

Plant Biodiversity and Its Role in Ecological Balance and Sustainability in the Changing Landscapes of Haryana, India

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ABSTRACT

Plant biodiversity is essential for maintaining ecosystem stability, productivity, and sustainability. This study explores the variation in species richness, abundance, and above-ground biomass productivity across three land-use zones in Haryana, India: forest ecosystems (Kalesar National Park and Morni Hills), agro-ecosystems (Hisar, Rohtak, Bhiwani), and urban green spaces (Ambala, Kurukshetra, Karnal). A total of 108 plant species were documented in forests, 62 in urban green spaces, and 41 in agro-ecosystems, comprising trees, shrubs, and herbaceous vegetation. Forest ecosystems exhibited the highest species richness, evenness, and above-ground biomass followed by urban green spaces while agro-ecosystems displayed the lowest diversity and productivity. Comparative analyses revealed that dominant species largely determine biomass distribution, and diversity indices confirmed greater ecological stability in forests compared to other zones. Urban green spaces, though moderately productive, serve as important biodiversity reservoirs in human-dominated landscapes, while agro-ecosystems present opportunities for enhancing ecological function through sustainable management practices. The study highlights that land-use type significantly influences plant diversity and ecosystem functioning, with natural forests providing key ecosystem services, urban green spaces supporting biodiversity amidst development, and agro-ecosystems requiring targeted interventions. These findings emphasize the importance of conservation, habitat restoration, and species-rich urban planning, providing a reference data for sustainable land-use strategies and policy development in semi-arid regions of Haryana.

Keywords- Plant biodiversity, Species richness, Ecological stability, Above-ground biomass, Haryana, Land-use zones, Sustainability.

I. INTRODUCTION

Biodiversity, encompassing genetic, species, and ecosystem diversity, forms the basis of ecological integrity and environmental sustainability. Among its components, plant biodiversity is particularly significant because plants function as primary producers, regulate biogeochemical cycles, stabilize soils, influence hydrological regimes, and provide habitat and resources for diverse organisms (Tilman et al., 2014). The diversity of plant species enhances ecosystem structure and functional complexity, thereby supporting ecological balance and resilience.

Ecological balance refers to a dynamic equilibrium in which biotic and abiotic components interact harmoniously, allowing ecosystems to maintain

stability in the face of disturbances. Sustainability, in ecological terms, involves meeting present human needs while safeguarding the capacity of ecosystems to support future generations (WCED, 1987). Plant biodiversity lies at the intersection of these concepts, as diverse vegetation communities contribute to ecosystem productivity, resilience, and long-term viability.

India, one of the world's megadiverse countries, harbors approximately 47,000 plant species and a wide range of ecosystems, from tropical rainforests to alpine meadows and arid deserts (MoEFCC, 2014). Haryana, located in northwestern India, represents a transitional landscape comprising Shivalik foothills, alluvial plains, semi-arid tracts, and rapidly expanding urban areas. Vegetation in this region includes native dry deciduous and thorn forest species such as *Prosopis*

cineraria, *Acacia nilotica*, *Shorea robusta*, *Ziziphus mauritiana*, and *Capparis decidua*, which play critical roles in soil stabilization, carbon sequestration, and livelihood support.

However, accelerating land-use change, agricultural intensification, urban expansion, deforestation, invasive species, and climate variability have resulted in widespread degradation of vegetation and loss of plant diversity. Indian ecologists such as Madhav Gadgil, Ramachandra Guha, and J. S. Singh have emphasized that biodiversity erosion undermines both ecological stability and socio-economic sustainability, particularly in rural and semi-arid landscapes.

The present study aims to (i) assess plant biodiversity across three distinct land-use zones in Haryana, (ii) examine the relationship between plant diversity and key ecosystem functions, and (iii) evaluate the implications of plant biodiversity for ecological balance and sustainability. By integrating field-based ecological data with sustainability perspectives, this research seeks to contribute to evidence-based conservation planning and sustainable land management.

II. REVIEW OF LITERATURE

2.1 Plant Biodiversity and Ecosystem Functioning

Plant biodiversity is widely recognized as a key factor shaping ecosystem structure, productivity, and stability. Ecosystems with higher species richness tend to have greater productivity, stability, and resistance to environmental disturbances (Tilman, Reich, & Knops, 2006; Hooper et al., 2012). Variation in functional traits among species, such as differences in growth patterns, nutrient use, and reproductive strategies, enhances complementarity and allows ecosystems to utilize resources efficiently, supporting long-term stability (Tilman, Isbell, & Cowles, 2014).

