Plant Species Composition and Visitor Perceptions of Urban Green Spaces in Kathmandu Valley

A Dissertation Submitted for the Partial Fulfillment of the Requirement of a Master's Degree in Botany

By

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Declaration

The dissertation entitled **Plant Species Composition and Visitor Perceptions of Urban Green Spaces in Kathmandu Valley**, which is being submitted to the Central Department of Botany, Institute of Science and Technology, Tribhuvan University, Nepal for the partial fulfilment of the requirements of M. Sc. in Botany, has been carried out by me under the supervision of **Prof. Dr. Suresh Kumar Ghimire**. This work has not been submitted to any other institution for any academic degree.

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Recommendation

This is to recommend that **Ronish Pandey** has carried out the dissertation entitled **Plant Species Composition and Visitor Perceptions of Urban Green Spaces in Kathmandu Valley** for the partial fulfilment of the requirements of M. Sc. in Botany under my supervision. To my knowledge, this work has not been submitted to any other institution for any academic degree. He has fulfilled all the requirements of the Central Department of Botany, Institute of Science and Technology, Tribhuvan University, Kirtipur for the submission of the dissertation for the M. Sc. in Botany.

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Letter of Approval

The dissertation work entitled **Plant Species Composition and Visitor Perceptions of Urban Green Spaces in Kathmandu Valley** submitted at the Central Department of Botany, Institute of Science and Technology, Tribhuvan University by **Ronish Pandey** has been accepted for the partial fulfilment of M. Sc. in Botany.

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Abstract

Urban Green Space is open space dominated by vegetation, which ranges from pocket parks to large forest landscapes. These spaces provide social, physical, psychological, and ecological benefits. With the aim to assess plant species composition, floral diversity and visitor perception, 15 urban green spaces with eight parks, six forests and one botanical garden were selected based on three primary criteria: urban area, urban integration and visitor accessibility. Data were collected from enumeration vegetation, quadrate method for woody species, questionnaire survey for visitor and key information interview. Transect walk for enumeration and quadrat of 10 m × 10 m for tree with two nested 5 m × 5 m subplots for shrub/sapling and three nested sub-subplots of area 1 m × 1 m for sapling was were laid for 193 sampling plot. It consisted of both horticultural design and naturalistic landscapes. Total 437 species with 127 trees, 73 shrubs, 57 subshrubs, 134 herbs, and 46 climbers belonging to 114 families were recorded from 14 urban green spaces. It consists of 54.46% introduced species with 12 invasive species. Additionally, 104 historical specimens representing 79 species were recorded. Total carbon stock of tree species was 566.80 t/ha with urban parks (629.00 t/ha) higher than urban forests (511.31 t/ha). Nine types of tree-related microhabitats were recorded from 59.76% of individual trees. Major disturbances included plastic waste, foot traffic, and lopping of vegetation. Total 230 respondents were surveyed to understand visitor perceptions. Although 45.22% of respondents had heard about invasive species but lacked detailed knowledge. Total 64 plant species were familiar to the visitors, including 70.3% of the tree species. Total 47.39% respondents expressed a willingness to pay an entry fee. Despite being a critical element, it has been underutilized, making it necessary to prepare and implement urban biodiversity management strategies.

Keywords: Floral diversity, Kathmandu valley, Plant composition, Urban green space, Visitor perception

शोध सार

शहरी हरियाली क्षेत्र भन्नाले शहरी बसोबास क्षेत्रभित्र रहेका हरियाली स्थानहरू बुझिन्छन्, जुन साना उद्यानदेखि ठूला वनसम्म फैलिएका हुन्छन्। यस्ता स्थानहरूले सामाजिक, शारीरिक, मानसिक र पारिस्थितिक लाभ प्रदान गर्छन्। वनस्पति प्रजाति संरचना, पुष्प विविधता र आगन्तुकहरूको धारणा बुझ्ने उद्देश्यले आठवटा उद्यान, छवटा वन र एकवटा वनस्पति उद्यान गरी १५ वटा शहरी हरियाली क्षेत्र छनोट गरिएको थियो। यी स्थानहरू शहरी क्षेत्रमा रहेका, चारैतिर कङ्क्रिट भवनहरूले घेरिएका र सर्वसाधारणलाई सजिलै प्रवेश गर्न मिल्ने थिए। अध्ययनका लागि वनस्पति नामको सूची, काष्ठीय वनस्पतिका लागि नमूना क्षेत्र, आगन्तुकहरूसँग प्रश्नावली सर्वेक्षण र स्रोत व्यक्तिसँग अन्तरवार्ता लिइएको थियो। प्रत्येक स्थानमा १० × १० वर्ग मिटरको चतुर्भुज विधिबाट रुख प्रजातिको तथ्याङ्क संकलन गरिएको थियो। त्यस भित्र बुट्यान/झाडी र सानो बोटबिरुवाका लागि ५ × ५ वर्ग मिटरको दुईवटा चतुर्भुज र बिरुवाका लागि १ × १ वर्ग मिटरको तीन वटा चतुर्भुज राखिएको थियो। यसरी कुल १९३ वटा नमूना क्षेत्रमा अध्ययन गरिएको थियो। शहरी हरियाली क्षेत्रमा बागवानी कला र प्राकृतिक परिदृश्य दुवै समावेश थिए। सबै १४ वटा शहरी हरियाली क्षेत्रमा १२७ वटा रुख, ७३ वटा बुट्यान/झाडी, ५७ वटा साना बुट्यान १३४ वटा झार र ४६ वटा लहरे वनस्पति सहितको जम्मा ११४ परिवार बाट ४३७ प्रजातिका वनस्पति पाईएको थियो। तीमध्ये ५४.४६% आयातित (बाहिरी) प्रजातिहरू र १२ वटा मिचाहा प्रजातिहरू समावेश थिए। यसका अतिरिक्त ७९ प्रजातिहरूमा पर्ने १०४ वटा ऐतिहासिक नमूनाहरू पनि फेला परेका थिए।रुख प्रजातिहरूको कुल कार्बन संचयन ५६६.८० टन प्रति हेक्टर पाइएको थियो, जसमा शहरी उद्यानहरूमा ६२९.०० टन/हेक्टेयर र शहरी वनहरूमा ५११.३१ टन/हेक्टेयर कार्बन संचयन अभिलेख गरिएको थियो। कुल ५९.७६% रुखहरूबाट नौ प्रकारका सूक्ष्म वासस्थान (microhabitats) पत्ता लागेका थिए। मुख्य समस्याहरूमा प्लास्टिक फोहोर, अत्यधिक हिँडडुल र वनस्पतिको काटछाँट (lopping) समावेश थिए। आगन्तुकहरूको धारणा बुझ्नका लागि कुल २३० जनाको सर्वेक्षण गरिएको थियो। तीमध्ये ४५.२२% जनाले मिचाहा प्रजातिको बारेमा सुनेका थिए, तर विस्तृत जानकारी थिएन। आगन्तुकहरूले ६४ वटा वनस्पति प्रजातिको नाम उल्लेख गरेका थिए, जसमा ७०.३% रुख प्रजातिहरू थिए। कुल ४७.३९% आगन्तुकहरूले प्रवेश शुल्क तिर्ने इच्छा व्यक्त गरेका थिए। यस्ता शहरी हरियाली क्षेत्रहरू अत्यन्तै महत्त्वपूर्ण भए तापनि पर्याप्त रूपमा उपयोगमा आएका छैनन्, त्यसैले शहरी जैवविविधता व्यवस्थापन रणनीति तयार पार्नु र कार्यान्वयन गर्नु आवश्यक देखिन्छ।

List of Abbreviations and Acronyms

AGTB	: Above Ground Tree Biomass
BGTB	: Below Ground Tree Biomass
CABI	: Centre for Agriculture and Biosciences International
CBD	: Convention on Biological Diversity
CF	: Community Forest
CITES	: Convention on International Trade in Endangered Species of Wild Fauna and Flora
D-D	: Density Diameter
DBH	: Diameter at Breast Height
DEGURBA	: Degree of Urbanization
DFO	: Division Forest Office
DFRS	: Department of Forest Research and Survey
DPR	: Department of Plant Resources
EICAT	Environmental Impact Classification for Alien Taxa
FAO	: Food and Agriculture Organization
FRTC	: Forest Research and Training Centre
GBIF	: Global Biodiversity Information Facility
GI	: Green Infrastructure
GPS	: Global Positioning System
ha	: Hectare
IAPS	: Invasive Alien Plant Species
IPCC	: Intergovernmental Panel on Climate Change
IVI	: Importance Value Index
KATH	: National Herbarium & Plant Laboratories
KII	: Key Information Interview
LTER	: Long-term Ecological Research
POWO	: Plants of the World Online
QGIS	: Quantum Geographic Information System

RECPHEC : Resource Centre for Primary Health Care

REDD+ : Reducing Emissions from Deforestation and Forest Degradation plus

RF : Religious Forest

SPSS : Statistical Package for Social Sciences

t/ha : Tonne per hectare

TOF-URB : Trees Outside Forests at urban

TOFs : Trees Outside Forests

TreMs : Tree-related Microhabitats

TUCH : Tribhuvan University Central Herbarium

UGS : Urban Green Spaces

WFO : World Flora Online

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1. Introduction

1.1 Background

There is no universally accepted definition of an urban area. However, it is commonly defined as a region with a dense human population, where the population density exceeds ten individuals per hectare and more than 50% of the surface represents built-up area (Seto *et al.*, 2013). From an ecological perspective, urban areas are densely populated zones where energy consumption exceeds local production and waste disposal becomes a significant challenge (Ress, 1997).

The term "urban" is derived from the names of the ancient cities, *Ur* and *Uruk*, of Mesopotamian civilization (Hall, 2019). Urbanization refers to the processes by which an increasing proportion of a population comes to reside in urban areas, leading to the growth and development of cities and their surrounding areas (Pacione, 2009). Historically, the proportion of urban dwellers has increased dramatically; for example, in 1930, only 30% of the world's population lived in cities, but the figure increased to 55% in 2018, and is expected to reach 68% by 2050 (United Nations, 2019). Lwasa *et al.* (2022) suggest that due to the rapid expansion of urban populations and infrastructure, the 21st century is likely to be known as the 'Urban Century'.

Urbanization involves both the densification and spatial expansion of human settlements and infrastructure (Forman, 2008). In Nepal, the degree of urbanization (DEGURBA) classification indicates that the urban population has increased to 66.81% (National Statistics Office, 2024). Kathmandu Valley, in particular, has become one of the fastest-growing urban centers in South Asia due to rapid urbanization (Muzzini & Aparicio, 2013). There are relatively more educational and economic opportunities in urban areas than in rural areas (Bhattarai *et al.*, 2023). Therefore, Ishtiaque *et al.* (2017) mention that rural-to-urban migration is the primary cause of rapid urbanization in the Kathmandu Valley. During the past two decades, the Kathmandu District has experienced a massive transition from green spaces to concrete environments, marked by a centrifugal pattern of urban expansion from the core of the city, with the highest transition in agricultural land (Aryal *et al.*, 2022). This transformation of land use and land cover in urban areas has serious implications for biodiversity, resulting in habitat loss, reduced biomass, and low carbon storage (Seto *et al.*, 2012). Thus, urban areas are considered to be synonymous with ecological disturbance and loss of biodiversity (Murphy, 1988).

Cities have three primary types of infrastructure: grey, blue, and green. 'Grey infrastructure' includes residential and industrial buildings, roads, utilities and parking lots; 'blue infrastructure' comprises rivers, lakes, ponds and water channels; and 'green infrastructure' includes trees, shrubs and grasses found in parks, forests, gardens, and along streets (FAO, 2016). Green infrastructure (GI) refers to interconnected networks of multifunctional ecological systems, ranging from street trees and private gardens to parks and peri-urban forests in densely populated areas (Pearlmutter *et al.*, 2017). The term 'green' not only symbolizes trees and vegetation but is also used as an adjective for environment-friendly practices and technologies (Sangwan *et al.*, 2022). Urban green space (UGS) is the basic unit of green infrastructure (Liu & Russo, 2021). Terms such as 'urban nature' and 'urban green' are also used interchangeably with UGS (Grunewald *et al.*, 2018).

Urban green spaces (UGS) are defined as urban areas predominantly composed of permeable and soft vegetated surfaces (Werner & Kelcey, 2017), which may be partly or completely covered with grass, trees, shrubs, or other types of vegetation (De Haas *et al.*, 2021). These spaces encompass a diverse range of habitats, including remnant patches of natural vegetation, urban wastelands like brownfields, vacant lots, home gardens, yards, purposefully designed green infrastructure like bioswales and green roofs (Aronson *et al.*, 2018). UGS vary in shape and size from small pocket city parks to large forest landscapes, and from rounded ponds and gardens to linear greenbelts and river corridors (Forman, 2008). Therefore, Sangwan *et al.* (2023) defined UGS as multifunctional vegetated spaces of varying spatial scales. Among them, parks and forests are the largest and most visible green spaces in cities (Harasimowicz, 2018).

'Urban greening' and 'urban forestry' are the terms used to describe the management of green spaces in urban areas, including trees, parks, and other open spaces. However, these two terms differ in scope: urban forestry focuses on trees and forests in the urban setting, while urban greening takes a broader perspective, encompassing all types of vegetation or green spaces, including gardens, parks, and green roofs (Konijnendijk & Randrup, 2002).

According to FAO (2010), 'forests' and 'other wooded land' are areas covering more than 0.5 ha with trees over 5 m in height, and canopy cover above 10% and 5–10%, respectively. Trees Outside Forests (TOFs) refer to trees that do not belong to the definition of forest or other wooded land, but include trees in urban areas, on farms, along roads, and in many other locations (FAO, 2001). TOF at urban (TOF-URB) is defined as all lands in urban areas like private gardens, parks, streets, and parking lots covering more than 0.5 hectares

with trees and/or shrubs of different shapes (FAO, 2013). The canopy cover in TOF-URB is designated as at least 5% if trees are present, or at least 10% if trees, bushes, and shrubs are present. The spatial criteria for TOF-URB are a length and width of at least 25 m and 3 m, respectively.

Urban forests include all tree-dominated green spaces in and around city areas, which include forests, wooded lands, and TOFs (Konijnendijk & Randrup, 2004). Therefore, urban forests are networks or integrated systems of woodlands, tree groups, and individual trees in parks, gardens, streets, and abandoned lands (FAO, 2016). In the Kathmandu Valley, common urban forest types are parks, gardens, religious forests, community forests, private and institutional gardens, roadside plantations, canal/riverside plantations, and individual trees in resting places (*chautaris*). Compared to non-urban forests, urban forests consist of a higher number of recreational facilities and are fragmented in size and ownership (Lorenz & Lal, 2012).

Urban parks are natural, semi-natural, or planted areas set aside for public recreation and protection of wildlife and natural habitats (Sadeghian & Vardanyan, 2015). It contains an abundance of trees, but is often dominated by lawns, pastures, gardens, and other infrastructure (Gustavsson *et al.*, 2005). Parks generally cover areas larger than 0.5 ha, while gardens are smaller green spaces under 0.5 ha (Bherwani *et al.*, 2022). Parks and gardens serve as a connection between humans and nature (Kendle & Stoneham, 2014). Based on maintenance levels, these are categorized into high-maintenance and low-maintenance parks (Schaefer *et al.*, 2004). High-maintenance parks are continuously maintained with ornamental landscaping and offer a variety of recreational opportunities to the public. In contrast, low-maintenance parks have more natural conditions with limited infrastructure. Although botanical and zoological gardens were primarily developed in cities for scientific purposes, they also contribute to maintaining urban vegetation (Forrest & Konijnendijk, 2005). However, urban parks vary globally in size, shape, type, and purpose (Tate & Eaton, 2015).

Urban forests are also historically linked to religious, spiritual, or symbolic values (Feng & Tan, 2017). Such forests are known as sacred groves, which are conserved and managed by the indigenous communities based on their socio-religious beliefs, cultural values, traditional land tenure systems, and the enforcement of taboos, and the practice is inherited from ancestors over generations (Khumbongmayum *et al.*, 2005). The practice of maintaining sacred groves is a global phenomenon that is not linked to any specific religion

(Devkota, 2013). Sacred groves serve as early models of community-based natural resource management (Shrestha *et al.*, 2020) and provide habitats for endangered, rare, or sacred plant species (Bhattarai & Baral, 2009). In the Kathmandu Valley, many forested areas have been destroyed by human activities, but forests with specific religious or cultural significance remain relatively protected (Ghimire *et al.*, 2005). The community-based forest management approach traditionally practiced in Nepal is widely recognized as a successful participatory management model, promoting forest conservation and supporting rural livelihoods (KC *et al.*, 2017; Ghimire & Lamichhane, 2020). However, increasing urbanization exerts recreational and developmental pressure on community forests, such as in the Kathmandu Valley, as it starts to be maintained and modified because of human interest (Maharjan *et al.*, 2006).

Urban trees have been historically appreciated for their aesthetic value, but now as urbanization accelerates, their value has increased for addressing environmental problems (Blum, 2017). According to Millennium Ecosystem Assessment (2005), ecosystem services include provisioning services (e.g., food and water), regulating services (e.g., floods, drought, land degradation, and disease regulation), cultural services (e.g., aesthetic and spiritual benefits), and supporting services (e.g. formation of soil, primary production, nutrient cycling). Urban green spaces can provide several ecosystem services that enhance quality of life in cities (Gómez-Baggethun & Barton, 2012). These serve as "oases" in the city, where people may socialize in a peaceful and healthy atmosphere (Chiesura, 2004). The major ecosystem services of urban green spaces include mitigation of the Urban Heat Island (UHI) effect (Hiemstra *et al.*, 2017), reduction of air pollution (Samson *et al.*, 2017), water regulation and purification (Vilhar, 2017) and carbon sequestration (Fares *et al.*, 2017). Therefore, urban green spaces are increasingly viewed as nature-based solutions to tackle various environmental issues of urbanization (Mexia *et al.*, 2018). In highly urbanized areas, the promotion and preservation of urban green spaces have the potential to decelerate biodiversity loss (Alvey, 2006). Plant communities in urban areas play a crucial role in conserving biodiversity and enhancing ecosystem services through strategic planning, restoration, and management (Aronson *et al.*, 2018). However, policymaking and urban planning often lack sufficient integration of scientific knowledge related to biodiversity (Ossola *et al.*, 2018).

1.2 Rationale

A well-planned, coordinated, and controlled urbanization is a boon to society, whereas unplanned and unsustainable urban growth often becomes a curse (Pandey *et al.*, 2019). Industrialization in the 19th century, along with land-use planning and urban design approaches in the 20th century, have directly contributed to the climate crisis of the 21st century (Kim 2018). Natural landscapes around the world have been drastically altered by urbanization, with significant negative effects on biodiversity and ecosystem services (Wu, 2008). In Kathmandu Valley, urban areas have expanded by up to 412% over the past three decades, with the maximum conversion of 31% of agricultural land (Ishtiaque *et al.*, 2017). The lack of urban green space has become a critical issue in cities (Xue *et al.*, 2017). Among the 23 global biodiversity targets set for 2030, Target 12 of the Kunming-Montreal Global Biodiversity Framework (GBF) emphasizes the role of urban green space and urban planning (CBD, 2022). However, due to the lack of the government's willingness to recognize the importance of vegetation in and around urban areas, there are currently no specific policies or plans for managing peri-urban and urban forests in Nepal (Goutam, 2018). The National Forest Policy 2019 of Nepal barely mentions urban forests under two minor policies of Forests Outside National Forests (FRTC, 2021). Despite this policy gap, urban forestry still has great potential in the Kathmandu Valley, with studies indicating a strong willingness among the communities toward active participation and support in this sector (Gautam *et al.*, 2006).

Globally, the majority of sacred groves, located near settlements, are highly disturbed by human activities (Parthasarathy & Babu, 2019). The sacred forests in the Kathmandu Valley are similarly being severely affected (Shrestha *et al.*, 2020). Maharjan *et al.* (2006) also noticed that many sites of community forests in the Kathmandu Valley were damaged and modified by developmental activities, including the construction of stone-paved stairs, overhead water tanks, rest sheds, and other recreational infrastructure. Similarly, in other areas, such as Pokhara Sub-Metropolitan City and Bharatpur Municipality, the condition of urban forests is poor and lacks proper planning, with little recognition of their ecological and socio-cultural value (Lamichhane & Thapa, 2011). Besides this, Pun (2013) found that the parks in the Kathmandu Valley are facing difficulties in maintaining infrastructure and services. Bajracharya *et al.* (1997) published an illustrated guide of flowers commonly grown in parks and gardens of the Kathmandu Valley; however, the study did not cover the full range of floral species within the urban parks of the valley. In general, scientific studies in urban green spaces mainly focused on woodland and trees, while urban parks,

and religious and community-managed forests have received much less attention (Bentsen *et al.*, 2010). Effective management of urban vegetation requires concrete scientific and technical knowledge (Gurung *et al.*, 2011). Therefore, a basic understanding of the vegetation found in parks, gardens, sacred forests, and community-managed forests is essential for biodiversity conservation and management in urban green spaces.

Likewise, Lin *et al.* (2019) showed that the majority of urban forest research focuses on biophysical benefits like air pollution removal, microclimate modification, and carbon sequestration, and few consider the economic and social benefits of urban vegetation. The introduction of ornamental plant species and the eradication of native vegetation due to human preferences significantly influence the types and patterns of urban vegetation (Williams *et al.*, 2008). Human perception of urban green spaces is important because it determines how people value and utilize these areas. Therefore, understanding visitor perception can help in determining human visitation patterns in urban green spaces, vegetation preference, user satisfaction, willingness to pay, and the major challenges of green areas. Hence, this study aims to assess vegetation composition, floral diversity, and visitor perceptions of urban green spaces in the Kathmandu Valley. The results of the study will help in the development of sustainable and resilient ecosystems that address ecological processes and aesthetic needs.

1.3 Research questions

- How does plant species composition vary with the size and type (i.e., forest vs. park) of urban green spaces in the Kathmandu Valley?
- What is the ratio of native to introduced plant species across different urban green spaces in the Kathmandu Valley?
- How do visitor perceptions vary among different types of urban green spaces in the Kathmandu Valley?

1.4 Objectives

The general objective of the study is to assess plant species composition, floral diversity and visitor perceptions of urban green spaces in the Kathmandu Valley.

The specific objectives are:

i. To assess the variation in plant species composition with the size and type (i.e., forest and park) of urban green spaces in the Kathmandu Valley.

ii. To compare native and introduced plant species diversity across different urban green spaces.

iii. To analyze visitor perceptions and preferences regarding different urban green spaces in the valley.

1.5 Limitations

This study focuses on urban forests and parks, and does not include urban green spaces like road- and riverside plantations, open spaces, private forests, green roofs and cemeteries. Similarly, regarding plant life form, the study is particularly focused on herbs, shrubs, and trees, so the information on algae, fungi, lichen, bryophytes, and pteridophytes are not included.

2. Literature Review

2.1 Urbanization

In 2024, the global population was estimated at 8.2 billion and would peak at 10.3 billion in the mid-2080s and then decline to 10.2 billion by the end of the century (United Nations, 2024). Humans have dominated urban ecosystems in the form of demographics, socioeconomic and political activities, and advanced technology (Alberti, 2008). These activities have altered ecosystems, which contribute to substantial gains in human wellbeing and economy, but also increase the risk of nonlinear changes in many ecosystem services (Millennium Ecosystem Assessment, 2005). From Mesopotamian civilization, cities are the greatest human inventions; however, in the 21st century, they are now considered unhealthy places (Boone & Modarres, 2006). Cribb (2017) defines *Homo urbanus* in his book 'Surviving the 21st Century' as a group of people living in urban environments who face challenges associated with climate change, pandemic diseases, and urban vulnerability.

In urban areas, environmental changes are occurring at multiple scales, such as land use, biodiversity, hydrosystems, and waste discharge, which affect local as well as global biogeochemical cycles and climate (Grimm *et al.*, 2008). The numerous taxa, their habitats and even entire ecosystems were destroyed and altered by single species *Homo sapiens* through urban expansion (Ossola *et al.*, 2018). Urbanization is a double-edged sword, on which one edge provides social and economic opportunities while the other edge fragments natural ecosystems and alters their processes (Müller *et al.*, 2013). In cities, green infrastructures include patches of vegetation, which provide benefits to residents (McDonald, 2015). It is a network of natural, semi-natural, and cultivated spaces strategically planned in urban and peri-urban areas to deliver a wide range of ecosystem services and preserve biodiversity (FAO, 2016). Therefore, in areas where traditional habitat restoration is impossible, green infrastructure supports urban biodiversity better than conventional infrastructure (Filazzola *et al.*, 2019). However, Nepal still lacks basic urban infrastructure and facilities (Joshi, 2023).

In the Kathmandu Valley, the overpopulation and densification are the reasons for the decrease in open space because land value is in high demand for housing and other infrastructure developments (Timalsina, 2021). In the next 20 years, Kathmandu District is expected to convert 33.33 km² of forest, 66.67 km² of agricultural land, and 0.35 km² of

green space into built-up areas (Aryal *et al.*, 2022). The decline in cultivated land may have serious consequences for food security and the sustainability of the environment (Rimal *et al.*, 2020). Due to unplanned expansion and development, the city faces risks of environmental, social and disaster (Pokhrel, 2019). Over the past decades, the valley has experienced haphazard development, which has caused a loss of public space in newly unplanned areas, while public space in the planned areas also remains poor, which is insufficient to support the needs and activities of the community (Chitrakar *et al.*, 2015). Likewise, the temperature of the city is higher than adjoining areas of Kathmandu valley (Thapa *et al.*, 2023). Hence, Nepal needs effective governance for managing urbanization, however, slow implementation of laws and corruption remain major challenges (Singh and Dhakal, 2024).

2.2 Urban Green Spaces

Although urban areas have an artificial composition, they are not biological deserts (Schaefer *et al.*, 2004). In urban environments, seven different ecosystems have been discovered; they are street trees, lawns or parks, urban forests, cultivated land, wetlands, lakes or sea, and streams (Bolund & Hunhammar, 1999). McDonald (2015) describes the gradient of naturalness, from (1) Very natural area, which consists of wilderness, (2) Somewhat natural area also known as critical natural habitat where ecosystem processes are affected by nearby urban areas, (3) Little natural areas such as a constructed wetland and park, to (4) Entire man-made areas such as pieces of grey infrastructure. These ecosystems have diverse biodiversity due to both natural and anthropogenic factors, such as the introduction of both native and exotic plant species as well as the formation of new microhabitats (Rahmonov *et al.*, 2019).

Urban flora are mainly affected by four factors, among them habitat transformation and fragmentation are present in almost all ecosystems, while human preference and urban environmental conditions are unique to cities (Williams *et al.*, 2008). Since the earliest periods, plants were probably introduced as food or aesthetics; therefore, 30–35% of the plant species found in cities are non-native species (Werner & Kelcey, 2017). A variety of military terminology, such as invade, attack, wipe out, aggressive, and even racial purification, alien, and exotic, has been used in the literature relating to non-native species (Forman, 2014). There is also the fragmentation of natural habitat, which increases demands on urban green spaces in terms of biodiversity conservation (Goddard *et al.*, 2010).

Traditionally, landscape architects and horticulturists have designed and managed parks and other green areas (Randrup *et al.*, 2005). Mexia *et al.* (2018) found that lawns had a higher seed dispersal potential, and mixed forests had the prime habitat quality. Conservation of urban biodiversity begins with deciding what species or ecosystem roles are suitable and possible in cities; otherwise, efforts may be insufficient and valuable resources may be wasted (Dearborn & Kark, 2010). In 1997, two urban long-term ecological research (LTER) projects were established in Baltimore and Phoenix (USA), marking the beginning of a modern high-tech investigation of urban ecosystems (Ossola *et al.*, 2018). Since 2002, the journal Urban Forestry & Urban Greening has been publishing research on urban and peri-urban woody and non-woody vegetation from various perspectives (Bentsen *et al.*, 2010).

2.3 Global History of Urban Green Space

The early symbol of green urban spaces was the Hanging Garden of Babylon, built by King Nebuchadnezzar II around 600 BCE (Groening & Hennecke, 2014). Boone & Modarres (2006) state that parks have always been refuges from the city, regardless of their design or purpose changed over time. In the course of human history, three things, i.e., gold, spices, and drugs, have motivated people to travel far on earth, therefore, botanic gardens were established in the tropics for spices, whereas in Europe for the need of drugs (Hill, 1915). A small house garden used to grow medicinal plants was later transformed into a botanical garden after botany science was developed and established for education and research in schools and universities (Faraji & Karimi, 2020). The oldest botanical gardens in the world are the Pisa Botanical Garden and the University of Padova Botanical Garden, which were established in 1543 and 1545, respectively (Shrestha & Uprety, 2024). However, urban woodland and royal parks were used for hunting (Tyrväinen *et al.*, 2005). Most urban forests had their origins as hunting areas, which not only provided recreation opportunities for kings and aristocracy but also helped to upgrade prestige and strengthen power relations within them (Konijnendijk, 2008). From 1635, Green Park and Hyde Park in London were open to the public and mainly used for royal celebrations (Forrest & Konijnendijk, 2005).

At the height of the industrial revolution, many residents of big cities had a combination of low quality of life, ill circumstances, and limited access to regions with trees or greenery (Elinc & Polat, 2012). Due to a lack of open space in British cities, the Select Committee on public walks warned parliament in 1833 that the poorer populations would have shorter

lifespans (O'Reilly, 2019). Therefore, urban parks were intended to benefit urban dwellers and factory workers who lack access to greenery and fresh air (Vogt *et al.*, 2017). Then, royal and private parks that were closed to the public were also opened, and new green areas were developed for active uses (Konijnendijk & Randrup, 2004). Created for hunting, St James's Park was redesigned in 1827 to become England's first town park, which was entirely for public use (Tate & Eaton, 2015). Similarly, Regent's Park was created in 1811 as a royal park, which was opened to the public in 1835 (Crompton, 2006). In 1847, Birkenhead Park was the first urban park built entirely with public funds (Henneberger, 2002). Central Park, built in 1858, is the oldest urban park in the United States (Young, 1995).

Likewise, in the USA, the earliest protected urban areas were common lands like Boston Common, which was originally protected in the seventeenth century for grazing animals; later in the nineteenth century was converted to urban parks for recreation (McDonald, 2015). Boston's Public Garden was built in 1859, Chicago's Lincoln Park was built in 1861, and San Francisco's Golden Gate Park was completed in 1887 (Taylor, 1999). The concept of Urban Forestry (UF) was developed during the 1960s in North America with a novel approach to managing urban natural resources, while during the 1990s it gained wider acceptance in Europe (Lamichhane & Thapa, 2011). Cranz (1982) carried out a comparative study of the four separate ages in the evolution of urban parks in America, i.e., Pleasure Ground (1850-1900), Reform Park (1900-1930), Recreation Park (1930-1965), and Open Space System (1965). Likewise, a new model of sustainable park was introduced in 1990, where it is self-sufficient in resources and maintenance, solving wider urban issues outside of its boundaries and creating new aesthetic standards and landscape management (Cranz and Boland, 2004). Ecological, social, and economic benefits can be derived from sustainable parks (Nady, 2016). Similarly, botanical gardens were initially developed in the 16th century for the study of medicinal plants, and in the 17th to 19th centuries, they were important centers for trading seeds and fruit, while in the 20th century, loss of biodiversity increases, therefore focus shifts toward conservation (Demïrel *et al.*, 2022). It also has important roles in providing green spaces in urban areas with tourist attractions, economic objects, and aspects of human well-being (Faraji & Karimi, 2020).

2.4 Urban Green Space History of Nepal

Urban forestry practice in Nepal started during the Malla rule. King Jayasthiti Malla (1380–1395 AD) ordered officials and commoners to plant trees along walking streets and near

wells (Goutam, 2018). Furthermore, he issued an order that those who cut trees along roadsides would be sent to prison with a fine of Rs 5, which is huge money in the 14th century (Kattel & Khanal, 2021). During Rana rule, Kathmandu's architecture shifted to pro-British and Western European styles (Singh & Dhakal, 2024). In 1850 AD, when Jung Bahadur Rana visited the UK and France, some exotic fruits and ornamental plants were introduced to Nepal (Acharya & Atreya, 2012). Baral and Kurmi (2005) believed that tree planting began in palace gardens and along Kathmandu's streets after a visit to Europe. Wet valley floors do not favor natural growth of *Pinus roxburghii*, therefore assumed that it was planted around a century ago to provide some greenery in the valley, and based on a dendrochronological study, oldest tree at Singh Durbar was 110 years old (sown year 1900 AD), which coincided almost with the construction of Singh Durbar (Bhuju & Gaire, 2012). During the construction of Singha Durbar, everything, including plants, was imported from abroad; therefore, it consists of many exotic plant species (Bhattarai, 2019). Since Nepal's forest management history was closely linked to its political and economic conditions, any change in economic and political conditions also affected the forest management practices (Ranjit, 2019). Bhugol Park, the first public park of Nepal, was built by Judda Samsher Rana in 1934 AD in memory of the people who lost their lives in the 1934 (1990 BS) earthquake (Pun and Maharjan, 2013). Rana had maintained small private gardens in the palaces that were not open for the public; however, after Nepal adopted democracy in 1950, some public gardens began to take shape in the form of public parks (Shrestha & Uprety, 2024). In 1962, the National Botanical Garden (NBG) was established by the late King Mahendra Bir Bikram Shah Dev, who was inspired by his visit to the Royal Botanic Garden Edinburgh, UK, in 1960 (Hughes & Lamichhane, 2017). In addition to plant conservation, the botanical garden provides education, research, and recreation services (Parmar *et al*., 2024). The Ratna Park is named after the then-queen Ratna, the second queen of King Mahendra, whose palace was constructed in 1962 and completed in 1965 (RECPHEC, 2016). Tribhuvan Park and Bhikutimandap Park in Kathmandu were established in 1972 (Pun and Maharjan, 2013).

In 1975, the Coronation Garden was established in the premises of Tribhuvan University, Kirtipur, Kathmandu to commemorate the coronation of the late King Birendra Bir Bikram Shah, where late Prince Gyanendra Bir Bikram Shah planted the first tree of *Rhododendron arboreum,* and several guests, including Akihito, emperor of Japan, participated in the plantation (Bajracharya *et al*., 1997). In 1987, the first SAARC summit was held in Kathmandu; therefore, small open patches of road habitats were converted into gardens

(Baral & Kurmi, 2005). In 1993, ICIMOD Knowledge Park was established to rehabilitate the degraded land at Godavari, Lalitpur (Karki *et al.*, 2016). Later, in 1995 AD, a United Nations (UN) Park was established in Lalitpur to commemorate 50 years of United Nations involvement in the development of Nepal (Pun and Maharjan, 2013). There are 12 botanical gardens in Nepal officially recognized and managed by the Department of Plant Resources (Shrestha & Uprety, 2024). Despite having enough area, government and public offices do not make an effort to beautify office grounds through the maintenance of gardens (Bhandari & Pun, 2022).

2.5 Urban Forests

Urban forest is all woody vegetation within the area of all populated places, including trees within the city, as well as trees on associated land such as greenbelts, municipal watersheds, recreational sites, and roadsides (Grey & Deneke, 1978). The Urban forestry matrix describes three types of urban forests based on locations: the first are trees on the streets and roadside, the second are individual or small groups of trees growing in gardens, parks, cemeteries, on derelict land or in industrial areas, and the third is woodland and shrubs vegetation (Randrup *et al.*, 2005). According to FAO (2016) main urban forest types are Peri-urban forests and woodlands; City parks and urban forests (>0.5 ha); Pocket parks and gardens with trees (<0.5 ha); Trees on streets or in public squares; Other green spaces with trees (example are urban agricultural plots, sports grounds, vacant lands, lawns, river banks, open fields, cemeteries and botanical gardens). Based on establishment, urban forests are of two types: natural and planned urban forests (Bherwani *et al.*, 2022). Natural urban forests are the remaining part of pre-urban natural forests that have been reduced due to the expansion of buildings; whereas, planned urban forests are green areas created as part of urban planning and eventually developed into full-grown urban forests.

Likewise, Forest Research and Training Centre (2021) categorized urban forests in Nepal based on ownership and tree alignment. According to ownership, there are five types of urban forests. They are Community (managed by Local clubs, Civil society, Tole Sudhar Samitis, Community Forest User Groups, Religious Forest Groups, and Leasehold Forest Groups); Institutional (managed by Schools, Colleges, Universities, Government Offices, Non-Governmental Organizations); Private (managed by individuals in their land); Public (managed by local government) and National (other than community owned). Similarly, based on tree alignment, there are 3 types: linear (roadside plantation, canal/riverside plantation), non-linear (parks and woodland), and individual/scattered (randomly in

derelict corners or resting places, i.e., *chautari*). Unlike the traditional definition, urban forestry emphasizes services that contribute to urban sustainability (Lin *et al.*, 2019). Since a sustainable urban forest does not emerge at random, it results from a commitment of the community to development and management (Clark *et al.*, 1997). The entire tree populations of cities were managed in urban forestry, while single trees were maintained in arboriculture (Vogt, 2020).

2.6 Urban Parks and Gardens

A park is a large, open public space for recreation and conservation, while a garden is smaller, more private, and focused on intimate plantings and horticulture (Jones, 2018). The concept of the word 'horticulture' is different from 'nature' as it is the growth of plants due to the influence of human activities (Kendle & Stoneham, 2014). According to Shrestha (2023), different of types of urban parks are pocket park (small and strategically placed in densely populated area), neighbourhood park (small to medium-sized within residential areas), town square park (used for community gatherings, events, and celebrations), city and cultural parks (serve the recreational, social, and cultural needs) and pop-up parks (temporary green spaces created from reclaimed areas). Even the office garden provides a pleasant, picturesque, and naturalistic effect that creates a comfortable and productive working environment for both staff and clients (Bhandari & Pun, 2022).

The vegetation composition in the urban parks was influenced by area, year of construction, lighting conditions, and frequency of management (Xu *et al.*, 2024). Due to habitat heterogeneity, urban parks consist of the most diverse types of vegetation within the urban green spaces (Nielsen *et al.*, 2013). However, Li *et al.* (2005) revealed that the number of nonnative species is higher in parks while native species are neglected. These areas were intensively managed by horticultural activities to enhance the aesthetic value, especially with the introduction of exotic species (Rahmonov *et al.*, 2019). It is mainly due to the postcolonial urban greening concept, where the parks were influenced by European design along with the introduction of species from Europe (Fischer *et al.*, 2016). Talal & Santelmann (2019) differentiate three types of parks based on public use, where a higher number of native species were found in natural-passive use parks than recreational-active use parks, and multi-use parks. Therefore, Figueroa *et al.* (2018) suggest the reorientation of native plants through proper management at urban parks.

2.7 Sacred Groves

Historically, people have protected sacred lands using sociological, cultural, and religious perspectives long before the establishment of protected areas (Devkota, 2013). A sacred grove is physically a forested area containing a small or large temple, but culturally, it holds deep connections to ancestral spirits, myths, rituals, and taboos (Parthasarathy & Babu, 2019). Due to its association with many taboos and beliefs, it facilitates biodiversity conservation more effectively than government management systems (Shrestha *et al.*, 2020). Sullivan *et al.* (2023) reported that religious forests have more plant diversity than other forests. However, people's perception of sacred groves has changed over the centuries; therefore, forests are no longer free from anthropogenic pressure (Khan *et al.*, 2008).

From the 19th century, Francis Buchanan-Hamilton (1802–1803) and Nathaniel Wallich (1820–1821) explored the Swayambhu hillock for the earliest botanical exploration of Nepal (Ranjitkar & Chaulagain, 2004). Sacred groves of Kathmandu valley maintain vegetation diversity along with other ecological and cultural significance (Sapkota *et al.*, 2022). Lumbini Sacred Grove was extended through the plantation and contains 11% of the total tree diversity of Nepal, which serves as an ex-situ conservation (Bhattarai & Baral, 2009). Forests like Bhandarkhal in urban areas could serve as a refuge for various species as well as a venue for nature excursion programs to raise public awareness on conservation (Ghimire *et al.*, 2005). Sacred groves not only protect forest ecosystems but also help in combating climate change by carbon sequestration (Shrestha *et al.*, 2019). Religious forests in urban and semi-urban areas attract the visitor for recreational activities, which becomes a boon for local people due to an increase in a source of income (Thapa, 2021).

2.8 Urban Community Forests

Throughout the world, community-based forestry has become a widely used practice for forest management, biodiversity conservation, landscape restoration, and supporting livelihoods (Paudyal *et al.*, 2017). Although some forest areas remain in their natural state, others have been modified by humans through management or exploitation (Bell *et al.*, 2005). Sharma (1999) reported that before the Private Forest Nationalisation Act 1957, forests were kept under private properties; therefore, conservation and utilization of resources depended on personal performance. In the late 1970s, regulations for community forestry were introduced to empower local communities to protect, manage,

and sustainably use forests (Ranjit, 2019). In 1989, a Forestry Sector Master Plan was approved, and since then, community forest has gained international recognition and has been widely recognized as the best forest management model for both sustainability and social well-being (Paudel *et al*, 2022). During the last four decades, it has undergone a substantial shift through the implementation of organizational and policy reform from state-dominated top-down approaches to participatory forest management (Ghimire & Lamichhane, 2020).

In the Kathmandu valley, community forests outside the urban areas have a higher number of species, such as the Lakuribhanjyang community forest in Lalitpur, Central Nepal, which contains 111 species (Gautam *et al*., 2023). However, Sharma *et al*. (2020) recorded only two tree species, i.e., *Eucalyptus citriodora* and *Pinus roxburghii,* in Adinath Community Forest, Kirtipur, because it is a plantation forest. In the REDD+ (Reducing Emissions from Deforestation and Forest Degradation plus) program, many community forests were engaged in increasing carbon stocks only for payments, which may negatively impact vegetation richness and the significance of other ecosystem services (Pandey *et al*., 2015). Lamichhane & Thapa (2011) suggested that urban community forests could be improved with adequate institutions, financial resources, and effective cooperation and coordination among concerned stakeholders.

2.9 Ecosystem Services and Disservices of Urban Green Spaces

With the emergence of the concept of sustainable development in the 1970s, the interest in urban vegetation and green spaces increased significantly (Weber & Medhi, 2013). In urban areas, even a single tree provides the basic units for plants and animals to survive (Werner & Kelcey, 2017). Vegetation can play a major role in restoring an urban climate to its pre-industrial state (Emilsson & Sang, 2017). The ecosystem services significantly contribute to the quality of life in urban areas (Bolund & Hunhammar, 1999).

In Nepal, the urban forests will be able to address the provision of the fundamental right of every citizen to live in a clean environment as guaranteed by the Constitution of Nepal (FRTC, 2021). As non-consumptive use values, urban forests provide benefits such as an enjoyable landscape, clean air, peace, as well as recreational activities which have no market price (Tyrväinen *et al*., 2005). The vegetation in urban areas contributes to the microclimate by providing shade and reducing the air temperature (Erell, 2017). It can mitigate the Urban Heat Island (UHI) effect and enhance thermal comfort for the citizens (Hiemstra

et al., 2017). In addition, it reduces stormwater runoff, improves air quality, and improves mental health (Lwasa *et al.*, 2022).

The planning and management of urban green spaces in cities play important roles in the conservation of global biodiversity (Aronson, 2017). More than 80% of the world's area lies outside of strictly protected areas; therefore, many endangered species and unique ecosystems may exist partially or entirely outside (Primack, 2014). For instance, rare forms of plants can be grown which maintain their genetic diversity, and can also contribute to other aspects of biodiversity (population structure, genetic diversity) where flowers attract butterflies, which increases butterfly diversity (Savard *et al.*, 2000). Therefore, there is a positive correlation between the composition of the flora with the diversity and abundance of the fauna (Delahay *et al.*, 2023). On the urban-rural gradient in Kathmandu valley, 14 types of tree-related microhabitats were found, including cavity, fungi, lichens, climbers, ferns, orchids, bird nests, ant nests, and beehives (Shrestha *et al.*, 2022a). In addition, ponds found within green space provide freshwater biodiversity habitat with ecosystem services of stormwater storage and water treatment (Hill *et al.*, 2016). Even the restoration of urban microbial biodiversity promotes not only healthier ecosystems but also provides cost-effective methods to public health by treating epidemics of noncommunicable diseases such as asthma, diabetes, and inflammatory bowel disease (Mills *et al.*, 2019).

Urban parks can also play a role as a catalyst for community development and enhancement by transforming and enriching the cities (Nady, 2016). Vogt *et al.* (2017) mention a unique initiative programme of 'Park Prescriptions' which aims to improve the health of individuals and communities through the use of parks and open spaces in the United States. There is also a correlation between urban parks and mental health, with people living within 400 meters of the park reporting better mental health (Sturm & Cohen, 2014). In addition to improving individual well-being, it also improves the sustainability of a community (Chiesura, 2004). Tate (2018) suggests parks as safe places after traumatic events, as Golden Gate Park became a refuge after the 1906 San Francisco earthquake, or Hamburg Stadtpark became a shelter for homeless people after World War II.

However, urban green spaces do not provide ecosystem services, but also disservices such as pollen allergies and pavement breakup; therefore, valuation should include both ecosystem services and disservices (Gómez-Baggethun & Barton, 2012). In Nepal, *Alstonia scholaris* has been planted in municipalities, but there are no official records of health hazards due to pollen allergies; however, studies in Indian cities indicate negative effects

(Devkota, 2023). The urban forest is also associated with different fears, such as criminal activities, dangerous animals, and mythological beliefs (Konijnendijk, 2008). Likewise, it also increases disease as insects/animals act as vectors, such as mosquito habitat and waste from leaves, nuts, fruits, seeds, including sap dripping (Vogt, 2020). Throughout the Kathmandu District, leopards are widely distributed in adjacent forests and peri-urban habitats of high human densities (Bista *et al.*, 2021).

2.10 Carbon Sequestration

According to IPCC (2022), carbon sequestration is defined as the process of taking up carbon-containing substances, while carbon stock is the amount of carbon in its reservoir. Urban forests contribute both directly and indirectly to carbon sequestration, where direct contribution occurs by absorbing carbon dioxide for biomass photosynthesis, and indirect contribution is by providing a cooling effect through shade, which reduces energy consumption and carbon emissions (Bherwani *et al.*, 2022). For growing forests, the annual sequestration rate is positive, but it reduces over time with forest maturity, while forest decline or loss occurs with carbon emissions from dead trees (e.g., decomposition, fire), then rates of sequestration become negative (Nowak *et al.*, 2013). Globally, urban trees store about 7.4 billion tons of carbon and sequester about 217 million tons annually (Lwasa *et al.*, 2022). The total amount of carbon sequestered is influenced by types of tree species, number of trees and spatial coverage, age and health of trees, mortality rates, soil interaction, and disposal or use of those trees (Fares *et al.*, 2017). As urban vegetation captures a small fraction of carbon compared to anthropogenic emissions, urban greenery has a limited role in carbon sequestration (Velasco *et al.*, 2016). In Shenyang, China, urban forests stored 3.02% of the annual carbon emissions from fossil fuel combustion, with carbon sequestration of 0.26% (Liu & Li, 2011). Therefore, urban forest carbon sequestration potential can be improved by selecting species with longer lifespans, higher wood densities, and greater tolerances to urban stresses (Scharenbroch, 2012).

As there are still more total carbon dioxide emissions due to vehicles (i.e., transportation sector) than the carbon removal by avenue plantations in the Ring Road area of Kathmandu Valley (Joshi *et al.*, 2023). The Sacred groves of Kathmandu Valley have important roles in carbon sequestration with enhancing the aesthetic values (Sapkota *et al.*, 2022). However, if they are managed effectively, then only it can play a significant role in carbon stock (Nepali *et al.*, 2015). In the last decade, forest resources managed by

community forest user groups have increased forest growth, carbon stock, and carbon sequestration rates (KC *et al.*, 2017). The Adinath community forest, Kirtipur has sequestered a significant amount of carbon emitted from densely populated Kathmandu metropolitan city (Sharma *et al.*, 2020).

Similarly, trees outside forests of urban strata have higher average heights and diameter at breast height; therefore, they play a major role in carbon storage in Kathmandu Valley (Shrestha *et al.*, 2023). However, the urban park of Kathmandu valley has a lower number of trees per hectare; therefore, it only has an average total carbon content of 54.56 tons per hectare, which is a lower carbon content than other types of forest (Mishra *et al.*, 2024). Whereas a large number of trees were planted at Coronation Garden, therefore has 196.4 tons per hectare, which is a higher value of Carbon stock than other parks and gardens (Bhatta *et al.*, 2018). Similarly, Karki *et al.* (2016) found that there was an increase in carbon stock in forests of the ICIMOD Knowledge Park from 263.44 to 269.22 tons per hectare. In addition, the urban forest of Gokarna also has a significant role to sink carbon with various ecosystem services; therefore, long-term monitoring is necessary (Dhakal *et al.*, 2021). Therefore, urban forest patches can be upgraded with proper management of urban trees by replacing old trees to new ones for carbon capture effectively (Devi *et al.*, 2021).

2.11 Urban Green Spaces Challenges

In the 17th century, forests near cities were transformed and new ones were planted with the primary objective of recreational purposes (Forrest & Konijnendijk, 2005). As society continues to change and develop, new demands are placed on the urban forest; even designs that fulfilled society's needs 50 years ago do not meet today's satisfaction (Bell *et al.*, 2005). Aronson *et al.* (2018) mention that management of UGS is influenced by a complex interaction of social, cultural, and economic factors, including governance, economics, social networks, multiple stakeholders, individual preferences, and social constraints.

In Nepal, urban forests and greenery have not been effectively incorporated into urban land use and planning (Ministry of Urban Development, 2017). Tinkune Park in Kathmandu is the perfect example of developing without a plan, as it is greening repeatedly without a maintenance plan (Pun, 2021). In addition, Bhugol Park has since been drastically reduced in size due to a lack of an appropriate park policy (Pun, 2013). Baral & Kurmi (2005) claim that the practice of planting trees along the road habitats is erroneous and is the main cause of the green road belt not being established in urban areas in Nepal. There

has been rapid urban development since the declaration of many new municipalities; however, no consideration for the selection of plant species during the beautification of the roads (Devkota, 2023). Gautam *et al.* (2006) identified several issues in urban forestry of the valley, such as poor management of planted species, tree hazards, inadequate coordination between stakeholders, poor planning priority, and insufficient financial resources. Additionally, gardens in government offices are being cleared to construct parking areas and buildings (Bhattarai, 2019). Shrestha (2023) revealed that the green spaces of Kathmandu valley are poorly managed, even though residents value them. Because Nepal lacks a modern policy on urban land use zoning, it is necessary to formulate an urban land use policy with proper implementation plans (Pradhan & Sharma, 2016). However, the National Urban Development Strategy (NUDS) from the Ministry of Urban Development (2017) has a milestone of "*Vision 2031: Balanced and Prosperous National Urban System*" for the development of the urban sector. Ministry of Federal Affairs and Local Development (2013) under greenery promotion indicator, mentions the establishment and maintenance of a park in at least one location for residents of sixty thousand, as well as plantation and protection of trees in at least 10% of all the public open spaces and riverside corridors.

Urban wastelands, including brownfields and abandoned open space, can be developed into urban parks (Aronson *et al.*, 2018). However, it may be easier to preserve vegetation in natural environments within cities than to create new ones in artificial parks (Erell, 2017). Shapkota & Gautam (2023) suggest that tree species should be selected before plantation based on their silvicultural characteristics and their social and economic values; and regular tree inspections, soil management, pest and disease monitoring should be conducted after plantation. There is a dilemma for city planners: planting trees near pollutant sources may decrease pollutants, but might increase the allergenicity of pollen grains, therefore, potential allergenic impacts should be considered (Samson *et al.*, 2017). In modern urban forestry, one of the goals is to promote multifunctional and attractive urban landscapes at the strategic level (Konijnendijk, 2008). The effective design of multifunctional urban green spaces can provide both ecological and economic opportunities (Feng & Tan, 2017). These nature-based solutions are crucial for achieving a sustainable and livable compact city in the future (Emilsson & Sang, 2017). Therefore, the provision of urban green spaces has become globally an important objective of urban planning (Farkas *et al.*, 2023).

3. Materials and Methods

3.1 Study Area

3.1.1 Location and physiography

Kathmandu Valley is located between latitudes 27° 37' 30" N to 27° 45' 0" N and longitudes 85° 15' 0" E to 85° 22' 30" E in the central region of Nepal. It is a bowl-shaped valley with an average elevation of 1300 m asl (Pradhan & Sharma, 2016). The valley is surrounded by four mountain ranges: Chandragiri/Champa Devi towards southwest, Phulchowki towards southeast, Shivapuri towards northwest and Nagarkot towards northeast (Rana *et al.*, 2007).

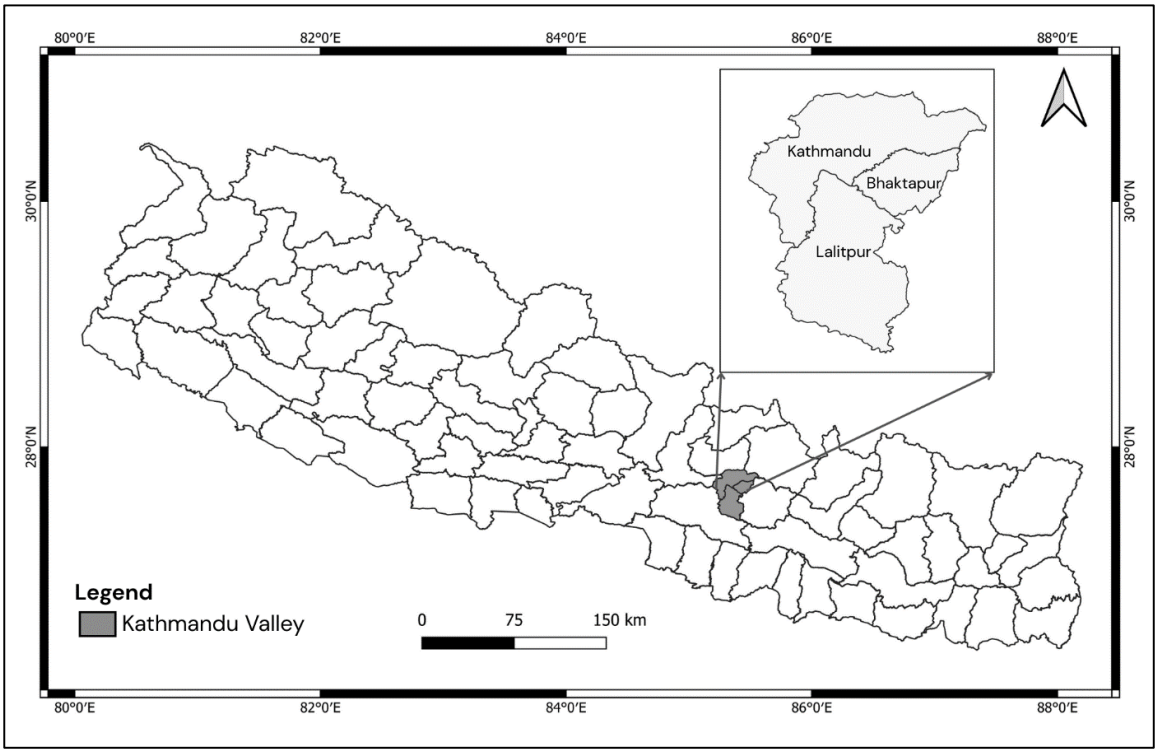


Figure 1. Map of Kathmandu Valley.

The valley comprises the Kathmandu, Lalitpur, and Bhaktapur Districts, covering an area of 899 km^2, whereas the area of the valley as a whole is 665 km^2 (Mohanty, 2011). It covers the entire area of Bhaktapur, 85% area of Kathmandu, and 50% area of Lalitpur District (Rana *et al.*, 2007). The main drainage system of the valley is Bagmati River with its tributaries, Bishnumati, Manahara, Hanumante, Dhobi Khola, Nakkhu Khola, Balkhu Khola, Godavari, and Tukucha; which all flow out of the valley from Chobhar (Pradhan *et*

al., 2020). Likewise, Pleistocene lacustrine deposits are found in the valley (Malla *et al.*, 1986).

3.1.2 Climate

The climate in the Kathmandu Valley is cool subtropical and temperate (Thapa *et al.*, 2008). The four climatic seasons of the valley are pre-monsoon from March to May, monsoon from June to September, post-monsoon in October and November, and winter season from December to February (Phuyal, 2024). The six years (2017–2022 AD) climatic data from eight weather stations of Kathmandu Valley show a record of average annual maximum temperature of 25.45°C and average annual minimum temperature of 12.07°C (DHM, 2024). During 1991–2020, based on data from six stations, the average highest annual temperature was recorded for the monsoon season with a maximum of 27.63°C and a minimum of 19.10°C. Likewise, the lowest temperature was recorded for the winter season with a maximum of 19.07°C and a minimum of 4.62°C (DHM, 2024). However, 4.07°C was the average temperature difference between urban and surrounding areas of Kathmandu Valley during 1990 to 2020 (Thapa *et al.*, 2023). The seven-year (2016–2022) climatic data from 17 stations in the Kathmandu Valley showed a mean annual precipitation of 1595.97 mm (DHM, 2024). Over 80% of the precipitation occurs during the monsoon season (Ishtiaque *et al.*, 2017). The mountain slopes receive greater precipitation than the valley floor (Phuyal, 2024). Due to its excellent soils and suitable climatic conditions, the valley used to produce large amounts of rice, wheat, maize, potatoes, mustard, and oil crops in the past (Haack & Rafter, 2006).

3.1.3 Vegetation

Kathmandu valley features a diverse range of vegetation, with deciduous trees at lower altitudes and conifers at higher altitudes (Rokaya *et al.*, 2024). The important forests in the Kathmandu valley are mostly in the mountainous terrain, including Rajanikunj, Godavari-Phulchoki, Chandragiri, Shivapuri, Hatiban, and Nagarjun (Bajracharya *et al.*, 1997). Increased human pressure and urbanization create forest islands in the valley floor (Ghimire *et al.*, 2005). Therefore, there are a few forests that are found within the valley floor, including Bhandarkhal and Slesmantak in the Pashupati area, Swoyambhu hillock, Changunarayan, Bajrabarahi, and Ranibari (Maharjan *et al.*, 2006).

The Kathmandu Valley is estimated to have 44.89% (41,769 ha) forest area (Department of Forest Research and Survey, 2018). Among the three districts, the highest forest cover

is in Lalitpur, with 61.07% (24,151 ha), followed by Kathmandu with 36.74% (15,144 ha), and the lowest in Bhaktapur with 20.16% (2,474 ha). At the local level, Bhaktapur Municipality is represented with 0.20% (one ha) of forest. Similarly, Lalitpur Metropolitan City consists of 2% (71 ha) and Kathmandu Metropolitan City with 2.20% (106 ha) forest area. However, the highest forest coverage of 83.10% (6,826 ha) is found in Mahankal Rural Municipality in Lalitpur District, followed by Gokarneshwor Municipality in Kathmandu District with 64.70% (3,769 ha), and Suryabinayak Municipality in Bhaktapur District with 29.60% (1,253 ha).

