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The negative and positive impacts of *Prosopis juliflora* on the Kenyan and Ethiopian ecosystems: A review study

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Abstract

Invasive alien species pose a serious threat to the world's ecosystems and livelihoods. This review aimed to investigate the negative and positive impacts of *Prosopis juliflora* (Sw.) DC on ecosystems in Kenya and Ethiopia. The bibliographic analysis highlighted that *Prosopis juliflora* was introduced to Kenya and Ethiopia to tackle desertification, ensure the self-sufficiency of wood products, and conserve water and soil in semi-arid areas. Years later, this species has turned invasive; although the communities in infested areas have realized some benefits from this tree such as obtaining timber, charcoal, firewood, shelter, and livestock feed from its pods; the negative impacts of this tree have far outweighed the positives. Notably, this invasive plant has significantly impacted agricultural and livestock productivity by invading pasturelands and farmlands. For instance, the negative health implications for livestock significantly reduce their productivity. Similarly, this plant has reduced the diversity of the native trees, herbaceous, and grasses because of its ability to outcompete them. Control methods such as biological, mechanical, chemical, and control by utilization have been tried but none have so far been effective in controlling this invasive plant. Our results showed that *Prosopis juliflora* is a serious invader that has a huge potential to invade the arid and semi-arid lands of Kenya and Ethiopia.

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Therefore, stakeholders at all levels need to implement integrated management strategies to reduce the spread and the negative impacts of this species.

Keywords: ecosystems; impacts; invasive species; livelihoods; *Prosopis juliflora*

Introduction

Encroachment of invasive alien species is a challenge that the world is grappling with. These species often cause detrimental effects on the environment and rural households in developing countries. *Prosopis juliflora* (Sw.) DC (here in after referred to as *Prosopis juliflora)* is one of the world's worst invasive alien species (Figure 1); it has triggered severe environmental degradation in the arid and semi-arid areas of Eastern Africa. Today, countries such as Ethiopia, Kenya, Sudan, Somalia, and Eritrea are heavily infested (Ahmed *et al*., 2022). This species belongs to the genus *Prosopis* which is highly adapted to drylands and 44 species in this genus have been identified. *Prosopis juliflora* has been widely introduced in many parts of the world (Figure 2); other species include *P. glandulosa*, *P. pallida* and *P. velutina* (Eshete *et al*. 2020). *Prosopis juliflora* native to the Caribbean, Central America, South America and North America is a fast-growing evergreen tree species. At maturity, it can reach a height of 12 meters with a trunk diameter of 1.2 meters. This tree species adapts well in dry areas because of its ability to grow well in poor soils, to fix nitrogen as well as tolerate arid saline soils (Turyasingura *et a*l., 2023). Additionally, these plants form impenetrable spiny thickets; the above characteristics help these plants to out-compete the native plant species and colonize huge tracks of land within a short period (Abdulahi *et al*., 2017) thus, degrading the natural environment (Shiferaw *et al*., 2021).

Figure 1. *P. juliflora* habitat (Source: original)

Figure 2. *P. juliflora* along the riverbank (Source: original)

The need to reduce deforestation and desertification and to address fuel shortage in the 1970s and early 1980s encouraged interventions that sought to introduce *P. juliflora* and other woody tree species to a new environment across the globe. For instance, in Kenya, it was introduced to combat desertification and to ensure the self-sufficiency of wood products. In Ethiopia, this plant species was introduced to tackle desertification and to conserve soil and water in semi-arid areas; whereas, in Somalia, it was introduced for dune fixation, in Tanzania this invasive plant was introduced for the restoration of degraded sites, to control soil erosion and also for the greening of open areas (Abdulahi *et al*., 2017; Kilawe *et al*., 2017).

P. juliflora has become the worst weed in pastoral and agro-pastoral communities because of its infestation in the pastureland causing irreversible displacement of the native pasture grasses and other natural tree species (Abdulahi *et al*., 2017). In Ethiopia, the area invaded by *P. juliflorais* estimated to be about 1.5 million ha and its annual rate of invasion is around 50,000 ha/year; of this about 700,000 ha is located in the Afar Region. It is in the light of the socio-ecological disaster that this invasive species has caused that this paper seeks to critically review the impacts of *P. juliflora* on Kenyan and Ethiopian ecosystems with a specific focus on the following issues; the contribution of *P. juliflora* in combating desertification, its effects on grasses and herbaceous plants (*i.e*. shading and allelopathic effects as well as the socio-economic impacts especially on livestock production). Having an in-depth understanding of the positive and negative impacts (Table 1) of this invasive species will enable the government and other stakeholders to develop management strategies that are economically viable and environmentally friendly to bring them under control.