In India, Singh and Singh (2012) reported that forests and grasslands with greater species diversity maintain more stable nutrient cycles, energy flows, and water regulation compared to less diverse systems. Gadgil and Guha (1995) further highlighted the intertwined ecological and cultural roles of plant diversity, showing that it supports human livelihoods while maintaining ecosystem integrity.

2.2 Ecosystem Services Supported by Plant Biodiversity

Plant diversity underpins provisioning, regulating, supporting, and cultural ecosystem services (MEA, 2005). Provisioning services include food crops (e.g., *Triticum aestivum*, *Oryza sativa*), medicinal plants (e.g., *Withania somnifera*, *Azadirachta indica*), timber (e.g., *Dalbergia sissoo*, *Tectona grandis*), and fuelwood (e.g., *Prosopis cineraria*). Regulating services involve climate regulation, water purification, and erosion control; supporting services include soil formation, nutrient cycling, and primary production. Cultural

services provide aesthetic, spiritual, and recreational benefits.

Traditional agroforestry systems in semi-arid regions, such as *Prosopis cineraria*-based systems in Rajasthan and Haryana, demonstrate sustainable land-use practices that balance biodiversity conservation with agricultural productivity (Singh, 2002).

2.3 Plant Biodiversity and Climate Change

Diverse plant communities contribute to climate change mitigation and adaptation by increasing carbon storage and enhancing resilience to droughts, heatwaves, and floods (Lal, 2004; IPBES, 2019). However, climate change alters species distributions, growth cycles, and productivity, posing threats to plant diversity, particularly in semi-arid ecosystems (IPBES, 2019).

2.4 Threats to Plant Biodiversity

Biodiversity loss is driven by habitat destruction, land-use change, overexploitation, invasive species, pollution, and climate change (Sala et al., 2000; MoEFCC, 2014). In India, deforestation, monoculture agriculture, urban expansion, and infrastructure development are major contributors (MoEFCC, 2014). Additionally, the erosion of traditional ecological knowledge reduces the effectiveness of community-based resource management (Gadgil, Berkes, & Folke, 1993).

2.5 Conservation and Sustainability Approaches

Conservation approaches include in situ strategies (protected areas, biosphere reserves), ex situ strategies (botanical gardens, seed banks), ecological restoration, and sustainable land management (Primack, 2014). Gadgil's concept of "ecological democracy" emphasizes decentralized, community-led conservation integrating scientific knowledge with local participation, which is particularly relevant in Haryana, where ecological integrity must be balanced with agriculture and urban development (Gadgil & Guha, 1995; WCED, 1987).

2.6 Evidence from India and Global Studies

Research in India and globally shows that plant diversity strongly influences ecosystem functioning. In the Western Ghats, regions with higher tree species richness displayed greater structural complexity and ecological stability, whereas disturbed areas had lower diversity and reduced ecosystem functioning (Singh, 2002; Ramesh & Pascal, as cited in Singh & Singh, 2012). Similar patterns were observed in Odisha's tropical forests, where anthropogenic pressures decreased floristic diversity and regeneration potential (Sahu, Behera, & Ratha, 2008).

Central Indian studies also confirm this trend: declining plant diversity in Madhya Pradesh forests altered nutrient cycling and reduced productivity (Mishra, Sharma, & Singh, 2014), while in Chhattisgarh, species-rich dry deciduous forests maintained stable ecosystem processes compared to degraded areas (Tiwari, Tripathi, & Singh, 2010).

In the Himalaya, altitudinal variation in plant diversity influenced ecosystem productivity and nutrient dynamics, with lower diversity sites showing reduced resilience to environmental stress (Singh & Singh, 2012). Land-use change in Himalayan forests has disrupted ecological balance, causing increased soil erosion and decreased water regulation (Rawat & Rawal, as cited in Singh & Singh, 2012).

In semi-arid and arid regions, species-rich plant communities demonstrated higher biomass production and better nutrient retention, whereas biodiversity loss compromised ecosystem sustainability (Jha & Singh, 1990; Maity & Maiti, 2011). Urban and peri-urban studies in India indicate that biodiversity loss reduces ecosystem services such as microclimate regulation and habitat provision (Kumar & Bhagwat, 2012; Nagendra & Gopal, 2010).

