

# Local ecological knowledge of invasive Alien species *Opuntia ficus-indica* in three local municipalities in the Eastern Cape Province, South Africa

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## ABSTRACT

*Opuntia ficus-indica* is a succulent plant species that originated from Mexico and introduced in South Africa in the eighteenth century. *Opuntia ficus-indica* is now categorized as invasive in South Africa but the species has both commercial and non-market uses. This study evaluated the local ecological knowledge about *O. ficus-indica* in Makana, Ngqushwa and Raymond Mhlaba Local Municipalities in the Eastern Cape province in South Africa. Data on the local ecological knowledge on the biology, use values and management of *O. ficus-indica* in the study area were gathered through community focus group discussions and household surveys using semi-structured questionnaires between June 2018 and August 2019 with a sample of 150 participants selected via snowball-sampling technique. The importance of *O. ficus-indica* as a useful plant species was ubiquitously perceived, with all respondents reporting its contribution towards their livelihood needs and more than three quarters (88.0%) using the species on a regular basis. Majority of the respondents (41.0%) regarded *O. ficus-indica* as an important source of cash income while about a third (33.0%) regarded the species as an important source of food products and nutrition. Interviews with respondents revealed that *O. ficus-indica* is currently being harvested from the wild with 73.3% of the respondents reporting that the abundance of the species was decreasing. The positive socio-economic contributions of *O. ficus-indica* need to be taken into account when assessing the costs resulting from invasions caused by alien plant species.

**Key words :** *Local ecological knowledge, Opuntia ficus-indica, Perceptions, South Africa, Succulent plant, Traditional knowledge*

## Introduction

*Opuntia ficus-indica* (L.) Mill. is a succulent plant species which belongs to the Cactaceae or cactus family. *Opuntia ficus-indica* originated in Mexico and the neighbouring middle-America but the species has long been a domesticated crop and it is now naturalized throughout arid and semi-arid parts of the world (Griffith, 2004). *Opuntia ficus-indica* is used as forage (Inglese *et al.*, 2017) and for fresh fruit

production which are available in local and commercial markets worldwide (Barbera *et al.*, 1992; Basile, 2001; Inglese *et al.*, 2002; Griffith, 2004; Inglese *et al.*, 2017). The young cladodes (stem segments) of *O. ficus-indica* are harvested as a vegetable crop and sold in local and commercial markets (Sáenz-Hernandez *et al.*, 2002; Griffith, 2004; Inglese *et al.*, 2017). The species is grown as a host plant for cochineal insects (*Dactylopius coccus*) for the production of valuable, vivid red and purple dyes (Donkin,

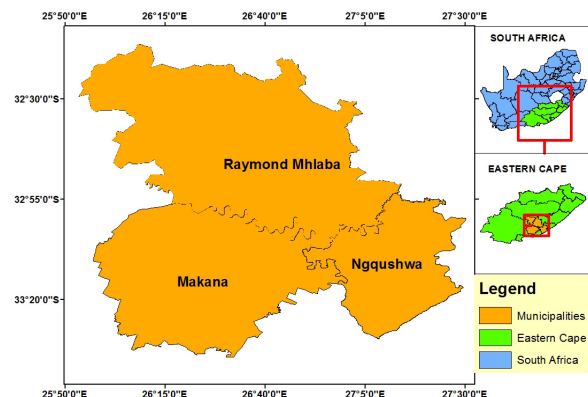
1977; Nobel, 1994; Anderson, 2001; Griffith, 2004; Inglese *et al.*, 2017). *Opuntia ficus-indica* is widely used as fence or hedge and as firewood, to control erosion, land-slope partitioning or obstacle to runoff or areas subject to wind erosion to rehabilitate degraded landscapes in Algeria by planting the species on stony and rocky slopes (Inglese *et al.*, 2017). The flowers, fruits and leaves of *O. ficus-indica* are used as herbal medicines for treating and managing arteriosclerosis, burns, bronchial, asthma, edema, indigestion, diabetes, gastritis, hyperglycaemia, intestinal disorders and wounds (Trejo-González *et al.*, 1996; Park and Chun, 2001; Galati *et al.*, 2002; Lee *et al.*, 2002; Abdel-Hameed *et al.*, 2014; Van Wyk and Wink, 2017).

