



Urban forestry for sustainable urban management: A study from Hetauda Sub-metropolitan City, Nepal

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ABSTRACT

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Developing sustainable urban areas in such a way that every citizens can enjoy a high quality of life and environment is one of the pressing environmental challenges we face today. This study was conducted to identify the major urban tree species and people's perceptions towards urban forestry for sustainable urban development in Hetauda Sub-metropolitan City, Nepal. Mixed method of field assessment and questionnaire survey with urban households (N=125) was used to collect information regarding urban forestry by applying simple random sampling. Data were analyzed using descriptive and Likert scale rating through SPSS. The results showed that 46 different tree species were recorded in the study area with most frequent being *Saraca asoca*, *Mangifera indica* and *Ficus religiosa*. Based on local people's preference *Sparaco asoca*, *Nyctanthes arbortristis*, and *Thusa spp.* are top 3 species for urban plantation. People opined that management of urban forest is not so good and they responded that poor management of roadside trees is due to lack of people participation with weighted mean value of 2.10. More than 90% of the respondents agreed that urban trees are essential for sustainable urban planning. Furthermore, rapid urbanization, lack of public awareness, and limited institutional support are major challenges while community engagement, ecological resilience, and government initiatives and policies are major opportunities for urban forestry development in the city. Therefore, appropriate selection of tree species, community participation and awareness regarding urban forestry should be emphasized. Furthermore, urban forestry program requires its prioritization and integration in the local and national policies.

Contribution/Originality: This research assessed the major urban tree species planted, local people's preferred species for plantation and major challenges and opportunities for urban forestry development through combined approach of field assessment and local people's perspective. Previous studies lacked these aspects of urban forestry study in the Hetauda Sub-metropolitan City, Nepal.

1. INTRODUCTION

Urban forestry is the practice of planning, establishing, and managing tree resources in urban settings to improve the quality of life, enhance biodiversity, and provide ecosystem services [1]. It goes beyond the mere planting of trees; it encompasses the strategic management of green spaces within cities, such as public parks, residential areas, street trees, community gardens, and natural forests located in or around urban zones [1, 2]. The concept of urban forestry was originated in North America during 1960s as an innovative strategy to manage natural resources in urban settings, and then spread to Europe during 1990s before gaining widespread acceptance and support. With the increased environmental awareness among individuals throughout the world, there is a growing need for techniques

to develop urban forestry in the difficult settings of most urban environments [1, 3]. Urban forestry contributes to enhance urban livability by offering various social, environmental, and economic benefits, essential for sustainable urban development [4–6].

Globally, urban area occupy merely 2 percent of the Earth's surface yet, their inhabitants use 75 percent of its natural resource [5]. The world is rapidly urbanizing and it is projected that by 2050, 70 percent of the global population will reside in urban areas [7, 8]. Urban forests acts as the green lungs of urban areas and they are critical for sustainable development. However, urban forests are facing challenges in surviving due to harsh growing conditions, limited resources, pressures form development, and a lack of awareness about them. Addressing these challenges appropriately can contribute to achieve Sustainable Development Goals (SDGs) [8–10]. Therefore, sustainable urban development is critical for maintaining the quality of life for the global population. In this context, trees in and around urban areas can play vital role in the planning, design, and management of sustainable and resilient urban areas [8, 11, 12].

Urban forestry is critical to sustainable urban development because it improves the environmental, social, and economic health of cities. As cities expand, urban forests provide critical ecological services that improve the quality of life for residents [5, 9, 13]. They help to lessen the urban heat island effect by providing shade and cooling, reduce air pollution by absorbing toxic gasses, and improve water management by minimizing storm water runoff. Urban forests also help to preserve biodiversity by providing habitat for species in the urban setting [5, 13, 14]. Socially, green spaces in cities improve mental and physical well-being by providing leisure opportunities, improving aesthetic beauty, and building a sense of belonging. Economically, well-managed urban trees can enhance property values and attract businesses while lowering energy costs through natural temperature regulation [10, 13]. From the sustainability point of view, urban forestry contributes to climate adaptation goals by sequestering carbon, increasing resistance to extreme weather events, and enhancing overall environmental quality. Integrating urban forestry into sustainable urban development programs and strategies helps cities remain livable, resilient, and equitable by promoting a balance between urbanization and natural conservation [5, 10, 13]. Involving local people in urban forestry projects, such as tree planting and maintenance, strengthens the programs' sustainability by encouraging stewardship and long-term care of green spaces. Cities can achieve more inclusive and environmentally responsible urban growth by linking urban forestry activities with sustainable development goals.

