Project Update: February 2021

This first phase of the project, conducted between November 2020 and January 2021, organised a successful inception workshop involving most stakeholders. It also sought to map *Millettia vatkei* P.K. Lôc, *Euphorbia friesiorum* (Hassl.) S. Carter, *Thunbergia napperae* Mwachala, Malombe & Vollesen, and *Pavetta teitana* K. Schum. Finally, it documented the estimates of their population sizes and threat information within Ngutwa-Nzaui landscape, Makueni County-Kenya.

OUTPUTS

(i) Organization of an Inception Workshop

Figure 1: (a) a group photo of representatives of various groups, (b, c) stakeholders listening during a teaching session, (d) members of the community taking some notes.

The Inception workshop was used to officially launch the project in the Ngutwa-Nzaui location. In adherence to COVID-19 guidelines, the appropriate number of community representatives, county extension officers as well as representatives of the county administration were invited to the workshop. The threatened species in question were presented to the communities as living collections and as sample specimens from the natural vegetation. Besides, their importance and narrow range were explained to the communities. The community was taught on nursery establishment, the importance of seed and tree conservation, and record keeping. It raised awareness among the key stakeholders and identified areas of possible engagement. A clear guideline across all the stakeholders regarding how the project will be implemented was attained and communicated.

(ii) Mapping and the Estimation of the Population Sizes for the Threatened Species

Throughout the study locality, we identified fifteen (15) populations of *Millettia vatkei* with an estimated population size of nine hundred (900) individuals. Twelve (12) populations of *Euphorbia friesiorum,* were mapped with about six hundred (600) mature individuals. *Pavetta teitana* recorded the highest population size of more than 2000 individuals spread across 19 populations within the study locality. Of the four (4) threatened plant species, *Thunbergia napperae,* was the rarest with the least population size. Seven (7) populations of this rare species yielded less than four hundred (<400), mature individuals. The species representation by their population sizes is as in the figure 2 below. All the four species were either in flowering or fruiting phenology.

