



# Diversity, Potential Utilization and Management of Cacti in Northern Kenya

Mary Nyawira Muchane<sup>1,\*</sup>, Muchane Muchai<sup>2</sup>, Geoffrey Mungai<sup>1</sup>, William Wambugu<sup>1</sup>

<sup>1</sup>Botany Department, National Museums of Kenya, Nairobi, Kenya

<sup>2</sup>Department of Clinical Studies (Wildlife Management & Conservation Section), College of Agriculture and Veterinary Sciences, University of Nairobi, Nairobi, Kenya

## Email address:

mmurethi@yahoo.com (M. N. Muchane)

\*Corresponding author

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**Abstract:** Cactus family (Cactaceae) is popular horticultural plant group with worldwide introduction outside their native ranges for ornamental purposes or as drought tolerant crops for arid and semi-arid lands (ASALS). Despite their importance the species are also the most damaging invasive, yet very little information exists about their status, diversity, potential utilization and problems associated with their management. Field and socio-economic surveys were carried out in ASALS of Northern Kenya to document (i) abundance and diversity of introduced Cactus species, (ii) identify reasons for their introduction, (iii) find potential uses and any invasive problems associated with introduced species. Field methods recorded species richness and abundance of cactus species while socio-economic methods recorded local knowledge on potential utilization and problems associated with management of Cactus species using semi-structured questionnaires. This study recorded only three species of cactus; *Opuntia ficus-indica* (both spined and spineless), *Opuntia exaltata* and *Cereus peruvianus*. The species were found mainly in settled areas and within urban centres. The species were introduced as ornamental (horticulture), dry land crop with ability to provide food (fruits and vegetable) or fodder (for humans or livestock) and as live fences due to their ability to thrive dry conditions. Cactus species in particular *O. ficus-indica* plays an important role in the region in providing fodder and fruits in the extremely dry seasons. Although cactus species in this region are not yet problematic weed, overgrowth if left unmanaged and thorns were cited as major problems associated with its introduction necessitating sustainable management options to avoid any invasive problem. Proper management of the spineless variety has great potential in improving rural livelihoods.

**Keywords:** Cactus, Utilization, Management, ASALS, Invasive, Northern Kenya

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## 1. Introduction

Arid and Semi-arid lands (ASALS) cover one-third of the earth's land surface with more than 50% of the land in developing countries and 55% of the African land mass supporting quarter of the earth's population [1]. In Kenya, more than two thirds of total land surface (80%) is classified as dry land, and host approximately 20% of the total human population, and slightly half of the total livestock population [2]. The dry areas resources are among the most threatened resources in Kenya by the ever increasing human and livestock population and drought prevalence which have resulted in a

constant ecological degradation. The result of this is continued inter-community fighting for the declining resources, which in return is deteriorating the quality of life of the people and posing threats to their survival [2]. There is need to use dry areas zones more productively by identifying, developing and advocating for wise utilization of the potential crops, which tolerate dry conditions and management of any invasive species that may decline their productivity.

Cactus family (Cactaceae) is a large and diverse group of stem succulents predominantly occurring in warm and arid

north and South America [3]. Cacti species are among the popular horticultural plant groups with worldwide introduction outside their native ranges for ornamental purposes or as drought tolerant crops in ASALS [4]. The species have wide introduction and adaptation in dry and warm climate such as Australia, the Mediterranean and East Africa [5, 6]. Their distribution encompasses various habitats, including bare, hot deserts, sandy coastal stretches, scrublands, dry deciduous forests, high alpine steppes, and even tropical rain forests [7]. Most of the cactus family members have numerous uses. Among other most important cactus species is prickly pears (*Opuntia ficus-indica* L. Mill) grown for the large and sweet fruits available in local and commercial markets worldwide [8, 9]. Important growing regions include Mexico, Sicily, Algeria, Chile, Brazil, and northern Africa [9, 10]. In addition, young cladodes (stem segments) of *O. ficus-indica* are harvested as a vegetable crop available in many local and commercial markets [11]. Other uses of *O. ficus-indica* include binding and waterproofing agent in adobe [12], medicinal properties [13] and host plant for cochineal insects (*Dactylopius coccus*) used in production of valuable, vivid red and purple dyes [14–16].

