DARWIN INITIATIVE

Coordinated invasive plant management to protect Tanzanian biodiversity and livelihoods

Prosopis Management Plan for the Lake Natron Basin

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CABI (Switzerland and Kenya)

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Tanzania Wildlife Management Authority (TAWA)

Community Research and Development Services (CORDS)

Tanzania Natural Resource Forum (TNRF)

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Contents

List of abbreviations

CBD	Convention on Biological Diversity
COP	Conference Of the Parties
EDRR	Early Detection and Rapid Response
GIS	Geographic information system
IAS	Invasive alien species
LIG	Local Implementation Group
NISSAP	National Invasive Species Strategy and Action Plan
NGOs	Non-governmental organizations
PMP	Prosopis Management Plan

Executive summary

Invasion by alien plant species is a major reason for land degradation, as such species can have massive impacts on ecosystems and livelihoods. *Prosopis juliflora* (also called prosopis, Mrasha, Mathenge or other local names) is an invasive tree or shrub that threatens natural grasslands, water resources, livestock and crop land, as well as the livelihoods that depend on them. The species is spread by people, livestock and water and has recently started spreading into the Lake Natron Basin, a region dominated by grassland habitats that is likely to be invaded by prosopis if not managed.

The early stage of spread of Prosopis in the area makes it an opportune moment to manage the species before the impacts become severe and widespread. The return on investment early in the invasion is relatively high and delayed interventions are likely not successful, because of the difficulty and excessive cost of mitigating the impacts of a widespread species. It is therefore recommended that authorities allocate budget for the management from the next financial year onwards.

This document describes a spatial management plan for prosopis in the Lake Natron Basin, roughly from the Kenyan border to the southern side of Lake Manyara, developed by a diverse group of stakeholders from the area as part of a project funded by the Darwin Initiative (Coordinated invasive plant management to protect Tanzanian biodiversity and livelihoods – DARCC013). Further, the document describes Prosopis; characteristics and impacts, invasive alien plant species management strategies, the legal framework, the prosopis management plan and how it was developed, and effective prosopis management methods.

1. Introduction

Invasion by alien plant species is a major cause of land degradation, as such species can have massive impacts on ecosystems and livelihoods. *Prosopis juliflora*, known locally as Prosopis, Mathenge, Promi, Mrasha or other, is a tree originally from Central and South America that is one of the most harmful invasive species in the world. Prosopis was introduced in Eastern Africa in the 1960s, mainly as a windbreak in degraded habitats and to provide wood and timber. Nowadays, it is widely established and causes loss of grazing land and of water. Livestock, human activities, and water contribute to spreading Prosopis seeds to new areas, and there are no native insects or fungi in Eastern Africa that help to slow down its spread. Prosopis has recently started spreading into the Lake Natron Basin, a region dominated by grassland habitats that is likely to be severely affected by prosopis if not managed.

The early stage of spread of Prosopis in the area makes it an opportune moment to manage the species before the impacts become severe and widespread. The return on investment early in the invasion is relatively high and delayed interventions are likely not successful, because of the difficulty and excessive cost of mitigating the impacts of a widespread species. It is therefore recommended that authorities allocate budget for the management starting from the next budget period.

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Description of Lake Natron basin

Lake Natron Basin covers about 930 km^2 and is largely located in northern Tanzania, with part of it in Kenya. The area is dominated by grasslands, lakes, volcanoes and few towns. On the Tanzanian side, the basin is situated in Ngorongoro, Longido and Monduli Districts within Arusha Region (Fig. 1). Important permanent rivers that feed to Lake Natron from Tanzania are Pinyinyi, Lolgorie and Engaresero. Springs and a few perennial streams in the lake margins are a source of freshwater for Maasai, cattle, wildlife and flamingos that co-exist in the area. The basin extends into Kenya along the Ewaso Ng'iro River that flows from the north. There are several Game Controlled Areas and Wildlife Management Areas within the basin, which make an important connection to world famous wildlife conservation areas such as Ngorongoro Conservation Area, Manyara and Tarangire National Parks. Lake Natron is the only important and regular breeding area for 75% of the global population of lesser flamingo (*Phoeniconaias minor*). Due to its unique soda flats and lakeshore environments, the basin also offers feeding and roosting opportunities for many 1,000's of birds of other waders and waterbirds, many of them Palearctic migrants.

The Lake Natron Basin harbors a human population of ca. 677,000, with a growth rate of 3.2% per year as per the National Census of 2022. The major economic activity in the basin is livestock keeping as it is estimated that 95% of the population are Maasai, who practice traditional pastoralism. Tourism is probably the second most important economic activity for people living in the basin. Despite its ecological and human livelihood importance, the basin is subject to various threats which are exacerbated by increased human population and livestock movements, which is largely uncontrolled. Such threats include watershed degradation, pollution, sedimentation, invasion by alien plants, loss of both terrestrial and aquatic habitats caused by deforestation, overgrazing, poor waste management and small-scale agricultural activities. If not controlled, the invasion by alien plants will be the most pervasive threats degrading grazing lands for livestock and wildlife. In 2016, scientists who were doing surveys in the basin under the Woody Weeds Project (www.woodyweeds.org)

noted the presence of an invasive *Prosopis juliflora* spreading along livestock routes and commonly used earth roads that lead to the lake shores.