Major forest types in the Kathmandu Valley include *Schima-Castanopsis* at lower elevations, oak-laurel at middle elevations, and evergreen oak forests at the upper elevations (Malla *et al.*, 1986; Kattel *et al.*, 2015; Dani & Baniya, 2022). Different places in the valley also comprise plantations of conifers, mainly *Pinus* spp. The *Schima-Castanopsis* forest is found at an elevation range of 1400–1800 m asl with *Castanopsis indica*, *Schima wallichii*, *Myrica esculenta*, *Ilex* sp., and *Rhododendron arboreum* as major component species. Similarly, oak-laurel forest is found in 1800–2400 m asl with *Quercus glauca*, *Q. incana*, *Rhododendron arboreum*, *Myrsine semiserrata*, and *Castanopsis tribuloides* as major species. Likewise, evergreen oak forests, found above 2000 m to 2700 m asl, comprise *Quercus semecarpifolia*, *Eurya acuminate*, *Ilex dipyrena*, *Michelia champaca*, *Rhododendron arboreum*, and *Symplocos* spp. as major components. In addition, upper mixed hardwood forest is found between 1500 and 2700 m asl with *Acer* species, *Aesculus indica*, *Alnus nepalensis*, *Betula alnoides*, *Celtis australis*, *Fraxinus floribunda*, *Juglans regia*, *Salix* spp., and *Quercus* spp. The Bagmati riverbank that spans from Sundarijal to Chovar also has a diverse array of aquatic plants, with the presence of weeds, grasses, and sages in agricultural fields (Rokaya *et al.*, 2024).

3.1.4 Urbanization status of the valley

The Kathmandu Valley represents the earliest human settlements in the central Himalayas (Thapa *et al.*, 2008). It has been a major urban hub for more than two thousand years since medieval times (Chitrakar *et al.*, 2015). According to the census of 2021, the valley comprised a total human population of 2,636,467, with Kathmandu District representing 2,041,587; Bhaktapur 432,132; and Lalitpur 551,667 individuals (National Statistics Office, 2023).

Administratively, Kathmandu District consists of one metropolitan city and 10 municipalities, Bhaktapur District consists of four municipalities, and Lalitpur District consists of one metropolitan city, two municipalities, and three rural municipalities (Baniya

et al., 2018). According to the Degree of Urbanization (DEGURBA), Kathmandu Valley consists of approximately 90.34% urban, 7.37% peri-urban, and 2.28% rural area (National Statistics Office, 2024). Bhaktapur District is predominantly covered by 90.71% urban and 9.3% peri-urban areas, with no rural area. Kathmandu District is 93.51% urban, 5.6% peri-urban, and 0.9% rural (the latter includes three wards from Shankharapur Municipality and one ward each from Dakshinkali and Gokarneshwor Municipality). The Lalitpur District consists of 86.81% urban, 7.2% peri-urban, and 5.94% rural areas, of which rural areas include seven wards from Bagmati Rural Municipality, 6 from Mahankal Rural Municipality, 5 from Konjyosom Rural Municipality, and 1 each from Mahalaxmi Municipality and Godawari Municipality. Due to the destruction of river and forest ecosystems, the valley faces extreme land resource stress in urban and peri-urban areas (Thapa & Murayama, 2012).

3.1.5 Selection of the study sites

As there is no clear definition of urban forest, urban park, or garden, different researchers used different terminology to the same urban green spaces based on their personal preference. Pun and Maharjan (2013) listed 13 public parks in Kathmandu Valley, whereas UNDP (2020) has added another 37 park and garden at local levels from Bhaktapur Municipality, Kathmandu Metropolitan City, Kirtipur Municipality and Lalitpur Metropolitan City. Likewise, Aryal *et al.* (2021) mentions UN Park and Tribhuvan University Forest (i.e., coronation garden as the urban forest. In addition, Mishra *et al.* (2024) listed 30 urban gardens and parks, which include community forest as Bishnubir Park and Nilbarahi Park as well as Sallaghari forest. Therefore, based on the secondary data published from Division Forest Office (DFO) of Kathmandu, Bhaktapur and Lalitpur as well as information from local level were included for selection of urban green spaces from Kathmandu valley.

The study areas were selected based on three primary criteria: Urban area, Urban integration and Visitor accessibility. The selected study areas were located in urban areas at ward levels as per the definition of National Statistics Office (2024) for urban areas based on Degree of Urbanization (DEGURBA). Similarly, in urban integration, the selected urban green spaces are surrounded by city buildings and isolated geographically from other vegetation patches. Additionally, each green patch selected is accessible to visitors. Therefore, urban green spaces are integrated into the urban landscape.

The total 15 urban green spaces were selected using a stratified random sampling based on forest and park type. A total of eight urban parks and gardens, six forests and one botanical garden were selected for study. In the six forests, three were Religious Forests (RF) and three were Community Forests (CF). Likewise, among eight urban parks and gardens, four have paid entrance fees and four were free for visitors. Forest is an area fully or partly covered by trees or plants, which is governed under the Forest Act 2019 by Government of Nepal. Parks are the green spaces, which are not included under the Forest Act 2019 and managed by various government institutions and local communities. The forest generally covers more tree area than the parks. However, the coronation garden consists of a larger tree area than other forest patches of Kathmandu valley. Similarly, parks and gardens consist of a ticket system for visitor recreation; however, urban community forests of the valley also implement a similar type of ticket system to manage access and generate revenue.

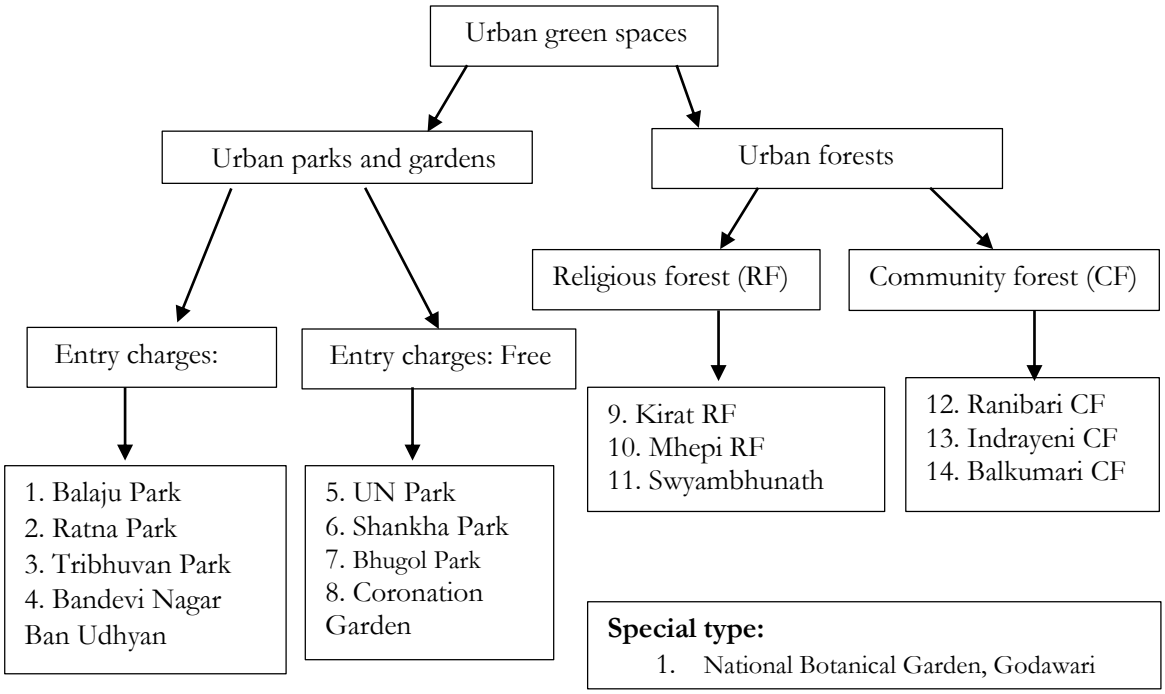


Figure 2: Diagrammatic representation of different types of urban green spaces.

Although the National Botanical Garden lies in Godawari Municipality wards 2 and 3 (Parmar *et al.*, 2024), which is classified as a peri-urban area (National Statistics Office, 2024), but also selected for the study site as it is a major area for conservation of vegetation in Kathmandu valley. Therefore, understanding visitor perceptions and management challenges of botanical gardens will provide valuable insights for park and forest management communities.

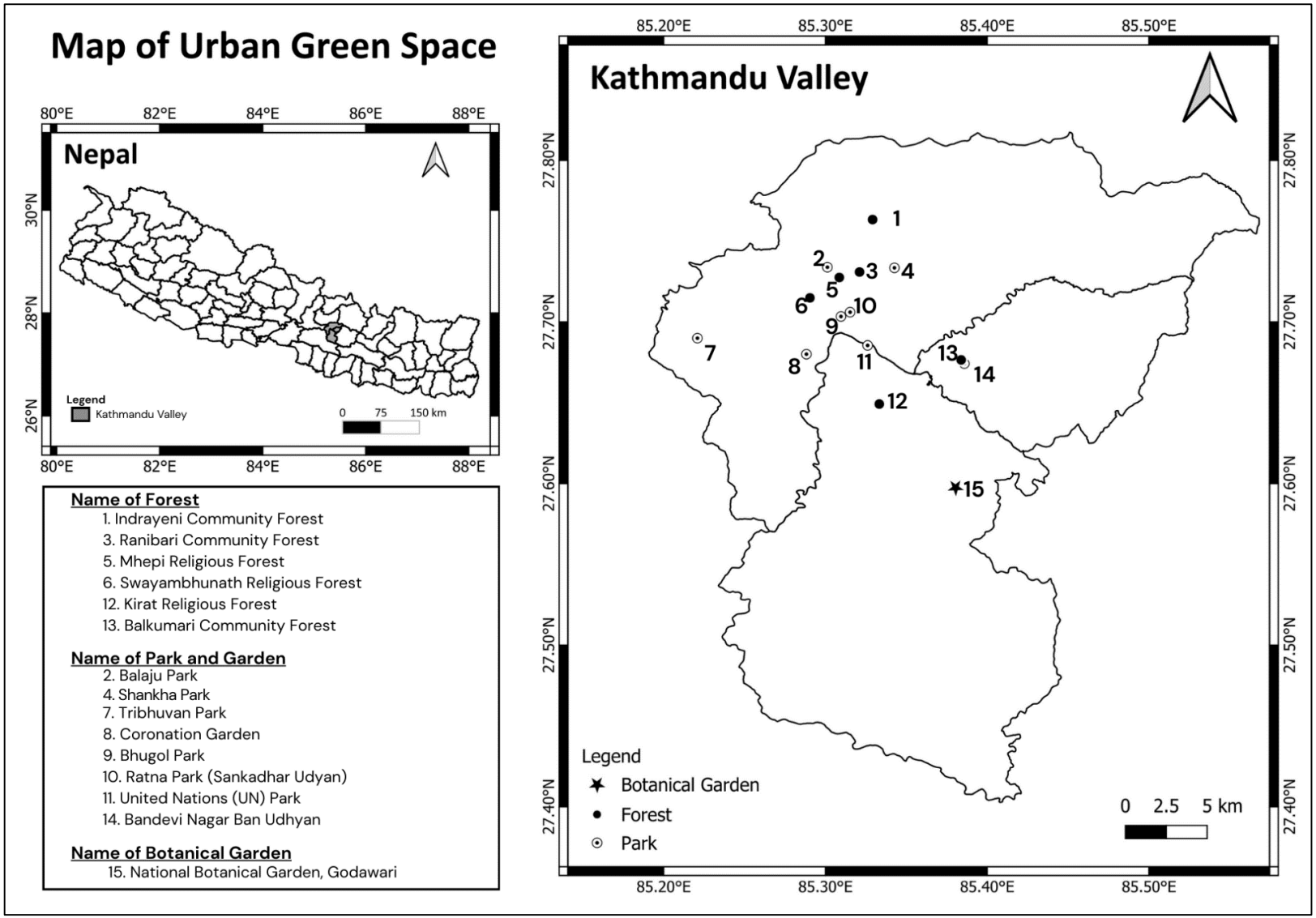


Figure 3. Map of urban green spaces in the Kathmandu Valley.

Table 1. Urban green spaces in the Kathmandu Valley selected for this study.

SN	Name	Location	Local level
1	Bhugol Park	New Road	Kathmandu Metropolitan City, Ward 22
2	Bandevi Nagar Ban Udhyan	Madhyapur Thimi	Madhyapur Thimi Municipality, Ward 4
3	Shankha Park	Maharajgunj	Kathmandu Metropolitan City, Ward 4
4	Ratna Park (Sankadhar Udyan)	Bhotahity	Kathmandu Metropolitan City, Ward 31
5	UN Park	Jwagal	Lalitpur Metropolitan City, Ward 10
6	Balaju Park (Baisdhara)	Bypass Balaju	Kathmandu Metropolitan City, Ward 16
7	Tribhuvan Park	Thankot	Chandragiri Municipality, Ward 4
8	Coronation Garden	Kirtipur	Kirtipur Municipality, Ward 4
9	Mhepi Religious Forest	Mhepi, Newbuspark	Kathmandu Metropolitan City, Ward 16
10	Kirat Religious Forest	Sano Hattiban	Lalitpur Metropolitan City, Ward 23
11	Ranibari Community Forest	Ranibari	Kathmandu Metropolitan City, Ward 3
12	Balkumari Community Forest	Madhyapur Thimi	Madhyapur Thimi Municipality, Ward 4
13	Indrayeni Community Forest	Tokha, Bhootkhel	Tokha Municipality, Ward 6
14	Swayambhunath Religious Forest	Swyambhunath	Kathmandu Metropolitan City, Ward 15
15	National Botanical Garden	Godawari	Godawari Municipality wards 2 and 3

3.2 Research Design

The study was a mixed-methods approach with integrated quantitative and qualitative methods as followed by Talal & Santelmann (2019, 2020). Quantitative methods include statistical analysis for vegetation composition while qualitative methods consist of semi-structured interviews for visitor perception and management challenges.

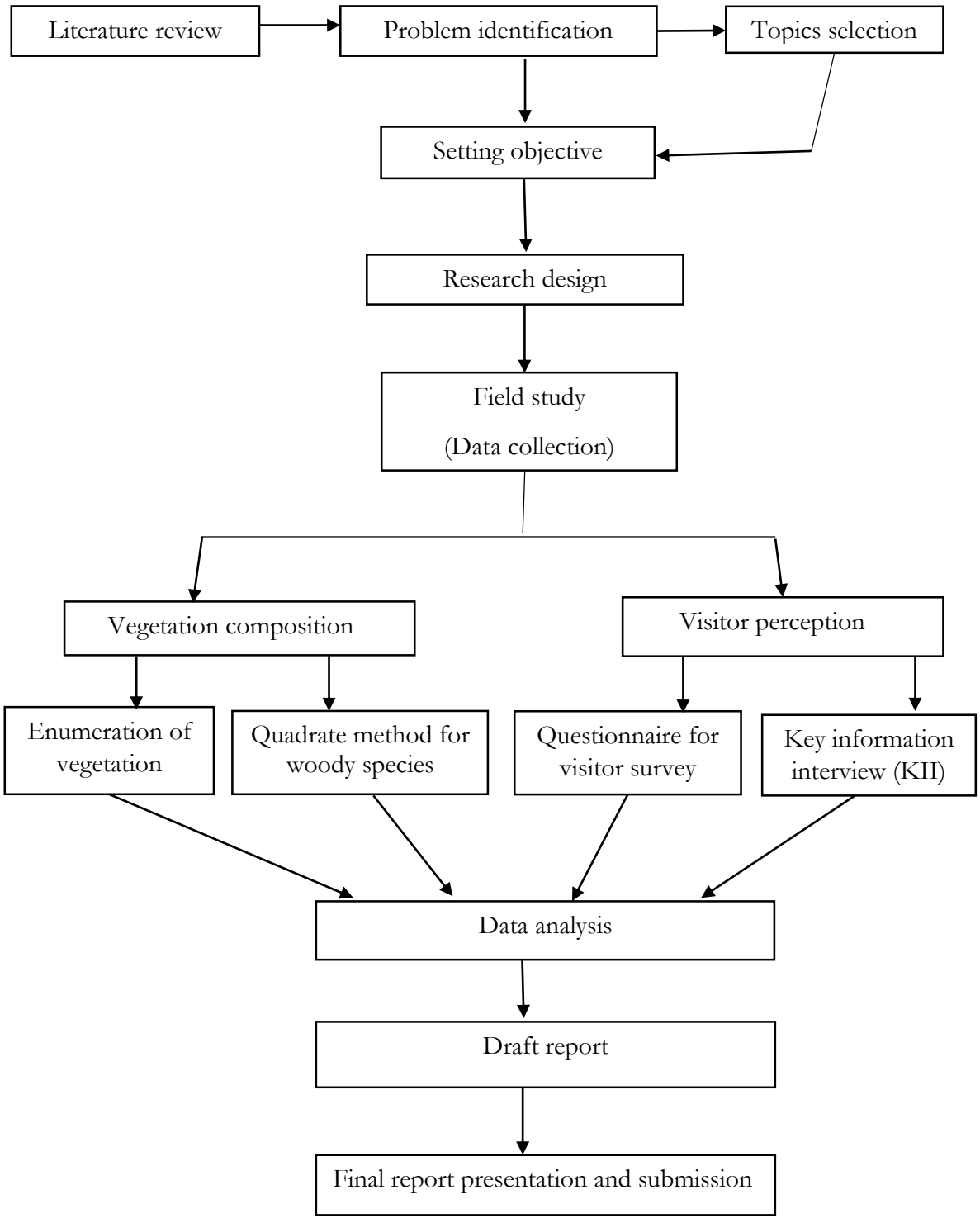


Figure 4: Diagrammatic representation of research design.

3.3 Data Collection

The field data collection consists of four types, i.e., Enumeration of overall vegetation (trees, shrubs, herbs and pteridophytes), Quadrate method for woody species, Questionnaire survey for visitor and Key Information Interview (KII). The preliminary field visit for selection of 15 urban green spaces of Kathmandu valley was carried out in January 2025. During this process, the issue and suggestion regarding urban greenery were taken from Division Forest Office (DFO) of Kathmandu, Bhaktapur and Lalitpur as well as Kathmandu Metropolitan City. Then, the permission letter from the Department of Forests and Soil Conservation was taken along with coordination from Division Forest Office (DFO) of Kathmandu, Bhaktapur and Lalitpur. In addition, other permits were taken from Kathmandu Metropolitan City for urban parks; National Botanic Garden Godawari; Natural History Museum, Tribhuvan University and other local authorities. Then, field study was carried out in the urban green space of Kathmandu valley from 18 February to 13 May 2025, covering 45 days in total at different time intervals. The visitor survey and Key Information Interview (KII) was carried out in all the 15 selected urban green spaces of Kathmandu valley. However, the National Botanical Garden, Godawari had already compiled a plant list in the Catalogue of Plants (Parmar *et al.*, 2024) therefore, vegetation enumeration and the quadrat method for woody species were conducted in 14 other urban green spaces.

3.3.1 Enumeration of vegetation

Line transect method was conducted to enumerate the vegetation in urban green spaces of Kathmandu valley. The transect walk was carried out along the visitor trail as well as inside the off-trail dense vegetation zone to ensure that all habitats of urban parches were covered. The name of each species of trees, shrubs, herbs and pteridophytes was recorded with latitude, longitude, altitude, habit, habitat and abundance. According to Pauli *et al.* (2015), plant abundances were categorized into five qualitative categories i.e., dominant species (d), common species (c), scattered species (s), rare species (r) and very rare species (r). In the fields, plant species were identified by examining their leaves, flowers, and fruits with hand jewelry lenses of 30×22mm and 60×12mm focal lengths. For unidentified plants, specimens were collected with proper tag numbers for the herbarium preparation. In addition, vernacular names of unidentified plants were obtained through discussions with locals and urban green space employees.

3.3.1.1 Identification, collection, and herbarium preparation

The plants were collected from 14 urban green spaces of Kathmandu Valley. Before collection, plants were photographed in their natural habitat, along with macro photography to capture detailed features essential for taxonomic differentiation. All the types of trees, shrubs, herbs and pteridophytes were collected, marked with a tag number and its associated data on latitude, longitude, altitude, habitat and distinguishing characteristics were recorded in the field note. For low-population species, ethical norms were followed during plant collection. The species from the very rare (r!) and rare (r) abundance categories were not collected for herbarium preparation.

For herbarium preparation, the collected plant specimens were pressed, dried and mounted by standard technique Rajbhandari & Rajbhandary (2015). The both unidentified and identified species were further confirmed with the help of different available literature like Flora of China and Flora of Bhutan. Also, Plants of Nepal: Gymnosperms and Angiosperms (Shrestha *et al.*, 2022b), Plants of Kathmandu Valley: A Pictorial Guide (Rokaya *et al.*, 2024) were reviewed. Also, Garden Flowers: An illustrated guide to indoor and outdoor garden plants in Nepal (Bajracharya *et al.*, 1997), Enumeration of the Flowering Plants of Singha Durbar (Bhattarai, 2019), Important ornamental plants of Bharatpur Metropolitan City (Das, 2022), Checklist of floral species at the Institute of Forestry, Pokhara Campus, Pokhara, Nepal (Miya & Gautam, 2021) were reviewed for ornamental species. Each collected herbarium specimen from the field was cross-examined with digital photographs of National Herbarium & Plant Laboratories (KATH) and international herbaria. For valid nomenclature and author citation, online databases such as Plants of the World Online (www.powo.science.kew.org), World Flora Online (www.worldfloraonline.org), Global Biodiversity Information Facility (www.gbif.org), and Centre for Agriculture and Biosciences International (www.cabidigitallibrary.org) were reviewed. After the accurate identification, each specimen was mounted on herbarium paper and labeled the associated field data on the lower right corner of the herbarium sheet. Then, herbarium specimens were deposited at Tribhuvan University Central Herbarium (TUCH), Central Department of Botany, Tribhuvan University.

3.3.1.2 Native and exotic species

This list of Native and Exotic species was prepared by following Plants of Nepal: Gymnosperms and Angiosperms (Shrestha *et al.*, 2022b), Plants of the World Online (POWO, 2025), and Centre for Agriculture and Biosciences International (CABI, 2025).

Likewise, the list of Invasive Alien Plant Species (IAPS) of Nepal was prepared by following Plant Invasions in Nepal: What We Do Not Know? (Shrestha *et al.*, 2024).

3.3.1.3 Threatened species

The IUCN Red List of Threatened Species version 2025-1 (www.iucnredlist.org) was used to prepare the list of threatened species found in urban green spaces of Kathmandu Valley. Likewise, Joshi *et al.* (2017) was followed for the species listed in the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) Appendices.

3.3.2 Quadrat sampling for woody species

The plot sampling method was used to estimate the population size of woody species from the 14 urban space areas of valley. The number of plots required for sampling was generated from various sizes of grid intersections (Table 2) based on the total area of the urban green space. Then the grid was overlaid on a Quantum Geographic Information System (QGIS) version 3.40.5 (Figure 5). Since the urban green space areas range from 0.15 ha in Bhugol Park to 31.38 ha in Swyambhunath Religious Forest, the number of plots for different green spaces varied from 3 to 32 plots.

Table 2: Sample plots in urban green spaces of Kathmandu Valley.

SN	Name of urban green space	Total area (hectares)	Grid size (m)	Number of sample plots	Sample area (hectares)
1	Bhugol Park	0.15	30	3	0.03
2	Bandevi Nagar Ban Udhyan	0.797	30	8	0.08
3	Shankha Park	1.44	50	9	0.09
4	Ratna Park (Sankadhar Udyan)	2.34	50	9	0.09
5	UN Park	5.11	50	12	0.12
6	Balaju Park (Baisdhara)	8.09	5	10	0.1
7	Tribhuvan Park	7.83	50	15	0.15
8	Coronation Garden	16.1	100	25	0.25
9	Mhepi Religious Forest	2.46	50	10	0.1
10	Kirat Religious Forest	2.47	50	10	0.1
11	Ranibari Community Forest	6.95	50	20	0.2
12	Balkumari Community Forest	8.2	50	15	0.15

13	Indrayeni Community Forest	6.09	50	15	0.15
14	Swayambhunath Religious Forest	31.38	120	32	0.32
	Total	99.407	30–120	193	1.93

The total sample area was 1.93 ha, representing about 1.94% of the total vegetation patch area (99.407 ha) from 14 distinct urban green spaces selected for this study (Table 2). The eight urban parks and gardens represented an area of 41.857 ha, while six urban forests represented 55.09 ha. A total of 91 sample plots (0.91 ha), representing about 2.17% of the total vegetation patch area, were selected from eight urban parks and gardens. Likewise, 102 sample plots (1.02 ha), representing about 1.85% of the total vegetation patch area, were selected from six urban forests. Generally, parks and gardens were small in size with high maintenance of ornamental landscaping (Schaefer *et al.*, 2004). Therefore, smaller grid sizes with a larger number of sample plots were taken following Xu *et al.* (2024) to enhance the accurate representation of vegetation across different sub-habitat types.

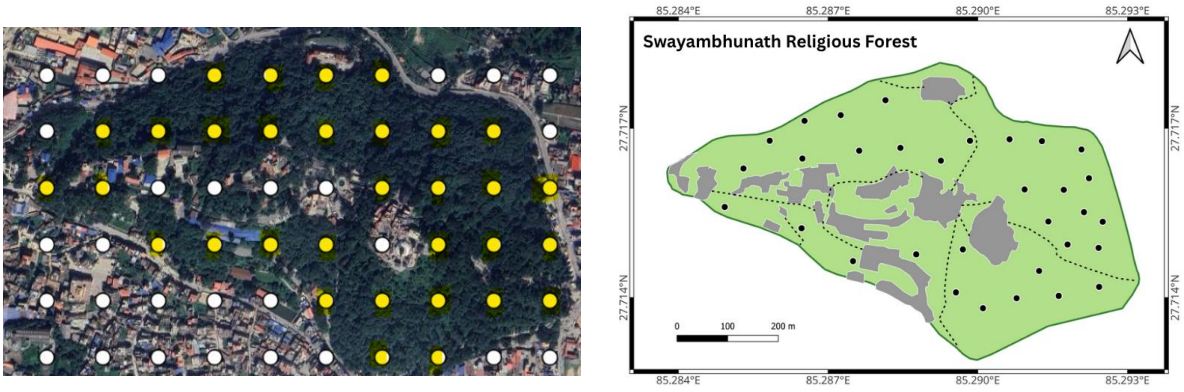
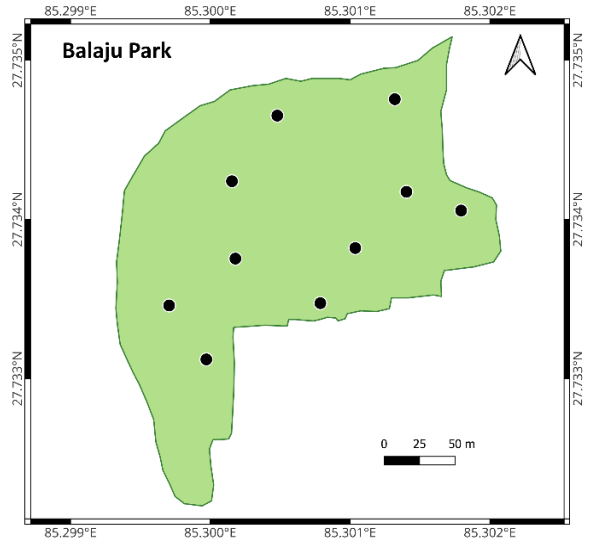
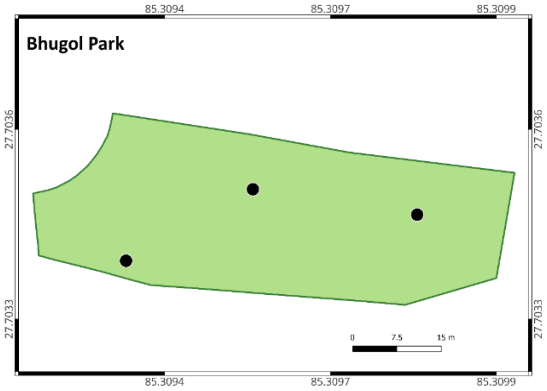
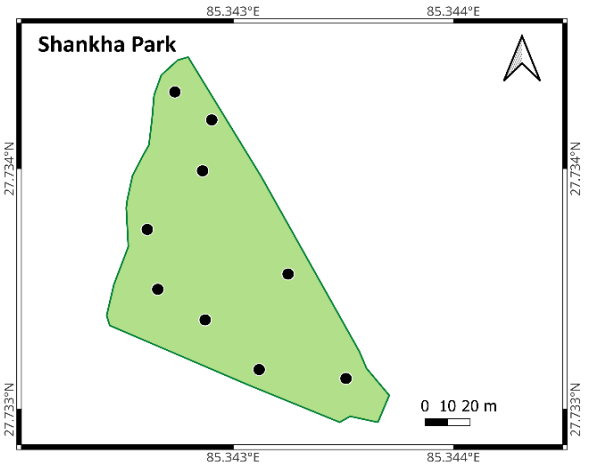


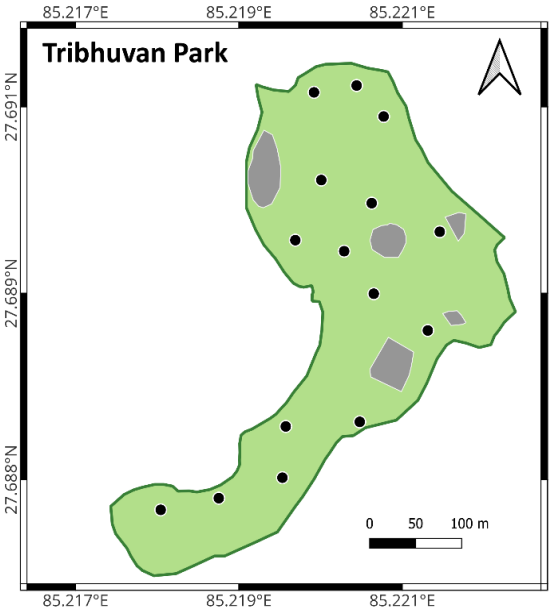
Figure 5: Relocation of sample plots.

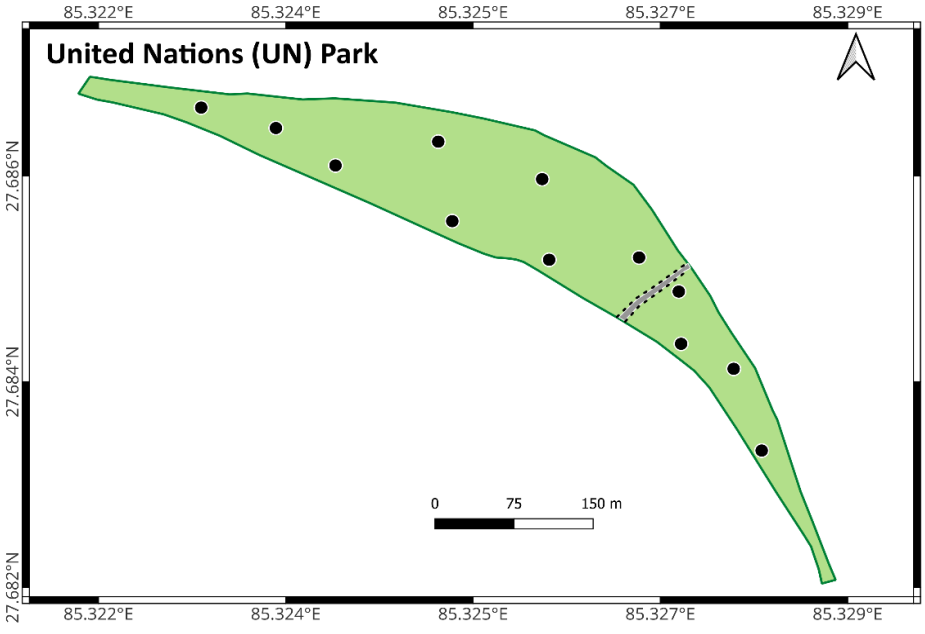
Grid-based sampling ensures the equal coverage of a study area by dividing it into uniform sections. However, urban forests are highly maintained and modified for recreational activities (Maharjan *et al.*, 2006). The construction of roads and trails, as well as picnic areas, has replaced or fragmented forest areas (Shrestha *et al.*, 2020). It also consists of open space, areas for human activities, and even places for waste disposal (Ghimire *et al.*, 2005). Therefore, if the predefined grid insertion points covered less than 50% coverage of woody species, then the sample plot was relocated within 20 m of the adjacent area or removed (Figure 5) following Xu *et al.* (2024) to include each green patch within the study site. Therefore, the dot symbols (sample plot) on maps of urban green space are more likely to be located in the interior of the green patch and away from recreation sites.

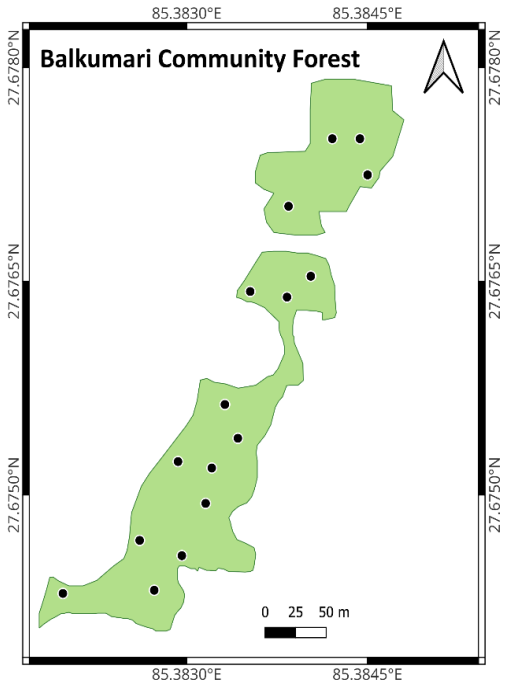

Balaju Park
85.299°E
85.300°E
85.301°E
85.302°E
27.735°N
27.734°N
27.733°N
0 25 50 m

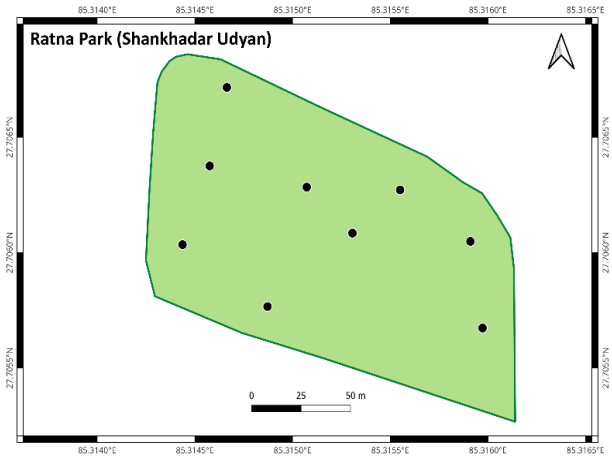

Bhugol Park
85.3094
85.3097
85.3099
27.7036
27.7033

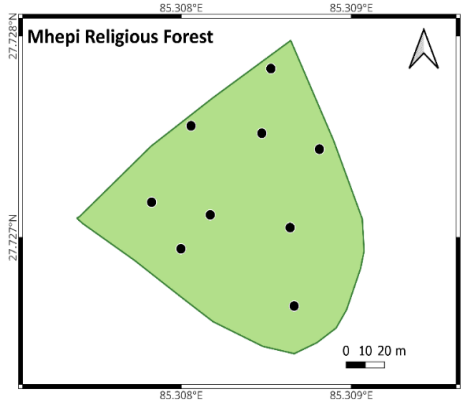

Shankha Park
85.343°E
85.344°E
27.734°N
27.733°N
0 10 20 m

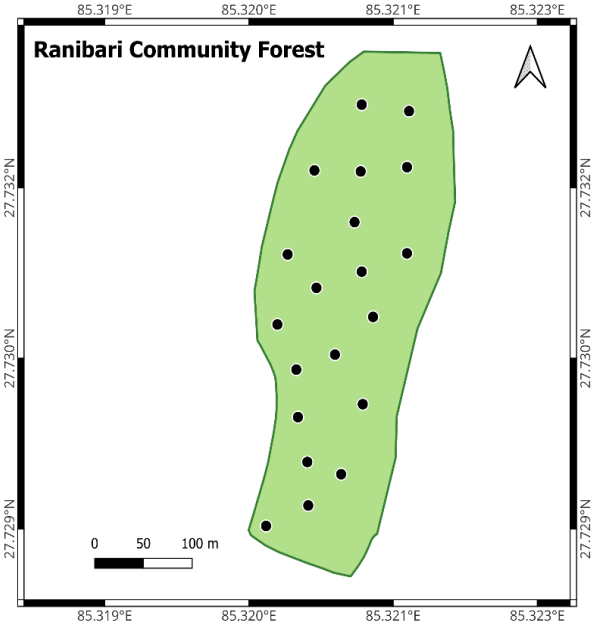

Tribhuvan Park
85.217°E
85.219°E
85.221°E
27.691°N
27.689°N
27.688°N
0 50 100 m

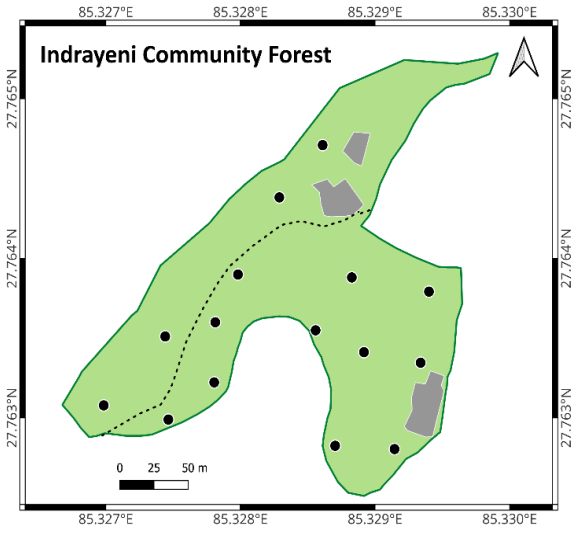

United Nations (UN) Park
85.322°E
85.324°E
85.325°E
85.327°E
85.329°E
27.686°N
27.684°N
27.682°N
0 75 150 m

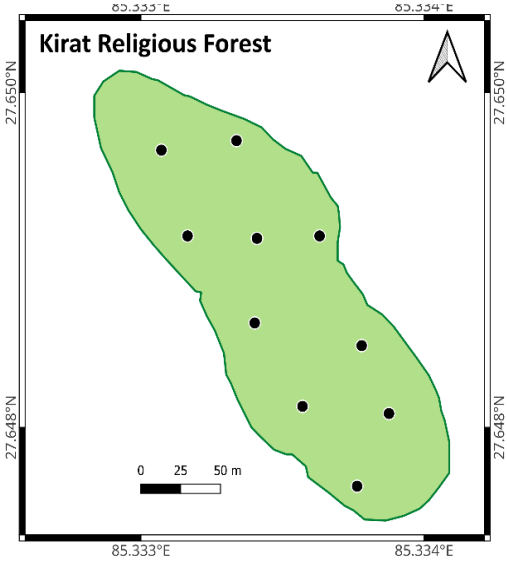

Balkumari Community Forest
85.3830°E
85.3845°E
27.6780°N
27.6765°N
27.6750°N
0 25 50 m


Ratna Park (Shankhadar Udyan)
85.3140°E
85.3145°E
85.3150°E
85.3155°E
85.3160°E
85.3165°E
0 25 50 m


Mhepi Religious Forest
85.308°E
85.309°E
0 10 20 m


Ranibari Community Forest
85.319°E
85.320°E
85.321°E
85.323°E
27.732°N
27.730°N
27.729°N
0 50 100 m


Indrayeni Community Forest
85.327°E
85.328°E
85.329°E
85.330°E
27.765°N
27.764°N
27.763°N
0 25 50 m


Kirat Religious Forest
27.650°N
27.648°N
0 25 50 m
85.333°E
85.334°E

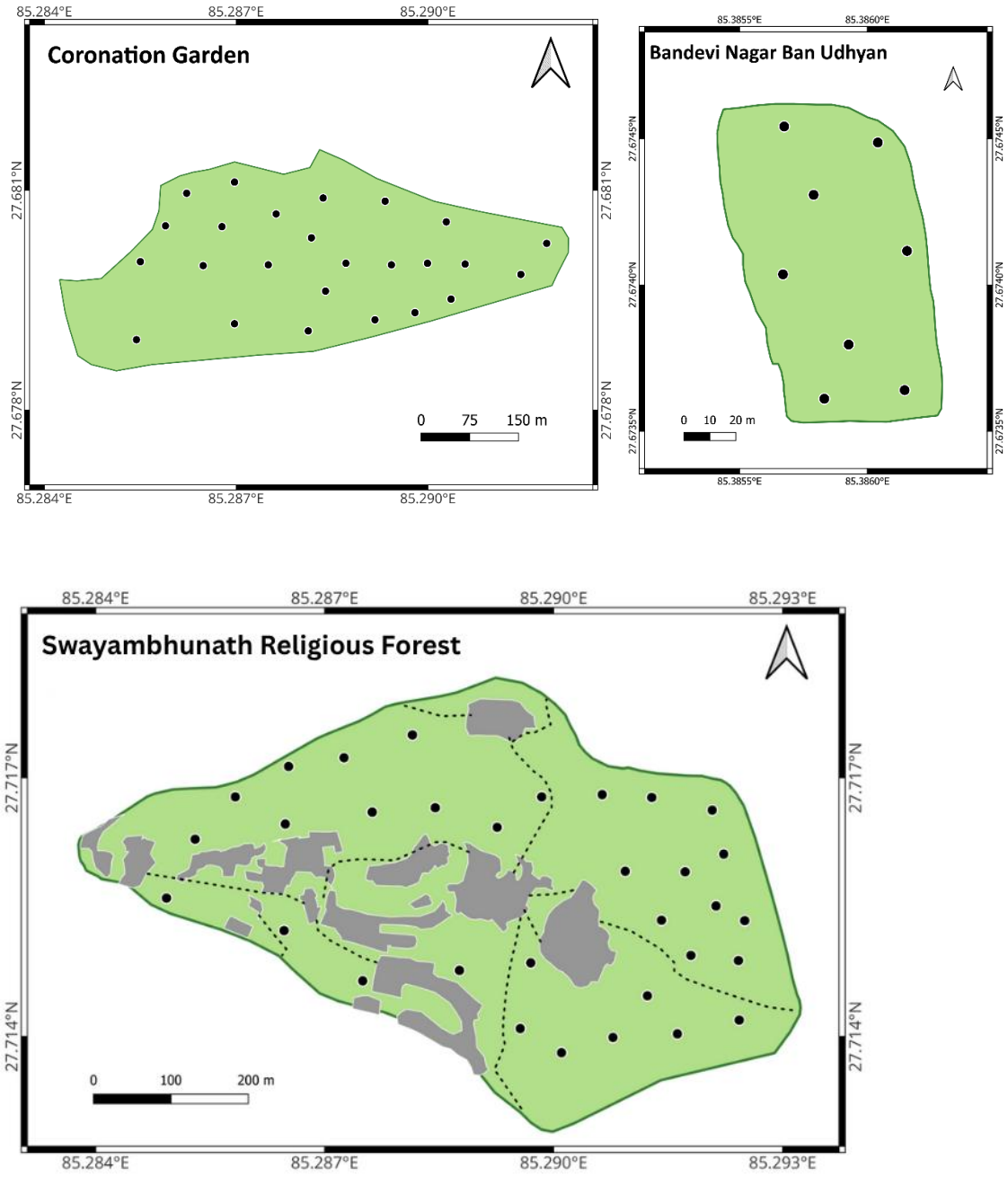


Figure 6: Sampling plots in urban green space areas of Kathmandu Valley.

The shape file containing the location (latitude and longitude) of dots was generated, and a Global Positioning System (GPS) was used in the field to pinpoint the exact center position of the plot. Three types of sampling units were used for the spatial representation of vegetation (Figure 7). Based on the area of urban green space, 3 to 32 sampling plots (main plots, each of 10 m × 10 m) were laid for sampling tree species. The two nested 5 m × 5 m subplots were diagonally laid within the main (10 m × 10 m) plots for recording tree saplings and shrubs. In addition, three nested sub-subplots of area 1 m × 1 m were

diagonally laid within the main plot for recording seedlings and herb species. Trees are perennial woody species with a diameter at breast height (DBH) greater than 5 cm; saplings are woody species taller than 1.3 m with a DBH less than 5 cm; and seedlings are woody species shorter than 1.3 m (Forest Research and Training Centre, 2022).

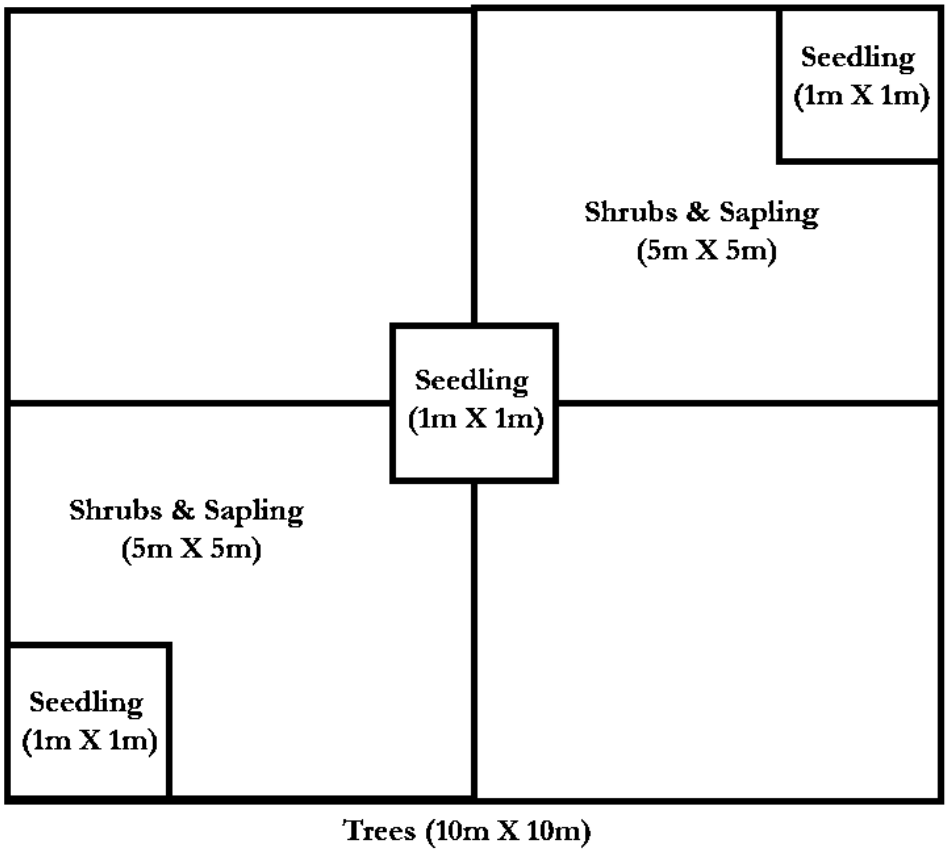


Figure 7: Sampling layout.

In addition, modular organization types (i.e., Phalanx type and Guerrilla type) of species were also observed and different ramet levels of individuals were counted as single individual. Therefore, all the genet level individuals on each sampling plot were recorded in the field data sheet. Similarly, Diameter at Breast Height (dbh) of each tree at height of 1.37m from the base was measured using DBH tape (Yamayo 10m Diameter tape). Likewise, a clinometer (Eyeskey OP006) was used to measure the angle between the observer eye and tip of the tree and measuring tape was used to measure distance between observer and tree. Then, the height of the individual tree above the observer eye was calculated with the help of trigonometry tangent formula. At last, the total height of the tree was determined by adding an observer height up to the eye. In addition, tree-related microhabitats like moss, lichen, epiphytic and bird nests, squirrel nests, insect hives of individual trees were recorded. The physical location (like latitude, longitude, elevation,

slope, aspect, water availability), vegetation structure (tree canopy cover, sapling/shrub/herb cover, litter cover & thickness, humus thickness, rock cover) were also observed.

Disturbances like freshly cut trees, dead/rotten trees, lopped, burnt, grazing, slashing, dropping, resin tapping, erosion were recorded. In addition, other human induced disturbances like rubbish, foot traffic, earthworks, picnic spots and power lines were recorded as described in the field manual (Forest Research and Training Centre, 2022). The intensity of disturbance is as follow

- **0 (No disturbance):** there are no significant disturbances.
- **1 (Minor disturbance):** there is little or no effect where less than 10 % of the trees/seedlings were affected by the such disturbance.
- **2 (Medium disturbance):** there is some effect where it covers 10–25 % of the trees/seedlings affected by the disturbance or some trees felled/died.
- **3 (Strong disturbance):** there is a remarkable effect where more than 25 % of the trees/seedlings affected by the disturbance or several trees fell/died.

3.3.3 Visitor Survey

The questionnaire survey was conducted with the 230 visitor from 15 urban green spaces through face-to-face interviews. For diverse representation of visitors, a purposive sampling approach was applied for selection of visitors from each green space. The number of respondents surveyed in each urban green space ranged from 10 to 20, based on the visitor frequency at each site. The parks had a higher number of visitors than the forests (except for Bandevi Nagar Ban Udhyan); therefore, 20 visitors were surveyed. Despite a high number of visitors at Swayambhunath and Mhepi, only a limited number accessed the green spaces as their main purpose was temple visitation. Therefore, only 10 visitors were surveyed in each forest. In order to minimize visitor biases, surveys were conducted at morning, day, and evening times with equal numbers of men and women. However, more men were found in the morning and evening in urban green spaces. In addition, diverse age groups as students, the elderly and young adults were interviewed in the survey.

Questionnaire of survey (Appendix 19) consists of 37 questions, categorized into five main sections: Demographic information, visitation patterns, visitor perception, willingness to pay and affect local communities. The questionnaire on survey included both open and

closed-ended questions. The five-point Likert scale was used to assess the level of agreement in visitor perceptions. The interview was conducted in Nepali language.

3.3.4 Key Information Interview (KII)

The interviews were carried out with the key informants i.e., urban green spaces employees of different management levels such as supervisors, horticulturalists, and field technicians. Similarly, upcoming plans and challenges were discussed with officers of Division Forest Office (DFO) of Kathmandu, Bhaktapur and Lalitpur as well as Kathmandu Metropolitan City.

3.4 Data Analysis

The field data of enumeration of vegetation, quadrat sampling and questionnaire survey from 15 urban green spaces were compiled through Microsoft Excel version 2016. Then, the following parameters were calculated and illustrated with charts, tables, and bar graphs.

3.4.1 Diversity indices

Diversity indices define the number of different species and their distribution among individuals in particular locations. It includes both species richness (number of species) and species evenness (relative abundance of each species) which summarizes the complexity of a community into a single value. The species diversity was calculated by following formula of Shannon and Weaver (1964) and Simpson (1949).

3.4.1.1 Shannon Wiener Diversity Index (H)

Shannon and Weaver (1964) diversity index based on the concept of entropy, which describes the degree of uncertainty in identifying the species of a randomly chosen individual. It combines both species richness and evenness into a single value.It is given by:

$$H = -\Sigma (ni/N) \ln (ni/N)$$

$$= -\Sigma pi \ln pi$$

Where

N = Total no. of individuals of all the species.

ni = No. of individuals of a species

In a particular community, the value of H is directly proportional to species diversity. The higher the value of Shannon Wiener diversity index (H), the greater the species diversity. If the value of H is zero then only one species is found in that particular community. The value usually lies between 1.5 and 3.5 and rarely exceeds 4.5 (Magurran, 1988). If the value is near to 4.6 then all the individuals of species have an even distribution.

Similarly, Species evenness (e) within urban green space is calculated by using Shannon Wiener Diversity Index (H). It was calculated as follows.

$$e = H/ (\ln S)$$

Where,

H = Shannon-Wiener's Diversity Index

S = No. of species

The value of species evenness(e) ranges from 0 to 1. The value of one indicates complete evenness where all species have the same or nearly equal number of individuals. The lower values indicate that the community is dominated by a few species.

3.4.1.2 Simpson index (D)

Simpson (1949) index was derived from the concept of probability in which two randomly chosen individuals from a sample will belong to distinct species. The Simpson index is also known as dominance index because it gives more value to common species than the rare species.

$$D = \frac{\sum n(n-1)}{N(N-1)}$$

Where,

ni = No. of individuals of each species,

N = Total of individuals of all the species.

Simpson index (D) values range between 0 and 1, where 0 represents infinite diversity and 1 represents no diversity in a particular community. Since, dominance is inversely proportional to diversity. Since the dominance index has the issue of interpretability and logical consistency for diversity, Gini-Simpson index has been developed. The Gini-Simpson index is derived by deduction of Simpson dominance index (D) from one. It is also known as Simpson's index of diversity (1-D) which also ranges from 0-1 but zero

represents no diversity and 1 represents infinite diversity. In addition, others used Simpson's Reciprocal index (1/D) for species diversity.

3.4.2 Community attributes

For the community structures analysis, different parameters such as density, frequency, coverage, basal area, relative density, relative frequency, relative coverage, relative basal area and Importance Value Index (IVI) were calculated by using Zobel *et al.* (1987). The formulae, which were used for the calculation of these attributes, are given below:

3.4.2.1 Density and Relative Density

Density is the number of individuals per unit area. It expresses the numerical strength of a given species in a particular community. Its unit is plant per unit hector (Pl/ha)

$$\text{Density (D)} = \frac{\text{Total number of individual in all sampling units}}{\text{Total number of quadrats studied} \times \text{Area of quadrat taken}} * 10000$$

Relative density is density of a particular species in relation to the total frequency of all the species present in the community.

$$\text{Relative density (RD)} = \frac{\text{Density of individual species}}{\text{Total density of all species}} * 100\%$$

3.4.2.2 Frequency and Relative Frequency

Frequency is degree of distribution or dispersion of given species in a particular area. It indicates the number of sampling units in which a given species occurs and thus expressed in percentage.

$$\text{Frequency (F)} = \frac{\text{Number of sampling units (quadrates) in which a species occurs}}{\text{Total number of sampled units studied}} * 100\%$$

Relative frequency is frequency of a particular species in relation to the total frequency of all the species present in the community.

$$\text{Relative Frequency (RF)} = \frac{\text{Frequency of individual species}}{\text{Sum of the frequencies for all species}} * 100\%$$

3.4.2.3 Basal area and Relative Basal area

Basal area is the cross-sectional area of a tree stem. The stem was measured from diameter at breast height (dbh) and then basal area (m^2) of each tree species was calculated by following formula. For the tree, basal area was calculated.

Basal area of tree = $\pi d^2/4$

Where

d = Diameter at breast height

π = 3.1416

Relative basal area is the area of the surface covered by one species as compared to the total coverage area of all the species.

$$\text{Relative basal area} = \frac{\text{Basal area of individual species}}{\text{Total basal area of all species}} * 100\%$$

3.4.2.4 Coverage and Relative Coverage

Coverage is the area of the canopy coverage of particular species around its habitat. The coverage percentage for shrubs was calculated based on visual estimation. The relative cover is the area of the surface covered by an individual species as compared to the total coverage area of all the species

$$\text{Relative coverage} = \frac{\text{The coverage area of individual species}}{\text{The total coverage area of all species}} * 100\%$$

3.4.2.5 Importance Value Index (IVI)

Importance Value Index (IVI) is the concept used to express the dominance and ecological success of any species with a single value. It is the sum of relative density, relative frequency, and relative basal area/coverage of a species in a community.

For shrubs, IVI= Relative Frequency + Relative Density +Relative Coverage

For trees, IVI= Relative Frequency +Relative Density +Relative Basal area

The IVI value of any species in the community ranges between 0-300, where higher the value describes the larger distribution of particular species in the community. The total sum of IVI of all species in a particular community is 300. It helps to describe the relative contribution of a particular species to the entire community of urban green space.

3.4.3. Biomass and Carbon Stock of trees

Carbon stock of tree species was estimated from aboveground biomass, which was calculated by using an allometric equation proposed by Chave *et al.* (2005). The unit of aboveground tree biomass (AGTB) is kg.

$AGTB = 0.0509 \times \varrho D^2H$

Where,

ϱ = dry wood density (gm/cm^3)

D = tree diameter at breast height (cm)

H=height of tree (m)

Wood density values were primarily obtained from the Global Wood Density Database (Zanne *et al.*, 2009). For those tree species whose value were lacking, supplementary values were taken from Sharma and Pukkala (1990), Shrestha *et al.* (2023), Mahato *et al.* (2019), and Karki *et al.* (2016). For tree species lacking wood density data in the above literature, the closest taxonomically related species was selected for estimation purposes (Ravindranath & Ostwald, 2008).

Similarly, below-ground tree biomass was estimated using a root-to-shoot ratio of 1:5 (i.e., 20% of the above-ground tree biomass), as suggested by MacDicken (1997) in his guide to monitoring carbon storage in forestry and agroforestry projects.

Biomass stock density (kg/m^2) was calculated by dividing the total weight of tree species by the area sample plot size. The biomass stock density (kg/m^2) was then converted to tons per hectare (t/ha) by multiplying the value by 10. At last, total carbon stock of tree species was estimated by multiplying their biomass (t/ha) by a carbon fraction of 0.47, following IPCC (2006) guidelines.

Then, the carbon contribution of species was calculated by the carbon stock of particular species in relation to the total carbon stock of all the species present within the same forest. . Its unit is percentage.

$$\text{Carbon contribution} = \frac{\text{Carbon stock of a particular tree species}}{\text{Sum of carbon stock of all tree species}} * 100\%$$

3.4.4 Regeneration of species

Good and Good (1972) mentions that the regeneration of tree species depends on three types of ability i.e., germination, survival and growth of seedlings and saplings. Therefore,

regeneration status of urban green space and its major tree species was determined based on the density of seedlings, saplings, and adult trees by following regeneration categories of Shankar (2001).

Table 3: Regeneration types with its criteria

SN	Regeneration Status	Criteria
1	Good regeneration	Seedling > Sapling >Adult
2	Fair regeneration	Seedlings > Saplings < Adults
3	Poor regeneration	Seedlings absent; Saplings may be <, >, or = Adults
4	No regeneration	Both Seedlings and Saplings absent; Adults present
5	New regeneration	Adults absent; only Saplings and/or Seedlings present

In addition, the Density-Diameter (D-D) curve of tree species was prepared by the density and diameter of the 10 DBH class interval. The D-D curve was used to visualize the state of tree regeneration and population stability in the urban green space. If the density in each size class is stable then urban green spaces have good regeneration status of tree species.