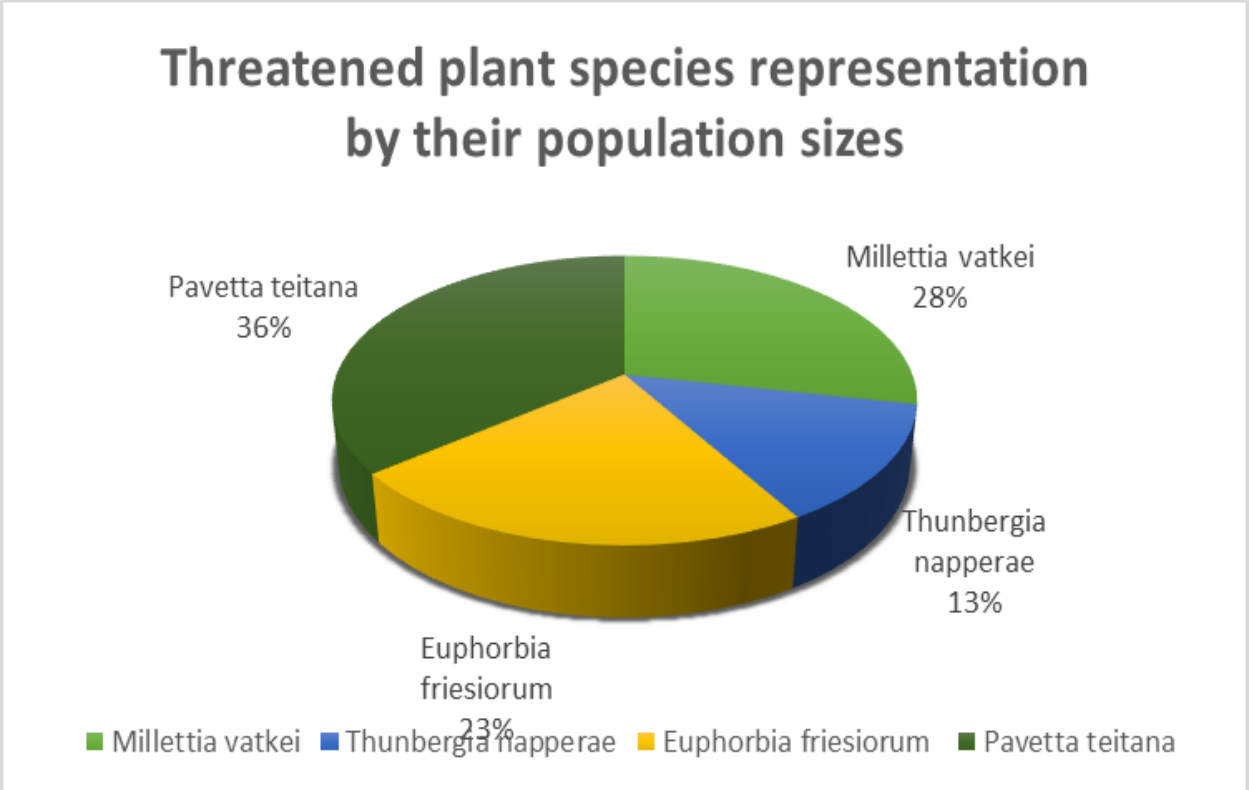

Figure 2: Threatened plant species representation by their population sizes

(iii) Documentation of Threat Information within the Study Locality

Throughout the fieldwork, we quantified the extent to which various anthropogenic activities are threatening the survival of the flora of the region. A coarse-scale examination identified habitat loss/ destruction and/ or degradation and the introduction of non-native (alien) and invasive plant species as the major threats to the endangered plants. Fine-scale analysis of habitat loss, destruction, or degradation identified the following indicators of disturbance, agriculture, soil erosion, herbivory, overexploitation, infrastructure development, and fires.

1. Habitat loss

In Ngutwa-Nzaui, the destruction of natural habitat through degradation or fragmentation is posing the greatest threat to the survival of the *Millettia vatkei, Pavetta teitana*, *Thunbergia napperae*, and *Euphorbia friesiorum*. In this landscape, human activities are actively altering the natural vegetation every single day lowering the area of occupancy of these endangered species. The following indicators of disturbance were recorded in the first phase of the project: -

(a) Herbivory

Overgrazing/browsing by animals is contributing to the decline of the above-mentioned threatened plant species throughout the study locality. For example, *Millettia vatkei*, which remains green all year round, forms a good fodder for domesticated and wild animals. When fodder is inadequate during the dry season, locals graze their animals on *Millettia vatkei* species (see figure 3a and b). Because of the unavailability of other green fodder during the dry period, the animals consume the leaves, the pods, and at times the barks.

Similarly, indigenous knowledge and personal observations have it that *Millettia vatkei* forms a suitable nesting site and fodder for rock hyraces because of its dense-matted characteristics. Rock hyraces are gregarious diurnal herbivores that live in rock crevices. Because of the limited studies on the relationship between *Millettia vatkei* and rock hyraces in the study locality, their preference for *Millettia vatkei* largely remains anecdotal. Although they are very secretive and shy of human presence, we validated the local's knowledge of their feeding behavior by making inferences.

We tried to explain rock hyraces' preference for Millettia vatkei in several ways; - Both Millettia vatkei and rock hyraces prefer rock outcrops as their habitat. Because of the heat stress prevalent in drylands, the humidity retained in the rock crevices helps the hyraces survive in such hot and dry areas. Because of their thermoregulatory and the denning requirements, rock hyraces usually forage less than 50m from their dens. Since Millettia vatkei establishes itself on rocky habitats, it forms the convenient food for these animals. During the dry season, most forbs, grasses, and herbs die in the study area, and thus the hyraces solely rely on the evergreen Millettia vatkei. Similarly, grazing of the domesticated animals is shifted to the Millettia vatkei exerting more pressure than during wet seasons. These herbivores prefer young leaves, new shoots, and buds to more woody portions of the plant. In times of acute shortage, they are forced to consume coarser parts such as pods and debark the stems during dry seasons when palatable food is inadequate. This feeding of pods by animals prevents the establishment of new seedlings.