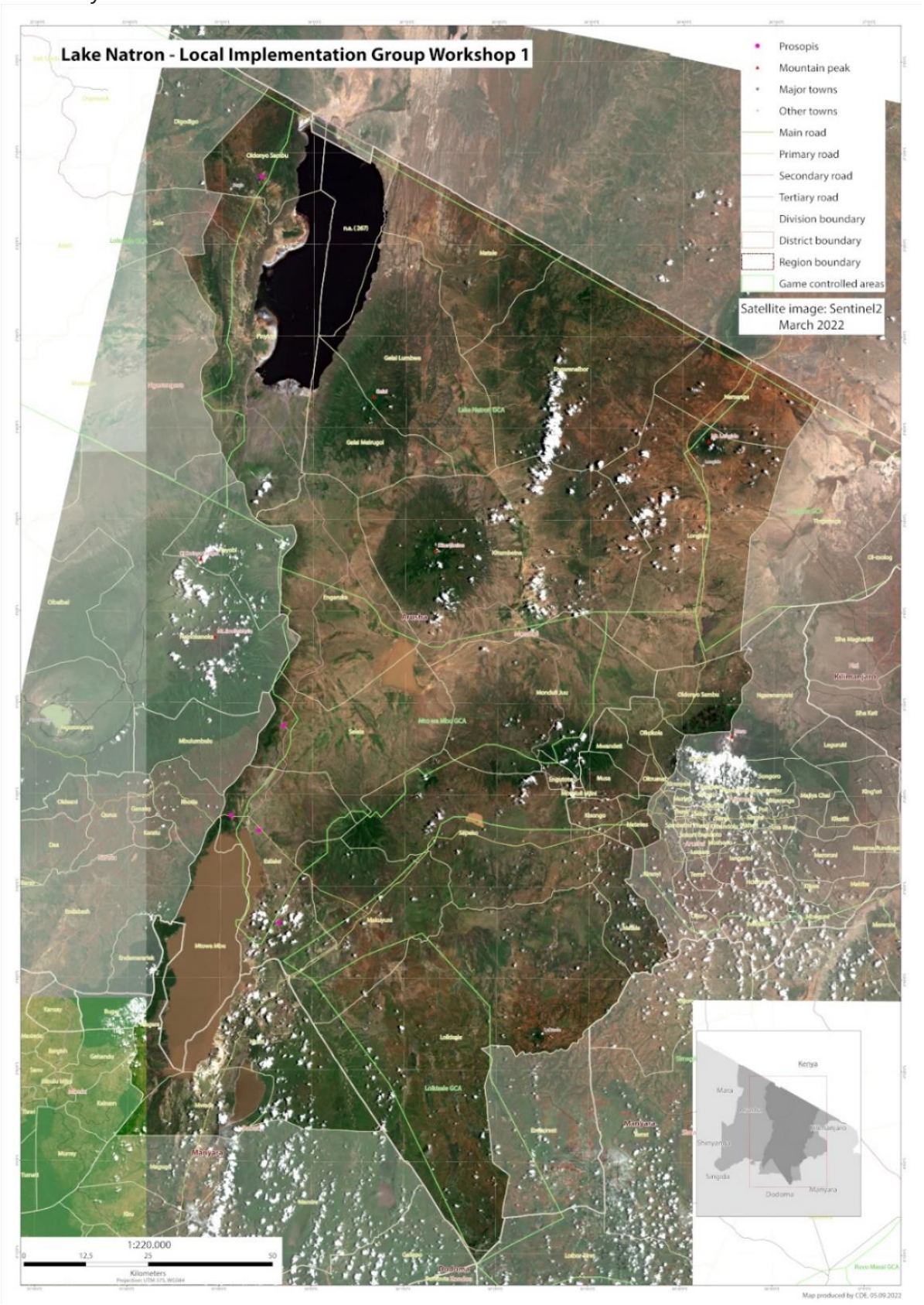

Figure 1. Map of the project region, with boundaries of administrative units and Game Controlled Areas indicated.

Situation analysis

Although Prosopis is known to be abundant in few areas of the Lake Natron Basin, its presence and spread have not been well documented, partly because its impact have not been felt and people still confuse the tree with native Acacia species (*Vachellia* sp.). Recent surveys by members of the Darwin Project revealed that Prosopis is already present in Gelai, Pinyinyi, Wosiwosi, Engaresero, Engaruka, Selela, Migungani, Kigongoni, Baraka and Esilalei villages. However, with the exclusion of Kigongoni, Mto wa Mbu, Wosiwosi and Pinyinyi, the invasion of Prosopis in the basin is still at an early stage. Hence managing its spread is of paramount importance, as prevention of biological invasions requires considerably less efforts and resources than combatting them when already established and causing problems.

The majority of people living in the basin are unaware of the impacts Prosopis can cause to the environment and their livelihoods (See Section 3 below for an overview of impacts), and many still consider Prosopis as a beautiful, useful tree for shade and fodder for livestock. In Mto wa Mbu town there is a well-established tree nursery that every year supplies thousands of Prosopis seedlings for planting in private lands and public institutions. Most of the old trees planted around Mto wa Mbu and along the tarmac road to Arusha originated from this tree nursery. It might have taken time for Prosopis to establish and start spreading, but the presence of many young trees far away from the mature trees shows that there is already an effective agent of spread, which has to be controlled to save the environment and the livelihood of people. According to interviews with local residents, no management is implemented in Mto wa Mbu. In villages far away from Mto wa Mbu, on the northern and eastern side of Lake Natron, the spreading seems to come from the Kenyan side as a result of livestock movement.

In the Tanzanian context, particularly in pastoral communities where traditional leadership structures still count in decision making, effective management of invasive plants depends on the strength of these structures. In multi-cultural small towns like Mto wa Mbu, where there are more than 120 tribes, the traditional leadership structures might have little influence on practices and decision on resources management. Therefore, management of Prosopis in Mto wa Mbu and protection of the diversified sources of livelihoods may require different approaches than in communities that rely on traditional leadership. It is clear that the interest to manage Prosopis to protect livelihood resources in the Lake Natron Basin is higher among pastoralists than other groups who seem to have different livelihood options that do not directly depend on grazing lands.

Legal framework

The preparation and implementation of this Management Plan is a requirement of the National Invasive Species Strategy and Action Plan (NISSAP), whose mission is to reduce negative impacts of invasive species by establishing an efficient and effective legal and institutional framework, communication, education and public awareness system and technologies for prevention, eradication and control of the species. The NISSAP draws its mission, targets and activities from Tanzania's Policies and Acts that deal with environmental conservation. For example, Section 67(2h) of the Environment Act no 20/2004 requires leaders at all levels to prevent the introduction and control or eradicate alien species which threaten ecosystems, habitats or other species. In that case, the Act impresses on the environmental officers and environmental committees at all levels from Hamlet (Kitongoji) to regional level the responsibility to manage invasive species, and share information to respective ministries and to the Office of the Vice President.

Tanzania has also ratified several international conventions and agreements to protect its environment. According to the treaty establishing the East African Community, Article 111 (c), Partner States will ensure sustainable utilization of natural resources like lakes, wetlands, forests and other aquatic and terrestrial ecosystems; Also article 112 states that Partner States should promote enhancement of the quality of the environment through adoption of common measures and programmes of tree planting, afforestation and reforestation, soil conservation

and recycling of materials; and to adopt common policies for conservation of biodiversity and common regulations for access to, management and equitable utilization of genetic resources.

The most relevant to the Prosopis Management Plan (PMP) presented here is the Convention on Biological Diversity (CBD) and the Aichi agreement which are implemented through the National Biodiversity Strategy and Action Plans (NBSAPs). Target 9 of this strategy required that by 2020, invasive alien species and pathways are identified and prioritized, priority species are controlled or eradicated, and measures are in place to prevent their introduction and establishment. This target was partly attained by developing a list of priority species; Prosopis was listed second after fall armyworm. To ensure proper coordination of activities the Government developed the Environment Master plan that will guide implementation of environmental interventions for the period of 10 years (2022-2032). One of the targets in this plan is to develop and implement plan to control at least 50% of National priority invasive species by 2032. This target is in line with the target 9 of the CBD/COP/15 which emphasized eradication and controlling invasive species in priority sites. Therefore, implementation of the PMP will help Tanzania to fulfil its contractual obligation, especially at the regional levels by protecting grasslands and other assets in a landscape that encompasses protected areas and areas used by local communities through joint decision making and coordinated actions by all relevant stakeholders.

Thus, management of Prosopis in the Lake Natron Basin will contribute to meeting the broader objectives of the NISSAP. The NISSAP requires that stakeholders are coordinated to take actions in developing and implementing procedures for Early Detection and Rapid Response to manage emerging invasive species such as Prosopis to protect resources and conserve biodiversity in the country. Therefore, members of a group of stakeholders (a “Local Implementation Group”: LIG) from the Lake Natron Basin recognized that fragmented efforts to manage Prosopis cannot result to reducing impacts of the species on their livelihoods and biodiversity, unless integrated into the regional planning. This is due to the fact that while some may take actions to manage Prosopis, others still want to maintain and plant the tree in their compounds for benefits such shade and animal feeds resulting to abundant seed sources in the area. Also, there are constant interactions between districts of Arusha region and between neighboring regions such as Kilimanjaro and Manyara, and indeed Kenya, maintaining a high risk of further spread and re-introduction of Prosopis through livestock movement.

Purpose of the present document

This document presents and describes a Prosopis Management Plan (PMP) for the Lake Natron Basin, which was developed by the LIG that was convened for this purpose by a project funded by the Darwin Initiative. The overall goal of the PMP is to set out approaches and framework for coordinated implementation of activities to prevent further spread, and limit local abundance of Prosopis in the Lake Natron Basin through engagement of all relevant stakeholders particularly local communities.

The PMP described here provides details of anticipated procedures and requirement of resources to manage Prosopis in the Lake Natron Basin. It also highlights the roles of stakeholders within and outside the basin who may have influence on decisions, practices and actions to manage the species. Therefore, integration of the PMP into National, regional and local planning and budgeting will ensure inter-sectoral collaboration and coordination of relevant regional sectors, such as agriculture, livestock, forests, wildlife, water, and environment, and minimize counteracting activities that contribute to the spread Prosopis. The regional sectors will continue to create awareness, manage and monitor progress of Prosopis management through established government structures and ensure coordination of activities and resources that are received through conservation projects.