3.4.2 Statistical analysis

The statistical analysis was conducted after all data had been entered and organized in MS Excel 2016. The Mann–Whitney U test and Spearman's rank correlation analysis was performed using the Statistical Package for Social Sciences (SPSS) version 25.0. Principal Component Analysis (PCA) and the hierarchical cluster dendrogram were generated using RStudio (R Core Team, 2025).

4. Results

4.1. Historical context of urban green spaces

Urban green spaces in the Kathmandu Valley consisted of both horticultural design and naturalistic landscape elements, and featured a mixture of natural and planted species, including tall and medium-sized trees, as well as a thick understory of shrubs and herbs. These spaces encompassed both densely wooded areas and open grasslands. The highest levels of formal horticultural design were found in urban parks primarily intended for active and recreational use. On the other hand, more naturalistic landscape approaches predominated in urban forests, reflecting their passive and ecological functions. The Coronation Garden, however, exhibited a purely naturalistic landscape with no evidence of formal horticultural design, largely due to inadequate management and maintenance. Balaju Park and Tribhuvan Park demonstrated a mixture of both horticultural designs and naturalistic landscapes, where horticultural design elements were prominent near main entrances, and the rear sections of the parks transitioned into more naturalistic settings. Some urban forests introduced ornamental plant species within their boundaries to enhance recreational appeal and attract visitors.

4.1.1. Early Botanical Exploration

The plant exploration in Nepal began in 1802-1803 with Francis Buchanan-Hamilton's visit to Kathmandu Valley (Rajbhandari, 2016). The specimens collected by Buchanan significantly contributed to *Prodromus Florae Nepalensis* (Press & Shrestha, 200). During 1820-1822, Nathaniel Wallich collected plant specimens in Nepal, but some earlier specimens thought to be his were actually collected by Edward Gardner before Wallich's visit to Nepal (Rajbhandari, 2016). The Prodromus florae Nepalensis was the first documentation of flora from Nepal which recorded 766 species of phanerogam (Don, 1825). About 382 valid taxa were recorded from collections of flowering plants by Hamilton from Nepal (Press & Shrestha, 2000). Similarly, around 700 species were collected from Nepal by Wallich and his team of collectors (Rajbhandari, 2016).

Among them, 104 historical specimens of 79 species were recorded from urban green space of Kathmandu valley. Of these, 56 specimens were originally collected by F. Buchanan-Hamilton, 46 specimens by N. Wallich, and 2 specimens by E. Gardner. Additionally, 25 specimens were collected by at least two of these early collectors. The 79 historically recorded species found in the urban green spaces of Kathmandu valley

included 25 tree species, 22 herbs, 12 climbers, 11 shrubs, and 9 subshrubs. They were collected from 17 locations, including Narayanhiti (28 species), Swayambhu (13), Hetauda (5), Shivapuri (4), Thankot (3), and others, with 37 species labeled only as "Nepal" without specific locality (Figure 8).

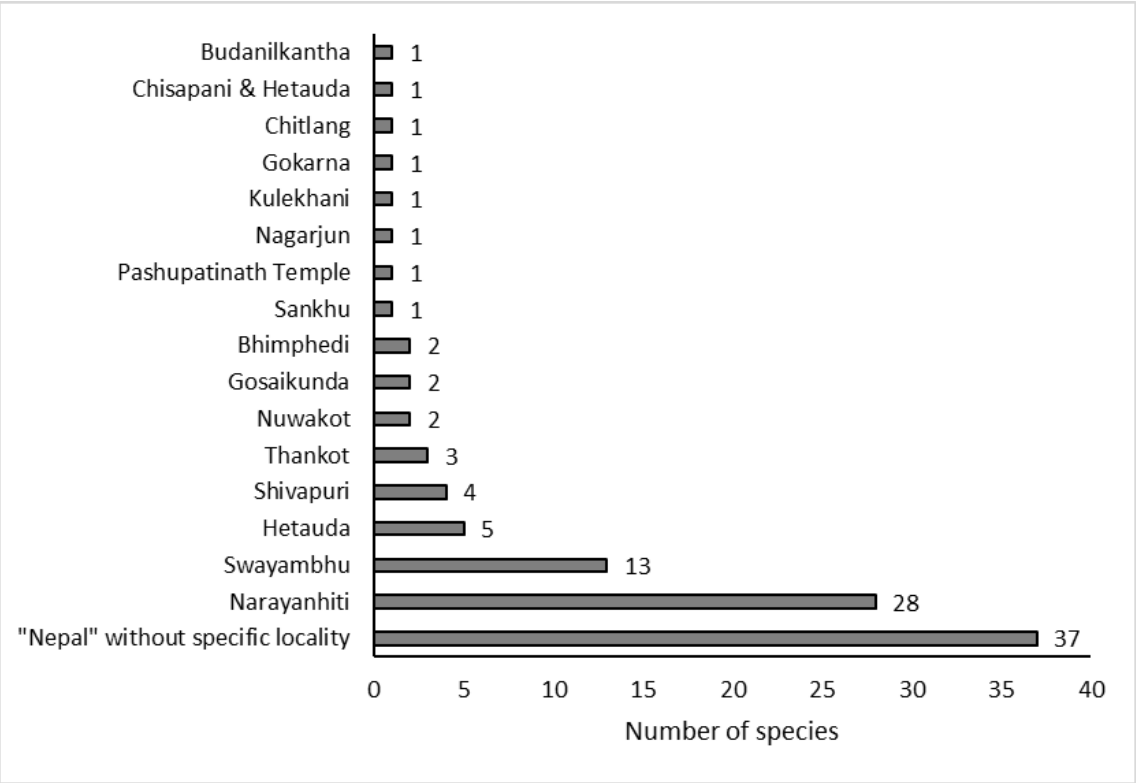


Figure 8: Collection sites of historical specimens from Kathmandu Valley.

Among the 104 historical specimens, 15 were new to science, 16 were holotypes, five lectotypes, one neotype, and 60 were type specimens. The type status of seven specimens remains unknown. In addition, 15 species collected were l identified as new to science. It includes *Alnus nepalensis* D.Don, *Campanula cana* Wall., *Euonymus echinatus* Wall., *Galium asperifolium* Wall., *Juniperus recurva* Buch.-Ham. ex D.Don, *Lepidagathis incurva* Buch.-Ham. ex D.Don, *Maesa chisia* D.Don, *Ophiopogon intermedius* D.Don, *Ophiorrhiza fasciculata* D.Don, *Phyllanthus parvifolius* Buch.-Ham. ex D.Don, *Podocarpus neriifolius* D.Don, *Prunus cerasoides* Buch.-Ham. ex D.Don, *Pyrus pashia* Buch.-Ham. ex D.Don, *Scutellaria barbata* D.Don and *Thunbergia coccinea* Wall. ex D.Don. Additionally, two species i.e., *Ficus sarmentosa* Buch.-Ham. ex Sm. and *Ficus semicordata* Buch.-Ham. ex Sm. were also recorded, which were originally described by Francis Buchanan-Hamilton and later validly published by Smith.

In addition, 10 species originally described by early botanical explorers were later transferred to different genera based on subsequent taxonomic revisions. It includes

Brassaiopsis hainla (Buch.-Ham.) Seem., *Cinnamomum tamala* (Buch.-Ham.) T.Nees & C.H.Eberm., *Gymnosporia rufa* (Wall.) Hook.f., *Ilex excelsa* (Wall.) Voigt, *Laggera alata* (D.Don) Sch.Bip. ex Oliv., *Lonicera macrantha* (D.Don) Spreng., *Luculia gratissima* (Wall.) Sweet, *Lyonia ovalifolia* (Wall.) Drude, *Neolitsea cuipala* (D.Don) Kosterm., *Stranvaesia nussia* (Buch.-Ham. ex D.Don) Decne. Likewise, tree plant species found during the botanical exploration carry epithets that honor the early botanical collectors of Nepal. It includes *Clematis buchananiana* DC., *Cirsium wallichii* DC., and *Schima wallichii* (DC.) Korth. where species epithet "buchananiana" honors Francis Buchanan-Hamilton while "wallichii" honors Nathaniel Wallich. In addition, three species were named with the epithet nepalensis, indicating their association with Nepal. They are *Alnus nepalensis* D.Don, *Geranium nepalense* Sweet, and *Hedera nepalensis* K.Koch.

4.2. Species Diversity and Composition

4.2.1. Comparison of total diversity

A total of 437 species of spermatophytes, belonging to 347 genera and 114 families, were recorded from 14 urban green spaces. Of these, gymnosperms comprised 16 species from 6 families, while angiosperms represented 421 species from 108 families. Among the angiosperms, 70 species (from 16 families) were monocotyledons, and 351 species (from 92 families) were dicotyledons. The recorded species included 127 tree species, 73 shrubs, 57 subshrubs, 134 herbs, and 46 climbers.

A total of 384 plant species were recorded in eight urban parks, whereas 296 species were documented in six urban forests. In urban parks, herbs accounted for the highest number of species (120), followed by trees (106). In contrast, trees slightly outnumbered herbs (105 vs. 88 species) in urban forests. Climbers had the lowest representation in both urban parks (39 species) and urban forests (27 species) (Figure 9).

The most dominant family, in terms of species number, was Asteraceae (31 species), followed by Poaceae (19 species). Other notable families included Fabaceae, Moraceae, and Solanaceae, each represented by 15 species, along with Rosaceae (14), Lamiaceae (13), Malvaceae (13), Asparagaceae (12), and Acanthaceae and Amaranthaceae (10 species each) (Table 4). The genus *Ficus* had the highest number of species (11), followed by *Solanum* (8 species), *Euphorbia* and *Tradescantia* (5 species each), and *Araucaria, Citrus*, and *Eucalyptus* (4 species each).

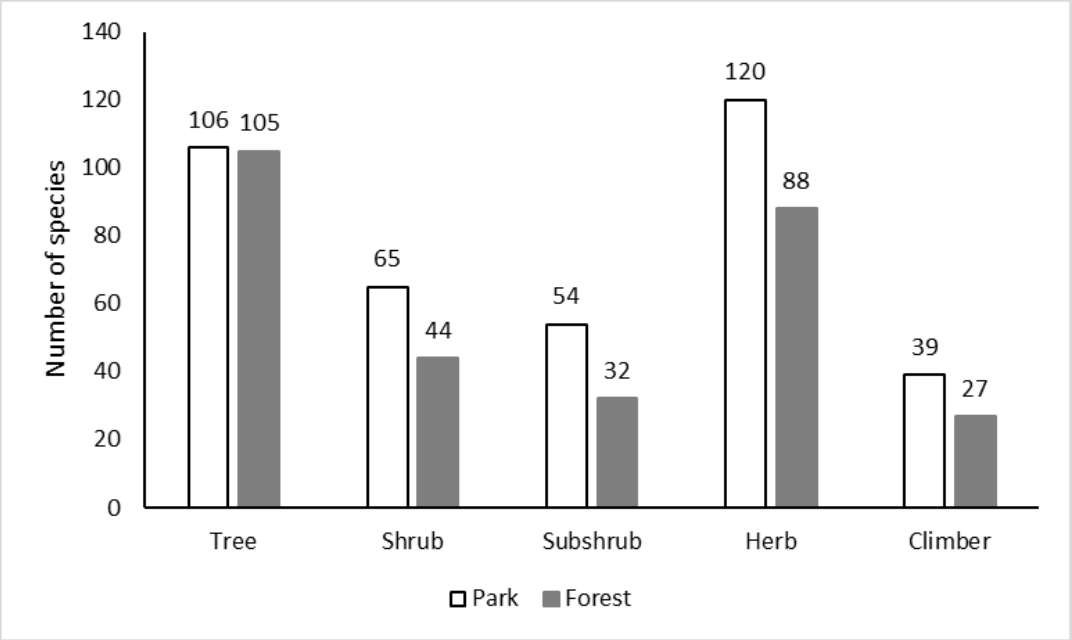


Figure 9: Number of plant species among different lifeforms recorded in the urban green spaces (urban parks and urban forests) studies in the Kathmandu Valley.

Table 4: Family-wise composition of the plant species.

Number of species	Name of family
31	Asteraceae
19	Poaceae
15	Fabaceae, Moraceae, Solanaceae
14	Rosaceae
13	Lamiaceae, Malvaceae
12	Asparagaceae
10	Acanthaceae, Amaranthaceae
9	Myrtaceae
8	Araceae, Euphorbiaceae, Oleaceae, Rutaceae
7	Arecaceae, Commelinaceae, Cupressaceae, Polygonaceae, Rubiaceae
6	Apocynaceae, Araliaceae, Brassicaceae, Crassulaceae, Lauraceae, Urticaceae
5	Amaryllidaceae, Plantaginaceae, Salicaceae
4	Araucariaceae, Apiaceae, Bignoniaceae, Celastraceae, Lythraceae
3	Asphodelaceae, Begoniaceae, Boraginaceae, Caryophyllaceae, Menispermaceae, Nyctaginaceae, Phyllanthaceae, Ranunculaceae
2	Anacardiaceae, Balsaminaceae, Berberidaceae, Bromeliaceae, Buxaceae, Cactaceae, Cannabaceae, Caprifoliaceae, Convolvulaceae, Cucurbitaceae, Ebenaceae, Ericaceae, Geraniaceae, Hydrangeaceae, Iridaceae, Juglandaceae, Magnoliaceae, Onagraceae, Orchidaceae, Oxalidaceae, Pinaceae, Piperaceae,

	Primulaceae, Proteaceae, Sapindaceae, Theaceae, Verbenaceae, Violaceae
1	Annonaceae, Aquifoliaceae, Basellaceae, Betulaceae, Campanulaceae, Cannaceae, Capparaceae, Caricaceae, Casuarinaceae, Combretaceae, Cornaceae, Cycadaceae, Cyperaceae, Elaeocarpaceae, Ginkgoaceae, Hypericaceae, Hypoxidaceae, Linaceae, Malpighiaceae, Mazaceae, Meliaceae, Musaceae, Nymphaeaceae, Pandanaceae, Passifloraceae, Paulowniaceae, Pentaphylacaceae, Platanaceae, Plumbaginaceae, Podocarpaceae, Pontederiaceae, Portulacaceae, Rhamnaceae, Santalaceae, Sapotaceae, Scrophulariaceae, Simaroubaceae,Smilacaceae, Strelitziaceae, Symplocaceae, Tropaeolaceae, Viburnaceae, Zingiberaceae

4.2.2. Species composition among study sites

Of the 437 total species, only six species were recorded in all 14 urban green spaces, and these were classified as dominant species (Table 5). Additionally, six species were present in 13 sites, and 19 species were found in 12 sites. In contrast, 129 species were found to be rare, recorded at only one site, indicating a high degree of site-specificity or human preference for planting.

Table 5: Common species across urban green spaces in the Kathmandu Valley.

Total sites represented	Name of species
14	*Alternanthera philoxeroides* (Mart.) Griseb., *Camphora officinarum* Boerh. ex Fabr., *Duranta erecta* L., *Ficus religiosa* L., *Platycladus orientalis* (L.) Franco, *Youngia japonica* (L.) DC.
13	*Celtis australis* L., *Erigeron sumatrensis* Retz., *Ficus benghalensis* L., *Grevillea robusta* A.Cunn. ex R.Br., *Jacaranda mimosifolia* D.Don, *Oxalis corniculata* L.
12	*Ageratina adenophora* (Spreng.) R.M.King & H.Rob., *Bidens pilosa* L., *Bougainvillea spectabilis* Willd., *Buddleja asiatica* Lour., *Cestrum parqui* (Lam.) L'Hér., *Chrysojasminum humile* (L.) Banfi, *Crassocephalum crepidioides* (Benth.) S.Moore, *Ficus benjamina* L., *Galinsoga quadriradiata* Ruiz & Pav., *Hippeastrum vittatum* (L'Hér.) Herb., *Lantana camara* L., *Ligustrum sinense* Lour., *Morus alba* L., *Persea americana* Mill., *Psidium guajava* L., *Rosa chinensis* Jacq., *Solanum nigrum* L., *Sonchus oleraceus* L., *Stellaria aquatica* (L.) Scop.

In total, the urban park and forest consisted of 384 and 296 plant species, respectively. Comparison with the plant species found in the National Botanical Garden (NBG), Lalitpur, Nepal (total 1128 species, Parmar *et al.* 2024) showed that 299 species found

across the 14 sites covered in the present study were also recorded in the NBG. A total of 176 species were common to all three categories: urban parks, urban forests, and the NBG (Figure 10). Additionally, 67 species were shared only between urban parks and forests, 89 species between parks and the NBG, and 34 species were shared exclusively between urban forests and the NBG. Unique species included 52 species found only in parks, 19 species only in forests, and 829 species only in the NBG.

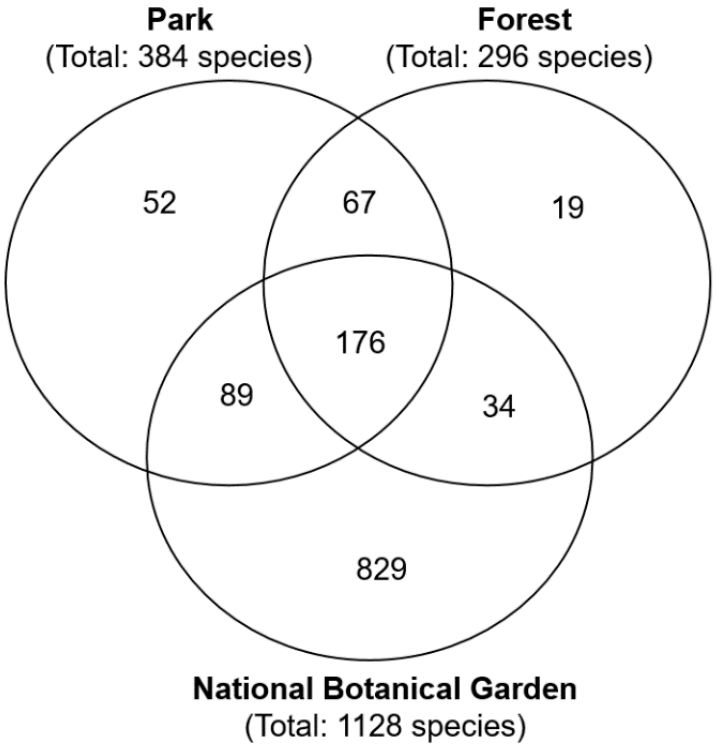


Figure 10: Venn diagram illustrating the compositional similarity of plant species among urban parks, forests, and the National Botanical Garden, Godavari.

The similarity in plant species composition among urban green spaces was visualized using a cluster dendrogram (Figure 11). The results indicated that species composition in such spaces was influenced by management practices. For example, Ratna Park, Bhugol Park, and Sankha Park formed a distinct cluster, likely due to similar vegetation influenced by common management practices under Kathmandu Metropolitan City. Tribhuvan Park and Balaju Park originally had native species, and ornamental species were added later. Therefore, they shared both types of species, reflecting their transition from native forest patches to managed parks. Among forests, Swayambhunath RF and Ranibari CF had high native species richness and were less influenced by the introduction of ornamental species. Indrayeni CF and UN Park, both plantation forests, also showed strong similarity and clustered together (Figure 11).

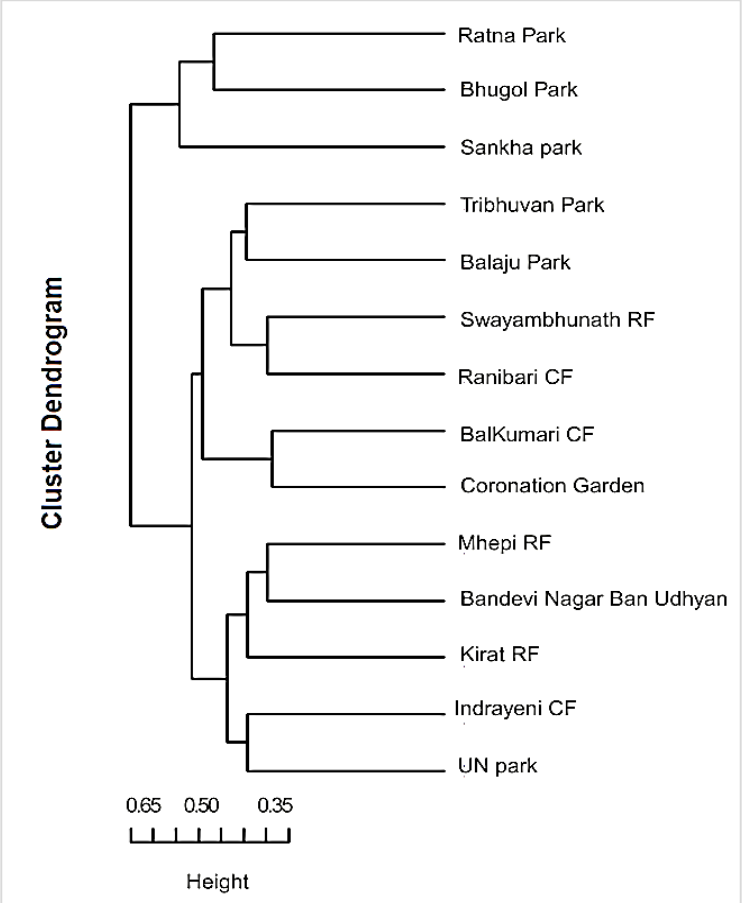


Figure 11: Cluster diagram showing the similarity in plant species composition among urban green spaces in the Kathmandu Valley. The x-axis height represents a level of dissimilarity; sites grouped closer together share more similar species.

4.2.3 Species richness by site

Among urban parks, the highest number of species (235) was recorded in Balaju Park (with a total area of 8.09 ha), while the lowest species count of 79 was recorded in Bhugol Park (0.15 ha). Interestingly, Coronation Garden, having the largest area among the parks (16.1 ha), had only 119 species, which is lower than Bandevi Nagar Ban Udhyan (0.79 ha) with 122 species (Figure 12). Among urban forests, Ranibari Community Forest (6.95 ha) had the highest species richness (152 species), while Balkumari Community Forest (8.2 ha) had the lowest richness (111 species). However, Swayambhunath Religious Forest, despite being the largest (31.38 ha), had 148 species (Figure 13). Among urban parks, the highest number of species per plot (9.25) was recorded in Bandevi Nagar Ban Udhyan, while the lowest species per plot (3.78) was recorded in Ratna Park. Among urban forests, Balkumari Community Forest had the highest plot wise species richness (9.67 species), while Indrayeni Community Forest had the lowest plot wise richness (5.2) (Figure 14).

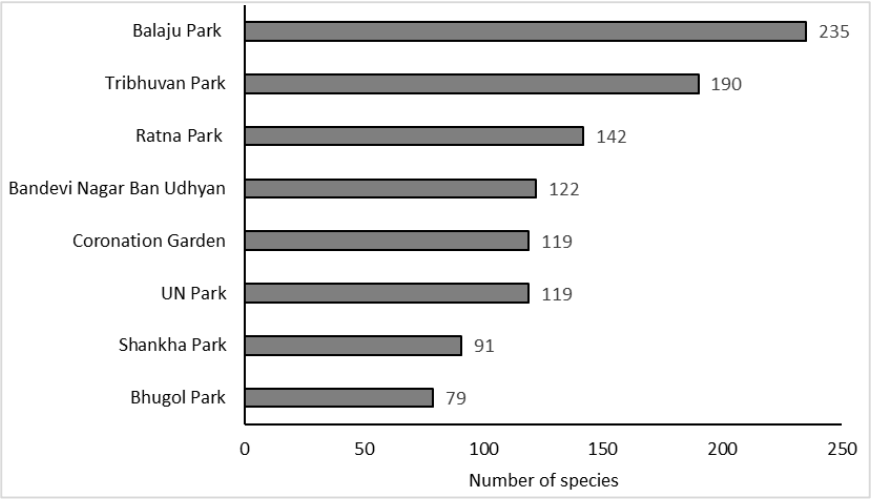


Figure 12: Number of plant species recorded in eight urban parks studied in Kathmandu Valley.

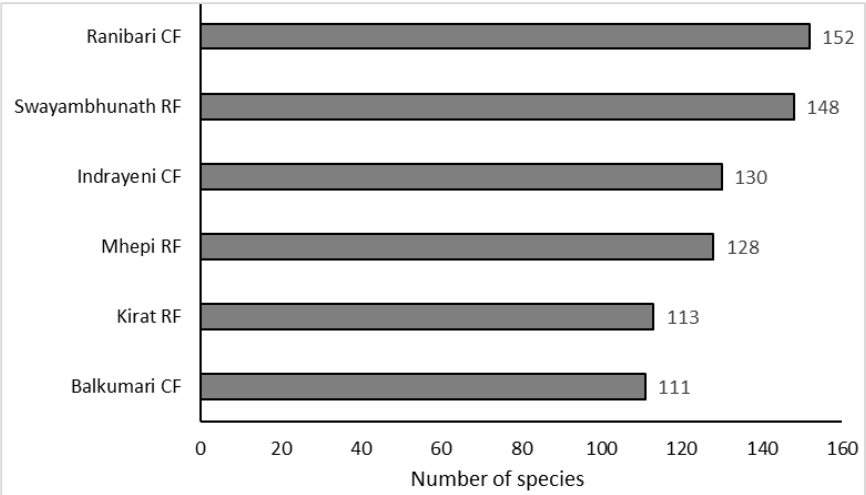


Figure 13: Number of plant species recorded in six urban forests studied in Kathmandu Valley.

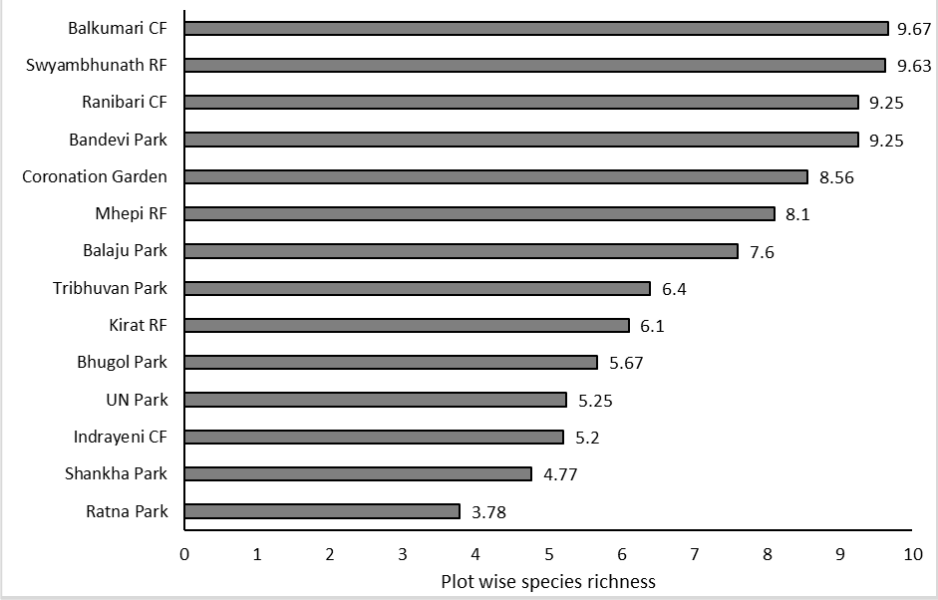


Figure 14: Number of plant species per plot recorded in the urban green spaces (urban parks and urban forests) studies in the Kathmandu Valley.

4.2.4 Relationship between area and species richness

Due to human intervention, there is no significant (p = 0.109, n = 14) Spearman's rank correlation between area and number of species in the urban green space of Kathmandu valley. Linear regression analysis also showed no significant relationship (R^2 = 0.074, p = 0.348) between the size of urban green space and total species richness (Figure 15). This indicates that total species richness is not strongly dependent on area in these urban settings. Unlike natural ecosystems, where species richness often increases with area, human-driven plantation practices shape species composition in urban areas and influence species diversity. However, Spearman's rank correlation showed a strong positive and significant relationship between habitat area and native species richness (ρ = 0.832, p < 0.001, n = 14). Also, moderate positive relationship was observed between native species richness and area of the urban green space (R^2 = 0.306, p = 0.04), suggesting that larger green spaces may support a greater number of native species (Figure 15). However, native species diversity may also be influenced by management practices and human plantation preference.

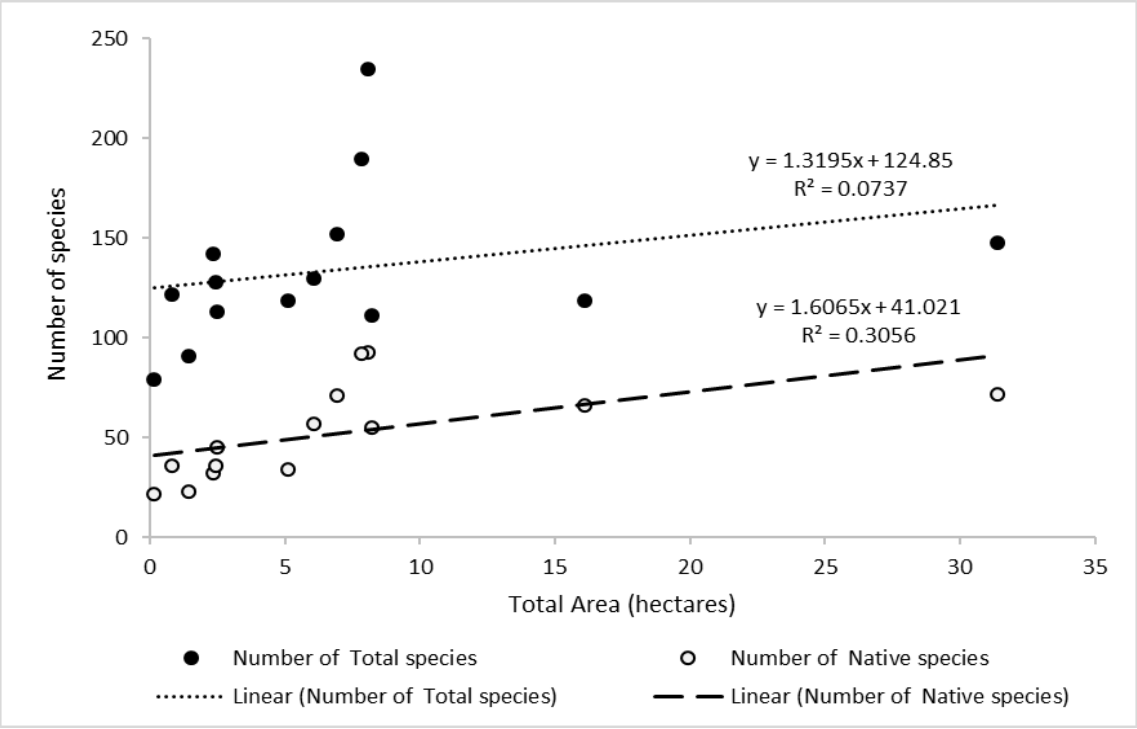


Figure 15: Relationship between species richness and size of urban green spaces (urban parks and urban forests) studies in the Kathmandu Valley.

4.3. Species origin and structural composition

4.3.1 Native vs. exotic species diversity

Out of the 437 recorded plant species in the urban green spaces of Kathmandu Valley, 40.73% (178 species) were native, 54.46% (238 species) were introduced, and 4.81% (21 species) were of uncertain origin (Figure 16). The uncertain species (Appendix 8) represent taxa with conflicting information about their origin across different literature sources, including Shrestha *et al.* (2022b), (POWO, 2025), and (CABI, 2025). In terms of urban space type, urban parks included 38.80% (149 species) native species, and 56.51% (217 species) exotic species; whereas, urban forests supported 43.24% (128 species) native and 50.34% (149 species) exotic species. The ratio of native to exotic species was far greater in urban forests (0.85) than in urban parks (0.68).

Overall, exotic species had greater structural dominance across the urban green spaces (Figure 16). In the combined data set, trees and climbers consisted of a slightly higher number of exotic than native species, but for other growth forms (shrubs, subshrubs, and herbs), exotics greatly outnumbered natives (Figure 17). Individually, in urban parks, exotic species always outnumbered native species across all growth forms, with the most remarkable difference observed in shrubs, subshrubs, and herbs. The number of exotic shrubs and subshrubs was almost twice than that of their native counterparts in urban parks (Figure 17). In urban forests, the distribution of native and exotic trees was equal (48 species), while exotics slightly outnumbered natives across other growth form categories (Figure 18).

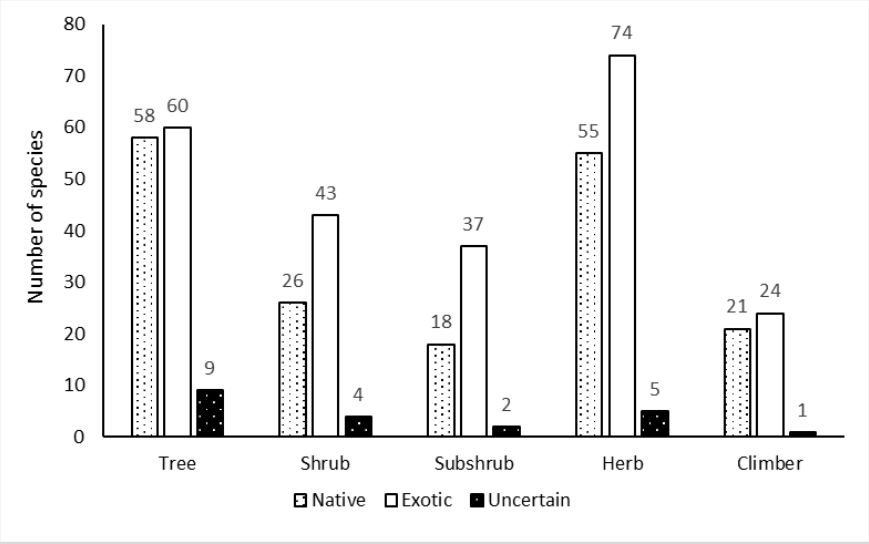


Figure 16: Species origin across plant growth forms in urban green spaces of Kathmandu Valley (combined dataset).

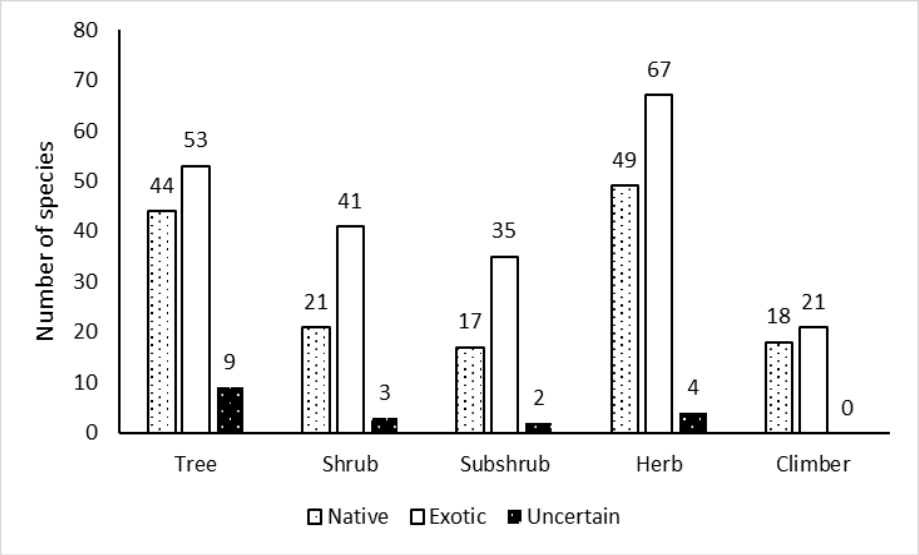


Figure 17: Species origin across plant growth forms in urban parks of Kathmandu Valley.

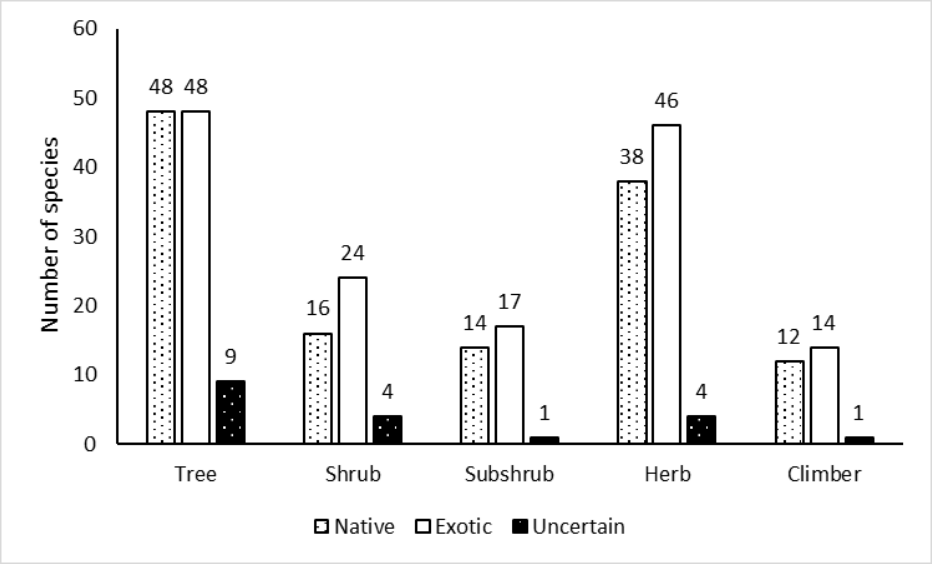


Figure 18: Species origin across plant growth forms in urban forests of Kathmandu Valley.

The proportion of native and exotic species varied across the 14 urban green spaces (Figure 19). Urban parks, such as Ratna Park and Shankha Park, had a high dominance of exotic species (over 68% of their flora), and a relatively low representation of native species (22–25%). In contrast, community (e.g., Balkumari, Ranibari) and religious (e.g., Swayambhunath) forests had a higher proportion of native species, exceeding 45%. Coronation Garden had the highest percentage of native species (55.46%) and the lowest exotics (37.82%). Bhugol Park and Mhepi religious forest also showed relatively higher levels of uncertainty in species origin, with more than 10% of species unverified.

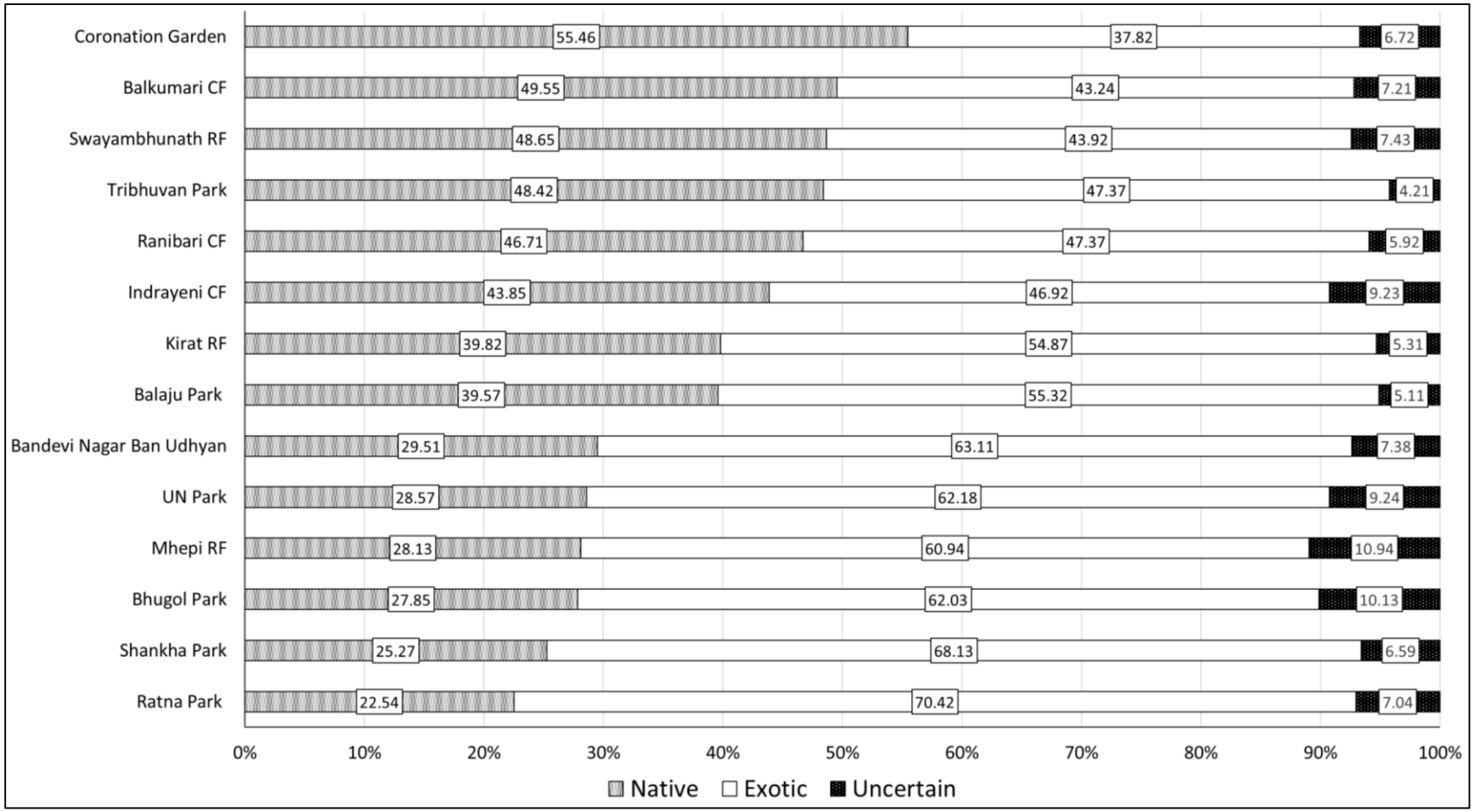


Figure 19: Species origin across 14 urban green spaces of Kathmandu Valley.

4.3.2. Nature of exotic species

Out of the total 238 exotic species recorded in the urban green spaces, 178 (74.78 %) species were cultivated, 57 (23.94%) were naturalized, and three (1.26%) were both cultivated and naturalized.

4.3.2.1. Cultivated species

Of the cultivated species, nine (5.05%) were identified as hybrids, while the remaining 169 species (94.95%) were pure species. The hybrid species were mainly used for ornamental purposes. They were *Begonia* × *erythrophylla* Hérincq, *Chrysanthemum* × *morifolium* (Ramat.) Hemsl., *Crocosmia* × *crocosmiiflora* (Lemoine) N.E.Br., *Gladiolus* × *hybridus* C.Morren, *Hibiscus* × *rosa-sinensis* L. *Musa* × *paradisiaca* L., *Pelargonium* × *hybridum* (L.) L'Hér., *Citrus* × *aurantiifolia* (Christm.) Swingle, and *Citrus* × *limon* (L.) Osbeck.

4.3.2.2. Naturalized species

Among the exotic species, 45 species were naturalized in Nepal (Appendix 1, 2, 3, 4, 5). The most common species are *Cannabis sativa* L., *Duranta erecta* L., *Ipomoea purpurea* (L.) Roth, *Psidium guajava* L. and *Ricinus communis* L. Likewise, three species i.e., *Anethum graveolens* L., *Artabotrys hexapetalus* (L.f.) Bhandari, and *Mirabilis jalapa* L. were cultivated and naturalized in Nepal.

4.3.2.3 Invasive species

Out of the 30 naturalized invasive alien plant species found in Nepal (Shrestha *et al.*, 2024), 12 species (11 terrestrial and 1 aquatic) were recorded from the study area. Among them, *Lantana camara* L. and *Pontederia crassipes* Mart. Is listed in the world's 100 worst invasive species (Lowe *et al.*, 2000). However, *Rubus ellipticus* Sm. is also listed in the world's 100 worst invasive species, but it is native to Nepal. Based on the magnitude of impact, Environmental Impact Classification for Alien Taxa (EICAT) has categories alien species into major five classes (Adhikari *et al.*, 2022). Among them *Lantana camara* L. and *Pontederia crassipes* Mart. have a Massive (MV) impact (Table 6).

Table 6: Environmental Impact Classification for Alien Taxa (EICAT) categories of alien species found in urban green spaces of Kathmandu Valley.

EICAT categories	Name of species
Massive (MV)	*Lantana camara* L., *Pontederia crassipes* Mart.
Major (MR)	*Ageratina adenophora* (Spreng.) R.M.King & H.Rob., *Parthenium hysterophorus* L.

Moderate (MO)	*Ageratum houstonianum* Mill., *Alternanthera philoxeroides* (Mart.) Griseb.
Minor (MN)	*Amaranthus spinosus* L., *Bidens pilosa* L., *Galinsoga quadriradiata* Ruiz & Pav., *Oxalis latifolia* Kunth, *Senna occidentalis* (L.) Link, *Xanthium strumarium* L.
Minimal Concern (MC)	–

Among them, *Alternanthera philoxeroides* was found in all 14 urban green spaces (100%). Likewise, *Ageratina adenophora* and *Lantana camara* were found in 12 green spaces each (85.71%), followed closely by *Bidens pilosa*, *Galinsoga quadriradiata*, and *Oxalis latifolia* which are recorded in 11 green space (78.57%). In contrast, *Senna occidentalis* and *Xanthium strumarium* were observed in only two green spaces (14.29%), while *Pontederia crassipes* was recorded at a single site (7.14%) (Figure 20).

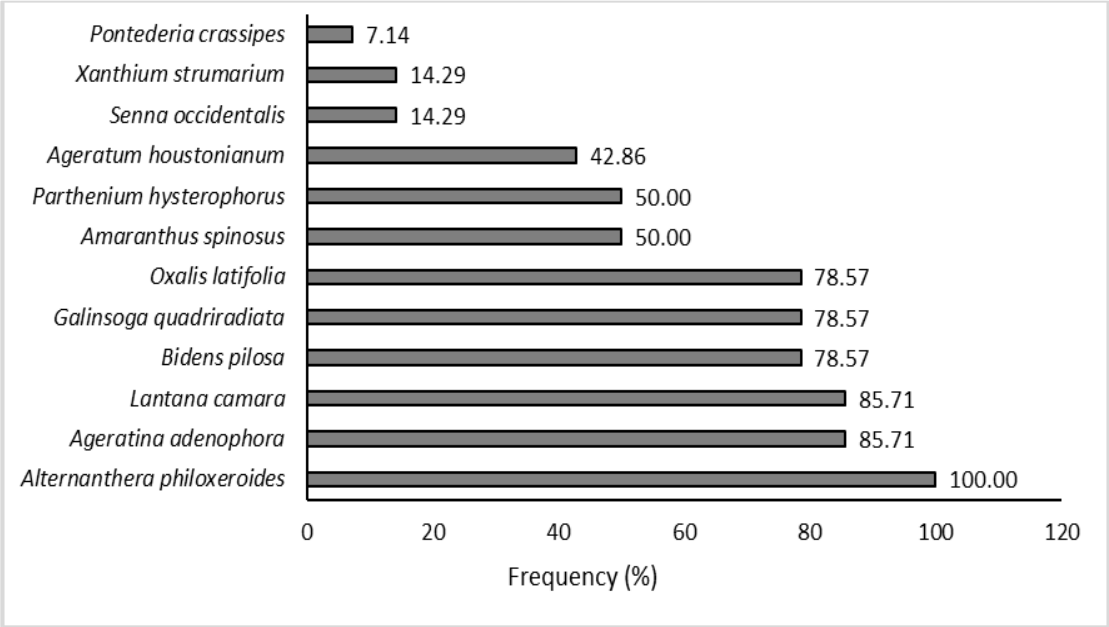


Figure 20: Frequency of invasive species across urban green spaces (urban parks and urban forests) studies in the Kathmandu Valley.

The lowest number of species (5) were found in Bhugol Park, Indrayeni CF, Ranibari CF, and Ratna Park. Similarly, slightly higher numbers were observed in Shankha Park (6 species) and Bandevi Nagar Ban Udhyan and Mhepi Religious Forest (7 species each). The Eight invasive species were recorded in Balkumari Community Forest, Kirat Religious Forest, and Swayambhunath Religious Forest. The highest number of invasive species (9) was recorded in UN Park, Coronation Garden, Balaju Park, and Tribhuvan Park (Figure 21).

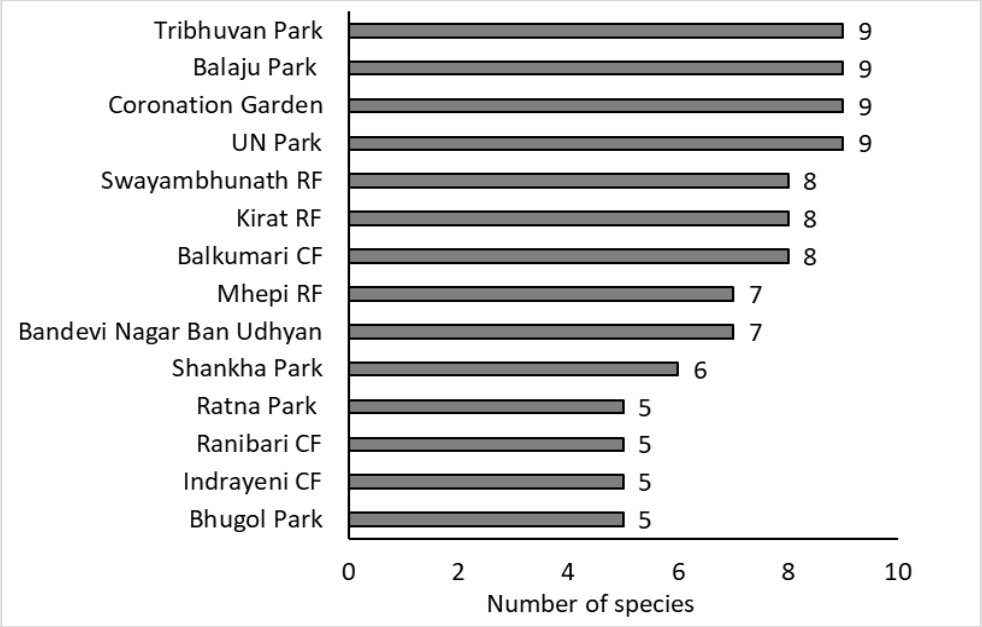


Figure 21: Number of invasive species across urban green spaces (urban parks and urban forests) studies in the Kathmandu Valley.

Out of 12 invasive alien plant species, only eight species were recorded in the sampling plot method. The average abundance of invasive species varies across the 14 urban green spaces in the Kathmandu Valley. Among them, *Ageratina adenophora* had the highest total average abundance (20.64), indicating it is the most dominant invasive species across the sites, followed by *Lantana camara* (12.72), *Galinsoga quadriradiata* (6.33), and *Bidens pilosa* (4.31). *Ageratum houstonianum* (0.85) and *Amaranthus spinosus* (0.11) were the least represented among the recorded species (Figure 22).

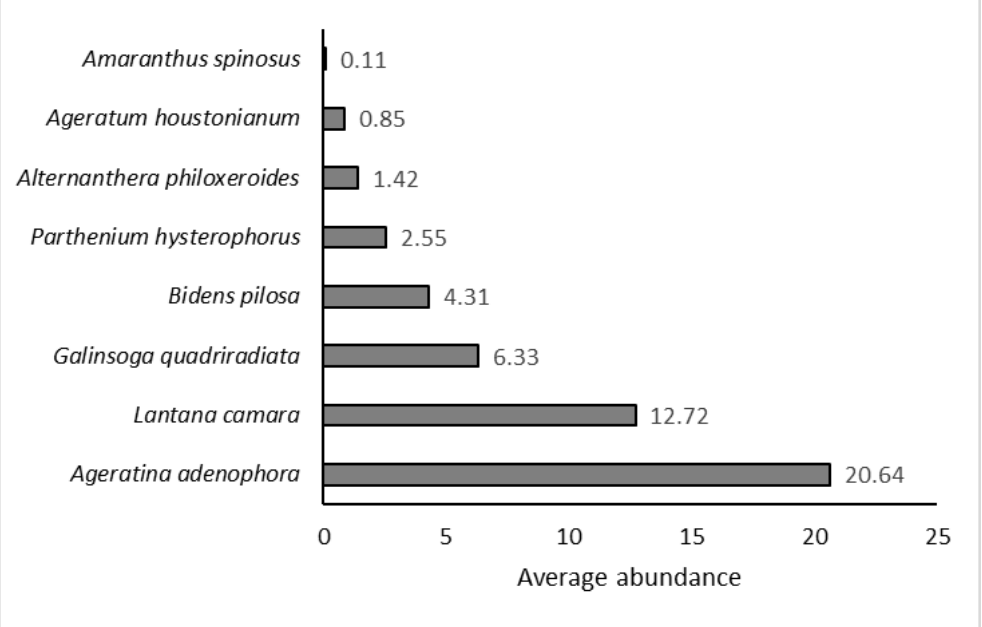


Figure 22: Abundance of invasive species across urban green spaces (urban parks and urban forests) studies in the Kathmandu Valley.

Based on the presence and abundance of these species across different urban green spaces Principal Component Analysis (PCA) was used to visualize patterns of plant species composition (Figure 23). The total inertia was 4.73, all of which was explained by the unconstrained axes, indicating that the PCA fully captured the variation in species abundance across the 14 urban green spaces of the valley. The UN Park (UNP) was distinctly separated along PC1, characterized by high abundance of *Alternanthera philoxeroide*s (Alt_phi), *Parthenium hysterophorus* (Par_hys), *Galinsoga quadriradiata* (Gal_qua), and *Amaranthus spinosus* (Ama_spi). In contrast, Coronation Garden (CG), Balkumari Community Forest (BCF), and Indrayeni Community Forest (ICF) clustered on the opposite side of PC1. These sites were strongly associated with *Lantana camara* (Lan_cam), *Ageratum houstonianum* (Age_hou), and *Ageratina adenophora* (Age_ade).

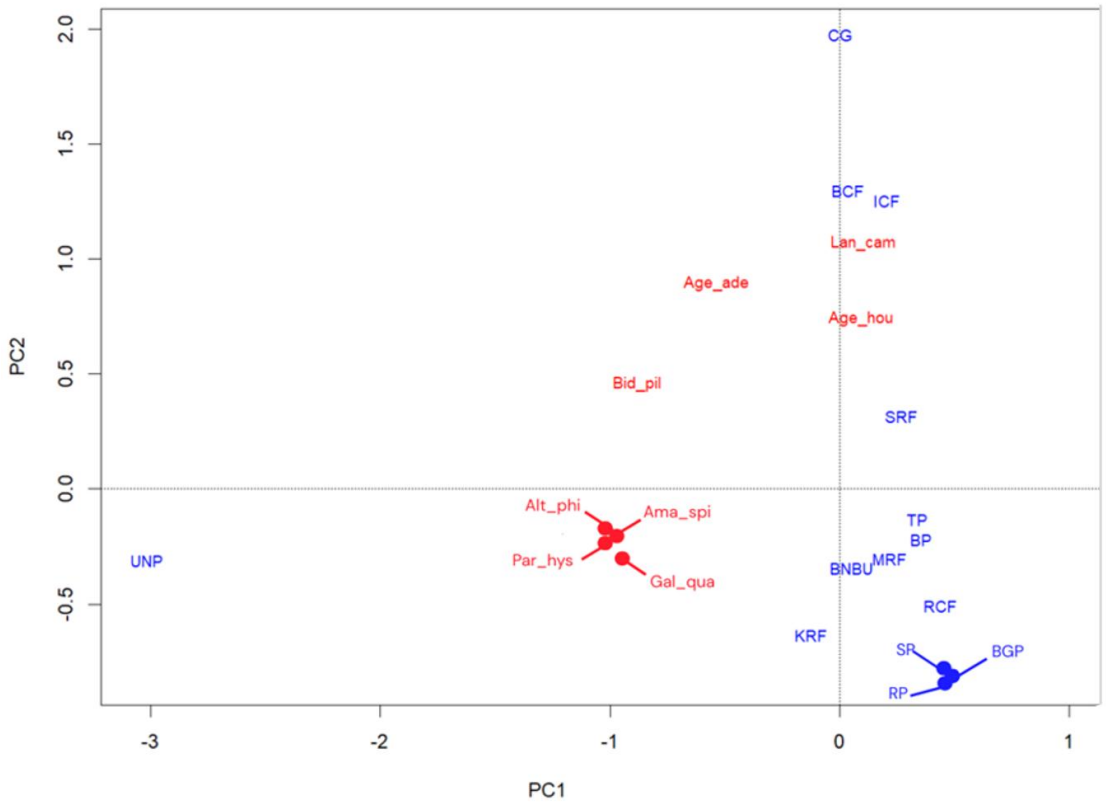


Figure 23: Distribution of invasive species across urban green spaces (urban parks and urban forests) studies in the Kathmandu Valley.

Similarly, *Bidens pilosa* (Bid_pil) was positioned between the two major species clusters on the PCA biplot. This intermediate position suggests that *Bidens pilosa* (Bid_pil) *was* not strongly associated with any specific urban green spaces, but instead occurred moderately across multiple urban green spaces. However, a cluster of Bhugol Park (BGP), Ratna Park (RP), Shankha Park (SP) is opposite to *Bidens pilosa* indicating its relatively low presence in

these sites. This cluster also lacked close association with any of the recorded invasive species, suggesting weaker invasion pressure and lower dominance of any single species.

4.2.4 IUCN Red List of threatened species

Among the 437 plant species recorded from the urban green spaces of Kathmandu valley, the majority 249 species (57.0%) were categorized as Not Evaluated (NE) under the IUCN Red List of threatened species version 2025 with 93 native species. Similarly, 161 species (36.9%) were listed under the Least Concern (LC) category, including 83 native, 65 exotic, and 13 uncertain species. In addition, seven species (1 native and 6 exotic) were identified as Near Threatened (NT), which is likely to be a threatened category in future (Figure 24).

