Ecological and social impacts of invasive plant species on Maputo Special Reserve and Integration of surrounding communities in management, Mozambique.

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FINAL DETAILED PROJECT REPORT-2020

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1: Acknowledgement

This project was supported by the Rufford Foundation under Rufford Foundation small grants for nature conservation.

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2: Project summary

The project provided an inventory and documentation of the spatial distribution of the invasive plant species on the Maputo special reserve and analysed the potential ecological and social impacts on Reserve in different parts based on the changes since the invasive plant species were observed. The project results have been handled to decision makers to assist to them in making decisions that can facilitate optimal allocation of resources to manage invasive plant species that are most harmful in the area ecosystem. In order to provide information about various invasive plant species to the surrounding communities allowing them to priotise certain high impacts species for management, a total of 243 households were engaged in project activities. This raised awareness among communities on the need to control invasive plant species in the reserve.

3: Introduction

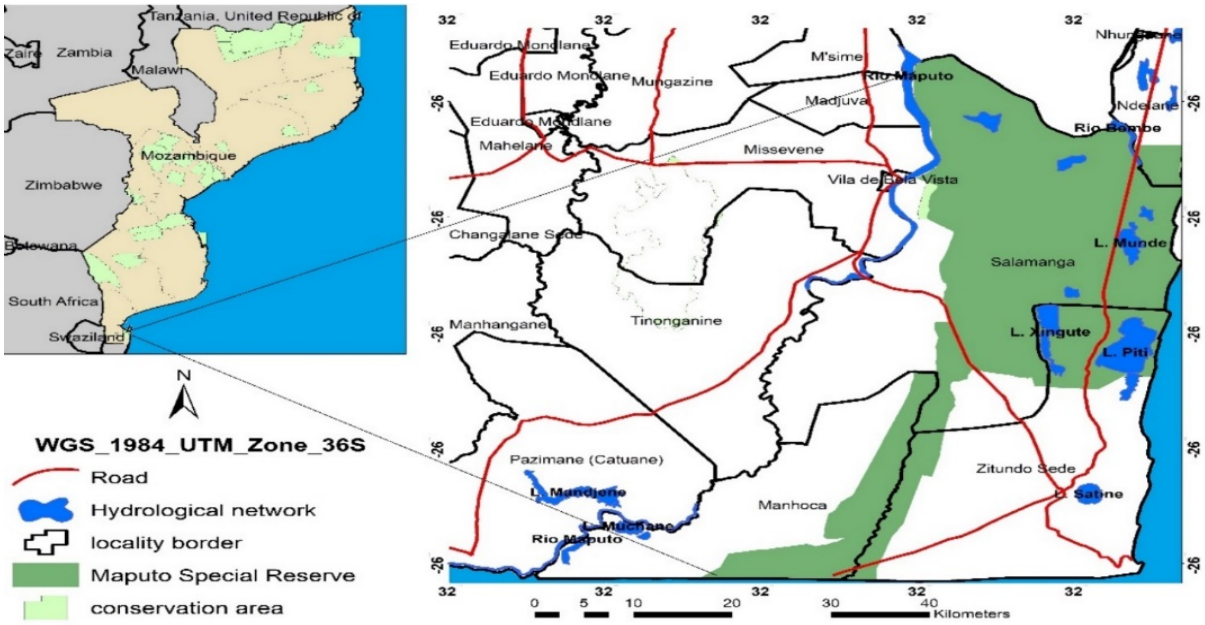
In Maputo special reserve, Invasive Plant Species (IPSs) are regarded as one of the threats to the conservation of the area biodiversity following direct habitat destruction anthropogenic activities, which was notable especially during the civil war between 1980-1993, where most of the area was abandoned giving chance for the spread of invasive plants in the reserve. (MICOA, 2014). Invasive plant species are problematic to native and other plant communities as they can compete for resources and displace competitors. Local extirpation of native plant species has obvious impacts on wildlife and natural habitats. Competition between plant species is a part of any habitat, but the introduction of non-native species disrupts relationships evolved among native plants and their communities within those specific habitats.