2. IAS management strategies

The spread and impacts of invasive species are dynamic and the impacts generally increase as the species spreads across an area and becomes more abundant. While species may be

introduced to provide benefits, over time the negative effects become more important and will dominate. In parallel to the spread, the cost of managing the species increases, while the chance to minimize impacts decreases (Fig. 2). This highlights the need to manage invasive species while they are not widespread or abundant, as management is then most likely to succeed in reducing impacts and more cost effective.

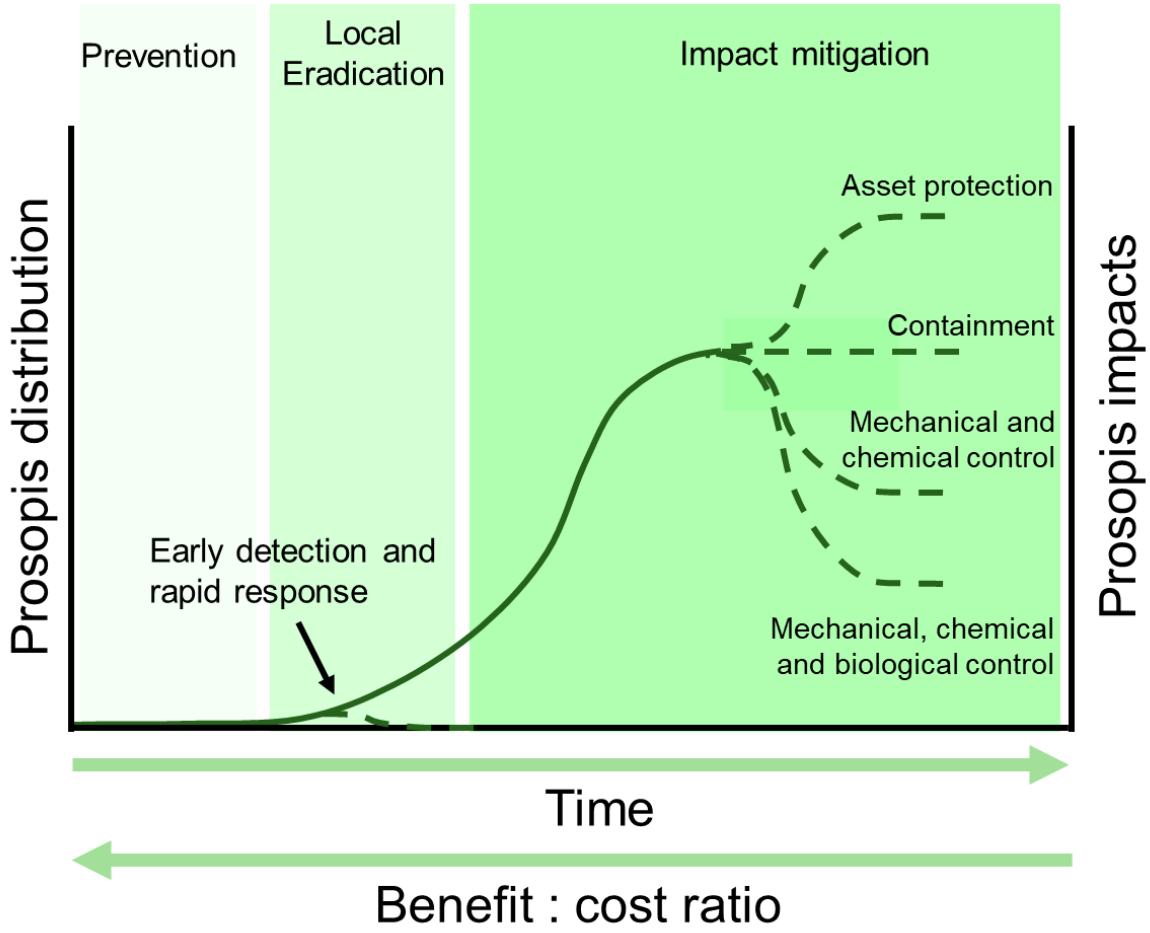

Figure 2. Standardized representation of the evolution of biological invasions, illustrating the stages of invasion by Prosopis at a landscape scale and appropriate management responses to each stage. The solid line indicates abundance of Prosopis and Prosopis impacts without management, whereas the effects of different management approaches are indicated by dashed lines. Abundance of Prosopis generally increases with time since the start of the invasion and the benefit-cost ratio decreases at the same time, indicating that prevention of establishment and early detection and rapid response (EDRR) are less costly than containment, asset protection and control of widely established species. Asset protection doesn't affect, containment stops the increase of and control reduces the size of the infested are and overall impacts of Prosopis, respectively.

Management of Prosopis can be achieved using a variety of measures and tools (see Section 4) and the selection of the most appropriate one depends on the local context. Hence, Prosopis management strategies and related management practices must be identified in a spatially explicit way, meaning that the management goal varies across the landscape, depending on the presence and abundance of Prosopis, the accessibility of the area and pathways of spread, or the presence of valuable assets (Fig. 3). Depending on these criteria, one of three main types of management objectives should be selected:

Prevention: to prevent Prosopis from arriving and establishing in areas where it is not yet present but might establish owing to the suitability of the habitat for its growth and the existence of pathways.

Early Detection and Rapid Response (EDRR): to remove Prosopis from areas where a few trees have established but its removal is still feasible because invasion is not too advanced.

Control: to reduce the density of Prosopis in the area and to contain it in its location by preventing further spread. Alternatively, the objective may be to protect important assets, such as irrigation schemes, access to water or places of worship, in areas where Prosopis is very abundant and cannot be removed.

Each of these management objectives can be achieved using practices that target the spread, establishment or survival of the seeds or plants. It is important to understand the biology and ecology of Prosopis to select the most appropriate practice.