Nepal is facing a rapid change in its population dynamic, characterized by unprecedented urban growth. According to the 2021 census, Nepal's urban population has increased significantly over the last few decades (10.18% from 2011 to 2021), driven by rural-to-urban migration, infrastructure development, and urban economic opportunities [15]. As a result, Nepal's urban centers facing numerous issues, including air pollution, traffic congestion, inadequate infrastructure, biodiversity loss, and increased demand for natural resources. The urban population is expected to grow continue, putting extra burden on the environment and creating a demand for sustainable urban development solutions [16].

Hetauda city is regarded as one of the cleanest and greenest cities in Nepal. It is also the first roadside plantation area in Nepal. The city is recognized for its strategic importance as a business and transit hub, has witnessed rapid urbanization over the past decade [17]. Because of its geographical features and climate, it has been a favorite destination for people migrating from the northern Hilly regions to the south and the southern Terai region, resulting in an annual population rise. As a result of the high incidence of rural-urban migration, the green city is converting into urban habitats [18]. The population growth of the city is 2.20% from 2011 to 2021 [17] and city's built-up areas have continuously increased, and agricultural areas have decreased from 1990 to 2020 [17, 19]. The city is currently facing a number of serious environmental and socio-economic challenges. In this context, urban forestry offers a viable solution to mitigate the environmental impacts of urbanization while enhancing the quality of life for city dwellers. The integration of green spaces, including parks, street trees, and community forests, can help address issues like air quality, urban heat islands, water management, and loss of biodiversity [1, 3, 20]. This study aims to study

the current state of urban forestry in Hetauda sub metropolitan city, identifying the major urban tree species, challenges and opportunities, and people's perceptions towards urban forestry for sustainable urban management.

2. METHODOLOGY

2.1. Study Area

The study was carried out in Hetauda sub-metropolitan city of Makwanpur district, Bagmati Province Nepal (Figure 1). The city is situated in the confluence of the two prominent national highways viz. Tribhuvan highway and Mahendra highway. Administratively, the city is divided into 29 wards and covers the area of 261.58 sq.km. It is extended from $85^{\circ} 53' 27''$ to $85^{\circ} 11' 24''$ E and $28^{\circ} 32' 31''$ to $27^{\circ} 19' 58''$ N. The elevation of the SMC ranges between 300m to 390m above mean sea level [17]. The average temperature in Hetauda is 27°C . Hetauda typically receives about 232 millimeters of precipitation annually.