In MSR, invasive plant species like *Eucalyptus sp* and *Pinus* were introduced over the years deliberately for commercial purposes and fencing of agriculture fields whereas *the Lantana camera* was for ornamental purposes. Plant species like casuarina were for the conservation of the environment along the coast (MEWC,2014). Other IPSs for example *Ipomoea carnea, Opuntia indica, Ipomea Alba, Pinanga Coronata, Ricinus communis* have invaded in a natural way (MICOA,2014). Some introduced plant species important economically, socially, and ecologically; On the other hand, IPSs have caused imbalances in protected area ecosystems and extinction of native plant species and probably reduction of genetic diversity (MICOA,2014). Surrounding communities depending on the reserve for firewood (domestic use and for sale) and collection of other non-timber forest products (medicine, grass for thatch, wild fruit, mushrooms, honey, and fibre) are under threat due to the presence and potential impacts of invasive species hence an impact on their livelihoods. Although the above consequences are noted, there are limited studies that have tried to consolidate information on the state of invasive plant species in MSR. Therefore, there was need for recognition that societies need to mitigate the negative impacts of invasive plant species and find appropriate means to manage them in a way that the impacts are at least minimized. This study was carried to provide an inventory of the spatial distribution of IPSs on the reserve and analysed the potential environmental impacts on the reserve. Also, the study results assisted decision-makers to facilitate optimal allocation of resources to manage IPSs, provide information about various IPSs and their impact allowing decision-makers to prioritized certain high impacts species for management, and assist policymakers and planners develop measures to reduce the vulnerability of the reserve to IPSs invasion.

4: Objectives of the project

1. *To determine the spatial distribution of different Invasive Plant Species in the Reserve*
2. *Assess the social impacts of Invasive Plant species on the communities within close proximity to special Reserve*
3. *Determining whether invasive plant species cause changes in the abundance of native plants with domestic use.*
4. *To raise community awareness about different strategies that can be put in place to address invasive plants occurrence in reserve.*

4.1 Map location of the project area.



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4.2 Vegetation types in Maputo Special Reserve.

Project site - the project was carried out in Maputo special reserve covering a total area of 700 km2. The reserve lies in the Matutuíne District of Maputo Province in Southern Mozambique, south of Machangulo Peninsula. Its current boundaries are the Maputo Bay in the north; the Indian Ocean to the east; the Maputo River, the Futi River and a line 2 km east of the Salamanga- Ponta do Ouro road in the west, and the southern end of Lake Xingute and the southern restriction of Lake Piti in the south. This area has high number of plants characterized by a unique mosaic of varied ecosystems (MAE, 2005), including: Mangroves: predominantly composed of Avicennia marina and Rhizophora mucronata. Dune Vegetation: composed by pioneer species like the Scaevola plumieri, Ipomoea pes-caprae and Canavalia rosea. Wooded Grasslands: These support species like Sideroxylon inerme, Diospyros rotundifolia, Mimusops caffra, Cyperus compactus and Monanthotaxis caffra. Sand Forest-Woodland Mosaic: Composed by Some of these mosaic woodlands are waterlogged during rainy season. Sand Forest: dominated by Ochna natalitia, Mimusops caffra, Euclea natalensis, Psydrax locuples, Afzelia quanzensis, and Dialium schlecterii (Bodasing, 2011). Savannah: relatively open areas dominated by species like Strychnos madagascariensis, Strychnos spinosa, Dichrostachys cinerea, Garcinia livingstonei, Vangueria infausta, Syzygium cordatum, Sclerocarya birrea, Afzelia quanzensis, and Terminalia sericea. Futi Riverine Vegetation: dominated by Phragmites australis, Juncus kraussii and Cyperus compactus. In some cases, in this vegetation you can find encrached island bushes of Ficus sycomorus, Syzygium cordatum, Kigelia africana, Helichrysum kraussii, and artificial Eucalyptus Forests: encroaching into the natural vegetation of Maputo Special Reserve .It encompasses varying climate characterized

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by a warm wet summer (October-March with temperatures varying between 26ºC and 30ºC) and by a cool dry winter ,April – September with temperatures varying between 14ºC and 26ºC (MICOA, 2014). Average annual rainfall varies between 690-1000mm. The most striking feature of the climate is the variation of rainfall across the area in an east to west or inland direction. The area has variety of land uses including agriculture; farming (both livestock and game); tourism; trade; and housing being practiced by the various communities and concessionaires (MAE, 2005). Most of these activities occur along the Maputo River, yet a few are scattered along the Ponta do Ouro – Salamanga Road with a few housing initiatives close to the tourism core areas such as Ponta do Ouro and Ponta Malongane. MITADER (2016).