Table 1. Disadvantages and advantages of *Proposis juliflora* plant species

No.	Disadvantages	Advantages
1	Favour breeding and spreading malaria-causing mosquitoes	Can play a role in sustaining the livelihood of poor rural households
2	Thorns injure animals and people	Source of fuel and dry season animal feed
3	Depletes the water moisture	Wood does not spit, spark of smoke excessively
4	Limits availability of water to local plants	Often in the commonly owned areas where they are freely
5	Expands quickly even in the harshest environmental	Good animal feed especially for dairy cows
6	Hard and costly to remove	Wood can be processed into furniture or construction material
7	Obstructs paths and roads	Can act as vegetative fencing to delimit and protect properties
8	Lack of traditional knowledge on how to manage and control the plants	Produces good charcoal

P. juliflora spreads quickly, especially in locations where cattle grazes because the seedpods stick to the animal hides and disperse extensively. *P. juliflora* spreads quickly and is hard to eradicate once it has taken root in a location (Kilawe *et al*., 2017). It completely replaces the native vegetation, forbids undergrowth, and significantly lowers the land's value for grazing. Additionally, it frequently infiltrates dry riverbeds and other waterways, clogging them and sending flood rivers into a state of chaos (Qayyum *et al*. 2018). The thorns of *P. juliflora* are poisonous and have the potential to cause blindness. When calves in particular are fed almost only pods of *P. juliflora*, it might make them sick. Constipation and facial contortions are among the symptoms, which can occasionally be fatal. However, a number of studies have been conducted on *P. juliflora* species and invasiveness around the world including sub-Sahara Africa. The previous empirical studies used the quantitative and qualitative approaches to ascertain the impacts of *P. juliflora* plant species (Sintayehu *et al*. 2020). Among the reviewed studies there is no known study that used the robust Bibliometric analysis on negative and positive effects of *P. juliflora*. Therefore, an inclusive study is needed to identify the negative and positive impacts of *P. juliflora* plant species in Ethiopia and Kenya. As a result, this study investigated the negative and positive effects *P. juliflora* in Kenya and Ethiopia ecosystem through employing a bibliometric approach.

Materials and Methods

This article reviewed literature mostly from articles published in English and mostly published in the 21st century to come up with an extensive analysis of the impacts of *P. juliflora*. The articles were identified through keyword searches such as *P. juliflora*, invasive species, impacts, livelihoods, and ecosystems using google scholar guided by the above-mentioned categories and forward searches of publications that cited relevant articles helped in gathering publications. However, 100 publications were retrieved however only 31 from the preselected 100 qualified for this analysis. The 31 articles were all analyzed and incorporated into this review. The studies were mainly from Kenya and Ethiopia and few from other countries such as Sudan, United Arab Emirates, Tanzania, Somalia, Pakistan, and South Africa. The period searched was 2000-2019, the selection focused on the aforementioned impacts of *P. juliflora*. Table 2 presents the results for the research; it lists the 31 studies by country of research and a summary of the negative and positive impacts of *P. juliflora*.

Table 2. Reviewed articles regarding the positive and negative impacts of *P. juliflora*

No.	Authors	Country of Study	Negative impacts	Positive impacts
1	Abdulahi *et al*. (2017)	Ethiopia	Reduced biodiversity, agricultural production and impacts human and animal health	NI
2	Abebe (2017)	Ethiopia	Reduced species richness and diversity of herbaceous species	NI
3	Qayyum *et al*. (2018)	Pakistan	allelopathic effects of invasive *Prosopis juliflora* on grass species	Allelopathic effects
4	Bobassa (2008)	Ethiopia	Allelopathic chemicals from *Prosopis juliflora* toxic to natural habitats	NI
5	Sadeq *et al*. (2020)	Sudan	Effects of mesquite on soils and plant communities in the deserted rangelands	Reduce desertification
6	El-Keblawy and Abdelfatah (2014)	United Arab Emirates	Allelopathic effects on depressive effects on the associated flora	NI
7	da Silva *et al*. (2018)	Brazil	Neurotoxicity; from natural poisoning to mechanism of action	NI

