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Research Article

Impacts and Management Practices of Invasive Plant Species in Gullele Botanic Garden, Ethiopia

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Abstract

Invasive species refer to non-native organisms capable of rapidly spreading and imperilling biodiversity upon introduction to new environments. These species pose significant threats to native populations globally and are a leading cause of native species extinctions.This research was conducted in the Gullele Botanic Garden with the objective of developing management strategies for invasive species and potentially invasive species by examining their distribution and impacts. A total of 40 plots (10 x 10 m^2 size each) were established across different land use types to collect vegetation and environmental data. The impact rank was analysed using the R- packages, which shows the lower and higher impact rate ranges for the sampled land use type. ArcGIS (version 18.1) was used to map the spatial distributions of each species in the Botanic Garden. A total of 2550 individuals from 12 families comprising 16 invasive and potentially invasive species have been recorded in the the sampled plots. The highest species abundance appeared near the roadside. *Acacia decurrens, Cyathula uncinulata,* and *Acacia melanoxylon* were the three most predominant species, had a substantial contribution to the high impacts on the native species by dominating them and reduceing their growth and diversity within the Botanic Garden. To effectively manage these invasive plant pecies in the Botanic Garden, we suggested to introduce mechanical interventions including hand-weeding, uprooting, cutting before flowering, seed collection and replacement by with the native plant species, and regularly monitoring strategies.

Keywords: Biodiversity, Distribution, Gullele, Impacts, Invasive plants, Management strategies

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1. INTRODUCTION

Dspite high diversity of plant species found in tropical regions and African countries, these regions are host to the fewest and youngest botanical gardens (Jackson *et al*., 2000). Ethiopia is one of the tropical counties endowed with high biodiversity accompanied by endemism (Kelbessa and Demissew, 2014). Variable physiographic and climatic variables are the primary factors contributing to diversity. However, the diversified flora and fauna are gradually dwindling as a result of anthropogenic activity and climate change (Girmay *et al.,* 2020). To overcome these challenges, it is essential to thoroughly examine and preserve these resources in a given place, such as a botanical garden (Mittermeier *et al.,* 2011).

The majority of botanical gardens employ an ex-situ method of conservation. This might results the introduction of new invasive and alien species that could harm native plant species (Kumar 2018). The main contributors to the current reduction in biodiversity are invasive plant species (IPS), which also cause overexploitation, habitat modification, extinction of species, and climate change (Sharma *et al.,* 2009). Currently invasive species are becoming a global concern, due to their potential to spread rapidly, highly competitive, increased human movement on a global scale and can occupy vast areas. Global apprehension also arises from the nature and severity of the impacts these species have on national heritage, economic activities, society, and health. (Sonwa *et al.,* 2017; Kumar *et al.,* 2021).

The increasing worldwide trade, transportation, and travel are all contribute to the exponential rise in the threat posed by invasive plant species. This threat, aaccording to Goldberg and Reed (2023), varies from one place to another and is interrelated to differences in management, awareness, and other factors. The majority of introduced species will go undetected, especially in the developing world where lack of awareness, knowledge, and capacity hampers our ability to effectively manage the problem to manage the problem effectively. According to the study by McGeoch *et al*. (2010), research efforts and information availability play a major role in managing the expansion of invasive plant species. However, the number of documented studies on invasive plant species in many countries is considerably underestimated. Researchers such as Pyšek *et al.* (2008) and NuÇe and Pauchard (2009) noted that, the correlation between environmental, economic and biodiversity factors and invasive species in developing countries has not been thoroughly examined or presented in detail.

The problem caused by invasive species in Ethiopia ecosystem is largely determined by the disruption of biodiversity, changes in habitat structure, and effects on local livelihoods. For instance, *Prosopis juliflora* has extensively invaded the Afar region, competing with native vegetation and affecting pastoral communities' access to water and grazing (Shiferaw and Demissew, 2022). Similarly, the cochineal insect has affected the Tigray region's traditional crops (Gebreziher *et al*., 2025), while water hyacinth has proliferated at Lake Tana, disrupting aquatic ecosystems, fisheries, and water flow (Gezie *et al*., 2018). These invasions highlight the urgent need for integrated management strategies, which often involve trade-offs such as economic benefits from harvesting *Prosopis juliflora* for charcoal production against ecological degradation (Sintayehu *et al*., 2020). Effective management requires balancing ecological restoration with socio-economic considerations to mitigate the adverse impacts of invasive species across different ecosystems (Shiferaw and Demissew, 2022).