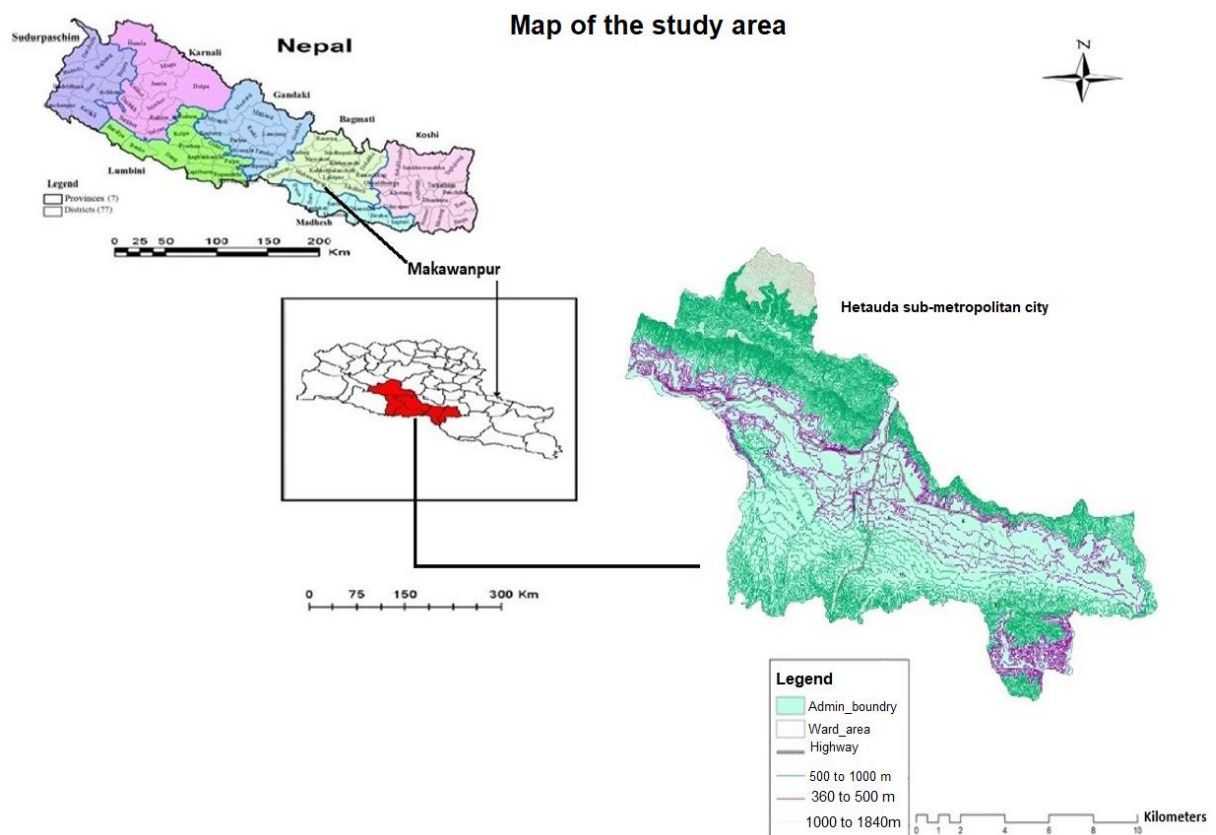


Figure 1. Map of the study area.

2.2. Sampling Design and Data Collection

Simple random sampling approach was applied for this research. Both quantitative data and qualitative information were collected for this study.

2.2.1. Transect Survey

A transect study ($n=4$) was conducted on four separate routes (length=3km) leading from the city center, i.e. Buddha Chok. At 200m intervals along the transect, 100m² plots were laid to collect data on tree species, diameter at breast height (DBH), height, and other associated information. The number of species and their conditions (trees and saplings), and their frequencies were documented by the transect line survey. The survey specifically targeted roadside plantations, urban parks, and other institutional plantations.

2.2.2. Social Survey

A semi-structured questionnaire survey (N=125) was conducted with local residents, local government officials, municipality offices, and the Divisional Forest Office (DFO) of Hetauda to learn about their perspectives on urban forestry, the current status, and the support needed to promote urban forestry in the city.

2.3. Data Analysis

The data collected from various sources was processed, tabulated and analyzed qualitatively and quantitatively using simple statistical techniques such as percentage, mean, and weighted mean with statistical computer software such as SPSS.

Preference ranking of tree species was performed on the basis of 5 criteria such as scenic beauty, aesthetic values, ease of availability, multipurpose uses and market demand. Based on these criteria each criterion was given the value as high as 3 and as low as 1. Accordingly, the Likert scale approach was used to assess people's perspectives on urban forestry [21]. The Likert scale is a psychometric scale that asks people to respond to interest-based questions in order to assess their opinions. In this study, respondents' attitudes about urban forestry were measured using a Likert Scale ranging from strongly agree to strongly disagree (1–5). The weighted mean was computed with the following formula:

$$\text{Weighted mean} = \sum (w_i \cdot x_i) / \sum w_i$$

Where, w_i represents respondents' responses in number and x_i represents the value assigned to strongly agree to strongly disagree.