8	Hussain *et al*. (2021)	Sudan	Impact of the invasive *Prosopis juliflora* on terrestrial ecosystems	Fix sand dunes
9	Bezaredie *et al*. (2023)	Ethiopia	Effects plant diversity on rangeland	Assist getting rid of unwanted plants
10	Seid *et al*. (2020)	Ethiopia	Blocks people and animal pathways	Animal feed from pods
11	Ahmed *et al*. (2022)	Ethiopia	Affects arable land	Reduce desertification and soil erosion
12	Wudad *et al*. (2021)	Ethiopia	Expansion of *Prosopis juliflora* affects land use cover and change	Stems from the plants are used
13	Noha *et al*. (2021)	Ethiopia	Distresses soil seed bank flora	NI
14	Kilawe *et al*. (2017)	Tanzania	Invading pasture and agricultural lands	Reduce grazing lands
15	Paul (2020)	Kenya	Disrupts the existing natural environment	Charcoal and wood for making beehives
16	Hussain *et al*. (2020)	Ethiopia	Invasive Mesquite (*Prosopis juliflora*), an allergy and health challenge	NI
17	Okumu (2019)	Kenya	Negative effects on the soil chemical properties and herbaceous species	Improves soil organic carbon
18	Okumu (2019)	Kenya	Invades water ways and productive areas	Biomass for cooking
19	Choge *et al*. (2022)	Kenya	Impacts livelihoods of local people and animals	Nitrogen fixing and desert food legume
20	Mohamed and Mbataru (2021)	Kenya	Invades pastoral land and agricultural fields	Socio-economic contribution to local communities' households
21	Sintayehu *et al*. (2020)	Ethiopia	Loss of feeding space for livestock	Socio-economic contribution to households' welfare
22	Sirmah (2018)	Kenya	Pods and leaves toxic to livestock	Pods are livestock feed
23	Edrisi *et al*. (2020)	India	Disturbs the existing natural ecosystem	Restoration of degraded land
24	Qayyum *et al*. (2018)	Pakistan	Allelopathic chemicals in *Prosopis juliflora* inhibit grass growth	Offers a solution to unwanted grass
25	Shiferaw *et al*. (2021)	Ethiopia	Invasion affects soil physicochemical properties	Improves soil fertility
26	Shackleton *et al*. (2015)	South Africa	Reduced species density, basal area, richness and diversity	NI
27	Madhu *et al*. (2018)	Global assessment	Very invasive and contains toxic chemicals	*Prosopis juliflora* fibers as composite reinforcement
28	Gewona (2018)	Kenya	A nuisance to the natural environment	Potential uses of *Prosopis juliflora* for renewable energy
29	Shiferaw *et al*. (2021)	Ethiopia	Impacts water catchment water budget and rural livelihoods	Stakes are used for construction

30	Eshete *et al*. (2020)	Ethiopia	Native woody plant species abundance invades grazing lands	Contributes to variations in soil properties
31	Shiferaw *et al*. (2023)	Ethiopia	Water abstraction of invasive *Prosopis juliflora*	Limiting water run offs

This study used a systematic bibliometric analysis on 100 publications which were retrieved from Google Scholar academic search engine. However, only 31 from the preselected 100 qualified for a detailed analysis using VOSviewer analysis application. Lastly, 31 articles which were analyzed and incorporated where from Ethiopia and Kenya.

Results and Discussion

Impacts of Prosopis juliflora

Throughout the world, exotic species have been introduced either due to their economic, environmental, or aesthetic values. It is important to note that the introduction of new species is not always a success and it may bring about the possibility of invasiveness which in turn results into negative impacts such as; reduction of crop production, encroachment in grazing areas, genetic erosion of biodiversity, blocked waterways and formation of impenetrable thickets among other impacts (Qayyum *et al*., 2018). This section will delve deep into highlighting some impacts (both positive and negative) that *P. juliflora*is causing in Kenyan and Ethiopian ecosystems. They include; but not limited to; combating desertification, effects on socio-economic livelihoods, negative impacts of grasses and herbaceous plant species as well as allelopathic effects among other impacts (Turyasingura *et al*., 2023).