Gullele Botanic Garden (GBG) Ethiopia's premier botanical garden, was established with the primary goals of promoting ecotourism, plant conservation, research, and education. To date, botanical gardens have employed both *in-situ* and *ex-situ* conservation strategies to protect a variety of native plant species at different levels of threat (GBG, 2024). Although, the primary focus of the conservation strategy is on the indigenous plant species, either intentionally or unintentionally, certain invasive plant species are also present in the garden. The impacts and management practices of these species are unknown and have not yet been thoroughly investigated.. Therefore, this study is essential for developing and implementing appropriate management strategies to minimize the adverse impacts of invasive plant species on nearby indigenous species in the Botanic Garden. Thus, this study was conducted to i) Assess the abundance and spatial distribution of invasive and/or potentially invasive species in the garden, ii) analyse the impacts of invasive and potentially invasive species on native plant species and iii) identify appropriate management practices for controlling invasive and potentially invasive plant species.

2. MATERIALS AND METHOD

2.1. Study area description

The Gullele Botanic Garden (GBG) is located on the outskirt of North West Addis Ababa at an altitude of 2,540–3,000 m.a.s.l. The area is 705 ha with coordinates between 9^0 1' 30" N and 9^0 5' 35" N and between 38^0 41'30"E and 38^0 44'20"E (Figure 1). This area is a portion of Ethiopia's central plateau. In this area, both hot and cold conditions can occur at the same time. The warmest month is February (20.7 °C), followed by March and May (20.2 ^{O}C and 20 °C, respectively). The coldest month is December (7.5 ^{O}C). The dry season lasts from March to May, and the average annual precipitation is 1,215.4 mm (Seta and Belay, 2021).

The garden's vegetation type is characterized by dry Afro-montane forest (majority) and some extent Afro-alpine vegetation dominated with *Juniperus procera*. Alongside, with *Juniperus procera*, species including *Rosa abyssinica, Olinia rochetiana, Jasminum abyssinicum, Myrsine africana, Sideroxylon oxyacanthum, Maesa lanceolata, Maytenus species, Jasminum stans,* and *Vernonia Leopoldi* were also codomaint species. Entoto (North of Addis Abeba) where Gullele Botanical Garden lay is dominated by Silicics rocks (Morton, 1974).

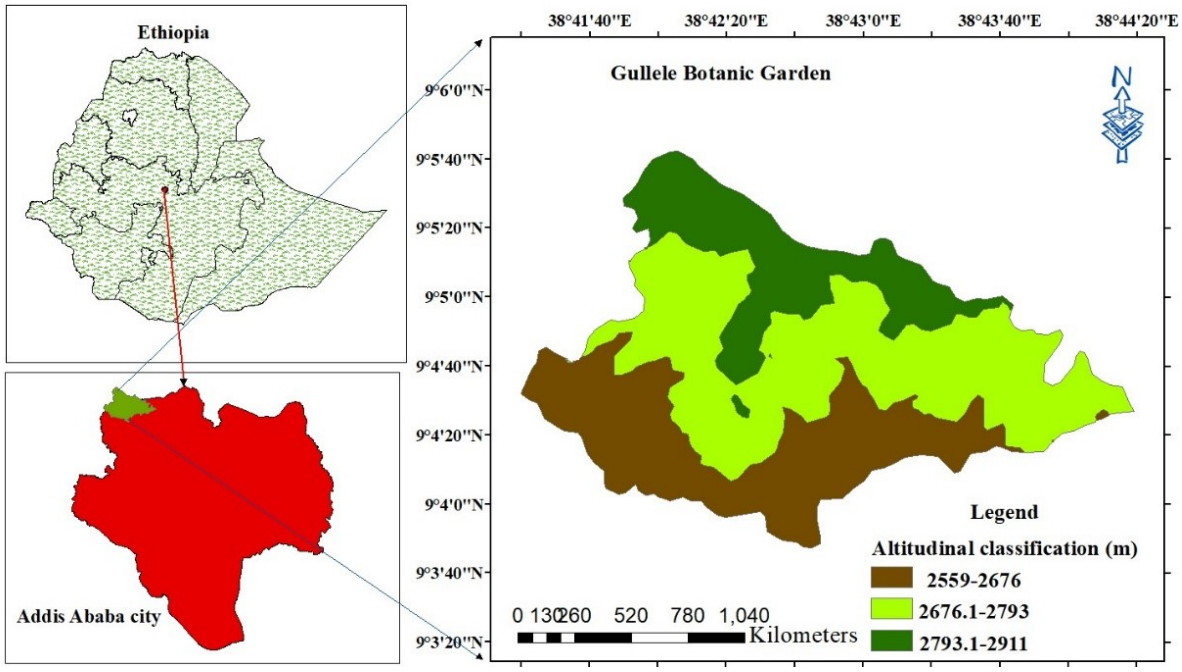


Figure 1. Map of the study area

2.2. Data collection

2.2.1. Field survey

During the the survey, the following data were collected: i) species data, including name, habit, and abundance, ii) geo-location (special data);and iii) abundance and relative frequency of the IPS (invasive plant species). The data were collected from three land use types withing the garden: natural vegetation, plantation areas and roadsides.

