DOI: https://doi.org/10.59983/s2024020104
AgroEnvironmental Sustainability, 2024, 2(1), 27-33

RESEARCH

Abundance, Morphological Features, and Economic Values of Selected Tree Species in Company Graden of Saharanpur District, Uttar Pradesh, India

Simran Saini [1], Aleeza Usmani [1], Shifa Naaz [1], Swarna Pal Singh [1] and Shalu Sharma [1]

[1] School of Environmental Studies, Maa Shakumbhari University, Punwarka Saharanpur 247120, Uttar Pradesh, India

[*] Author responsible for correspondence; Email: simransaini2203@gmail.com.

ARTICLE HISTORY
Received: 28 February 2024
Revised: 09 March 2024
Accepted: 20 March 2024
Published: 25 March 2024

KEYWORDS
agro-forestry
company garden
timber
tree abundance

EDITOR
Sami Abou Fayssal

eISSN 2583-942X

Abstract

This study aimed to assess the abundance, morphological features, and economic values of selected tree species (Mango, Eucalyptus, and Bottle brush) within Company Garden of Saharanpur, Uttar Pradesh, India. Through systematic survey and analysis, the results showed that Eucalyptus emerged as the most abundant species, constituting 40% of the tree population. Mango trees, comprising approximately 35% of the population, were out for their economic importance and cultural significance. While their cultivation offers economic benefits, their influence on biodiversity and soil health warrants careful evaluation, particularly in the context of human cultivation practices. Bottle brush trees, though least abundant at 15%, contribute uniquely to the ecosystem by providing ornamental value and potential wildlife habitat. Their ecological contributions emphasize the importance of preserving biodiversity within the ecosystem. On the other hand, analysis of morphological and economic features highlighted the distinct characteristics of each species. Eucalyptus, with its remarkable height and girth, proves valuable for timber production and ecological functions such as erosion control. Mango trees, prized for fruit production and shade provision, play a crucial role in agroforestry contexts. While Bottle brush trees may not be extensively utilized for timber, their ornamental value and ecological contributions are noteworthy. Overall, the study provides valuable insights into the abundance, morphological characteristics, and ecological significance of tree species within the Company Garden.

Citation: Saini, S., Usmani, A., Naaz, S., Singh, S. P., & Sharma, S. (2024). Abundance, Morphological Features, and Economic Values of Selected Tree Species in Company Graden of Saharanpur District, Uttar Pradesh, India. *AgroEnvironmental Sustainability*, 2(1), 27-33. https://doi.org/10.59983/s2024020104

Statement of Sustainability: This research presents abundance, morphological characteristics, and economic significance of specific tree species within the Company Garden of Saharanpur District, Uttar Pradesh, India. This study focused on integration of detailed assessments i.e., abundance dynamics, morphological attributes, and economic valuation, offering a holistic understanding of the ecological and socio-economic roles played by these selected tree species in a distinct geographical context, thus contributing valuable insights to both scientific and conservation communities.

1. Introduction

Approximately 4% of global forested areas consist of plantations, established primarily for the provision of various ecosystem services, notably timber and wood products (Bauhus et al., 2010). Alongside these services, plantation forests offer both direct and indirect advantages to biodiversity, serving as habitats for diverse species and mitigating negative impacts on natural forests by reducing the necessity for resource extraction. The empirical evidence indicates that biodiversity in forests worldwide is directly influenced by climate change, manifested through alterations in temperature, precipitation patterns, storm intensity, and frequency, fire occurrences, as well as pest and disease outbreaks (Hansen et al., 2001). However, the ramifications of climate change on biodiversity in plantation forests extend beyond direct effects. Climate-induced changes are expected to profoundly influence biodiversity through modifications in forest management strategies aimed at mitigating climate change's impact on plantation productivity (Pawson et al., 2013).

These strategies encompass alterations in species composition (including the utilization of species mixtures), rotation periods, thinning practices, pruning regimes, biomass extraction for bioenergy, and large-scale climate-driven afforestation, reforestation, and potentially, deforestation efforts (Hines et al., 2010). Considering both the direct and indirect consequences of climate change, it is evident that in the short to medium term, adjustments in plantation management practices intended to mitigate or adapt to climate change may exert a substantially greater influence on biodiversity within these forests than the direct climatic effects themselves (Felton et al., 2016).