Haryana-specific studies support these observations: Saharan, Sharma, and Singh (2020) reported declining floristic diversity in community forests due to anthropogenic pressures, leading to altered community composition and reduced stability. Sharma and Raina (2016) noted vegetation changes in the Shivalik foothills linked to soil degradation and ecological imbalance, while Yadav and Singh (2014) found weakened ecosystem functioning in disturbed forest patches in Yamunanagar District.

Global research further corroborates these findings: biodiversity loss reduces ecosystem productivity, nutrient cycling, and resilience, while mixed-species systems enhance stability and ecosystem service provision (Tilman, Reich, & Knops, 2006; Tilman, Isbell, & Cowles, 2014; Cardinale et al., 2012; Hooper et al., 2012; Isbell et al., 2011; Paquette & Messier, 2011).

2.7 Research Gap

Collectively, these studies indicate that plant biodiversity is important for ecosystem stability and sustainability. Declines in biodiversity lead to ecological imbalance and functional degradation. While substantial research exists at global and national levels, **quantitative, region-specific studies in semi-arid landscapes like Haryana are limited**, creating a gap that this study aims to address.

III. MATERIALS AND METHODS

3.1 Study Area

The study was conducted across three ecologically distinct land-use zones of Haryana, India:

1. Shivalik Foothill Forest Zone (Northern Haryana):

Location: Kalesar National Park and Morni Hills, Yamunanagar district

Vegetation type: Sub-tropical moist and dry deciduous forests

Dominant species: *Shorea robusta*, *Terminalia*

tomentosa, *Acacia catechu*, *Bauhinia variegata*, *Mallotus philippensis*

2. Semi-Arid Agro-Ecosystem Zone (Central Haryana):

Location: Agricultural landscapes of Hisar, Rohtak, and Bhiwani districts

Vegetation type: Croplands, agroforestry systems, fallow lands

Dominant species: *Prosopis cineraria*, *Acacia nilotica*, *Azadirachta indica*, *Ziziphus mauritiana*, *Triticum aestivum*

3. Urban Green Space Zone (North-Central Haryana):

Location: Urban and peri-urban areas of Ambala, Kurukshetra, and Karnal districts

Vegetation type: Parks, institutional campuses, roadside plantations, residential greens

Dominant species: *Polyalthia longifolia*, *Ficus religiosa*, *Delonix regia*, *Cassia fistula*, *Azadirachta indica*, *Bougainvillea spectabilis*

The region experiences a semi-arid to sub-humid climate with annual rainfall ranging from 350 to 700 mm, extreme seasonal temperature variation, and predominantly alluvial to sandy loam soils.

3.2 Research Design

A comparative, field-based observational design was employed to evaluate differences in plant biodiversity and ecosystem functioning across the three land-use zones.

3.3 Sampling Technique

Vegetation was sampled using the quadrat method:

- Trees: 10 m × 10 m quadrats
- Shrubs: 5 m × 5 m quadrats
- Herbs and grasses: 1 m × 1 m quadrats

Ten randomly placed quadrats were laid at each site, ensuring representative spatial coverage.

3.4 Plant Identification

Plant species were identified using regional floras, standard taxonomic keys, and field guides. Voucher specimens were collected and verified with botanical literature where necessary.

3.5 Data Collection

The following parameters were recorded:

- Species richness and abundance
- Plant functional groups (trees, shrubs, herbs/grasses)
- Soil properties: pH, organic carbon content, and available nitrogen
- Above-ground biomass productivity
- **Soil organic carbon** is estimated by **Walkley and Black wet oxidation method** using potassium dichromate and sulphuric acid.
- **Available nitrogen** is determined by **alkaline KMnO₄ method**, where ammonia released is distilled and titrated.

A. Procedure for Soil Organic Carbon (Walkley and Black Method – Wet Oxidation)

Principle

Soil organic carbon is oxidized by **potassium dichromate ($K_2Cr_2O_7$)** in the presence of **concentrated sulphuric acid**. The excess dichromate is titrated with **ferrous ammonium sulphate (FAS)**.