The diversity and abundance of the invasive plant species were thoroughly assessed in each land use type by y establishing 40 sample plots, each measuring 10 m × 10 m, where invasive and potentially invasive plants were present. Subsequently, the number of individual species per plot was recorded to evaluate their impacts on the other native species.In this instance, the field survey was carried out to:

i) Taxonomic data, including species identification, morphological traits, growth habit and abundance, were compiled.

ii) The ecological effects of invasive species were analysed, and diligent observations within and around the species range were conducted.

iii) GPS readings of the geolocations of the species were taken. Each GPS sample included a note of the ecological characteristics where the species was located.

2.2.2. Identification and description of invasive species

An invasive plant species is characterized as a non-native plant that, once introduced into a particular habitat, tends to spread extensively and proliferate beyond the typical range of indigenous plant populations (Kolar & Lodge, 2001). It is important to note that some native species may also possess traits similar to those of invaders. Typically, invasive species are biological contaminants introduced by humans either intentionally or accidentally that establish themselves and disperse into new areas, often far from their original distribution (Ascensão & Capinha, 2017). The traits that define and identify invasive species have been outlined by researchers such as Thompson (1991) and Strayer *et al*. (2006). These species are often classified as weeds or pests because they grow aggressively, outcompeting and displacing native plants within existing ecosystems. In Ethiopia, majority invasive species are exotic; however, not all exotic species are necessarily invasive (Girmay *et al*., 2024).

2.3. Data analysis

The collected data was analyzed using descriptive and inferential statistics. The species abundance, range cover and impact rank were computed using descriptive statistics whereas the remaining data including, invasive species diversity, relative frequency, relative abundance and spatial distribution were analyzed using respective inferential statistics. In each plot, all species of vascular plants were recorded and their cover abundance (%) was visually estimated. The proportion of individual species (cover and abundance of the plant species) encountered in each of the quadrants was recorded using the protocol outlined by Wittenberg *et al*. (2004), as indicated in Table (1).

Table 1. Abundance and scale coverage of the invasive plants in each sample plot

Scale	Abundances	Descriptions
0	Absent	No invasive alien weeds is found
1	Present	Individuals plentiful, but coverage small
2	Rare	Individuals very numerous; covering at least 5% of the area
3	Occasional	Individuals few or many; collectively covering 6–25% of the area
4	Frequent	Individuals few or many; collectively covering 26–50% of the area
5	Abundant	Weeds cover 51–75% of the area
6	Very Abundant	Weeds cover 76–100% of the area

The impact rank (IR) of the invasive species on the other plant species was determined and computed following the Morse *et al.* (2004) protocol. The protocol classifies the invasive species' detrimental effects on natural biodiversity within the ecosystem by assigning a level from insignificant to high impact rate. Based on the protocol, the following condition was taken into account while classifying the species impact ranks:

1). Current distribution & abundance (invasive: native species/sampled plots)

2). Ecological impact (favor for the growth of other species)

3). Trend in distribution and abundance (boosting/declining scenario)

4). Management difficulty (how much it is easily managed).

Accordingly the Invasive species impact rank calculation is described in Table 2 below.

Accordingly, the impact ranks were rated as: ‘high’ for $\sum IR > 4$, ‘moderate’ for $\sum IR = 2.1 - 4$, ‘low’ for $\sum IR = 1–2$ and ‘insignificant’ for $\sum IR = 0$ (if the sampled area has an invasive species/potential invasive species but the impact at that moment is not known/insignificant).

The impacts of invasive plant species were determined by comparing the final calculated results (summation of impact rank (∑IR)) within or among each land use category.

Table 2. Invasive Species Impact Rank (IR) Calculation

Section	Sub-rank values				∑ Impact rank interval	Impact rank
	High	Moderate	Low	Insignificant		
Current distribution & abundance	3	2	1	0	> 4	High
Ecological impact	3	2	1	0	2.1 - 4	Moderate
Trend in distribution and abundance	3	2	1	0	1 -2	Low
Management difficulty	3	2	1	0	0	Insignificant

The impact rank was also calculated and feed into the R package as a data frame, which generated a bar plot illustrating the ranges of lower and higher impact ranks among the sampled land-use types. Additionally, ArcGIS was employed to map the spatial distribution of invasive species. Each land-use type was then compared to the abundance of invasive species within the map, providing valuable insights essential for future invasive species management.

3. RESULTS

3.1. Invasive species in Gullele Botaic Garden

About 16 invasive and potentially invasive plant species belonging to 12 families were recorded in the study garden (Figure 2). The Fabaceae family had the greatest number of species (5). However, the remaining families, including Papaveraceae Cuscutaceae, Amaranthaceae, Asteraceae, Verbanaceae, Apocynaceae, Solanaceae, Myrtaceae, Euphorbiaceae, Scrophulariaceae and Orobanchaceae, were represented by a single species each.