Climate change exerts direct and indirect effects on biodiversity, altering species distributions, population dynamics, and ecosystem functioning (Matocha et al., 2012). Direct effects of climate change include changes in temperature, precipitation patterns, and extreme weather events, such as storms and droughts (Trenberth et al., 2005). These alterations can directly impact the physiology, behavior, and distribution of plant and animal species. For example, shifts in temperature regimes may affect the timing of phenological events, such as flowering and leaf emergence, leading to mismatches in species interactions. Changes in precipitation patterns can influence habitat availability and quality, affecting species' reproductive success and survival (Renner and Zohner, 2018). Indirect effects of climate change often arise through cascading ecological interactions. For instance, changes in temperature and precipitation can alter the frequency and intensity of forest fires, insect outbreaks, and disease epidemics, which can have profound consequences for tree populations and associated biodiversity (Abarca and Spahn, 2021). Increased frequency and severity of wildfires, for example, can lead to the loss of forest habitat and disrupt species assemblages. Similarly, changes in pest and pathogen dynamics can threaten tree health and survival, impacting entire ecosystems (Simler-Williamson et al., 2019). Thus, climate change can interact with other stressors, such as habitat fragmentation, invasive species, and land-use change, exacerbating its effects on biodiversity. These interactions can lead to synergistic or antagonistic outcomes, further complicating predictions of biodiversity responses to climate change (Oliver and Morecroft, 2014).

Mango trees in the Saharanpur region foster biodiversity by offering habitats to diverse insect, bird, and mammal species while contributing to soil preservation and erosion prevention (Kumar et al., 2017). Similarly, eucalyptus trees aid in enhancing soil quality and combating desertification through their extensive root systems and water-efficient traits, additionally aiding in carbon sequestration, thus mitigating climate change effects. Furthermore, Bottle Brush trees play a crucial role in attracting pollinators like bees and birds with their vibrant flowers, thereby facilitating pollination and supporting local ecosystems, alongside their contribution to soil stabilization and erosion control. Economically, mango cultivation serves as a vital source of income for numerous farmers, with potential for improvement through enhanced cultivation methods and market exploration (Truong et al., 2022). Similarly, eucalyptus plantations offer valuable resources such as timber, pulpwood, and essential oils, thereby benefiting the local forestry industry. Although less commonly cultivated, Bottle Brush trees hold economic promise through their ornamental value and medicinal applications, warranting further research for economic utilization. Mangoes hold cultural significance in Saharanpur, being intertwined with festivals, rituals, and traditional cuisines, shedding light on local customs and practices. Eucalyptus plantations potentially contribute to rural development and employment opportunities, necessitating an understanding of associated social dynamics for sustainable management. Bottle Brush trees enhance the aesthetic appeal of urban and rural landscapes, prompting the study of their role in urban greening and biodiversity conservation to foster community awareness and appreciation. Thus, the study of mango, Eucalyptus, and Bottle Brush trees in the Saharanpur region holds significant importance due to various ecological, economic, and social factors.

Considering the aforementioned, this study was conducted to the abundance, morphological features, and economic values of selected tree species i.e., Eucalyptus (*Eucalyptus alba*) Mango (*Mangifera indica*), and Bottle Brush (*Callistemon viminalis*) in Company Graden of Saharanpur district, Uttar Pradesh, India.

2. Materials and Methods

2.1. Study Area

The Company Garden (29°58'16.7"N and 77°33'23.3"E) of Saharanpur District, located in the state of Uttar Pradesh, India, is a verdant oasis nestled amidst the bustling cityscape (Figure 1). Established during the colonial era, this historical garden holds significant cultural and botanical importance, attracting visitors with its lush greenery, vibrant flora, and serene ambiance. Originally known as the 'Company Bagh', the garden traces its roots back to the British Raj period when it was developed by the East India Company as a retreat for the officers and residents of Saharanpur. Over the years, it has evolved into a cherished landmark, offering respite from the urban hustle and bustle while serving as a recreational spot for locals and tourists alike. Spread across acres of land, the Company Garden captivates visitors with its meticulously landscaped lawns, manicured pathways, and picturesque water features. Tall trees provide ample shade, creating a tranquil atmosphere ideal for leisurely strolls, family picnics, or simply unwinding amidst nature's splendor. One of the highlights of the Company Garden is its diverse collection of plant species. Botanical enthusiasts and nature lovers are treated to a mesmerizing array of flowers, shrubs, and trees, showcasing the rich biodiversity of the region. From vibrant roses and fragrant jasmine to towering palms and majestic banyans, the garden is a treasure trove of botanical wonders, offering a feast for the senses in every season. Thus, the Company Garden of Saharanpur district, Uttar Pradesh, India, has diverse tree species that contribute significantly to its ecological richness and economic value and therefore selected for this study.