3. RESULTS AND DISCUSSION

3.1. Species Composition

Total species recorded in the study area are listed in the Annex 1. A total of 46 tree species were recorded in the study area. The detail of dbh (Diameter at breast height) and height of the urban trees reported are presented in the Table 1. *Ficus religiosa* had the largest dbh while *Bombax ceiba* had maximum height. Accordingly, the largest dbh recorded was 111.60cm (*Ficus religiosa*) and maximum height was 31.40m (*Bombax ceiba*). A study by Khanal, et al. [22] identified 30 plant species from 13 families along the Balkumari-Shankhamul Road in Kathmandu. Pandey and Luitel [23] identified 2531 trees from 28 families in the Kathmandu Valley, representing 61 woody species. In comparison, floral diversity in the study site was found to be relatively higher to some extent. This indicate that the state of urban forestry in Hetauda sub-metropolitan city is promising and it needs further support from all stakeholders, including government bodies, communities, and the private sector for sustainable development.

Table 1. Descriptive statistics of urban trees in Hetauda.

Category	N	Mean	SD	Max.	Min.
DBH	694	28.31	13.22	111.60	6.35
Height	694	13.68	7.45	31.40	5.20

The most frequently planted species reported in Hetauda were *Saraca asoca* followed by *Mangifera indica* and *Ficus religiosa* (Annex 1). Saplings of various species account for 17.58% (122/694) of the tree species in Hetauda city. Majority of saplings recorded were *Saraca asoca*, *Thuja spp.* and *Nyctanthes arbortristis* demonstrating that city people mostly preferred small, less branchy, and appealing tree species. Among the 122 saplings recorded, *Saraca asoca*, *Thuja spp.* and *Nyctanthes arbortristis* accounted for 34.42%, 14.75% and 10.65%, respectively. Lamichhane and Tapa [3] also reported 571 and 853 urban tree species in Pokhara and Bharatpur city, Nepal. Similarly, *Saraca asoca*, *Melia azedarach* and *Dalbergia sissoo* are most frequently planted species in the Bharatpur city Lamichhane and Tapa [3]. However, the species selected for urban plantation in this study site were and unplanned and unprofessional. Therefore, more study is needed on the selection of suitable species, silviculture, greenery, forest product utilization, soil analysis, and

technical help in UF management. Study on the socio-economic, ecological, and management aspects of urban forestry will be critical, particularly on species phenology and silvicultural characteristics, as well as their interaction with the urban environment and economic contribution [3, 24].

3.2. Local People's Preference of Urban Trees

Table 2 represents the top 10 most preferred urban tree species by urban dwellers in Hetauda metropolitan city. These species were selected on the basis of scenic beauty, aesthetic values, ease of availability, multipurpose uses and market demand. Urban people believe that most common motives to plant trees on their properties were scenic beauty, aesthetic values and for food [25].

Table 2. Most preferred tree species by local people for urban plantation.

S.N.	Botanical name	Local name	Family
1	<i>Sparaco asoca</i>	Ashoka	Fabaceae
2	<i>Nyctanthes arbortristis</i>	Parijat	Oleaceae
3	<i>Thusa spp.</i>	Dhupi	Cupressaceae
4	<i>Santalum album</i>	Shrikhanda	Santalaceae
5	<i>Cinamomum tamala</i>	Tejpat	Lauraceae
6	<i>Pterocarpus santalinus</i>	Raktachandan	Fabaceae
7	<i>Garcinia mangostana</i>	Mangosteen	Clusiaceae
8	<i>Cinamomum camphora</i>	Kapoor	Lauraceae
9	<i>Delonix regia</i>	Gulmohar	Fabaceae
10	<i>Grevillea robusta</i>	silky oak	Proteaceae

3.3. People's Perspectives Towards Urban Forestry

Figure 2 presents the level of awareness of urban people about urban forestry. From the study it is reported that urban people on Hetauda city were highly aware about the knowledge of urban forestry. Off the total, about 74% responded that they were aware about urban forestry. About 5% opined that they were completely unaware about urban forestry while about 21% responded they are undecided. Urban forestry in Nepal is still in its nascent stages [26] however people are becoming more aware about the importance of urban trees for sustainable development [3, 25].

