plantation land of Dayurejo Village is classified as less fertile, as indicated by the high level of soil acidity (pH 4.67), low C-organic content (<0.3%), suboptimal porosity, and thin and dry litter layers. To overcome this, it is necessary to add organic materials sustainably, either by returning the litter to the land or by providing organic fertilizers such as compost or manure. Organic materials have been proven to improve soil structure, increase water and nutrient storage capacity, and support the presence of soil Microorganisms.

In addition, the application of liming, especially using dolomite, is recommended to reduce soil acidity levels and increase nutrient availability. Soil with a pH close to neutral tends to be healthier and more conducive to microbial activity and the process of organic matter decomposition (Yanti & Kusuma, 2021). Litter management is also crucial, considering that excessive litter cleaning can damage the balance of organic matter in the soil and accelerate damage to soil structure. Litter left on the land plays a role in protecting. the soil from erosion, maintaining moisture, and being an important habitat for soil microfauna (Farrasati et al., 2019). Other efforts that can be made are planting cover crops such as legumes that can increase organic matter content, improve soil structure, and bind nitrogen naturally. In addition, these plants also function to reduce the direct impact of rain on the soil surface, thus supporting soil and water conservation (Siregar, 2017). To ensure the effectiveness of this strategy, routine monitoring of parameters such as pH, organic matter content, C-organic, and porosity is essential. This monitoring allows early identification of soil quality decline so that corrective actions can be taken immediately.

Overall, improving soil quality on coffee plantations requires a comprehensive, sustainable approach, in order to maintain its function as a medium for plant growth and support for a healthy ecosystem.

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