Despite these economic gains, cactus species are also the most damaging introduced invasive species causing biodiversity and economic losses worldwide (4). Cactus invasion has been reported in Australia, Africa and Europe [4, 17–22]. The easiness of Cactus vegetative propagation through clonal, abundance of photosynthetic tissue, shallow root structure, and ability to perform CAM photosynthesis makes it a noxious weed that out competes many other indigenous species [6, 23–25]. Presence of big and small hair-like spines makes its management and eradication difficult. Despite various documented economic importance and challenges, very little information exists about these species in Africa, Kenya included. Due to the growing interest in cultivation of many cacti to eradicate desertification [4, 5, 6, 9, 10], new introduction and invasion are expected even before proper management strategies are developed. There is therefore need to understand introduced Cactus diversity, management and their potential utilization especially in ASALs where they have become naturalized. This knowledge will be very vital while promoting their utilization

in the wild (and or cultivation) and in facilitating development of management strategies that may eradicate future invasion.

This study was undertaken to explore (i) abundance and diversity of introduced Cactus species and (ii) identify reasons for their introduction, current uses, potential utilization and sustainable management constraints in Northern Kenya.

## 2. Materials and Methods

### 2.1. Study Area

The study was conducted Northern Kenya in Samburu (Maralal, Baragoi) and Marsabit County (South Horr, Loiyangalani) all located in the North Rift Valley Region (Figure 1). The area lies between 1°04'N-2°45' and 36°42'-36°55'E longitude (Table 1). The region lies between 200m above sea level in lowland areas of Lake Turkana and 2050m in highland areas around Maralal town. The climate of the region is arid and semi-arid with average annual rainfall of 200mm in lowland of Lake Turkana and 400mm highland regions. The study area has an average temperature of 24°C. The climate of this region is influenced by altitude. Lowlands and plains experience high temperatures and relatively low rainfall while highlands have sub-tropical climatic conditions with low temperatures, low evaporation rates and high rainfall. The vegetation cover of the lowland is acacia woodland while that in highland zone comprises of wooded grassland with scattered and some cases dense Acacia dominated forests which serve as major water catchments for the entire region. The area is sparsely populated, with settled areas along main roads and major towns. Pastoralism is the major economic activities. Rain fed agriculture is only restricted along major rivers valleys where crops like millet, sorghum, cassava, bananas, cotton and vegetables are grown. Other economic activities include honey production, hunting, making and selling of ornaments from local materials, basketry and sale of medicinal herbs.

Table 1. Description of eleven (11) study sampling sites (block).

Site	Transect	Location			Temperature	Rainfall
		Latitude	Longitude	Altitude	°C	mm
Maralal	1	1°04'N	36°32'E	1945	24	604
Poro	2	1°12'N	36°60'E	2050	23	604
Morijo A	3	1°24'N	36°40'E	2044	23	800
Morinjo B	4	1°37'N	36°44'E	2025	25	800
Morijo C	5	1°47'N	36°47'E	1268	27	200
Baragoi A	6	1°57'N	36°53'E	1268	27	200
Baragoi B	7	2°12'N	36°56'E	1145	30	200
South Horr A	8	2°21'N	36°52'E	1145	30	200
South Horr B	9	2°32'N	36°45'E	450	31	200
Loiyangalani A	10	2°32'N	36°45'E	450	31	200
Loiyangalani B	11	2°45'N	36°43'E	300	31	200

Table 1. Continued.

Site	Distance from Marala Town	Vegetation
Maralal	0	Wooded grassland with scattered tree species ( <i>Acacia nilotica</i> , <i>Acacia seyal</i> , <i>Ricinus communis</i> , <i>Juniperus procera</i> , <i>Euphorbia candelabrum</i> , <i>Psidium punctulata</i> , <i>Euclea divinorum</i> , <i>Carissa edulis</i> )
Poroo	25	
Morijo A	50	Wooded grassland with fairly dense but scattered tree species ( <i>Acacia brevipica</i> , <i>Cordia purpurea</i> , <i>Euphorbia heterochroma</i> , <i>Duosperma eremophylla</i> , <i>Prosopis juliflora</i> , <i>Kleimia kleinoides</i> , <i>Balanites aegyptica</i> , <i>Euphorbia ughili</i> )
Morinjo B	75	
Morinjo C	100	
Baragoi A	125	
Baragoi B	145	Dry grassland, acacia, and cactus and dwarf shrubs with no agricultural activities
South Horr A	175	
South Horr B	200	Wooded grassland with sparsely spread Acacia trees, <i>Balanites aegyptiaca</i> and dry under growth grassland.
Loiyangalani A	225	
Loiyangalani B	233	Rocky and Grassy plains with speargrass ( <i>Imperata cylindrical</i> ) and scattered tree species ( <i>Commiphora</i> sp. <i>Acacia tortilis</i> , <i>A. elatior</i> , <i>Balanites aegyptiaca</i> ) and doum palm ( <i>Hyphaene coriacea</i> ) along water oasis