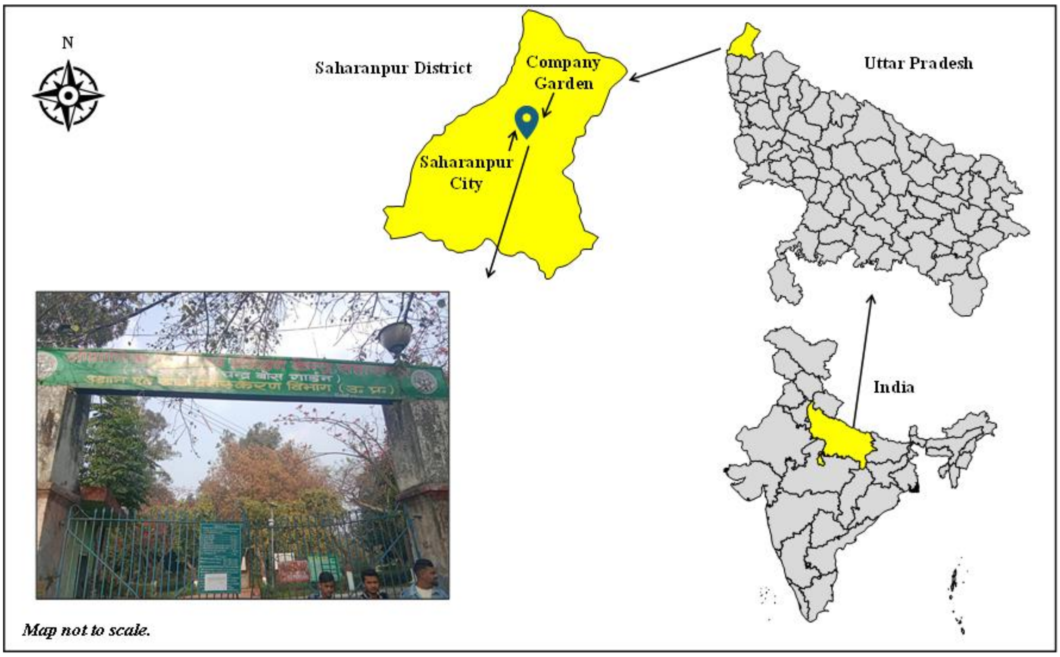

Figure 1. Map Showing Sample collection site.

2.2. Sampling and Data Collection

Data collection for the study conducted in February 2024 was done by frequent visits to the site, where 10 quadrates of 50 m^2 were established. Various parameters were recorded for analysis: tree height was measured using a clinometer and trigonometric principles; canopy size was determined by measuring foliage extent; diameter at breast height (DBH) was measured using a diameter tape at 1.37 meters above ground; tree health was assessed through appearance, growth patterns, and environmental conditions; leaves, bark, flowers, fruits, and timber characteristics were manually observed; resin type was determined based on previous studies; agroforestry uses were explored, focusing on integrating trees with agricultural crops or livestock; and pulp and paper potential was assessed, recognizing trees as a primary fiber source.

2.3. Data Analysis

The relative abundance of trees was calculated by dividing the number of individuals of a specific tree species by the total number of individuals of all tree species present, and then multiplying by 100 to express the result as a percentage:

$$\text{Relative Abundance (\%)} = (\text{No. of Individuals of Tree} / \text{Total No. of Individuals of All Tree}) \times 100$$

Moreover, mean, maximum, minimum, standard deviation (SD), and coefficient of variance (CV) values were also determined by using the MS Excel 2019 (Microsoft Corp., USA) software package.