Figure 3: Overgrazing within the study area for (a) shows heavily grazed *Millettia vatkei*, (b) a cow as an indicator of grazing within the study area (c) and (d) show bitten-off and a surviving *Thunbergia napperae* species respectively in an overgrazed area, (e) *Pavetta teitana* species in a grazing area within the study locality.

Foraging among the rock hyraces is mainly in groups ranging from 10-50 individuals. This strategy offers several advantages such as vigilance and dilution effect. They feed much over a short time in the morning after sunrise, late in the evening before sunset, and at times on moonlit nights. *Millettia vatkei* offers a safe foraging site because of its sub-vertical stems that make climbing easy for them. The degradation of their habitat quality through the removal of *Millettia vatkei* is the main threat facing these rock hyraces within the study locality. Therefore, this means that the dwindling *Millettia vatkei* populations will lead to further destruction due to perhaps constant or increasing hyrax populations. It is

also worth noting that hyrax's preference for *Millettia vatkei* forms an interesting feature that can be a source of motivation for further study.

Thunbergia napperae, which was found to occur on open areas within the study area faced a great threat from grazing as we noted some of the *Thunbergia napperae* individuals nipped-off by livestock (refer figure 3c above). *Pavetta teitana* species were found to experience the same threat within the same locality.

(b) Agriculture

Agriculture is the main economic activity among the locals of the Ngutwa-Nzaui region. As the human population continues increasing, the locals clear the forested areas to create more land for cultivation (see figure 4). With the continued increase in the human population, the locals are currently encroaching forests in higher elevations that were previously avoided. In the study area, more *Millettia vatkei* species occurred on those sites and are thus facing the same fate of encroachment.

Fig 4: A cleared forest in Ngutwa-Nzaui area to pave way for finger millet (*Eleusine coracana* L.)

Due to the ruggedness and maybe a relatively higher altitude, the above area served as a habitat for *Milletia vatkei* for a long time. Unfortunately, the increasing demand to create more room for agriculture has seen it destroyed. We found a few and disturbed individuals of *Millettia vatkei* in the cleared area and others on the edges of the farm. Still, we could identify planted on the cleared forest small seedlings of *Eucalyptus* species.

Habitat for the threatened species within Ngutwa-Nzaui landscape is also being lost through fragmentation as the locals are establishing fruit orchards (see figure 5). What was once continuous natural vegetation is now being sub-divided by agricultural activities within the study locality. People's farmlands are now being punctuated by tiny forest patches that are serving as the remaining habitats for the mentioned endangered plant species.

Figure 5: Fragmentation of a forested land in Ngutwa-Nzaui due to farming

Because of the continued land fragmentation, some individuals of the threatened species were found within abandoned farmlands and/or edges of forest fragments. For example, figure 6 below shows a surviving *Euphorbia friesiorum* species on an edge of a mango orchard.

Additionally, some locals informed us that they usually collect humus under the *Millettia vatkei* species to use for their agricultural purposes. As *Millettia vatkei* leaves fall from the plant, they form thick layers (see figure 7e) that the locals collect for mulching purposes. Similarly, they collect the decayed leaves as manure for their crops. They locals also use hyrax manure for their agricultural activities. Rock hyraces usually urinate and defecate at a single point that become big due to their continued use. Particularly, during field explorations, we identified three 5m-midden (latrine) which the locals use as their source of manure (refer figure 7d below). Because of the close association of the hyraces and the *Millettia vatkei* species on rocky outcrops, they collect manure in such *Millettia vatkei* -shaded dens (see figure 7b). As the locals collect manure, they clear the dense-matted *Millettia vatkei* to ensure ease of reach. Figure 7a shows a *Millettia vatkei* branch that possibly survived such a disturbance. Together with the foraging by the hyraces, this interference may be contributing to the decreasing trends of the *Millettia vatkei* population in the study area.

Figure 6: Euphorbia friesiorum species growing on abandoned farmland adjacent a mango orchard in the study area.

Figure 7: (a) shows a surviving *Millettia vatkei* branch in a midden (b) a *Millettia vatkei*-shaded rock crevice, (c) *Millettia vatkei* growing between two rocks inhabited by hyraces, (d) a hyrax midden, (e) Fallen *Millettia vatkei* leaves used as mulch by the locals.