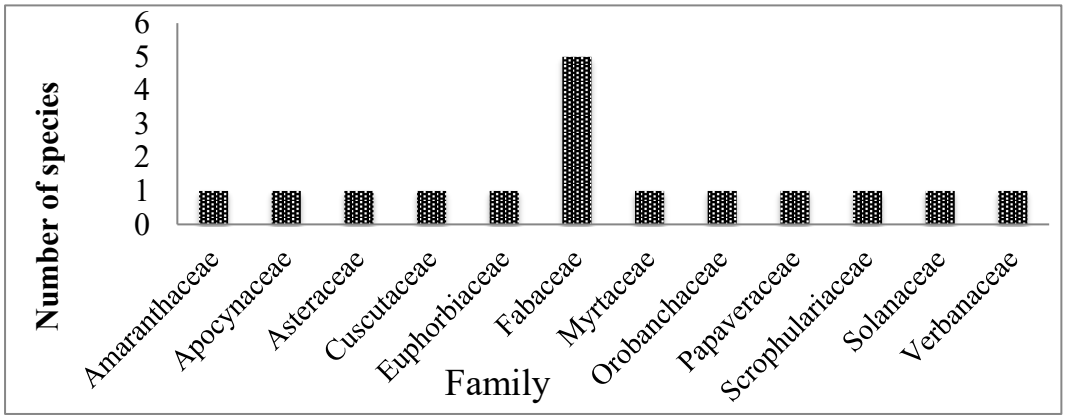


Figure 2. List of invasive species and their corresponding families

3.2. Habit of invasive species

Herbaceous species were the most dominant growth form represented by seven invasive plant species followed by shrubs (6) and trees (3) (Figure 3). Species including *Argemone mexicana, Cuscuta campestris, Cyathula uncinulata, Ageratum conyzoides, Ricinus communis, Striga gesnerioides,* and *Orobanche crenata* were dominant among the herbaceous invasive species, whereas *Acacia saligna, Lantana camara, Nerium oleander, Nicotiana glauca, Psidium guajava,* and *Senna didymobotrya* were invasive shrubs in the garden. *Acacia decurrens, Acacia mearnsii* and *Acacia melanoxylon* were the only invasive tree species found in the study garden.

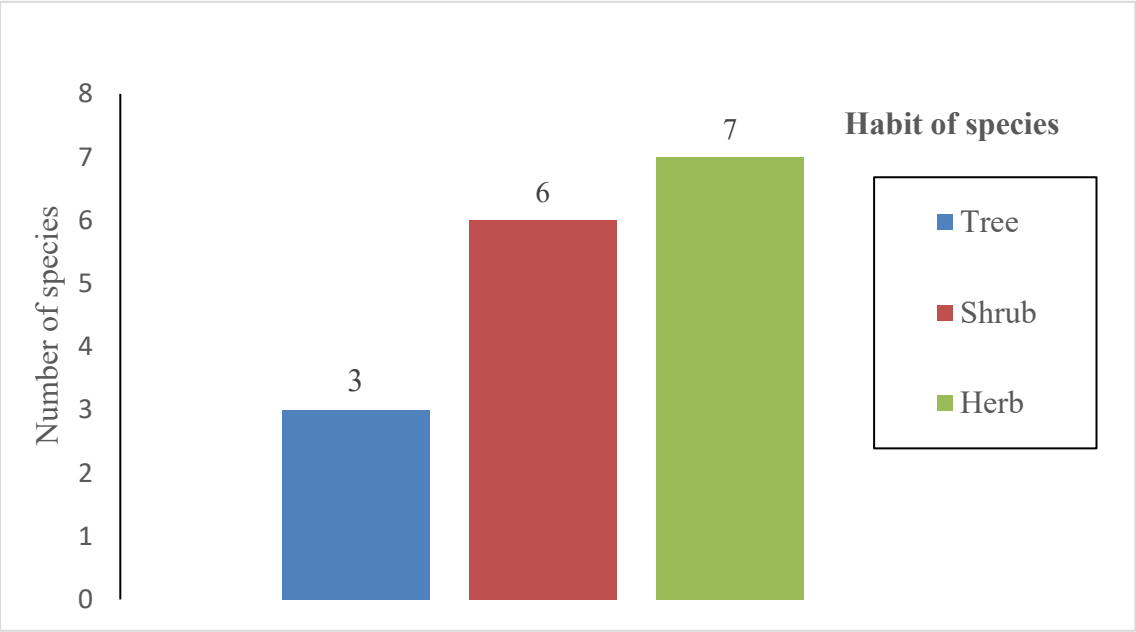


Figure 3. Habit of invasive species in Gullele Botanic Garden

3.3. Abundances and relative frequencies of invasive and potentially invasive species in the Gullele Botanic Garden

A total of 1255 individual of *Acacia decurrens* stems were found in 17 of the 40 sampled plots. On the other hand, 320 individuals of *Cyathula uncinulata* were recorded in only two plots. *Ageratum conyzoides* and *Acacia melanoxylon* were among the most abundant species (Table 3) while *Cuscuta campestris, Acacia mearnsii* and *Nicotiana glauca,* were less abundant in the garden. There was a direct correlation between the relative frequency of species and their abundance.