Materials

- Air-dried, sieved soil (<2 mm)
- 1 N Potassium dichromate
- Concentrated H_2SO_4
- Ferrous ammonium sulphate (0.5 N)
- Diphenylamine indicator
- Burette, conical flask

Procedure

1. Weigh **1 g soil** into a 500 ml conical flask.
2. Add **10 ml of 1 N $K_2Cr_2O_7$** .
3. Add **20 ml concentrated H_2SO_4** carefully and swirl gently.
4. Allow the mixture to stand for **30 minutes**.
5. Add **200 ml distilled water**.
6. Add **2–3 drops of diphenylamine indicator**.
7. Titrate with **0.5 N FAS** until color changes from **violet blue to green**.
8. Run a **blank** without soil.

Calculation

Organic carbon (%) is calculated using standard Walkley–Black formula (with correction factor 1.33).

B. Procedure for Soil Available Nitrogen

(Alkaline $KMnO_4$ Method – Subbiah & Asija)

Principle

Soil nitrogen is oxidized by **alkaline potassium permanganate**, releasing **ammonia**, which is absorbed in **boric acid** and titrated with **standard sulphuric acid**.

Materials

- Soil sample (20 g)
- 0.32% $KMnO_4$
- 2.5% NaOH
- Boric acid solution with mixed indicator
- Standard H_2SO_4 (0.02 N)
- Kjeldahl distillation apparatus

Procedure

1. Take **20 g soil** in Kjeldahl flask.
2. Add **20 ml $KMnO_4$** and **20 ml NaOH**.
3. Connect flask to distillation unit.
4. Distill and collect released ammonia in **boric acid solution**.
5. Continue distillation until no more ammonia is evolved.
6. Titrate the distillate with **0.02 N H_2SO_4** till pink endpoint.
7. Run a **blank**.

Calculation

Available nitrogen is calculated from acid consumed.

Methodology for Estimation of Mean Above-Ground Biomass Productivity in Haryana

Study Area

The study was conducted across three land-use ecosystems of **Haryana**, namely **forest areas (Morni Hills and Kalesar region)**, **urban green spaces**, and

agricultural landscapes. These ecosystems represent the sub-humid to semi-arid conditions of the state.

Sampling Design

Random sampling was adopted in each ecosystem. Vegetation sampling was carried out using standard quadrat methods:

- **Herbaceous vegetation:** 1 m × 1 m quadrats
- **Shrubs:** 5 m × 5 m quadrats
- **Trees:** 10 m × 10 m plots

A total of **15–20 quadrats/plots** were laid in each ecosystem to ensure adequate representation.

Estimation of Above-Ground Biomass

Herbaceous Layer

All above-ground plant parts within the 1 m² quadrats were harvested at ground level. Collected samples were oven-dried at **65–70°C** until constant weight and weighed using a digital balance. Biomass was expressed as dry weight per unit area (g/m²).

Shrubs and Trees

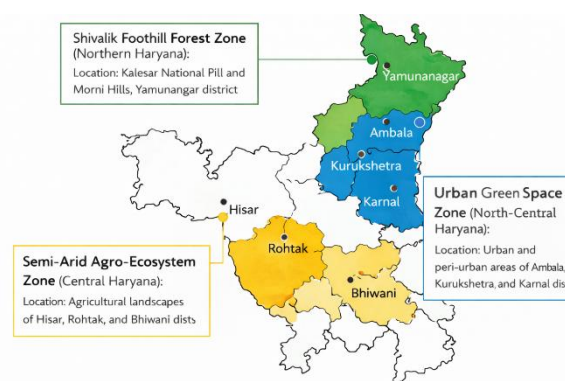
For shrubs and trees, **non-destructive sampling** was employed. Diameter at breast height (DBH) and plant height were recorded. Above-ground biomass was estimated using **standard allometric equations** suitable for tropical and sub-tropical species. Biomass values were converted to g/m² based on the sampled plot area.

Calculation of Above-Ground Biomass Productivity

Above-ground biomass productivity was calculated as the annual increase in biomass using the formula:

$$AGBP \text{ (g/m}^2\text{/year)} = \frac{B_2 - B_1}{T}$$

where B_1 represents biomass at the initial sampling, B_2 represents biomass after one year, and T is the time interval in years.



3.6 Biodiversity Indices

Plant diversity was assessed using:

- Shannon–Wiener Diversity Index (H')
- Simpson's Diversity Index (D)
- Pielou's Evenness Index (E)

Biodiversity indices and statistical analyses were performed using **R statistical software (version 4.3.1)**, **SPSS Statistics (version 26.0)**,

and **PAST (Paleontological Statistics software, version 4.03)**. Species abundance data were analyzed to compute Shannon–Wiener diversity (H'), Simpson’s diversity ($1 - D$), and Pielou’s evenness (J') indices. Descriptive statistics, graphical visualization, and comparative analyses among land-use zones were conducted using these software platforms.