3. Results and Discussion

3.1. Abundance of Selected Tree Species in Company Garden

The bar graph depicted in Figure 2 shows the relative abundance of three distinct tree species: Eucalyptus, Mango, and Bottle brush studied in Company Garden of Saharanpur. The results showed that Eucalyptus emerges as the dominant species, constituting approximately 40% of the tree population. This prevalence hints at Eucalyptus trees' strong adaptation to the local environment, possibly owing to factors like rapid growth, resilience to specific soil conditions, and efficient resource utilization (Gonçalves et al., 2017). However, further investigation is warranted to comprehend the ecological ramifications of such dominance, including its potential effects on the survival of other species or alterations in ecosystem dynamics. Mango trees follow closely, representing around 35% of the tree population. Given the cultural and economic significance of mangoes, their abundance may be influenced by human cultivation practices. It is imperative to evaluate the impact of mango orchards on biodiversity and soil health (Adil et al., 2019). On the other hand, Bottle brush trees are the least abundant, accounting for approximately 15% of the population. Their presence suggests specific ecological niches or preferences. Thus, investigating their role in supporting local fauna, soil enrichment, or erosion control is essential for a comprehensive understanding of the ecosystem.

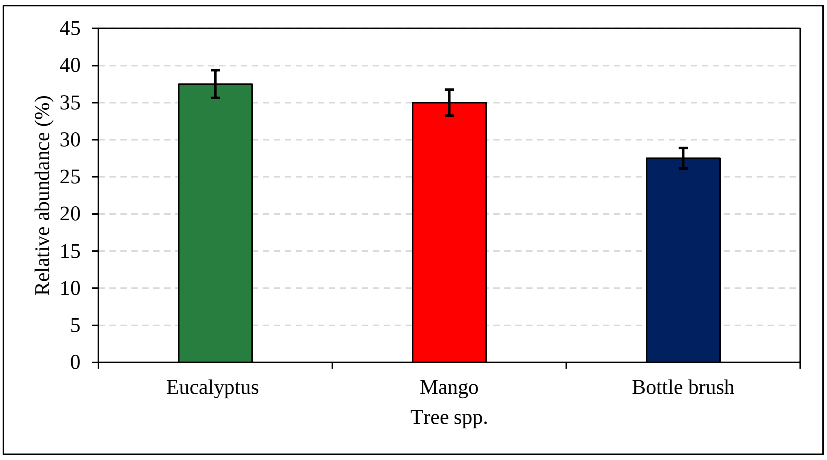

Figure 2. Relative abundance of selected tree species in Company Garden, Saharanpur, India.

3.2. Morphological and Economic Features of Eucalyptus Tree

As shown in Table 1, Eucalyptus trees observed in the study displayed a diverse range of characteristics contributing to their significance in various domains. Standing tall, their heights varied between 38.00 to 54.00 m, averaging 47.60 m, showcasing a moderate variability with a coefficient of variation (CV) of 13.66%. This variation in height was complemented by their canopy sizes, spanning from 28.00 to 58.00 m^2, with an average of 44.40 m^2, indicating a considerable diversity in canopy coverage. Furthermore, their substantial girth, with diameters at breast height (DBH) ranging from 49.00 cm to 75.00 cm and a mean DBH of 59.80 cm, highlighted their suitability for timber production. All the trees were reported as healthy, attesting to their robust growth and vitality, while their broad, lanciolate, aromatic leaves added to their aesthetic appeal. The smooth, strip-shedding bark, along with creamy white flowers in clusters, enhanced their ornamental value. The trees' woody capsules served as a source of seeds for regeneration, contributing to their perpetuation. Additionally, their hard and durable timber made them ideal for construction purposes, while their high resin content found applications in perfumes and oils. Moreover, the fast-growing nature of Eucalyptus trees rendered them effective for windbreaks and erosion control in agroforestry settings (Nair et al., 2021). As a major source of raw material for the paper and pulp industry, Eucalyptus played a pivotal role in sustaining these sectors, underlining its multifaceted importance in various industries and ecosystems alike.