(c) Soil Erosion

The Ngutwa-Nzaui landscape is situated in a dryland ecosystem, characterized by high temperatures and low rainfall. These conditions favor the establishment of glades with loose particles which make the soil susceptible to wind and water erosion (see figure 8a). We identified the occurrence of *Thunbergia napperae* species along rills in unsheltered areas (refer figure 8b). Besides, their occurrence on open spaces exposed them further to disturbance through grazing. Effects of grazing on soil erosion was evidenced within the study area by cattle tracks (see figure 8c). When it rains, the erosive power of water exposes the plant's roots (see figure 8d) or even wash the whole plant away. Continued soil erosion carries away humus on topsoil thus making it poor for luxuriant growth of plant species.

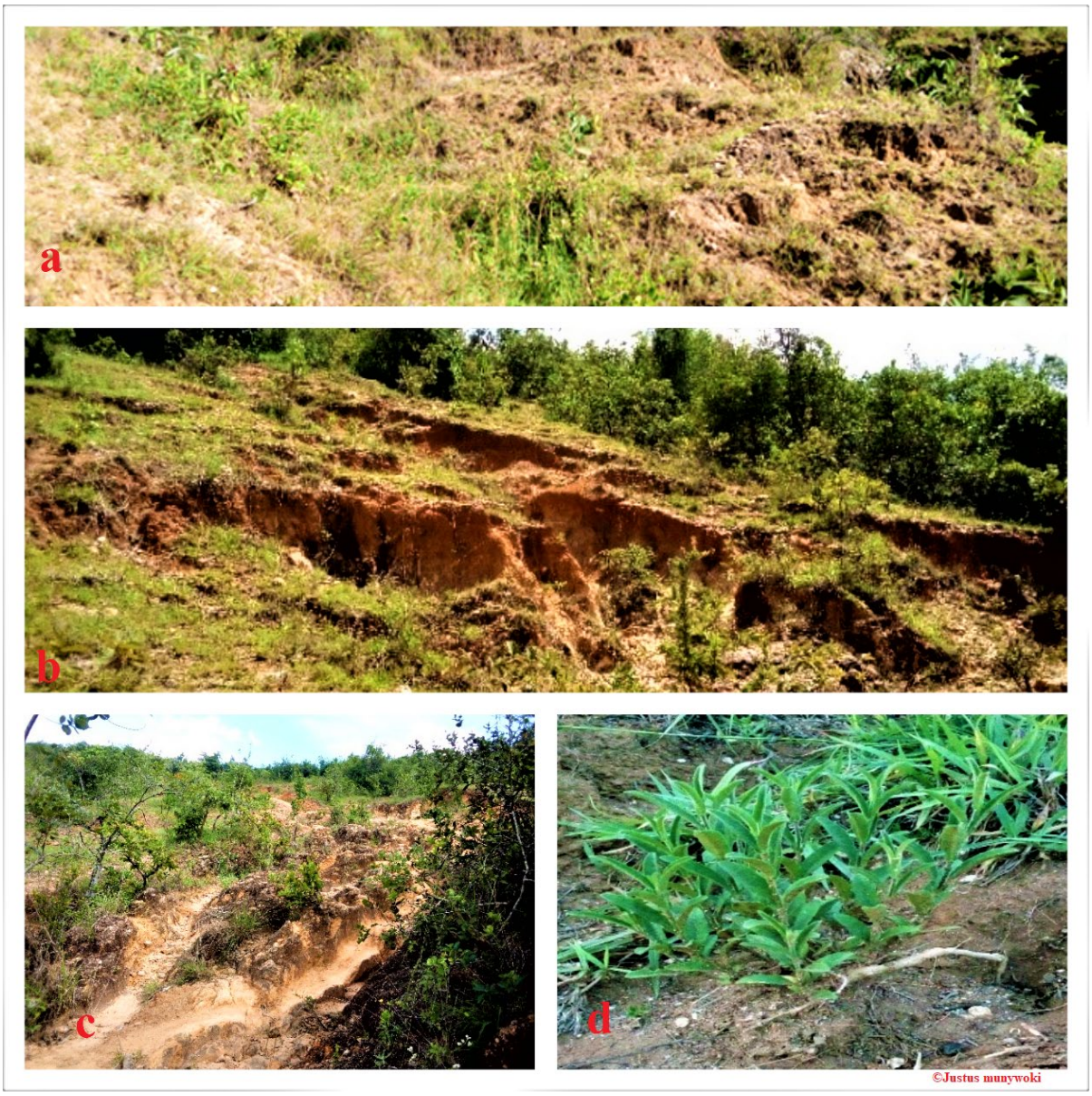

Figure 8: (a) and (b) show eroded landscapes in Ngutwa Nzaui area, (c) cattle track and (d) exposed roots of *Thunbergia napperae* species within the study area.

We also identified the occurrence of *Millettia vatkei* along streams and rivers where erosion is common in case of a downpour. For example, four populations of the said species were observed to occur along streams with some individuals partially buried in the eroded soil.

(d) Infrastructure Development

With the devolved system of governance in the country, Makueni county has witnessed various projects, including road construction and maintenance, water development, and erection of housing structures, among others (see figure 9). These new developments have come with adverse effects on the flora of the area. For example, during field assessment, we encountered young *Thunbergia napperae* individuals growing in piled concrete sand in one of the local's homesteads (refer to figure 9a). This means that the individuals were entirely buried by the sand and regenerated after the sand was used up during the construction. This form of disturbance greatly affected the *Thunbergia napperae* individuals as we noted only five individuals, of which three were growing in the sand as mentioned above. Still, in another locality, we encountered a young *Euphorbia friesiorum* individual growing next to an abandoned house (figure 9b).

Similarly, in a recently erected house, we encountered a mature *Euphorbia friesiorum* next to the house (see figure 9d). The owners of the house did not know the importance of the plant. We also encountered a similar case for *Pavetta teitana* (see figure 9c). In some of these homesteads, the relatively older people appreciated the importance of the species mentioned above. Therefore, there is a need to educate the locals, especially the youth, on the significance of the said threatened plant species.