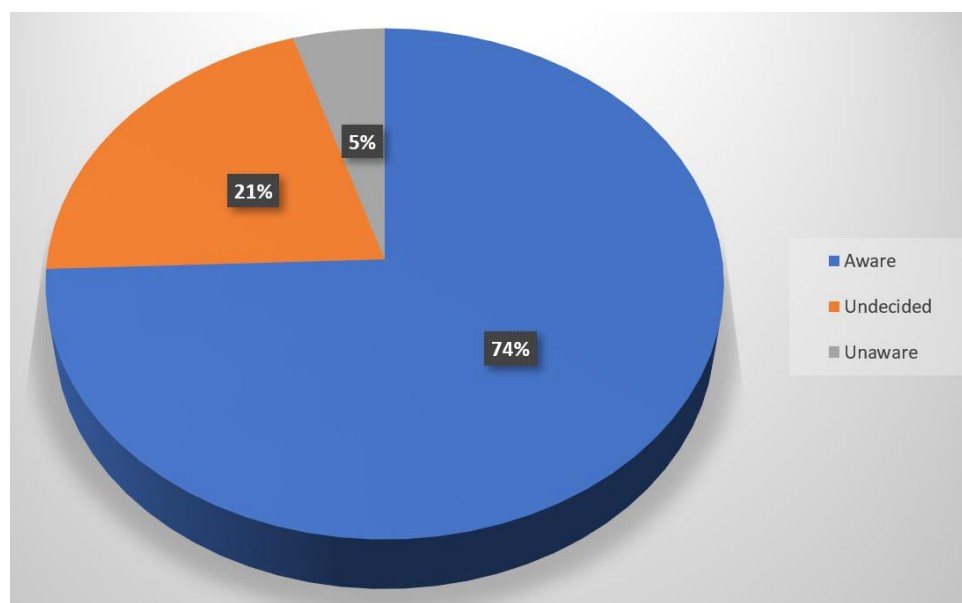


Figure 2. Level of awareness about urban forestry.

Table 3 shows people's perceptions towards urban forestry in Hetauda sub-metropolitan city. Local people responded very positively towards urban forestry. Majority of respondents in the city strongly agreed with the statement that trees in the city are environmentally beneficial and trees in the urban settings increases beauty. Likewise, most of the people feel that poor management of roadside trees is due to lack of people participation however the management of urban trees in the city area are not poor. Furthermore, majority of the respondents responded that urban trees maintenance and management should be done by government and local people participation. Very large proportions of respondents in the city advocated for the Community participation is very critical for urban forest management and its sustainable development. The management of urban forest in the city was found to be fair. While community-driven programs exist, these are frequently limited to specific events like plantation drives. To ensure long-term management, community engagement must be institutionalized, where residents can play a continuous role in caring for these green spaces. However people were more aware about urban forestry in Hetauda city than Bharatpur city and Gaidakot city [3, 27]. Most importantly, more than 90% of the respondents feel that urban trees are critical for sustainable urban planning. Similar, type of people's opinion was reported by Lamichhane and Thapa [3] from Pokhara and Bharatpur city metropolitan city and Gaidakot municipality [27] respectively. Urban forests are the backbone of green infrastructure, connecting rural and urban areas and reducing a city's environmental footprint [28].

Table 3. People' perception towards urban forestry.

S.N.	Statements	Percentage of responses					Weighted mean
		Strongly agree	Agree	Neutral	Disagree	Strongly disagree	
		1	2	3	4	5	
1	Urban trees are beneficial for environment	107	18	0	0	0	1.14
2	Trees in the urban settings increase its beauty	98	27	0	0	0	1.22
3	Want to participate in any urban forestry activities	73	46	0	6	0	1.51
4	Tree along roadside been planted according to your desire	40	19	15	18	33	2.88
5	Satisfied with availability of current trees along roadside	17	12	7	30	59	3.82
6	Urban forest maintenance and management should be done by government and local people participation	105	16	2	2	0	1.21
7	Poor management of roadside trees is due to lack of people participation	32	57	30	4	2	2.10
8	Trees along roadsides are hazardous to home and life	42	45	20	12	6	2.16
9	Present selection of tree species and poor management are major causes of tree hazards	39	68	18	0	0	1.83
10	There is urgent need to remove hazardous trees and plant with new species	66	55	4	0	0	1.50
11	Satisfied with the urban tree management municipality authority	3	29	45	32	16	3.05
12	Urban trees are critical for sustainable urban planning	113	12	0	0	0	1.10
13	Local peoples' participation is essential for urban forest management	61	64	0	0	0	1.51