Table 3. Abundances and relative frequencies of invasive and potentially invasive species

No.	Name of the species	Abundance (individuals)	Plot occurred	Relative frequency	Scale of abundance
1	*Acacia decurrens*	1255	17	42.5	Very abundant
2	*Ageratum conyzoides*	780	9	22.5	Very abundant
4	*Acacia melanoxylon*	90	8	20	Very abundant
5	*Orobanche crenata*	29	4	10	Frequent
7	*Nerium oleander*	11	3	7.5	Occasional
3	*Cyathula uncinulata*	320	2	5	Rare
6	*Senna didymobotrya*	22	2	5	Rare
8	*Acacia saligna*	8	2	5	Rare
9	*Lantana camara*	7	2	5	Rare
10	*Ricinus communis*	7	2	5	Rare
12	*Psidium guajava*	4	2	5	Rare
11	*Striga gesnerioides*	7	1	2.5	Rare
13	*Argemone mexicana*	3	1	2.5	Rare
14	*Cuscuta campestris*	3	1	2.5	Rare
15	*Acacia mearnsii*	2	1	2.5	Present
16	*Nicotiana glauca*	2	1	2.5	Present

3.4.Invasive species distribution in different land use types

The distribution of invasive species among the garden land use types revealed that roadsides had the greatest number of invasive species (14) (Figure 4). There are no invasive species that are restricted to only natural forests. However, only two and four invasive species were restricted to the plantation and roadside land use types, respectively. On the other hand, 10 invasive species found at the roadside were also found in other land use types, whereas 7 invasive species in natural forests and 6 invasive species in plantations were shared with other land use types.

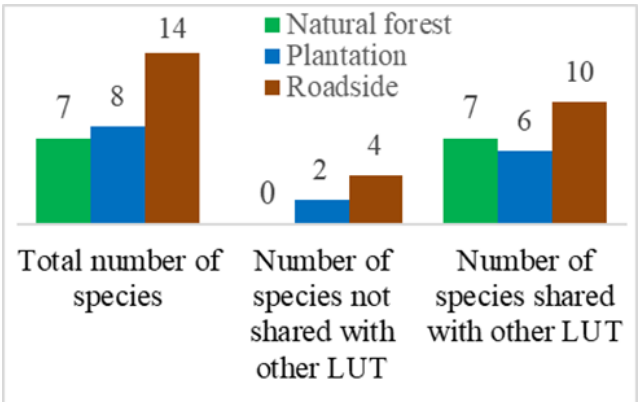


Figure 4. Invasive species distribution in different land use types

3.5. Invasive species abundance and density in the land use types

The density of invasive species in the sampled land use types revealed that approximately 2550 individual invasive species were recorded in the sampled plots across the three land use types

(Table 4). The roadside area had the highest density (7040 indivuduals/ha), followed by the natural forest (6341.7 indivuduals /ha) and plantation (4762.5 indivuduals /ha) areas.

Table 4. Invasive species abundance and density in the land use types in the garden

Land Use Types	Abundance (indivuduals/ha)	Sampled plots	Sample area in hectare	Density
Natural forest	761	12	0.12	6341.7
Plantation	381	8	0.08	4762.5
Roadside	1408	20	0.2	7040
Total	2550	40	0.4	6,375

3.6. Rate of invasive species

Using the methodology established by Morse *et al*. (2004), the effects of the 16 documented invasive species were evaluated and assigned impact ratings (see Table 5). As a result, *Acacia decurrens, Acacia melanoxylon,* and *Cyathula uncinulata* were identified as having high levels of impact on native species and garden ecosystems, whereas species such as *Nicotiana glauca*, *Ageratum conyzoide* and *Senna didymobotrya* have moderate rates of impact. Species such as *Acacia mearnsii, Acacia saligna, Argemone Mexicana, Cuscuta campestris, Lantana camara, Nerium oleander, Psidium guajava, Ricinus communis, Striga gesnerioides* and *Orobanche crenata* had lower distributions and impact rates.

Table 5. Impact Rate of invasive species

SN	Species Name	Rate of impact	Distribution and description
1	*Acacia decurrens*	High	High distribution and high rate of impacts
2	*Acacia mearnsii*	Low	Due to less abundance and distribution and easily Manageable
3	*Acacia melanoxylon*	High	High distribution and high rate of impacts
4	*Acacia saligna*	Low	The distribution and impact is less
5	*Argemone mexicana*	Low	Due to less abundance and distribution and easily Manageable
6	*Cuscuta campestris*	Low	The distribution and impact is less
7	*Cyathula uncinulata*	High	High distribution and high rate of impacts
8	*Ageratum conyzoide*	Moderate	High distribution and dominance, but they annual species
9	*Lantana camara*	Low	Due to less abundance and distribution and easily Manageable
10	*Nerium oleander*	Low	The distribution and impact is less
11	*Nicotiana glauca*	Moderate	Has moderate distribution and impact
12	*Psidium guajava*	Low	The distribution and impact is less
13	*Ricinus communis*	Low	The distribution and impact is less
14	*Senna didymobotrya*	Moderate	Moderate distribution and impact
15	*Striga gesnerioides*	Low	The distribution and impact is less
16	*Orobanche crenata*	Low	The distribution and impact is less