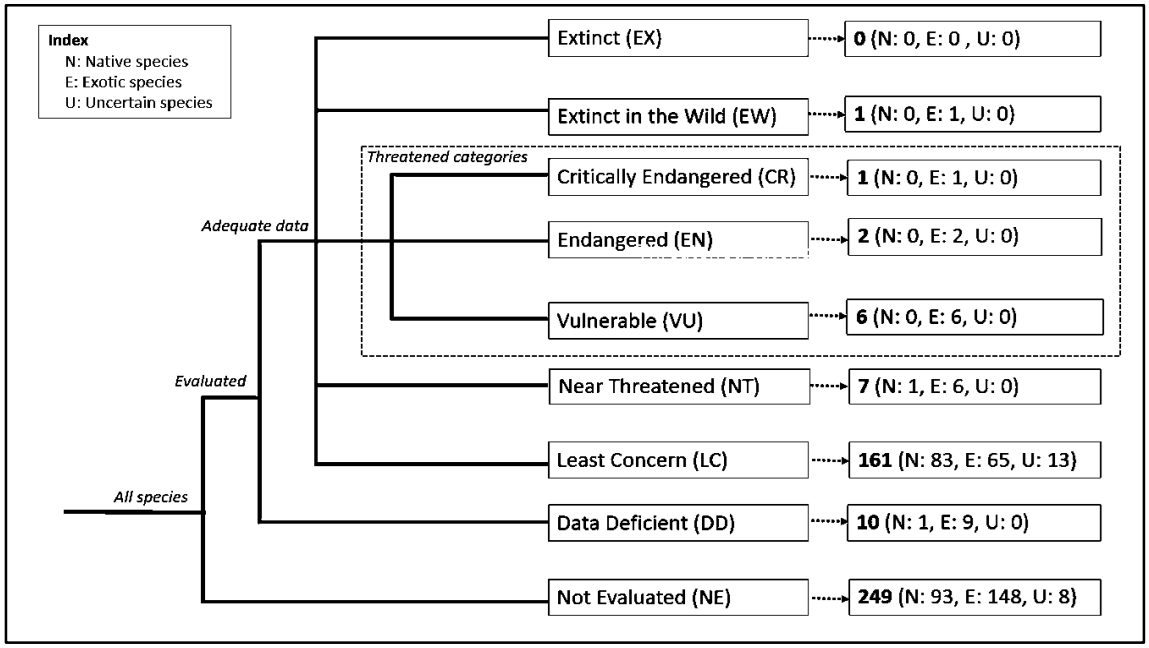


Figure 24: IUCN Red List of threatened species (urban parks and urban forests) studies in the Kathmandu Valley.

In threatened categories, no single native species were recorded. However, one exotic species as Critically Endangered (CR), 2 exotic species as Endangered (EN), and six exotic species as Vulnerable (VU) were recorded from urban green space of Kathmandu valley. It also includes one exotic species i.e. *Brugmansia suaveolens* (Humb. & Bonpl. ex Willd.) Sweet which is listed in Extinct in the Wild (EW) as IUCN global assessment of 2014. Extinct in the Wild species survive in cultivation or as a naturalized population. In addition, 10 species (1 native and 9 exotic) were listed as Data Deficient (DD), which means the lack of sufficient information for proper assessment.

4.2.5 CITES-listed plant species

Out of the 171 CITES-listed plant species of Nepal (Joshi *et al.*, 2017), two species were found in the urban green spaces of Kathmandu valley. They are *Rhynchostylis retusa* (L.) Blume from Appendix II and *Podocarpus neriifolius* D.Don from Appendix III. The Appendix II includes species, which could become endangered if trade is not regulated to prevent overutilization. Similarly, Appendix III includes species, which are protected within the country.

4.2.6 Endemic species

Among the 437 plant species recorded from the urban green spaces of Kathmandu Valley, only one species was endemic to Nepal. *Hypericum cordifolium* Choisy was recorded from Tribhuvan Park, Thankot.

4.3 Vegetation Diversity

A Mann–Whitney U test was conducted to compare species richness between forest and park sampling plots. Results showed a statistically significant difference in species richness between the two habitat types (U = 3315.000, Z = -3.437, p = 0.001, two-tailed). The median species richness was higher in forests (Median = 9) compared to parks (Median = 7), indicating that forest plots generally supported a greater number of species than park plots.

4.3.1 Shannon Wiener Diversity Index (H)

The value of Shannon-Weiner diversity index (H) of tree and shrub/sapling in the urban green space of Kathmandu valley were found to be 3.602 and 3.047 respectively. The forest type had a slightly higher average tree diversity index (3.57) and shrub/sapling diversity (2.977) compared to park type with tree (3.193) and shrub/sapling (2.832) respectively.

The diversity of tree species ranged from 1.54 at Bhugol Park to 3.10 at Balkumari CF, indicating varying levels of species richness and evenness among urban green spaces. Generally, forests have more value for tree diversity than the parks. In parks, Bhugol Park recorded the lowest tree diversity index of 1.54 followed by UN Park (1.87). The highest diversity was Coronation Garden with 2.750 followed by Bandevi Park (2.737). In forest, Kirat RF has the lowest tree diversity index of 2.099 followed by Indrayeni CF (2.453).

The highest diversity was of Balkumari CF with (3.1) followed by Ranibari CF (2.970) and Swayambhunath RF (2.770) respectively (Figure 25).

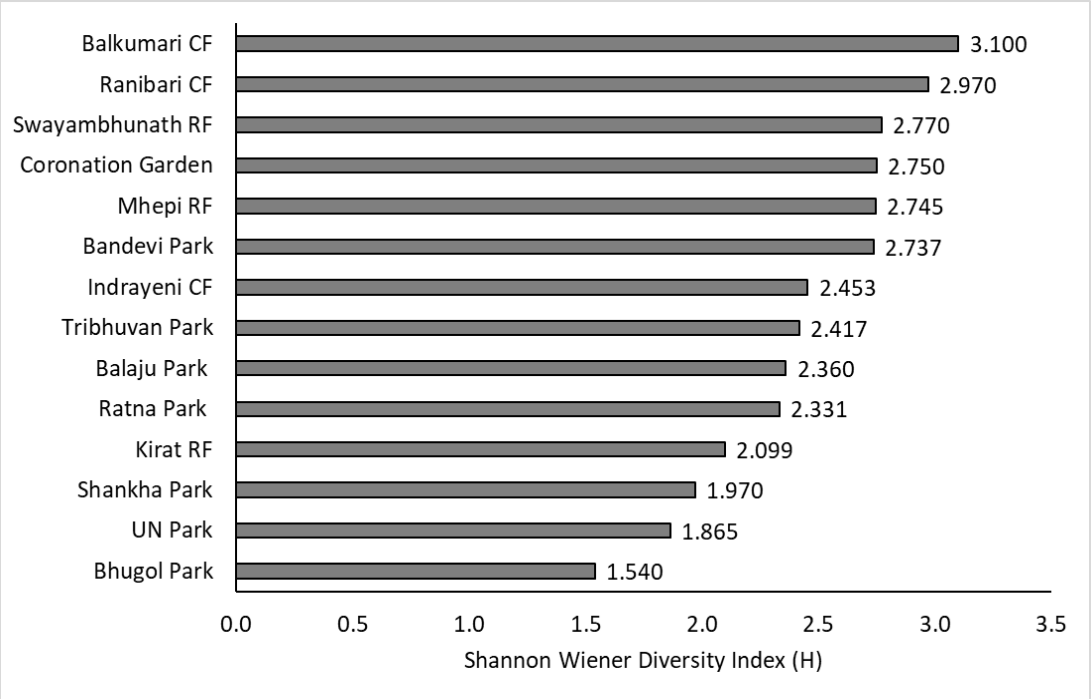


Figure 25: Shannon Wiener Diversity Index of tree species in urban green spaces of Kathmandu Valley.

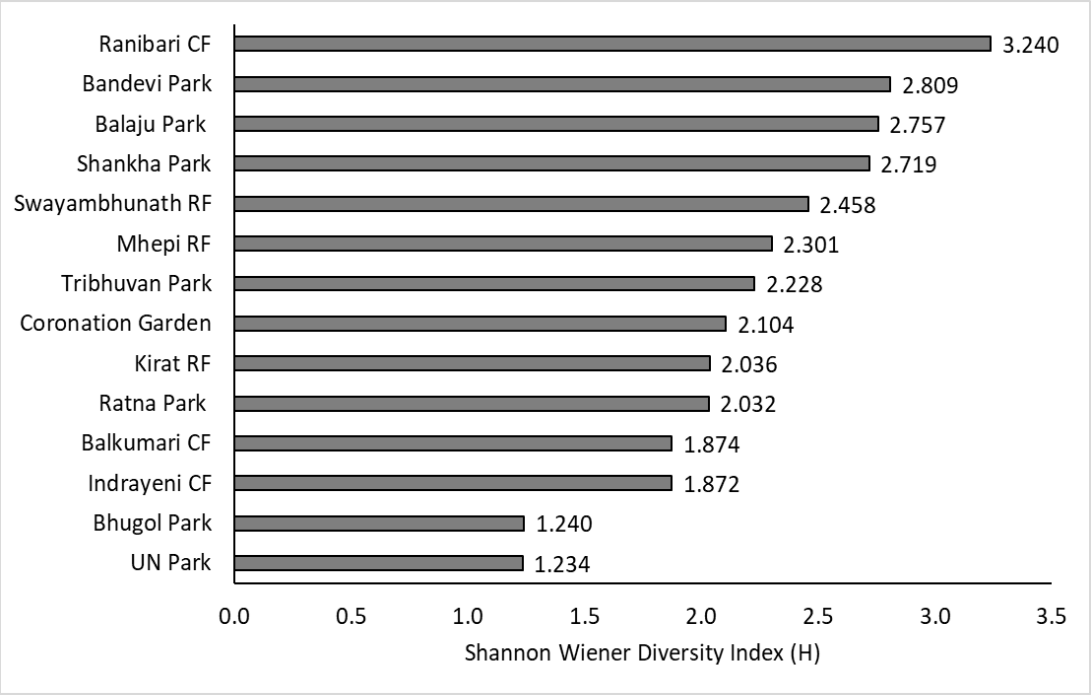


Figure 26: Shannon-Wiener Diversity index for shrubs/sapling species in urban green spaces of Kathmandu Valley.

Similarly, the Shannon-Wiener Diversity index for shrubs/sapling species (Figure 26) ranged from lowest of 1.234 at UN Park to highest of 3.240 at Ranibari CF. In parks, UN

Park and Bhugol Park recorded the lowest diversity indices with 1.234 and 1.240 respectively. The highest diversity value was of Bandevi Park (2.809) followed by Balaju Park (2.757), and Shankha Park (2.719) respectively. In forest, Indrayeni CF and Balkumari CF have lowest diversity indices with 1.872 and 1.874 respectively. Ranibari CF displayed the highest diversity value of 3.24 followed by Swayambhunath RF (2.458).

4.3.2. Simpson Diversity Index (1- D)

The Simpson Diversity Index (1-D) values of tree and shrub/sapling in the urban green space of Kathmandu valley were found to be 0.955 and 0.873 respectively. The forest type had a slightly higher average tree diversity index (0.966) and shrub/sapling diversity (0.882) compared to park type with tree (0.937) and shrub/sapling (0.858) respectively. The diversity of tree species ranged from 0.728 at UN Park to 0.948 at Balkumari CF. In parks, UN Park (0.728) and Bhugol Park (0.800) had the lowest diversity indices, indicating a more uneven species distribution or dominance by fewer species. The highest diversity was Bandevi Park (0.924) followed by Coronation Garden (0.922). In forest, Kirat RF has the lowest tree diversity index of 0.828 followed by Indrayeni CF (0.878). Balkumari CF recorded the highest diversity with an index of 0.948, followed by Ranibari CF (0.936) and Mhepi RF (0.930) respectively (Figure 27).

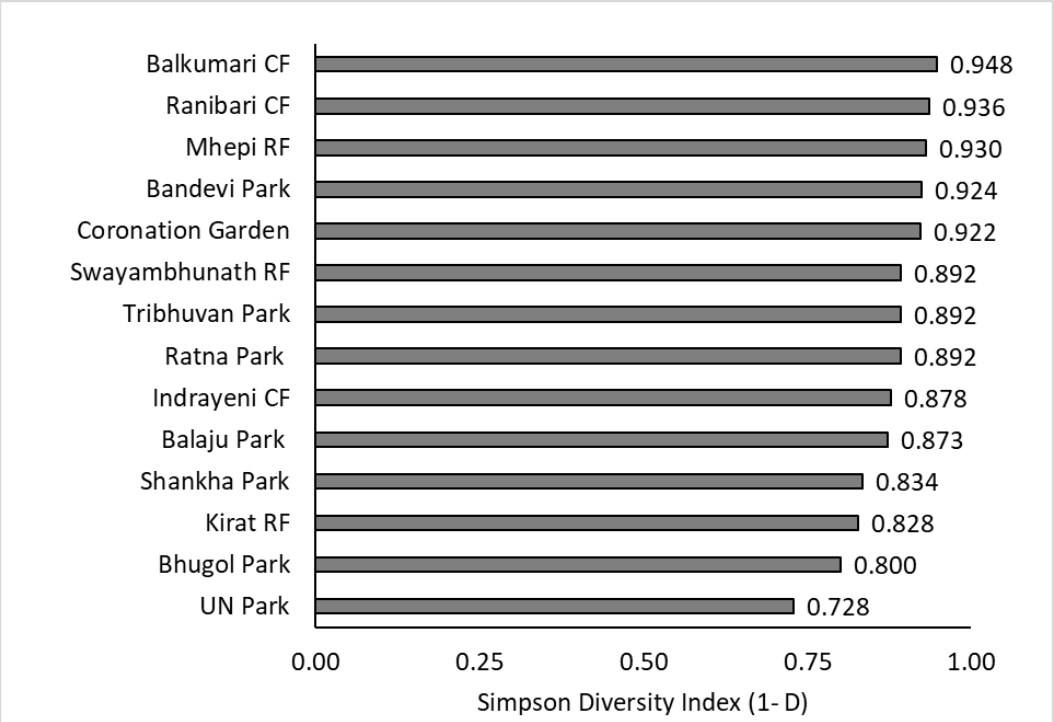


Figure 27: Simpson Diversity Index of tree species in the urban green spaces of Kathmandu Valley.

Similarly, the Simpson Diversity Index (1- D) for shrubs/sapling species (Figure 28) ranged from lowest of 0.568 at UN Park to 0.951 at Ranibari CF. In parks, UN Park recorded the lowest diversity index of 0.568 followed by Bhugol Park (0.623). The highest diversity value was of Shankha Park (0.939) followed by Bandevi Park (0.929), and Balaju Park (0.912) respectively. In forest, Balkumari CF has the lowest diversity index of 0.718 followed by Indrayeni CF (0.754). Ranibari CF had the highest diversity (0.951) followed by Mhepi RF (0.887).

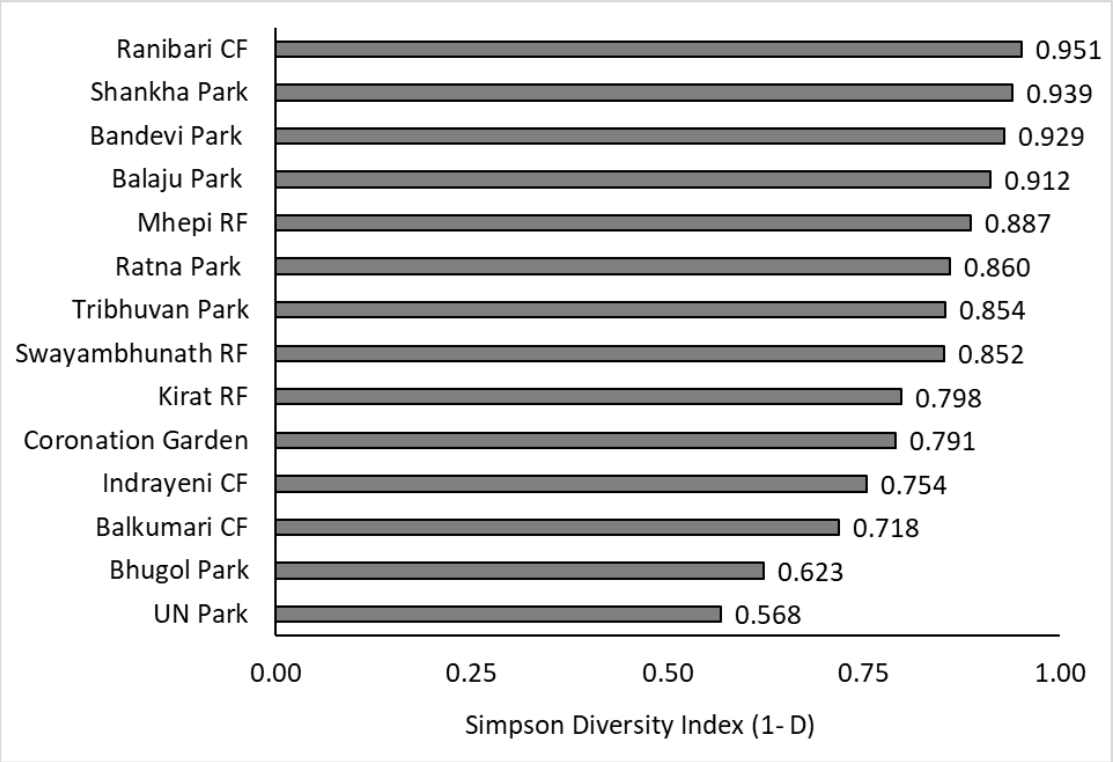


Figure 28: Simpson Diversity Index of shrubs/sapling species in the urban green spaces of Kathmandu Valley.

4.3.3. Species evenness (e)

The value of species evenness (e) of tree and shrub/sapling in the urban green space of Kathmandu valley were found to be 0.815 and 0.652 respectively. The forest type had a slightly higher evenness of both tree species (0.838) and shrub/sapling species (0.683) compared to park type with tree (0.793) and shrub/sapling (0.650) respectively. The lower species evenness reflects a higher dominance of certain species in these areas. The species evenness of tree species ranged from 0.673 at UN Park to 0.902 at Mhepi RF. In parks, UN Park recorded the lowest species evenness of 0.673 followed by Balaju Park (0.817). The highest evenness value was of Bandevi Park (0.885) followed by Coronation Garden (0.877), and Ratna Park (0.861) respectively. In forest, Swayambhunath RF (0.767) has

lowest species evenness followed by Kirat RF (0.775). Mhepi RF recorded the highest species evenness of 0.902 followed by Balkumari CF (0.894) (Figure 29).

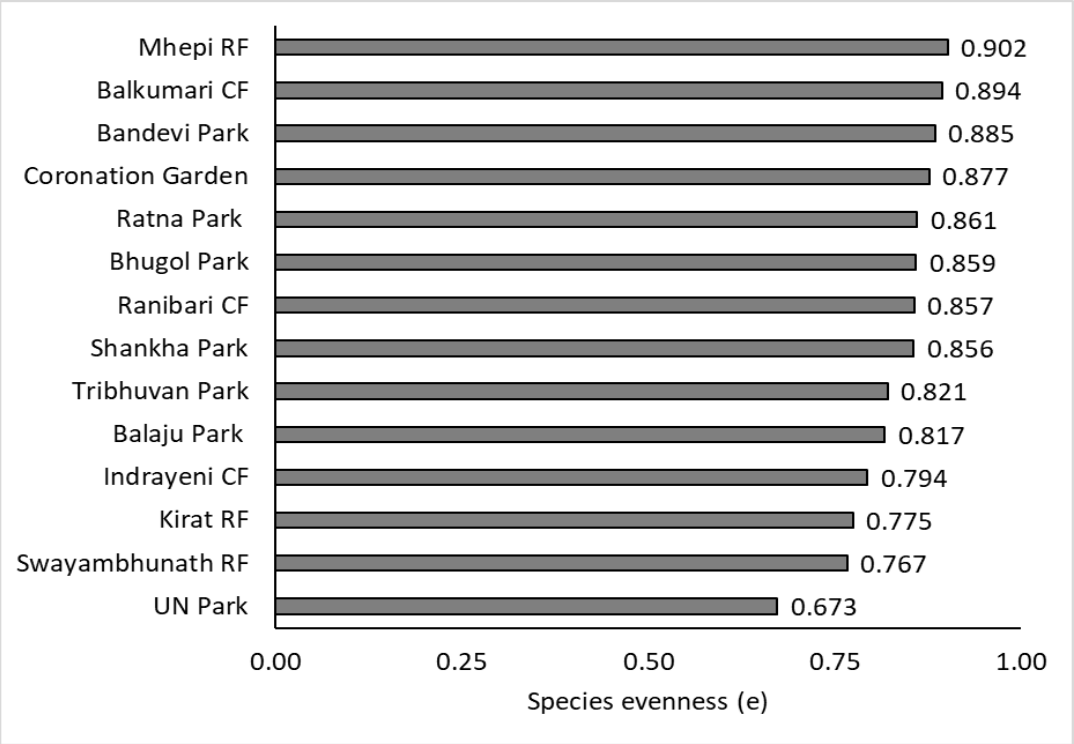


Figure 29: Species evenness of tree species in the urban green spaces of Kathmandu Valley.

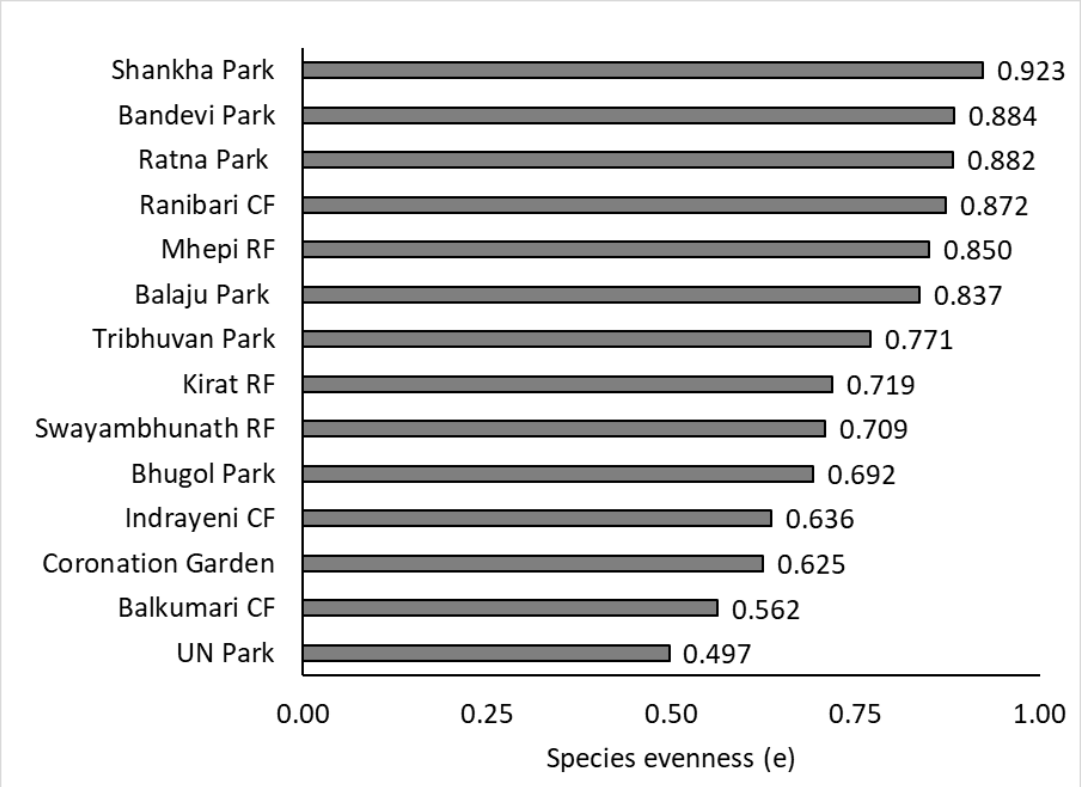


Figure 30: Species evenness of shrub/sapling species in the urban green spaces (urban parks and urban forests) of Kathmandu Valley.

The species evenness of shrub/sapling species (Figure 30) ranged from 0.497 at UN Park to 0.923 at Shankha Park. In parks, UN Park recorded the lowest species evenness of 0.497 followed by Coronation Garden (0.625). The highest evenness value was of Shankha Park (0.923) followed by Bandevi Park (0.884), and Ratna Park (0.882) respectively. In forest, Balkumari CF (0.562) has lowest species evenness followed by Indrayeni CF (0.636). Ranibari CF recorded the highest species evenness of 0.872 followed by Mhepi RF (0.850).

4.4 Community attributes

4.4.1 Vegetation Characteristics of Tree Species

During enumeration, urban green spaces recorded 127 species of trees by Line transect method. However, only 83 tree species were recorded in the quadrat method. The forest type had a slightly higher number of tree species compared to park type. The total of 71 species with 843 individual trees were recorded from urban forests while 56 tree species with 648 individual trees from urban parks. The number of individual trees (Figure 31) ranged from 11 individuals at Bhugol Park to 288 individuals at Swayambhunath RF. In parks, Bhugol Park recorded the lowest 11 individuals, followed by Shankha Park (39) and Ratna Park (42). The highest number of individual trees was Coronation Garden (207) followed by Tribhuvan Park (140). In forest, Kirat RF has the lowest number of individual trees (57) followed by Mhepi RF (65). Swayambhunath RF recorded the highest 288 individual trees followed by Balkumari CF (161) and Ranibari CF (160) respectively.

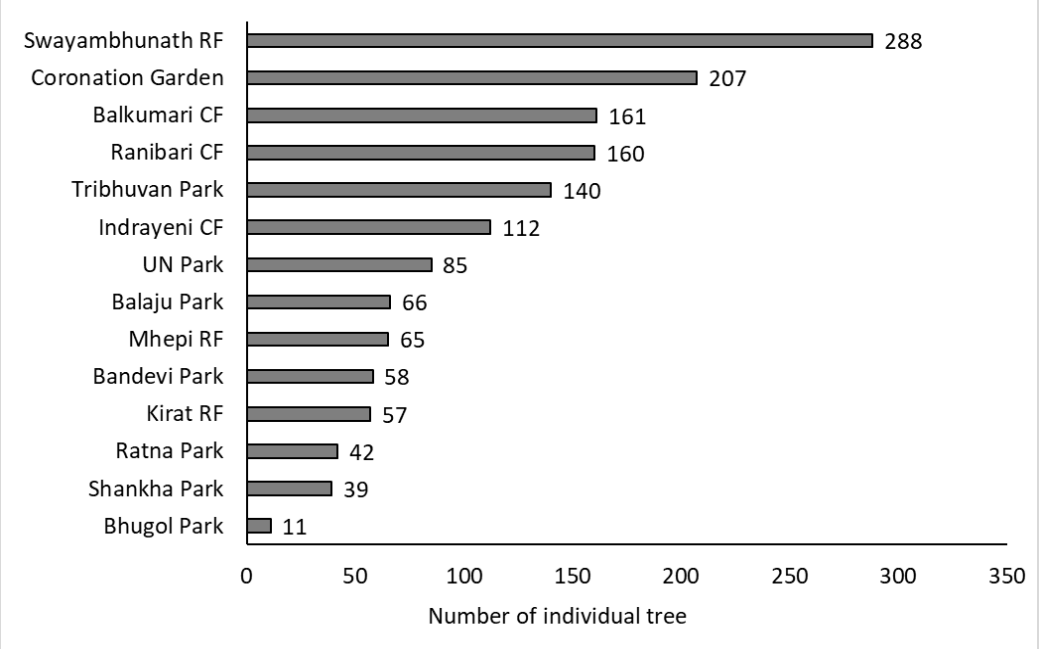


Figure 31: Number of individual trees across the urban green spaces of Kathmandu Valley.

4.4.1.1 Density of Tree Species

The total tree density of urban green spaces of Kathmandu valley was 772.54 individuals per hectare. The tree density was slightly higher in forests (834.65 individuals/ha) compared to parks (712.09 individu als/ha) (Figure 32). The tree density ranged from 366.67 individuals/ha at Bhugol Park to 1073.33 individuals/ha at Balkumari CF. In parks, Bhugol Park recorded the lowest tree density (366.67 individuals/ha), followed by Shankha Park (433.33 individuals/ha) and Ratna Park (466.67 individuals/ha). The highest tree density in the park was Tribhuvan Park (933.33 individuals/ha) followed by Coronation Garden (828.00 individuals/ha). In forest, Kirat RF has the lowest tree density (570.00 individuals/ha) followed by Mhepi RF (650.00 individuals/ha). Balkumari CF recorded the highest tree density 1073.33 individuals per hectare followed by Swayambhunath RF (872.73 individuals/ha) (Figure 38).

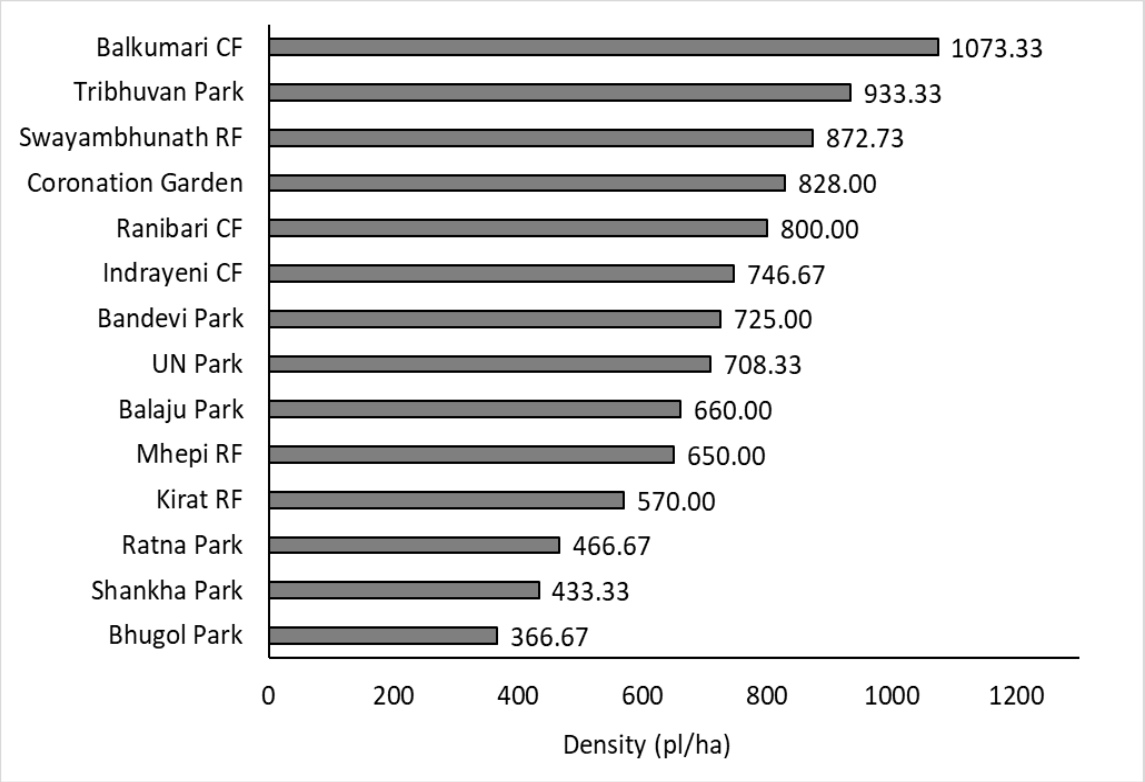


Figure 32: Density of tree species across urban green spaces (urban parks and urban forests) studies in the Kathmandu Valley.

4.4.1.2 Basal Area of Tree Species

The number of individual trees and density was slightly higher in forests compared to parks. However, the total basal area was greater in parks (9333.62 m^2/ha) than in forests (7736.93 m^2/ha), indicating that parks may have larger or more mature trees contributing to a higher basal area despite slightly lower number and density. The total basal area ranged

from Bhugol Park (186.83 m²/ha) to Coronation Garden (3110.47 m²/ha). Among the parks, Bhugol Park had the lowest basal area of 186.83 m²/ha, followed by Bandevi Park (551.02 m²/ha) and Shankha Park (587.59 m²/ha). The highest value among parks was recorded in Coronation Garden with 3110.47 m²/ha, followed by Tribhuvan Park (2155.14 m²/ha). In forest, Indrayeni CF had the lowest basal area of 658.95 m²/ha, followed by Kirat RF (691.47 m²/ha). Swayambhunath RF recorded the highest basal area of 2586.97 m²/ha, followed by Ranibari CF (2139.58 m²/ha) (Figure 33).

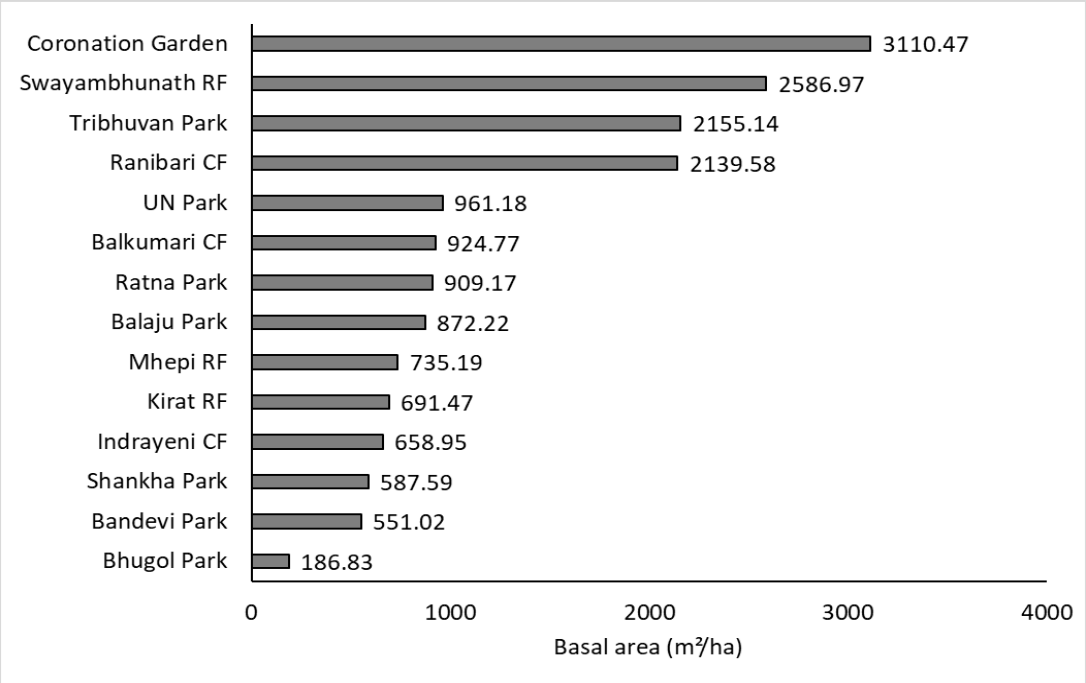


Figure 33: Basal area of tree species across urban green spaces (urban parks and urban forests) studies in the Kathmandu Valley.

4.4.1.3 Importance Value Index (IVI) of Tree Species

In urban green spaces of Kathmandu valley (Table 8). *Pinus roxburghii* had highest IVI (28.95) followed by *Camphora officinarum* (27.53) and *Celtis australis* (22.74). Whereas, *Nyctanthes arbor-tristis* had lowest IVI (0.21) followed by *Lithocarpus elegans* (0.21) and *Cryptomeria japonica* (0.21). In parks, *Camphora officinarum* had highest IVI (47.28) followed by *Grevillea robusta* (31.87) and *Pinus roxburghii* (23.58). The lowest IVI was *Prunus persica* (0.51) followed by 0.52 of *Cryptomeria japonica*, *Citrus maxima* and *Mangifera indica*. In Forest, *Pinus roxburghii* had highest IVI (35.12) followed by *Schima wallichii* (29.62) and *Celtis australis* (26.12). The lowest IVI was *Citrus limon* (0.34) followed by 0.35 of *Nyctanthes arbor-tristis*, *Lagerstroemia indica* and *Ficus elastica*.

Table 7: IVI of major five tree species across urban green space in Kathmandu Valley.

Type	Major Tree Species with IVI (Highest to Lowest)
Urban Green Space	*Pinus roxburghii* (28.95), *Camphora officinarum* (27.53), *Celtis australis* (22.74), *Grevillea robusta* (21.92), *Schima wallichii* (18.74)
Urban Park	*Camphora officinarum* (47.28), *Grevillea robusta* (31.87), *Pinus roxburghii* (23.58), *Juniperus recurva* (19.76), *Celtis australis* (18.76)
Urban Forest	*Pinus roxburghii* (35.12), *Schima wallichii* (29.62), *Celtis australis* (26.12), *Grevillea robusta* (14.06), *Ziziphus incurva* (11.52)

The six tree species had the highest individual IVI in eight urban parks of Kathmandu valley (Table 8). Amog them, *Juniperus recurva* in the Bhugol Park had the highest IVI (147.73) while *Camphora officinarum* in the Tribhuvan Park had lowest IVI (58.63). *Camphora officinarum* was the most frequently species, ranking highest IVI in three urban parks i.e. Ratna Park, Tribhuvan Park and Coronation Garden.

Table 8: IVI of major tree species across urban park of Kathmandu Valley.

SN	Urban Park	IVI (Importance Value Index) of Tree
1	Bhugol Park	*Juniperus recurva* (147.73)
2	Bandevi Park	*Pinus roxburghii* (69.08)
3	Shankha Park	*Populus nigra* (90.44)
4	Ratna Park	*Camphora officinarum* (87.91)
5	UN Park	*Grevillea robusta* (106.94)
6	Balaju Park	*Schima wallichii* (58.87)
7	Tribhuvan Park	*Camphora officinarum* (58.63)
8	Coronation Garden	*Camphora officinarum* (55.54)

The five tree species had the highest individual IVI in six urban forests of Kathmandu valley (Table 9). Among them, *Pinus roxburghii* in the Indrayeni CF had the highest IVI (81.35) while *Celtis australis* in the Balkumari CF had lowest IVI (36.98). *Pinus roxburghii* had highest IVI in both Indrayeni CF and Swayambhunath RF.

Table 9: IVI of major tree species across urban forest of Kathmandu Valley.

SN	Urban forest	IVI (Importance Value Index) of Tree
1	Mhepi RF	*Jacaranda mimosifolia* (61.93)
2	Kirat RF	*Eucalyptus robusta* (75.36)
3	Ranibari CF	*Schima wallichii* (38.11)
4	Balkumari CF	*Celtis australis* (36.98)
5	Indrayeni CF	*Pinus roxburghii* (81.35)

6	Swayambhunath RF	*Pinus roxburghii* (62.94)

4.4.2 Vegetation Characteristics of Shrubs/Sapling

A total of 107 shrub and sapling species were recorded across all studied urban green spaces, with an equal 78 number of species between parks and forests. However, the number of individual shrubs and saplings was slightly higher in forests (1,317 individuals) compared to parks (1,210 individuals). The number of individual shrubs and saplings ranged from 29 individuals at Bhugol Park to 600 individuals at Coronation Garden. In parks, Bhugol Park recorded the lowest 29 individuals, followed by Ratna Park (47) and Shankha Park (60). The highest number of individuals was Coronation Garden (600) followed by Tribhuvan Park (158). In forest, Mhepi RF had the lowest number of individuals (90) followed by Kirat RF (92). Swayambhunath RF recorded the highest 456 individuals of shrubs and saplings, followed by Balkumari CF (302) (Figure 34).

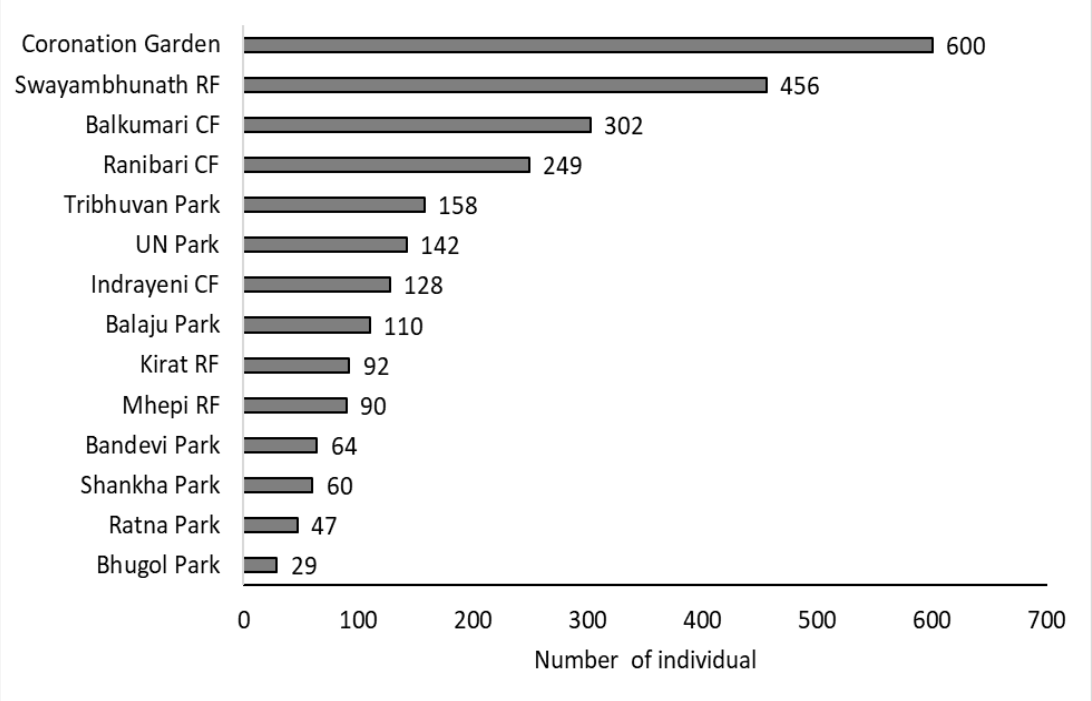


Figure 34: Number of individual shrubs/saplings across urban green spaces of Kathmandu Valley.

4.4.2.1 Density of Shrubs/Sapling

The total shrubs/sapling density of urban green spaces of Kathmandu valley was 2618.65 individuals per hectare. The density was slightly higher in parks (2659.34 individuals/ha) compared to forest (2582.35 individuals/ha). The shrubs/sapling density ranged from 1044.44 individuals/ha at Ratna Park to 4800 individuals/ha at Coronation Garden. In parks, Ratna Park recorded the lowest density (1044.44 individuals/ha), followed by

Shankha Park (1333.33 individuals/ha) and Bandevi Park (1600 individuals/ha). The highest tree density in the park was Coronation Garden (4800 individuals/ha) followed by UN Park (2366.67 individuals/ha). In forest, Indrayeni CF had the lowest density (1706.67 individuals/ha) followed by Mhepi RF (1800 individuals/ha). Balkumari CF recorded the highest density 4026.67 individuals per hectare followed by Swayambhunath RF (2850 individuals/ha) (Figure 35).

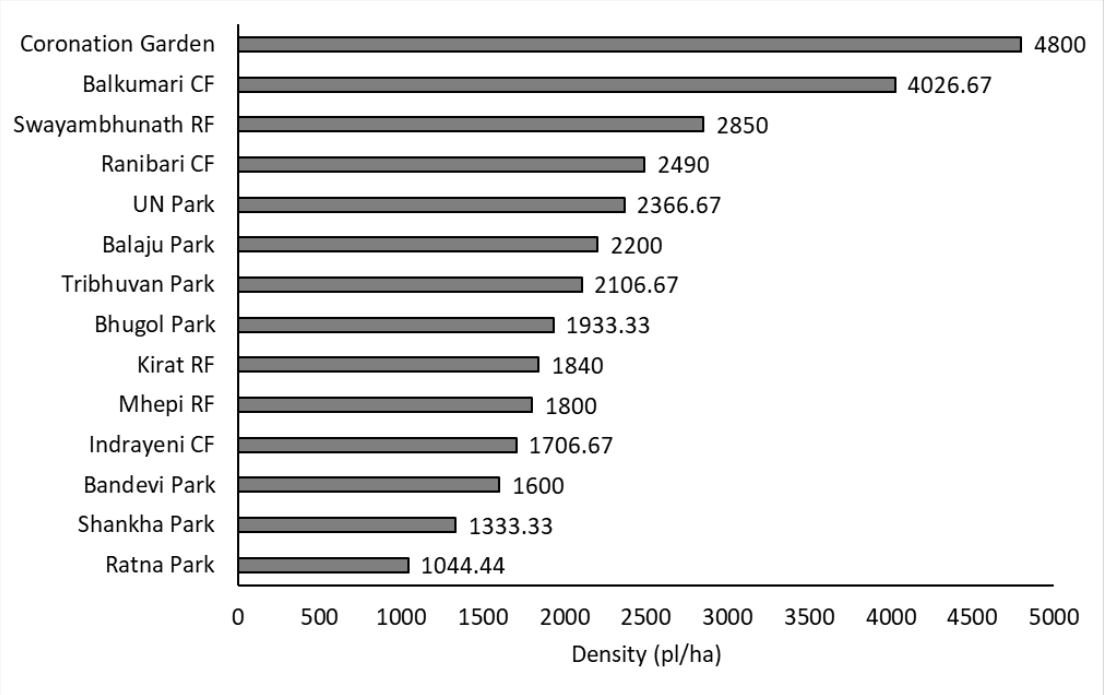


Figure 35: Density of Shrubs/Sapling across urban green spaces of Kathmandu Valley.

4.4.2.2 Importance Value Index (IVI) of Shrubs/Sapling

In urban green spaces of Kathmandu valley (Table 10), *Ageratina adenophora* had highest IVI (64.93) followed by *Lantana camara* (52.09) and *Cestrum parqui* (16.76). Whereas, *Eucalyptus camaldulensis*, *Gardenia jasminoides*, *Rubus niveus*, *Solanum lycopersicum* had lowest IVI (0.17) followed by 0.18 of *Caryota urens*, *Prunus persica*, *Punica granatum*, *Sarcococca coriacea*, *Solanum torvum* and *Syzygium jambos*. In Park, *Ageratina adenophora* had the highest IVI (67.05) followed by *Lantana camara* (49.56) and *Duranta erecta* (18.02). Whereas, *Boehmeria virgata*, *Eucalyptus camaldulensis*, *Ficus elastica*, *Grevillea robusta*, *Jacaranda mimosifolia*, *Melia azedarach*, *Rubus niveus* and *Solanum lycopersicum* had lowest IVI (0.39) followed by 0.42 of *Caryota urens*, *Cinnamomum tamala*, *Ficus religiosa*, *Phyllanthus emblica* and *Solanum torvum*. In the Forest, *Ageratina adenophora* had the highest IVI (62.91) followed by *Lantana camara* (54.26) and *Cestrum parqui* (15.82). Whereas, *Hypoestes phyllostachya* and *Rosa chinensis* had lowest IVI (0.28) followed by 0.31 of *Gardenia jasminoides*, *Leucaena leucocephala* and *Sida rhombifolia*.

Table 10: IVI of major five Shrubs/Sapling across urban green space in Kathmandu Valley.

Type	Major Shrubs/Saplings with IVI (Highest to Lowest)
Urban Green Space	*Ageratina adenophora* (64.93), *Lantana camara* (52.09), *Cestrum parqui* (16.76), *Duranta erecta* (13.65), *Cyathula capitata* (8.30)
Urban Park	*Ageratina adenophora* (67.05), *Lantana camara* (49.56), *Duranta erecta* (18.02), *Cestrum parqui* (17.96), *Solanum viarum* (12.17)
Urban Forest	*Ageratina adenophora* (62.91), *Lantana camara* (54.26), *Cestrum parqui* (15.82), *Cyathula capitata* (12.72), *Justicia adhatoda* (11.58)

The four shrub species had the highest individual IVI in eight urban parks of Kathmandu valley (Table 11). Among them, *Ageratina adenophora* in the UN Park had the highest IVI (153.21) while *Hibiscus rosa-sinensis* in Shankha Park had lowest IVI (37.77). *Ageratina adenophora* was the most frequently species, ranking highest IVI in five urban parks i.e. Bandevi Park, Balaju Park, Coronation Garden, Tribhuvan Park and UN Park.

Table 11: IVI of major Shrubs/Sapling across urban park of Kathmandu Valley.

SN	Urban Park	IVI (Importance Value Index) of Shrub/Sapling
1	Bhugol Park	*Rosa chinensis* (142.50)
2	Bandevi Park	*Ageratina adenophora* (46.87)
3	Shankha Park	*Hibiscus rosa-sinensis* (37.77)
4	Ratna Park	*Duranta erecta* (73.24)
5	UN Park	*Ageratina adenophora* (153.21),
6	Balaju Park	*Ageratina adenophora* (47.45)
7	Tribhuvan Park	*Ageratina adenophora* (65.40)
8	Coronation Garden	*Ageratina adenophora* (74.62)

The two shrub species had the highest individual IVI in six urban forests of Kathmandu valley (Table 12). Among them, *Ageratina adenophora* in the Balkumari CF had the highest IVI (95.92) while *Cestrum parqui* in the Ranibari CF had lowest IVI (27.95). *Ageratina adenophora* was the most frequently species ranking highest IVI in four urban forests i.e. Balkumari CF, Indrayeni CF, Kirat RF and Swayambhunath RF.

Table 12: IVI of major Shrubs/Sapling across urban forest of Kathmandu Valley.

SN	Urban forest	IVI (Importance Value Index) of Shrub/Sapling
1	Mhepi RF	*Cestrum parqui* (55.07)
2	Kirat RF	*Ageratina adenophora* (94.35)
3	Ranibari CF	*Cestrum parqui* (27.95)
4	Balkumari CF	*Ageratina adenophora* (95.92)

5	Indrayeni CF	*Ageratina adenophora* (91.67)
6	Swayambhunath RF	*Ageratina adenophora* (63.58)

4.5 Carbon Stock

The carbon stock of tree species across urban green spaces was a total average of 566.80 t/ha. The urban parks had a higher average carbon stock of 629.00 t/ha, while urban forests had a slightly lower average of 511.31 t/ha (Figure 52). This higher carbon stock in parks attributed to greater tree basal area and presence of mature, large-canopied species with proper management strategies. The carbon stock of tree species ranged from Bandevi Park (127.15 t/ha) to Ranibari CF (1358.37 t/ha). In parks, Bandevi Park recorded the lowest carbon stock of 127.15 t/ha followed by Bhugol Park (228.08 t/ha). The highest carbon stock was UN Park with 1070.31 t/ha followed by Balaju Park (880.19 t/ha). In forest, Mhepi RF has the lowest carbon stock of 187.82 t/ha followed by Indrayeni CF (219.35 t/ha). The highest was of Ranibari CF was 1358.37 t/ha followed by Kirat RF (731.22 t/ha) (Figure 36).

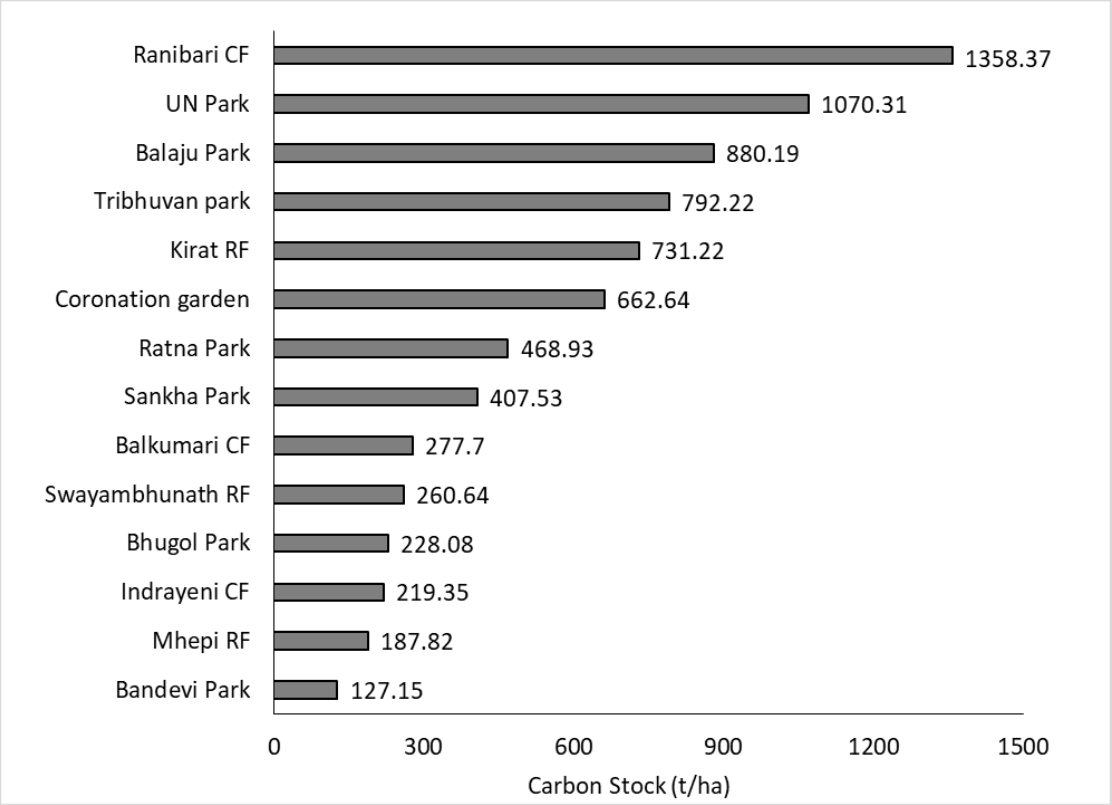


Figure 36: Carbon stock across urban green spaces in the urban green spaces of Kathmandu Valley.

In total, *Camphora officinarum* had the highest carbon contribution 10.35 % (58.65 t/ha) followed by 8.43% of *Grevillea robusta* (47.78 t/ha) and 6.76 % of *Pinus roxburghii*

(38.29 t/ha. Similarly, *Camphora officinarum* also had a highest carbon contribution at parks with 19.25 % (121.10 t/ha) followed by 10.22 % of *Grevillea robusta* (64.29 t/ha) and 6.13% of *Celtis australis* (38.54 t/ha). In forest, *Schima wallichii* had the highest carbon contribution 10.82 (55.33 t/ha) followed by 10.36% of *Pinus roxburghii* (52.97 ha) and 6.47% of *Grevillea robusta* (33.06 t/ha) (Table 13).

Table 13: Carbon contribution of major tree species across urban green space in Kathmandu Valley.

Type	Major Tree Species with Carbon Contribution (%)
Urban Green Space	*Camphora officinarum* (10.35), *Grevillea robusta* (8.43), *Pinus roxburghii* (6.76), *Schima wallichii* (6.49), *Celtis australis* (5.53)
Urban Park	*Camphora officinarum* (19.25), *Grevillea robusta* (10.22), *Celtis australis* (6.13), *Pinus roxburghii* (3.50), *Juniperus recurva* (2.11)
Urban Forest	*Schima wallichii* (10.82), *Pinus roxburghii* (10.36), *Grevillea robusta* (6.47), *Celtis australis* (4.87), *Ziziphus incurva* (2.70)

4.6 Forest Regeneration

4.6.1 Regeneration Status of trees

In urban green space, seedlings were the highest with a total density of 5785.8 individuals/ha, followed by adult trees (772.5 individuals/ha) and saplings (470.5 individuals/ha) which indicate the fair regeneration. The urban parks showed a higher seedling density (6337.0 individuals/ha) compared to forests (5294.1 individuals/ha) which suggest favorable conditions for seed germination, mainly due to open canopy and human intervention. However, forests had a greater density of saplings (547.1 individuals/ha) and adults (834.7 individuals/ha) than parks (384.6 and 712.1) individuals/ha respectively, indicating better survival rates and more stable population structures in forest.

Among the five dominant tree species across the 14 urban green spaces based on their Importance Value Index (IVI), *Celtis australis* showed the strongest regeneration, with a significantly higher number of seedlings (1001.73 individuals/ha), followed by saplings (47.67/ha) and adult trees (64.77/ha), indicating fair regeneration. However, *Pinus roxburghii*, despite being the highest IVI had no regeneration, with zero seedlings and saplings recorded, and only adult individuals (91.71/ha). Other major species, like *Schima wallichii*, *Grevillea robusta* and *Camphora officinarum* also had fair regeneration (Figure 37).

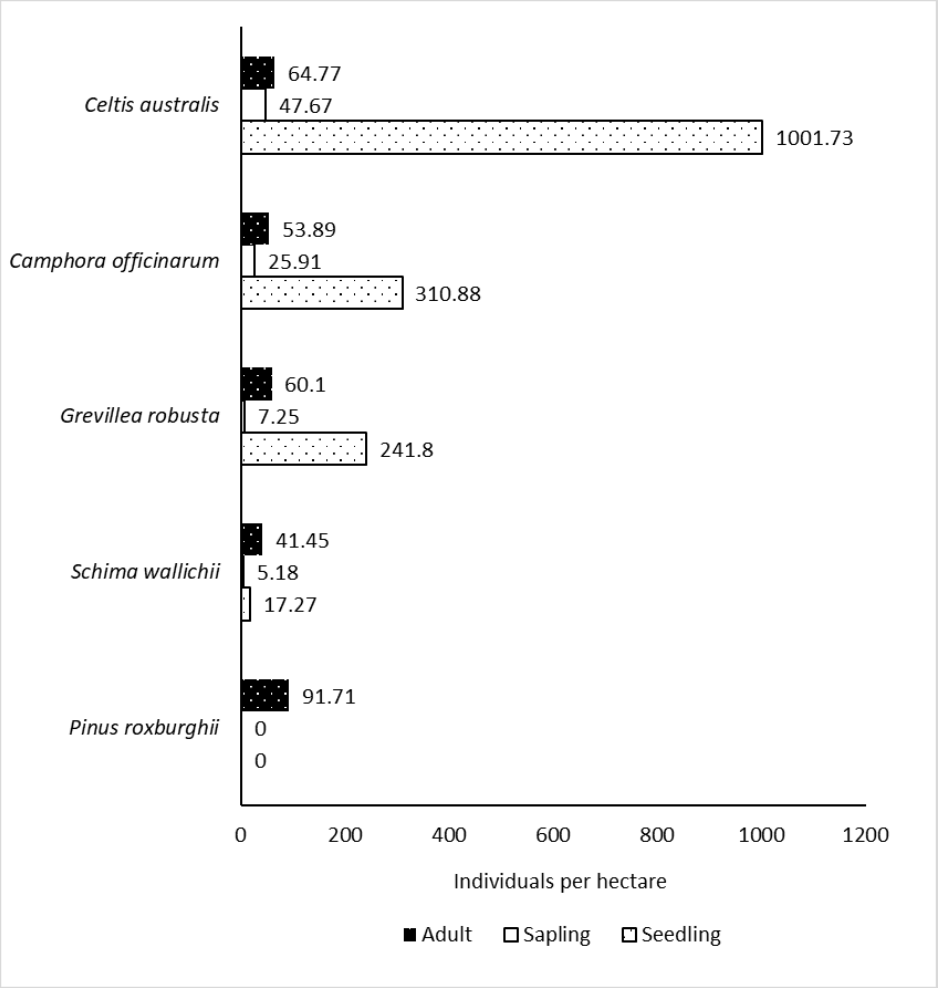


Figure 37: Density of seedling, sapling and tree of major IVI species of urban green spaces in Kathmandu Valley.

Figure 38: Regeneration status of urban green spaces in Kathmandu Valley.