Impacts of Prosopis julifloraon desertification

P. juliflora is a small, fast-growing, drought-resistant, evergreen that originated in tropical America. It produces good timber and shade and rapidly turns a bare arid environment green. *P. juliflora* trees play an important part in enhancing sustainable land-use systems, carbon sequestration, regulation of rainfall, and improving livelihoods of the desert population by preventing further soil degradation and assisting in land reclamation. These qualities made it an attractive candidate for arid and semi-arid lands rehabilitation programs, and it is one of the reasons that this tree was introduced to Eastern Africa ASAL areas (Sintayehu *et al*., 2020).

In Kenya, the arid and semi-arid lands (ASAL) constitute about 80% of Kenya's total landmass. 35% (13 million people) of Kenya's population is hosted by arid and semi-arid areas and 60% of the inhabitants live in poverty, subsisting on less than one US dollar per day (Choge *et al*., 2022). Hussain *et al.* (2021) also points out that, over 70% of national livestock and the bulk of wildlife that support the tourist sector are found in the Kenyan ASAL areas (Turyasingura *et al*., 2023)

In Ethiopia, Arid and semi-Arid lands constitute more than 62% of the total national land. It contributes to 30% of the gross national product and 90% of the foreign currency from animal exports and employs about 27% of the total national population of Ethiopia (Shiferaw *et al*., 2019; Shiferaw *et al*., 2021).

In Kenya and Ethiopia, we could not find any published studies that indicate whether or not *P. juliflora* has contributed to combating desertification. Nonetheless, evidence from other parts of the world suggests that *P. juliflora* has huge potential to reduce desertification and plays an integral role in assisting to reclaim arid and semi-arid ecosystems. For example, Mohamed and Mbataru (2021) pointed out that most of the people interviewed observed that these plants have helped control desert storms of the early 1980s. In Yemen, the use of *P. juliflora* to reduce desertification showed successful results in 240,000 ha of land in the arid and semi-arid

areas of Yemen. Its main advantage is it has covered many arid and semi-arid lands. In Mali, *P. juliflora* has been used to stabilize sand dune and to protect 2750 ha, desertification (Koech *et al*., 2021). In Sudan, *Prosopis juliflora* has been useful in combating desertification by stopping the sand dune or sheet sand encroachment on sandy soil (Sadeq *et al*., 2020).

Socio-economic impacts of Prosopis juliflora

P. juliflora is a multi-purpose tree; it is known to cause both negative and positive impacts on the communities living in *P. juliflora* infested areas. The tree has potential uses such as fuel, charcoal, fodder, food, bio-char, biocontrol, windbreaks, shade, construction and furniture materials, and soil stabilization (Abdulahi *et al*., 2017). This section will highlight some of the socio-economic impacts that *P.s juliflora* has caused since its introduction to Kenyan and Ethiopian ecosystems. They include; electricity generation, charcoal, and honey production.

Bee keeping and honey production

P. juliflora is a highly flowering evergreen plant with bright yellow flowers that easily attract bees. Its flowers (Figure 3) produce plenty of pollen grains and nectar over a relatively long time that is high in sugar content which is forage for bees thus supporting the production of honey. *P. juliflora*honey is light yellow and is of good quality with pleasant taste and aroma. Honey and its products can be sold to generate household income. Bees may extract enough nectar and pollen fro a single flowering tree which is equivalent to one kilogram of honey and 100-400 Kg/ha/yr (da Silva *et al.,* 2018). Edrisi *et al*. (2020) also pointed out that the locals in Baringo (Kenya) harvests 240 litres of honey per household per year. Between 1990 and 1995, Gujarat Agricultural University in India, collected, processed and marketed 300 metric tons of honey. This is attributed to the abundance of *P. juliflora* in the region.

Figure 3. *P. juliflora* flowering (Source: original)

Charcoal and electricity production

According to the survey conducted by Kenya Forest Research Institute (KEFRI) in the past, charcoal made from *P. juliflora* is widely acknowledged to be of high quality and is more popular than charcoal from other trees. In Garissa, 240 ha of government land that was infested with *Prosopis juliflora* was leased with permission from the forestry department to sell charcoal.

In their quest to control *P. juliflora*, non-governmental organizations (NGOs) e.g. Farm Africa in the Afar region in the past formed cooperatives that produced and sold *P. juliflora*'s charcoal. The charcoal was distributed and sold in major cities such as Mekelle and Addis Ababa (Abdulahi *et al.*, 2017). Additionally, a fifth report on the implementation of the Okumu (2019), noted there is a high demand for charcoal in Somalia.