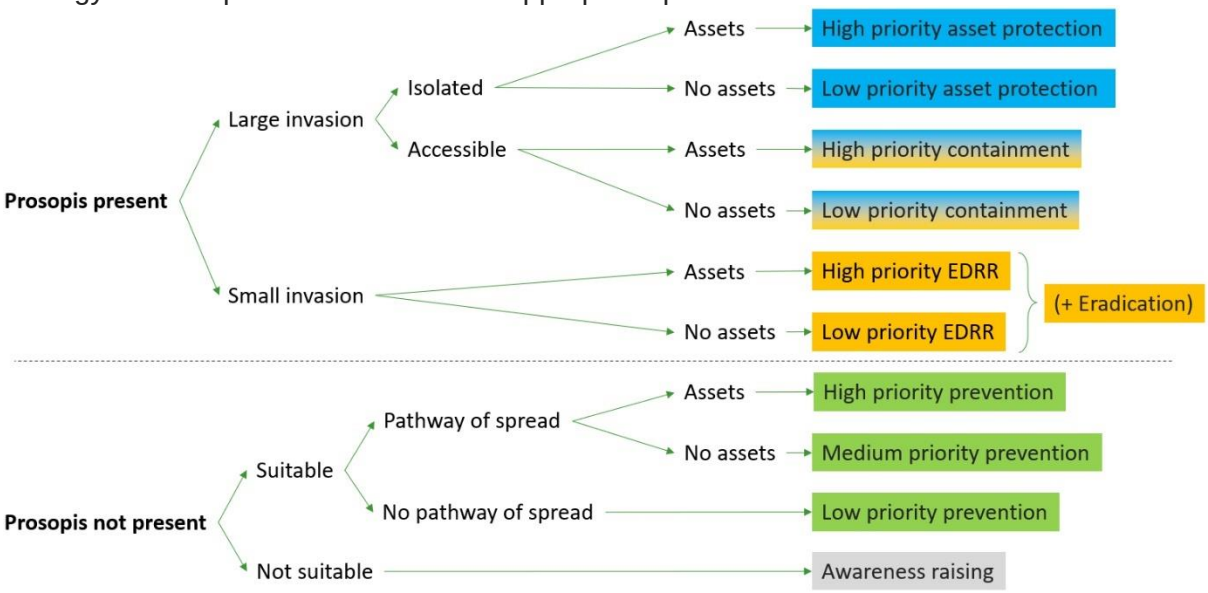

Figure 3. Decision support tool for selecting Prosopis management objectives for a defined area. The selection of appropriate management objectives depends on the presence and abundance of Prosopis in an area. Whether an area is suitable for Prosopis may change if the climate changes and large or small invasions are defined by the ability to remove Prosopis entirely from the area. Management objectives related to Prevention, Early Detection and Rapid Response (EDRR) and Control (including asset protection and containment) are indicated with green, orange and blue boxes. Multi-coloured boxes are situations with a combination of objectives.

3. Prosopis characteristics and impacts

General characteristics of Prosopis trees

Prosopis juliflora is a thorny tree or shrub that has leaves all year round (evergreen), with branches that bend down towards the twigs, often forming a drooping canopy (Fig. 4). By contrast, native Acacia (*Vachellia*) species have branches that are either horizontal or growing upward, allowing to see the stem where the branches are attached (Fig. 5). Prosopis trees usually have several stems and often grow together as dense bushes that can cover a large area. Prosopis reaches up to a height of 3 – 5 meters (old trees can be 10 – 15 meters tall) and is typically found in dry grassland or in Acacia savanna, but also in other habitats such as agricultural land, wetlands or settlements.

Figure 4. Typical appearance of Prosopis trees and shrubs. Branches often droop and the attachment to the stem is hidden.

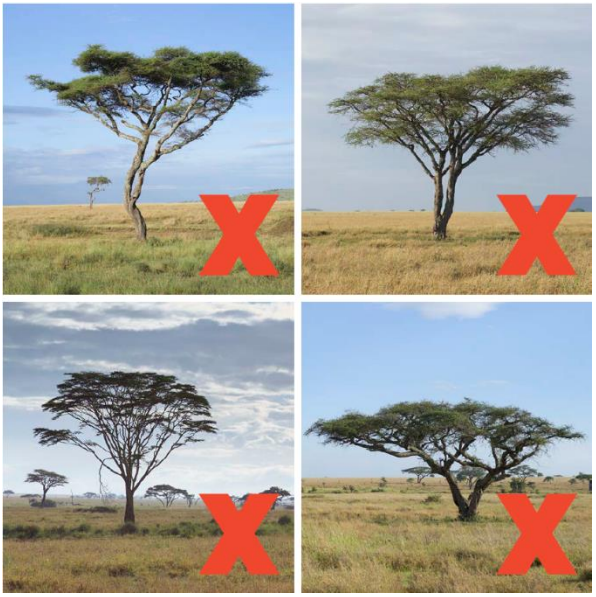

Figure 5. Many native tree species have branches that either grow horizontal or upward, which allows one to *see the stem where the branches are attached. With few exceptions, native Acacia (Vachellia) trees do not grow in thickets. The pictures above show trees that resemble Prosopis, but that are not Prosopis.*

Details of Prosopis trees

Prosopis can be identified up close when the following characteristics are seen (Fig. 6):

The leaves have many leaflets (often 10-15 pairs);

Twigs have a zig-zag shape;

Pairs of straight spines that are equal in size;

Pods are glossy and shinier than most native species

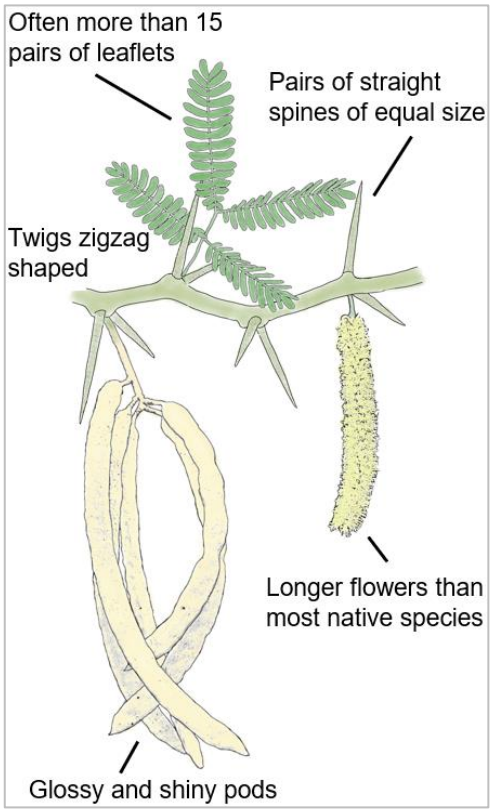

Figure 6. Characteristics of Prosopis that can be used to identify the tree or shrub when looking at it in detail.

Growth and spread of Prosopis

Prosopis can grow in very dry areas as a result of its deep tap root that allows it to access deep ground water. The dominant Prosopis species in Eastern Africa, *Prosopis juliflora*, is evergreen.

The trees coppice easily after aboveground parts are cut, for example for making charcoal, and the new shoots can flower and set seed within less than a year (Fig. 7).

Prosopis can be spread by humans, animals and water. Humans may sell seeds or plant young trees, which can lead to the establishment of Prosopis in areas where it didn't occur before.

Animals often eat pods, which contributes to the spreading of the species when seeds are defecated; this can lead to new infestations along pathways of animal movement (including along roads and livestock and wildlife migration routes) or re-infestation of land that has been cleared of Prosopis. Flooding, for example due to changes in water levels of lakes or heavy rain, can spread the seeds over a large area, resulting in new infestations.

Figure 7. If aboveground parts are cut, the trees coppice easily. Livestock and humans can spread Prosopis seeds.

Impacts of Prosopis

Prosopis increases the availability of wood and honey production, which benefits some people in the community. However, there are many negative impacts of Prosopis on the environment and rural livelihoods. The negative impacts become increasingly severe as the species spreads and grows denser (Fig. 8). Negative impacts include:

• Prosopis displaces native grasses, flowering plants and trees;

• Prosopis reduces availability and accessibility of grassland and fodder for livestock;

• Prosopis consumes a lot of water throughout the year because it is evergreen and has deep roots. It can consume up to 36 liters of water per stem per day, which strongly reduces the availability of water and lowers the groundwater table;

• Prosopis thickets block access to surface water and grazing land and offer hiding places for predators;

• The reduction of fodder and water lowers the number of cattle per household that the landscape can sustain;

• The loss of grazing land (particularly dry season grazing land) leads to conflicts among land users;

• The presence of Prosopis increases the cost of cultivating land for agriculture;

• Prosopis increases the density of malaria-transmitting mosquitos.