Out of 90 tree species recorded across urban green spaces, only 20 species (22.2%) had good regeneration. Similarly, 17 species (18.9%) were observed with fair regeneration. In

addition, Poor regeneration was identified in 18 species (20%). However, 31 species (34.4%) showed no regeneration, with only adult individuals present. In addition, four species (4.4%) were recorded as new regeneration (Figure 38). Out of 76 tree species recorded across forest, only 18 species (23.68%) had good regeneration. Similarly, 17 species (22.37%) were observed with fair regeneration. In addition, Poor regeneration was identified in 14 species (18.42%). However, 25 species (32.89%) showed no regeneration, with only adult individuals present. In addition, two species (2.63%) were recorded as new regeneration (Figure 39).

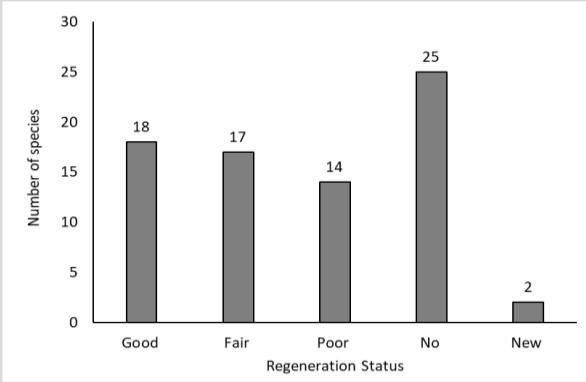


Figure 40: Regeneration status of urban forest in Kathmandu Valley.

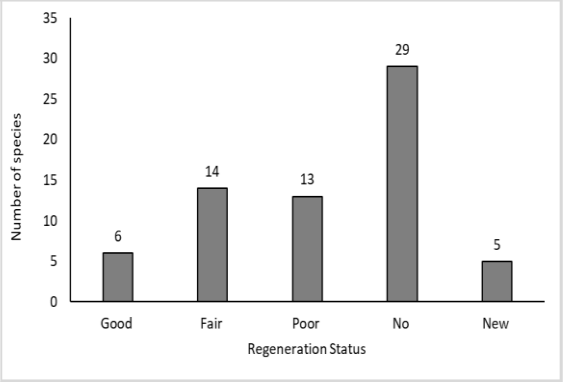


Figure 40: Regeneration status of urban park in Kathmandu Valley.

Out of a total 67 tree species recorded across parks, only six species (8.96%) had good regeneration. Similarly, 14 species (20.90%) were observed with fair regeneration. In addition, Poor regeneration was identified in 13 species (19.40%). However, 29 species (43.28%) showed no regeneration, with only adult individuals present. In addition, 5 species (7.46%) were recorded as new regeneration (Figure 40). The relative abundance of seedlings, saplings, and adults varies across the urban green space of Kathmandu valley. In parks, Shankha Park had no seedlings recorded, but a high sapling count (55.2%) followed by adults (44.8%). In contrast, highest seedlings were found in Bandevi Park (91.2%) and Bhugol Park (90.3%). In forests, Ranibari CF and Mhepi RF exhibit favorable regeneration with over 85% seedlings while Swayambhunath RF had relatively lowest 47.4 % seedling. Likewise, Tribhuvan Park had the highest number of adults (63.4%) followed by Shankha Park (44.8%). Whereas, Bhugol Park had the lowest number of adults (4.3%) followed by Bandevi Park (4.7%) (Figure 41).

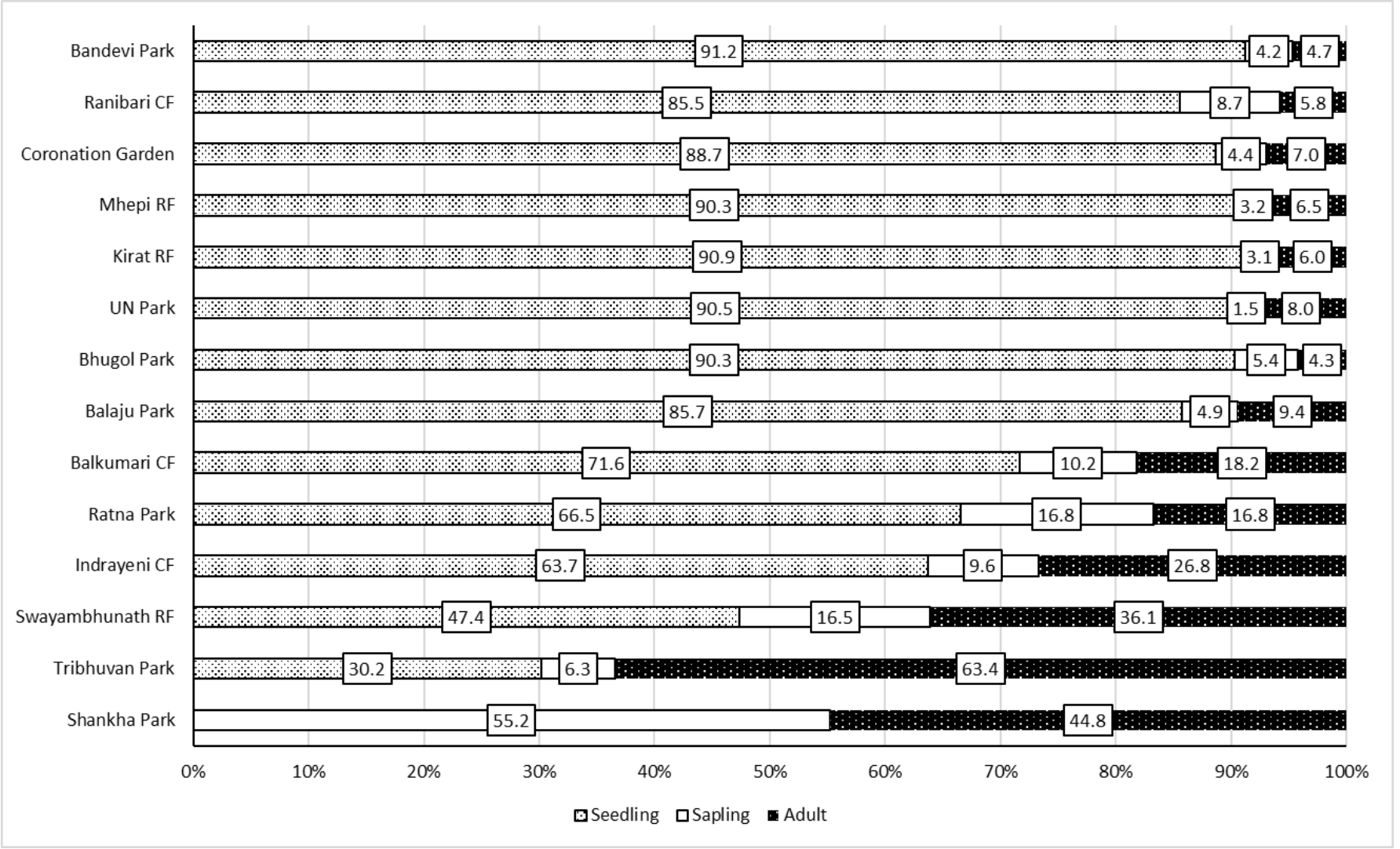


Figure 41: Relative abundance of seedlings, saplings, and adults varies across the urban green in Kathmandu Valley.

4.6.2 Density diameter relationship of trees

The diameter distribution of tree species across urban green spaces shows a reverse J-shaped curve, indicating a healthy regeneration trend. The highest density was recorded in the 5–15 cm DBH class (237.82 individuals/ha), gradually decreasing with increasing diameter. The lowest density was recorded in the 85 - 95 cm DBH class (8.81 individuals/ha) (Figure 42).

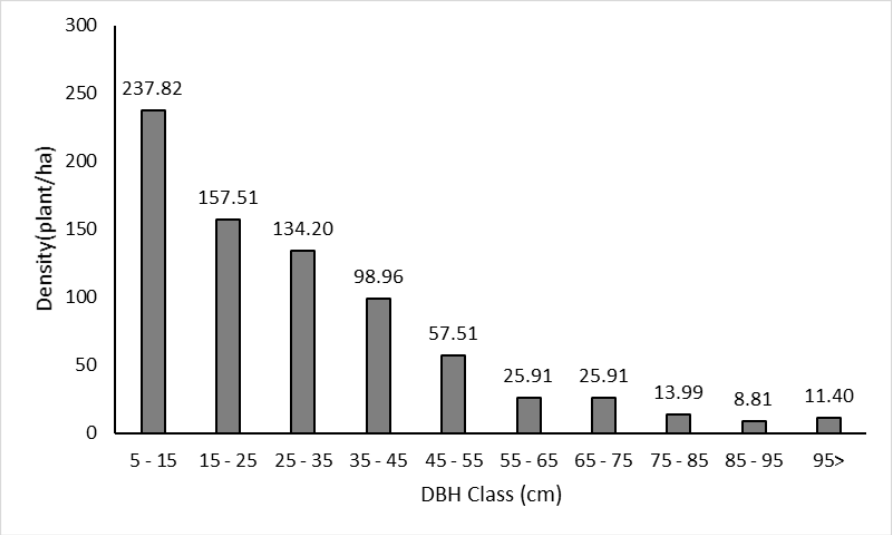


Figure 42: Density diameter relationship of trees across urban green spaces in Kathmandu Valley.

The diameter distribution of trees in urban parks shows a bell-shaped curve, peaking in the 15–25 cm DBH class (156.04 individuals/ha). This indicates a dominance of mid-sized trees with lower densities in both 5–15 cm DBH class (134.07 individuals/ha) and 25 – 35 cm DBH class (136.26 individuals/ha). There is gradually decreasing with increasing diameter from 25 - 35cm DBH class (Figure 43).

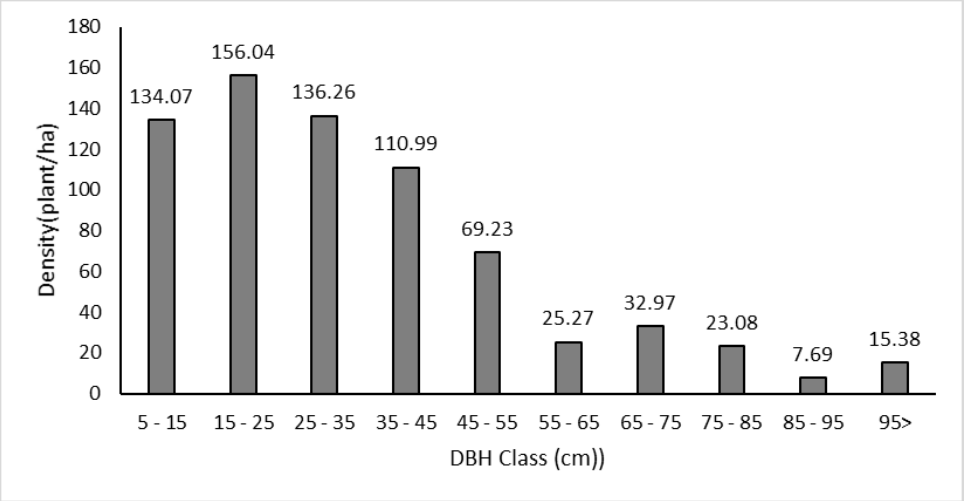


Figure 43: Density diameter relationship of trees across urban park in Kathmandu Valley.

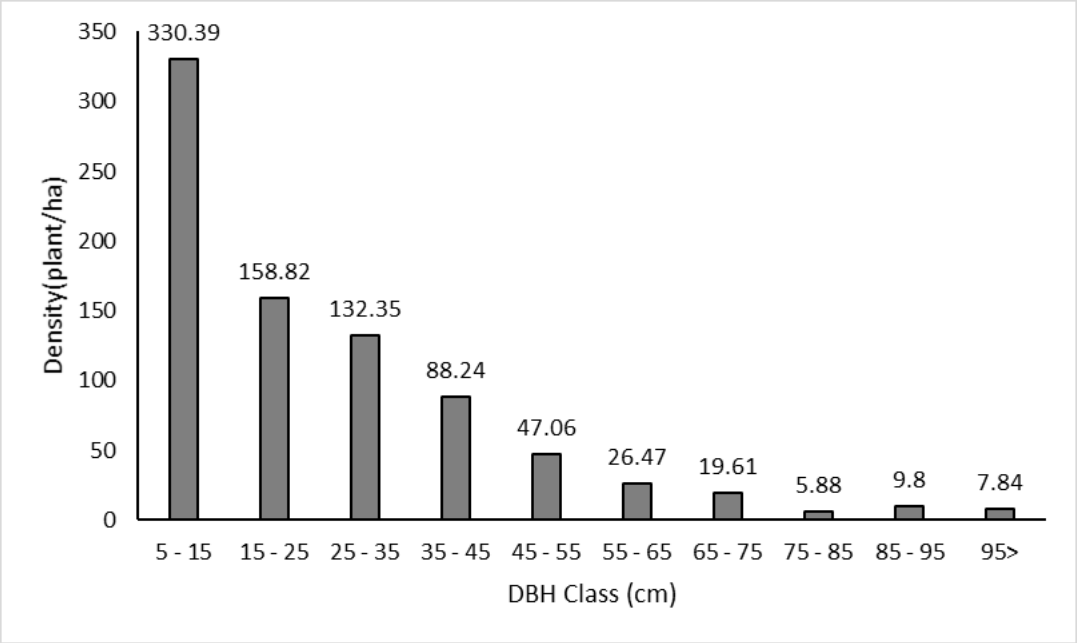


Figure 44: Density diameter relationship of trees across urban forest in Kathmandu Valley.

The forest also shows a reverse J-shaped diameter distribution, with the highest density in the 5–15 cm DBH class (330.39 individuals/ha) gradually declining toward larger size classes. The lowest density was recorded in the 75 - 85 cm DBH class (5.88 individuals/ha) (Figure 44).

4.7 Tree-related microhabitats (TreMs)

Out of the total 1,491 trees on the urban green spaces, 891 trees (59.76%) had tree-related microhabitats (TreMs), while 600 trees (40.24%) lacked microhabitats. The tree-related microhabitats recorded on urban green areas are fungi, moss, lichen, fern, climber, orchids, bird nest, other nesting species and other phanerogams. Among the 891 trees that exhibited tree-related microhabitats (TreMs), the 518 trees (58.14%) supported two types of habitat features. This was followed by 284 trees (31.87%) with one type of microhabitat and 81 (9.09%), hosted three habitat types. The four types of microhabitat were supported by eight trees (0.90%) A total of 83 tree species were recorded with tree-related microhabitats (TreMs) in the urban green spaces studied. Among these, lichens were found in 59 tree species, followed closely by mosses with 55 tree species. The ferns and climbers were recorded from 24 and 21 tree species respectively. Likewise, orchids were recorded from seven tree species and fungi from 2 tree species. The bird nests were found in nine tree species and nests of other species in four tree species. Likewise, other phanerogams were recorded from five tree species (Figure 45).

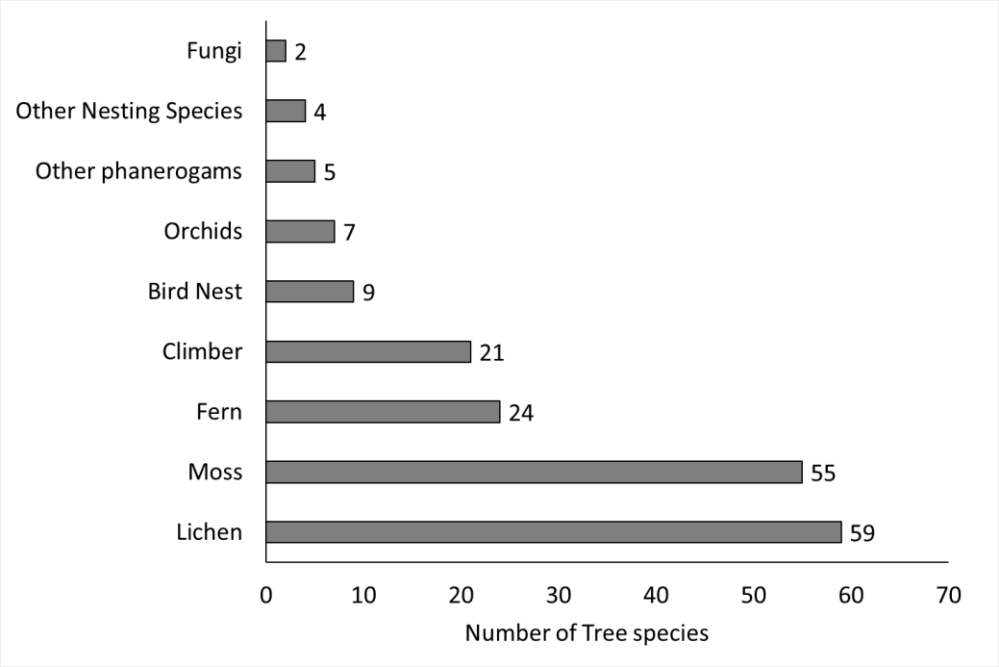


Figure 45: Type of tree-related microhabitats (TreMs) in urban green spaces of Kathmandu Valley.

The fungi (polypore) were recorded on 4 individuals of 2 tree species i.e, *Stranvaesia nussia* (1) and *Schima wallichii* (3). The orchid species only *Rhynchostylis retusa* were recorded from 18 individuals of 7 tree species i.e, *Alnus nepalensis* (4), *Camphora officinarum* (8), *Celtis australis* (1), *Jacaranda mimosifolia* (1), *Juniperus recurva* (2), *Melaleuca citrina* (1) and *Stranvaesia nussia* (1). The bird nests were recorded from 25 individuals of 9 tree species, with the highest on *Populus nigra* (7) followed by *Grevillea robusta* (5). The other nesting species like bee hive and insect hive were recorded from 8 individuals of 4 tree species i.e, *Alnus nepalensis* (1), *Celtis australis* (1), *Grevillea robusta* (5) and *Schima wallichii* (1). The other phanerogams like *Peperomia tetraphylla*, *Ficus religiosa* were recorded from 5 individuals of 5 tree species of *Celtis australis*, *Engelhardia spicata*, *Grevillea robusta*, *Juniperus recurva*, *Pinus roxburghii*. The climber like *Dolichandra unguis-cati*, *Hedera nepalensis*, *Ficus sarmentosa*, *Ipomoea purpure*, *Philodendron bipinnatifidum*, *Monstera deliciosa* were commonly found in 52 individuals of 21 tree species with highest on *Schima wallichii* (11) followed by *Celtis australis* (6).

The ferns like *Drynaria* sp, *Lygodium* sp, *Lepisorus* sp *Vittaria* sp were recorded from 61 individuals of 24 tree species with highest on *Camphora officinarum* (7) followed by *Celtis australis* (6). The moss were recorded from 687 individuals of 55 tree species with highest on *Pinus roxburghii* (166) followed by *Grevillea robusta* (67) and *Camphora officinarum* (65). The lichen was the highest recorded microhabitat with 736 individuals of 59 tree species with highest on *Pinus roxburghii* (166) followed by *Grevillea robusta* (66) and *Camphora officinarum* (56).

4.8 Disturbances

The vegetation in urban green spaces exhibited significant disturbance, primarily due to the activities of park visitors. The recreational activities of visitors cause disturbance like plastic rubbish, foot traffic and picnic spots. Similarly, infrastructure development for recreational spots causes physical modifications, which bring disturbance like drain, erosion, earthworks and power lines. Both direct and indirect human activities have caused various forms of vegetation exploitation, including cutting, lopping, slashing, burning, resin tapping, and the presence of dead or rotten trees. Additionally, indirect pressures such as coppice regrowth, grazing, animal droppings, and the spread of plant diseases were also used to analyze vegetation degradation in urban green spaces.

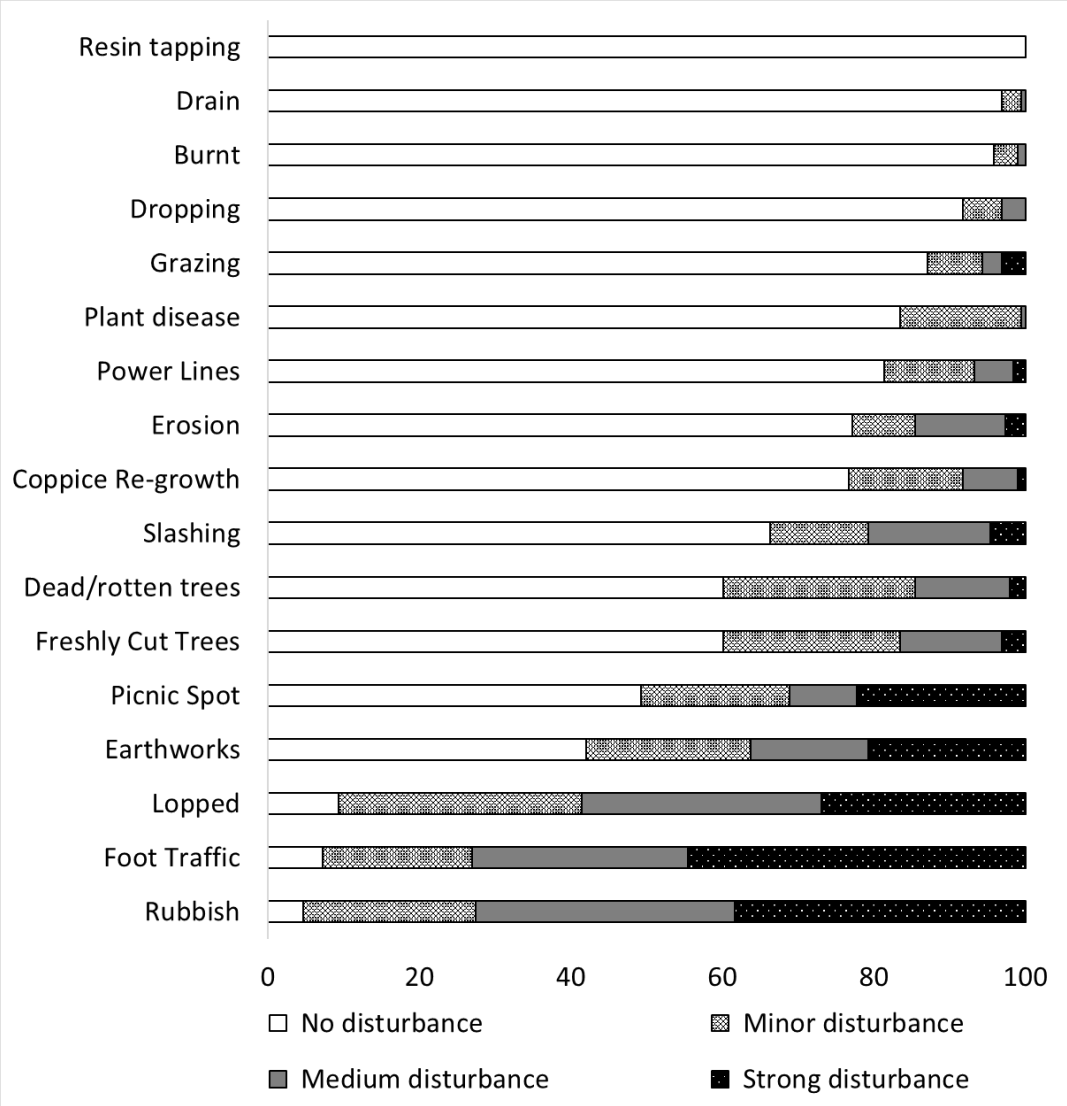


Figure 46: Intensity of disturbance of different parameter in urban green spaces of Kathmandu Valley.

The disturbances such as resin tapping were not present in all 193 sampling plots, indicating complete absence with 100% no disturbance. Similarly, drainage alteration, burning, and droppings were also mostly absent, with more than 95% of the sites without disturbance. Similarly, disturbances like grazing were absent for 87.05%, plant disease for 83.42%, and power lines for (81.35%) which indicate very minimal impact to the vegetation (Figure 46). In contrast, disturbance like foot traffic had 44.56% of strong disturbances followed by rubbish accumulation (38.34%). Similarly, lopping had 26.94% of strong disturbance and earthworks with 20.73 % of strong disturbance. The disturbance like rubbish and foot traffic were only free from 4.66% and 7.25% area respectively. Likewise, only 9.33% of the area had no lopping of vegetation.

Likewise, vegetation degradation near picnic areas was found with 22.28% of the area having strong disturbance due to soil compaction, waste, and unregulated human activity. However, almost half (49.22%) of the areas have no disturbance which indicates unused recreational zones. Tree cutting was mostly absent (60.10%) however, there is 23.32% of minor disturbance, 13.47 % medium and 3.11% strong disturbance area. Likewise, dead or decaying trees were absent in 60.10% of the area, however 25.39 % and 12.44% had experienced minor and medium disturbance respectively. Only 2.07 % of the area had strong disturbance. Vegetation slashing was absent in 66.32% of sites. However, minor (12.95%), medium (16.06%), and strong (4.66%) disturbances occur for maintaining open space for visitors. Therefore, coppice regrowth was not visible in 76.68% area; however minor (15.03%) and medium (7.25%) levels indicate partial vegetation recovery, with only 1.04% having strong regrowth activity.

Based on the intensity of disturbance (no, minor, medium and strong) of 10 parameters (cutting, lopping, slashing, burning, resin tapping, dead or rotten trees, coppice regrowth, grazing, animal droppings, and spread of plant diseases), Principal Component Analysis (PCA) is used to visualize patterns of disturbance across urban green spaces (Figure 47). Resin Tapping (Resin) was near the origin indicating no disturbance in any 14 urban green spaces. Tribhuvan Park (TP), Indrayeni CF (ICF), and Coronation Garden (CG) had a disturbance like plant disease (Pla_Dis), grazing (Graz), and droppings (Drop). Similarly, Swayambhunath RF (SRF) had major disturbances like lopping (Lop), slashing (Slas) and burning (Burnt). The Coppice regrowth (Copp) was more common on Kirat RF (KRF) and Balkumari CF (BCF) with cutting (Cut) and dead or rotten trees (De/Rot). A smaller cluster of Ratna Park (RP), Shankha Park (SP) and Bhugol Park (BGP) have less disturbance intensity.

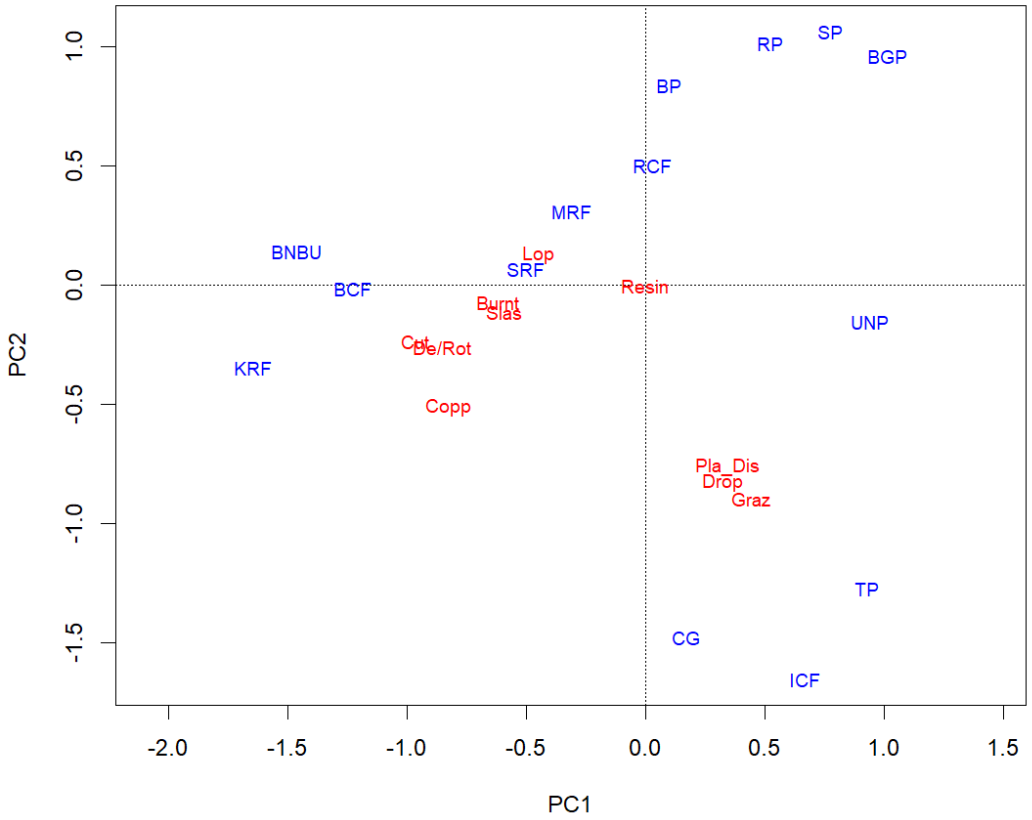


Figure 47: Principal Component Analysis of disturbance across urban green spaces of Kathmandu Valley.

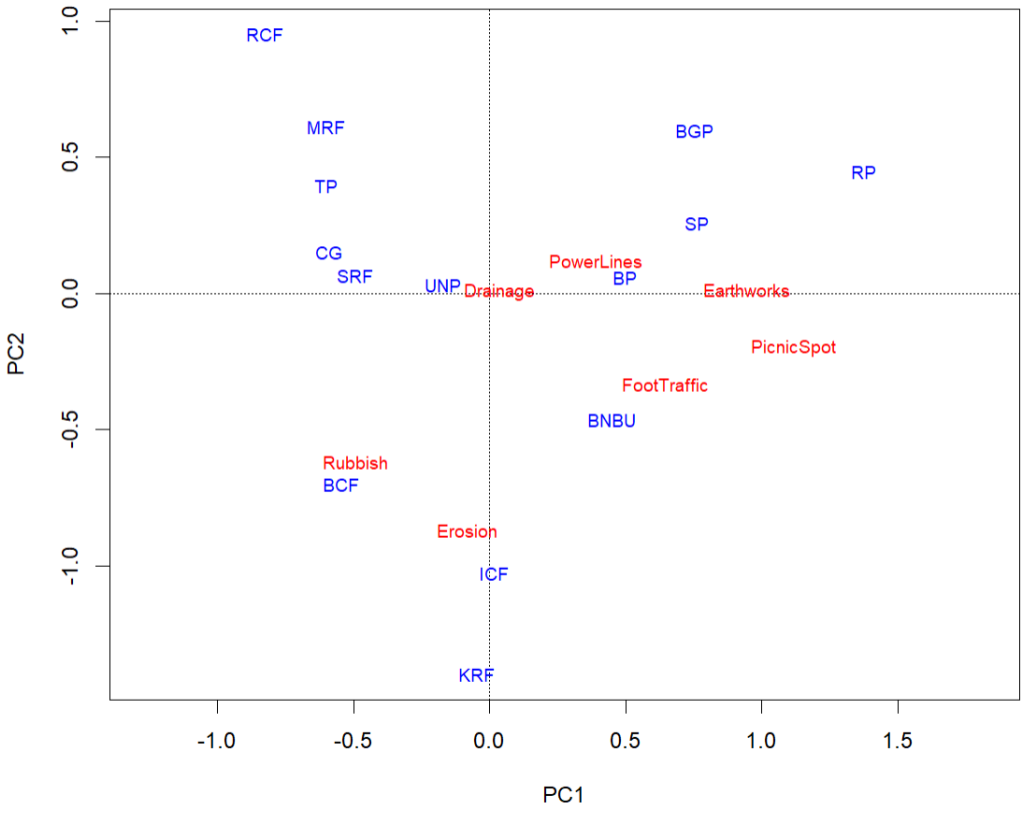


Figure 48: Principal Component Analysis of recreational disturbance across urban green spaces of Kathmandu Valley.

Similarly, based on the intensity of disturbance (no, minor, medium and strong) of recreational activities of visitors (plastic rubbish, foot traffic, picnic spots) and infrastructure development for recreational spots (drain, erosion, earthworks and power lines). Principal Component Analysis (PCA) is used to visualize patterns of recreational disturbance across urban green spaces (Figure 48). Among the disturbance variables, Foot traffic was major on Bandevi Nagar Ban Udhyan (BNBU). Picnic Spot was strongly associated with Ratna Park (RP) and Shankha Park (SP) as these parks serve as recreational spots. Likewise, earthworks were most common on Bhugol Park (BGP) and Shankha Park (SP). Drainage was near origin with moderate disturbance with UN Park (UNP). Erosion was higher on Indrayeni Community Forest (ICF) and Kirat Religious Forest (KRF). The highest disturbance of rubbish was found near Balkumari CF (BCF). In contrast, Ranibari Community Forest (RCF) has less recreational disturbance intensity.

4.9 Visitor Perception

4.9.1 Demographic Variations

A total of 230 respondents were surveyed to understand visitor perceptions of urban green spaces. Among them, 51.74% were female (n = 119) and 48.26% were male (n = 111). The marital status of 43.91% (n = 101) visitors were single, while 56.09% (n = 129) were married. Similarly, the majority of respondents were in the middle adulthood group (25–44 years) with 50.43% (n = 116) of the total visitors, followed by young adults (15–24 years) at 26.09% (n = 60), older adults (45–64 years) at 18.26% (n = 42), and individuals in the retirement age group (>65 years) at 5.22% (n = 12). Likewise, the majority of respondents had university-level education (45.65%, n = 105), followed by secondary education (33.91%, n = 78). Additionally, 18.70% (n = 43) of visitors had primary education, while only 1.74% (n = 4) had no formal education. In employment status, the largest proportion of respondents were students (35.22%, n = 81), followed by self-employed (26.09%, n = 60) and employed full-time (15.65%, n = 36). A smaller percentage of visitors were unemployed (9.57%, n = 22), retired (9.13%, n = 21), temporarily employed (3.04%, n = 7), and engaged in foreign employment (1.30%, n = 3)

4.9.2 Familiarity with Plant Species

Out of 230 respondents, 223 individuals (96.96%) were able to name plant species in the urban green spaces, while seven respondents (3.04%) were unsure. All together 64 species names were mentioned by 223 respondents (Appendix 14). The majority of names

belonged to trees (45), followed by shrubs (8), herbs (7), climbers (3), and subshrubs (1). The visitors are more familiar with woody plant species (mainly trees). Among the listed species, few plant names were mentioned more frequently than others which reflect their cultural or ecological significance. The most frequently mentioned species was *Ficus religiosa* (Peepal) by 98 visitors (42.61%), followed by *Pinus roxburghii* (Salla) with 87 visitor (37.83%) and *Juniperus recurva* (Dhupi) with 85 visitor (36.96%). Other commonly named species included *Camphora officinarum* (Kapur) by 37 visitors (16.09%), and *Ficus benghalensis* (Bar) by 26 visitors (11.30%). Most visitors estimated that the urban green space contains between 40 to 60 plant species, with 50 species being the most common response. A few respondents believed a higher number of species estimated over 100 to 300 species while a lower number of species estimated by respondents is about 10 to 12 species.

4.9.3 Visitor Awareness of Invasive Species

Out of 230 visitors, 104 (45.22%) had heard about invasive species but lacked detailed knowledge. Most were familiar with the term "Banmara" (commonly referred to as the forest killer), but they were unaware of its causes, impacts, or other invasive species. Meanwhile, 88 visitors (38.26%) had a basic understanding, mainly recognizing invasive species through their experiences in agricultural fields. Only 38 respondents (16.52%) had good understanding, showing awareness of the ecological problems caused by invasive plants and actively engaging in removal practices in home gardens and agricultural fields. There is an increase in the awareness level across the age. Among young adults (15–24 years), 61.67% (37 individuals) had heard of invasive species but lacked understanding, while 26.67% (16 individuals) had a basic understanding, and only 11.67% (7 individuals) had a good understanding. In the middle adulthood group (25–44 years), 46.55% (54 individuals) had heard of invasive species. While 39.66% (46 individuals) had a basic understanding, and 13.79% (16 individuals) had a good understanding (Figure 49). Among older adults (45–64 years), 47.62% (20 individuals) had a basic understanding, 23.81% (10 individuals) a good understanding, and only 28.57% (12 individuals) heard about it. In the retirement group (>65 years), awareness was the highest with 50.00% (6 individuals) had a basic understanding, 41.67% (5 individuals) had a good understanding, and 8.33% (1 individual) had only heard of invasive species. Therefore, awareness and understanding of invasive species tend to increase with age.

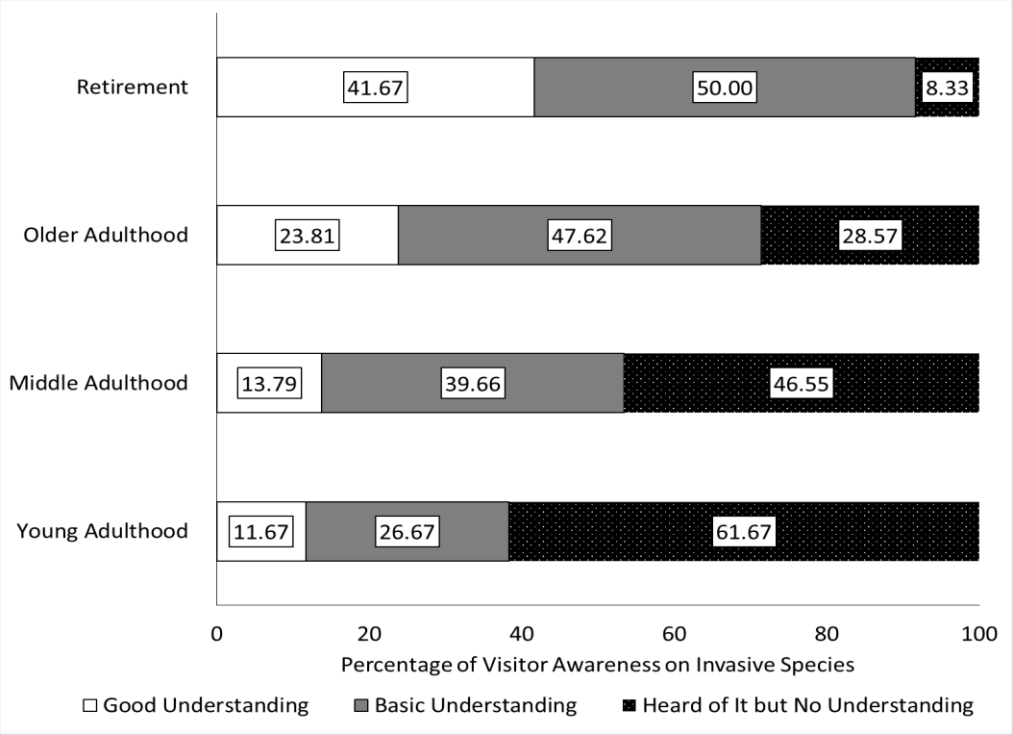


Figure 49: Awareness on invasive species across age of visitors in the urban green spaces of Kathmandu Valley.

4.9.4 Preferences of Visitors

The most preferred aspect of visitors was the maintenance, 85 respondents (36.96%) had suggested improving existing vegetation by proper management. Similarly, 82 respondents (35.65%) preferred ornamental flowers to increase aesthetic appeal of urban green space. Additionally, 50 visitors (21.74%) favored the plantation of medicinal or edible plants. Likewise, addition of educational signage was preferred by 8 respondents (3.48%). Only five respondents (2.17%) suggested tree plantation. A majority of visitors were concerned about the management of plastic and solid waste, which is well managed in Ratna and Sankha Park. Visitors suggested regular cleaning activities. Additionally, many respondents suggested increasing the number of seating areas, including sheltered spaces for protection during rainy weather. Also, suggest expanding recreational facilities such as children's play areas and gym equipment. Similarly, maintenance of water bodies, slopes, and walking trails were also suggested.

4.9.5 Willingness to Pay

The eight urban green spaces in the study area were identified as free to access while seven charged entry fees (Table 11). An assessment of willingness to pay for entry revealed that 52.61% (n = 121) of respondents preferred free access, whereas 47.39% (n = 109)

expressed a willingness to pay an entry fee. Among respondents for free access, the majority of visitors suggested a ticketing system during the daytime, which helps to self-sustainability and effective management. While 1.74% respondent (n = 4) believed that parks are public property which should be maintained using taxpayer money, and thus should not require additional payment. Similarly, for religious forest, maximum visitors opposed the ticketing system.

Table 14: Classification of urban green spaces based on access types in the Kathmandu Valley.

Free Access Urban Green Spaces	Paid Access Urban Green Spaces
Bhugol Park	Bandevi Park
Shankha Park	Ratna Park
UN Park	Balaju Park
Coronation Garden	Tribhuvan Park
Mhepi Religious Forest (RF)	Ranibari Community Forest (CF)
Kirat Religious Forest (RF)	Indrayeni Community Forest (CF)
Balkumari Community Forest (CF)	National Botanical Garden
Swayambhunath Religious Forest (RF)	

Out of the 15 urban green spaces studied, eight urban green spaces were free to access. Most visitors preferred to keep these spaces free. Mhepi Religious Forest (RF) had 100% of respondents preferring it to remain free. Similarly, Bhugol Park and Balkumari CF had 90% and 80% respondent's free preference respectively. Likewise, 75% respondents prefer free access to the coronation garden. However, 30 % of respondents on Swayambhunath RF prefer a ticket system suggesting it can managed more like a park. Similarly, 40 % of respondents prefer the ticket system on Kirat RF. Among the free access urban green space, UN Park had the highest 45% respondents prefer the ticket system (Figure 50). Seven urban green spaces in the study area charge entry fees. The majority of visitors accepted the paid access model in these spaces. The National Botanical Garden exhibited the highest support for paid access, with 95% of respondents preferred for paid access, which is due to its educational services and better infrastructure. Other parks such as Balaju Park, Tribhuvan Park, and Ranibari CF also showed a high proportion of visitors (65–70%) preferring the continuation of the paid system. However, in Bandevi Park, which had a ticket system of Rs10, opinions were evenly divided with 50% preferring free and 50% preferring paid. Majority of respondents expressed that a paid entry system could contribute positively to the maintenance and infrastructure development. Some respondents emphasized that revenue generated from ticket sales could help ensure self-

sustenance without relying entirely on government funding. In addition, several visitors noted that the natural beauty, and refreshing environment offered by these green spaces were valuable experiences, which are worth a ticket. Also, some respondents suggested that controlled entry through ticketing could help limit overcrowding, enhance visitor safety, and promote more responsible park usage.

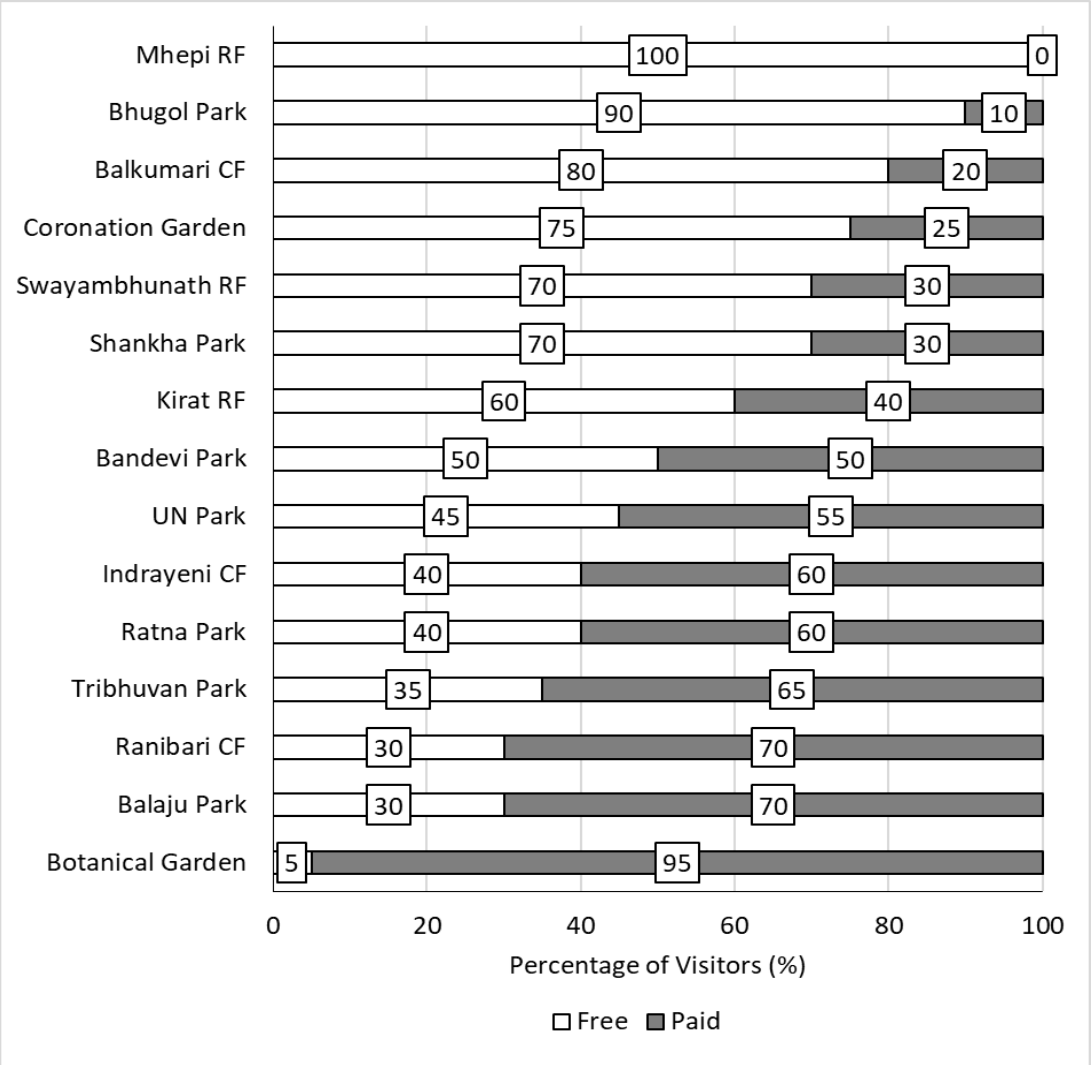


Figure 50: Willingness to Pay of visitor across the urban green spaces in the Kathmandu Valley.

However, a significant number of respondents strongly supported free access to parks. Respondent argued that these urban green spaces are public property therefore maintained with taxpayer funds and should not have additional charges. Also, respondents added a paid system would create barriers for students, elderly citizens, and low-income groups. Moreover, certain respondents were satisfied with current levels of park maintenance and did not necessitate a paid system. Therefore, many visitors proposed a hybrid model where parks remain free during early morning and evening times commonly used by local residents for exercise and relaxation while allowing for paid entry during day.

5. Discussion

5.1 Plant community across Urban Green Spaces

A total 437 species of spermatophytes from 114 families were recorded from 14 the urban green spaces of Kathmandu valley, which closely align with the 426 vascular plant species from 83 families, recorded in 10 urban parks of Poland (Rahmonov *et al.*, 2019). However, only 288 vascular plant taxa from 72 families were recorded in the 24 urban green spaces from inner city of Beijing, China (Li *et al.*, 2005). Likewise, only 178 from 65 families were from 15 urban parks (inducing forest and natural area) of Oregon, USA (Talal & Santelmann, 2019). Figueroa *et al.* (2018) recorded 550 species from 49 urban green spaces of Santiago, Chile with individual parks containing between 42 and 146 species. However, individual urban green spaces of Kathmandu valley varies from 79 species in Bhugol Park to 235 species in Balaju Park. According to Pun and Maharjan (2013), species richness was highest in Balaju Park (138 species), followed by Ratna Park (132), Shankha Park (42), and Bhugol Park (8); all values are lower than the present findings of 235, 142, 91, and 79 species, respectively. In addition, eight urban green spaces of Cilegon City, Indonesia, recorded 114 species of 46 families with the number of species per park ranging from 7 to 47 (Muhlisin *et al.*, 2021). Likewise, Flores *et al.* (2020) recorded 100 plant species in five urban parks in Metro Cebu, Philippines with a range of 11 to 85 plant species per park. Hence, the number of species varies across the urban green space, as human intervention plays a dual role in urban green spaces, either increasing due to the introduction of ornamental plants or decreasing due to human-induced disturbances.

Likewise, Maharjan *et al.* (2006) recorded 108 species from 58 families in Ranibari Forest, whereas the present study documented 152 species. Similarly, compared to the 104 species from 55 families reported by Ranjitkar and Chaulagain (2004), the present study recorded a higher count of 148 species in Swayambhu forest. In addition, Ghimire *et al.* (2005) recorded 61 plant species from 41 families in Bhandarkhal Forest at the Pashupati area; however, the present study recorded a slightly higher number (79 species), the lowest among all 14 green spaces. This variation in the number of species may vary depending on the survey method. In the current study, 127 tree species were recorded using the line transect method, while only 83 were recorded using the quadrat method on urban green spaces. However, the higher number of species recorded compared to earlier studies is mainly due to introduction of ornamental species. Zerbe *et al.* (2003) also mentioned that

species dispersal of non-native species was influenced by both direct and indirect anthropogenic mechanisms.

Urban parks host a high diversity of plant species in cities, but many of them are exotic species (Nielsen *et al*., 2013). More than 90% of the flowers in the gardens of Kathmandu valley are the exotic species (Bajracharya *et al*., 1997). During study, 54.46% of species were exotic in urban green space of Kathmandu valley, with the highest 70.42% exotic species in Ratna Park. However, Singha Durbar comprises 65% introduced plant species, as most elements, including vegetation, were imported from Europe during construction (Bhattarai, 2019). Similarly, more than 90% were exotics species mostly from Europe were recorded in the 15 parks along an urban-rural gradient of Santiago, Chile (Fischer *et al*., 2016). Since the concept of urban green space emerged in Europe after the industrial revolution. European design influence across the globe therefore native plants are not often used for decoration (Figueroa *et al*., 2018). However, 52% exotic species from other countries and continents were recorded in Buttes-Chaumont Park of Paris, France (Muratet *et al*., 2015). Flores *et al*. (2020) recorded the highest 95% of exotics species in urban spaces of Metro Cebu, Philippines. DeCandido (2004) reported that from 1947 to 1994, 25.5% of the native plant species in Pelham Bay Park disappeared at an average rate of 2.9 species per year, and 39.7% were replaced by non-native species.

Native plant species increased the diversity of birds and butterflies significantly (Burghardt *et al*., 2008). Sulaiman *et al*. (2013) claimed that native vegetation is 10-50 times more beneficial to native birds. Likewise, Khera *et al*. (2009) recorded the most abundant exotic species *Prosopis juliflora* in 19 public green spaces of Delhi, India had negatively affected the diversity of birds. In contrast, an exotic species *Grevillea robusta* had the most bird species in Mexico City (MacGregor-Fors & Ortega-Álvarez, 2011). Similarly, in the current study, the maximum number of bird nests were recorded from exotic species, *Populus nigra* (7) followed by *Grevillea robusta* (5). Likewise, other nesting species like beehive and insect hive were recorded highest from *Grevillea robusta*. Additionally, ferns and orchid species were also highest recorded from *Camphora officinarum*, an exotic species from the Kathmandu valley. Similarly, six habitat types were found in one *Camphora officinarum* tree (Shrestha *et al*., 2022 a). However, improving the urban habitat for native species is a vital aspect of biodiversity conservation on a global scale (Shwartz *et al*., 2014).

Invasive alien species cause an impact on the carrying capacity of the ecosystem with a decrease in the number of native species (Adhikari *et al*., 2022). Out of the 30 naturalized

invasive alien plant species found in Nepal (Shrestha *et al.*, 2024), 12 species were recorded from urban green spaces. Likewise, Parmar *et al.* (2024) recorded 15 invasive species from the National Botanical Garden. Similarly, Paudel *et al.* (2021) recorded 13 invasive species across various land use types in Kathmandu. However, Karki *et al.* (2022) recorded only nine invasive alien species in Shivapuri Nagarjun National Park, Kathmandu. Additionally, 14 invasive alien species were recorded from the Parsa National Park (Chaudhary *et al.*, 2020).

Urban green spaces of Kathmandu valley recorded 127 tree species. However, (Shrestha *et al.*, 2023) recorded 150 species from trees outside forests of Kathmandu valley. Similarly, Mishra *et al.* (2024) recorded 88 tree species from 30 urban gardens and parks of Kathmandu valley. Joshi *et al.* (2023) recorded 33 tree species in the avenue plantation sites in ring road. However, only 23 tree species were documented in the Pashupati sacred grove and 19 species in the Bajrabarahi sacred grove (Shrestha *et al.*, 2020). Sapkota *et al.* (2022) recorded 19 species from Swayambhu followed by Mhepi (15), however, current study recorded 37 and 21 tree species from Swayambhu and Mephi religious forest. Likewise, Sharma *et al.* (2020) recorded only two tree species from Adinath Community Forest, Kirtipur.

The carbon stock of tree species across urban green spaces was a total average of 566.80 t/hectare with highest on urban parks (629.00 t/ha) than urban forest (511.31 t/ha) due to due to the low basal area, DBH, and proper management strategies. The Bandevi park had the lowest 127.15 t/ha of carbon stock. However, Mishra *et al.* (2024) calculated an average 54.56 t/hectare of carbon from 30 urban gardens and parks of Kathmandu valley. Likewise, Bhatta *et al.* (2018) recorded a carbon stock of 196.4 t/ha in the Coronation Garden, whereas the current study shows a significantly higher value of 662.64 t/ha. This increase may be due to the reduction of edge of garden areas by increased construction of buildings and increase in human induced plantation activities within the core garden area. Likewise, Karki *et al.* (2016) found that there was an increase in carbon stock at forests of the ICIMOD Knowledge Park from 263.44 to 269.22 tons per hectare.

Similarly, Paudyal *et al.* (2022) reported lower carbon stock in community forest than in religious forest due to management practices like thinning, litter and firewood collection and timber extraction. However, Ranibari community forest had higher carbon stock than Swayambhunath regional forest due to proper management of species. Sapkota *et al.* (2022) also recorded the lowest carbon stock of Swayambhunath (129.40 t/ha) than Mhepi

(150.19 t/ha), however, in current study, Mhepi RF (187.82 t/ha) had lowest than Swayambhunath (260.64t/ha), mainly due to increased infrastructure development within Mhepi forest for recreational purposes.

5.2 Visitor Perception across Urban Green Spaces

The majority of visitors were positive toward the urban green space. Khadka *et al.* (2023) also reveal the majority of the people were aware of the advantages associated with urban green space. Similarly, Gurung *et al.* (2011) found that one-third of respondents visit the green spaces two to three times a week. However, urban people are unsatisfied with the existing species in urban spaces (Lamichhane & Thapa, 2011). During this study, the majority of visitors suggested maintenance of existing vegetation and plantation of ornamental species. Maharjan & Pun (2013) listed the top 10 major preference plants among the Park users. Among them, the visitor in the urban green spaces mentioned nine species (except *Nyctanthes arbor-tristis*). Similarly, Muratet *et al.* (2015) found that visitors primarily identified the cultivated vegetation within garden landscapes.

The 47.39% visitor expressed a willingness to pay an entry fee in the urban green space of Kathmandu valley. However, Khadka *et al.* (2025) found 66% of respondents were willing to pay for maintenance of the urban parks. Gautam *et al.* (2021) indicates that 90 % of the respondents were willing to pay for the improved condition of Balaju Park. However, in the current study, only 70% showed willingness, likely because morning visitors, many of whom were not interested in paying for entry were also included. Introducing entry fees may restrict access for communities relying on parks for traditional activities and livelihoods; thus, effective management requires local user involvement (Basu & Nagendra, 2021).

Shrestha *et al.*, (2020) also recorded various disturbance factors that degrade the sacred groves of Kathmandu valley. The Ranibari Forest has also been altered due to human intervention (Maharjan *et al.*, 2006), although it experiences less disturbance compared to other urban green spaces. The Swayambhunath forest is a highly disturbed, predominantly dominated by planted species, which is consistent with the findings of Ranjitkar and Chaulagain (2004). Plastic waste generated by visitors was a major issue in urban parks, except in those managed by the Kathmandu Metropolitan City. This aligns with Khadka *et al.* (2025), who also identified solid waste management as a major problem in Kathmandu's urban parks.

Urban areas consist of both problems and sustainable solutions (Grimm *et al.*, 2008). The ecological and social value of urban green space can be improved through stronger collaboration and continued investment by government bodies, NGOs, and local communities (Talal & Santelmann, 2020). Although the local government has encouraged urban greenery, it lacks the necessary legislation and regulatory frameworks (Gurung *et al.*, 2011). Goutam (2018) suggested holistic urban plans for urban green space with strict implementation. The certain areas within urban green spaces should be designated for natural conditions, free from anthropogenic activities, as suggested by Gustavsson *et al.* (2005).

6. Conclusion and Recommendation

6.1 Conclusion

Urban green spaces consist of a higher number of species compared to other land use types. Shannon-Weiner diversity index was above three indicating higher species diversity. However, more than half were exotics species recorded in the urban green space which are mainly used for aesthetic and recreational purposes. It also includes nine hybrid species. Likewise, lack of proper management strategies, growth of invasive species was higher in the urban green spaces. The single endemic species and two CITES-listed plant species were recorded, but no single native species recorded from IUCN threatened categories. However, 79 species historical collection specimens were recorded from urban green space of Kathmandu valley. More than half individual trees provide eight types of tree-related microhabitats. However, one third of tree species have no regeneration in the urban green space. The construction of a concrete picnic spot and walking trail caused the decline in the vegetation. The plastic waste, foot traffic and lopping of vegetation were the major disturbance for urban green spaces.

Urban parks recorded a higher number of plant species with greater carbon stock compared to urban forests. This contrast is due to better management practices in parks, facilitated by revenue generated through the ticketing system. Urban green space provides social, physical, and psychological benefits to visitors. Visitors were more positive towards the conservation of urban green space. All together 64 species names were familiar to the visitor with 70.3 % of tree species; along with the most frequently, mentioned species was *Ficus religiosa*. However, 45.22% of the visitors had heard about invasive species but lacked detailed knowledge, with an increase in the awareness level with increasing age. The suggestion of the majority of visitors was to maintain existing vegetation and plantations of ornamental species. However, visitors blamed poor management and lack of government support for the decline of urban green spaces, while the management group pointed to irresponsible visitor behavior for the degradation. Similarly, governments and policymakers neglected conservation, management and utilization of urban green space. In addition, coordination gap exists between the forest division and the local municipality in species selection and plantation across the green spaces. The conflicts on stakeholder for decision making based on political ideology.

6.2 Recommendation

Urban green spaces are a critical element of urban green infrastructure but have been underutilized. Therefore, sustainable management of urban green space requires engaging all stakeholders together.

- It is necessary to prepare and implement urban biodiversity management strategies, including species selection, plantation and monitoring systems.
- The collaborative framework should be established between the Division Forest Office and local municipal bodies to ensure coordinated efforts in conservation of urban green spaces.
- The complete enumeration and documentation of the vegetation should be carried out in urban green space with labelling and tagging of major plant species.
- At least 20% of the total area within each urban green space should be declared as a conservation zone with restricted human access for ecological restoration.
- The ex situ conservation of native threatened species should be prioritized in the urban green spaces.
- The plastic waste management regulations should be introduced with strict prohibition of single-use plastics and regular clean-up programs.
- Academic institutions and relevant stakeholders should be encouraged to conduct multidisciplinary research for proper management of urban green spaces.