They indicate that the annual charcoal consumption in the major cities is approximately 2,309, 200 sacks. Studies conducted in India also suggest that making charcoal from *P. juliflora* is profitable. For instance, the Gujarat Agricultural University manufactures charcoal from *P. juliflora* for the government of Gujarat. Between 1990-1995, it manufactured about 300,000 bags of charcoal and generated about 300,000-man-days of labor demand (Madhu *et al*., 2018; Paul, 2023). Although, the use of *P. juliflora* for charcoal production of charcoal provides income; it is also attributed to the disastrous exploitation of the indigenous trees. Sirmah (2018) indicates that in Afar region of Ethiopia, ever since some non-governmental organizations started promoting the use of *P. juliflora* to produce charcoal, the rate of illegal cutting of the indigenous tree species went up because, the charcoal produced by the indigenous trees are of higher quality compared to the charcoal produced from *Prosopis juliflora*, hence preferred by locals and the traders.

Impacts of Prosopis juliflora on agricultural production

P. juliflora poses a threat to rangelands; it causes shortages of grazing land for livestock. Features such as tolerance to saline soils, fast-growing, nitrogen-fixing, rooting abilities, as well as coppicing abilities, ability to stay dormant for a long time in the soil and germinate when condition are favorable make it an aggressive competitor. Therefore, it can displace the desirable grass species that are not able to withstand competition (Benzougagh *et al*., 2023; Banerjee *et al*., 2024). In areas where *P. juliflora* has invaded, it has destroyed natural pasture, displaced native trees which led to fewer and lower quality grazing sites especially in rangelands. Niguse and Amare (2016) indicated that there is a negative relationship between an increase in *P. juliflora* invasion and fodder/feed availability on grazing lands.

The shortage of grazing land for livestock results in a drastic reduction of livestock numbers as well as their products. Mbaabu *et al.* (2019) and Seid *et al.* (2020) in their study found out that in Amibara zone, camel and cattle declined at a rate of and 20% and 36%, respectively, between 1997 and 2011 due to the problems related to bush encroachment such as *P. juliflora* invasion. Additionally, other studies show that there is a negative relationship between *P. juliflora* invasion and livestock productivity. The invasion of this plant species has caused a considerable decline in livestock productivity due to loss of grazing areas and palatable grass species (Shiferaw *et al*., 2023; Bezaredie *et al.,* 2023). Reduced grass availability has a direct impact on milk production and weight of the livestock, a study that was conducted by Bekele *et al.* (2018) in Dire Dawa administration; they found out that; on average, the invasion by *P. juliflora* significantly reduced annual income from livestock and their products sale by 28.82%. This reduction might be attributed to reduced grazing land and loss of palatable grass species as a result of invasion by this species.

Invasion by *P. juliflora* has also been reported to decrease the size of farmlands and its roots make it difficult to plough lands (Niguse and Amare 2016). Ashenafi (2008) also reported negative impacts of *P. juliflora* on crop production through competition of agricultural land, wastage of time for clearing land, and increment of labor cost. However, other studies have linked increased crop yields in farms with *P. juliflora* because of its ability to fix nitrogen, desalinize soil, and mulch the soils with its leaves (Kader *et al*., 2023; Kader *et al*., 2022; Ljavić *et al*., 2023; Youssef *et al*., 2023). Just like in Ethiopia, communities in Kenya living in *P. juliflora* infested areas reported that these invasive plants have caused a reduction of pasture for livestock; it has also reduced farmlands and associated opportunities for cultivation. The livestock keepers are forced to take their livestock to pastures 40-50 km away; this often leads to conflicts with their neighbors (Noha *et al.,* 2021).

Different studies have shown that *P. juliflora* can have serious health implications on animals (Abdulahi *et al.,* 2017; Ahmed *et al.,* 2019). It causes toxicity to livestock and reduces stocking rate and density. For instance, although *P. juliflora* pods (Figure 4) are palatable to livestock, the chemical content is thought to cause problems for goats, cattle, and camel; a high diet of pods can cause death in sheep and goats. The cattle can die if they feed on the *P. juliflora's* leaves over a long period due to its tannin contents. The thorns have also been reported to damage the eyes and hooves of livestock eventually leading to death. Additionally, due to high

sugar content in the pods, it depresses the rumen bacterial activity and this causes permanent impairment on the ability to digest cellulose. The high sugar content in pods also causes dental disfiguration and tooth decay thus reducing their browsing and grazing capacity (Wudad *et al*. 2021). In 2006, the IIchamus community of Baringo presented a toothless goat in Nairobi court as evidence of the negative impacts of *P. juliflora*. Seid and Legesse (2020), also noted that households incur a lot of economic losses for livestock treatment; an estimated cost of 150 US dollars/yr to treat *P, juliflora* related ailments.