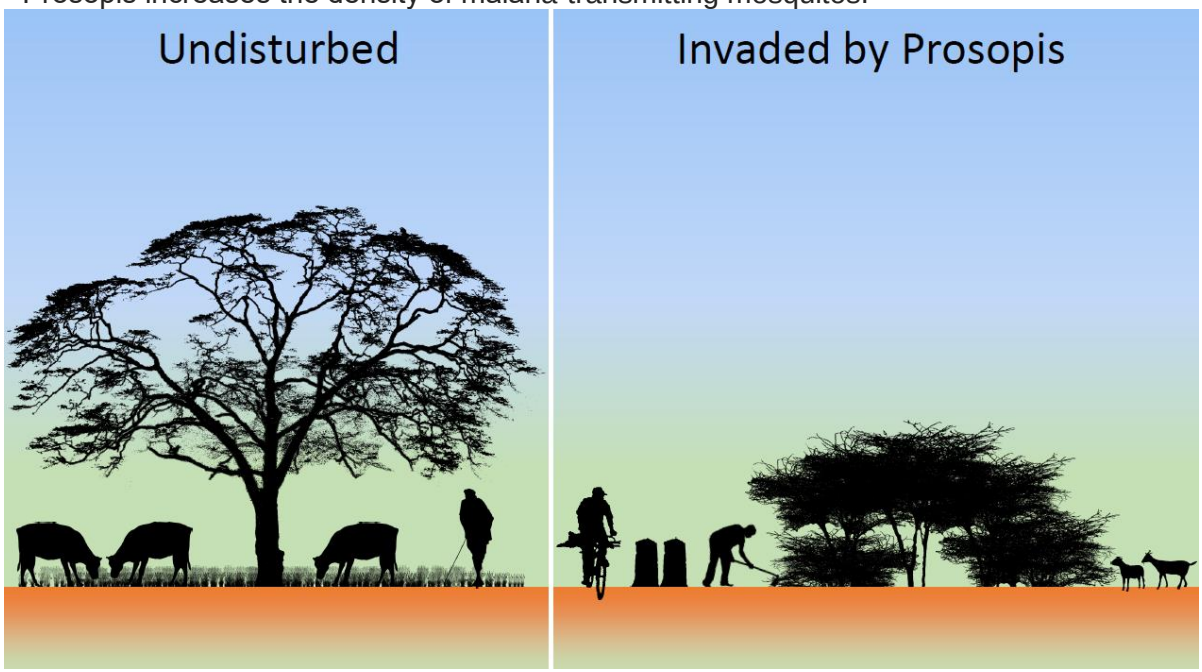

Figure 8. As a result of prosopis invasion people's major income source shifts from livestock and agriculture to wood products.

4. Prosopis management methods

Prosopis can be challenging to manage due to its prolific nature of reproduction and ability to adapt to various environmental conditions and the pathways that support its spread. Effective management methods for Prosopis include:

Manual and Mechanical Control

Prosopis can be managed by physical removal and hand-pulling of prosopis including the roots to prevent re-sprouting and coppicing. Manual uprooting is a labor-intensive practice to remove Prosopis but is very effective for new seedlings before seed set (Fig. 9). Therefore, it can only be performed for relatively small invasions unless a large number of laborers is available. For manual uprooting target seedlings and young plants that can easily be pulled out using a tree popper or puller. Using a tractor/ bulldozer can be effective in clearing larger areas within a short time but this is expensive and care should be taken to follow up with uprooting new sprouts. Larger trees can be controlled by cutting and removal at ground level and removing them from the site. It is important to ensure complete removal, including the roots, to prevent regrowth and coppicing. Any seedlings emerging following removal of prosopis should be removed immediately to avoid setting and if possible should be done just after rainy season when the soil/ground is moist.

Figure 9. Removal of Prosopis, especially of individual trees or small infestations, can be achieved by mechanical means. These include manual uprooting to remove roots to a depth of 30 cm, the use of a "tree popper" to pull small trees from the ground.

Control Using Fire

Burning is most effective as part of an integrated management plan for prosopis. Slow, concentrated fire and burning may be used to remove prosopis biomass, destroy emerging seedlings and kill viable seeds. Burning can lead to some 60-70% mortality of Prosopis trees although prosopis is quite fire-resistant and can survive if there is not enough grass underneath that fuels the fire. However, communities in Eastern Africa have developed methods that increase the impact of fire on Prosopis by Cutting stems at ground level exposing the rootstocks by removing the soil down to ca. 50 cm, fill the hole around the rootstock and cover rootstocks with dry branches or other flammable material and maintain a slow burn until the tree dies.

Chemical control

Herbicides are commonly used for controlling weeds in both agricultural and non-agricultural situations. Numerous forms of application techniques and equipment are available to apply herbicides. The options chosen should be determined by the size of the infestation, the available resources, access and personal preferences. Chemical control is a faster and less tedious practice and can therefore be used for larger invasions. There are two types of chemical control: Basal bark treatment, where an herbicide is applied to the base of each stem (from 0 to 75 cm above ground and around the entire circumference of the stem) with a brush or a knapsack sprayer and Cut-stump treatment, where stems are cut using a chainsaw and the stumps are painted with an herbicide immediately after the cutting (Fig. 10). The choice of herbicide should be based on local regulations and recommendations from agricultural or environmental authorities.

Figure 10. Cutting stems to immediately apply herbicide to the stump and herbicide application to the entire bark at the base of trees are effective, safe methods to kill Prosopis.

Biological control

Involves releasing natural enemies (mainly insects) that only attack the invasive Prosopis trees. Some insects feed on the seeds, which reduces its ability to spread. Other insects are tying the leaves together, which reduces the plant's photosynthesis, growth and seed production. Biological control is very efficient and does not require tedious labor. Biocontrol is a long-term approach and agents are only released after rigorous scientific trial and research to ensure that they will not damage native and other beneficial plants. Once the biological control agent has been approved for field release by the government, it will be released at different locations; the biological control agent will establish, multiply and damage the invasive Prosopis trees. For classical biocontrol, local stakeholders do not have to invest time or labor in biological control, because biological control agents can multiply and spread by themselves.

Restoration and rehabilitation

This is a very important follow-up measure after any control practice (Fig. 11). In the case of grassland, a well-designed grazing management plan, including rotational grazing, is required to prevent damage due to overgrazing. In those cases where the rangeland has been degraded for a long time, reseeding with native species may be needed. On cropland, Prosopis seedlings should be removed regularly and livestock should not be allowed in, except when coming out of a holding area as described above, to avoid introduction of new Prosopis seeds. Rangeland restoration should be based on a well designed management plan adopted by all stakeholders of the landscape.

Figure 11. Good grassland can be restored on land that was invaded by Prosopis, after the trees were killed using manual removal of cut stump herbicide treatment.

Integrated Weed Control

Integrated weed management combines the use of complementary weed control methods resulting in more effective, long term weed management outcomes. Integrated control requires planning, as often the timing of one control method can enhance the effect of another. An example of integrated weed management is the release of biological control agents to reduce vigor in a dense weed infestation coupled with use of herbicides to control satellite infestations of prosopis elsewhere on the land and management of a buffer zone around the dense infestation using physical/chemical control techniques as well as reducing of grazing pressure on the landscape to avoid further spread. Combining multiple control methods, such as mechanical removal, herbicide application, and biological control, can enhance the effectiveness of Prosopis management.

Surveillance and monitoring

Long-term monitoring and follow-up actions are necessary to prevent re-infestation and to address any new seedlings or regrowth. Surveillance and monitoring can be a regular, systematic checking of an area to spot new Prosopis seedlings or trees as quickly as possible and remove them as long as it is still easy to do so. People engaged in other activities, e.g., livestock herding, tourism, agriculture, or wildlife conservation, can be trained in finding and recording new occurrences of Prosopis. Ideally, surveillance is conducted by people who are living in or regularly travelling within the area. For that reason, awareness creation and capacity building among these people are key for surveillance to be successful. The following steps are needed to set up surveillance:

• Define the area to be constantly surveyed, e.g. dry season grazing land or community conservancy. Also consider surveillance of pathways of spread into the selected area (e.g. along roads, livestock routes, wildlife migration corridors, or rivers);

• Agree on who will survey (rangers, farmers, pastoralists and/or community members). Agree to whom any suspected cases of Prosopis establishment should be reported;

• Train people who will remove Prosopis in how to identify Prosopis and how to permanently remove seedlings and trees;

• Repeatedly visit sites where trees have been removed and timely remove newly emerging seedlings. The best period is when the soil is moist, because at least 30 cm of the roots must be removed to permanently remove a seedling.