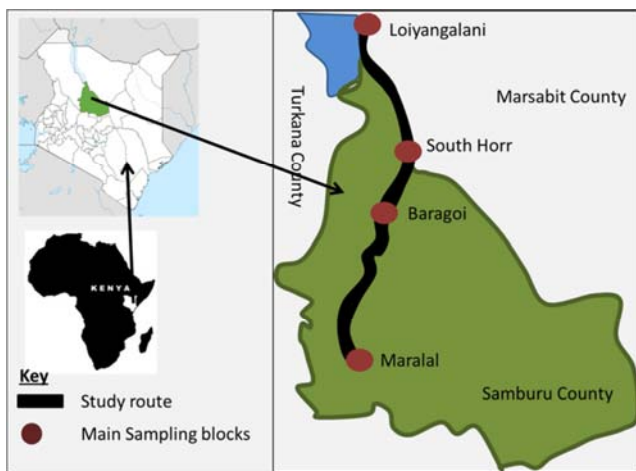


Figure 1. Map of study area showing main sampling block; Maralal, Baragoi, South Horr and Loiyangalani in Northern Kenya.

## 2.2. Experimental Design, Collection and Identification of Cactus Species

The survey was done using a standard method of vegetation assessment. Eleven study blocks were identified along Maralal-Loiyangalani road transect, with our first block situated at Maralal town (0km). The study blocks were 25km away and included Maralal (0km), Poroo (25km), Morijo A (50 km), Morijo B (75 km), Morinjo C (100km), Baragoi A (125 km), Baragoi B (150km), South Horr (175km), South Horr B (200km), Loiyangalani South (225km) and Loiyangalani North (236 km). In each block one (1) km transect was installed 100m away from the main road. Five sampling plots of 5x5m were demarcated 200m apart along 1km transects using Permanent markers (with their GPS readings). A total of 55 sampling plots were used for this study. Cactus species within or with parts leaning into the plot were identified and the percentage of the plot covered by each species was recorded. Percentage cover was chosen as a measure of abundance because many cactus species are clonal, making it difficult to distinguish between discrete individuals [26]. Percentage cover was estimated visually in 1% intervals up to 5%, then by 5% intervals up to 100%. Encountered cactus species were collected and identified by consulting the East Africa Herbarium where necessary.

## 2.3. Socio-Economic Survey

Social economic survey was carried out in three regions (Maralal, Baragoi and Loiyangalani) using semi-structured questionnaires to establish reasons for cactus introduction, levels of awareness, current uses, potential of cultivating cactus species as food and fodder provision and any possible management constraints. The sites were chosen based on abundance of species recorded. In each area, 20 households were randomly selected. Semi-structured interviews guided by semi-structured questionnaire were conducted with any member of the household above 18 years old. The questionnaire was divided in three thematic sections: (A) Information on socio-cultural and economic characteristic (family size, gender affiliation and age of respondents), (B) Awareness, reasons for introduction, current uses, (C) Cultivation potential for food and fodder provision and possible management constraints. A total of 60 household respondents were interviewed in the entire region.

## 2.4. Data Analysis

The Cactus species abundance was estimated as percentage ground cover per each 5x5m plot (25 m<sup>2</sup> area). The data was used to estimate species richness and abundance in each sampling site (block) using PAST programme [27]. One-way ANOVA were performed to assess effects of site (block) on species richness, total abundance (percentage ground cover) and individual species abundance. Differences between site means were separated by Turkey's post hoc test at  $P < 0.05$ . Percentage and count data was tested for normality, and percentage data was arcsine transformed while count data were logarithm (log+1) transformed to ensure conformity of the data with ANOVA assumptions. Mean value of all the data are presented alongside standard error (SE) of the means. Diversity measures were not calculated due to low number of species observed. Socio-economic data was analysed using descriptive Statistics such as percentages. The data are presented graphically or in a table.

# 3. Results and Discussions

## 3.1. Cactus Species in Northern Kenya

Cactus plants were introduced in Kenya during the pre-



colonial period. The first record of cactus in Kenya was recorded in 1933, and since then five more species (*Opuntia exaltata*, *Opuntia ficus-indica*, *Opuntia cochenifera*, *Opuntia streptacantha* and *Rhipsalis baccifera*) have been documented [28]. In this study three (3) species distributed in two genera (*Opuntia* and *Cereus*) were recorded (Table 2). Two *Opuntia* species included *Opuntia ficus-indica* Mill comprising of two varieties, spineless (Figure 2) and spined (Figure 3) varieties and *Opuntia exaltata* A. Berge (Figure 4). *Cereus* genus comprised of one species, *Cereus peruvianus* Haw (Figure 5). The species were introduced in Kenya as ornamentals during the colonial period [28]. Record of *O. ficus-indica* was expected in this study, since is among the several long-domesticated cactus species and is widely used as ornamentals and in landscaping [29, 30]. *Opuntia exaltata* though introduced as ornamental is currently used by local community as live hedge to exclude livestock, large and small wild mammals.