Figure 4. *P. juliflora* dried fruit pods (Source: original)

Impacts of Prosopis juliflora on grasses and herbaceous species

Studies have revealed that *P. juliflora* invasion leads to loss of biodiversity. Hussain *et al.* (2020) found out that *P. juliflora* can suppress the growth of grasses under its canopy by delaying seed germination and reducing plant growth in terms of roots, shoots, leaf area, stem diameter, and plant height. Similarly, in the study that was conducted in the wetland of the middle Awash basin, it indicated that *P. juliflora*, increasingly out-competed the native vegetation like grasses and shrubs and displaced the valuable grasses leading to a considerable shift in the vegetation composition (Debella *et al*., 2023). Debella *et al.* (2023) in their study carried out in Baringo Kenya also reported that *P. juliflora* tends to smother the growth of the native grasses and is much associated with declining pasture availability in the study area. Getachew (2002) also mentioned that *P. juliflora* has negative impacts on the pasturelands because it responds positively to overgrazed and bare grassland ecosystems, subsequently converting them to unusable bushlands. The most affected grass species includes; but not limited to Aucher's grass (*Chrysopogon plumulosus)*, African foxtail grass (*Cenchrus ciliaris*). Additionally, *P. juliflora*has also caused a reduction in species richness and the basal cover of native herbaceous vegetation. Huho *et al*. (2020) also found that the cover of the understory of herbaceous plant species in plots invaded by *P. juliflora* was 27% less than that in the open areas. The lower total biomass production of the herbaceous species growing under *P. juliflora* indicates that canopies inhibit the production of understory plant species. The inhibition is attributed to the phytotoxic effects of *P. juliflora* leaves, allelopathic effects, shading, and competition for moisture and nutrients. Ahmed *et al.* (2022) indicated that *P. juliflora* invasion reduced significantly the cover of the native herbaceous species.

On canopy effect, the results from a study conducted by Abebe (2017) showed that increasing *P. juliflora* canopy cover until 40% favored species richness and diversity in the study area. But any further increase in canopy cover beyond 40% resulted in a decline in species richness and diversity of the herbaceous plants. *P. juliflora* starts branching closer to the ground compared to other tree species. This makes under canopy seedlings establishment very difficult because of the barrier created by the lower branches. The branches further stretch out sideways and intercept each other. This interferes with light penetration and hence the understory

vegetation is unable to survive. El-Keblawy and Abdelfatah (2014), also recorded that *P. juliflora* significantly reduced the evenness, richness, and density of the plants beneath compared with open spaces beyond their canopies; and the depressing effects of *P. juliflora's* canopy were higher in annuals than in perennials.

Allelopathic effects of Prosopis juliflora

Allelopathy is the beneficial or destructive impact of phytotoxic chemicals released by plants that cause an injurious effect on the growth and development of nearby plants or microorganisms, Qayyum *et al*. (2018). The chemicals released from the allelopathic plants are known as allelochemicals. Severe biochemical effects from invasive species may arise from increased biochemical concentrations as they adapt to the new environment or due to the lack of defense mechanisms of the native species in the invaded area (Huho *et al*., 2020).

Several studies have suggested that *P. juliflora* has allelopathic effects on other plant species. For instance, Alvarez *et al*. (2019) pointed out that the leaves of *P. juliflora* contain various chemicals including, tannins, flavonoids, steroids, hydrocarbons, alkanoids, and waxes. These chemicals are known to have effects on the germination of other plant species. They further mention that allelochemicals from *P. juliflora* may directly act upon the seeds and seedlings or may indirectly have effects on other soil organisms. Bobassa (2017), in his study, found out that the leaves extract of *P. juliflora* significantly reduced the germination percentage, plumule, and radicle length of the Ethiopian mustard. Chepkwony *et al.* (2020) also indicated that the results from their experiment showed that *P. juliflora* litter had a strong effect on the germination of the Acacia and even on its own germination. Similarly, Qayyum *et al*. (2018) also demonstrated that due to the allelopathic effects of *P. juliflora*, its leaf extracts significantly affected the shoot and root length of the grass species (*Cenchrus ciliaris*, *Panicum antidotale* and *Panicum maximum*) used in their experiment. Candido de Oiveira *et al*. (2018) also concluded that extracts from *P. juliflora* inhibited seed germination of the grasses by releasing growth retarding substances; the leaves seemed to have higher amounts of inhibitory compounds compared to the roots (Zejak *et al*., 2022). Additionally, El-Keblawy and Abdelfatah (2014), in their study pointed out that seed germination of five native plants associated with the *P. juliflora* species was significantly inhibited with the aqueous extracts of *P. juliflora*, compared with control (non-treated) seeds.