5: Methods

- For data collection, a stratified random sampling method was used according to the type of use and land cover in the area based on the vegetation cover map of 1: 250000 of MSR (MITADER,2016). According to the stratification of the study area, five land use and land cover areas were selected, namely: agriculture (4.34%), grasslands (25.09%), forest area (31.72%), flooded area (34.78%), and settlement (2.002%). The effective sampling area was (23,342.12 ha), which represented a sampling intensity of 33.03% of the project area.

Randomization was carried out using the package (Hawths tools extension) associated with GIS ArcGIS 10.5 Winther and Rasmus (2014). The location of the plots in the reserve area was done with the aid of a GPS, in which the geographic coordinates of the sample plots were previously launched to the device. After locating the points, sixteen circular plots of 20 m diameter formed by two replicates with north orientation were established in transects within a big plot of 160mx80m (Figure 3). For the survey of invasive plant species that are in the sampling area, I adapted the methodology described by Tinley (1997), which consists of identifying all invasive species of plants in a given plot and recording them in terms of occurrence in numbers per plot sample. For the IPSs identification it was done in the field with the help of a botanical collector and, a list previously prepared based on the Compendium of invasive plants with photos was used (Cabi, 2013). Invasive plant species that were not on Cabi's list were classified according to their typical characteristics and features and later recognized by a botanist at the study area. The abundance and coverage of all invasive plants were registered on the form.

- Analysis of the spatial distribution of invasive plants species in the study area

From the starting point of the survey, at every 10 km distance, field plots of 10 m × 10 m were examined on both sides of the road to record the distribution of invasive plant species. In between these predefined locations, some opportunistic observations were also made if encountered species not recorded in the immediate previous plot. This strategy was used to capture maximum possible records and locations of the distribution of invasive plant species. The surveys were carried out along routes from the restricted routes in the conservation areas, in the places where there is greater movement of employees and in the places with the greatest entry of tourists, going through and listing the species present, afterward all the coordinate was put to map the places of occurrence of the main invasive plant species. This was following the protocol used by (Araújo, 2011). The withdrawals took place within the limits of Maputo's special reserve and inside. Before carrying out the fieldwork, a study of each route, to obtain information about its characteristics, as well as the respective extension was done.

The fieldwork consisted of surveying the occurrence of invasive species over different routes, some of which were along the banks of the River Futi. GPS was used to signal the location of the species' coordinates for later mapping. In cases where two or more invasive plant species occur in the same nucleus, a visual estimate of the contribution of each species was made and recorded. With the ArcGIS 10.5 software, the invasive plant location coordinates were put on the map of MSR to ascertain the invasive plant location on the ground or field.

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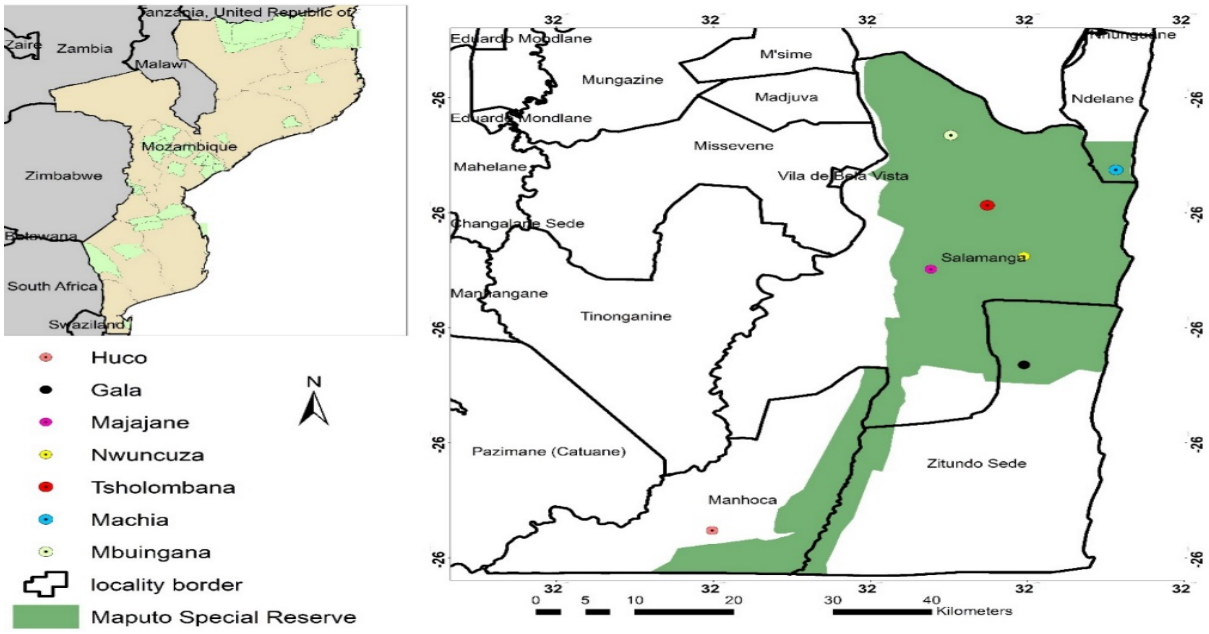
- Assessment of invasive plant species impact on study area biodiversity