*Opuntia ficus-indica* was introduced in South Africa in the 1770s by the earliest white settlers (Annecke and Moran, 1978) as fodder for sheep and cattle (Masubelele *et al.*, 2009). By 1890, *O. ficus-indica* had become a serious and troublesome weed in various parts of the country but characterized by numerous commercial and non-market uses (Annecke and Moran, 1978). Therefore, *O. ficus-indica* is an appropriate species to be used as a model to assess local ecological knowledge about invasive alien plant species in South Africa. Within the alien invasive plants management programmes there is considerable interest in combining local and scientific knowledge to achieve management objectives (Nxele *et al.*, 2019). However, few studies have examined the merits of incorporating local ecological knowledge (LEK) into scientific knowledge systems in the management of invasive alien plants. Charnley *et al.* (2007) defined LEK as cumulative body of knowledge, practices and beliefs about the ecological relationships that have been gained through personal observation and interaction with local ecosystems and other local resource users, and handed down over generations by cultural transmission. Joa *et al.* (2018) argued that LEK and management of plant resources are linked through various socially shared aspects, such as values and norms, perceptions of natural resources, ecosystem goods and services, and livelihood strategies. It is within this background that this study was carried out aimed at investigating the local ecological knowledge of *O. ficus-indica* in three local Municipalities in the Eastern Cape province of South Africa.

## Materials and Methods

### Study areas

The research focuses on three local municipalities within the Eastern Cape province in South Africa, the Makana, Ngqushwa and Raymond Mhlaba Local Municipalities (Figure 1). The population density of Ngqushwa (32 people per km<sup>2</sup>) is significantly higher than that Raymond Mhlaba (24 people per km<sup>2</sup>) and Makana (18 people per km<sup>2</sup>) (Statistics South Africa, 2016). The climate of the study area is mild with unevenly distributed annual rainfall received during summer months from October to March and it is hot in summer to cold. Annual rainfall ranging from 500 mm to 1000 mm while temperature ranges from of 4 °C in July to 38 °C in February (Jari and Fraser, 2012; Manyevere *et al.*, 2014). In spite of unfavourable agro-ecological conditions, households practise both livestock husbandry and fisheries (Ndhleve *et al.*, 2013) and are involved in production of maize, sorghum, potatoes, cabbage, spinach, beetroot and carrots. The residents also rely on natural plant resources for a diversity of livelihood needs (Hebinck and Lent, 2007; Alexander *et al.*, 2015). The vegetation of the study area was described by Mucina and Rutherford (2006) as succulent thicket and grassland biomes.



**Fig. 1.** The geographical position of study areas across three local Municipalities in the Eastern Cape Province, South Africa.

### Data collection

This study utilized the participatory rural appraisal (PRA) methods (Chambers, 1994), focusing on in-depth discussions using open-ended questionnaires and participant observation with local communities

in data gathering. The current study documented local ecological knowledge of *O. ficus-indica* in Makana, Ngqushwa and Raymond Mhlaba Local Municipalities, a species that has been in usage in the region since the 1770s (Annecke and Moran, 1978). One hundred and fifty participants selected from Makana, Ngqushwa and Raymond Mhlaba Local Municipalities through snowball or chain sampling (Heckathorn, 2011) were interviewed between June 2018 and August 2019. The questionnaire emphasized socio-economic characteristics of the participants and the following aspects meant to assess participants' local ecological knowledge on the biology, use values and management of *O. ficus-indica* as a declared invader plant species according to the Conservation of Agricultural Resources Act No. 43 of 1983 (CARA, 1983) and the South African National Environmental Management: Biodiversity Act 2004 (Government Gazette, 2004):