Control methods of Prosopis juliflora

P. juliflora tends to spread quickly and in areas that this species has colonized, the use of preventative methods to manage this species is not feasible. Generally, four methods are commonly used to control this invasive species, they include mechanical, biological, chemical and control by utilization (Bashir *et al*., 2024; Ouallali *et al*., 2024). The control programs are usually meant to reduce the abundance and density of infestation (Abdulahi *et al.,* 2017). In mechanical control, these trees are uprooted or physically fell often with the use of hands, tools, or machines (Kader *et al*., 2023). Whereas in chemical control, approved chemicals like the herbicides are judiciously applied to cut tree-stumps or to incisions made in the barks of these trees. In biological control, insects, mites, or pathogens are introduced which are physiologically adapted to feeding exclusively on this plant species (Kader *et al*., 2022; Kader *et a*l., 2022). On the other hand, control by utilization involves exploiting the economic potential of this species to meet the human basic needs while at the same time controlling its spread. It entails the use of this plant to make products such as livestock feeds, food, timber, charcoal, and poles among others (Kader *et al*., 2021; Shuraik and Lizny, 2022). These control methods have been applied in different countries; developing countries like Ethiopia and Kenya tend to apply control by utilization, the developed countries use the mechanical and chemical control methods whereas countries like South Africa and Australia are using biological control methods (Shackleton *et al*., 2014). Although, the above mentioned have been tried in different countries; to date, no cost-effective and efficient methods to manage and contain the spread and invasion of this species have been found (Ahmed *et al*. 2022).

Conclusions

The study analyzed the literature and contextualized the impacts of *Prosopis juliflora* in the Kenyan and Ethiopia Ecosystems. Highlighted and discussed the various impacts that the communities in the infested areas are struggling to cope with. For instance, the impacts of this invasive species on agricultural production, grasses and herbaceous species, impacts on desertification, socio-economic impacts, and its allelopathic effects as well as the different mechanisms that have been employed to try to control this invasive species. *P. juliflora* is a multi-purpose tree and can be converted to valuable resources to improve the livelihoods of the communities living in the arid and semi-arid areas. On the other hand, this plant species is among the worst noxious species; it damages croplands, pasturelands, wetlands, watersheds, and has negative health implications on humans and animals. These negative impacts have far out-weighted the positive impacts and hence the call to control it. This invasive plant species has the potential to quickly spread and that is why it has become of major concern in the arid and semi-arid areas in the invaded regions. The rapid spread of *P. juliflora* means that its detrimental impacts on the environment and human livelihoods will continue to escalate from time to time. Therefore, there is a need for the government(s) and the stakeholders especially in invaded regions to be intentional about devising integrated management approaches that are more effective and efficient to control this species, reduce its adverse impacts while at the same time enhancing its benefits. Pay close attention to removing *P. juliflora* from waterways, extremely productive land, and land that is crucial for the local food supply. Use these lands with extreme caution and vigilance. Communities that occupy the land should be urged to remove *P. juliflora* seedlings while they are still easily removed. Land use planning: prohibit cattle from moving between *P. juliflora*-affected areas. It is advisable to encourage the use of *P. juliflora* in common areas. It is necessary to find methods for enabling communities to work together with the public and private sectors, such as in the conversion of biomass. Investigate novel applications, such as the use of energy biomass or *P. juliflora* biochar. To enable the marketing of *P. juliflora* goods, new rules are needed. Policies need to encourage the manufacture of charcoal and poles for construction and fencing, as this has historically been discouraged. Additionally, more research needs to be conducted to fully understand the biological characteristics of this invasive species, this will help in determining the most efficient control methods to employ.

Authors' Contributions

All authors read and approved the final manuscript.

Ethical approval (for researches involving animals or humans)

Not applicable.

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Conflict of Interests

The authors declare that there are no conflicts of interest related to this article.

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