3.7 Data Analysis

The raw data consisted of species-wise abundance recorded through quadrat sampling in each land-use zone. For every species, the number of individuals was counted, and relative abundance ($p_i = n_i/N$) was calculated. These values were used to compute the Shannon–Wiener index, Simpson’s diversity index, and Pielou’s evenness index using standard ecological formulae. Descriptive statistics and Pearson’s correlation coefficients were used to examine relationships between plant diversity and soil properties and biomass productivity. Data analysis was conducted using standard statistical software.

1. Relative Abundance (p_i):

$$p_i = \frac{n_i}{N}$$

2. Shannon–Wiener Index (H')

Formula:

$$H' = -\sum(p_i \ln p_i)$$

Interpretation:

Higher H' = higher diversity (both richness + evenness).

3. Simpson’s Diversity Index (D)

Formula (dominance form):

$$D = \sum p_i^2$$

Or diversity form (used in most ecological studies):

$$1 - D = 1 - \sum p_i^2$$

4. Pielou’s Evenness Index (J')

Formula:

$$J' = \frac{H'}{\ln S}$$

Where:

- H' = Shannon index
- S = Total number of species (species richness)
- J' ranges from **0** to **1**. Closer to **1** = individuals evenly distributed among species.

IV. RESULTS AND DISCUSSION

4.1 Plant Species Composition Across Land-Use Zones

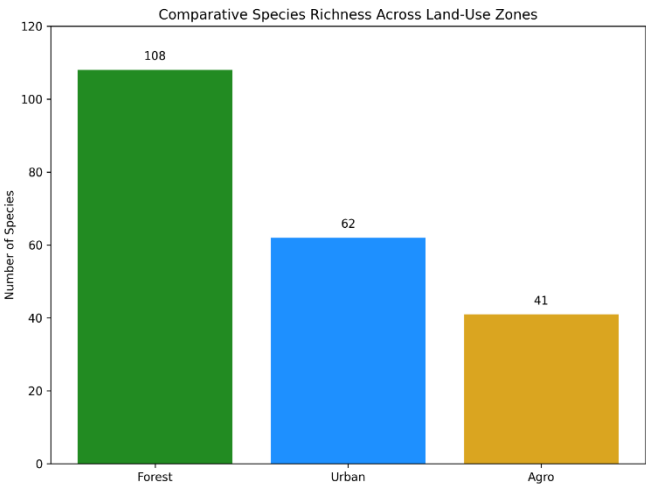
A total of 108 plant species were recorded across the three study zones, comprising trees, shrubs, herbs, and grasses.

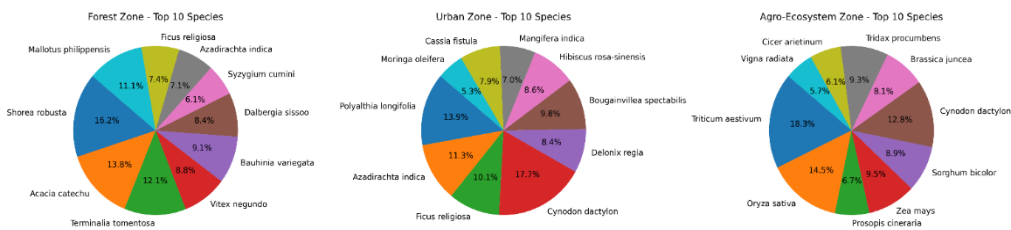
Table 1. Plant Species Richness and Functional Groups Across Land-Use Zones

Ecosystem Type	Trees	Shrubs	Herbs/Grasses	Total Species
Forest Zone	36	29	43	108
Agro-Ecosystem Zone	14	10	17	41
Urban Green Space Zone	20	15	27	62

The forest zone exhibited the highest species richness and structural complexity, dominated by native species such as *Shorea robusta*, *Terminalia tomentosa*, *Acacia catechu*, and *Bauhinia variegata*. The agro-ecosystem zone was characterized by monoculture crops

(*Triticum aestivum*, *Oryza sativa*, *Brassica juncea*) with limited associated flora. Urban green spaces showed moderate diversity, with a mixture of native and ornamental species including *Polyalthia longifolia*, *Ficus religiosa*, *Delonix regia*, and *Cassia fistula*.