Road construction and maintenance is another infrastructural development adversely affecting the survival of the threatened plant species in the study area. Their viable populations are being fragmented by a network of paths and roads. As noted during the field assessment, some of the mapped populations for the threatened plant species occurred along transport corridors or near human settlements (refer figure 9, 10a, b, and c).

(e) Overexploitation

All the four threatened plant species have high utility in the area as they serve as either timber, dry season feed, or have medicinal properties. For example, the locals of Ngutwa-Nzaui area use Millettia vatkei stems for timber as they can be easily bent during construction. Also, their inner barks were (and are still) converted into ropes and strings for weaving traditional baskets and building purposes before the introduction of sisal. Since Millettia vatkei is ever-green, it is commonly used by the locals in the cut-and-carry system. It is usually overexploited during the dry season when green fodder for livestock is inadequate.

Figure 9: (a), *Thunbergia napperae* growing in a pile of concrete sand in one of the local's homestead, (b) a young *Euphorbia friesiorum* growing next to an abandoned house, (c) *Pavetta teitana* growing near a homestead within the study locality, (d) a house erected beside a *Euphorbia friesiorum* species population within the study area.

Fig 10: (a) *Euphorbia friesiorum* species beside an earthen road in Ngutwa-Nzaui area, (b) a young *Euphorbia friesiorum* growing in a cliff along a recently maintained road, (c) a footpath passing through a *Milletia vatkei* population within the study locality.

Pavetta teitana is also used for construction by the locals as it forms good timber. Overextraction of this plant species due to increasing demand brought about by human population is threatening their existence in the wild. Both *Euphorbia friesiorum* and *Pavetta teitana* species are used by the local people as a source of medicine. While *Pavetta teitana* is used by the locals in the treatment of body pains, *Euphorbia friesiorum* is used to cure toothache, coated tongue (*'kivuti'* Kamba), and also in the treatment of cow glands. The medicinal purposes attached to these species create demand and opens doors to their continued over-extraction. Besides, the approaches used to extract them destroy the mature plants. All except *Thunbergia napperae* are used as a source of firewood especially when dry.