3.3. Morphological and Economic Features of Mango Tree

The study focused on morphological and economic attributes of mango trees within Company Garden, Saharanpur, India. Table 2 showed that Mango trees had a considerable range in height, spanning from a minimum of 4.00 m to a maximum of 9.00 m, with an average height of 6.32 m (SD = 2.00). This variance was notable, with a coefficient of variation (CV) standing at 31.69%, indicating significant diversity in tree height. Regarding canopy size, measurements ranged between 18.00 and 32.00 m^2, with an average canopy size of 24.60 m^2 (SD = 4.98), signifying moderate variation in canopy coverage. In terms of Diameter at Breast Height (DBH), mango trees exhibited substantial girth, with measurements ranging from 22.00 to 37.00 cm and a mean DBH of 29.80 cm (SD = 6.02), potentially advantageous for timber production. All mango trees surveyed were reported as healthy, reflecting their overall well-being, while their broad, lanceolate, and aromatic leaves contributed to their aesthetic allure. The bark of mango trees was observed to be smooth initially, with a grey-brown hue that gradually transformed into a rough texture with age, a common characteristic of this species. Mango trees bore small, yellowish or pinkish-red flowers clustered together in panicles, augmenting their ornamental value, while their fruits, irregular in shape and fleshy drupes, represented the delectable mangoes familiar to many. Despite its moderate hardness, mango timber found applications in furniture and handicrafts, albeit it was not commonly utilized in the paper-making industry, unlike some other tree species (Skolmen et al., 1974). Furthermore, mango trees served as shade providers and were highly prized for their fruit production (Snelder et al., 2007), underscoring their significance in agroforestry contexts and beyond within Company Garden, Saharanpur, India.

Table 1. Results morphological and economic features of Eucalyptus tree in Company Garden, Saharanpur, India.

Parameters	Minimum	Maximum	Mean	SD	CV
Tree Height (m)	38.00	54.00	47.60	6.50	13.66
Canopy size (m^2)	28.00	58.00	44.40	11.97	26.96
Diameter at Breast Height (DBH)	49.00	75.00	59.80	10.08	16.86
Health Condition	Healthy				
Leave	Broad, lanciolate, aromatic				
Bark	Smooth, Shedding in strips				
Flower	Creamy white, Cluster				
Fruit	Woody capsule				
Timber	Hard durable, used in construction				
Resin	High resin content, used in perfume and oils				
Agroforestry Uses	Fast growing, windbreak, erosion control				
Pulp and Paper	A major source for the paper and pulp industry				

SD: Standard deviation; CV: coefficient of variance.

Table 2. Results morphological and economic features of mango tree in Company Garden, Saharanpur, India.

Parameters	Minimum	Maximum	Mean	SD	CV
Tree Height (m)	4.00	9.00	6.32	2.00	31.69
Canopy size (m^2)	18.00	32.00	24.60	4.98	20.24
Diameter at Breast Height (DBH)	22.00	37.00	29.80	6.02	20.19
Health Condition	Healthy				
Leave	Broad, lanceolate, aromatic				
Bark	Smooth, grey-brown, become rough with age				
Flower	Small, yellowish or pinkish-red colored, clustered together in panicles				
Fruit	Irregular, egg-shaped fruit which is a fleshy drupe				
Timber	Moderately hard, used in furniture and handicraft				
Resin	No resin				
Agroforestry Uses	Shade provider, fruit production				
Pulp and Paper	Not commonly used for paper-making				

SD: Standard deviation; CV: coefficient of variance.

Table 3. Results morphological and economic features of bottle brush tree in Company Garden, Saharanpur, India.

Parameters	Minimum	Maximum	Mean	SD	CV
Tree Height (m)	7.00	10.00	8.50	1.12	13.15
Canopy size (m^2)	14.00	37.00	26.00	9.41	36.18
Diameter at Breast Height (DBH)	27.00	61.00	39.30	14.39	36.63
Health Condition	Healthy				
Leave	linear, narrow, stiff evergreen				
Bark	Thick, rough, fissured, and brownish grey				
Flower	cylindrical, yellow, pink, and red spikes				
Fruit	Woody capsule, Woody fruit cluster				
Timber	Not commonly used for Timber				
Resin	Limited resin production				
Agroforestry Uses	Ornamental, attracts pollinators				
Pulp and Paper	Not commonly used for paper-making				

SD: Standard deviation; CV: coefficient of variance.