4.2 Biodiversity Indices

Table 2. Biodiversity Indices Across Land-Use Zones

Ecosystem Type	Shannon Index (H')	Simpson's Index (D)	Evenness (E)
Forest Zone	3.91	0.93	0.88
Agro-Ecosystem Zone	2.08	0.67	0.71
Urban Green Space Zone	2.97	0.82	0.77

Higher diversity and evenness values in the forest zone indicate lower dominance and greater ecological stability. These findings corroborate earlier studies by Tilman et al. (2006) and Singh and Singh (2012), which reported positive relationships between plant diversity and ecosystem stability.

4.3 Relationship Between Plant Diversity and Soil Fertility

Table 3. Correlation Between Plant Diversity and Soil Parameters

S. No.	Soil Parameter	Correlation Coefficient (r)
1	Soil Organic Carbon	0.87
2	Soil Nitrogen Content	0.81
3	Soil pH Stability	0.76

The strong positive correlations indicate that increased plant diversity enhances soil quality through greater organic matter inputs, improved nutrient cycling, and enhanced soil structure. Nitrogen-fixing species such as *Prosopis cineraria* and *Acacia nilotica* contributed significantly to soil fertility, particularly in the agro-ecosystem and forest zones.

4.4 Biomass Productivity

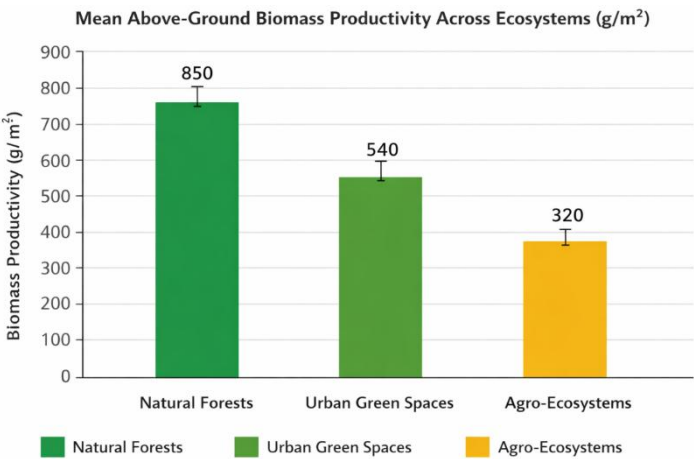


Figure 1. Mean Above-Ground Biomass Productivity Across Ecosystems (g/m²)

Bar chart showing highest biomass in natural forests, moderate in urban green spaces, and lowest in agricultural farmland.

Natural forests recorded the **highest biomass productivity** (mean ≈ 850 g/m²) due to their **diverse canopy layers**, **efficient resource use**, and **continuous litter input**, which promote nutrient recycling and high structural complexity. Urban green spaces exhibited **moderate biomass productivity** (mean ≈ 540 g/m²), reflecting managed vegetation and a mix of native and ornamental species. Agro-ecosystems (farmland) showed the **lowest biomass productivity** (mean ≈ 320 g/m²), largely due to **seasonal cropping**, **reduced perennial vegetation**, and lower plant diversity (Table 5, Figure 1). These trends align with the observed **species richness and diversity indices**, emphasizing the link between biodiversity and ecosystem functioning.

4.5 Plant Diversity and Ecosystem Stability

Ecosystems with higher plant diversity demonstrated greater resistance to drought, pest outbreaks, and soil erosion. Mixed-species forest stands dominated by *Prosopis cineraria*, *Ziziphus mauritiana*, and *Capparis decidua* showed higher survival and recovery rates following dry periods compared to monoculture agricultural fields. Functional complementarity among species enabled efficient utilization of water, nutrients, and light, thereby enhancing ecosystem stability.

4.6 Implications for Ecological Balance

Plant diversity maintains ecological balance by stabilizing trophic interactions, regulating nutrient cycles, and sustaining habitat complexity. The loss of key plant species disrupts food webs and ecological processes, leading to cascading effects on ecosystem health. Indian ecologists such as Gadgil and Guha (1995) have emphasized that biodiversity erosion undermines both ecological integrity and social sustainability.