3.7. Distribution and impact of invasive species

The analysis of distribution and impact rankings revealed that among the sampled plots, approximately 13 exhibited a high impact rank. In contrast, 13 plots had a moderate impact,

and 14 plots showed a low impact rank (see Figure 5). Notably, out of the plots with high impact, 10 were collected from roadside land use areas, while the remaining 3 high-impact plots originated from natural forests. Conversely, most samples taken from plantations demonstrated a low impact level.

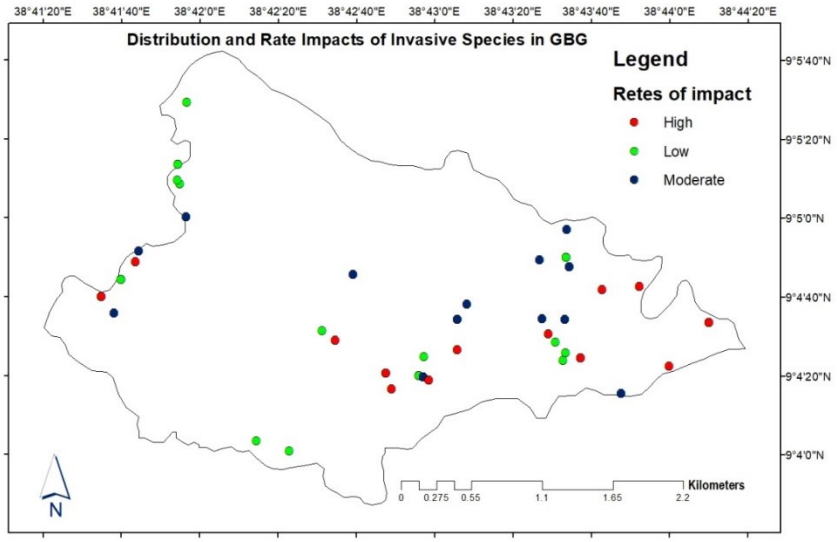


Figure 5. Distribution and impact rate of invasive species in the study garden

Generally, the highest impact rate among the three land use types was observed along the roadside (Figure 6), whereas natural forests experienced the lowest impact rate. In natural forests, the impact rank of invasive species varied from no impact (nonsignificant) to low, while in plantation areas, it ranged from low to moderate (1-3). Invasive plants generally exhibit a high impact score (averagely 4) concerning their effects along roadsides.

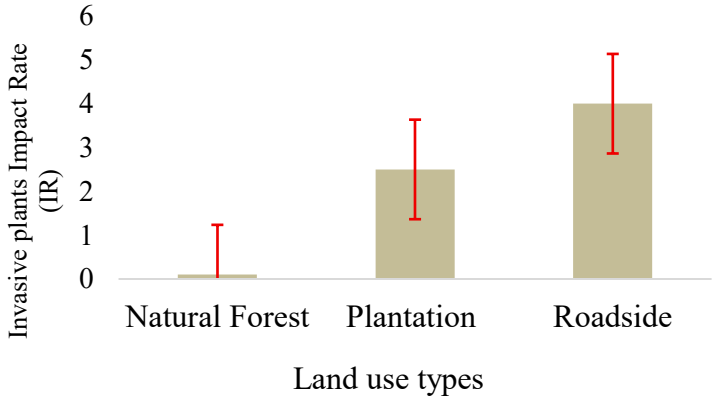


Figure 6. Impact rate of invasive garden species on the sampled land use types

3.8. Abundant invasive species in the Garden

The most abundant invasive species in the garden were *Acacia decurrens, Cyathula uncinulata* and *Acacia melanoxylon.* Of the sampled plots, 13 contained *Acacia decurrens*, 9 contained

Cyathula uncinulata, and 6 contained *Acacia melanoxylon* (see Figure 7).