5. The Prosopis Management Plan for the Lake Natron Basin

The Prosopis Management Plan

The Prosopis Management Plan is represented as a map of the area that indicates approximate occurrence of the species, as well as management objectives in the entire area (Fig. 12). Currently, Prosopis is present in part of the Lake Natron Basin, and its abundance in the area varies widely. As a consequence, management objectives vary in the area:

A large part of the area is thought to be free of Prosopis and the objective here is to prevent the species from arriving, in order to protect habitats and livelihoods from the negative impacts. Management actions may include awareness raising and banning of planting Prosopis trees, management of livestock movement to avoid spread of seeds, and surveillance of the entire area to detect any Prosopis trees as soon as possible in order to remove the and avoid establishment in a previously unaffected part of the Basin.

Other areas, especially west of Lake Natron and eastwards along the Kenyan border up to Namanga, have sparse Prosopis and it is still possible to remove all trees from this part of the area. The management objective in this area is Early Detection and Rapid Response, which involves scouting of the area to find all Prosopis trees and immediate removal of these trees. Removal should be done in a way that kills the trees, for example by uprooting (using a tree popper or panga) or targeted application of chemical herbicides. It is important to conduct surveillance of the area following removal of the trees and remove any Prosopis seedlings that emerge.

A few areas, in particular in Mto wa Mbu and east of Lake Natron (Wosiwosi), have such high abundances of Prosopis that it is unlikely that the tree can be completely removed from the area. Here, the species must be controlled. It is important that control includes 1) containment of the species to these areas with high abundance to prevent spread and impacts to surrounding areas, and 2) protection of assets, by local removal of trees. The latter may include ensuring access watering points, or removal of Prosopis trees from important locations such as compounds with community buildings or places of worship. An important aspect of containment includes limiting livestock access to infested areas and removal of Prosopis seedlings that grow on the edge of the area. Removal of Prosopis as part of asset protection may use similar practices as described in the previous paragraph.

Awareness raising about the impacts and spread of Prosopis should be carried out in the entire Lake Natron Basin, to inform the population about the negative impact of the species and the need to manage it before it becomes widespread. Prosopis management methods should be explained and demonstrated and alternative, non-invasive tree species promoted.

A computer-based habitat suitability model, based on occurrence of Prosopis in East Africa and the climate and elevation of the locations where the species has been recorded, indicates that a few areas in the Lake Natron Basin are unsuitable for growth of Prosopis. These are mainly a few mountains east and south-east of Lake Natron and areas of higher elevation to the west of the Basin. No management objectives have been defined for these parts of the Basin, but it is recommended that awareness raising about Prosopis be carried out there too, as these areas may become suitable in the future and people living in the area may also spread or manage Prosopis.

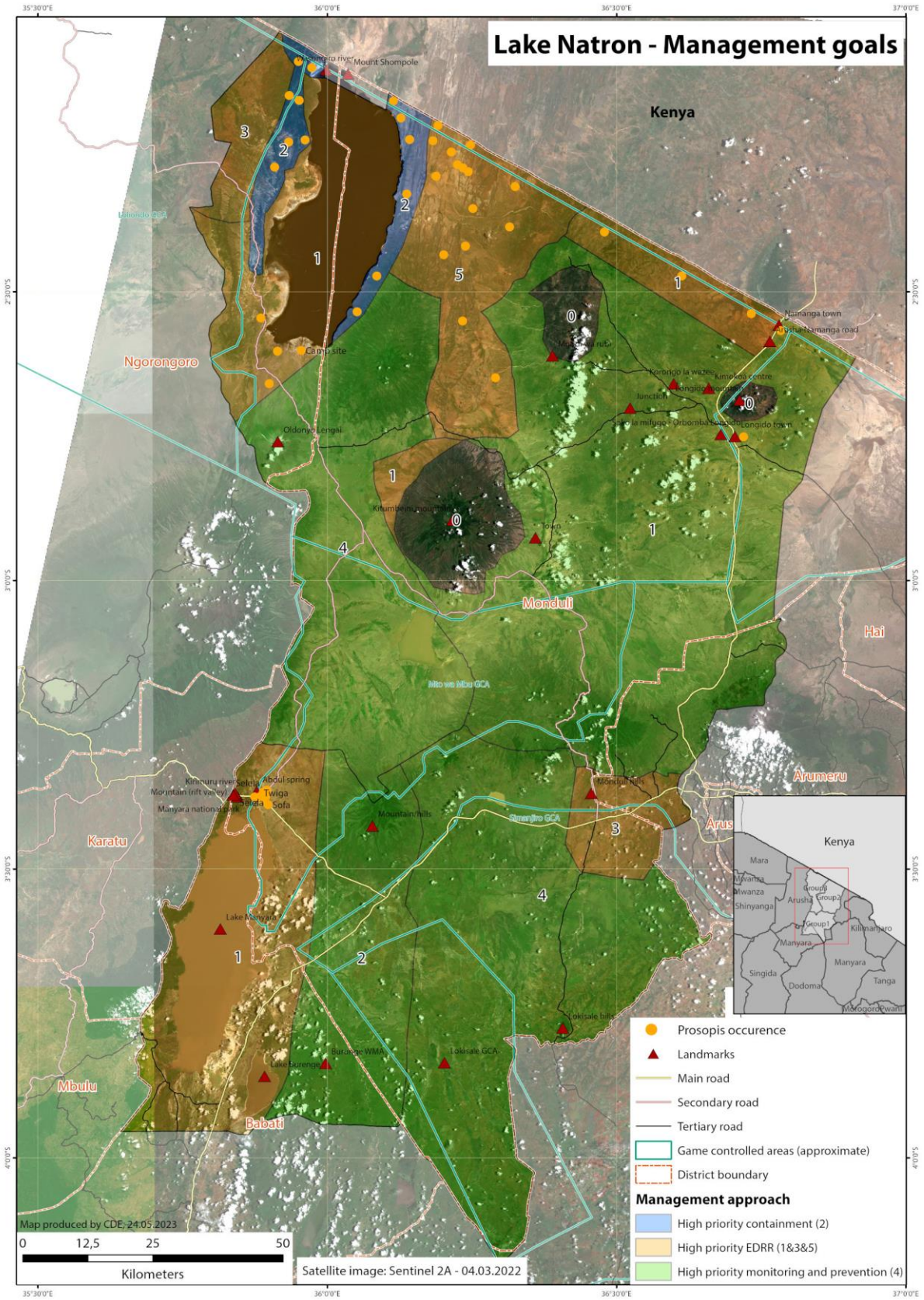

Figure 12. The prosopis Management Plan for the Lake Natron Basin.

How the Plan was developed

The PMP was developed in a participatory manner by stakeholders from the Lake Natron Basin, who were accompanied in this process by Tanzanian and international experts in communal land use planning and invasive plant species management. The development process involved two multi-day workshops and a consultation process, which ensured that the views of a wide range of stakeholders on the local and District level were taken into account.

The project invited community members from the three Districts that comprise the project area, Longido, Ngorongoro and Monduli Districts, to participate in the workshops and who constituted a Local Implementation Group (LIG; see Section 7 for a list of LIG members). Members of the LIG were selected from the three Districts based on their role in managing IAS or protected areas and their ability to influence and mainstream IAS management across landscapes, as well as their knowledge of the area. The project strived to include women as much as possible since women play an active role in all activities. Local community members involved in the LIG process represented a diverse selection of stakeholders, including women, pastoralists, local and district administrations, as well as managers of protected areas and representatives of relevant local and international NGOs.