3.4. Challenges and Opportunities for Urban Forestry

Figure 3 shows the key challenges for urban forestry development in Hetauda sub-metropolitan city. According to the local residents of urban area, rapid urbanization (36.80%), lack of public awareness and participation (27.20%), and limited institutional support (16.80%) are major challenges for urban forestry development. Land use pressure and pollution and environmental degradation also posing significant obstacles for urban forestry development in Hetauda city (Figure 3).

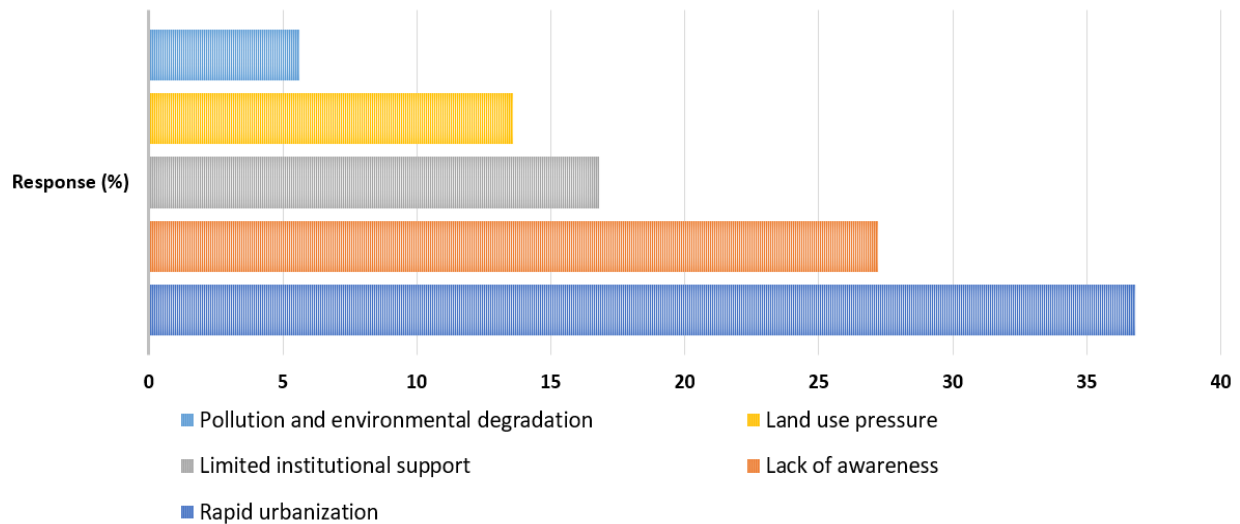


Figure 3. Major challenges for urban forestry development in Hetauda city.

Similarly, Figure 4 presents major opportunities for urban forestry development in Hetauda sub-metropolitan city. Results show that community engagement (34.40%), ecological resilience (28.80%) and government initiatives and policies (19.20%) are major opportunities in the study area. In addition, integrated urban planning, and opportunities for tourism and recreation are critical for the success of urban forestry program in the Hetauda sub-metropolitan city.