**Figure 2.** Spineless *Opuntia ficus-indica* in Loiyangalani catholic mission, Northern Kenya.



**Figure 3.** Spined *Opuntia ficus-indica* variety in Morijo (50km from Maralal), Northern Kenya.



**Figure 4.** *Opuntia exaltata* in Baragoi (145km from Maralal town), Northern Kenya.



**Figure 5.** *Cereus peruvianus* in Maralal (0km), Northern Kenya.

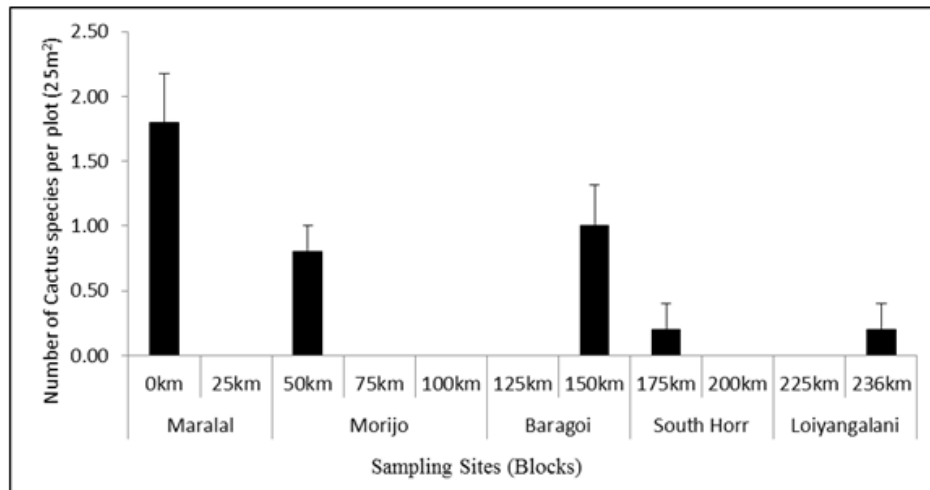
This study revealed introductions of *Cereus peruvianus* and *O. ficus-indica* spineless variety, which had not been documented in Kenya before, according to Flora of Tropical East Africa [28]. *Cereus peruvianus* (apple cactus) is a large erect, thorny columnar cactus found in South America. It is mainly planted as an ornamental and is recorded among the most promising cactus species in dry region in terms of its rapid growth and precocious early yielding [31- 33]. In this area *Cereus peruvianus* could have been introduced as ornamentals within the urban areas. Alternatively, *O. ficus-indica* spineless variety was a recent introduction in Loiyangalani from Marsabit region. It is also long domesticated plant, and has a wide usage as fodder [6]. Results of this study suggest need for more detailed studies in other regions in Kenya to document all cactus species. The last report of Cactaceae species in Kenya is Flora of Tropical East Africa [28]. Since then, many more cactus species could have been introduced. Here we have shown introductions of *Cereus peruvianus* and *O. ficus-indica* spineless cultivar not

documented earlier. *Opuntia stricta* has also been shown to occur widely in Kenya with recent introduction of less than ten years [19].

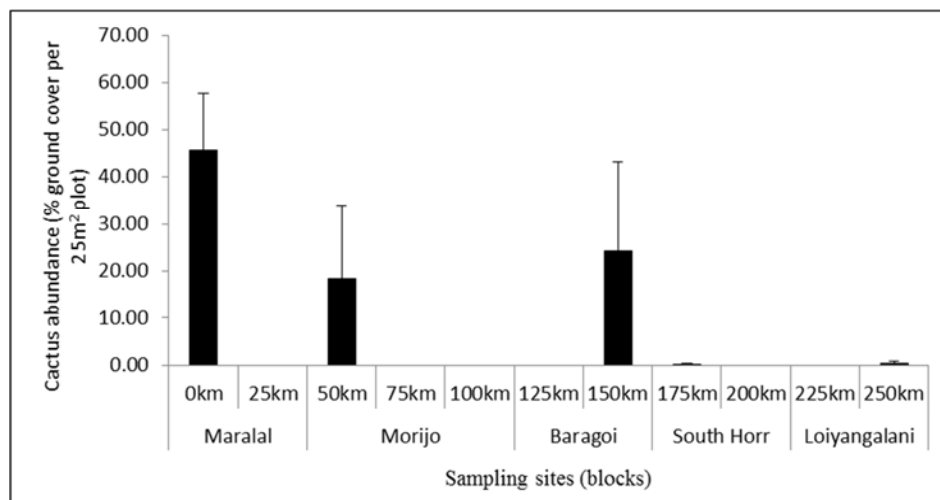
### 3.2. Cactus Species Richness, Abundance in Northern Kenya