Ten 10 m x 10 m random quadrants were established in the areas that did not have a record of any invasive plant species and a similar number of random quadrants in the areas where invasive plant species were recorded. Within each quadrant both in the invaded and non-invaded areas, all the trees, shrubs, herbs, and grasses were identified and documented. The objective of this exercise was to determine if there was any significant difference in species diversity between the invaded and non- invaded areas

- Sampling method and procedures on social data collection

Social data collection was done along settlement patterns targeting villages within Maputo special reserve. A sample of five villages: Mbuingana, Majajane, Gala, Huco, and Machia were purposively selected for the study. These villages represent the communities around the reserve. A systematic random sampling method was used to select the number of households in the selected villages whereby every 3rd household was included in the sample. For this project, a cross-sectional type of study was adopted. A sample of 243 households from five villages was considered representing 39.2%.

5.1 Map of the villages covered by project.



A reconnaissance survey was done before data collection to get acquainted with the study area.

Pre-testing of questionnaires was done in November 2019 to ensure that before administering the questionnaire, all errors associated with the survey research are minimized. During the exercise, problems regarding the terminology used in the study arose among both the enumerators and the respondents and were addressed accordingly. This helped to improve the quality of the data and was done on a small sample of respondents from the target population in one of the selected villages.

Social data were collected in November 2019, February, and July 2020 using the household survey method through structured questionnaires which comprised both open and closed questions. Open-ended questions were used to seek opinions from the respondents about their perceptions of invasive species plant species and how they have impacted them. Interviews were conducted to get a clear knowledge of the invasive plant species with regards to the mechanism of dispersal and cause of their infestation, their benefits as well as their notable

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ecological impacts and the management systems that have been applied so far and to get their perceptions about the invasive species and what should be done to solve the problem.
A semi-structured questionnaire that included both close and open-ended were designed and employed to generate quantitative data from respondents. The questionnaire was prepared in English language and translated to Portuguese. Field assistants who understand English, Portuguese, and Changana languages were involved to administer questionnaires.
Direct observation was used in the households while surveying to obtain and confirm information about utilization, direct observations were done on the reserve to note the presence of invasive plant species

5.2 Field Conditions.




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6: Project Activities:

6.1 Documentation of invasive plant species.

The documentation and inventory of invasive plants was carried out in Maputo special reserve across different strata. The strata were made depending on the land use and land cover change. The inventory was conducted during 2019 -2020. In addition, the spatial distribution of invasive plants was also carried out successfully.



6.2 Community engagement awareness programmes.

As a part of education and awareness program different individuals from 243 households across five villages were engaged in the need to control invasive plants species in Maputo special reserve. Group and individual discussion were held throughout project activities in different households. Informal and focus group discussions were also held with local people to know their views. Moreover, the local people were engaged as field assistants and field guides this raised their knowledge about invasive plants species and the effects they could cause on the ecosystem.




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7: Project outcomes

7.1: Documented invasive plants species.