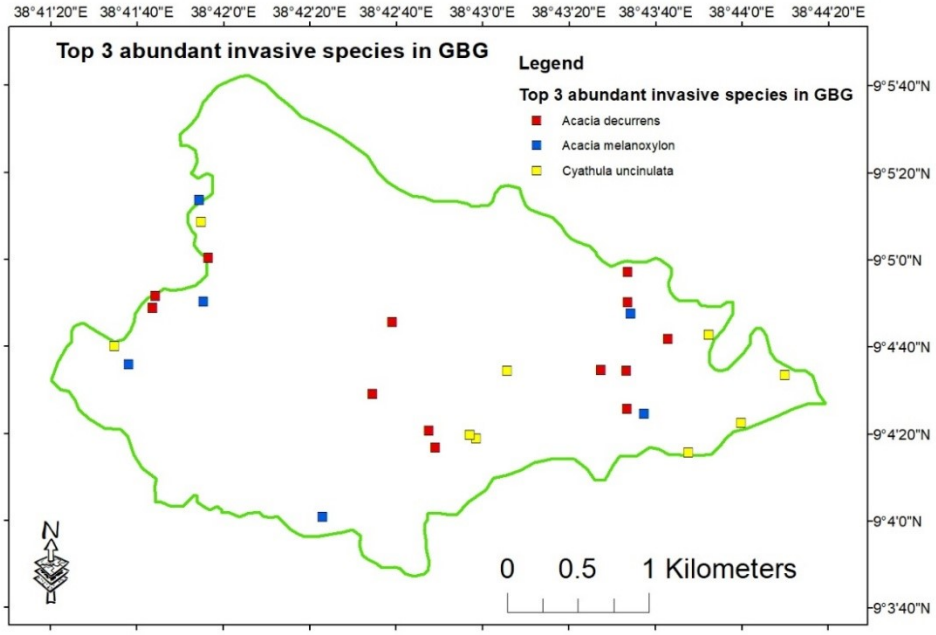


Figure 7. Geospatial characteristics of the top three plant species in GBG

4. DISCUSSION

4.1. Invasive and potentially invasive species in Gullele Botanic Garden

The study indicated that 16 invasive and potentially invasive species identified in the garden belong to 12 distinct plant families, highlighting the significant diversity of these species within Gullele Botanic Garden. Their presence is likely linked to various introduction pathways, including accidental means such as wind, birds, animals, water, vehicles, and other vectors, as well as deliberate introductions for purposes like agroforestry, horticulture, forestry, through wild animal pellets, and soil and water conservation (Girmay *et al*., 2024). Perrings (2005) explains that once invasive species are introduced into an ecosystem, they tend to become dominant by competing for resources like light, water, and nutrients, and by releasing toxins that suppress the growth of native plants.

Approximately 95.9% of the total recorded invasive and potentially invasive species in the study garden were represented by *Acacia decurrens, Ageratum conyzoides, Cyathula uncinulata* and *Acacia melanoxylon.* The high prevalence observed is primarily attributed to a significant portion of the garden was once bare land, making it vulnerable to various types of land degradation and soil erosion. To combat these ecological issues, a range of conservation measures have been implemented. As a result, certain plant species, now abundantly present in

specific parts of the garden, were intentionally introduced to help restore the degraded areas without considering their impacts (Girmay *et al*., 2024).

4.2. Distribution of invasive and potentially invasive species in the garden

Invasive and potentially invasive plant species were present across all land use types within the garden (Girmay *et al.,* 2024), although their abundance, composition, and distribution varied among the different land use types . Their widespread occurance may be attributed to their ability to produce many seeds and to spread quickly within ecosystem (Richardson *et al.,* 2000). Similarly Hobbs (2000) reported that invasive species have the potential to overwhelm native species in a given habitat, thereby challging to control them once they have distributed. Variations in the distribution of the invasive species across different land use types are possibly associated with factors such as plantations, degradation, and human accessibility (Witt *et al.,* 2018; Balogh e *et al.,* 2023). According to a study by Girmay *et al.* (2024), there was a clear correlation between anthropogenic involvement and the abundance of invasive and potentially invasive species in the roadside of the gardens. On the other hand, invasive and potentially invasive species are less common in land use types with natural vegetation likely due to less human intervention in these area. This was also consistent with other studies reported by Fessehaie and Tessema (2014) and Witt *et al.* (2018).

4.3. Impact of invasive and potentially invasive species in the garden

The impact of invasive species within the garden ranged from low to high, influenced by various ecological factors and environmental conditions (Simberloff *et al*., 2013). According to the Morse *et al.* (2004) protocol, assessing the impact involves considering criteria such as the species' current distribution and abundance, ecological effects, trends over time, and the challenges associated with managing these species. For instance, species like *Acacia decurrens*, *Acacia melanoxylon*, and *Cyathula uncinulata* tend to have a high impact, likely due to their prolific seed and seedling production, adaptability to diverse environments, and minimal management requirements once established (Huebner, 2022). On the other hand, species with contrasting characteristics, including *Acacia mearnsii, Acacia saligna, Argemone Mexicana, Cuscuta campestris, Lantana camara, Nerium oleander, Psidium guajava, Ricinus communis, Striga gesnerioides,* and *Orobanche crenata*, may have a lower impact rate of the native plant species (Mathakutha *et al*., 2019).