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Appendix

Appendix 1: Tree species found in Urban Green Spaces

SN	Name of species	Family	Nepali name	Common Name	Origin/ Naturalized	IUCN Red List
1	*Acer oblongum* Wall. ex DC.	Sapindaceae	फिरफिरे (Firphire), पुतली फूल (Putali phul)	Himalayan Maple	Native	LC
2	*Aegle marmelos* (L.) Corrêa	Rutaceae	बेल (Bel), बेलपत्र (Belpatra)	Wood Apple	Native	NT
3	*Alangium chinense* (Lour.) Harms	Cornaceae	भालु पाईले (Bhalu paile)	Chinese Alangium	Native	LC
4	*Albizia julibrissin* Durazz.	Fabaceae	रातो शिरीष (Rato sirish)	Persian Silk Tree	Native	NE
5	*Alnus nepalensis* D.Don	Betulaceae	उत्तिस (Uttis)	Nepal Black Cedar	Native	LC
6	*Araucaria bidwillii* Hook.	Araucariaceae	काँडे सल्ला (Kande salla)	Monkey Puzzle Tree	Exotic	LC
7	*Araucaria columnaris* (G.Forst.) Hook.	Araucariaceae	-	Coral Reef Araucaria	Exotic	LC
8	*Araucaria cunninghamii* Mudie	Araucariaceae	-	Hoop Pine	Exotic	LC
9	*Araucaria heterophylla* (Salisb.) Franco	Araucariaceae	-	Norfolk Island Pine	Exotic	VU
10	*Artocarpus lacucha* Buch.-Ham.	Moraceae	बडहर (Badahar)	Monkey Jack	Native	NE
11	*Bauhinia variegata* L.	Fabaceae	सेतो कोइरालो (Seto koiralo)	Orchid Tree	Native	LC
12	*Beaucarnea recurvata* (K.Koch & Fintelm.) Lem.	Asparagaceae	नोलिना (Nolina)	Elephant's Foot,	Exotic	CR
13	*Bombax ceiba* L.	Malvaceae	सिमल (Simal)	Silk-Cotton Tree	Native	LC
14	*Brassaiopsis hainla* (Buch.-Ham.) Seem.	Araliaceae	सेतो चुलेत्रो (Seto chuletro)	Chuletro Tree	Native	NE
15	*Bridelia retusa* (L.) A.Juss.	Phyllanthaceae	गायो (Gayo), कजा (Kaja)	Spinous Kino Tree	Native	LC
16	*Buddleja asiatica* Lour.	Scrophulariaceae	भीमसेन पाती (Bhimsen pati)	Butterfly Bush	Native	LC
17	*Calliandra haematocephala* Hassk.	Fabaceae	-	Red Powder Puff	Exotic	LC
18	*Camphora officinarum* Boerh. ex Fabr.	Lauraceae	कपुर (Kapoor)	Camphor Tree	Exotic	LC

19	*Carica papaya* L.	Caricaceae	मेवा (Mewa)	Papaya	Exotic	DD
20	*Caryota urens* L.	Arecaceae	वन सुपारी (Ban supari), जगर (Jagar)	Fishtail Palm	Exotic	LC
21	*Cassia fistula* L.	Fabaceae	राजवृक्ष (Rajbrichya), अमलतास (Amaltas)	Indian Laburnum	Native	LC
22	*Castanopsis indica* (Roxb. ex Lindl.) A.DC.	Fagaceae	ढाले कटुस (Dhale katus)	Chestnut	Native	LC
23	*Casuarina equisetifolia* L.	Casuarinaceae	-	Australian Pine Tree	Exotic	LC
24	*Cedrus deodara* (Roxb. ex D.Don) G.Don	Pinaceae	देवदार (Devdar)	Himalayan Cedar	Native	LC
25	*Celtis australis* L.	Cannabaceae	खरी (Khari)	Southern Nettle Tree	Uncertain	LC
26	*Cereus hildmannianus* K.Schum.	Cactaceae	-	Hedge Cactus	Exotic	LC
27	*Choerospondias axillaris* (Roxb.) B.L.Burtt & A.W.Hill	Anacardiaceae	लप्सी (Lapsi)	Nepalese Hog Plum	Native	LC
28	*Cinnamomum tamala* (Buch.-Ham.) T.Nees & C.H.Eberm.	Lauraceae	तेजपात (Tejpat)	Nepali Cinnamon	Native	LC
29	*Citrus* × *aurantiifolia* (Christm.) Swingle	Rutaceae	निबुवा (Nibuwa)	Lime	Exotic	NE
30	*Citrus* × *limon* (L.) Osbeck	Rutaceae	कागती (Kagati)	Lemon	Exotic	NE
31	*Citrus maxima* (Burm.) Merr.	Rutaceae	भोगटे (Bhogate):	Pummelo	Exotic	LC
32	*Citrus reticulata* Blanco	Rutaceae	सुन्तला (Suntala)	Mandarin orange	Exotic	NE
33	*Corymbia citriodora* (Hook.) K.D.Hill & L.A.S.Johnson	Myrtaceae	मसला (Masala)	Lemon-Scented Gum	Exotic	LC
34	*Crateva unilocularis* Buch.-Ham.	Capparaceae	सिप्लिकान (Siplikan)	-	Native	LC
35	*Cryptomeria japonica* (Thunb. ex L.f.) D.Don	Cupressaceae	कत्ले सल्ला (Katle salla)	Japanese Red Cedar	Exotic	NT
36	*Cupressus sempervirens* L.	Cupressaceae	-	Mediterranean Cypress	Exotic	LC
37	*Diospyros malabarica* (Desr.) Kostel.	Ebenaceae	खल्लुक (Khalluk), तिजु (Tiju)	Indian persimmon	Native	NE
38	*Dombeya spectabilis* Bojer	Malvaceae	-	Maple Leaved Dombeya	Exotic	LC
39	*Duranta erecta* L.	Verbenaceae	निल काँडा (Nil kanda)	Golden Dewdrop	Exotic/N	LC
40	*Ehretia acuminata* R.Br.	Boraginaceae	चिल्ले (Chille)	Heliotrope Tree	Native	LC

41	*Elaeocarpus angustifolius* Blume	Elaeocarpaceae	रुद्राक्ष (Rudrakchya)	Utrasum Bead Tree	Uncertain	LC
42	*Engelhardia spicata* Lechen ex Blume	Juglandaceae	मौवा (Mauwa)	Mauwa	Native	LC
43	*Eriobotrya japonica* (Thunb.) Lindl.	Rosaceae	लोकट (Lokat), सुवर्ण आलु (Suwarna aalu)	Loquat	Exotic	NE
44	*Erythrina crista-galli* L.	Fabaceae	-	Cockspur Coral Tree	Exotic	LC
45	*Eucalyptus alba* Reinw. ex Blume	Myrtaceae	मसला (Masala)	White Gum	Exotic	LC
46	*Eucalyptus camaldulensis* Dehnh.	Myrtaceae	मसला (Masala)	River Red Gum	Exotic	NT
47	*Eucalyptus grandis* W.Hill ex Maiden	Myrtaceae	मसला (Masala)	Rose Gum	Exotic	NT
48	*Eucalyptus robusta* Sm.	Myrtaceae	मसला (Masala)	Swamp Mahogany	Exotic	NT
49	*Ficus auriculata* Lour.	Moraceae	तिमिला (Timila), निमारो (Nimaro)	Elephant Ear Fig	Native	LC
50	*Ficus benghalensis* L.	Moraceae	बर (Bar)	Banyan Fig	Native	NE
51	*Ficus benjamina* L.	Moraceae	समी (Sami), स्वामी (Swami)	Weeping Fig	Native	LC
52	*Ficus elastica* Roxb. ex Hornem.	Moraceae	रबर (Rabar)	Rubber Tree	Uncertain	LC
53	*Ficus glaberrima* Blume	Moraceae	पाखुरी (Pakhuri)	-	Native	LC
54	*Ficus hispida* L.f.	Moraceae	खस्रेटो (Khasreto)	Hairy Fig	Native	LC
55	*Ficus lacor* Buch.-Ham.	Moraceae	काब्रो (Kabro)	Java Fig	Native	NE
56	*Ficus religiosa* L.	Moraceae	पिपल (Pipal)	Sacred Fig	Native	LC
57	*Ficus semicordata* Buch.-Ham. ex Sm.	Moraceae	खनायो (Khanayo), खन्यु (Khanyu)	Drooping Fig	Native	LC
58	*Flacourtia jangomas* (Lour.) Raeusch.	Salicaceae	पनेली (Paneli), करेली (Kareli)	Coffee Plum	Native	NE
59	*Ginkgo biloba* L.	Ginkgoaceae	बाल कुमारी (Bal kumari)	Maiden Hair Tree	Exotic	EN
60	*Grevillea robusta* A.Cunn. ex R.Br.	Proteaceae	काँगियो फूल (Kangiyo phul)	Silk Oak	Exotic	LC
61	*Grewia optiva* J.R.Drumm. ex Burret	Malvaceae	भिमाल (Bhimal), स्याल फुस्रे (Syal fusre)	Bihul	Native	LC
62	*Gymnosporia rufa* (Wall.) Hook.f.	Celastraceae	काँडे खसु (Kande khasru), केशरी (Keshari)	Rusty Spike Thorn	Native	LC
63	*Hesperocyparis lusitanica* (Mill.) Bartel	Cupressaceae	-	Mexican cypress	Exotic	LC

64	*Hesperocyparis macrocarpa* (Hartw.) Bartel	Cupressaceae	गोल्डक्रेस्ट धुपी (GoldCrest Dhupi)	Monterey Cypress	Exotic	VU
65	*Homalium napaulense* (DC.) Benth.	Salicaceae	कुफ्रे (Kuphre)	Kuphre	Native	NE
66	*Ilex excelsa* (Wall.) Voigt	Aquifoliaceae	निर स्याउल (Nir syaul), पुवाले (Puwale)	-	Native	LC
67	*Jacaranda mimosifolia* D.Don	Bignoniaceae	निल फूल (Nil phul)	Blue Mimosa	Exotic	VU
68	*Juglans regia* L.	Juglandaceae	ओखर (Okhar)	Common Walnut	Uncertain	LC
69	*Juniperus chinensis* L.	Cupressaceae	-	Chinese Juniper	Exotic	LC
70	*Juniperus recurva* Buch.-Ham. ex D.Don	Cupressaceae	धुपी (Dhupi), भैरुँग धुपी (Bhairung dhupi)	Drooping Juniper	Native	LC
71	*Lagerstroemia indica* L.	Lythraceae	असारे फूल (asare phul)	Crape myrtle	Uncertain	LC
72	*Lagerstroemia speciosa* (L.) Martyn	Lythraceae	ठूलो असारे फूल (Thulo asare phul)	Queen Crape Myrtle	Exotic	LC
73	*Leucaena leucocephala* (Lam.) de Wit	Fabaceae	सेतो बबुल (Seto babul)	Ipil-Ipil, White Lead Tree	Exotic/N	NE
74	*Ligustrum lucidum* W.T.Aiton	Oleaceae	-	Glossy privet	Native	LC
75	*Lithocarpus elegans* (Blume) Hatus. ex Soepadmo	Fagaceae	अर्खौलो (Arkhaulo)	Elegant Himalayan Oak	Native	LC
76	*Litsea monopetala* (Roxb.) Pers.	Lauraceae	कुटमिरो (Kutmiro), कदमेरो (Kadmero)	Many-Flowered Litsea	Native	LC
77	*Livistona chinensis* (Jacq.) R.Br. ex Mart.	Arecaceae	-	Chinese Fan Palm	Exotic	LC
78	*Lyonia ovalifolia* (Wall.) Drude	Ericaceae	अङ्गेरी (Angeri)	Staggerbush	Native	LC
79	*Macadamia integrifolia* Maiden & Betche	Proteaceae	-	Macadamia Nut	Exotic	VU
80	*Machilus duthiei* King ex Hook.f.	Lauraceae	काठे काउलो (Kathe kaulo)	Lanceleaf Bay Tree	Native	LC
81	*Madhuca longifolia* (L.) J.F.Macbr.	Sapotaceae	महुवा (Mahuwa)	Indian Butter Tree	Native	LC
82	*Magnolia champaca* (L.) Baill. ex Pierre	Magnoliaceae	सुन चाँप (Sun chanp)	Champak	Uncertain	LC
83	*Magnolia grandiflora* L.	Magnoliaceae	रुख कमल (Rukh kamal)	Southern Magnolia	Exotic	LC
84	*Mallotus philippensis* (Lam.) Müll.Arg.	Euphorbiaceae	सिन्दूरे (Sindure), रोहिणी (Rohini)	Kaamala Tree	Native	LC
85	*Mangifera indica* L.	Anacardiaceae	आँप (Aap)	Mango	Exotic/N	DD
86	*Melaleuca citrina* (Curtis) Dum.Cours.	Myrtaceae	कल्की फूल (Kalki phul)	Bottle Brush Tree	Exotic	NE

87	*Melia azedarach* L.	Meliaceae	बकाइनु (Bakainu)	China Berry	Native	LC
88	*Morus alba* L.	Moraceae	किम्बु (Kimbu)	Common Mulberry	Exotic	LC
89	*Morus serrata* Roxb.	Moraceae	कालो काफल (Kalo kaphal), किम्बु (Kimbu)	Himalayan Mulberry	Native	NE
90	*Neolitsea cuipala* (D.Don) Kosterm.	Lauraceae	कल्चे (Kalche)	Woolly Litsea	Native	LC
91	*Nerium oleander* L.	Apocynaceae	करवीर (Karbir)	Oleander	Exotic	LC
92	*Nyctanthes arbor-tristis* L.	Oleaceae	पारिजात (Parijat)	Night-Flowering Jasmine	Native	LC
93	*Osmanthus fragrans* Lour.	Oleaceae	सिरिङ्गे (Siringe)	Fragrant Olive	Native	LC
94	*Pachygone laurifolia* (DC.) L.Lian & Wei Wang	Menispermaceae	तिलफोरा (Tilphora)	Laurel-Leaved Snail Tree	Native	NE
95	*Paulownia tomentosa* (Thunb.) Steud.	Paulowniaceae	पउलोनिया	Princess Tree	Exotic	LC
96	*Persea americana* Mill.	Lauraceae	घिउफल (Ghiuphal)	Avocado	Exotic	LC
97	*Phoenix sylvestris* (L.) Roxb.	Arecaceae	खजुर (Khajur)	Date Palm	Native	NE
98	*Phyllanthus emblica* L.	Phyllanthaceae	अमला (Amala)	Indian Gooseberry	Uncertain	LC
99	*Pinus roxburghii* Sarg.	Pinaceae	खोटे सल्ला (Khote salla)	Chir Pine	Native	LC
100	*Platanus orientalis* L.	Platanaceae	चिनार (Chinar)	Oriental Plane Tree	Exotic	DD
101	*Platycladus orientalis* (L.) Franco	Cupressaceae	मयूर पङ्खी (Mayur pankhi)	Oriental Arborvitae	Exotic	NT
102	*Plumeria rubra* L.	Apocynaceae	चुवा फूल (Chuwa phul)	Red Frangipani	Exotic	LC
103	*Podocarpus neriifolius* D.Don	Podocarpaceae	गुन्सी (Gunsi), काठे सल्लो (Kathe sallo);	Brown Pine	Native	LC
104	*Populus nigra* L.	Salicaceae	लहरे पिपल	Poplar,	Exotic	DD
105	*Prunus armeniaca* L.	Rosaceae	खुर्पानी (Khurpani)	Apricot	Exotic/N	DD
106	*Prunus cerasoides* Buch.-Ham. ex D.Don	Rosaceae	पैंयु (Painyu)	Himalayan Cherry	Native	LC
107	*Prunus persica* (L.) Batsch	Rosaceae	आरु (Aaru)	Peach	Exotic	NE
108	*Psidium guajava* L.	Myrtaceae	अम्बा (Amba), बेलौती (Belauti)	Guava	Exotic/N	LC
109	*Punica granatum* L.	Lythraceae	अनार (Anar), दारिम (Darim)	Pomegranate	Exotic/N	LC

110	*Pyrus communis* L.	Rosaceae	नासपाती (Naspati)	Common Pear	Exotic	LC
111	*Pyrus pashia* Buch.-Ham. ex D.Don	Rosaceae	मयल (Mayal)	Himalayan Pear	Native	LC
112	*Quercus lanata* Sm.	Fagaceae	बांझ (Banjh)	Woolly-Leaved Oak	Native	LC
113	*Ravenea rivularis* Jum. & H.Perrier	Arecaceae	-	Majesty Palm	Exotic	VU
114	*Ricinus communis* L.	Euphorbiaceae	अँडेर (Ander);	Castor Oil Plant	Exotic/N	LC
115	*Salix babylonica* L.	Salicaceae	बैंस (Bains), तिस्सी (Tissi)	Babylon Willow	Exotic	DD
116	*Sapindus mukorossi* Gaertn.	Sapindaceae	रीट्ठा (Rittha)	Soap Nut Tree	Uncertain	LC
117	*Schima wallichii* (DC.) Korth.	Theaceae	चिलाउने (Chilaune)	Needlewood Tree	Native	LC
118	*Solanum betaceum* Cav.	Solanaceae	रुख गोलभेंडा (Rukh golbhenda)	Tree Tomato	Exotic	DD
119	*Stranvaesia nussia* (Buch.-Ham. ex D.Don) Decne.	Rosaceae	जुरे मयल (Jure mayal)	Indo-China Chokeberry	Native	LC
120	*Syzygium cumini* (L.) Skeels	Myrtaceae	कालो जामुन (Kalo jamun)	Black Plum	Native	LC
121	*Syzygium jambos* (L.) Alston	Myrtaceae	गुलाब जामुन (Gulab jamun)	Malabar Plum	Uncertain	LC
122	*Tecoma stans* (L.) Juss. ex Kunth	Bignoniaceae	घटा पुष्प (Ghata puspa)	Savari	Exotic	LC
123	*Tectona grandis* L.f.	Lamiaceae	टिक (Tik)	Teak Tree	Exotic	EN
124	*Trachycarpus fortunei* (Hook.) H.Wendl.	Arecaceae	-	Chinese Windmill Palm	Exotic	LC
125	*Xylosma controversa* Clos	Salicaceae	डाँडे काँडा (Dande kanda)	-	Native	LC
126	*Yucca gigantea* Lem.	Asparagaceae	केत्तुके (Kettuke)	Spineless Yucca	Exotic	NE
127	*Ziziphus incurva* Roxb.	Rhamnaceae	हाडे बयर (Hade bayar)	Common Jujube	Native	LC

Appendix 2: Shrub species found in Urban Green Spaces

SN	Name of species	Family	Nepali name	Common Name	Origin	IUCN Red List
1	*Abelmoschus manihot* (L.) Medik.	Malvaceae	वन नालु (Ban nalu), वन कपास (Ban kapas)	Sweet Hibiscus	Native	DD
2	*Ageratina adenophora* (Spreng.) R.M.King & H.Rob.	Asteraceae	बोके घाँस (Boke ghans)	Billygoat Weed	Exotic	NE

3	*Begonia cucullata* Willd.	Begoniaceae	-	Clubed Begonia	Exotic	NE
4	*Benkara fasciculata* (Roxb.) Ridsdale	Rubiaceae	-	-	Native	LC
5	*Berberis aristata* DC.	Berberidaceae	चुत्रो (Chutro), रसाजन (Rasajan)	Barberry	Native	LC
6	*Berberis napaulensis* (DC.) Spreng.	Berberidaceae	जमाने मान्द्रो (Jamane mandro)	Nepal Barberry	Native	NE
7	*Bergera koenigii* L.	Rutaceae	कडी पत्ता (Kadi patta)	Curry Leaf Tree	Native	LC
8	*Boehmeria virgata* (G.Forst.) Guill.	Urticaceae	भरौं (Bharaun)	Ramie	Native	LC
9	*Brucea javanica* (L.) Merr.	Simaroubaceae	भकि अमिलो (Bhaki amilo)	Macassar kernels	Native	LC
10	*Brugmansia suaveolens* (Humb. & Bonpl. ex Willd.) Sweet	Solanaceae	धतुरे फूल (Dhature phul)	Angel's Trumpet	Exotic/N	EW
11	*Brunfelsia pauciflora* (Cham. & Schltdl.) Benth.	Solanaceae	निल जाई (Nil jai)	Yesterday,Today& Tomorrow	Exotic	LC
12	*Buxus sempervirens* L.	Buxaceae	-	Boxwood, Common Box	Exotic	LC
13	*Callianthe picta* (Gillies ex Hook. & Arn.) Donnell	Malvaceae	-	Painted Mallow	Exotic	NE
14	*Callicarpa macrophylla* Vahl	Lamiaceae	दहीचाम्ले (Dahichamle), गुयाँलो (Guyanlo)	Large-Leaf Beauty Berry	Native	LC
15	*Calotropis gigantea* (L.) W.T.Aiton	Apocynaceae	आँक (Ank), सेतो आँक (Seto ank)	Crown Flower	Native	NE
16	*Camellia japonica* L.	Theaceae	चिनिया गुराँस (Chiniya gurans)	China Rose	Exotic	LC
17	*Catunaregam spinosa* (Thunb.) Tirveng.	Rubiaceae	मैदाल (Maidal), मैन फल (Main phal)	Spiny Randia	Native	LC

25	*Codiaeum variegatum* (L.) Rumph. ex A.Juss.	Euphorbiaceae	-	Garden Croton	Exotic	LC
26	*Cordyline fruticosa* (L.) A.Chev.	Asparagaceae	-	Ti Plant	Exotic	LC
27	*Cycas revoluta* Thunb.	Cycadaceae	कलवल (Kalwal)	Sago Palm	Exotic	LC
28	*Diospyros kaki* Thunb.	Ebenaceae	हलुवाबेद (Haluwabed)	Japanese Persimmon	Exotic	LC
29	*Dracaena fragrans* (L.) Ker Gawl.	Asparagaceae	-	Corn Plant	Exotic	LC
30	*Euonymus hamiltonianus* Wall.	Celastraceae	वन चितु (Ban chitu), निल डाँठे (Nil danthe)	Spindle Tree	Native	LC
31	*Euonymus japonicus* Thunb.	Celastraceae	-	Japanese Euonymus	Exotic	NE
32	*Euphorbia cotinifolia* L.	Euphorbiaceae	-	Smoke Tree Spurge	Exotic	LC
33	*Euphorbia neriifolia* L.	Euphorbiaceae	सिजा (Sija)	Indian Spurge Tree	Uncertain	LC
34	*Euphorbia pulcherrima* Willd. ex Klotzsch	Euphorbiaceae	लालुपाते (Lalupate)	Poinsettia	Exotic	LC
35	*Eurya acuminata* DC.	Pentaphylacaceae	भिगाने (Jhigane), टिन्गर (Tinger),	Edible Leaf Eurya	Native	LC
36	*Gardenia jasminoides* J.Ellis	Rubiaceae	इन्द्र कमल (Indra kamal)	Cape Jasmine	Exotic	LC
37	*Hibiscus mutabilis* L.	Malvaceae	नालु फूल (Nalu phul)	Cotton Rose	Exotic	NE
38	*Hibiscus* × *rosa-sinensis* L.	Malvaceae	घन्टी फूल (Ghanti phul)	China Rose	Exotic	NE
39	*Hibiscus syriacus* L.	Malvaceae	दतिवने फूल (Datiwane phul)	Rose of Sharon	Exotic	NE
40	*Hydrangea macrophylla* (Thunb.) Ser.	Hydrangeaceae	हँसराज (Hansraj)	Common Hydrangea	Exotic	NE
41	*Hypericum cordifolium* Choisy	Hypericaceae	अरेटो (Areto), अरेली (Areli)	-	Native	NE
42	*Justicia adhatoda* L.	Acanthaceae	असुरो (Asuro)	Malabar Nut	Native	LC
43	*Justicia brandegeeana* Wassh. & L.B.Sm.	Acanthaceae	-	Shrimp Plant	Exotic	NE
44	*Justicia carnea* Lindl.	Acanthaceae	-	Brazilian Plume Flower	Exotic	NE
45	*Lantana camara* L.	Verbenaceae	मसिनो काँडा (Masino kanda)	Wild Sage	Exotic	NE
46	*Ligustrum sinense* Lour.	Oleaceae	केरी (Keri)	Chinese Privet	Uncertain	LC
47	*Luculia gratissima* (Wall.) Sweet	Rubiaceae	दराभरी (Daravari), गाई फूल (Gai phul)	Pleasant Luculia	Native	LC

48	*Lycium barbarum* L.	Solanaceae	-	Common Matrimony Vine	Exotic/N	NE
49	*Maesa chisia* D.Don	Primulaceae	बिलौनी (Bilauni)	Chisia Wild Berry	Native	NE
50	*Malvaviscus arboreus* Dill. ex Cav.	Malvaceae	बाहमासे (Barhamase)	Turk' Scap, Wax Mallow	Exotic	LC
51	*Muehlenbeckia platyclada* (F.Muell.) Meisn.	Polygonaceae	-	Tapeworm Plant	Exotic	NE
52	*Murraya paniculata* (L.) Jack	Rutaceae	कामिनी फूल (Kamini phul)	Orange Jasmine	Native	NE
53	*Opuntia monacantha* Haw.	Cactaceae	नागफनी काँडा (Nagphani kanda)	Prickly Pear	Exotic/N	LC
54	*Pandanus furcatus* Roxb.	Pandanaceae	केउरा (Keura), वनतरी (Bantari)	Himalayan Screw Pine	Native	NE
55	*Pouzolzia rugulosa* (Wedd.) Acharya & Kravtsova	Urticaceae	दार (Dar), गेथा (Getha), गिथी (Githi)	-	Native	LC
56	*Reinwardtia indica* Dumort.	Linaceae	बाखे घाँस (Bakhre ghans), प्याउली (Pyauli)	Winter Flax	Native	NE
57	*Rhapis excelsa* (Thunb.) A.Henry	Arecaceae	-	Lady Palm, Bamboo Palm	Exotic	LC
58	*Rhododendron simsii* Planch.	Ericaceae	-	Azaleas	Exotic	NE
59	*Rosa chinensis* Jacq.	Rosaceae	अत्तर गुलाफ (Attar gulaf)	Rose	Exotic	NE
60	*Sambucus canadensis* L.	Viburnaceae	कनिके फूल (Kanike phul)	American Elder	Exotic	NE
61	*Santalum album* L.	Santalaceae	श्रीखण्ड (Shrikhanda), चन्दन (Chandan)	Sandalwood	Exotic	VU
62	*Sarcococca coriacea* (Hook.) Sweet	Buxaceae	फितिफिया (Fitiphiya)	Thickleaf Sweet-Box	Native	NE
63	*Senna didymobotrya* (Fresen.) H.S.Irwin & Barneby	Fabaceae	गैंडे फूल (Gainde phul)	African Senna	Exotic	LC
64	*Solanum mauritianum* Scop.	Solanaceae	-	Tobacco	Exotic	NE
65	*Solanum pseudocapsicum* L.	Solanaceae	बिही (Bihi), खोर्सने भरकार (Khorsane jhar)	Jerusalem Cherry	Exotic/N	NE
66	*Solanum torvum* Sw.	Solanaceae	ठूलो बिही (Thulo bihi), सेती बिही (Seti bihi)	Devil's Fig	Exotic/N	NE
67	*Solanum viarum* Dunal	Solanaceae	काँडे भन्टा (Kande bhanta)	Tropical Soda Apple	Exotic/N	LC
68	*Solanum violaceum* Ortega	Solanaceae	निलो बिहि (Nilo Bihi)	Indian Nightshade	Uncertain	NE
69	*Spiraea cantoniensis* Lour.	Rosaceae	-	Reeves' Spirea	Exotic	LC
70	*Symplocos paniculata* (Thunb.) Miq.	Symplocaceae	लोध (Lodh), चम्लानी (Chamlanee)	Sapphire Berry	Native	LC

71	*Urena lobata* L.	Malvaceae	नालु कुरो (Nalu kuro)	Caesarweed	Native	LC
72	*Yucca gloriosa* L.	Asparagaceae	केत्तुके (Kettuke)	Spanish Dagger	Exotic	LC
73	*Zanthoxylum armatum* DC.	Rutaceae	पपरे टिमुर (Parpare timur)	Nepal Pepper	Native	LC

Appendix 3: Subshrub species found in Urban Green Spaces

SN	Name of species	Family	Nepali name	Common Name	Origin	IUCN Red List
1	*Achyranthes bidentata* Blume	Amaranthaceae	दतिवन (Datiwan)	Ox Knee	Native	NE
2	*Aeonium arboreum* (L.) Webb & Berthel.	Crassulaceae	-	Tree Aeonium	Exotic	NE
3	*Agave attenuata* Salm-Dyck	Asparagaceae	-	Foxtail, Lion's Tail	Exotic	LC
4	*Alocasia cucullata* (Lour.) G.Don	Araceae	-	Chinese Taro	Uncertain	NE
5	*Alternanthera philoxeroides* (Mart.) Griseb.	Amaranthaceae	जल जम्बु (Jal jambu)	Aligator Weed	Exotic	NE
6	*Alternanthera sessilis* (L.) DC.	Amaranthaceae	भिरिङ्गी भार (Bhiringi jhar)	Amaranthus Weed	Native	LC
7	*Antirrhinum majus* L.	Plantaginaceae	भ्यागुते फूल (Bhyagute phul)	Snapdragon	Exotic	NE
8	*Asclepias curassavica* L.	Apocynaceae	खुर्मानी फूल (Khursani phul)	Blood Flower	Exotic	NE
9	*Barleria cristata* L.	Acanthaceae	भेंडे कुरो (Bhende kuro)	Philippine Violet	Native	NE
10	*Begonia coccinea* Hook.	Begoniaceae	-	Angel Wing Begonia	Exotic	NE
11	*Blumea aromatica* DC.	Asteraceae	-	-	Native	NE
12	*Blumea axillaris* (Lam.) DC.	Asteraceae	-	Pink Blumea	Native	NE
13	*Brassica oleracea* L.	Brassicaceae	-	Ornamental Cabbage	Exotic	DD
14	*Callisia fragrans* (Lindl.) Woodson	Commelinaceae	-	Basket Plant	Exotic	NE
15	*Callisia repens* (Jacq.) L.	Commelinaceae	-	Turtle Vine	Exotic	NE
16	*Catharanthus roseus* (L.) G.Don	Apocynaceae	नयन तारा (Nayan tara)	Periwinkle	Exotic	NE
17	*Coleus scutellarioides* (L.) Benth.	Lamiaceae	-	Beauty of Lyon	Exotic	NE

18	*Crassula ovata* (Mill.) Druce	Crassulaceae	--	Jade Plant	Exotic	NE
19	*Cuphea hyssopifolia* Kunth	Lythraceae	-	Mexican Heather	Exotic	NE
20	*Cyathula capitata* Moq.	Amaranthaceae	-	Roundhead Pastureweed	Native	NE
21	*Dianthus barbatus* L.	Caryophyllaceae	-	Sweet William	Exotic	NE
22	*Dicliptera bupleuroides* Nees	Acanthaceae	खुर्सानि (Khursane)	Thorowax Foldwing	Native	NE
23	*Euphorbia milii* Des Moul.	Euphorbiaceae	सिम्री (Simri)	Crown-of-Thorns	Exotic	LC
24	*Gazania rigens* (L.) Gaertn.	Asteraceae	-	Treasure Flower	Exotic	NE
25	*Graptopetalum paraguayense* (N.E.Br.) E.Walther	Crassulaceae	-	Ghost Plant	Exotic	NE
26	*Hydrangea febrifuga* (Lour.) Y.De Smet & C.Granados	Hydrangeaceae	असेरु (Aseru), वन्सुली (Bansuli)	Blue Himalayan Hydrangea	Uncertain	NE
27	*Hydrocotyle sibthorpioides* Lam.	Araliaceae	टिके घोरताप्रे (Tike ghortapre)	Water Pennywort	Native	LC
28	*Hypoestes phyllostachya* Baker	Acanthaceae	टिकटिके भार (Tiktike jhar)	Polka Dot Plant	Exotic/N	NE
29	*Impatiens walleriana* Hook.f.	Balsaminaceae	-	Japanese balsam	Exotic	NE
30	*Iresine diffusa* Humb. & Bonpl. ex Willd.	Amaranthaceae	आयोतिन फुल (Ayotin phul)	Herbst's Blood Leaf	Exotic	NE
31	*Kalanchoe crenata* (Andrews) Haw.	Crassulaceae	-	Scalloped Kalanchoe	Exotic	NE
32	*Kalanchoe prolifera* (Bowie ex Hook.) Raym.-Hamet	Crassulaceae	-	Blooming Boxes	Exotic	NE
33	*Lepidagathis incurva* Buch.-Ham. ex D.Don	Acanthaceae	सेतो फूली (Seto fuli), हातकाटे (Hatkate)	Curved Lepidagathis	Native	NE
34	*Lobularia maritima* (L.) Desv.	Brassicaceae	-	Sweet Alyssum	Exotic	NE
35	*Malvastrum coromandelianum* (L.) Garcke	Malvaceae	घटा पत्रा (Ghata patra)	--	Exotic/N	NE
36	*Matthiola incana* (L.) W.T.Aiton	Brassicaceae	-	Stocks	Exotic	NE
37	*Mazus pumilus* (Burm.f.) Steenis	Mazaceae	मालती भार (Malati jhar)	Japanese mazus	Native	NE
38	*Ocimum tenuiflorum* L.	Lamiaceae	कृष्ण तुलसी (Krishna tulasi)	Holy basil	Native	NE
39	*Ophiorrhiza fasciculata* D.Don	Rubiaceae	गर्दैनो (Gardaino), मुसाकाने (Musakane)	Fascicled-Flower Snake-root	Native	NE
40	*Ouret sanguinolent*a (L.) Kuntze	Amaranthaceae	अैतिनबोट (Aitinbot)	Climbing Wool-Plant	Native	NE

41	*Phyllanthus parvifolius* Buch.-Ham. ex D.Don	Phyllanthaceae	खरेटो (Khareto)	-	Native	NE
42	*Pilea peperomioides* Diels	Urticaceae	-	Chinese Money Plant	Exotic	NE
43	*Rhynchostylis retusa* (L.) Blume	Orchidaceae	घोडे गाभा (Ghode gava)	Foxtail Orchid	Native	NE
44	*Ruellia simplex* C.Wright	Acanthaceae	-	Desert Petunia	Exotic/N	NE
45	*Rungia pectinata* (L.) Nees	Acanthaceae	उकुची भार (Ukuchi jhar)	Comb Rungia	Native	NE
46	*Salvia coccinea* Buc'hoz ex Etl.	Lamiaceae	--	Texas Sage	Exotic	NE
47	*Salvia splendens* Sellow ex Nees	Lamiaceae	ठूलो ल्वाङ्ग फूल (Thulo Lwang Phool)	Scarlet Sage	Exotic	NE
48	*Sedum morganianum* E.Walther	Crassulaceae		Donkey's Tail	Exotic	NE
49	*Senna occidentalis* (L.) Link	Fabaceae	कसौडी (Kasaudi), ताप्रे (Tapre)	Coffee Senna	Exotic	LC
50	*Serissa japonica* (Thunb.) Thunb.	Rubiaceae	-	Snow rose	Exotic	NE
51	*Sida rhombifolia* L.	Malvaceae	सानो चिल्या (Sano chilya)	Rhombic-Leaf Sida	Native	NE
52	*Tradescantia fluminensis* Vell.	Commelinaceae	सेतो खाने फूल (Seto khane phul)	Wandering Jew	Exotic/N	NE
53	*Tradescantia pallida* (Rose) D.R.Hunt	Commelinaceae	-	Purple Heart	Exotic	NE
54	*Tradescantia spathacea* Sw.	Commelinaceae	-	Oyster Plant	Exotic	NE
55	*Tradescantia zebrina* Bosse	Commelinaceae	-	Striped Wandering Jew	Exotic	NE
56	*Veronica anagallis-aquatica* L.	Plantaginaceae	धाप्रे भार (Dhapre jhar)	Blue Water-Speedwell	Native	LC
57	*Viola tricolor* L.	Violaceae	-	Pansy	Exotic	NE

Appendix 4: Herb species found in Urban Green Spaces

SN	Name of species	Family	Nepali name	Common Name	Origin	IUCN Red List
1	*Aechmea gamosepala* Wittm.	Bromeliaceae	-	Matchstick Bromeliad	Exotic	NE
2	*Agapanthus africanus* (L.) Hoffmanns.	Amaryllidaceae	निरकमल (Nirkamal)	Blue African Lily	Exotic	NE

3	*Agave sisalana* Perrine	Asparagaceae	-	Sisal Agave	Exotic	NE
4	*Ageratum houstonianum* Mill.	Asteraceae	निलो गन्धे (Nilo gandhe)	Blueweed	Exotic	NE
5	*Aloe vera* (L.) Burm.f.	Asphodelaceae	घिउकुमारी (Ghiukumari)	Barbados Aloe	Exotic	NE
6	*Alopecurus aequalis* Sobol.	Poaceae	-	Orange Foxtail	Native	LC
7	*Amaranthus caudatus* L.	Amaranthaceae	लट्टे दाना (Latte dana)	Foxtail Amaranth	Exotic	NE
8	*Amaranthus cruentus* L.	Amaranthaceae	लट्टे घाँस (Latte ghans)	Red Amaranth	Exotic/ N	NE
9	*Amaranthus spinosus* L.	Amaranthaceae	वन लुँडे (Ban lunde)	Spiny Pigweed	Exotic	NE
10	*Anethum graveolens* L.	Apiaceae	सोया (Soya)	Dill	Exotic	NE
11	*Artemisia dubia* Wall. ex Besser	Asteraceae	तितेपाती (Titepati)	East-Asian Wormwood	Native	NE
12	*Artemisia indica* Willd.	Asteraceae	तिते पाति (Titepati)	Indian Wormwood	Native	NE
13	*Arundo donax* L.	Poaceae	ठूलो नर्कट (Thulo narkat)	Giant Reed	Native	LC
14	*Asparagus officinalis* L.	Asparagaceae	कुरिलो (Kurilo)	Asparagus	Exotic	LC
15	*Aspidistra elatior* Blume	Asparagaceae	-	Cast-Iron-Plant	Exotic	NE
16	*Axonopus compressus* (Sw.) P.Beauv.	Poaceae	ठूलोबन्सो (Thulo banso)	Cow Grass	Exotic/N	LC
17	*Bambusa balcooa* Roxb.	Poaceae	वन बाँस (Ban bans)	Balcooa Bamboo	Native	NE
18	*Begonia* × *erythrophylla* Hérincq	Begoniaceae	-	Beefsteak Begonia	Exotic	NE
19	*Bellis perennis* L.	Asteraceae	-	English Daisy	Exotic	NE
20	*Bidens pilosa* L.	Asteraceae	तिखे कुरो (Tikhe kuro)	Black Fellows	Exotic	NE
21	*Bothriospermum zeylanicum* (J.Jacq.) Druce	Boraginaceae	-	Leaf between flower	Native	NE
22	*Brassica rapa* L.	Brassicaceae	गान्टेमूला (Gantemula), शलगम (Shalgam)	Turnip	Exotic	NE
23	*Calanthe tankervilleae* (Banks) M.W.Chase, Christenh. & Schuit.	Orchidaceae	-	Nun's Orchid	Native	NE
24	*Calendula officinalis* L.	Asteraceae	असर्फी फूल (Asarfi phul)	Pot Marigold	Exotic	NE

25	*Campanula cana* Wall.	Campanulaceae	-	Hoary Bellflower	Native	NE
26	*Canna indica* L.	Cannaceae	गने सर्बदा (Gane sarbada)	Wild canna	Exotic	NE
27	*Cannabis sativa* L.	Cannabaceae	भाङ (Bhang), गाँजा (Ganja)	Hemp, Marijuana	Exotic/N	NE
28	*Capsella bursa-pastoris* (L.) Medik.	Brassicaceae	चाल्ने (Chalne), चम्सुरे भार (Chamsure jhar)	Shepherd's Purse	Uncertain/N	NE
29	*Centella asiatica* (L.) Urb.	Apiaceae	घोड्टाप्रे (Ghodtapre)	Water Pennywort	Native	LC
30	*Chenopodium album* L.	Amaranthaceae	बेथे साग (Bethe sag)	Bathua	Native	NE
31	*Chlorophytum comosum* (Thunb.) Jacques	Asparagaceae	-	Spider Plant	Exotic	NE
32	*Chrysanthemum* × *morifolium* (Ramat.) Hemsl.	Asteraceae	गोदावरी फूल (Godawari phul)	Florist's Chrysanthemum	Exotic	NE
33	*Cirsium wallichii* DC.	Asteraceae	थाकल (Thakal)	Long-Spine Thistle	Native	NE
34	*Clivia miniata* (Lindl.) Verschaff.	Amaryllidaceae	-	Kafir Lily	Exotic	NE
35	*Colocasia esculenta* (L.) Schott	Araceae	कर्कलो (Karkalo), गाभा (Gava)	Coco Yam	Native	LC
36	*Coreopsis pubescens* Elliott	Asteraceae	-	Star Tickseed	Exotic	NE
37	*Coriandrum sativum* L.	Apiaceae	धनियाँ (Dhaniyan)	Coriander	Exotic	NE
38	*Craniotome furcata* (Link) Kuntze	Lamiaceae	बाटुले सिलाम (Batule silam)	Multicolored Catmint	Native	NE
39	*Crassocephalum crepidioides* (Benth.) S.Moore	Asteraceae	अनिकाले भार (Anikale jhar)	Redflower ragleaf	Exotic/N	NE
40	*Crocosmia* × *crocosmiiflora* (Lemoine) N.E.Br.	Iridaceae	-	Montbretia	Exotic	NE
41	*Curculigo capitulata* (Lour.) Kuntze	Hypoxidaceae	-	Palm Star Grass	Native	NE
42	*Curcuma zedoaria* (Christm.) Roscoe	Zingiberaceae	कचुर (Kachur)	Zeodary	Exotic	DD
43	*Cuscuta reflexa* Roxb.	Convolvulaceae	आकाश बेली (Akash beli), अमरलता (Amarlata)	Giant Dodder	Native	LC
44	*Cynodon dactylon* (L.) Pers.	Poaceae	दुबो (Dubo)	Bermuda Grass	Native	NE
45	*Cynoglossum lanceolatum* Forssk.	Boraginaceae	कुरो (Kuro)	Lanceleaf Forget-Me-Not	Native	NE
46	*Cyperus alternifolius* L.	Cyperaceae	छाता मोथे (Chhaataa Mothe)	Umbrella palm	Exotic/N	LC

47	*Dahlia pinnata* Cav.	Asteraceae	लाहुरे फूल (Lahure phul)	Garden Dahlia	Exotic	NE
48	*Datura stramonium* L.	Solanaceae	सेतो धतुरो (Seto dhaturo)	Thorn Apple	Exotic/N	NE
49	*Delphinium ajacis* L.	Ranunculaceae	-	Larkspur	Exotic	NE
50	*Dendrocalamus hookeri* Munro	Poaceae	भालु बाँस (Bhalu bans)	Bamboo	Native	NE
51	*Dendrocalamus strictus* (Roxb.) Nees	Poaceae	तारु बाँस (Taru bans), माल बाँस (Mal bans)	Hard bamboo	Native	NE
52	*Dichrocephala integrifolia* (L.f.) Kuntze	Asteraceae	हाछ्युँ भरार (Hachyun jhar)	Sneeze Weed	Native	NE
53	*Dracaena trifasciata* (Prain) Mabb.	Asparagaceae	-	Snake Plant	Exotic	NE
54	*Drymaria diandra* Blume	Caryophyllaceae	अभिजालो (Abhijalo)	Golondrina	Native	NE
55	*Dyckia brevifolia* Baker	Bromeliaceae	-	Sawblade	Exotic	NE
56	*Erigeron annuus* (L.) Desf.	Asteraceae	-	Annual Fleabane	Exotic/N	NE
57	*Erigeron sumatrensis* Retz.	Asteraceae	-	Tall Fleabane	Exotic/N	NE
58	*Euphorbia heterophylla* L.	Euphorbiaceae	मैतुला भार (Maitula jhar)	Wild Poinsettia	Exotic/N	LC
59	*Fagopyrum esculentum* Moench	Polygonaceae	मिठो फापर (Mitho fapar)	Buckwheat	Exotic	NE
60	*Galinsoga quadriradiata* Ruiz & Pav.	Asteraceae	झुसे चितलाङगे (Jhuse chitlange)	Shaggy Soldier	Exotic	NE
61	*Galium asperifolium* Wall.	Rubiaceae	चितु (Chitu), कुरकुरे घाँस (Kurkure ghans)	Rough-Leaved Clivers	Native	NE
62	*Gamochaeta pensylvanica* (Willd.) Cabrera	Asteraceae	-	Pennsylvania Cudweed	Exotic/N	NE
63	*Gasteria obliqua* (Aiton) Duval	Asphodelaceae	-	Lawyer's Tongue	Exotic	NE
64	*Geranium nepalense* Sweet	Geraniaceae	चुनित्रो घाँस (Chunitro ghans)	Nepal Geranium	Native	NE
65	*Gladiolus* × *hybridus* C.Morren	Iridaceae	तरवारे फूल (Tarbare phul)	Gladiolus	Exotic	NE
66	*Gonostegia hirta* (Blume) Miq.	Urticaceae	चिप्ले घाँस (Chiple ghans)	Hairy Pouzolz's Bush	Native	NE
67	*Hemerocallis fulva* (L.) L.	Asphodelaceae	दिनशोभा (Dinshova)	Orange Day Lily	Exotic	NE
68	*Hippeastrum vittatum* (L'Hér.) Herb.	Amaryllidaceae	ध्वाङ्ग फूल (Dhwang phul)	Barbados Lily	Exotic	NE
69	*Hordeum vulgare* L.	Poaceae	जौ (Jau)	Barley	Exotic	NE

70	*Impatiens balsamina* L.	Balsaminaceae	तिउरी (Tiuree)	Garden Balsam	Exotic/N	NE
71	*Imperata cylindrica* (L.) Raeusch.	Poaceae	सिरु (Siru)	Cogon Grass	Uncertain	NE
72	*Laggera alata* (D.Don) Sch.Bip. ex Oliv.	Asteraceae	मनाग्रे भार (Managre jhar)	Winged-Stem Laggera	Native	NE
73	*Lotus corniculatus* L.	Fabaceae	नखर सिम्बी (Nakhar simbi)	Bird's-Foot Trefoil	Native	NE
74	*Malva parviflora* L.	Malvaceae	सानो मजिनो (Sano majino)	Small Mallow	Exotic/N	NE
75	*Mecardonia procumbens* (Mill.) Small	Plantaginaceae	-	Baby Jump Up	Exotic/N	NE
76	*Mentha spicata* L.	Lamiaceae	पुदिना (Pudina), बाबरी (Babari)	Spearmint	Native	LC
77	*Mirabilis jalapa* L.	Nyctaginaceae	लंका फूल (Lanka phul)	Four-O'Clock Plant	Exotic	NE
78	*Musa* × *paradisiaca* L.	Musaceae	केरा (Kera)	Banana	Exotic	NE
79	*Nothoscordum gracile* (Aiton) Stearn	Amaryllidaceae	-	False Garlic	Exotic	NE
80	*Nymphaea mexicana* Zucc.	Nymphaeaceae	जल कमल (Jal kamal)	Yellow Water Lily	Exotic	NE
81	*Oenothera biennis* L.	Onagraceae	पिताम्बर (Pitambar)	Evening Primrose	Exotic	NE
82	*Oenothera rosea* L'Hér. ex Aiton	Onagraceae	-	Rose of Mexico	Exotic/N	NE
83	*Ophiopogon intermedius* D.Don	Asparagaceae	वन कसुर (Ban kasur)	Himalayan Lily Turf	Native	NE
84	*Oplismenus compositus* (L.) P.Beauv.	Poaceae	--	Running Mountain Grass	Native	LC
85	*Oxalis corniculata* L.	Oxalidaceae	चरी अमिलो (Chari amilo)	Creeping Sorrel	Uncertain/N	NE
86	*Oxalis latifolia* Kunth	Oxalidaceae	चरी अमिलो (Chari amilo)	Purple Wood Sorel	Exotic	NE
87	*Parthenium hysterophorus* L.	Asteraceae	नक्कली पाती (Nakkali pati)	Carrot Grass	Exotic	NE
88	*Paspalum dilatatum* Poir.	Poaceae	-	Dallis Grass	Exotic/N	NE
89	*Pelargonium* × *hybridum* (L.) L'Hér.	Geraniaceae	जर्मनी फूल (Germani phul)	Garden Geranium	Exotic	NE
90	*Peperomia tetraphylla* (G.Forst.) Hook. & Arn.	Piperaceae	-	Four-Leaf Peperomia	Native	NE
91	*Perilla frutescens* (L.) Britton	Lamiaceae	सिलाम (Silam)	Perilla	Native	LC
92	*Persicaria chinensis* (L.) H.Gross	Polygonaceae	कुकुर ठोटने (Kukur thotne)	Smart Weed	Native	NE

93	*Persicaria longiseta* (Bruijn) Kitag.	Polygonaceae	--	Asiatic Smartweed	Native	NE
94	*Petunia* × *atkinsiana* (Sweet) D.Don ex W.H.Baxter	Solanaceae	-	Garden Petunia	Exotic	NE
95	*Pilea microphylla* (L.) Liebm.	Urticaceae	-	Gunpowder Plant	Exotic	NE
96	*Plantago major* L.	Plantaginaceae	इसबगोल (Isabgol)	Broad-Leaved Plantain	Native	LC
97	*Poa annua* L.	Poaceae	पोडे घाँस (Pode ghans)	Annual Meadow Grass	Native	LC
98	*Pogonatherum crinitum* (Thunb.) Kunth	Poaceae	मुसे खरी (Muse khari), खरुकी (Kharuki)	Bamboo Grass	Native	NE
99	*Polygonum plebeium* R.Br.	Polygonaceae	मसिनो पिरे (Masino pirre)	Small Knotweed	Native	LC
100	*Polypogon fugax* Nees ex Steud.	Poaceae	भ्याप्ले घाँस (Jhyaple ghans)	Asian Minor Bluegrass	Native	NE
101	*Polypogon monspeliensis* (L.) Desf.	Poaceae	-	Annual Beard Grass	Native	LC
102	*Pontederia crassipes* Mart.	Pontederiaceae	जल कुम्भी (Jal kumbhi)	Water Hyacinth	Exotic	NE
103	*Portulaca oleracea* L.	Portulacaceae	कुल्फा साग (Kulpha sag)	Pusley	Exotic/N	LC
104	*Potentilla indica* (Andrews) Th.Wolf	Rosaceae	सर्पे काफल (Sarpe kaphal)	Mock strawberry	Native	NE
105	*Primula malacoides* Franch.	Primulaceae	-	Fairly Primrose	Exotic	NE
106	*Pseudognaphalium affine* (D.Don) Anderb.	Asteraceae	बुके फूल (Buke phul), कैरो भार (Kairo jhar)	Cotton Weed	Native	NE
107	*Ranunculus sceleratus* L.	Ranunculaceae	नक्कोरे (Nakkore)	Celery-Leaved Buttercup	Native	LC
108	*Rorippa palustris* (L.) Besser	Brassicaceae	-	Marsh Yellow Cress	Native	NE
109	*Rumex nepalensis* Spreng.	Polygonaceae	हलहले (Halhale)	Sheep Sorrel	Native	NE
110	*Saccharum spontaneum* L.	Poaceae		Kans Grass	Native	LC
111	*Scutellaria barbata* D.Don	Lamiaceae	निलो बुट्टे घाँस (Nilo butte ghans)	Swollen Skullcap	Native	NE
112	*Setaria palmifolia* (J.Koenig) Stapf	Poaceae	कनिके कागुनो (Kanike kaguno)	Marsh Brittle Grass	Uncertain/N	NE
113	*Sigesbeckia orientalis* L.	Asteraceae	दुधे भार (Dudhe jhar)	Pig Pungent Weed	Native	NE
114	*Solanum nigrum* L.	Solanaceae	कालो बिही (Kalo bihee)	Black Nightshade	Native	NE
115	*Soliva anthemifolia* (Juss.) Sweet	Asteraceae	-	Button Burrweed	Exotic/N	NE

116	*Sonchus oleraceus* L.	Asteraceae	दुधे काँडा (Dudhe kanda)	Hare's-lettuce, Milk thistle	Exotic/N	NE
117	*Spathiphyllum floribundum* (Linden & André) N.E.Br.	Araceae	पिस लिली (Peace lily)	Peace lily	Exotic	NE
118	*Stellaria aquatica* (L.) Scop.	Caryophyllaceae	-	Water Chickweed	Native	NE
119	*Strelitzia reginae* Banks	Strelitziaceae	--	Bird-of-paradise	Exotic	NE
120	*Tagetes erecta* L.	Asteraceae	सयपत्री (Sayapatri)	French Marigold	Exotic	NE
121	*Taraxacum officinale* F.H.Wigg.	Asteraceae	टुकी फूल (Tuki phul), दुधे भार (Dudhe jhar)	Dandelion	Exotic/N	NE
122	*Thysanolaena latifolia* (Roxb. ex Hornem.) Honda	Poaceae	अम्रिसो (Amriso)	Broom Grass	Native	NE
123	*Torilis japonica* (Houtt.) DC.	Apiaceae	छतरे (Chhatare)	Upright Hedge Parsley	Native	NE
124	*Tradescantia virginiana* L.	Commelinaceae	-	Virginia Spiderwort	Exotic	NE
125	*Trifolium repens* L.	Fabaceae	बेउली (Beulee), सेतो बेउली (Seto beulee)	White Clover	Uncertain/N	NE
126	*Triticum aestivum* L.	Poaceae	गहुँ (Gahun)	Wheat	Exotic	NE
127	*Tropaeolum majus* L.	Tropaeolaceae	-	Garden Nasturtium	Exotic	NE
128	*Urtica parviflora* Roxb.	Urticaceae	सिस्नु (Sisnu)	Stinging Nettle	Native	NE
129	*Veronica cana* Wall. ex Benth.	Plantaginaceae	-	Hoary Speedwell	Native	NE
130	*Viola pilosa* Blume	Violaceae	घट्टे घाँस (Ghatte ghans)	White viola	Native	NE
131	*Xanthium strumarium* L.	Asteraceae	भेंडे कुरो (Bhende kuro), कस्तोलो (Kastolo)	Rough Cockle-Bur	Exotic	NE
132	*Xerochrysum bracteatum* (Vent.) Tzvelev	Asteraceae	सूर्यभक्ति फूल (Suryabhakti phul)	Straw Flower	Exotic	NE
133	*Youngia japonica* (L.) DC.	Asteraceae	चौलाने (Chaulane), दुधे (Dudhe)	Oriental Hawkweed	Native	NE
134	*Zephyranthes carinata* Herb.	Amaryllidaceae	-	Pink Rain Lily	Exotic/N	NE

Appendix 5: Climber species found in Urban Green Spaces

SN	Name of species	Family	Nepali name	Common Name	Origin	IUCN Red List
1	*Anredera cordifolia* (Ten.) Steenis	Basellaceae	मायालु (Mayalu), पोइ साग (Poi sag)	Madeira Vine	Exotic/N	NE

2	*Artabotrys hexapetalus* (L.f.) Bhandari	Annonaceae	कनक चम्पा (Kanak champa)	Tail Grape	Exotic	NE
3	*Bougainvillea glabra* Choisy	Nyctaginaceae	मदानी फूल (Madani phul)	Paper Flower	Exotic	LC
4	*Bougainvillea spectabilis* Willd.	Nyctaginaceae	कागज पाते (Kagaj pate)	Paper Flower	Exotic	NE
5	*Campsis grandiflora* (Thunb.) K.Schum.	Bignoniaceae	घटा पुष्पलता (Ghata puspalata)	Chinese Trumpet Vine	Exotic	NE
6	*Cissampelos pareira* L.	Menispermaceae	चिल्लो बाटुल्पाते (Chillo batulpate)	Velvet Leaf	Native	NE
7	*Clematis buchananiana* DC.	Ranunculaceae	जुँगे लहरा (Junge lahara),	Lemon Clematis	Native	NE
8	*Clerodendrum thomsoniae* Balf.f.	Lamiaceae	बूढानीलकण्ठ फूल (Budhanilkantha Phool)	Bleeding Glory-Flower	Exotic	NE
9	*Combretum indicum* (L.) DeFilipps	Combretaceae	लाल चमेली (Lal chameli), मालती (Malati)	Rangoon Creeper	Native	NE
10	*Cucurbita maxima* Duchesne	Cucurbitaceae	फर्सी (Farsi)	Pumpkin, Squash	Exotic	NE
11	*Dolichandra unguis-cati* (L.) L.G.Lohmann	Bignoniaceae	चरीनङ्ग्रे लहरो (Charinangre laharo)	Cat's Claw	Exotic	NE
12	*Epipremnum aureum* (Linden & André) G.S.Bunting	Araceae	-	Money Plant	Exotic	NE
13	*Euonymus echinatus* Wall.	Celastraceae	-	Climbing Spindle Bush	Native	LC
14	*Ficus pumila* L.	Moraceae	-	Climbing fig	Exotic/N	NE
15	*Ficus sarmentosa* Buch.-Ham. ex Sm.	Moraceae	वन तिमिला (Ban timila),	Nepal Fig	Native	NE
16	*Gynostemma pentaphyllum* (Thunb.) Makino	Cucurbitaceae	-	Southern Ginseng	Native	NE
17	*Hedera helix* L.	Araliaceae	-	English Ivy	Exotic	NE
18	*Hedera nepalensis* K.Koch	Araliaceae	काठे लहगो (Kathe laharo)	Nepal Ivy Climber	Native	NE
19	*Heptapleurum calyptratum* (Hook.f. & Thomson) Y.F.Deng	Araliaceae	कुर्सिम्लो (Kursimlo)	Tupidanthus	Exotic	LC
20	*Heptapleurum venulosum* (Wight & Arn.) Seem.	Araliaceae	डाडडिंगे (Dangdinge), कुर्सिमल (Kursimal)	Schefflera Vine	Uncertain	LC
21	*Hiptage benghalensis* (L.) Kurz	Malpighiaceae	चारपाते लहरो (Charpate laharo)	Hiptage	Native	LC
22	*Ipomoea purpurea* (L.) Roth	Convolvulaceae	-	Purple Morning Glory	Exotic/N	NE
23	*Jasminum multiflorum* (Burm.f.) Andrews	Oleaceae	बेली पुष्प (Beli puspa);	Chinese Jasmine	Native	NE