Sampling sites significantly influenced Cactus species richness ( $F=10.71$ ,  $p<0.001$ ) and abundance (% ground cover,  $F=3.347$ ,  $p=0.003$ ). Maralal town recorded all the three cactus species, highest species richness and abundance

followed by Baragoi which had two species namely *Opuntia exaltata* and *Opuntia ficus-indica* (Table 2, Figure 6-7). *O. ficus-indica* was the only cactus species found at Loiyangalani and South Horr with evidences of recent introductions (Table 2, Figure 6-7). South Horr and Loiyangalani had the least species abundance and richness only recorded in sites near the settled areas and in urban centres (175km and 236km, Figure 6-7). In all the sampling sites, the three species were recorded either in previously settled areas or near urban centres.



**Figure 6.** Cactus species richness (number of species per 25m<sup>2</sup>) across the study sites in Northern Kenya. 0km-Maralal, 25km-Poro, 50km-Morijo A, 75km-Morijo B, 100km-Baragoi A, 125km-Baragoi B, 145km-Baragoi (C) town, 175km represents South Horr A, 200 South Horr B, 225km- Loiyangalani. Error bars represents standard error (SE).



**Figure 7.** Cactus species abundance (% ground cover per sampling plot, 25m<sup>2</sup>) across different study sites in Northern Kenya. 0km-Maralal, 25km-Poro, 50km-Morijo A, 75km-Morijo B, 100km-Baragoi A, 125km-Baragoi B, 145km-Baragoi (C) town, 175km represents South Horr A, 200 South Horr B, 225km-Loiyangalani. Error bars represents standard error (SE).

**Table 2.** Cactus species recorded in Northern Kenya and their uses.

Cactus species	Uses	Maralal		Morijo			Baragoi	
		0km	25km	50km	75km	100km	125km	145km
<i>Opuntia exaltata</i> A Berge	ORN, LF, NDLs	+	–	–	–	–	–	+
<i>Opuntia ficus-indica</i> (L) Mill	ORN, LF, NDLs, FD, FDD, MD	+	–	+	–	–	–	+
<i>Cereus peruvianus</i>	ORN	+	–	–	–	–	–	–

Table 2. Continued.

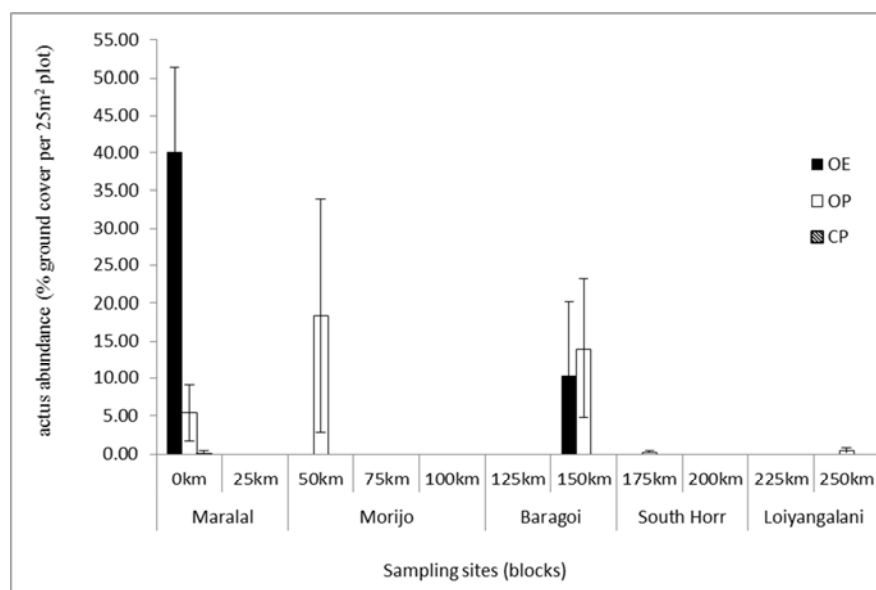
Cactus species	Uses	South Horr		Loiyangalani	
		175km	200km	225km	232km
<i>Opuntia exaltata</i> A Berge	ORN, LF, NDLs	—	—	—	—
<i>Opuntia ficus-indica</i> (L) Mill	ORN, LF, NDLs, FD, FDD, MD	+	—	—	+
<i>Cereus peruvianus</i>	ORN	—	—	—	—