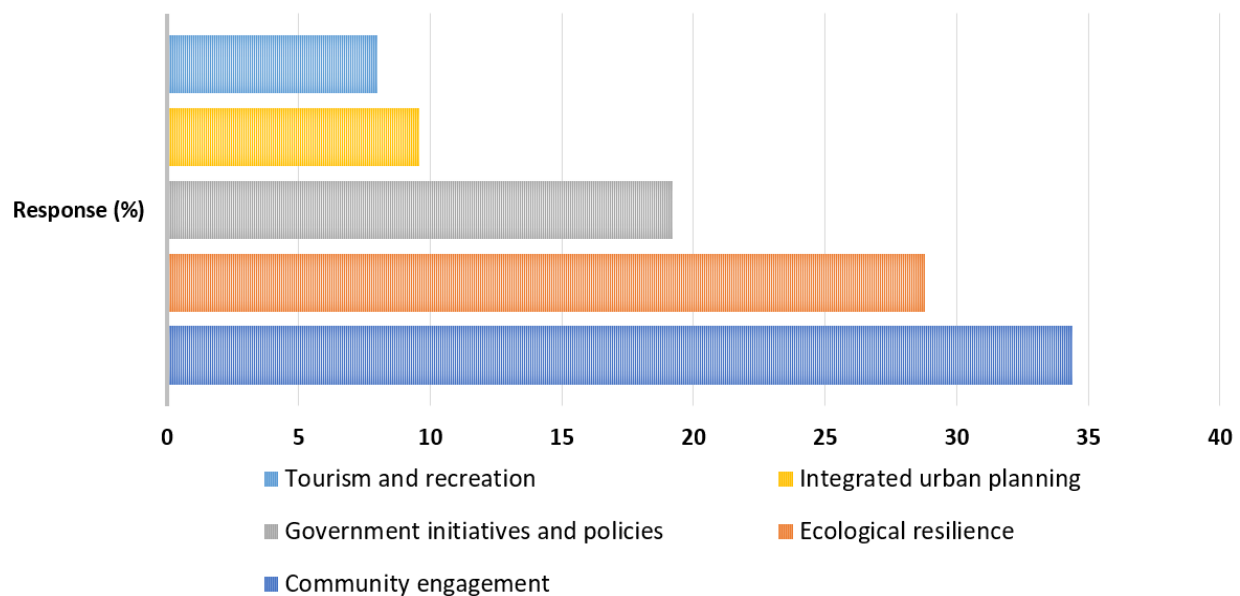


Figure 4. Major opportunities for urban forestry development in Hetauda city.

Hetauda is one of the fastest-growing cities in Nepal and rapidly growing as a commercial center. The results are in line with Lamichhane and Tapa [3] and Sharma and Ghimire [27] who reported similar type of challenges

and opportunities for urban forestry in Bharatpur city, Chitwan and Gaidakot, Nawalpur district respectively. Urban forestry is a new branch of ecological management that has great promise for promoting sustainable urban development, especially in fast urbanizing countries like Nepal [29]. As urban populations grow, the demand for well-planned, environmentally friendly green spaces becomes critical. It is becoming less feasible as cities expand since green spaces and wooded areas are frequently turned into residential or commercial zones. The fragmented green spaces that result from poorly planned urban landscapes are inadequate for maintaining biodiversity and providing ecosystem services [9, 30]. It is critical to create integrated green spaces that focus on connecting green areas, creating a cohesive network, and safeguarding green corridors for sustainable development.

4. CONCLUSION

A total of 46 different urban tree species were recorded in the study area. About one third (74%) of surveyed people were found to be aware about the urban forestry. More than 90% of them opined that urban forests are the backbone of green infrastructure, connecting rural and urban areas and reducing a city's environmental footprint. However, rapid urbanization, lack of public awareness, and limited institutional support poses significant challenges whereas strong willingness of community engagement, government initiatives and policies provisions are major opportunities for urban forestry development in the study area. Nonetheless, urban forestry in Hetauda Sub-metropolitan city is still in its early phases, with some initiatives showing great promise. To realize the full potential of urban forestry, it is essential to prioritization and inclusion of urban forestry program in the national plans and policies are imperative that should include all stakeholders such as government bodies, communities, and the private sector.

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Institutional Review Board Statement: The Ethical Committee of the Agriculture and Forestry University Faculty of Forestry, Hetauda, Nepal has granted approval for this study on 27 August 2023 (Ref. No. 117).

Transparency: The authors declare that the manuscript is honest, truthful and transparent, that no important aspects of the study have been omitted and that all deviations from the planned study have been made clear. This study followed all rules of writing ethics.

Competing Interests: The authors declare that they have no competing interests.

Authors' Contributions: Both authors contributed equally to the conception and design of the study. Both authors have read and agreed to the published version of the manuscript.

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Annex 1. Species diversity and frequencies in the Hetauda sub-metropolitan city.