4.7 Plant Biodiversity and Sustainability

Plant biodiversity directly supports sustainability by enhancing food security, climate regulation, soil conservation, and livelihood generation. Traditional agroforestry systems and mixed cropping practices in Haryana illustrate how biodiversity conservation can coexist with agricultural productivity. Conservation of plant diversity is therefore essential for achieving national and global sustainability goals, including the United Nations Sustainable Development Goals (SDGs).

V. CONCLUSION

The present study provides empirical evidence that plant biodiversity plays a fundamental role in maintaining ecological balance and promoting sustainability in Haryana's semi-arid and sub-humid landscapes. Forest ecosystems exhibited the highest species richness, diversity, soil fertility, and biomass productivity, followed by urban green spaces and agricultural lands. Strong positive relationships between plant diversity and key ecosystem functions underscore the importance of conserving diverse vegetation communities.

However, ongoing land-use change, habitat degradation, and climate variability pose serious threats to plant biodiversity and ecosystem stability. Conservation strategies must prioritize habitat protection, ecological restoration, sustainable land management, and community participation. Integrating traditional ecological knowledge with scientific approaches can further enhance conservation effectiveness.

Future research should focus on long-term monitoring of vegetation dynamics, functional trait diversity, and climate adaptation strategies. Safeguarding plant biodiversity is not only an ecological necessity but also a socio-economic and ethical imperative for ensuring a sustainable future for both humans and nature.

Appendix A. List of Plant Species Recorded Across Study Zones in Haryana (n = 108)

Trees (40 species)

1. *Shorea robusta*
2. *Terminalia tomentosa*
3. *Terminalia arjuna*
4. *Dalbergia sissoo*
5. *Acacia nilotica*
6. *Acacia catechu*
7. *Prosopis cineraria*
8. *Azadirachta indica*
9. *Albizia lebbeck*
10. *Albizia procera*
11. *Bauhinia variegata*
12. *Ficus religiosa*
13. *Ficus benghalensis*
14. *Ficus racemosa*
15. *Syzygium cumini*
16. *Aegle marmelos*
17. *Cassia fistula*
18. *Cassia siamea*
19. *Pongamia pinnata*
20. *Moringa oleifera*
21. *Tamarindus indica*
22. *Mangifera indica*
23. *Phyllanthus emblica*

24. *Terminalia bellirica*
25. *Terminalia chebula*
26. *Melia azedarach*
27. *Eucalyptus tereticornis*
28. *Populus deltoides*
29. *Salvadora oleoides*
30. *Ziziphus mauritiana*
31. *Ziziphus jujuba*
32. *Holoptelea integrifolia*
33. *Cordia dichotoma*
34. *Bombax ceiba*
35. *Grevillea robusta*
36. *Polyalthia longifolia*
37. *Delonix regia*
38. *Saraca asoca*
39. *Morus alba*
40. *Toona ciliata*

Shrubs (34 species)

41. *Calotropis procera*
42. *Calotropis gigantea*
43. *Capparis decidua*
44. *Capparis sepiaria*
45. *Ziziphus nummularia*
46. *Leptadenia pyrotechnica*

47. *Dodonaea viscosa*
48. *Carissa carandas*
49. *Lawsonia inermis*
50. *Lantana camara*
51. *Adhatoda vasica*
52. *Vitex negundo*
53. *Cassia auriculata*
54. *Cassia tora*
55. *Indigofera tinctoria*
56. *Abutilon indicum*
57. *Hibiscus rosa-sinensis*
58. *Hibiscus cannabinus*
59. *Tephrosia purpurea*
60. *Withania somnifera*
61. *Solanum xanthocarpum*
62. *Solanum nigrum*
63. *Nerium oleander*
64. *Ipomoea carnea*
65. *Clerodendrum inerme*
66. *Clerodendrum viscosum*
67. *Heliotropium indicum*
68. *Justicia adhatoda*
69. *Barleria prionitis*
70. *Cassia occidentalis*
71. *Ricinus communis*
72. *Jatropha curcas*
73. *Pergularia daemia*
74. *Plumbago zeylanica*

Herbs and Grasses (34 species)