The high impact rate of invasive and potentially invasive species in roadside areas indicates that these araes are subject to greater human and animal interference (Mollot *et al*., 2017). Conversely, the low impact rate observed in the plantation area may be attributed to the fact that such areas are often intentionally established with considerations of the invasiveness of certain species (Omeer and Deshmukh, 2021). Overall, the presence of invasive species tends to decrease native species diversity and richness, contributing to biotic homogenization by reducing the uniqueness of biological communities (McKinney, 2005).

4.4. Management mechanisms of invasive invasion

Invasive species cause significant economic damage and societal disruptions, leading to substantial investments in programs aimed at their eradication (Greenlees *et al*., 2020). Controlling or eliminating these invasive species can also provide advantages for native species (Nottingham *et al*., 2019). Economic loss due to invasion is estimated at $336 billion per year for Canada United States, Britain and India combined (Semenya *et al.,* 2012) while it is up to $123 billion for United States only and ¥57.433 billion annually for China (Yan *et al.,* 2020). Invasive insect species alone are thought to be responsible for more than $70 billion per year in lost ecosystem goods and services (Johnson *et al.,* 2020). Hence, invasive species management and control is an important environmental, social, and economic issue (Johnson *et al.,* 2020; Yan *et al.,* 2020).

Based on Tye's (2018) guidelines for invasive species planning and management, there are three key mechanisms for controlling invasive species introduced into specific vegetation ecosystems. These are:

i. **Biological method**: Include the use of natural adversary, such as a fungus or insect that objects the target species solely and spares native or economically significant species.
ii. **Mechanical Methods**: Theis techniques includs mowing, hoeing, tilling, chopping, and constructing barriers using tools or machines to harvest invasive plants by removing and collecting them, transporting them elsewhere and allowing them to decompose in place. This mechanism could complement herbicide (chemical) control
iii. **Chemical Control Methods:** These methods include the use of pesticides, herbicides, fungicides, and insecticides. Although chemical use can be very effective, it can be

dangerous to other species or to the ecosystem in general. Chemical control may be difficult, and expensive, may create concerns about environmental health.

Despite the fact that the methods mentioned above are applied worldwide to inhibit, avoid and mitigate the spread of invasive species (Flory and Clay, 2009), management strategies vary depending on the characteristics of invasive and local condtions (Crowley *et al.,* 2017).

iv. Pilot test on the management practices of invasive plants in the garden

A pilot test on the management practices for existing invasive species was conducted in specific areas. Biological techniques, being too costly and less favorable for the predominantly non-weed invasive species present, were considered less viable (Prior *et al*., 2018). Similarly, chemical control methods also incurred high costs and posed adverse impacts on other plants and the overall ecosystem (Weidlich *et al*., 2020). Therefore, considering both economic and ecological factors, mechanical methods such as uprooting, cutting at the early flowering stage, hand-weeding, followed by frequent monitoring and rehabilitation with native species were experimented with and found to be the most effective for controlling most invasive and potentially invasive plants (Prior *et al*., 2018; Weidlich *et al*., 2020).

Particularly, species with a high impact rating, including *Acacia decurrens, Acacia uncinulata,* and *Acacia melanoxylon*, demand prompt and extensive regulatory measures. Their prolific seed and seedling production likely overwhelm native ecosystems by suppressing or displacing indigenous species (Flory and Clay, 2009; Girmay *et al*., 2024). Essential control measures for woody species include uprooting seedlings, cutting before fruiting, creating seed-collecting pits followed by burning, and ongoing monitoring for changes (Tye, 2018). For herbaceous species that exhibit high impact rates, it is advisable to conduct frequent hand-weeding prior to flowering during the rainy season. Dried weeds should be incinerated along with any excavations, and the area should be topped with a fresh and healthy layer of soil. Additional regulatory strategies involve the application of herbicides, although further research into their phytochemical properties is necessary to optimize their use (Flory and Clay, 2009).

5. CONCLUSION

The study was carried out at Gullele Botanic Garden to investigate the impacts and management practices of invasive and potentially invasive plant species on native plants and ecosystem integrity. A total of 16 species belonging to diverse families, predominantly from

the Fabaceae, were identified, with a notable dominance of herbaceous and shrubs. The findings reveal that invasive species like *Acacia decurrens, Cyathula uncinulata,* and *Acacia melanoxylon* are highly abundant and exert substantial ecological pressure in the garden. Spatial distribution analysis showed that invasive species are widespread across all land use types within the garden, with the highest densities recorded along roadsides, highlighting the role of anthropogenic factors in their proliferation. The impact ranking shows some invasive species threaten native flora due to rapid growth, seed production, and adaptability, risking reduced biodiversity through competition and habitat change. The mechanical methods for managing invasive species, such as uprooting, cutting before flowering, and consistent monitoring, were chosen for their cost-effectiveness and environmental friendliness.The study stresses tailored, integrated strategies based on species-specific impacts and distribution to reduce invasion risks. Proactive control and ongoing monitoring are vital to protect native biodiversity and ecosystem health in the Gullele Botanic Garden, serving as a model for managing invasives found in similar ecosystems.

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