S.N.	Common name	Local name	Scientific name	Frequencies	%
1	Mango	Aap	<i>Mangifera indica</i>	61	8.79
2	Peach	Aaru	<i>Prunus persica</i>	3	0.43
3	Guava	Amba	<i>Psidium guava</i>	9	1.3
4	Ashoka	Ashok	<i>Saraca asoca</i>	153	22.05
5	Chinaberry	Bakaino	<i>Melia azedarach</i>	20	2.88
6	Indian fig	Bar	<i>Ficus bengalensis</i>	26	3.74
7	Bengal quince	Bel	<i>Aegle marmelos</i>	11	1.58
8	Jacaranda	Birendraphul	<i>Jacaranda ovalifolia</i>	4	0.58
9	Champak	Champ	<i>Magnolia champaca</i>	4	0.58
10	Thujas	Dhupi	<i>Thuja spp.</i>	32	4.61
11	Gulmohar	Gulmohar	<i>Delonix regia</i>	5	0.72
12	Ipil-Ipil	Ipil Ipil	<i>Leucaena leucocephala</i>	3	0.43
13	Silky oak	Kagiyo	<i>Grevillea robusta</i>	4	0.58
14	Creek bottlebrush	Kalkiphul	<i>Callistemon viminalis</i>	7	1.01
15	Orange jasmine	Kamini	<i>Murraya paniculata</i> ,	1	0.14
16	Kapok	Kapok	<i>Ceiba pentandra</i>	5	0.72
17	Camphor tree	Kapoor	<i>Camphora officinarum</i>	15	2.16
18	Jackfruit	Katahar	<i>Artocarpus heterophyllus</i>	11	1.59
19	Java fig	Kavro	<i>Ficus lacor</i>	1	0.14
20	Cutchtree	Khayar	<i>Acacia catechu</i>	2	0.29
21	White mulberry	Kimbu	<i>Morus alba</i>	16	2.30
22	Litsea	Kutmiro	<i>Litsea monopetala</i>	2	0.29
23	Laapsi	Lapsi	<i>Choerospondias axillaris</i>	11	1.59
24	Litchi	Lichi	<i>Litchi chinensis</i>	23	3.31
25	Mangosteen	Mangosteen	<i>Garcinia mangostana</i>	12	1.73
26	Eucalyptus	Masala	<i>Eucalyptus camaldulensis</i>	3	0.43
27	Coconut	Nariwal	<i>Cocos nucifera</i>	4	0.58
28	Indian lilac	Neem	<i>Azadirachta indica</i>	19	2.74
29	Palm tree	Palm tree	<i>Areca spp.</i>	3	0.43
30	Night-blooming jasmine	Parijat	<i>Nyctanthes arbor-tristis</i>	32	4.61
31	Sacred fig	Pipal	<i>Ficus religiosa</i>	48	6.92
32	Golden shower	Rajbrikshya	<i>Cassia fistula</i>	2	0.29
33	Red sanders	Raktachandan	<i>Pterocarpus santalinus</i>	3	0.43
34	Indian bean tree	Rudrakshya	<i>Elaeocarpus sphaericus</i>	9	1.30
35	Drumstick tree	Sitalchini	<i>Moringa oleifera</i>	17	2.45
36	Sakhuwa	Sal	<i>Shorea robusta</i>	10	1.44
37	Chirpine	Rani Salla	<i>Pinus roxburghii</i>	2	0.29
38	Weeping fig	Sami	<i>Ficus benjamina</i>	3	0.43
39	Indian rosewood	Satisal	<i>Dalbergia latifolia</i>	1	0.14
40	Sandalwood	Shrikhanda	<i>Santalum album</i>	20	2.88
41	Silk-cotton	Simal	<i>Bombax ceiba</i>	13	1.88
42	Siris	Siris	<i>Albizia spp.</i>	23	3.31
43	Sheesham	Sissoo	<i>Dalbergia sissoo</i>	14	2.02
44	Areca nut	Supari	<i>Areca catechu</i>	6	0.86
45	Teak	Teak	<i>Tectona grandis</i>	3	0.43
46	Tejpatta	Tejpat	<i>Cinnamomum tamala</i> ,	18	2.60
Total				694	100

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