(f) Fire

Though fire is used as a management tool in forest conservation, it poses a great threat to the existence of plants when out of control. In the study area, prescribed burning was and is still used (though on small scale) in converting forestland into farmlands. At times, the fire is uncontrollable and thus destroy unintended vegetation nearby (see figure 11c). During the field assessment, incidents and effects of uncontrolled fires were noticeable within the study locality. We found surviving individuals of *Millettia vatkei*, *Pavetta teitana*, and *Euphorbia friesiorum* species (see figure 11a and b below) in recently burnt area.

Figure 11: (a and b), surviving *Euphorbia friesiorum* individuals after uncontrolled fire, (c) effects of uncontrolled burning on vegetation.

2. Introduction of alien (non-native) and/or invasive species

Invasive species is the second main threat to biodiversity after habitat loss. Ngutwa-Nzaui landscape has witnessed a surge in efforts to plant trees initially designed for food, aesthetics, wood fuel, and timber. These activities have seen single-species introductions of exotic timber species such as *Eucalyptus* in the study area (see figure12b). During the mapping exercise, we encountered several single-species plantations with at least one of the four threatened plant species either occurring in or adjacent the plantation.

In one of the known populations of *Thunbergia napperae* in the study area, we witnessed the allelopathic effects of *Eucalyptus* species as what was previously known as the largest population was reduced to few individuals (refer figure 12a and c). Before the introduction of *Eucalyptus* species, the area was densely populated by *Millettia vatkei* species. Currently, relatively small individuals of *Millettia vatkei* are found within the plantation and restricted to rocky outcrops where much of it is eaten by rock hyraces.

Figure 12: (a), *Thunbergia napperae* species in a *Eucalyptus* plantation, (b) Introduction of a single-species *Eucalyptus* plantation within a native vegetation in Ngutwa-Nzaui area, (c) reduced understory due to allelopathic effects of *Eucalyptus* species.

Additionally, various alien invasive plant species such as *Lantana camara* L, *Euclea divinorum* Hiern, and *Cuscuta japonica* were observed in the study area. Interestingly, for *Lantana camara,* which previously established itself on low elevations were found at higher altitudes during the mapping exercise, an indication of their continuous spread presumably due to bird dispersal. In most of the mapped populations of the threated plant species, *Lantana camara* was found in close association (see Figure13a, b, & c).

Figure 13: (a) *Milletia vatkei* growing together with *Lantana camara*, (b) and (c) *Euphorbia friesiorum* in close association with *Lantana camara.*

Another invasive species identified during the field assessment is *Cuscuta japonica* commonly known as the Japanese dodder. It is not only attacking natural vegetation but has also invaded farmlands where it is causing havoc in fruit orchards within the study

locality (refer figure14 c, e). *Cuscuta japonica* is holoparasitic and thus requires a host plant for survival. It kills its host by obtaining water and nutrients from it.

Figure 14: (a) *Euphorbia friesiorum* surrounded by *Cuscuta japonica*, (b)-*Pavetta teitana* in proximity with the *Cuscuta japonica,* (c & e) invasion of farmlands by the killer weed within Ngutwa-Nzaui area, (d)-dying effect of *Cuscuta japonica* on *Ficus* species.

During the field investigation, we encountered several individuals of *Pavetta teitana*, and *Euphorbia friesiorum* surrounded by this killer weed (see fig. 14a, b). In other species such as *Ficus*, signs of its parasitic effects were evident from drying branches (refer to figure14d).

An incentive for the next phase: Existence of Green Infrastructure in Ngutwa-Nzaui Area

During the field assessment, one of the motivating moments was seeing some locals using *Pavetta teitana* and *Euphorbia friesiorum* species as live fences or hedgerows in their homesteads and farms. Ngutwa-Nzaui landscape is a simple mosaic of forest fragments immersed in a matrix of land uses. In this area, live fences and hedgerows form a conspicuous feature in many local homesteads within the region. Therefore, in the next phase of the project, I will use hedgerows and live fences as one approach to conserving the four threatened plant species within the study area. Both plants and animals use living fences and hedgerows in moving from one location to another. Therefore, the study will use hedgerows and live fences as one way of extending the habitat for the four threatened plant species and, in so doing, increase their habitat connectivity in the Ngutwa-Nzaui landscape.