Key; ORN-Ornamental, LF-Live fences, NDLs-Needles, FD-Food (fruits), FDD-Fodder and MD-Medicine,

The results of this study suggest that urbanization, development and accessibility are the major factors influencing presence, species richness and abundance of cactus species in this area. Maralal town is among the old towns in this area. It is also more developed compared to other urban centre in this region (Baragoi, South Horr, Loiyangalani) and is easily accessible with well-developed and accessible road network. Inception of modern guest house and modern Catholic mission at South Horr and Loiyangalani respectively and development of the road network have seen the introduction of *O. ficus-indica* species in these two regions. In Loiyangalani, two varieties (both spineless and spined, Figure 2, 3) of the *O. ficus-indica* were recorded in a newly established catholic mission site for ornamental purposes. The results of this study support finding showing cactus species colonizing areas located less than 200 m within the vicinities of urban settlements [35]. This indicates humans are the main means of cactus dispersal, suggesting a wide spread of the species as a result of anthropogenic dispersal via garden throw-outs [36] or by deliberate planting as ornamentals, after which cactus colonize and expands its range into the surrounding shrublands [35]. The ease of the species to propagate from segments, explains its rapid spread. When the fallen segment is exposed to diffuse sunlight for 7-15 days, it partially withers improving the rooting and proliferation of pads. We predict a wide spread of these species with expected increase in modern facilities and urban development with time. There

is urgent need to educate the local communities about the potential utilization, management options and the dangers, threats and impacts of this invasive species.

Individual species abundance in this region were also significantly affected by sampling sites ( $p < 0.05$ ). *Opuntia exaltata* abundance was high in Maralal (0km) while *O. ficus-indica* abundance was high in Morijo (50km) (Figure 8). In Baragoi (145km) *Opuntia exaltata* and *O. ficus-indica* abundance did not differ significantly ( $p > 0.05$ ) while abundance of *O. ficus-indica* was extremely low in South Horr and Loiyangalani. *Cereus peruvianus* only occurred in Maralal and its abundance was extremely low ( $< 1\%$  ground cover). Although most of cactus species were initially introduced as ornamentals and for hedging purposes, these species tend to spread to other non-targeted areas due to their easiness to propagate through clodades [20, 36]. Lack of any management further increase their spread and invasion non-targeted areas [19]. High abundance observed in Maralal, Baragoi and Morijo may be associated with species spread to non-targeted areas where management or attempts to remove or control are not applied. *O. ficus-indica* was a recent introduction in South Horr and Loiyangalani explaining their low level of abundance. *Cereus peruvianus* was also a new introduction in Maralal Kenyatta House Museum. This implies need for community awareness on benefits and management of these species to control spread to non-targeted areas to minimize any future negative impacts.



**Figure 8.** Distribution and abundance (% ground cover per 25m<sup>2</sup>) for three cactus species; *Opuntia exaltata* -OE, *O. ficus-indica*-OP and *C. peruvianus*-CP across different study sites in Northern Kenya. 0km-Maralal, 25km-Poro, 50km-Morijo A, 75km-Morijo B, 100km-Baragoi A, 125km-Baragoi B, 145km-Baragoi (C) town, 175km represents South Horr A, 200 South Horr B, 225km- Loiyangalani. Y error bars represents standard error (SE).

### 3.3. Socio-Economic Surveys

#### 3.3.1. Awareness, Reason for Introduction and Current Uses

Local communities in this region are generally aware of Cactus species and their possible uses. More than 40% of people interviewed were aware of presences of Cactus species and had directly or indirectly used them (Table 3). Maralal recorded the highest level of cactus awareness (45%), followed by Baragoi (40%). Loiyangalani (25%) had the least level of awareness. Cactus species in this area were introduced for three main reasons. Thirty (30%) percent of people interviewed cited ornamental as major reason for introduction of Cactus species, followed by live fences (28%) while drought resistant crop was least with

only 5% respondents all from Loiyangalani (Table 2). In settled and urban area especially in Maralal and Baragoi, *O. ficus-indica* was introduced as ornamental (horticulture) species due to its ability to thrive dry conditions. *Opuntia ficus-indica* was also introduced in Marsabit County as dry land crop with ability to provide food (fruits and vegetable) or fodder (i. e. for humans or livestock). In Maralal and part of Baragoi, *O. exaltata* and *O. ficus-indica* were introduced for hedging around the home compounds. This is in line with earlier reports showing major driver of Cactus spread as ornamental and hedges [20, 22]. The growing interest in cultivation of *O. ficus-indica* for fruit and fodder production introduced the spineless *O. ficus-indica* in Marsabit [6].