24	*Jasminum officinale* L.	Oleaceae	चमेली (Chameli)	White Jasmine	Native	NE
25	*Jasminum sambac* (L.) Aiton	Oleaceae	बेली फूल (Beli phul)	Arabian Jasmine	Exotic	NE
26	*Lonicera japonica* Thunb.	Caprifoliaceae	जुही (Juhi)	Japanese Honeysuckle	Exotic	NE
27	*Lonicera macrantha* (D.Don) Spreng.	Caprifoliaceae	वन जुही (Ban juhi)	Long-Flower Honeysuckle	Native	NE
28	*Maclura cochinchinensis* (Lour.) Corner	Moraceae	डम्बरे काँडा (Dambare kanda)	Cockspur Thorn	Native	NE
29	*Monstera deliciosa* Liebm.	Araceae	लहरे कर्कलो (Lahare karkalo)	Split-Leaved Philodendron	Exotic	NE
30	*Passiflora vitifolia* Kunth	Passifloraceae	-	Passion Flower	Exotic	NE
31	*Persicaria perfoliata* (L.) H.Gross	Polygonaceae	अमिलो पिर्रे लहरो (Amilo pirre laharo)	Mile-A-Minute Vine	Native	NE
32	*Phaseolus vulgaris* L.	Fabaceae	असारे सिमी (Asare simi), राजमा (Rajma)	Common Bean	Exotic	LC
33	*Philodendron bipinnatifidum* Schott ex Endl.	Araceae	-	Philodendron	Exotic	NE
34	*Piper nigrum* L.	Piperaceae	मरिच (Marich)	Black Pepper	Exotic	NE
35	*Plumbago zeylanica* L.	Plumbaginaceae	चितु (Chitu), सेतो कुरो (Seto kuro)	Leadwort	Native	NE
36	*Rhaphidophora decursiva* (Roxb.) Schott	Araceae	-	Creeping Philodendron	Native	NE
37	*Rubus ellipticus* Sm.	Rosaceae	ऐसेलु (Ainselu)	Golden Himalayan Raspberry	Native	LC
38	*Rubus niveus* Thunb.	Rosaceae	कालो ऐसेलु (Kalo ainselu)	Mysore Raspberry	Native	NE
39	*Rubus paniculatus* Sm.	Rosaceae	रुख ऐंसेलु (Rukh ainselu)	Heart-Leaf Raspberry	Native	NE
40	*Smilax lanceifolia* Roxb.	Smilacaceae	चोपचिनी (Chopchini)	Lanceleaf Smilax	Native	NE
41	*Solanum lycopersicum* L.	Solanaceae	गोलभेंडा (Golbhenda), टमाटर (Tamatar)	Tomato	Exotic	NE
42	*Stephania japonica* (Thunb.) Miers	Menispermaceae	पाठा (Patha), बाटुल्पाते (Batulpate)	Tape Vine	Native	NE
43	*Syngonium podophyllum* Schott	Araceae	-	Arrowhead Plant	Exotic	LC
44	*Thunbergia coccinea* Wall. ex D.Don	Acanthaceae	रातो काग चुच्चे (Rato kag chuchche)	Scarlet Clock Vine	Native	NE
45	*Trachelospermum jasminoides* (Lindl.) Lem.	Apocynaceae	दुधया फूल (Dudhya phul)	Star Jasmine	Exotic	NE
46	*Wisteria sinensis* (Sims) DC.	Fabaceae	निलहार फूल (Nilhar phul)	Chinese Wisteria	Exotic	NE

Appendix 6: List of Collection location of Historical specimens

SN	Name of species	Habit	Collection date	Collector	Location	Type specimen
1	*Acer oblongum* Wall. ex DC.	Tree	1818	N. Wallich	-	Type of *Acer buzimpala, Acer laurifolium*
			24 February 1802	F. Buchanan-Hamilton	Narayanhiti	Type of *Acer buzimpala, Acer laurifolium*
2	*Alnus nepalensis* D.Don	Tree	25 October 1802	F. Buchanan-Hamilton	Narayanhiti	New to science
3	*Barleria cristata* L.	Subshrub	26 August 1802	F. Buchanan-Hamilton	Narayanhiti	Type of *Barleria cristata*
4	*Benkara fasciculata* (Roxb.) Ridsdale	Shrub	April 1802	F. Buchanan-Hamilton	Hetaunda	Type of *Fagerlindia fasciculata, Randia triflora*
5	*Berberis aristata* DC.	Shrub	-	N. Wallich	-	--
			10 April 1802	F. Buchanan-Hamilton	Chitlong	Type of *Berberis chitria*
6	*Berberis napaulensis* (DC.) Spreng.	Shrub	15 November 1802	F. Buchanan-Hamilton	Narayanhiti	Holotype of *Mahonia napaulensis*
7	*Blumea aromatica* DC.	Subshrub	-	N. Wallich	Nuwakot	Type of *Conyza aromatica*
8	*Blumea axillaris* (Lam.) DC.	Subshrub	-	N. Wallich	-	Type of *Erigeron mollis*
9	*Boehmeria virgata* (G.Forst.) Guill.	Shrub	15 December 1820	N. Wallich	Bhimphedi	Lectotype of *Boehmeria canescens*
			3 September 1802	F. Buchanan-Hamilton	Narayanhiti	Types of *Boehmeria macrophylla, B. platyphylla*
10	*Bothriospermum zeylanicum* (J.Jacq.) Druce	Herb	-	F. Buchanan-Hamilton	-	Types of *Cynoglossum prostratum*
11	*Brassaiopsis hainla* (Buch.-Ham.) Seem.	Tree	10 February 1802	F. Buchanan-Hamilton	Narayanhiti	Holotype of *Hedera hainla*
			February 1821	N. Wallich	Shivapuri	Type of *Hedera polyacantha*
12	*Buddleja asiatica* Lour.	Tree	1802	F. Buchanan-Hamilton	Narayanhiti	Type of *Buddleja subserrta*
13	*Campanula cana* Wall.	Herb	October 1821	N. Wallich	Gosaikunda	New to science
14	*Canna indica* L.	Herb	1821	N. Wallich	-	Neotype of *Canna nepalensis*
15	*Choerospondias axillaris* (Roxb.) B.L.Burtt & A.W.Hill	Tree	1821	N. Wallich	Nuwakot	Type of *Spondias axillaris*
16	*Chrysojasminum humile* (L.) Banfi	Shrub	-	N. Wallich	Gosaikunda	Type of *Jasminum pubigerum*
17	*Cinnamomum tamala* (Buch.-Ham.) T.Nees & C.H.Eberm.	Tree	1821	N. Wallich	-	Type of *Cinnamomum albiflorum*
18	*Cirsium wallichii* DC.	Herb	1821	N. Wallich	-	--
19	*Cissampelos pareira* L.	Climber	21 May 1802	F. Buchanan-Hamilton	Swayambhu	Holotype of *Cissampelos hirsuta*
20	*Clematis buchananiana* DC.	Climber	30 October 1802	F. Buchanan-Hamilton	Narayanhiti	Type of *Clematis buchananii*

21	*Craniotome furcata* (Link) Kuntze	Herb	1821	N. Wallich	-	--
22	*Delphinium ajacis* L.	Herb	1802	F. Buchanan-Hamilton	Narayanhiti	Type of *Delphinium pauciflorum*
23	*Dichrocephala integrifolia* (L.f.) Kuntze	Herb	1802	F. Buchanan-Hamilton	-	Type of *Ethulia integrifolia*
24	*Dicliptera bupleuroides* Nees	Subshrub	13 December 1820	N. Wallich	Hetaunda	--
25	*Ehretia acuminata* R.Br.	Tree	-	N. Wallich	-	Type of *Ehretia pyrifolia*
26	*Euonymus echinatus* Wall.	Climber	August 1821	N. Wallich	Shivapuri	New to science
27	*Eurya acuminata* DC.	Shrub	1821	N. Wallich	-	Type of *Eurya acuminata*
			30 August 1802	F. Buchanan-Hamilton	Narayanhiti	Holotype of *Diospyros serrata*
28	*Ficus sarmentosa* Buch.-Ham. ex Sm.	Climber	18 December 1820	N. Wallich	Chessapani & Hetaunda	Type of *Pogonotrophe foveolata*
			10 February 1802	F. Buchanan-Hamilton	Narayanhiti	Types of *Ficus cabur*
29	*Ficus semicordata* Buch.-Ham. ex Sm.	Tree	1802	F. Buchanan-Hamilton	-	Holotype of *Ficus semicordata* var. *montana*
30	*Galium asperifolium* Wall.	Herb	August 1821	N. Wallich	Thankot	New to science
			August 1802	F. Buchanan-Hamilton	Narayanhiti	Type of *Galium parviflorum*
31	*Geranium nepalense* Sweet	Herb	4 October 1802	F. Buchanan-Hamilton	Kule Khani	Holotype of *Geranium quinquenerve*
32	*Grewia optiva* J.R.Drumm. ex Burret	Tree	18 May 1802	F. Buchanan-Hamilton	Swayambhu	Type of *Grewia oppositifolia*
33	*Gymnosporia rufa* (Wall.) Hook.f.	Tree	1821	N. Wallich	-	Type of *Celastrus rufa*
34	*Gynostemma pentaphyllum* (Thunb.) Makino	Climber	1821	N. Wallich	-	Type of *Zanonia cissoides*
35	*Hedera nepalensis* K.Koch	Climber	-	N. Wallich	-	-
			16 September 1802	F. Buchanan-Hamilton	Narayanhiti	Types of *Hedera helix*
36	*Homalium napaulense* (DC.) Benth.	Tree	-	N. Wallich	-	--
37	*Hydrocotyle sibthorpioides* Lam.	Subshrub	-	F. Buchanan-Hamilton	-	Types of *Hydrocotyle tenella*
			-	N. Wallich	-	Lectotype of *Hydrocotyle tenella*
38	*Hypericum cordifolium* Choisy	Shrub	1821	N. Wallich	Shivapuri	Lectotype of *Hypericum bracteatum*
			16 April 1802	F. Buchanan-Hamilton	Thankot	Lectotype of *Hypericum bracteatum*
39	*Ilex excelsa* (Wall.) Voigt	Tree	June 1821	N. Wallich	Gokarna	Type of *Cassine excelsa*
			9 May 1802	F. Buchanan-Hamilton	Swayambhu	Type of *Ilex rotunda*, *Ilex saysia*
40	*Impatiens balsamina* L.	Herb	1802	F. Buchanan-Hamilton	-	Type of *Balsamina odorata, Balsamina racemosa*

41	*Jasminum multiflorum* (Burm.f.) Andrews	Climber	28 October 1802	F. Buchanan-Hamilton	Narayanhiti	Types of *Jasminum pubescens*
42	*Juniperus recurva* Buch.-Ham. ex D.Don	Tree	February 1803	F. Buchanan-Hamilton	Narayanhiti	New to science
43	*Laggera alata* (D.Don) Sch.Bip. ex Oliv.	Herb	October 1802	F. Buchanan-Hamilton	Narayanhiti	Holotype of *Erigeron alatus*
44	*Lepidagathis incurva* Buch.-Ham. ex D.Don	Subshrub	27 January 1803	F. Buchanan-Hamilton	Narayanhiti	New to science
			-	N. Wallich	-	Type of *Lepidagathis hyalina*
45	*Lithocarpus elegans* (Blume) Hatus. ex Soepadmo	Tree	5 May 1802	F. Buchanan-Hamilton	Swayambhu	Type of *Quercus spicata*
45	*Lonicera macrantha* (D.Don) Spreng.	Climber	6 February 1802	F. Buchanan-Hamilton	Swayambhu	Holotype of *Caprifolium macranthum*
47	*Luculia gratissima* (Wall.) Sweet	Shrub	-	N. Wallich	Nagarjun	Type of *Cinchona gratissima*
			-	F. Buchanan-Hamilton	-	Type of *Mussaenda luculia*
48	*Lyonia ovalifolia* (Wall.) Drude	Tree	30 April 1802	F. Buchanan-Hamilton	Swayambhu	Type of *Andromeda ovalifolia, Andromeda capricida*
49	*Maesa chisia* D.Don	Shrub	April 1802	F. Buchanan-Hamilton	Narayanhiti	New to science
50	*Neolitsea cuipala* (D.Don) Kosterm.	Tree	27 February 1803	F. Buchanan-Hamilton	Narayanhiti	Holotype of *Tetranthera cuipala*
			February 1821	N. Wallich	Swayambhu	Type of *Tetradenia lanuginosa*
51	*Ophiopogon intermedius* D.Don	Herb	-	N. Wallich	-	New to science
			21 August 1802	F. Buchanan-Hamilton	Narayanhiti	Type of *Ophiopogon wallichianus, Sultea humilior*
52	*Ophiorrhiza fasciculata* D.Don	Subshrub	22 June 1802	F. Buchanan-Hamilton	Swayambhu	New to science
53	*Osmanthus fragrans* Lour.	Tree	18 October 1802	F. Buchanan-Hamilton	Narayanhiti	Holotype of *Notelaea posua*
			1821	N. Wallich	Pashupatinath	Type of *Olea acuminata*
54	*Perilla frutescens* (L.) Britton	Herb	1 October 1802	F. Buchanan-Hamilton	Narayanhiti	Types of *Perilla ocimoides*, *Mentha perilloides*
55	*Persicaria chinensis* (L.) H.Gross	Herb	-	N. Wallich	-	Type of *Polygonum patens*
			-	N. Wallich	Hetaunda	Type of *Polygonum chinense* var. *ovalifolium:*
56	*Phyllanthus parvifolius* Buch.-Ham. ex D.Don	Subshrub	6 May 1802	F. Buchanan-Hamilton	Swayambhu	New to science
			1821	N. Wallich	-	Type of *Phyllanthus juniperinus*
57	*Podocarpus neriifolius* D.Don	Tree	1821	N. Wallich	Sankhu	New to science
58	*Polygonum plebeium* R.Br.	Herb	-	F. Buchanan-Hamilton	-	Type of *Polygonum prostratum*
59	*Potentilla indica* (Andrews) Th.Wolf	Herb	1821	N. Wallich	-	Type of *Potentilla denticulosa*, *Potentilla wallichiana*
60	*Prunus cerasoides* Buch.-Ham. ex D.Don	Tree	1821	N. Wallich	-	Type of *Prunus puddum*

			26 October 1802	F. Buchanan-Hamilton	Narayanhiti	New to science
61	*Pseudognaphalium affine* (D.Don) Anderb.	Herb	1821	N. Wallich	-	Type of *Gnaphalium multiceps*
62	*Pyrus pashia* Buch.-Ham. ex D.Don	Tree	6 November 1802	F. Buchanan-Hamilton	Narayanhiti	New to science
63	*Quercus lanata* Sm.	Tree	17 December 1802	F. Buchanan-Hamilton	Narayanhiti	Holotype of *Quercus lanuginosa*
64	*Reinwardtia indica* Dumort.	Shrub	5 November 1802	F. Buchanan-Hamilton	Narayanhiti	Types of *Linum repens, Linum semitrigynum*
65	*Rhynchostylis retusa* (L.) Blume	Subshrub	22 June 1802	F. Buchanan-Hamilton	Swayambhu	Type of *Aerides spicata*
66	*Rubus ellipticus* Sm.	Climber	9 April 1802	F. Buchanan-Hamilton	Hetaunda	Holotype of *Rubus ellipticus*
			April 1802	F. Buchanan-Hamilton	Hetaunda	Type of *Rubus flavus*
67	*Rubus niveus* Thunb.	Climber	1819	E. Gardner	-	Type of *Rubus distans*
			1821	N. Wallich	-	Type of *Rubus pauciflorus, Rubus micranthus*
68	*Rubus paniculatus* Sm.	Climber	18 November 1802	F. Buchanan-Hamilton	Narayanhiti	Holotype of *Rubus paniculatus*
			2 June 1802	F. Buchanan-Hamilton	Swayambhu	Holotype of *Rubus tiliaceus*
69	*Salix babylonica* L.	Tree	16 February 1803	F. Buchanan-Hamilton	Narayanhiti	Type of *Salix japonica*
70	*Schima wallichii* (DC.) Korth.	Tree	17 May 1802	F. Buchanan-Hamilton	Swayambhu	Holotype of *Gordonia chilaunea*
			1821	N. Wallich	-	Type of *Gordonia wallichii*
71	*Scutellaria barbata* D.Don	Herb	-	N. Wallich	-	New to science
72	*Stranvaesia nussia* (Buch.-Ham. ex D.Don) Decne.	Tree	1821	N. Wallich	-	Type of *Stranvaesia glaucescens*
			26 April 1802	F. Buchanan-Hamilton	Budanilkantha	Holotype of *Pyrus nussia*
73	*Symplocos paniculata* (Thunb.) Miq.	Shrub	16 April 1802	F. Buchanan-Hamilton	Thankot	Type of *Symplocos crataegoides, Palura odorata*
74	*Thunbergia coccinea* Wall. ex D.Don	Climber	1818	E. Gardner	-	New to science
75	*Torilis japonica* (Houtt.) DC.	Herb	1821	N. Wallich	-	Lectotype of *Caucalis elata*
76	*Urtica parviflora* Roxb.	Herb	1821	N. Wallich	-	Type of *Urtica virulenta*
77	*Veronica cana* Wall. ex Benth.	Herb	August 1821	N. Wallich	Shivapuri	--
78	*Viola pilosa* Blume	Herb	1819	N. Wallich	-	Type of *Viola aspera*
			3 December 1802	F. Buchanan-Hamilton	Bhimphedi	Type of *Viola palmaris*
79	*Ziziphus incurva* Roxb.	Tree	18 May 1802	F. Buchanan-Hamilton	Swayambhu	Type of *Zizyphus paniculata*

Appendix 7: Checklist of Plant species across 14 Urban Green Spaces

BP22: Balaju Park (Baisdhara), **BN**: Bandevi Nagar Ban Udhyan, **BP**: Bhugol Park, **CG**: Coronation Garden, **RP:** Ratna Park (Sankadhar Udyan), **SP:** Shankha Park, **TP:** Tribhuvan Park, **UN:** UN Park, **BC:** Balkumari Community Forest, **IC:** Indrayeni Community Forest, **KR:** Kirat Religious Forest, **MR:** Mhepi Religious Forest, **RC:** Ranibari Community Forest, **SR:** Swayambhunath Religious Forest

SN	Name of species	Park and Garden								Forest						Total
		BP22	BN	BP	CG	RP	SP	TP	UN	BC	IC	KR	MR	RC	SR	
1	*Abelmoschus manihot*	✓			✓											2
2	*Acer oblongum*	✓								✓				✓	✓	4
3	*Achyranthes bidentata*	✓			✓			✓		✓	✓	✓	✓	✓	✓	9
4	*Aechmea gamosepala*	✓														1
5	*Aegle marmelos*								✓					✓		2
6	*Aeonium arboreum*	✓						✓								2
7	*Agapanthus africanus*	✓													✓	2
8	*Agave attenuata*					✓			✓		✓					3
9	*Agave sisalana*	✓				✓		✓	✓		✓	✓		✓	✓	8
10	*Ageratina adenophora*	✓	✓		✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	12
11	*Ageratum houstonianum*	✓		✓	✓			✓	✓	✓	✓					7
12	*Alangium chinense*	✓			✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	11
13	*Albizia julibrissin*	✓	✓					✓	✓		✓					5
14	*Alnus nepalensis*				✓			✓		✓	✓			✓		5
15	*Alocasia cucullata*	✓	✓					✓	✓						✓	5
16	*Aloe vera*		✓	✓		✓										3
17	*Alopecurus aequalis*				✓				✓							2
18	*Alternanthera philoxeroides*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	14
19	*Alternanthera sessilis*	✓				✓										2
20	*Amaranthus caudatus*	✓							✓							2
21	*Amaranthus cruentus*	✓														1
22	*Amaranthus spinosus*	✓		✓		✓		✓	✓	✓			✓		✓	8
23	*Anethum graveolens*								✓	✓						2
24	*Anredera cordifolia*		✓		✓											2
25	*Antirrhinum majus*	✓	✓			✓	✓	✓								5
26	*Araucaria bidwillii*					✓	✓	✓			✓			✓		5
27	*Araucaria columnaris*	✓				✓		✓		✓						4
28	*Araucaria cunninghamii*					✓		✓							✓	3
29	*Araucaria heterophylla*	✓	✓				✓				✓	✓		✓	✓	7
30	*Artabotrys hexapetalus*												✓	✓		2
31	*Artemisia dubia*	✓		✓	✓	✓		✓	✓	✓	✓	✓			✓	10
32	*Artemisia indica*	✓			✓			✓	✓	✓	✓					6
33	*Artocarpus lacucha*	✓														1
34	*Arundo donax*								✓	✓						2
35	*Asclepias curassavica*	✓											✓			2

36	*Asparagus officinalis*	✓		✓		✓		✓					✓		**5**
37	*Aspidistra elatior*	✓				✓	✓		✓						**4**
38	*Axonopus compressus*	✓	✓		✓	✓		✓			✓			✓	**7**
39	*Bambusa balcooa*										✓				**1**
40	*Barleria cristata*	✓			✓			✓			✓		✓		**5**
41	*Bauhinia variegata*				✓			✓	✓	✓	✓	✓	✓	✓	**9**
42	*Beaucarnea recurvata*						✓						✓	✓	**3**
43	*Begonia coccinea*												✓		**1**
44	*Begonia cucullata*	✓													**1**
45	*Begonia erythrophylla*	✓						✓							**2**
46	*Bellis perennis*	✓													**1**
47	*Benkara fasciculata*	✓													**1**
48	*Berberis aristata*							✓					✓		**2**
49	*Berberis napaulensis*	✓				✓		✓						✓	**4**
50	*Bergera koenigii*	✓	✓		✓	✓			✓				✓		**6**
51	*Bidens pilosa*	✓	✓	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	**12**
52	*Blumea aromatica*	✓											✓		**2**
53	*Blumea axillaris*										✓				**1**
54	*Boehmeria virgata*	✓						✓			✓	✓	✓	✓	✓	**7**
55	*Bombax ceiba*	✓													**1**
56	*Bothriospermum zeylanicum*				✓										**1**
57	*Bougainvillea glabra*	✓	✓								✓			✓	**4**
58	*Bougainvillea spectabilis*	✓	✓	✓		✓	✓	✓	✓	✓	✓		✓	✓	✓	**12**
59	*Brassaiopsis hainla*													✓		**1**
60	*Brassica oleracea*	✓					✓									**2**
61	*Brassica rapa*	✓							✓				✓			**3**
62	*Bridelia retusa*	✓														**1**
63	*Brucea javanica*											✓				**1**
64	*Brugmansia suaveolens*	✓	✓		✓		✓	✓	✓	✓	✓	✓	✓	✓		**11**
65	*Brunfelsia pauciflora*	✓				✓										**2**
66	*Buddleja asiatica*	✓	✓		✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	**12**
67	*Buxus sempervirens*					✓										**1**
68	*Calanthe tankervilleae*	✓														**1**
69	*Calendula officinalis*	✓				✓	✓	✓								**4**
70	*Calliandra haematocephala*	✓	✓					✓			✓		✓	✓	✓	**7**
71	*Callianthe picta*		✓													**1**
72	*Callicarpa macrophylla*	✓														**1**
73	*Callisia fragrans*	✓	✓										✓			**3**
74	*Callisia repens*								✓							**1**
75	*Calotropis gigantea*	✓														**1**
76	*Camellia japonica*	✓				✓	✓	✓				✓				**5**
77	*Campanula cana*	✓														**1**

78	*Camphora officinarum*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	**14**
79	*Campsis grandiflora*					✓		✓								**2**
80	*Canna indica*	✓	✓	✓		✓		✓	✓		✓	✓	✓	✓		**10**
81	*Cannabis sativa*		✓		✓				✓	✓		✓	✓	✓		**7**
82	*Capsella bursa-pastoris*	✓		✓	✓	✓			✓							**5**
83	*Carica papaya*					✓							✓			**2**
84	*Caryota urens*	✓				✓					✓	✓	✓			**5**
85	*Cassia fistula*					✓										**1**
86	*Castanopsis indica*				✓									✓	✓	**3**
87	*Casuarina equisetifolia*				✓											**1**
88	*Catharanthus roseus*	✓						✓	✓		✓	✓				**5**
89	*Catunaregam spinosa*	✓						✓							✓	**3**
90	*Cedrus deodara*							✓			✓			✓	✓	**4**
91	*Celtis australis*	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	**13**
92	*Centella asiatica*	✓			✓		✓	✓								**4**
93	*Cereus hildmannianus*	✓												✓	✓	**3**
94	*Cestrum nocturnum*												✓	✓		**2**
95	*Cestrum parqui*	✓	✓		✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	**12**
96	*Chaenomeles japonica*							✓								**1**
97	*Chenopodium album*	✓							✓	✓	✓					**4**
98	*Chlorophytum comosum*	✓	✓	✓		✓	✓	✓	✓		✓		✓	✓		**10**
99	*Choerospondias axillaris*	✓	✓	✓				✓	✓	✓	✓	✓		✓	✓	**10**
100	*Chrysalidocarpus lutescens*			✓		✓	✓	✓					✓			**5**
101	*Chrysanthemum morifolium*	✓	✓	✓		✓		✓					✓			**6**
102	*Chrysojasminum humile*	✓	✓	✓	✓	✓	✓	✓	✓		✓		✓	✓	✓	**12**
103	*Cinnamomum tamala*	✓	✓		✓					✓	✓	✓				**6**
104	*Cirsium wallichii*				✓			✓	✓							**3**
105	*Cissampelos pareira*							✓								**1**
106	*Citrus aurantiifolia*		✓						✓	✓		✓			✓	**5**
107	*Citrus limon*	✓	✓							✓			✓			**4**
108	*Citrus maxima*	✓	✓		✓	✓				✓	✓		✓	✓		**8**
109	*Citrus reticulata*	✓	✓			✓	✓				✓		✓			**6**
110	*Clematis buchananiana*	✓														**1**
111	*Clerodendrum chinense*				✓								✓		✓	**3**
112	*Clerodendrum japonicum*										✓					**1**
113	*Clerodendrum thomsoniae*						✓									**1**
114	*Clivia miniata*	✓					✓							✓		**3**
115	*Codiaeum variegatum*	✓					✓									**2**
116	*Coleus scutellarioides*	✓	✓				✓							✓		**4**
117	*Colocasia esculenta*	✓			✓	✓		✓			✓				✓	**6**
118	*Combretum indicum*						✓									**1**

119	*Cordyline fruticosa*	✓		✓											**2**
120	*Coreopsis pubescens*	✓								✓					**2**
121	*Coriandrum sativum*			✓		✓									**2**
122	*Corymbia citriodora*										✓				**1**
123	*Craniotome furcata*	✓						✓						✓	**3**
124	*Crassocephalum crepidioides*	✓	✓		✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	**12**
125	*Crassula ovata*							✓						✓		**2**
126	*Crateva unilocularis*							✓								**1**
127	*Crocosmia crocosmiiflora*	✓											✓			**2**
128	*Cryptomeria japonica*	✓			✓	✓	✓	✓								**5**
129	*Cucurbita maxima*			✓				✓	✓			✓				**4**
130	*Cuphea hyssopifolia*	✓				✓	✓	✓			✓				✓	**6**
131	*Cupressus sempervirens*	✓				✓	✓									**3**
132	*Curculigo capitulata*	✓	✓		✓	✓			✓		✓					**6**
133	*Curcuma zedoaria*												✓			**1**
134	*Cuscuta reflexa*				✓					✓						**2**
135	*Cyathula capitata*				✓			✓		✓		✓		✓	✓	**6**
136	*Cycas revoluta*		✓	✓		✓	✓	✓	✓				✓	✓	✓	**9**
137	*Cynodon dactylon*	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓			**11**
138	*Cynoglossum lanceolatum*										✓					**1**
139	*Cyperus alternifolius*					✓		✓	✓						✓	**4**
140	*Dahlia pinnata*					✓	✓									**2**
141	*Datura stramonium*		✓						✓		✓		✓			**4**
142	*Delphinium ajacis*	✓														**1**
143	*Dendrocalamus hookeri*	✓														**1**
144	*Dendrocalamus strictus*	✓	✓			✓		✓	✓		✓	✓	✓	✓	✓	**10**
145	*Dianthus barbatus*					✓	✓	✓	✓							**4**
146	*Dichrocephala integrifolia*	✓	✓	✓	✓	✓	✓	✓			✓	✓		✓	✓	**11**
147	*Dicliptera bupleuroides*		✓					✓		✓				✓		**4**
148	*Diospyros kaki*	✓	✓								✓					**3**
149	*Diospyros malabarica*														✓	**1**
150	*Dolichandra unguis-cati*	✓			✓	✓								✓	✓	**5**
151	*Dombeya spectabilis*	✓														**1**
152	*Dracaena fragrans*	✓		✓		✓			✓			✓	✓			**6**
153	*Dracaena trifasciata*	✓					✓			✓				✓	✓	**5**
154	*Drymaria diandra*	✓	✓		✓		✓	✓		✓	✓			✓	✓	**9**
155	*Duranta erecta*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	**14**
156	*Dyckia brevifolia*	✓					✓									**2**
157	*Ehretia acuminata*	✓	✓			✓		✓		✓	✓	✓		✓		**8**
158	*Elaeocarpus angustifolius*	✓	✓	✓		✓	✓			✓	✓	✓	✓	✓	✓	**11**
159	*Engelhardia spicata*													✓		**1**
160	*Epipremnum aureum*						✓									**1**

161	*Erigeron annuus*								✓							**1**
162	*Erigeron sumatrensis*	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	**13**
163	*Eriobotrya japonica*								✓							**1**
164	*Erythrina crista-galli*		✓		✓						✓			✓	✓	**5**
165	*Eucalyptus alba*													✓		**1**
166	*Eucalyptus camaldulensis*		✓		✓				✓	✓	✓		✓			**6**
167	*Eucalyptus grandis*	✓			✓			✓								**3**
168	*Eucalyptus robusta*	✓										✓				**2**
169	*Euonymus echinatus*							✓								**1**
170	*Euonymus hamiltonianus*												✓			**1**
171	*Euonymus japonicus*	✓				✓									✓	**3**
172	*Euphorbia cotinifolia*	✓				✓										**2**
173	*Euphorbia heterophylla*								✓	✓						**2**
174	*Euphorbia milii*	✓						✓							✓	**3**
175	*Euphorbia neriifolia*	✓	✓				✓				✓		✓	✓	✓	**7**
176	*Euphorbia pulcherrima*	✓	✓	✓		✓	✓		✓	✓		✓	✓			**9**
177	*Eurya acuminata*							✓				✓				**2**
178	*Fagopyrum esculentum*									✓		✓	✓			**3**
179	*Ficus auriculata*										✓				✓	**2**
180	*Ficus benghalensis*	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	**13**
181	*Ficus benjamina*	✓	✓	✓		✓	✓		✓	✓	✓	✓	✓	✓	✓	**12**
182	*Ficus elastica*					✓						✓	✓	✓		**4**
183	*Ficus glaberrima*											✓	✓			**2**
184	*Ficus hispida*	✓			✓						✓			✓	✓	**5**
185	*Ficus lacor*	✓	✓		✓					✓	✓	✓	✓	✓	✓	**9**
186	*Ficus pumila*								✓							**1**
187	*Ficus religiosa*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	**14**
188	*Ficus sarmentosa*	✓												✓		**2**
189	*Ficus semicordata*														✓	**1**
190	*Flacourtia jangomas*							✓							✓	**2**
191	*Galinsoga quadriradiata*	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓		✓	**12**
192	*Galium asperifolium*							✓								**1**
193	*Gamochaeta pensylvanica*			✓		✓			✓	✓		✓		✓		**6**
194	*Gardenia jasminoides*	✓						✓					✓	✓	✓	**5**
195	*Gasteria obliqua*							✓								**1**
196	*Gazania rigens*	✓				✓	✓	✓								**4**
197	*Geranium nepalense*				✓			✓		✓						**3**
198	*Ginkgo biloba*	✓														**1**
199	*Gladiolus hybridus*					✓	✓									**2**
200	*Gonostegia hirta*							✓			✓					**2**
201	*Graptopetalum paraguayense*		✓	✓			✓									**3**
202	*Grevillea robusta*	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	**13**

203	*Grewia optiva*	✓							✓			✓	✓	✓	**5**
204	*Gymnosporia rufa*							✓							**1**
205	*Gynostemma pentaphyllum*	✓						✓					✓		**3**
206	*Hedera helix*					✓									**1**
207	*Hedera nepalensis*							✓		✓			✓	✓	**4**
208	*Hemerocallis fulva*			✓			✓							✓	**3**
209	*Heptapleurum calyptratum*	✓	✓	✓		✓		✓	✓		✓		✓	✓	✓	**10**
210	*Heptapleurum venulosum*												✓			**1**
211	*Hesperocyparis lusitanica*					✓					✓		✓			**3**
212	*Hesperocyparis macrocarpa*	✓	✓			✓	✓	✓				✓				**6**
213	*Hibiscus mutabilis*							✓								**1**
214	*Hibiscus rosa-sinensis*		✓	✓		✓	✓		✓			✓	✓	✓		**8**
215	*Hibiscus syriacus*	✓	✓	✓		✓										**4**
216	*Hippeastrum vittatum*	✓	✓	✓		✓	✓	✓	✓		✓	✓	✓	✓	✓	**12**
217	*Hiptage benghalensis*	✓														**1**
218	*Homalium napaulense*	✓												✓		**2**
219	*Hordeum vulgare*											✓				**1**
220	*Hydrangea febrifuga*							✓								**1**
221	*Hydrangea macrophylla*			✓		✓		✓	✓							**4**
222	*Hydrocotyle sibthorpioides*	✓		✓	✓		✓	✓							✓	**6**
223	*Hypericum cordifolium*							✓								**1**
224	*Hypoestes phyllostachya*	✓	✓		✓			✓		✓			✓			**6**
225	*Ilex excelsa*							✓		✓					✓	**3**
226	*Impatiens balsamina*					✓										**1**
227	*Impatiens walleriana*	✓				✓					✓					**3**
228	*Imperata cylindrica*										✓					**1**
229	*Ipomoea purpurea*		✓		✓	✓				✓		✓	✓	✓	✓	**8**
230	*Iresine diffusa*												✓			**1**
231	*Jacaranda mimosifolia*	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	**13**
232	*Jasminum multiflorum*	✓	✓	✓		✓							✓			**5**
233	*Jasminum officinale*	✓						✓								**2**
234	*Jasminum sambac*			✓											✓	**2**
235	*Juglans regia*					✓									✓	**2**
236	*Juniperus chinensis*	✓	✓			✓							✓			**4**
237	*Juniperus recurva*	✓	✓	✓	✓	✓	✓	✓		✓		✓		✓	✓	**11**
238	*Justicia adhatoda*	✓	✓							✓			✓		✓	**5**
239	*Justicia brandegeeana*	✓				✓										**2**
240	*Justicia carnea*	✓	✓													**2**
241	*Kalanchoe crenata*		✓						✓							**2**
242	*Kalanchoe prolifera*							✓								**1**
243	*Lagerstroemia indica*	✓	✓		✓	✓			✓	✓	✓		✓		✓	**9**

244	*Lagerstroemia speciosa*													✓	**1**
245	*Laggera alata*			✓		✓				✓	✓	✓			✓	**6**
246	*Lantana camara*	✓	✓		✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	**12**
247	*Lepidagathis incurva*	✓						✓							✓	**3**
248	*Leucaena leucocephala*		✓		✓	✓			✓	✓	✓	✓		✓	✓	**9**
249	*Ligustrum lucidum*	✓														**1**
250	*Ligustrum sinense*	✓		✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	**12**
251	*Lithocarpus elegans*														✓	**1**
252	*Litsea monopetala*	✓	✓		✓					✓	✓		✓	✓	✓	**8**
253	*Livistona chinensis*	✓	✓	✓	✓	✓								✓	✓	**7**
254	*Lobularia maritima*					✓										**1**
255	*Lonicera japonica*										✓					**1**
256	*Lonicera macrantha*							✓								**1**
257	*Lotus corniculatus*							✓								**1**
258	*Luculia gratissima*							✓								**1**
259	*Lycium barbarum*								✓							**1**
260	*Lyonia ovalifolia*							✓								**1**
261	*Macadamia integrifolia*											✓				**1**
262	*Machilus duthiei*	✓								✓		✓		✓	✓	**5**
263	*Maclura cochinchinensis*														✓	**1**
264	*Madhuca longifolia*							✓								**1**
265	*Maesa chisia*							✓								**1**
266	*Magnolia champaca*	✓	✓	✓		✓		✓	✓	✓	✓		✓		✓	**10**
267	*Magnolia grandiflora*	✓				✓	✓		✓		✓		✓		✓	**7**
268	*Mallotus philippensis*														✓	**1**
269	*Malva parviflora*								✓							**1**
270	*Malvastrum coromandelianum*								✓							**1**
271	*Malvaviscus arboreus*	✓	✓		✓			✓	✓			✓	✓	✓	✓	**9**
272	*Mangifera indica*		✓		✓	✓	✓	✓			✓		✓	✓		**8**
273	*Matthiola incana*					✓										**1**
274	*Mazus pumilus*	✓			✓		✓				✓			✓		**5**
275	*Mecardonia procumbens*														✓	**1**
276	*Melaleuca citrina*	✓	✓		✓			✓	✓	✓	✓	✓	✓	✓	✓	**11**
277	*Melia azedarach*	✓			✓		✓		✓	✓	✓	✓		✓	✓	**9**
278	*Mentha spicata*			✓												**1**
279	*Mirabilis jalapa*	✓											✓		✓	**3**
280	*Monstera deliciosa*	✓				✓		✓						✓		**4**
281	*Morus alba*		✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	**12**
282	*Morus serrata*													✓		**1**
283	*Muehlenbeckia platyclada*		✓			✓										**2**
284	*Murraya paniculata*	✓				✓										**2**
285	*Musa paradisiaca*	✓								✓	✓	✓	✓			**5**

286	*Neolitsea cuipala*											✓	✓	✓	✓	**4**
287	*Nerium oleander*	✓	✓				✓					✓	✓			**5**
288	*Nothoscordum gracile*			✓												**1**
289	*Nyctanthes arbor-tristis*			✓										✓	✓	**3**
290	*Nymphaea mexicana*							✓								**1**
291	*Ocimum tenuiflorum*	✓											✓			**2**
292	*Oenothera biennis*												✓			**1**
293	*Oenothera rosea*			✓	✓			✓	✓		✓				✓	**6**
294	*Ophiopogon intermedius*	✓			✓	✓		✓	✓		✓		✓	✓	✓	**9**
295	*Ophiorrhiza fasciculata*	✓														**1**
296	*Oplismenus compositus*	✓	✓		✓	✓		✓		✓		✓	✓	✓	✓	**10**
297	*Opuntia monacantha*	✓	✓			✓		✓	✓		✓		✓	✓	✓	**9**
298	*Osmanthus fragrans*														✓	**1**
299	*Ouret sanguinolenta*	✓			✓	✓	✓								✓	**5**
300	*Oxalis corniculata*	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	**13**
301	*Oxalis latifolia*	✓	✓		✓	✓	✓	✓	✓			✓	✓	✓	✓	**11**
302	*Pachygone laurifolia*									✓				✓	✓	**3**
303	*Pandanus furcatus*	✓														**1**
304	*Parthenium hysterophorus*				✓		✓	✓	✓	✓		✓			✓	**7**
305	*Paspalum dilatatum*	✓				✓	✓	✓			✓			✓		**6**
306	*Passiflora vitifolia*	✓	✓													**2**
307	*Paulownia tomentosa*							✓						✓		**2**
308	*Pelargonium hybridum*	✓	✓					✓		✓	✓	✓		✓		**7**
309	*Peperomia tetraphylla*													✓		**1**
310	*Perilla frutescens*			✓												**1**
311	*Persea americana*	✓	✓	✓		✓		✓	✓	✓	✓	✓	✓	✓	✓	**12**
312	*Persicaria chinensis*							✓								**1**
313	*Persicaria longiseta*	✓			✓			✓	✓		✓				✓	**6**
314	*Persicaria perfoliata*	✓			✓					✓		✓		✓		**5**
315	*Petunia atkinsiana*	✓				✓	✓									**3**
316	*Phaseolus vulgaris*											✓				**1**
317	*Philodendron bipinnatifidum*			✓			✓							✓		**3**
318	*Phoenix sylvestris*		✓			✓	✓	✓		✓	✓		✓		✓	**8**
319	*Phyllanthus emblica*			✓			✓				✓		✓			**4**
320	*Phyllanthus parvifolius*							✓								**1**
321	*Pilea microphylla*	✓											✓			**2**
322	*Pilea peperomioides*					✓										**1**
323	*Pinus roxburghii*	✓	✓	✓	✓	✓		✓			✓	✓	✓	✓		**10**
324	*Piper nigrum*							✓								**1**
325	*Plantago major*	✓		✓	✓	✓	✓	✓							✓	**7**
326	*Platanus orientalis*							✓								**1**
327	*Platycladus orientalis*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	**14**

328	*Plumbago zeylanica*				✓										**1**
329	*Plumeria rubra*										✓				**1**
330	*Poa annua*	✓		✓	✓		✓	✓		✓	✓				**7**
331	*Podocarpus neriifolius*											✓			**1**
332	*Pogonatherum crinitum*									✓					**1**
333	*Polygonum plebeium*				✓			✓							**2**
334	*Polypogon fugax*	✓			✓			✓		✓					**4**
335	*Polypogon monspeliensis*							✓							**1**
336	*Pontederia crassipes*		✓												**1**
337	*Populus nigra*				✓		✓			✓					**3**
338	*Portulaca oleracea*													✓	**1**
339	*Potentilla indica*	✓		✓	✓			✓	✓	✓	✓	✓		✓	**9**
340	*Pouzolzia rugulosa*													✓	**1**
341	*Primula malacoides*	✓													**1**
342	*Prunus armeniaca*			✓											**1**
343	*Prunus cerasoides*		✓		✓			✓		✓	✓	✓	✓	✓	**9**
344	*Prunus persica*	✓	✓	✓				✓	✓	✓			✓	✓	**9**
345	*Pseudognaphalium affine*	✓	✓					✓	✓	✓	✓	✓			**7**
346	*Psidium guajava*	✓	✓	✓		✓	✓		✓	✓	✓	✓	✓	✓	**12**
347	*Punica granatum*	✓	✓	✓		✓			✓	✓	✓				**7**
348	*Pyrus communis*										✓			✓	**2**
349	*Pyrus pashia*	✓			✓	✓		✓		✓			✓	✓	**7**
350	*Quercus lanata*				✓			✓							**2**
351	*Ranunculus sceleratus*	✓			✓			✓	✓						**4**
352	*Ravenea rivularis*	✓				✓	✓								**3**
353	*Reinwardtia indica*			✓				✓					✓		**3**
354	*Rhaphidophora decursiva*												✓		**1**
355	*Rhapis excelsa*					✓	✓								**2**
356	*Rhododendron simsii*	✓													**1**
357	*Rhynchostylis retusa*	✓			✓			✓				✓	✓		**5**
358	*Ricinus communis*				✓				✓	✓		✓	✓	✓	**6**
359	*Rorippa palustris*		✓					✓	✓		✓	✓		✓	**6**
360	*Rosa chinensis*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		**12**
361	*Rubus ellipticus*	✓			✓			✓	✓	✓	✓	✓	✓	✓	**9**
362	*Rubus niveus*				✓			✓		✓			✓		**4**
363	*Rubus paniculatus*							✓							**1**
364	*Ruellia simplex*			✓											**1**
365	*Rumex nepalensis*	✓	✓		✓	✓	✓	✓	✓	✓				✓	**9**
366	*Rungia pectinata*				✓		✓	✓					✓	✓	**5**
367	*Saccharum spontaneum*							✓			✓				**2**
368	*Salix babylonica*				✓	✓		✓	✓		✓		✓		**6**
369	*Salvia coccinea*		✓												**1**

370	*Salvia splendens*	✓				✓		✓	✓				✓	✓		**6**
371	*Sambucus canadensis*				✓				✓	✓	✓	✓	✓		✓	**7**
372	*Santalum album*												✓		✓	**2**
373	*Sapindus mukorossi*	✓			✓				✓				✓	✓	✓	**6**
374	*Sarcococca coriacea*	✓						✓						✓	✓	**4**
375	*Schima wallichii*	✓	✓					✓						✓	✓	**5**
376	*Scutellaria barbata*						✓	✓								**2**
377	*Sedum morganianum*	✓														**1**
378	*Senna didymobotrya*		✓													**1**
379	*Senna occidentalis*	✓										✓				**2**
380	*Serissa japonica*					✓										**1**
381	*Setaria palmifolia*		✓					✓	✓	✓		✓	✓	✓		**7**
382	*Sida rhombifolia*				✓									✓		**2**
383	*Sigesbeckia orientalis*										✓					**1**
384	*Smilax lanceifolia*	✓												✓		**2**
385	*Solanum betaceum*													✓		**1**
386	*Solanum lycopersicum*	✓			✓						✓		✓	✓		**5**
387	*Solanum mauritianum*	✓		✓		✓						✓	✓			**5**
388	*Solanum nigrum*	✓	✓		✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	**12**
389	*Solanum pseudocapsicum*	✓	✓		✓			✓							✓	**5**
390	*Solanum torvum*	✓							✓		✓	✓				**4**
391	*Solanum viarum*	✓	✓		✓			✓	✓	✓	✓	✓		✓	✓	**10**
392	*Solanum violaceum*										✓					**1**
393	*Soliva anthemifolia*	✓		✓	✓	✓				✓						**5**
394	*Sonchus oleraceus*	✓	✓	✓		✓		✓	✓	✓	✓	✓	✓	✓	✓	**12**
395	*Spathiphyllum floribundum*	✓				✓										**2**
396	*Spiraea cantoniensis*	✓														**1**
397	*Stellaria aquatica*	✓	✓		✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	**12**
398	*Stephania japonica*	✓	✓		✓	✓		✓		✓	✓	✓	✓	✓	✓	**11**
399	*Stranvaesia nussia*	✓	✓		✓			✓		✓		✓	✓	✓	✓	**9**
400	*Strelitzia reginae*						✓							✓		**2**
401	*Symplocos paniculata*							✓								**1**
402	*Syngonium podophyllum*	✓				✓							✓	✓		**4**
403	*Syzygium cumini*	✓	✓	✓		✓		✓			✓	✓		✓	✓	**9**
404	*Syzygium jambos*	✓		✓					✓	✓	✓		✓	✓		**7**
405	*Tagetes erecta*	✓	✓	✓		✓	✓	✓	✓			✓	✓			**9**
406	*Taraxacum officinale*							✓								**1**
407	*Tecoma stans*		✓					✓			✓	✓	✓			**5**
408	*Tectona grandis*	✓														**1**
409	*Thunbergia coccinea*										✓					**1**
410	*Thysanolaena latifolia*										✓	✓	✓	✓		**4**
411	*Torilis japonica*				✓					✓						**2**

412	*Trachelospermum jasminoides*	✓				✓		✓							**3**
413	*Trachycarpus fortunei*							✓							**1**
414	*Tradescantia fluminensis*	✓	✓								✓	✓	✓		**5**
415	*Tradescantia pallida*		✓			✓	✓								**3**
416	*Tradescantia spathacea*	✓													**1**
417	*Tradescantia virginiana*	✓				✓									**2**
418	*Tradescantia zebrina*	✓				✓		✓	✓			✓	✓	✓		**7**
419	*Trifolium repens*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					**10**
420	*Triticum aestivum*										✓					**1**
421	*Tropaeolum majus*							✓								**1**
422	*Urena lobata*	✓	✓		✓			✓		✓	✓	✓	✓	✓	✓	**10**
423	*Urtica parviflora*	✓			✓			✓	✓	✓		✓	✓	✓	✓	**9**
424	*Veronica anagallis-aquatica*	✓														**1**
425	*Veronica cana*	✓			✓	✓		✓								**4**
426	*Viola pilosa*							✓							✓	**2**
427	*Viola tricolor*					✓	✓	✓	✓							**4**
428	*Wisteria sinensis*							✓								**1**
429	*Xanthium strumarium*				✓	✓										**2**
430	*Xerochrysum bracteatum*	✓				✓										**2**
431	*Xylosma controversa*														✓	**1**
432	*Youngia japonica*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	**14**
433	*Yucca gigantea*	✓					✓	✓				✓	✓	✓	✓	**7**
434	*Yucca gloriosa*	✓						✓						✓	✓	**4**
435	*Zanthoxylum armatum*									✓	✓					**2**
436	*Zephyranthes carinata*		✓	✓				✓					✓	✓		**5**
437	*Ziziphus incurva*	✓			✓			✓		✓		✓	✓	✓	✓	**8**

Appendix 8: List of Plant Species with Uncertain Origin

SN	Name of species	Plants of Nepal (Shrestha *et al.*, 2022b)	Plants of the World Online (POWO, 2024)	Centre for Agriculture and Biosciences International (CABI, 2025)
1	*Alocasia cucullata* (Lour.) G.Don	Not listed	Not mention	Native
2	*Capsella bursa-pastoris* (L.) Medik.	Naturalized	Native	Introduced
3	*Celtis australis* L.	Native	Not mention	Not Accessible
4	*Clerodendrum chinense* (Osbeck) Mabb.	Exotic	Native	Not listed
5	*Elaeocarpus angustifolius* Blume	Native	Not mention	Not Accessible
6	*Euphorbia neriifolia* L.	Native	Not mention	Not listed
7	*Ficus elastica* Roxb. ex Hornem.	Exotic	Native	Not listed
8	*Heptapleurum venulosum* (Wight & Arn.) Seem.	Native	Not mention	Not listed
9	*Hydrangea febrifuga* (Lour.) Y.De Smet & C.Granados	Native	Not mention	Not Accessible
10	*Imperata cylindrica* (L.) Raeusch.	Native	Introduced	Native

11	*Juglans regia* L.	Native	Introduced	Not Accessible
12	*Lagerstroemia indica* L.	Exotic	Native	Native
13	*Ligustrum sinense* Lour.	Native	Introduced	Not listed
14	*Magnolia champaca* (L.) Baill. ex Pierre	Native	Not mention	Not listed
15	*Oxalis corniculata* L.	Naturalized	Native	Not listed
16	*Phyllanthus emblica* L.	Native	Not mention	Not Accessible
17	*Sapindus mukorossi* Gaertn.	Native	Introduced	Not listed
18	*Setaria palmifolia* (J.Koenig) Stapf	Naturalized	Native	Native
19	*Solanum violaceum* Ortega	Not listed	Native	Not Accessible
20	*Syzygium jambos* (L.) Alston	Native	Introduced	Introduced
21	*Trifolium repens* L.	Naturalized	Native	Not Accessible

Appendix 9: List of Specific wood density (ϱ) of plant species

SN	Name of species	Wood density (gm/cm³)
1	*Acer oblongum*	0.603
2	*Alangium chinense*	0.422
3	*Albizia julibrissin*	0.673 *****
4	*Alnus nepalensis*	0.410
5	*Araucaria bidwillii*	0.417
6	*Araucaria columnaris*	0.58 *
7	*Bauhinia variegata*	0.653
8	*Bombax ceiba*	0.28
9	*Bougainvillea glabra*	0.56 *
10	*Brassaiopsis hainla*	0.594 ***
11	*Buddleja asiatica*	0.28
12	*Calliandra haematocephala*	0.6 ****
18	*Camphora officinarum*	0.50425
13	*Caryota urens*	0.67 *
14	*Castanopsis indica*	0.59575
15	*Cedrus deodara*	0.47
16	*Celtis australis*	0.55
17	*Choerospondias axillaris*	0.487
19	*Cinnamomum tamala*	0.575
20	*Citrus limon*	0.56 *
21	*Citrus maxima*	0.78 *
22	*Corymbia citriodora*	0.8035
23	*Cryptomeria japonica*	0.4
24	*Cupressus sempervirens*	0.38
25	*Duranta erecta*	0.56 *
26	*Ehretia acuminata*	0.435
27	*Elaeocarpus angustifolius*	0.39
28	*Engelhardtia spicata*	0.439
29	*Eucalyptus camaldulensis*	0.5885
30	*Eucalyptus grandis*	0.662
31	*Eucalyptus robusta*	0.5415
32	*Ficus benghalensis*	0.494
33	*Ficus benjamina*	0.459
34	*Ficus elastica*	0.618
35	*Ficus glaberrima*	0.6 ****
36	*Ficus hispida*	0.3815
37	*Ficus lacor*	0.34
38	*Ficus religiosa*	0.443
39	*Flacourtia jangomas*	0.923
40	*Grevillea robusta*	0.5054
41	*Grewia optiva*	0.646
42	*Heptapleurum venulosum*	0.6 ****
43	*Homalium napaulense*	0.67 *
44	*Ilex excelsa*	0.67 *
45	*Jacaranda mimosifolia*	0.49
46	*Juniperus recurva*	0.67 *
47	*Lagerstroemia indet*	0.62
48	*Leucaena leucocephala*	0.683
49	*Lithocarpus elegans*	0.799
50	*Litsea monopetala*	0.423
51	*Litsea monopetala*	0.423
52	*Machilus duthiei*	0.4724
53	*Madhuca longifolia*	0.79
54	*Magnolia grandiflora*	0.437
55	*Mallotus philippensis*	0.659
56	*Mangifera indica*	0.567

57	*Melaleuca citrina*	0.802
58	*Melia azedarach*	0.451
59	*Michelia champaca*	0.5275
60	*Morus alba*	0.6388
61	*Neolitsea cuipala*	0.67 **
62	*Nerium oleander*	0.6
63	*Nyctanthes arbor-tristis*	0.88
64	*Osmanthus fragrans*	0.8415
65	*Pachygone laurifolia*	0.6 ****
66	*Persea americana*	0.549
67	*Phyllanthus emblica*	0.636
68	*Pinus roxburghii*	0.327
69	*Platycladus orientalis*	0.51825
70	*Populus nigra*	0.353
71	*Prunus cerasoides*	0.72 *
72	*Prunus persica*	0.65 *
73	*Psidium guajava*	0.5895
74	*Pyrus pashia*	0.67 *
75	*Quercus lanata*	0.74 **
76	*Ricinus communis*	0.34 *
77	*Salix babylonica*	0.42
78	*Sapindus mukorossi*	0.7015
79	*Schima wallichii*	0.55775
80	*Stranvaesia nussia*	0.7 ***
81	*Syzygium cumini*	0.673
82	*Xylosma controversa*	0.6 ****
83	*Zizyphus incurva*	0.76 *

Where without any symbol is Zanne et al. (2009)
* (Shrestha et al., 2023);
** (Mahato et al., 2019);
*** (Karki et al., 2016);
**** (Ravindranath & Ostwald, 2008);
***** (Sharma & Pukkala, 1990)

Appendix 10: Importance value index (IVI) for Tree species of UGS

SN	Name	Relative Density	Relative Frequency	Relative Basal Area	IVI
1	*Pinus roxburghii*	11.871	5.055	12.027	28.953
2	*Camphora officinarum*	6.975	6.284	14.274	27.533
3	*Celtis australis*	8.384	9.290	5.065	22.738
4	*Grevillea robusta*	7.780	6.421	7.721	21.922
5	*Schima wallichii*	5.366	4.918	8.451	18.735
6	*Morus alba*	3.823	5.464	1.343	10.631
7	*Zizyphus incurva*	3.555	3.825	3.083	10.463
8	*Eucalyptus camaldulensis*	2.951	2.186	4.685	9.822
9	*Juniperus recurva*	4.024	2.459	2.674	9.157
10	*Jacaranda mimosifolia*	1.274	1.776	6.032	9.082
11	*Alnus nepalensis*	2.884	1.776	2.690	7.350
12	*Populus nigra*	1.811	0.956	4.187	6.955
13	*Ficus religiosa*	1.073	1.913	3.577	6.563
14	*Stranvaesia nussia*	1.543	2.186	2.493	6.221
15	*Melaleuca citrina*	2.482	1.639	0.801	4.922
16	*Ficus lacor*	0.134	0.273	4.363	4.770
17	*Pyrus pashia*	1.476	2.186	1.003	4.664
18	*Duranta erecta*	1.878	2.049	0.346	4.273
19	*Prunus cerasoides*	1.408	1.913	0.828	4.149
20	*Machilus duthiei*	1.207	1.776	1.006	3.989
21	*Neolitsea cuipala*	1.610	1.776	0.569	3.955
22	*Melia azedarach*	1.341	1.503	0.461	3.305
23	*Syzygium cumini*	1.207	1.366	0.687	3.261

24	*Eucalyptus robusta*	1.073	0.956	1.030	3.059
25	*Choerospondias axillaris*	0.671	1.230	0.927	2.827
26	*Elaeocarpus angustifolius*	1.274	1.230	0.205	2.709
27	*Salix babylonica*	0.939	0.683	0.790	2.412
28	*Acer oblongum*	0.402	0.820	1.114	2.336
29	*Buddleja asiatica*	0.805	1.366	0.156	2.327
30	*Persea americana*	1.073	1.093	0.074	2.240
31	*Litsea monopetala*	0.738	1.366	0.135	2.239
32	*Brassaiopsis hainla*	1.073	0.956	0.191	2.220
33	*Bauhinia variegata*	0.604	1.230	0.203	2.036
34	*Phyllanthus emblica*	0.939	0.546	0.433	1.919
35	*Albizia julibrissin*	0.402	0.683	0.794	1.879
36	*Ilex excels*	1.006	0.546	0.310	1.862
37	*Lagerstroemia indica*	0.604	0.956	0.260	1.820
38	*Ficus benjamina*	0.671	0.683	0.464	1.817
39	*Alangium chinense*	0.738	0.956	0.095	1.789
40	*Prunus persica*	0.537	0.956	0.089	1.582
41	*Ehretia acuminata*	0.805	0.683	0.050	1.538
42	*Platycladus orientalis*	0.604	0.820	0.027	1.450
43	*Leucaena leucocephala*	0.738	0.546	0.136	1.420
44	*Sapindus mukorossi*	0.335	0.546	0.426	1.308
45	*Araucaria bidwillii*	0.335	0.546	0.389	1.271
46	*Ficus benghalensis*	0.469	0.683	0.107	1.260
47	*Magnolia champaca*	0.335	0.683	0.220	1.239
48	*Grewia optiva*	0.335	0.546	0.284	1.166
49	*Engelhardia spicata*	0.335	0.410	0.400	1.145
50	*Flacourtia jangomas*	0.402	0.683	0.031	1.117
51	*Caryota urens*	0.335	0.546	0.122	1.004
52	*Cupressus sempervirens*	0.335	0.410	0.179	0.924
53	*Psidium guajava*	0.335	0.546	0.031	0.913
54	*Citrus maxima*	0.335	0.546	0.017	0.899
55	*Bombax ceiba*	0.201	0.273	0.376	0.851
56	*Cedrus deodara*	0.335	0.410	0.063	0.808
57	*Ficus elastica*	0.201	0.410	0.101	0.712
58	*Quercus lanata*	0.268	0.137	0.280	0.685
59	*Araucaria columnaris*	0.201	0.410	0.069	0.680
60	*Homalium napaulense*	0.134	0.273	0.230	0.638
61	*Mangifera indica*	0.201	0.410	0.015	0.626
62	*Citrus limon*	0.201	0.410	0.004	0.615
63	*Osmanthus fragrans*	0.268	0.273	0.011	0.552
64	*Ficus glaberrima*	0.134	0.273	0.122	0.530
65	*Castanopsis indica*	0.201	0.273	0.031	0.506