The members of the LIG co-developed the PMP based on their knowledge of the area, the regulations and resources, which was complemented by with knowledge provided by the experts about biological invasion processes and management strategies, as well as *Prosopis juliflora* ecology and management practices. Moreover, the members agreed on Terms of Reference (Appendix 1).

During the first workshop, LIG members were given background information about biological invasion processes and management strategies, as well as the ecology of Prosopis and effective management practices. Participants familiarized themselves with prepared maps (small groups of participants worked on one of four maps of a part of the project area) that indicated suitability of the area for Prosopis occurrence and a few landmarks (roads, approximate boundaries of protected areas, villages and rivers, for example) on top of a satellite image. Important missing landmarks were added to the maps and later digitized.

As part of the workshop, LIG members were taken to Kahe in Moshi Rural District to see *Prosopis juliflora* and to see its impact on communities in agricultural land and livestock grazing areas before embarking into maps preparation (Fig. 13). The field visit left participants, particularly livestock keepers, very impressed and the experience motivated them to take swift action.

Figure 13. LIG members during the field visit to Kahe observing invasion of Prosopis juliflora and hearing about impacts.

After the field visit workshop participants mapped areas invaded with prosopis in the Lake Natron Basin, and identified different invasion stages (i.e. Prosopis abundance) in different areas, including Wosiwosi, Charikisakina, Male A and B, Kweya, Magadini and Ngaresero. Thus, LIG members used their indigenous knowledge to indicate areas affected with Prosopis, assets and landmarks found in their areas, and this contributed significantly to the

Using their knowledge of the area, and the knowledge about Prosopis and invasive species management strategies, participants then identified Prosopis management units for the entire area that is suitable for the trees to grow, and allocated the most appropriate management goal for each unit using a decision support scheme (Fig. 14). Maps were reviewed by the entire LIG to ensure that there was agreement about the management goals, and to resolve any discrepancies in management goals in parts of the area that are adjacent but on maps of different groups in the workshop, thus contributing to a sense of ownership of the map and workshop outputs.

Figure 14: Impressions of the groups working with the maps, adding assets to the maps (left) and defining management zones and their respective management objectives (right).

Thus, the outcome of the first workshop was a map that constituted a draft Prosopis Management Plan for the Lake Natron Basin. The maps developed during the workshop were digitized using a Geographic information system (GIS) and printed.

Before the presenting the draft PMP to community members and before embarking down into community village lands, the project team introduced the project to the District Commissioner, District Executive Directors, respective District Heads of Department and Councilors to inform them about the planned project activities in the project area.

Together with the project team, selected LIG members took these plans to their communities for validation prior to the next LIG workshop. These community consultation meetings were conducted in May 2023 to inform a wider range of stakeholders than those involved in the LIG, and get feedback to community members, especially the Environment Committees. Specific feedback was sought regarding the mapped Prosopis occurrences and the draft Prosopis Management Plan. In this way, the LIG got a wide range of suggestions from community members who did not have the opportunity to attend the LIG workshop. Thus, the main purpose of Consultation meeting was:

a. to inform participants about Prosopis and the purpose of the PMP, about the workshop that led to the draft PMP, the formulation of LIG and the agreed resolution to recommend adoption and implementation of the PMP that was prepared during the workshop;
b. to present and explain the draft PMP and map additional assets, management objectives if requested by the community.

During the consultation meeting, the community critically reviewed the draft PMP and brought suggestions for improvement that were collected. Community opinions were incorporated into the second version of the PMP that is presented in the current document.

In the second workshop if the LIG, the maps were validated by the same people who attended the first workshop, but a few new participants were invited to validate and integrate other important issues that might have been forgotten. Inconsistencies at the boundaries between group maps were discussed and resolved.

During two sessions with group work, again using four maps that represent different parts of the project area and that together cover the entire Lake Natron Basin, LIG members:

a. added Prosopis occurrence in areas where this information was not shown on the maps;
b. refined, based on Prosopis occurrence and abundance in an area, management objectives.

A second group exercise focused on small, but more detailed parts of the four maps, for which the previous points were repeated and then the groups decided on suggestions for Prosopis management practices to achieve the management objective assigned to different parts of the area. The group discussed responsibilities for implementing and coordinating activities on the ground, as well as an indicative budget. This resulted in examples of specific priorities and suggestions for implementation of the PMP (Appendix 2).

6. Recommendations

6.1. Adoption and implementation of the Prosopis Management Plan

LIG members made suggestions for Prosopis management practices/interventions for a select number of priority areas. Selection of the areas was based on knowledge about Prosopis occurrence and preference of the participants. The selection of practices was informed by examples of sustainable land management practices prepared by the project team. Examples covered all management objectives (prevention, EDRR and control) and were largely based on management tools or approaches that are known to be effective against Prosopis (science based). However, the team made it clear that they didn't endorse any practice and that LIG members could modify the practices to meet local conditions and resource availability.

The suggested management interventions were presented as a logical framework ("log frame") for the period 2023-2028, and included location, objective, activities, performance indicators, required resources and budget, as well as the responsible stakeholders. The logical framework is presented below (see Appendix 2).

The LIG jointly reviewed the suggestions and recommends that Regional and District authorities adopt and implement these measures, which will significantly contribute to management of Prosopis in the Lake Natron Basin.

6.2. Monitoring and Evaluation

Biological invasions by species like *Prosopis juliflora* are dynamic and management will require significant investment. This may influence the spread and/or abundance of the species in an area with any management objective. It is therefore imperative that regular review of the management efforts and success are undertaken. We recommend that review takes place at least once a year, in order to assess success and possible needs to change resource allocation. Such review should also inform budgetary processes.

If management is unsuccessful, the objective or the management interventions may need to be reconsidered. Perhaps it has been impossible to prevent arrival and establishment of a few trees in an area. In that case preventative measures may still have value, but the overall objective for the area would become EDRR, with hope to eradicate the few trees that have become established.

It is also possible that where management is successful this leads to a change in management objective for an area. This is most obvious if EDRR is successful: removal of all Prosopis from the area is effectively local eradication, and once this has been achieved the new management objective would be prevention. The new objective requires different management practices.

Finally, it is possible that management has been (un-)successful in part of the area under that management. In that case it is possible to decide to split the area and apply different Prosopis management objectives or interventions to the different parts. For example, EDRR may have been successful in the fringe of the designated area, but unsuccessful in the center. In that case, the objective for the fringe could become prevention. In the center EDRR may continue to be the objective, or if this is deemed unlikely to become a success, the objective may become to contain the species in that area.

7. Members of the Local Implementation Group

Local Implementation Group for the Lake Natron Basin

District Executive Director Ngorongoro (Wildlife Officer) : Joseph Meng'oru
District Executive Director Longido (Agricultural Officer) : Mr Ukwai E. Godwin
District Executive Director Monduli (Livestock Officer): Mr Yandu Marmo
Division Secretary, Mtowambu town (Monduli district) : Havijawa Salum
Village Chairman, Pinyinyi Village (Ngorongoro district): Joshua L. Laizer
Village Chair, Gelai Lumbwa Village (Longido district): Richard Nduyai
Village Chairman, Gelai Bomba Village (Longido district): Emmanuel Oloulu
Village chair Engaresero villlage (Ngorongoro District) : Yohane M. Laizer
Division Secretary - from Sale (Ngorongoro District) : Felix Elibahati
Village Chair - from Oldonyo lengai Village (Monduli district) : Mathew Ole Misiko
District Executive Director Karatu (Forest Officer): Reginald N. Hallu
Ecologists from Ngorongoro Conservation Area: Dismas Macha
Representative of livestock keepers : Ms Flora Lerisio
One dominant Faith Based Organisation (Padre or Pastor): Daniel O. Siangau
Representative of women's groups : Ms Doris Ngaboli
Water Resources Users Association Representative: Tilito Karino
Tourism representative: Lepara Nandatwa
Representative conservation NGO: Neovitus Sianga
Representative of community on Kenyan side of Lake Natron: Dennis Kuyal
Lake Natron Ecosystem - Divisional Secretary: Lee Mamsita