**Table 3.** Demographic characteristics of the respondents, level of their awareness, reasons for Cactus introduction and current uses of Cactus species in the region.

		Loiyangalani	Maralal	Baragoi
		%	%	%
<b>Section A: Awareness of Cactus and its known uses</b>				
Age of respondents in years	18-20	20	25	15
	20-40	45	20	50
	>40	35	55	35
Gender of respondents	Female	50	60	55
	Male	50	40	45
General Awareness of Cactus	Aware	25	45	40
	Not aware	75	55	60
Reason for introduction	Ornamental	10	50	40
	Crop	5	0	0
	Live fence	0	40	45
Those interested or against cacti	Not sure	85	10	15
	Interested	65	45	35
	Against	5	5	10
	Undecided	30	50	55
Reasons for interest or against Cacti	others	0	0	0
	Live Fence	14	85	55
	Medicinal	14	65	55
	Needles use	0	0	10
	Nuisance	0	0	10
Current uses Cactus uses	Food	0	20	50
	Fodder	0	60	70
	Income sources	0	0	0
	Live Fence	0	100	85
	Others (dye, needles)	0	5	5
	No aware	71	0	0

Our results show wide utilization of *O. ficus-indica* as food (fruits) by both children and adults and fodder for livestock during dry period. The species were also found to play a significant role as sources of medicines, ornamental and needles in Maralal and Baragoi. Though cactus species may be associated with dense invasion of ASALs that result to negative effects on biodiversity, rangeland production and livestock [35], majority of local community in this region are still interested in having the cactus species for live fences (51%), medicinal purposes (44%) and provision of needles (3%, Table 3). In Maralal and Baragoi, over 50% of respondents utilize Cactus fruits and fodder during extremely dry season while over 80% are still interested with the species (*O. exaltata*) for fencing (Table 3). Their ability to

thrive dry conditions, ability to form dense thickets that keep away small mammals (and cattle) from home compounds and production of fruits and fodder during extremely dry period were cited as the major reasons for their interest. Only 6% of person interviewed were against the species. They termed the species as nuisance due it rapid invasion, overgrowth and presence of thorns that made it hard to manage. In Loiyangalani cactus species were not available except for the recent introduction at the Catholic Church and youth camp explaining presence of greater proportion of the population (70%) not aware of their common uses (Table 3).

Defensive and demarcative hedges were the major use cactus observed in this region. Although both *O. ficus-indica* and *Opuntia exaltata* are used as hedges, *Opuntia exaltata*

was the most preferred species due to its ability to form very sharp spines and slender stems which entangle to form a very thick fence. Under controlled pruning *Opuntia exaltata* formed a very thick fence, but if left uncontrolled the species can become notorious and even hard to control. We did not record any uses of *C. peruvians* species in this area, probably because the species is not common, and majority of the local communities were not aware of it. Elsewhere, *C. peruvians* is an important desert crop grown mainly for fruits and ornamental [32, 33]. It produces attractive, thornless, edible fruits, which are known as pitaya in Latin America [41].

### 3.3.2. Potential Cultivation and Constraints Against Cactus Cultivation

*Opuntia ficus-indica* is among the long-domesticated cactus crop and an important crop in agricultural economies

which is being recognized as ideal crops for arid regimes throughout ASALs [6]. In this region *O. ficus-indica* is a valuable resource providing food (fruits), fodder and source of medicine during extremely dry periods when other plants couldn't thrive. However cultivation of *O. ficus-indica* crop for provision of food (fruits, vegetable) and fodder received mixed reactions (Table 4). In, Baragoi and Maralal only a small proportion of the people (20%) interviewed supported their cultivation. However, in Loiyangalani, greater proportion of the people questioned (75%) were excited about having an alternative source of fodder and food since only few plants thrive in this area. Majority in this region felt introduction of *O. ficus-indica* as a dryland plant can play a significant role in providing fodder for their animal and fruits.

**Table 4.** Potential Utilization and possible constraints against cultivation cactus (*O. ficus-indica*) for food (fruit), fodder, medicine, ornamentals and live fencing in Northern Kenya (Maralal, Baragoi and Loiyangalani region).