Project findings indicated that the reserve is threatened by different IPSs. The Invasive plants species recorded with the highest frequency was Lantana Camara and Eucalyptus sp). Lantana Camara was found in almost all strata of the reserve sampled whereas Eucalyptus sp was more concentrated in abandoned settlement land and around edges of the reserve. Observation of Eucalyptus sp was also along river Futi. Most of these IPSs were found in the edges of the reserve, around water points, and along tourist roads. Other invasive and non-indigenous plant species recorded included Datura stramonium, Ricinus communis, Psidium guajava, Caesalpinia decapetala., Pinanga coronata. Ipomea alba, Agave sisalana Perrine., Cirsium vulgare, Paraserianthes lophantha, Prosopis velutina. Opuntia monacantha. Solanum elaeagnifolium. Ipomea indica. Solanum mauritianum, Acacia decurrens. Lilium formosanum Wallace, Xanthium spinosum Arundo donax Egeria densa, Nephrolepis exaltata, Senna didymobotrya, Chondrilla juncea. choromolaena odorata, Ipomoea carnea. Some of these IPSs were distributed across different strata but others like Nephrolepis exaltata and Egeria densa were only observed in the flooded area and around water points. In abandoned agriculture fields were Ricinus communis, Psidium guajava, and Datura stramonium.

Table I: Documented invasive plant species.

Species	**Frequencies**
Lantana camara	274
Eucalyptus sp	200
Nephrolepis exaltata	168
Pinanga coronata	138
Solanum elaeagnifolium	112
Xanthium spinosum	100
Senna didymobotrya	79
Ipomoea carnea	78
Ipomea indica	76
Acacia decurrens.	49
Ricinus communis	48
Psidium guajava	46
Egeria densa	35
Opuntia monacantha.	30
Arundo donax,	28
Datura stramonium	25
Caesalpinia decapetala	22
Agave sisalana	19
Paraserianthes lophantha,	19
Prosopis velutina	17

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7.2: Life form features of some invasive plant species documented.

Lantana Camara.

It is a floriferous shrub growing up-to 2metres or higher. Stems are four-angled and covered with short stiff hairs. Leaves are dark green, pale yellow, rough and hairy. Flowers pink, red, orange, yellow, or white in compact flat-topped heads. Fruits are glossy green turning purple black. It invades forests, savannahs and watercourses, roadsides, and degraded land.

Datura stramonium.

An erect herbaceous annual plant growing up-to 1.5m high. Stems sparsely hairy, green-brown, or purple. Leaves dark-green or purple ovate and up-to 200mm on long petioles. Leaf margins are coarsely and irregularly toothed or lobed. Flowers white, mauve, or purple. Fruits are brown hardened capsules, ovoid up-to 50mm long by 30mm wide, and covered with slender spines measuring 10mm long.

Eucalyptus sp.

A tree tall perennial plant with an elongated measuring around 33 ft with a trunk and branches made of wood. It can live for many years. It is divided into four main parts roots, trunks, branches, and the leaves. the roots of the tree are usually under the ground.

Psidium guajava

An evergreen shrub or small tree 2-10m high. Leaves bronze turning light-green, ovate to oblong-elliptic, often broad and rounded at both ends, with a small pointed apex. Flowers are white and in groups of 1-3. Fruits many-seeded berries which are green turning yellow when ripe with white, yellow, or pinkish flesh which is sweet and edible. It's cultivated for its fruits and invades forest margins, savannah, and roadsides.

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Ricinus communis

An annual herb or softly woody shrub up-to 4m high. Leaves shiny, dark green or red and large up-to 300mm wide. Palmately five-nine-lobbed, closely serrated margins. Flowers are reddish on the upper side and Cream on the lower part and stalks up-to 150mm long. Fruits are green, brown or red-three lobbed capsules about 10-15mm long and covered with soft spines. Seeds are silvery mottled brown.

Pinanga coronata

A caespitose, monoecious plant, rather variable, with erect stems, 2-5 m tall, with a diameter of 3-5 cm, smooth, of green colour on which stand out the rings trace of the junction of the fallen leaves. The leaves are pinnate, usually ascending, 1,5 m long on an about 30 cm long petiole, of intense green colour and subdivided into pleated segments, about 25-70 cm long and of variable width, with sharp or truncated and toothed tip; the leaves, when opening, are often pink with light dots. The basal sheath of the leaf, of yellowish-green colour, wraps wholly the stem for a length of about 30-50 cm.

Agave sisalana

A Perennial plant that consists of a rosette of sword-shaped leaves about 1.5–2 meters tall. Young leaves may have a few minute teeth along their margins, but lose them as they mature.

Opuntia monacantha

The green stems of this low-growing perennial cactus are flattened and are formed of segments. Barbed bristles are found around the surfaces of the segments, and longer spines are present. The flowers are yellow to gold in colour and are found along the margins of mature segments.