1. Are there any *O. ficus-indica* plants in this village? If yes, is the species common in the village?
2. Do you know any uses of *O. ficus-indica*? If yes, could you please provide details.
3. Who uses these products? How do users obtain these products?
4. Do you know that *O. ficus-indica* is a weed? If yes, how do you know about this?
5. Do you think that *O. ficus-indica* should be eradicated? If yes, how do you think this can be done?
6. What is your opinion about categorization of *O. ficus-indica* as a weed in South Africa. Do you think there are lessons that can be drawn from the relationship of local people with *O. ficus-indica*?

In terms of the questions on the local ecological knowledge on the biology, use values and management of *O. ficus-indica*, these were open-ended so as to avoid leading the participants. The responses from the PRA interviews and focus group discussions were written down in a notebook as well as tape recorded.

### Data analysis

Some of the data in this study were explained directly because were descriptive and qualitative in nature. However, some interview data were coded, divided into themes using content analysis (Dooley, 2007; Msuya and Wambura, 2016).

## Results

### Socio-economic characteristics of the respondents

Table 1 provides socio-economic characteristics of the participants who provided information on their perceptions about the biology, livelihood uses and management of *O. ficus-indica* in the study areas. The majority of the participants (54.0%) were females while 46.0% were males (Table 1). About two thirds of the respondents (67.3%) were between the 31 years to 60 years, while 14.0% were below 31 years and 18.7% were above 60 years of age (Table 1). About a third of the participants, 32.0% and 34.7%, were married and single, respectively, while 24.7% were widowed and 8.7% were divorced (Table 1). The majority of families (68.0% of households) comprised between one and five household members, while 26.0% comprised of six to ten household members and 6.0% had more than ten household members (Table 1). Most of the respondents were educated up to primary and secondary level (42.7% and 44.0%, respectively) and less than ten percent were either illiterate or educated up to tertiary level (5.3% and 8.0%, respectively) (Table 1). The majority of the participants (56.0%) were unemployed, 26.7% were self-employed, 13.3% employed by a private company and 4.0% employed by government (Table 1). Close to a third of the participants were dependent on their pension (28.0%), while 23.3% of the participants were managing small informal businesses, 17.3% depended on remittances and 14.7% depended on government grants (Table 1). The majority of participants (40.7%) had total annual income of R2 000.00 to R10 000.00 (US\$142.86 to US\$714.29) per month, 30.7% (>R10 000.00 (US\$714.29), 18.7% (R200.00 to R1999.99 (US\$14.29 to US\$142.86) and less than ten percent had either monthly income not exceeding R199.99 (US\$14.29) or did not disclose their income (Table 1).

### Utilization of *Opuntia ficus-indica*

Knowledge of the traditional uses of *O. ficus-indica* was reported by 88.0% of respondents and there were differences in people's knowledge of the values and uses of the species (Figure 2). Majority of the respondents, 41.0% and 33.0%, regarded *O. ficus-indica* as an important source of income and food, respectively (Figure 2). The respondents argued that fruits were used for making jam, syrup,

**Table 1.** The socio-economic characteristics of the respondents in Makana, Ngqushwa and Raymond Mhlaba Local Municipalities