		Loiyangalani	Maralal	Baragoi
		%	%	%
Awareness of Cactus cultivation for food/fodder	Yes	25	20	5
	No	10	80	95
	Not Sure	60	0	0
Proportion for cultivation of Cactus	Cultivate	75	20	20
	Remove	10	10	40
	Grow wild	0	60	30
	Management needed	15	10	5
	Not sure	0	0	0
Uses that may prompt need cultivation	Fruits/food	5	40	35
	Fodder	5	45	45
	Medicine	0	60	65
	Ornamental	0	5	20
	Not Sure	60	35	30
	Un-available	30	0	0
	Others	0	0	0
Possible Constraints against cultivation	Overgrowth	5	55	55
	Thorns	25	100	100
	Nuisance	0	0	5
	Poisonous	0	10	0
	Others	5	0	0
	none	5	0	0
	don't know	60	0	0
Known effects on Plants or animals	Yes	0	0	0
	No	80	85	100
	Not sure	20	15	0

Cultivation of *Opuntia* species has been successful in many developed countries due to their efficiency in converting water to dry matter, ability to withstand drought, prevent soil erosion and combat desertification [6]. In Northern Kenya, we predict an increase in exploitation of this crop in future due to expected prolonged drought periods with the changing climate. Our result has shown wide utilization of *O. ficus-indica* fruits as source of food and fodder during prolonged dry periods in this area. Additionally, our results have shown wide utilization of *O. ficus-indica* for medicinal purposes by local community mainly from the wild. This is an underutilization given that medicinal value of *O. ficus-indica* is well documented and medicines from this crop are being marketed in major pharmaceuticals of the world. For example, it has been

reported that *O. ficus-indica* alleviates the symptoms of benign prostatic hyperplasia [36], lowers levels of cholesterol [37] and diabetics need for insulin [38, 39], reduces hangover systems [40] and in-vivo oxidation injury in people suffering from hypercholesterolemia, and has significant cardiovascular benefit [41]. This indicates hidden potential of *O. ficus-indica* which needs to be explored to benefit local communities in Kenya especially regions where it has been naturalized or has dense infestations.

Cultivation of *O. ficus-indica* may have great potential in ASALs [6], but its implementation may pose great challenge especially managing and controlling its spread to non-targeted areas like national parks, grazing areas and riparian zones among others. Majority of respondents in this region cited thorns and overgrowth as the major constraints against



cactus utilization and management (Table 4). A few felt some cactus were poisonous, hence their utilization is always taken in caution. Despite these constraints, the majority of people in Maralal (60%) felt that, cactus species should be left to grow in the wild since they are a source of food and fodder to both man and animals during the dry season (Table 4). Furthermore majority of the local community in this area support its growth in the wild, as an alternative source of food and fodder especially in extremely drought period. This clearly show that with effective management options, cactus species can be manipulated as alternative sources of food, fodder and medicine in this region.

In Baragoi, only 30% of the people interviewed recommended its growth in wild, while greater proportion (40%) of the population recommended complete removal of cactus due constraints mentioned above (overgrowth and thorns). Majority of local community felt *O. ficus-indica* if left unmanaged colonizes fast forming dense thickets that are difficult to penetrate. Easiness for the species to proliferate has made it hard to control, while big thorns have made it hard to extract and manage. This has been the case in many other countries, where *Opuntia* species have often been reported as problematic weeds negatively affecting biodiversity and reducing production of grazing land [19, 42, 43]. *Opuntia* species are shown to outdo native botanical diversity and cause physical injury to native fauna [44]. Although biological control of these species has been successful in several countries, it is still a big problem in others. In northern Kenya, although we have shown overgrowth and thorns as major problems with the cactus species, the species are not yet a problematic weed like in many other countries. But owing to the fact that East Africa drylands have witnessed the introduction of various alien species in 1970s and 1980s (e.g. *Prosopis* species) which have become difficult and costly to control and eradicate, there is need for detailed studies on management options.

## 4. Conclusions

Our results clearly demonstrate that, cactus especially *O. ficus-indica* are valuable resource used as fruits and vegetables-cladodes, fencing, cattle fodder, cosmetics, natural medicines, and dye production. *O. ficus-indica* therefore can be developed to improve rural livelihood in this region. Exploring the utilization and cultivation of *O. ficus-indica* spineless cultivar can add value to the cactus products in this region. *O. ficus-indica* spineless cultivar has been shown to be favoured in production in their native range, and don't appear to survive in the wild [44]. Cactus species have ability to spread causing damage to the environment, biodiversity, economy and health. Invasive species may cause harm to wildlife. They can breed and spread aggressively, taking over an area thus out-competing native plant species that are food for wildlife. Before any introduction, a wide knowledge on its reproduction, dispersal, habitat and its impacts to flora and fauna diversity as well as human will be necessary. Precaution is needed to

avoid the disastrous consequences of poorly introduction of invasive exotic species. Any species proposed for introduction should be subject to rigorous risk assessment and ecological characterization prior to introduction.

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