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Solanum elaeagnifolium

A perennial 10 cm to 1 m in height. The stems are covered with nettle-like prickles, ranging from very few on some plants to very dense on others. Leaves and stems are covered with downy hairs (trichomes) that lie against and hide the surface, giving a silvery or greyish appearance. The leaves are up to 15 cm long and 0.5 to 2.5 cm wide, with shallowly waved edges.

Solanum mauritianum

A large shrub, 2 to 5 m high, branched, with a foul smell. The branches are thick, cylindrical, tomentose, greyish green, branching dichotomously.

Acacia decurrens

A large shrub or tree with twice-compound dark green leaves. Its young branches are generally hairless with conspicuous wings or ridges that emanate from the leaf bases. its main leaf stalk is hairless with a small raised gland at the junction of each pair of leaf branchlets. its yellow or golden-yellow flowers are borne in small globular clusters that are arranged into larger elongated compound clusters. It is fruit is an elongated and somewhat flattened pod.

Xanthium spinosum

An erect, rigid, much-branched annual herb, 3-10 dm tall and up to 15 dm or wider. Stems are striated, yellowish or brownish grey, and finely pubescent. The cotyledons are in shape, differing in appearance.

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Arundo donax

A perennial grass that reaches up to 20 ft height. It looks shorter when damaged or stressed. The stem resembles a corn stalk. Leaves are long, flat, and grow up to 1.5 ft. Long. They are green or have variegated green and white stripes the length of the blade. It invades ditches, stream banks, and lakeshores. It competes for water, nutrients, and radiation, suppresses and excludes native vegetation which degrades wildlife habitat, increases fire risks, and interferes with flood control.

Ipomea indica

It bears heart-shaped or has 3-lobed leaves and rich purple funnel-shaped flowers 6–8 cm in diameter.

Lilium formosanum

A perennial herb: bulb scales thickened, lanceolate; aerial stem annual, erect, slender, 0.5–2 m high. Leaves alternate, linear to lanceolate. Flowers are terminal

Prosopis velutina

The young bark is reddish-brown and smooth.it has Yellow thorns up to one inch long appear on the young branches. The leaves are about 3-6 in (7.5–15 cm) long, fine, and bipinnately compound.

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Paraserianthes lophantha

A Shrub or small tree up to 6 m; smooth, dark grey, fissured rhytidome when old. Leaves: evergreen, alternate, bipinnate, of 12-23 cm long, with 8-13 pairs of pinnae, which in turn have 15-40 pairs of oblong asymmetric and mucronate, leaflets, each with, dark green on the upper surface and much lighter on the lower surface.

Cirsium vulgare

A tall biennial or short-lived monocarpic thistle, forming a rosette of leaves and a taproot up to 70 cm long in the first year, and a flowering stem 1–1.5 m tall in the second. It sometimes functions as an annual, flowering in the first year. The stem is winged, with numerous longitudinal spine-tipped wings along its full length. The leaves are stoutly spine, grey-green, and deeply lobed; the basal leaves up to 15–25 cm long, with smaller leaves on the upper part of the flower stem; the leaf lobes are spear-shaped. The inflorescence is 2.5–5 cm diameter, pink-purple, with all the florets of similar form. The seeds are 5 mm long, with a downy pappus

7.3 Community perception engagement awareness raising.

Community perception assed indicated that communities accepted there was occurrence of invasive plant species in their areas and measures have to be taken to eradicate them. Individuals from 243 households that were involved in the project activities agreed that invasive plants exist in their locality but with varying degree of occurrence. Refer to the graph below. Plants like Lantana camara were mentioned by the county to be common in the area.