Project team

TAFORI: John Richard and Dickson Xavery
TAWA: Samson Samson and Ndimilanga (Lake Natron)
CORDS: Ms Lilian Joseph and Ms. Doris Itaely
TNRF: Zakaria Faustin and Alphonce Zenus
CDE (CH): Albrecht Ehrensperger
CABI (KE): Ms Winnie Nunda
CABI (CH): René Eschen and Urs Schaffner
MSc Student (Mapping): Filbert Meela
MSc Student (Socio economic): Enock Mbungu

Appendix 1: Terms of Reference of the Local Implementation Group

MAMBO MHIMU YA KUTEKELEZWA NA KIKUNDI CHA UTEKELEZAJI CHA JAMII (LOCAL IMPLEMENTATION GROUP (LIG))

Utangulizi

Uanzishaji wa Kikundi cha Utekelezaji cha Jamii kinacho saidia mfumo wa utekelezaji wa Mpango Mkakati wa kitaifa wa Mimea vamizi (NISSAP) ili kukuza mawasiliano na ushirikiano wa viwango tofauti.

Utekelezaji unaobadilika kulingana na Mahitaji ya Mpango Mkakati wa kitaifa wa Mimea vamizi (NISSAP) hivyo, kikundi kitapaswa kuwa mikutano ya kila mwaka ya kukagua maendeleo yanayohusiana na mkakati wa utekelezaji ulio wazi , ikiwa ni lazima, kurekebisha malengo ya usimamizi na uchaguzi wa mazoea ya usimamizi.

HADIDU ZA REJEA

1. Shiriki kikamilifu katika warsha mbili ambapo mpango na mwongozo wa usimamizi wa Mrasha (prosopis) wa Utekelezaji itatayarishwa.
2. Shiriki katika shughuli wakati na baada ya warsha ili kujadili na kutekeleza mpango wa usimamizi wa Mrasha *(*prosopis*)* na mimea mingine katika ngazi ya Wilaya,kata na kijiji.
3. Shiriki katika kuongeza ufahamu na kujenga uwezo kupitia katika matukio,mikutano na vikao mbalimbali.
4. Kutetea/Hamasisha na unga mkono uratibu wa usimamizi wa Mrasha kati ya wadau ndani ya Wilaya za bonde la ziwa Natron na na wanaopakana.
5. Shirikiana na wadau katika ngazi ya Jamii ili kuratibu udhibiti wa Mrasha mahali ulipo
6. Kukutana mara kwa mara angalau mara moja kwa mwaka ili kujadili maendeleo ya utekelezaji wa mpango wa udhibiti wa Mrasha pamoja na mimea vamizi mingine.
7. Kuanda na kuwasilisha taarifa yenye mapendekezo kwa wadau na kwa ofisi ya Makamu wa Rais (VPO) kitengo cha mazingira kuhusu fursa na changamoto zinazojitokeza
8. Dumisha ufuatiliaji wa mara kwa mara na endelevu kwa maeneo mapya yaliyovamiwa kwa hatua za haraka
9. Kupitia angalau kila baada ya miaka miwili mpango wa usimamizi wa Mrasha na Mwongozo wa Utekelezaji.
10. Baada ya kuidhinishwa na kupitishwa kwa mapendekezo hapo juu na kikundi/kamati ya utekelezaji,anzisha na ratibu mapitio ya mpango kazi wa udhibiti wa Mrasha na mimea mingine ya kipaumbele.
11. Shiriki katika mfumo wa mawasiliano ulioanzishwa ili kuweza kutoa na kupokea taarifa za udhibiti wa Mrasha.

Appendix 2: Logical Framework

Invasive Plant Management to Protect Tanzanian Biodiversity and Livelihoods: The Case of Lake Natron Basin 2023 - 2028

	Specific area	Objective	Activity	Indicators	Resources	Responsible	Estimated cost (TZS)	Period (Yrs)
1	**GILAI-WOSIWOSI**							
1a	**GILAI LUMBWA** Engong' Altaani, Alaililai Engirirati Lumbwa	To protect	• To uproot • Treatments • Time to time monitoring • Communication with stakeholders • Tree planting	• Number of trees uprooted • Number of trees under control • Number of planted trees	• Machete • Awareness/trainings • Labour power • Tree poppers • Hand hoes • Pick Axe	• Community • Village and District Councils • Traditional leaders • Livestock and grazing committee • Hunting blocks investors • Development partners • Religious leaders • Investors	331,250,000	5
			• Formulate and train environmental committees	• Number of committees formulate • Number and types of trainings conducted				
1b	**WOSIWOS**I Loorbilini, Loormeuti, Kasino, Loodua, Ilnchang'it-	To control;	• Uprooting • Treatments • Time to time monitoring • Communication with stakeholders	• Number of trees uprooted • Number of trees under control	• Chain saw • Machete • Tree poppers • Hand hoes • Pick Axes	• Community • Village and District Councils • Traditional leaders	348,750,000	5

	Sapukin, Idepen					• Livestock and grazing committees • Neighbouring country, Kenya		
	Ingukyon, Kipangaine	To uproot	• Uprooting • Treatment • Burning • Communication with stakeholders	• Number of trees uprooted • Number of trees under control	• Chainsaw • Machete • Tree poppers • Hand hoes • Pick axes	• Local community • Village and District Councils • Traditional leaders • Development partners	362,250,000	5
2	**PINYINYI**							
2a	Lorbilin, Masusu, Nadung'oro	To prevent	• Uprooting • Tree cutting • Treatments Assessment of affected areas • Planning for rotational and differed grazing • Control livestock movements from other areas	• Number of trees uprooted • Number of trees under control	• Machete • Community awareness/trainings • Labour power • Tree poppers • Hand hoes • Pick axes • Biological control (insects) • Chain saw • Tree burning • Map of the affected area • GPS • Communication with stakeholders	• Local community • Village councils • CBOs • Herders • Labour power (Morani-youth)	114,375,000	5
2b	Lositeti/Ijurleni, Oloserian, Embasi, Intinyika	Control (EDDR)	• Site visits • Uprooting • Tree cutting	• Number of trees uprooted • Number of trees under control			381,250,000	5

3	**ENGARESERO**							
	Naiborgoso, Moniki, Engaresero	Control (EDDR)	• Site visits • Uprooting	• Number of trees uprooted • Number of trees under control	• Machete • Axes • Hand hoes • Pick axes • Community awareness/trainings • GPS • Communication with stakeholders	• Local community • CBOs • Morani (youth) • Village governments	25,000,000	5
4	**MTO-WA -MBU**							
4a	Migungani, Selela, Esilalei, Engaruka,	Prevention	• Uprooting • Tree cutting for fuelwood • Planting of alternative trees • Community and village councils' awareness and trainings	• Number of trees uprooted • Number of trees under control	• Chain saws • Machete • Saws • Drones • Community awareness through publications	• Local community • CSOs • Village governments • Public institutions (TANAPA, JKT, TTB, TPW, Schools)	1,000,000,000	5
4b	Baraka, Munjere, Selela, Losirwa	Control (EDDR)	• Uprooting young trees • Frequent visits • Community awareness/trainings	• Number of trees uprooted • Number of trees under control	• Drones • Communications • Publications • Hand hoes for uprooting	• Local community • Village and ward governments	404,200,000	5
	GRAND TOTAL						**2,967,575,000**	