3.4. Morphological and Economic Features of Bottle Brush Tree

Data shown in Table 3 showed that bottle brush trees exhibited a relatively narrow range in height, ranging from 7.00 to 10.00 m, with an average height of 8.50 m (SD = 1.12). The coefficient of variation (CV) was calculated at 13.15%, indicating a comparatively low variability in tree height. In terms of canopy size, there was significant variance observed, spanning from 14.00 to 37.00 m^2, with a mean canopy size of 26.00 m^2 (SD = 9.41), suggesting a moderate variation in canopy coverage among the surveyed trees. Regarding Diameter at Breast Height (DBH), bottle brush trees displayed substantial girth, with measurements ranging from 27.00 to 61.00 cm and a mean DBH of 39.30 cm (SD = 14.39), hinting at potential implications for their ecological role. All bottle brush trees examined were reported as healthy, indicative of their overall well-being, while their linear, narrow, and stiff evergreen leaves contributed to the unique appearance of the species. The trees' bark was noted to be thick, rough, and fissured, with a brownish-grey hue—a characteristic commonly associated with this species. Bottle brush trees bore cylindrical flowers in yellow, pink, and red spikes, augmenting their ornamental value, while their woody capsules formed clusters of fruits, potentially serving as a food source for wildlife. Despite their substantial girth, bottle brush trees were not commonly utilized for timber due to their specific characteristics, and limited resin production was observed in these trees. Primarily ornamental, bottle brush trees attracted pollinators, underscoring their significance in agroforestry contexts, while their wood was not commonly used in the pulp and paper industry (Sawarkar et al., 2017).

4. Conclusion

The findings of this study showed dominance of Eucalyptus in the ecosystem, comprising 40% of the tree population which highlights its strong adaptation to local conditions and its multifaceted significance in various industries and ecological roles. However, the implications of such dominance on biodiversity and ecosystem dynamics necessitate further investigation. Mango trees, constituting approximately 35% of the population, stand out for their economic importance and cultural significance, highlighting the need to assess their impact on biodiversity and soil health amidst human cultivation practices. Conversely, Bottle brush trees, though the least abundant at 15%, play unique roles in providing ornamental value and potential habitat for wildlife, warranting attention for their ecological contributions. The morphological and economic features of each species further emphasize their distinct characteristics and ecological roles. Eucalyptus trees exhibit remarkable height, canopy size, and girth, making them ideal for timber production and various industrial applications, while also serving ecological functions such as erosion control. Mango trees, with their moderate height variability and substantial girth, are prized for their fruit production and shade-providing capabilities, contributing significantly to agroforestry contexts. Bottle brush trees, although not commonly utilized for timber, enhance landscapes with their ornamental value and provide potential habitat and food sources for wildlife. Overall, study shows useful findings regarding tree species abundance, morphological characteristics, and their ecological and economic significance within the Saharanpur. Further research and monitoring are essential to understand and manage the dynamics of these tree species for the sustainability of Company Garden's ecosystem and its surrounding environment.

Author Contributions: Conceptualization: Simran Saini; Data curation: Simran Saini, Aleeza Usmani, Shifa Naaz, Swarna Pal Singh, Shalu Sharma; Investigation: Simran Saini, Aleeza Usmani, Shifa Naaz, Swarna Pal Singh, Shalu Sharma; Methodology: Simran Saini; Software: Simran Saini, Aleeza Usmani, Shifa Naaz, Swarna Pal Singh, Shalu Sharma; Validation: Simran Saini, Aleeza Usmani, Shifa Naaz, Swarna Pal Singh, Shalu Sharma; Visualization: Simran Saini, Aleeza Usmani, Shifa Naaz, Swarna Pal Singh, Shalu Sharma; Writing – original draft: Simran Saini, Aleeza Usmani, Shifa Naaz, Swarna Pal Singh, Shalu Sharma; Writing – review & editing: Simran Saini, Aleeza Usmani, Shifa Naaz, Swarna Pal Singh, Shalu Sharma. All authors have read and agreed to the published version of the manuscript.

Funding: Not applicable.

Acknowledgment: The authors are grateful to Maa Shakumbhari University, Saharanpur for providing necessary facilities to conduct this research.

Conflicts of Interest: The authors declare no conflict of interest.

Institutional/Ethical Approval: Not applicable.

Data/Supplementary Information Availability: Not applicable.

References

Abarca, M., & Spahn, R. (2021). Direct and indirect effects of altered temperature regimes and phenological mismatches on insect populations. *Current Opinion in Insect Science*, 47, 67-74.

Adil, M. F., Sehar, S., Nordin, N. H. B., Chaudhry, A. N., Jilani, G., Shamsi, I. H., & Shakoor, N. (2019). Effect of spatio-temporal and landuse variability on earthworm distribution in mango orchards. *Wulfenia Journal*, 26(5), 63-83.