66	*Pachygone laurifolia*	0.201	0.273	0.028	0.502
67	*Cinnamomum tamala*	0.201	0.273	0.009	0.483
68	*Ficus hispida*	0.134	0.273	0.076	0.483
69	*Ricinus communis*	0.134	0.273	0.002	0.410
70	*Heptapleurum venulosum*	0.201	0.137	0.065	0.403
71	*Eucalyptus grandis*	0.067	0.137	0.195	0.399
72	*Mallotus philippensis*	0.134	0.137	0.018	0.288
73	*Heptapleurum calyptratum*	0.134	0.137	0.009	0.280
74	*Xylosma controversa*	0.134	0.137	0.008	0.278
75	*Bougainvillea glabra*	0.134	0.137	0.005	0.276
76	*Calliandra haematocephala*	0.067	0.137	0.060	0.263
77	*Madhuca longifolia*	0.067	0.137	0.044	0.248
78	*Corymbia citriodora*	0.067	0.137	0.041	0.245
79	*Magnolia grandiflora*	0.067	0.137	0.034	0.237
80	*Nerium oleander*	0.067	0.137	0.030	0.234
81	*Cryptomeria japonica*	0.067	0.137	0.008	0.212
82	*Lithocarpus elegans*	0.067	0.137	0.007	0.210
83	*Nyctanthes arbor-tristis*	0.067	0.137	0.003	0.206
	Total	**100**	**100**	**100.000**	**300.000**

Appendix 11: Importance value index (IVI) for Shrub/Saplings species of UGS

SN	Name	Relative Density	Relative Frequency	Relative Basal Area	IVI
1	*Ageratina adenophora*	30.154	12.467	22.304	64.925
2	*Lantana camara*	19.509	14.574	18.002	52.086
3	*Cestrum parqui*	5.026	6.497	5.233	16.755
4	*Duranta erecta*	3.522	4.039	6.086	13.647
5	*Cyathula capitata*	2.810	4.214	1.280	8.304
6	*Solanum viarum*	2.374	3.424	2.332	8.130
7	*Celtis australis*	1.820	3.073	1.735	6.628
8	*Justicia adhatoda*	1.741	1.668	2.815	6.225
9	*Brugmansia suaveolens*	1.820	2.371	1.934	6.125
10	*Morus alba*	1.306	2.809	1.763	5.879
11	*Urena lobata*	1.543	2.722	1.550	5.815
12	*Rubus ellipticus*	1.543	2.371	1.891	5.805
13	*Boehmeria virgata*	1.385	2.371	1.422	5.178
14	*Malvaviscus arboreus*	1.187	2.019	1.934	5.140
15	*Clerodendrum chinense*	1.227	1.317	1.792	4.335
16	*Hypoestes phyllostachya*	1.583	1.229	1.294	4.106
17	*Camphora officinarum*	0.989	1.580	0.953	3.522
18	*Rosa chinensis*	1.187	0.878	1.209	3.274
19	*Buddleja asiatica*	0.752	1.580	0.839	3.171
20	*Alternanthera philoxeroides*	1.345	0.351	1.422	3.119

21	*Ligustrum sinense*	0.673	0.966	1.010	2.648
22	*Platycladus orientalis*	0.594	0.966	0.910	2.469
23	*Neolitsea cuipala*	0.554	0.966	0.839	2.359
24	*Bergera koenigii*	0.594	0.878	0.583	2.055
25	*Hibiscus rosa-sinensis*	0.514	0.702	0.739	1.956
26	*Maclura cochinchinensis*	0.435	0.702	0.640	1.778
27	*Brassaiopsis hainla*	0.396	0.702	0.668	1.766
28	*Mangifera indica*	0.435	0.878	0.384	1.697
29	*Persea americana*	0.396	0.702	0.597	1.695
30	*Euphorbia pulcherrima*	0.435	0.527	0.583	1.545
31	*Litsea monopetala*	0.356	0.702	0.427	1.485
32	*Alangium chinense*	0.317	0.615	0.526	1.457
33	*Acer oblongum*	0.237	0.527	0.654	1.418
34	*Ziziphus incurva*	0.396	0.615	0.398	1.408
35	*Flacourtia jangomas*	0.396	0.615	0.284	1.295
36	*Ficus benjamina*	0.356	0.527	0.398	1.281
37	*Stranvaesia nussia*	0.317	0.615	0.327	1.258
38	*Cuphea hyssopifolia*	0.594	0.351	0.313	1.258
39	*Ficus benghalensis*	0.317	0.527	0.398	1.242
40	*Pyrus pashia*	0.356	0.439	0.384	1.179
41	*Solanum pseudocapsicum*	0.317	0.527	0.327	1.170
42	*Chrysojasminum humile*	0.277	0.527	0.313	1.117
43	*Grevillea robusta*	0.277	0.527	0.313	1.117
44	*Machilus duthiei*	0.237	0.527	0.313	1.077
45	*Tradescantia pallida*	0.554	0.351	0.171	1.076
46	*Engelhardia spicata*	0.277	0.439	0.355	1.071
47	*Melia azedarach*	0.237	0.527	0.299	1.063
48	*Barleria cristata*	0.277	0.439	0.242	0.958
49	*Berberis aristata*	0.198	0.351	0.398	0.947
50	*Psidium guajava*	0.198	0.439	0.242	0.879
51	*Citrus maxima*	0.198	0.351	0.327	0.876
52	*Schima wallichii*	0.198	0.439	0.213	0.850
53	*Syzygium cumini*	0.198	0.439	0.213	0.850
54	*Cinnamomum tamala*	0.198	0.439	0.199	0.836
55	*Hesperocyparis macrocarpa*	0.198	0.263	0.327	0.788
56	*Sida rhombifolia*	0.237	0.351	0.199	0.788
57	*Achyranthes bidentata*	0.198	0.351	0.199	0.748
58	*Elaeocarpus angustifolius*	0.158	0.351	0.228	0.737
59	*Bougainvillea glabra*	0.158	0.263	0.313	0.735
60	*Camellia japonica*	0.158	0.263	0.313	0.735
61	*Agave sisalana*	0.079	0.176	0.469	0.724
62	*Ficus religiosa*	0.158	0.351	0.199	0.709

63	*Murraya paniculata*	0.237	0.176	0.270	0.683
64	*Ilex excelsa*	0.158	0.263	0.199	0.621
65	*Benkara fasciculata*	0.119	0.263	0.213	0.595
66	*Phyllanthus emblica*	0.119	0.263	0.213	0.595
67	*Smilax lanceifolia*	0.158	0.263	0.156	0.578
68	*Pachygone laurifolia*	0.119	0.263	0.185	0.567
69	*Callianthe picta*	0.119	0.263	0.171	0.553
70	*Citrus limon*	0.119	0.263	0.171	0.553
71	*Leucaena leucocephala*	0.119	0.263	0.142	0.524
72	*Prunus cerasoides*	0.158	0.176	0.171	0.505
73	*Bougainvillea spectabilis*	0.079	0.176	0.142	0.397
74	*Calliandra haematocephala*	0.079	0.176	0.128	0.383
75	*Ricinus communis*	0.079	0.176	0.128	0.383
76	*Berberis napaulensis*	0.079	0.176	0.114	0.368
77	*Ficus elastic*	0.079	0.176	0.100	0.354
78	*Jacaranda mimosifolia*	0.079	0.176	0.100	0.354
79	*Tecoma stans*	0.079	0.176	0.100	0.354
80	*Grewia optiva*	0.079	0.176	0.085	0.340
81	*Brunfelsia pauciflora*	0.079	0.088	0.171	0.338
82	*Chrysalidocarpus lutescens*	0.119	0.088	0.114	0.320
83	*Heptapleurum calyptratum*	0.119	0.088	0.114	0.320
84	*Artabotrys hexapetalus*	0.079	0.088	0.142	0.309
85	*Aucuba japonica*	0.079	0.088	0.114	0.281
86	*Sambucus canadensis*	0.079	0.088	0.114	0.281
87	*Cestrum nocturnum*	0.040	0.088	0.114	0.241
88	*Cycas revolute*	0.040	0.088	0.114	0.241
89	*Juniperus recurva*	0.079	0.088	0.071	0.238
90	*Reinwardtia indica*	0.079	0.088	0.071	0.238
91	*Mallotus philippensis*	0.040	0.088	0.100	0.227
92	*Hibiscus syriacus*	0.040	0.088	0.085	0.213
93	*Euonymus hamiltonianus*	0.040	0.088	0.071	0.198
94	*Ficus lacor*	0.040	0.088	0.071	0.198
95	*Jasminum officinale*	0.040	0.088	0.071	0.198
96	*Melaleuca citrina*	0.040	0.088	0.071	0.198
97	*Muehlenbeckia platyclada*	0.040	0.088	0.071	0.198
98	*Caryota urens*	0.040	0.088	0.057	0.184
99	*Prunus persica*	0.040	0.088	0.057	0.184
100	*Punica granatum*	0.040	0.088	0.057	0.184
101	*Sarcococca coriacea*	0.040	0.088	0.057	0.184
102	*Solanum torvum*	0.040	0.088	0.057	0.184
103	*Syzygium jambos*	0.040	0.088	0.057	0.184
104	*Eucalyptus camaldulensis*	0.040	0.088	0.043	0.170

105	*Gardenia jasminoides*	0.040	0.088	0.043	0.170
106	*Rubus niveus*	0.040	0.088	0.043	0.170
107	*Solanum lycopersicum*	0.040	0.088	0.043	0.170
	Total	**100.000**	**100.000**	**100.000**	**300.000**

Appendix 12: Carbon stock across the UGS

SN	Name of Urban Green Space	AGTB (kg)	BGTB (Kg)	Total tree Biomass (kg)	Total Biomass (ton ha-1)	Carbon stock (t/ha)
1	Bandevi Park	18035.83	3607.17	21642.99	270.54	127.15
2	Mhepi RF	33301.92	6660.38	39962.31	399.62	187.82
3	Indrayeni CF	58337.66	11667.53	70005.19	466.70	219.35
4	Bhugol Park	12131.96	2426.39	14558.35	485.28	228.08
5	Swayambhunath RF	147879.67	29575.93	177455.60	554.55	260.64
6	Balkumari CF	73857.02	14771.40	88628.42	590.86	277.70
7	Sankha Park	21677.22	4335.44	26012.67	867.09	407.53
8	Ratna Park	74828.93	14965.79	89794.72	997.72	468.93
9	Coronation garden	293721.26	58744.25	352465.51	1409.86	662.64
10	Kirat RF	129649.56	25929.91	155579.47	1555.79	731.22
11	Tribhuvan park	210697.74	42139.55	252837.29	1685.58	792.22
12	Balaju Park	156061.53	31212.31	187273.84	1872.74	880.19
13	UN Park	227725.48	45545.10	273270.58	2277.25	1070.31
14	Ranibari CF	481689.86	96337.97	578027.83	2890.14	1358.37

Appendix 13: Regeneration status for Tree species of UGS

SN	Name of species	Seedling	Sapling	Tree	Regeneration Status
1	*Acer oblongum*	86.36	6.22	3.11	Good
2	*Alangium chinense*	86.36	8.29	5.70	Good
3	*Albizia julibrissin*	51.81	0.00	3.11	Fair
4	*Alnus nepalensis*	17.27	0.00	22.28	Fair
5	*Araucaria bidwillii*	17.27	0.00	2.59	Fair
6	*Araucaria columnaris*	0.00	0.00	1.55	No
7	*Artabotrys hexapetalus*	0.00	2.07	0.00	Poor
8	*Bauhinia variegata*	17.27	0.00	4.66	Fair
9	*Bombax ceiba*	0.00	0.00	1.55	No
10	*Bougainvillea glabra*	0.00	0.00	1.04	No
11	*Bougainvillea spectabilis*	17.27	0	0	New
12	*Brassaiopsis hainla*	120.90	10.36	8.29	Good
13	*Buddleja asiatica*	241.80	19.69	6.22	Good
14	*Calliandra haematocephala*	0.00	2.07	0.52	Poor

15	*Camphora officinarum*	310.88	25.91	53.89	Fair
16	*Caryota urens*	0.00	1.04	2.59	Poor
17	*Castanopsis indica*	0.00	0.00	1.55	No
18	*Cedrus deodara*	0.00	0.00	2.59	No
19	*Celtis australis*	1001.73	47.67	64.77	Fair
20	*Choerospondias axillaris*	0.00	0.00	5.18	No
21	*Cinnamomum tamala*	103.63	5.18	1.55	Good
22	*Citrus aurantiifolia*	17.27	0.00	0.00	New
23	*Citrus limon*	17.27	3.11	1.55	Good
24	*Citrus maxima*	34.54	5.18	2.59	Good
25	*Corymbia citriodora*	0.00	0.00	0.52	No
26	*Cryptomeria japonica*	0.00	0.00	0.52	No
27	*Cupressus sempervirens*	0.00	0.00	2.59	No
28	*Duranta erecta*	155.44	92.23	14.51	Good
29	*Ehretia acuminata*	0.00	0.00	6.22	No
30	*Elaeocarpus angustifolius*	51.81	4.15	9.84	Fair
31	*Engelhardia spicata*	51.81	7.25	2.59	Good
32	*Eucalyptus camaldulensis*	0.00	1.04	22.80	Poor
33	*Eucalyptus grandis*	0.00	0.00	0.52	No
34	*Eucalyptus robusta*	0.00	0.00	8.29	No
35	*Ficus benghalensis*	17.27	8.29	3.63	Good
36	*Ficus benjamina*	34.54	9.33	5.18	Good
37	*Ficus elastica*	17.27	2.07	1.55	Good
38	*Ficus glaberrima*	0.00	0.00	1.04	No
39	*Ficus hispida*	0.00	0.00	1.04	No
40	*Ficus lacor*	17.27	1.04	1.04	Fair
41	*Ficus religiosa*	51.81	4.15	8.29	Fair
42	*Flacourtia jangomas*	0.00	10.36	3.11	Poor
43	*Grevillea robusta*	241.80	7.25	60.10	Fair
44	*Grewia optiva*	0.00	2.07	2.59	Poor
45	*Heptapleurum calyptratum*	0.00	3.11	1.04	Poor
46	*Heptapleurum venulosum*	0.00	0.00	1.55	No
47	*Homalium napaulense*	0.00	0.00	1.04	No
48	*Ilex excelsa*	0.00	4.15	7.77	Poor
49	*Jacaranda mimosifolia*	86.36	2.07	9.84	Fair
50	*Juniperus recurva*	0.00	2.07	31.09	Poor
51	*Lagerstroemia indica*	0.00	0.00	4.66	No
52	*Leucaena leucocephala*	155.44	3.11	5.70	Fair
53	*Lithocarpus elegans*	0.00	0.00	0.52	No
54	*Litsea monopetala*	362.69	9.33	5.70	Good
55	*Livistona chinensis*	34.54	0.00	0.00	New
56	*Machilus duthiei*	0.00	6.22	9.33	Poor

57	*Madhuca longifolia*	0.00	0.00	0.52	No
58	*Magnolia champaca*	0.00	0.00	2.59	No
59	*Magnolia grandiflora*	0.00	0.00	0.52	No
60	*Mallotus philippensis*	0.00	0.00	1.04	No
61	*Mangifera indica*	310.88	11.40	1.55	Good
62	*Melaleuca citrina*	0.00	1.04	19.17	Poor
63	*Melia azedarach*	34.54	6.22	10.36	Fair
64	*Morus alba*	621.76	34.20	29.53	Good
65	*Neolitsea cuipala*	259.07	14.51	12.44	Good
66	*Nerium oleander*	0.00	0.00	0.52	No
67	*Nyctanthes arbor-tristis*	0.00	0.00	0.52	No
68	*Osmanthus fragrans*	0.00	0.00	2.07	No
69	*Pachygone laurifolia*	0.00	3.11	1.55	Poor
70	*Persea americana*	155.44	10.36	8.29	Good
71	*Phyllanthus emblica*	0.00	3.11	7.25	Poor
72	*Pinus roxburghii*	0.00	0.00	91.71	No
73	*Platycladus orientalis*	241.80	15.54	4.66	Good
74	*Populus nigra*	0.00	0.00	13.99	No
75	*Prunus cerasoides*	0.00	4.15	10.88	Poor
76	*Prunus persica*	0.00	1.04	4.15	Poor
77	*Psidium guajava*	259.07	5.18	2.59	Good
78	*Punica granatum*	0.00	1.04	0.00	Poor
79	*Pyrus pashia*	0.00	9.33	11.40	Poor
80	*Quercus lanata*	0.00	0.00	2.07	No
81	*Ricinus communis*	69.08	2.07	1.04	Good
82	*Salix babylonica*	0.00	0.00	7.25	No
83	*Sapindus mukorossi*	0.00	0.00	2.59	No
84	*Schima wallichii*	17.27	5.18	41.45	Fair
85	*Stranvaesia nussia*	51.81	8.29	11.92	Fair
86	*Syzygium jambos*	51.81	1.04	0.00	New
87	*Syzygium cumini*	120.90	5.18	9.33	Fair
88	*Tecoma stans*	0.00	2.07	0.00	Poor
89	*Xylosma controversa*	0.00	0.00	1.04	No
90	*Ziziphus incurva*	172.71	10.36	27.46	Fair

Appendix 14: Plant species mention by visitor in UGS

SN	Name of species	Number of visitor	Frequency of mention
1	*Ficus religiosa*	98	42.61
2	*Pinus roxburghii*	87	37.83
3	*Juniperus recurva*	85	36.96
4	*Camphora officinarum*	37	16.09
5	*Ficus benghalensis*	26	11.30
6	*Dendrocalamus strictus*	21	9.13
7	*Rosa chinensis*	21	9.13
8	*Morus alba*	20	8.70
9	*Grevillea robusta*	17	7.39
10	*Cynodon dactylon*	14	6.09
11	*Eucalyptus camaldulensis*	14	6.09

12	*Jacaranda mimosifolia*	12	5.22
13	*Alnus nepalensis*	10	4.35
14	*Choerospondias axillaris*	10	4.35
15	*Hibiscus rosa-sinensis*	10	4.35
16	*Lagerstroemia indica*	10	4.35
17	*Ficus lacor*	9	3.91
18	*Prunus persica*	8	3.48
19	*Celtis australis*	7	3.04
20	*Duranta erecta*	7	3.04
21	*Schima wallichii*	7	3.04
22	*Bauhinia variegata*	6	2.61
23	*Melaleuca citrina*	6	2.61
24	*Rubus ellipticus*	6	2.61
25	*Zephyranthes carinata*	6	2.61
26	*Araucaria columnaris*	5	2.17
27	*Elaeocarpus angustifolius*	5	2.17
28	*Mangifera indica*	5	2.17
29	*Urtica parviflora*	5	2.17
30	*Citrus maxima*	4	1.74
31	*Cycas revoluta*	4	1.74
32	*Ficus elastica*	4	1.74
33	*Malvaviscus arboreus*	4	1.74
34	*Solanum nigrum*	4	1.74
35	*Justicia adhatoda*	3	1.30
36	*Phyllanthus emblica*	3	1.30
37	*Platycladus orientalis*	3	1.30
38	*Ziziphus incurva*	3	1.30
39	*Aloe vera*	2	0.87
40	*Castanopsis indica*	2	0.87
41	*Jasminum officinale*	2	0.87
42	*Litsea monopetala*	2	0.87
43	*Magnolia grandiflora*	2	0.87
44	*Melia azedarach*	2	0.87
45	*Opuntia monacantha*	2	0.87
46	*Persea americana*	2	0.87
47	*Populus nigra*	2	0.87
48	*Prunus cerasoides*	2	0.87
49	*Sapindus mukorossi*	2	0.87
50	*Agave attenuata*	1	0.43
51	*Albizia julibrissin*	1	0.43
52	*Amaranthus cruentus*	1	0.43
53	*Berberis aristata*	1	0.43
54	*Bougainvillea glabra*	1	0.43
55	*Buddleja asiatica*	1	0.43
56	*Cinnamomum tamala*	1	0.43
57	*Citrus limon*	1	0.43
58	*Euphorbia pulcherrima*	1	0.43
59	*Ficus benjamina*	1	0.43
60	*Juglans regia*	1	0.43
61	*Livistona chinensis*	1	0.43
62	*Magnolia champaca*	1	0.43
63	*Pyrus pashia*	1	0.43
64	*Syzygium cumini*	1	0.43

Appendix 15: Questionnaire of visitor survey

Section 1: Demographic Information

1. Name:	2. Age: .....
3. Gender:	4. Marital Status: .....
5. Family:	6. Education: .....
7. Employment status	8. Location: ……..

Section 2: Pattern of Urban Green Space Visitation

1. What is your main reason for visiting this place? .....
2. With whom do you usually come to this place? .....
3. How long do you take to get to this place? .....
4. How do you usually get to this place? .....
5. How long do you stay in the place? .....
6. Preferred visit time (Period): .....
7. How many times have you visited this place in the past 12 months?.....
8. On average, how often do you visit this place? .....
9. When did you first visit this place? What improvements or changes in infrastructure, vegetation, or green space facilities have you observed since your first visit?.....
10. What three things do you like about this place?.....
11. What one word or phrase describes how a place makes you feel? .....
12. Have you visited other Urban Green Space? a. Yes b. No

If yes, name the place and compare with this place _____

Section 3: Visitors perception on Plant Diversity

1. Do you use any plant species from this place for any of the following purposes?

……

2. Are there any plant species you would like to see in the place that could serve a specific purpose for the local community? …….

3. Do you feel that the Urban Green Spaces vegetation helps reduce noise or improve air quality?

a. Strongly Disagree b. Disagree c. Neutral d. Agree e. Strongly Agree

4. Can you name any plant species in this place?

5. Have you noticed any rare or unique species in this place? If yes, please specify.

6. Do you have an idea of native, invasive, and exotic species?

7. What do you think about spontaneous species (wild species that grow naturally in the place)?

a. Cohabit with cultivated species. b. Eliminated to favor cultivated species. c. Favored over cultivated species

8. Please list the improvements or changes you would like to see for the place vegetation.

a. Add flowering plants for aesthetic appeal. b. Add more shade-providing trees.
c. Maintenance of existing vegetation. d. Add educational signage about the plants knowledge.
e. Add medicinal or edible plants. f. ……

9. How many number of species do you estimate to be present in this place? .....

10. Do you feel the biodiversity in this place is well-preserved?

a. Strongly Disagree b. Disagree c. Neutral d. Agree e. Strongly Agree

11. What suggestions do you have for improving biodiversity conservation in this place?

Section 4: Willingness to Pay Assessment

1. How satisfied are you with the place overall?

a. Strongly Disagree b. Disagree c. Neutral d. Agree e. Strongly Agree

2. If not satisfied, what are the problems you suggest need attention for Urban Green Space management?.....

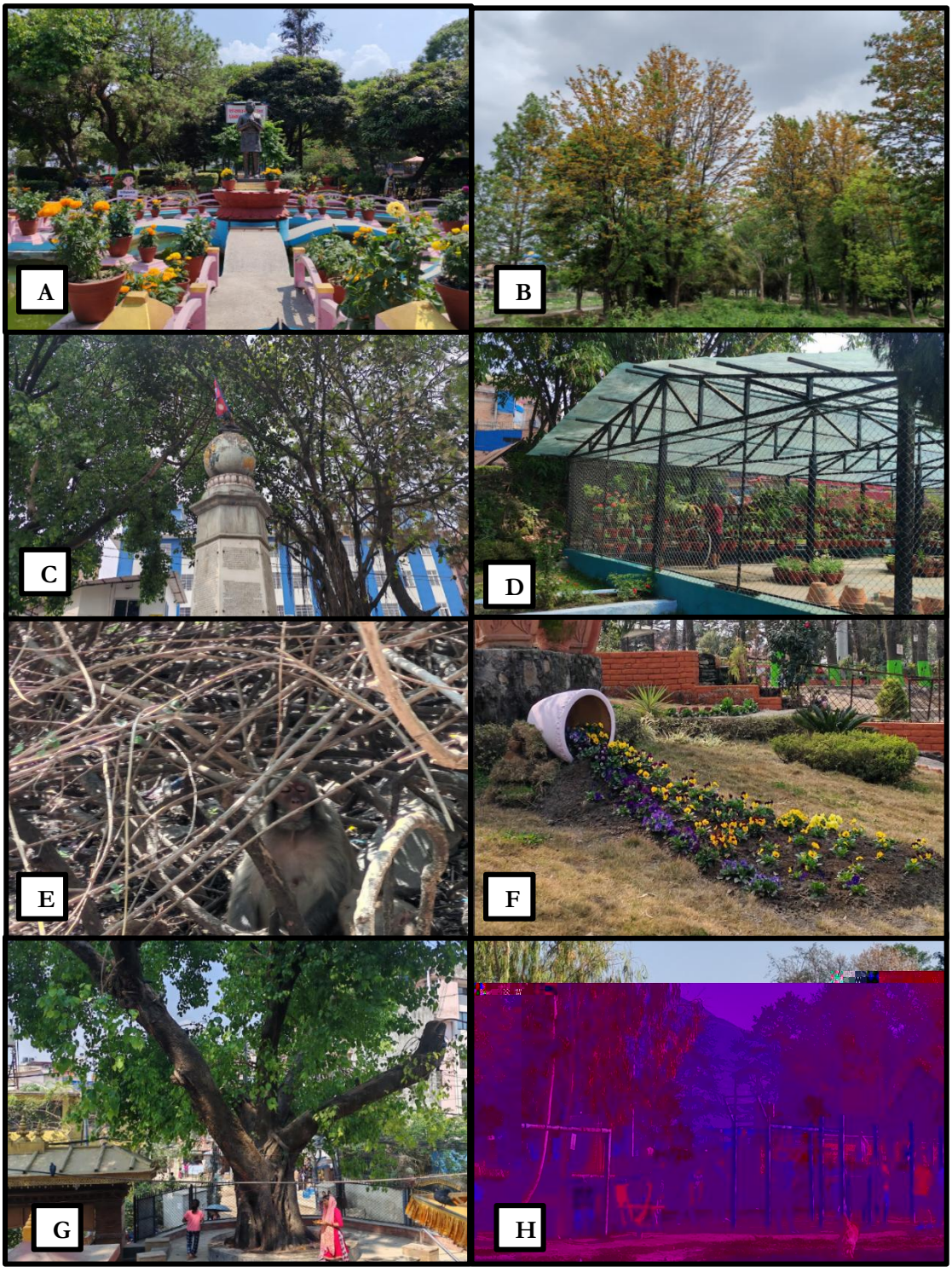
3. If the Urban Green Space authority needs a source of funding to improve visitor services, such as recreational facilities, cleanliness, and public safety, how should these services be financed?

4. Would you be willing to pay? If the authority increases the entry fee for improvement and development. Why?

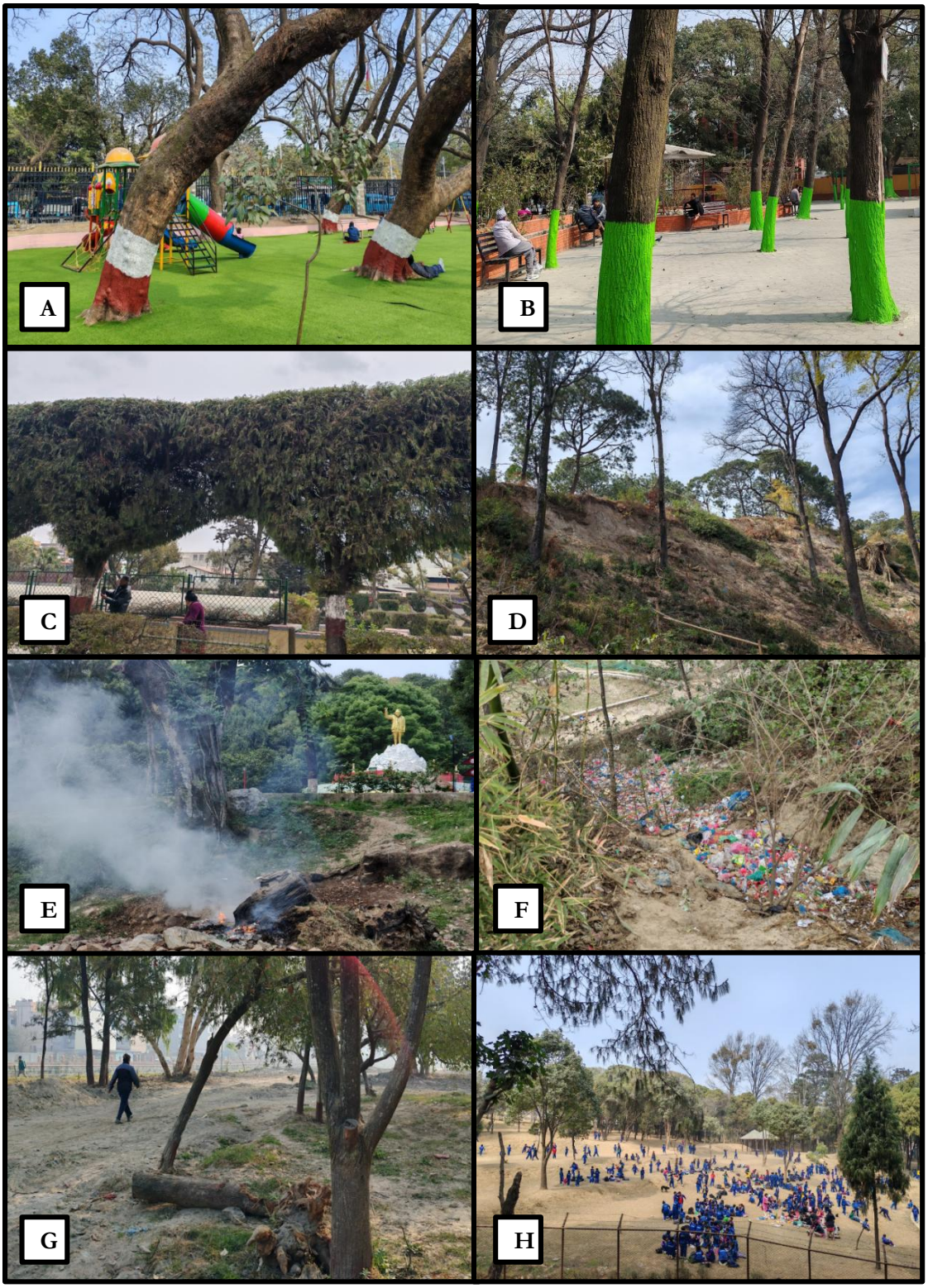
a. Yes Maximum amount: ……..
b. No

Appendix 16: Photographs

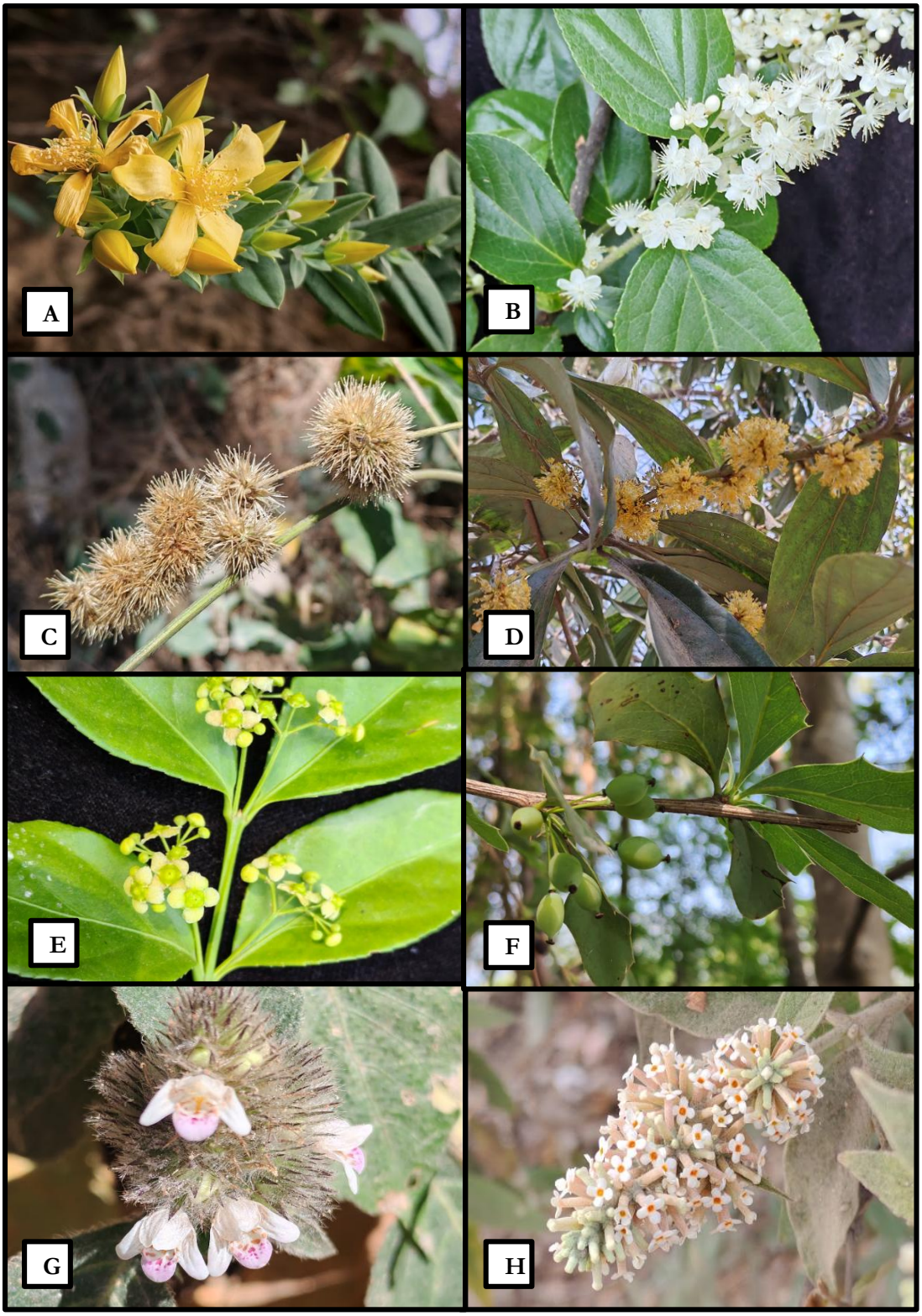
Photoplate 1: Data Collection on UGS; **A.** Locating sampling point using GPS; **B.** Fixing the quadrat; **C.** Measuring DBH; **D.** Measuring tree height using a clinometer; **E.** Collecting and Photographing plant specimens; **F.** Preparing herbarium samples; **G.** Key Informant Interview (KII) with park caretaker; **H.** Interaction with visitor



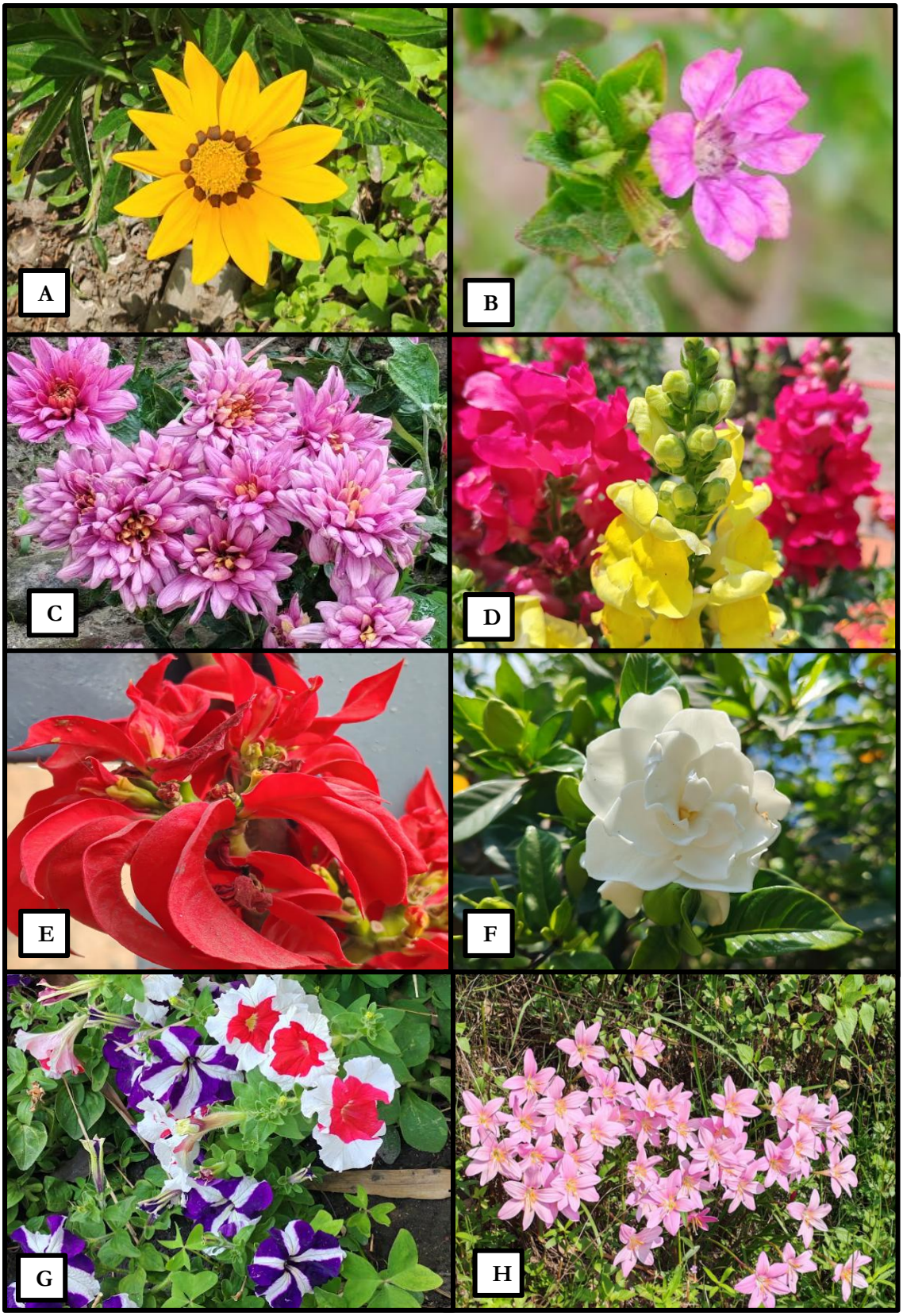
Photoplate 2: Key Features of UGS; A. Horticultural layout of Ratna Park; **B.** Naturalistic landscape of UN Park; **C.** Earthquake monument at Bhugol Park; **D.** Plant nursery at Balaju Park; **E.** Monkey shaded under *Lantana camara* at Swayambhunath Religious Forest; **F.** Ornamental plant decoration at Shankha Park; **G.** Worship and rotation ritual around a *Ficus religiosa* at Mhepi Religious Forest; **H.** Outdoor gym equipment at Indrayeni Community Forest



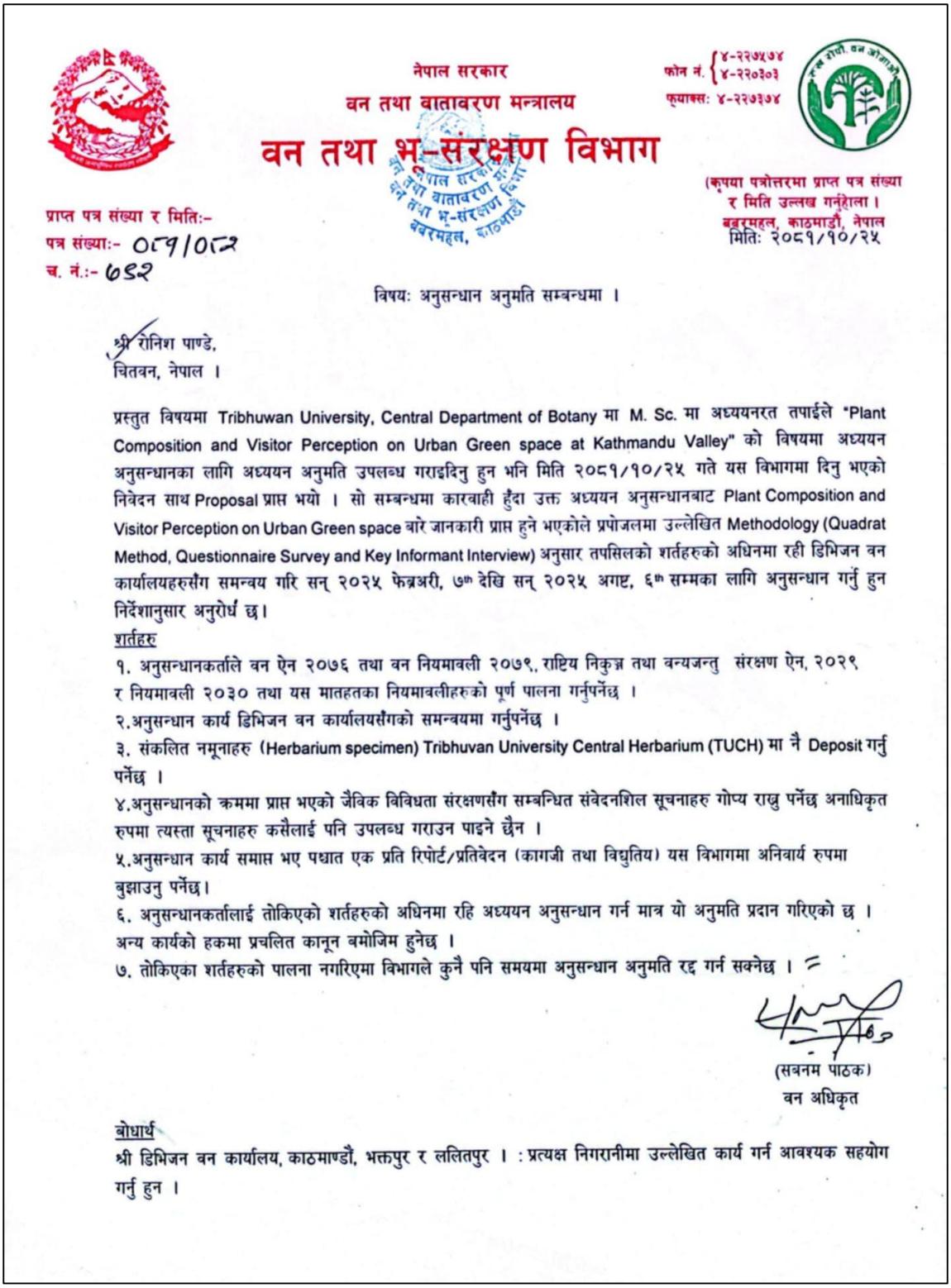
Photoplate 3: Disturbances Observed in UGS; **A.** Installation of artificial plastic grass at Ratna Park; **B.** Concrete flooring reducing natural ground cover at Shankha Park; **C.** Lopping of trees for horticultural design; **D.** Soil erosion at Kirat Religious Forest; **E.** Open burning of waste at Tribhuvan Park; **F.** Waste disposal site at Indrayeni Community Forest; **G.** Flood-induced damage at UN Park; **H.** Overcrowding of visitors at Tribhuvan Park



Photoplate 4: Native species; **A.** *Hypericum cordifolium* Choisy; **B.** *Symplocos paniculata* (Thunb.) Miq.; **C.** *Cyathula capitata* Moq.; **D.** *Neolitsea cuipala* (D.Don) Kosterm.; **E.** *Euonymus echinatus* Wall.; **F.** *Berberis aristata* DC.; **G.** *Lepidagathis incurva* Buch.-Ham. ex D.Don; **H.** *Buddleja asiatica* Lour.



Photoplate 5: Exotic ornamental species; **A.** *Gazania rigens* (L.) Gaertn.; **B.** *Cuphea hyssopifolia* Kunth; **C.** *Chrysanthemum* × *morifolium* (Ramat.) Hemsl.; **D.** *Antirrhinum majus* L.; **E.** *Euphorbia pulcherrima* Willd. ex Klotzsch; **F.** *Gardenia jasminoides* J.Ellis; **G.** *Petunia* × *atkinsiana* (Sweet) D.Don ex W.H.Baxter; **H.** *Zephyranthes carinata* Herb.



नेपाल सरकार
वन तथा वातावरण मन्त्रालय
वन तथा भू-संरक्षण विभाग
बबरमहल, काठमाडौं

फोन नं. ४-२२७५७४, ४-२२०३०३
फ्याक्स: ४-२२७३७४

(कृपया पत्रोत्तरमा प्राप्त पत्र संख्या र मिति उल्लेख गर्नुहोला ।
बबरमहल, काठमाडौं, नेपाल
मितिः २०८१/१०/२५

प्राप्त पत्र संख्या र मितिः-
पत्र संख्याः- ०८१/०८२
च. नं.:- ७९२

विषयः अनुसन्धान अनुमति सम्बन्धमा ।

श्री रोनिश पाण्डे,
चितवन, नेपाल ।

प्रस्तुत विषयमा Tribhuwan University, Central Department of Botany मा M. Sc. मा अध्ययनरत तपाईले "Plant Composition and Visitor Perception on Urban Green space at Kathmandu Valley" को विषयमा अध्ययन अनुसन्धानका लागि अध्ययन अनुमति उपलब्ध गराइदिनु हुन भनि मिति २०८१/१०/२५ गते यस विभागमा दिनु भएको निवेदन साथ Proposal प्राप्त भयो । सो सम्बन्धमा कारवाही हुँदा उक्त अध्ययन अनुसन्धानबाट Plant Composition and Visitor Perception on Urban Green space बारे जानकारी प्राप्त हुने भएकोले प्रपोजलमा उल्लेखित Methodology (Quadrat Method, Questionnaire Survey and Key Informant Interview) अनुसार तपसिलको शर्तहरुको अधिनमा रही डिभिजन वन कार्यालयहरुसँग समन्वय गरि सन् २०२५ फेब्रअरी, ७ᵗʰ देखि सन् २०२५ अगष्ट, ६ᵗʰ सम्मका लागि अनुसन्धान गर्नु हुन निर्देशानुसार अनुरोध छ।

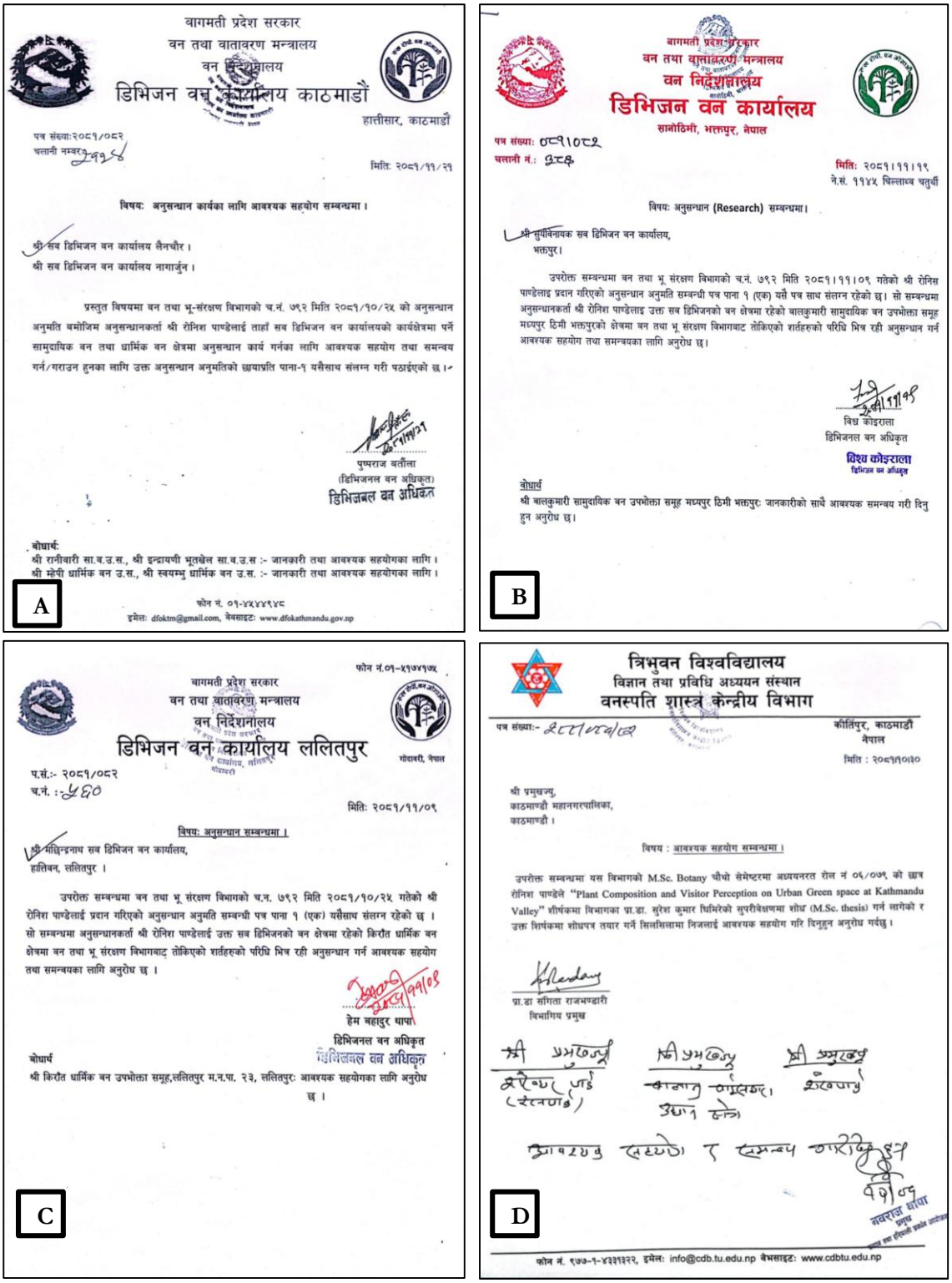
शर्तहरु

१. अनुसन्धानकर्ताले वन ऐन २०७६ तथा वन नियमावली २०७९, राष्ट्रिय निकुञ्ज तथा वन्यजन्तु संरक्षण ऐन, २०२९ र नियमावली २०३० तथा यस मातहतका नियमावलीहरुको पूर्ण पालना गर्नुपर्नेछ ।
२.अनुसन्धान कार्य डिभिजन वन कार्यालयसँगको समन्वयमा गर्नुपर्नेछ ।
३. संकलित नमूनाहरु (Herbarium specimen) Tribhuvan University Central Herbarium (TUCH) मा नै Deposit गर्नु पर्नेछ ।
४.अनुसन्धानको क्रममा प्राप्त भएको जैविक विविधता संरक्षणसँग सम्बन्धित संवेदनशिल सूचनाहरु गोप्य राख्नु पर्नेछ अनाधिकृत रुपमा त्यस्ता सूचनाहरु कसैलाई पनि उपलब्ध गराउन पाइने छैन ।
५.अनुसन्धान कार्य समाप्त भए पश्चात एक प्रति रिपोर्ट/प्रतिवेदन (कागजी तथा विद्युतिय) यस विभागमा अनिवार्य रुपमा बुझाउनु पर्नेछ।
६. अनुसन्धानकर्तालाई तोकिएको शर्तहरुको अधिनमा रहि अध्ययन अनुसन्धान गर्न मात्र यो अनुमति प्रदान गरिएको छ । अन्य कार्यको हकमा प्रचलित कानून बमोजिम हुनेछ ।
७. तोकिएका शर्तहरुको पालना नगरिएमा विभागले कुनै पनि समयमा अनुसन्धान अनुमति रद्द गर्न सक्नेछ ।

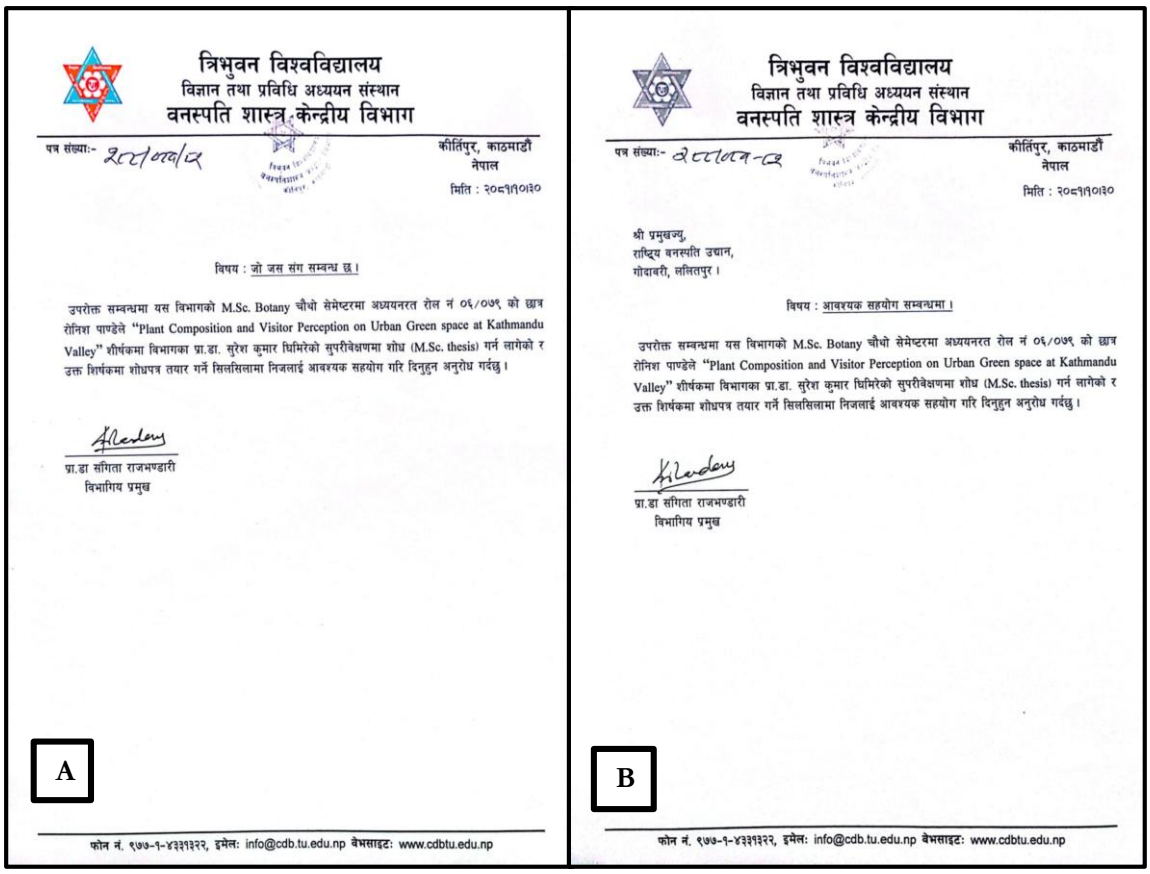
(सबनम पाठक)
वन अधिकृत

बोधार्थ
श्री डिभिजन वन कार्यालय, काठमाण्डौं, भक्तपुर र ललितपुर । : प्रत्यक्ष निगरानीमा उल्लेखित कार्य गर्न आवश्यक सहयोग गर्नु हुन ।

Photoplate 6: Permission letter from Department of Forests and Soil Conservation



Photoplate 7: Permission letter; **A.** Division Forest Office (DFO) Kathmandu for Mhepi Religious Forest, Indrayeni Community Forest, Ranibari Community Forest, and Swayambhunath Religious Forest; **B.** DFO Bhaktapur for Balkumari Community Forest; **C.** DFO Lalitpur for Kirat Religious Forest; **D.** Official approval from Kathmandu Metropolitan City for Balaju Park, Bhugol Park, Shankha Park, and Ratna Park (Sankadhar Udyan).



त्रिभुवन विश्वविद्यालय
विज्ञान तथा प्रविधि अध्ययन संस्थान
वनस्पति शास्त्र केन्द्रीय विभाग

पत्र संख्याः- २८८/०७९

कीर्तिपुर, काठमाडौं
नेपाल
मिति : २०८१।१०।३०

विषय : जो जस संग सम्बन्ध छ।

उपरोक्त सम्बन्धमा यस विभागको M.Sc. Botany चौथो सेमेष्टरमा अध्ययनरत रोल नं ०६/०७९ को छात्र रोनिश पाण्डेले "Plant Composition and Visitor Perception on Urban Green space at Kathmandu Valley" शीर्षकमा विभागका प्रा.डा. सुरेश कुमार घिमिरेको सुपरीवेक्षणमा शोध (M.Sc. thesis) गर्न लागेको र उक्त शिर्षकमा शोधपत्र तयार गर्ने सिलसिलामा निजलाई आवश्यक सहयोग गरि दिनुहुन अनुरोध गर्दछु।

प्रा.डा संगिता राजभण्डारी
विभागिय प्रमुख

A

फोन नं. ९७७-१-४३३१३२२, इमेलः info@cdb.tu.edu.np वेभसाइटः www.cdbtu.edu.np

त्रिभुवन विश्वविद्यालय
विज्ञान तथा प्रविधि अध्ययन संस्थान
वनस्पति शास्त्र केन्द्रीय विभाग

पत्र संख्याः- २८८/०७९-८२

कीर्तिपुर, काठमाडौं
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श्री प्रमुखज्यु,
राष्ट्रिय वनस्पति उद्यान,
गोदावरी, ललितपुर।

विषय : आवश्यक सहयोग सम्बन्धमा।

उपरोक्त सम्बन्धमा यस विभागको M.Sc. Botany चौथो सेमेष्टरमा अध्ययनरत रोल नं ०६/०७९ को छात्र रोनिश पाण्डेले "Plant Composition and Visitor Perception on Urban Green space at Kathmandu Valley" शीर्षकमा विभागका प्रा.डा. सुरेश कुमार घिमिरेको सुपरीवेक्षणमा शोध (M.Sc. thesis) गर्न लागेको र उक्त शिर्षकमा शोधपत्र तयार गर्ने सिलसिलामा निजलाई आवश्यक सहयोग गरि दिनुहुन अनुरोध गर्दछु।

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विभागिय प्रमुख

B

फोन नं. ९७७-१-४३३१३२२, इमेलः info@cdb.tu.edu.np वेभसाइटः www.cdbtu.edu.np

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Ronish Pandey

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