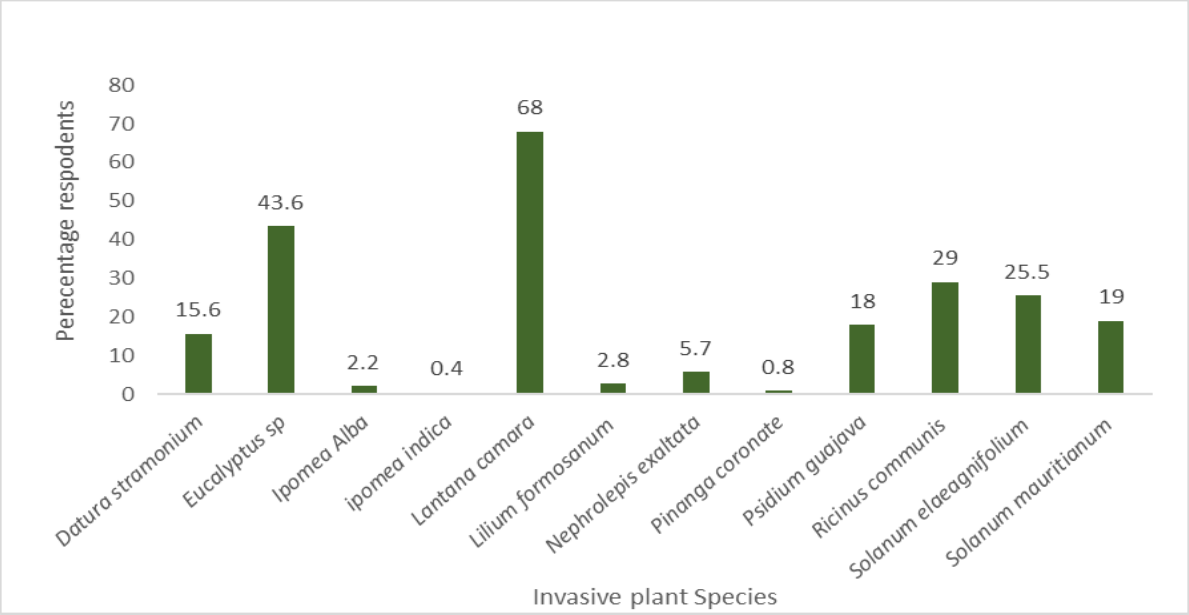

Figure 1: Community response on Invasive plant species in locality

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8: Constraints and Limitations

Constant rains remained major constrains throughout the survey period. Rainfall affected project work to a small extent we could delay to go to field due to early morning rains. The road with the reserve were very terrible at some point it would affect our daily planned activities as we could spend some hours to get passage once we meet obstacle in reserve. The problems were a raising from tree logs that we could find had fallen in roads, muddy sandy roads that could make our car fail to pass through.

9: Project recommendations

9.1 Areas for further research.

During project implementation, anthropogenic disturbances were observed as the main causes of the occurrence of the IPSs in the study area. However, they could be other factors contributing to the occurrence of an invasive plant in the study area including birds and mammal. Therefore, further investigation should be carried out in the following areas:

- The extent of other factors on the occurrence of invasive plant species in the reserve be assessed.
- Since invasive plants area already established in the study area, there is a need to investigate the best method of controlling them. The focus can be on best control strategies for example mechanical and chemical approaches to establish their effectiveness.
- To ascertain how wildlife is coping with the invasive plant occurrence in the area.
- Weather IPSs harm the feeding habits and distribution of some wildlife.

9.2 Management recommendations.

The control and management of established invasive species tiresome task when implementing effective Plans for eradication. Where invasive species are widespread and their numbers are high like the case of Maputo special reserve where Eucalyptus sp has established strongly, the resources required may be much. However, if species diversity is to be ensured within the reserve, strategies must be put in place to control further spread. In this case, the following recommendations drawn from the survey could minimize the spread of invasive plant species.

- Anthropogenic disturbances need to be minimized and if possible, eliminated. This could be achieved through fencing off the reserve.

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- Control and management strategies need to be put in place. These should include community land as these are an alternative source of propagules for invasive plant species.
- Management of the reserve should consider controlling the spread of invasive plant species using mechanical, chemical, or biological control methods depending on the type of invasive plant and the extent of invasion.
- As a potential threat to native biological diversity, invasive plant species in Maputo special reserve need to be controlled to maximize the productivity of native plants by reserve species.
- Local communities should be further sensitized on the impact of invasive plants as this will greatly improve the management of invasive plant species.
- Eradication of invasive species would come at a cost as various groups of stakeholders would lose all the many benefits, they obtain from them such as fuelwood, timber, and medicine. Therefore, the reforestation program should be implemented by planting plants
- There is a need for continuous sensitization on the dangers and magnitude of the problem posed by IPSs on the socio-economic livelihoods of stakeholders, the environment, and biodiversity.
- There is a need for the establishment and coordination of technical support from reserve and community in both short- and long-term management programs of IPSs.

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