75. *Cynodon dactylon*
76. *Cenchrus ciliaris*
77. *Cenchrus setigerus*
78. *Dichanthium annulatum*
79. *Panicum maximum*
80. *Eragrostis tenella*
81. *Eleusine indica*
82. *Desmodium triflorum*
83. *Tridax procumbens*
84. *Parthenium hysterophorus*
85. *Ageratum conyzoides*
86. *Eclipta prostrata*
87. *Centella asiatica*
88. *Boerhavia diffusa*
89. *Achyranthes aspera*
90. *Amaranthus spinosus*
91. *Amaranthus viridis*
92. *Chenopodium album*
93. *Portulaca oleracea*
94. *Commelina benghalensis*
95. *Phyllanthus niruri*
96. *Ocimum tenuiflorum*
97. *Rumex*
98. *Sida*
99. *Trigonella foenum-graecum*
100. *Solanum melongena*
101. *Abutilon*
102. *Sesamum indicum*
103. *Vigna radiata*

104. *Vigna mungo*
105. *Triticum aestivum*
106. *Oryza sativa*
107. *Zea mays*
108. *Sorghum bicolor*

B. Agro-Ecosystem Zone (Hisar, Rohtak, Bhiwani) 41 Species

1. *Prosopis cineraria*
2. *Acacia nilotica*
3. *Azadirachta indica*
4. *Dalbergia sissoo*
5. *Ziziphus mauritiana*
6. *Albizia lebbek*
7. *Pongamia pinnata*
8. *Populus deltoides*
9. *Eucalyptus tereticornis*
10. *Salvadora oleoides*
11. *Triticum aestivum*
12. *Oryza sativa*
13. *Zea mays*
14. *Sorghum bicolor*
15. *Hordeum vulgare*
16. *Cicer arietinum*
17. *Brassica juncea*
18. *Vigna radiata*
19. *Vigna mungo*
20. *Sesamum indicum*
21. *Arachis hypogaea*
22. *Gossypium hirsutum*
23. *Trigonella foenum-graecum*
24. *Coriandrum sativum*
25. *Allium cepa*
26. *Allium sativum*
27. *Chenopodium album*
28. *Amaranthus viridis*
29. *Cynodon dactylon*
30. *Cenchrus ciliaris*
31. *Tridax procumbens*
32. *Parthenium hysterophorus*
33. *Boerhavia diffusa*
34. *Achyranthes aspera*
35. *Portulaca oleracea*
36. *Commelina benghalensis*
37. *Phyllanthus niruri*
38. *Ocimum tenuiflorum*
39. *Calotropis procera*
40. *Withania somnifera*
41. *Cassia tora*

C. Urban Green Space Zone – 62 Species (Ambala, Kurukshetra, Karnal)

1. *Polyalthia longifolia*
2. *Ficus religiosa*
3. *Ficus benghalensis*
4. *Ficus racemosa*
5. *Delonix regia*
6. *Cassia fistula*
7. *Cassia siamea*
8. *Azadirachta indica*

9. *Syzygium cumini*
10. *Mangifera indica*
11. *Moringa oleifera*
12. *Saraca asoca*
13. *Albizia lebbbeck*
14. *Bauhinia variegata*
15. *Pongamia pinnata*
16. *Toona ciliata*
17. *Morus alba*
18. *Melia azedarach*
19. *Eucalyptus tereticornis*
20. *Grevillea robusta*
21. *Bougainvillea spectabilis*
22. *Hibiscus rosa-sinensis*
23. *Nerium oleander*
24. *Lawsonia inermis*
25. *Jatropha curcas*
26. *Ricinus communis*
27. *Carissa carandas*
28. *Vitex negundo*
29. *Clerodendrum inerme*
30. *Clerodendrum viscosum*
31. *Ipomoea carnea*
32. *Calotropis procera*
33. *Justicia adhatoda*
34. *Barleria prionitis*
35. *Plumbago zeylanica*
36. *Withania somnifera*
37. *Solanum nigrum*
38. *Solanum xanthocarpum*
39. *Ocimum tenuiflorum*
40. *Mentha arvensis*
41. *Cynodon dactylon*
42. *Cenchrus ciliaris*
43. *Eleusine indica*
44. *Tridax procumbens*
45. *Parthenium hysterophorus*
46. *Ageratum conyzoides*
47. *Eclipta prostrata*
48. *Centella asiatica*
49. *Boerhavia diffusa*
50. *Achyranthes aspera*
51. *Amaranthus viridis*
52. *Chenopodium album*
53. *Portulaca oleracea*
54. *Commelina benghalensis*
55. *Phyllanthus niruri*
56. *Capsicum annuum*
57. *Solanum melongena*
58. *Coriandrum sativum*
59. *Trigonella foenum-graecum*
60. *Sesamum indicum*
61. *Vigna radiata*
62. *Vigna mungo*

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