Bauhus, J., Pokorny, B., van der Meer, P. J., Kanowski, P. J., & Kanninen, M. (2010). Ecosystem goods and services–the key for sustainable plantations. In Ecosystem goods and services from plantation forests (pp. 205-227). Routledge.

Felton, A., Gustafsson, L., Roberge, J. M., Ranius, T., Hjältén, J., Rudolphi, J., & Felton, A. M. (2016). How climate change adaptation and mitigation strategies can threaten or enhance the biodiversity of production forests: Insights from Sweden. *Biological Conservation*, 194, 11-20.

Gonçalves, J. L., Alvares, C. A., Rocha, J. H., Brandani, C. B., & Hakamada, R. (2017). Eucalypt plantation management in regions with water stress. *Southern Forests: a Journal of Forest Science*, 79(3), 169-183.

Hansen, A. J., Neilson, R. P., Dale, V. H., Flather, C. H., Iverson, L. R., Currie, D. J., & Bartlein, P. J. (2001). Global change in forests: responses of species, communities, and biomes: interactions between climate change and land use are projected to cause large shifts in biodiversity. *BioScience*, 51(9), 765-779.

Hines, S. J. (2010). An annotated bibliography of scientific literature on managing forests for carbon benefits (No. 57). US Department of Agriculture, Forest Service, Northern Research Station.

Kumar, M., Singh, S. N., Kumar, A., Yadav, R. R., Doharey, R. K., & Kumar, M. (2017). Knowledge extent of management practices about mango cultivation in Saharanpur district (UP). *Journal of Pharmacognosy and Phytochemistry*, 6(3), 27-29.

Matocha, J., Schroth, G., Hills, T., & Hole, D. (2012). Integrating climate change adaptation and mitigation through agroforestry and ecosystem conservation. In Agroforestry-the future of global land use, pp. 105-126.

Nair, P. R., Kumar, B. M., Nair, V. D., Nair, P. R., Kumar, B. M., & Nair, V. D. (2021). Soil Conservation and Control of Land-Degradation. An introduction to agroforestry: Four decades of scientific developments, pp. 445-474.

Oliver, T. H., & Morecroft, M. D. (2014). Interactions between climate change and land use change on biodiversity: attribution problems, risks, and opportunities. *Wiley Interdisciplinary Reviews: Climate Change*, 5(3), 317-335.

Pawson, S. M., Brin, A., Brockerhoff, E. G., Lamb, D., Payn, T. W., Paquette, A., & Parrotta, J. A. (2013). Plantation forests, climate change and biodiversity. *Biodiversity and Conservation*, 22, 1203-1227.

Renner, S. S., & Zohner, C. M. (2018). Climate change and phenological mismatch in trophic interactions among plants, insects, and vertebrates. *Annual Review of Ecology, Evolution, and Systematics*, 49, 165-182.

Sawarkar, A. B. (2017). Foraging behaviour of Giant Rock honeybee, *Apis dorsata* on bottle brush, *Callistemon lanceolatus* (Myrtaceae). *Journal of Entomology and Zoology Studies*, 5(4), 605-607.

Simler-Williamson, A. B., Rizzo, D. M., & Cobb, R. C. (2019). Interacting effects of global change on forest pest and pathogen dynamics. *Annual Review of Ecology, Evolution, and Systematics*, 50, 381-403.

Skolmen, R. G. (1974). Some woods of Hawaii: Properties and uses of 16 commercial species (Vol. 8). Pacific Southwest Forest and Range Experiment Station, Forest Service, US Department of Agriculture.

Snelder, D. J., Klein, M., & Schuren, S. H. G. (2007). Farmers preferences, uncertainties and opportunities in fruit-tree cultivation in Northeast Luzon. *Agroforestry Systems*, 71, 1-17.

Trenberth, K. E. (2005). The impact of climate change and variability on heavy precipitation, floods, and droughts. *Encyclopedia of Hydrological Sciences*, 17, 1-11.

Truong, K. H. V. T., & Sidique, S. F. (2022). Integrated Economic Efficiency and Vulnerability of Chu-Mango Value Chain in the Mekong Delta, Vietnam. *International Journal on Food System Dynamics*, 13(3), 349-366.