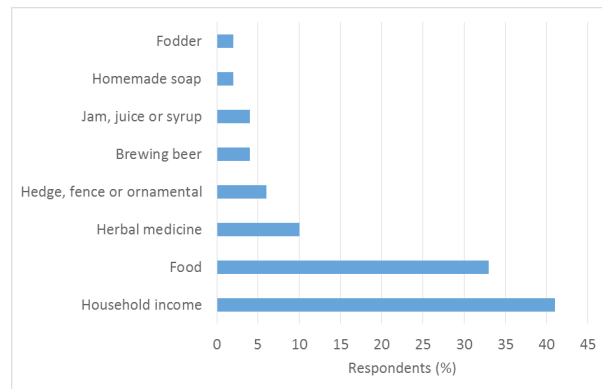
Characteristics	Makana	Ngqushwa	Raymond Mhlaba	No. of informants	Percentage (%)
Gender					
Male	26	22	21	69	46.0
Female	24	26	29	81	54.0
Age range					
<20 years	1	2	2	5	3.3
20-30 years	9	3	4	16	10.7
31-40 years	13	8	11	32	21.3
41-50 years	10	12	13	35	23.3
51-60 years	9	14	11	34	22.7
61-70 years	5	7	6	18	12.0
>70 years	3	4	3	10	6.7
Marital status					
Married	8	18	22	48	32.0
Single	33	11	8	52	34.7
Divorced	3	4	6	13	8.7
Widowed	6	17	14	37	24.7
Education					
None	2	2	4	8	5.3
Primary	21	13	30	64	42.7
Secondary	20	32	14	66	44.0
Tertiary	7	3	2	12	8.0
Household members					
1-5	41	24	37	102	68.0
6-10	6	21	12	39	26.0
>10	3	5	1	9	6.0
Employment status					
Unemployed	28	29	27	84	56.0
Employed by private company	2	10	8	20	13.3
Employed by government	1	1	4	6	4.0
Self-employed	19	10	11	40	26.7
Source of income					
Salary	3	11	11	25	16.7
Pension	1	25	16	42	28.0
Government grants	10	5	7	22	14.7
Remittance	15	4	7	26	17.3
Business	17	9	9	35	23.3
Income per month					
<R199.99 (US\$14.29)	3	1	2	6	4.0
R200.00 – 1999.99 (US\$14.29 – 142.86)	10	9	9	28	18.7
R2000.00 – R10000.00 (US\$142.86 – 714.29)	18	20	23	61	40.7
>R10000.00 (US\$714.29)	16	16	14	46	30.7
Not disclosed	3	4	2	9	6.0

\*R14.00 = US\$1.00

chutney, other preserves with over-ripe fruits used to brew beer or potent spirit. About 41.0% of the respondents argued that the fruits of *O. ficus-indica* were sold in informal markets and along highways

as source of income to different households (Figure 2). Some respondents indicated that some rich families usually hire casual labourers to market the fruits of *O. ficus-indica* between January and March every

year along highways. *Opuntia ficus-indica* was reported to be used as hedge or fence or ornamental or garden plant by 6.0%, while minor uses included fodder for livestock (2.0%) and using the species for making a homemade soap (2.0%) (Figure 2). About 10.0% of the respondents reported that *O. ficus-indica* was an important traditional medicine in the province, particularly as a laxative and blood purifier and herbal medicine against stomachache.



**Fig. 2.** Uses of *O. ficus-indica* in Makana, Ngqushwa and Raymond Mhlaba Local Municipalities in the Eastern Cape (n= 132)

Respondents provided a number of reasons to justify their attitudes and reasons regarding utilization of *O. ficus-indica* (Table 2). Majority of the participants (88.6% and 84.1%) argued that *O. ficus-indica* is required as an important source of livelihood needs and/or supplementing or complementing household food, fodder, income, hedge, fence, herbal medicines, homemade soap and beer brewing (Table 2). About 8.3% of the respondents emphasized the aesthetic role played by *O. ficus-indica* as hedge or live fence and the species is now regarded as an important component of the Eastern Cape province landscape with some respondents

expressing surprise when the researchers mentioned that the species was originally from Mexico. About 6.1% of the respondents argued that *O. ficus-indica* is now regarded as an integral part of the social and cultural framework for the local communities in the Eastern Cape with participants emphasizing the use of the species as herbal medicine, beer brewing and the fruits donated to neighbours or used as gifts to relatives or neighbours (Table 2). Focus group discussions with the respondents revealed that usage of *O. ficus-indica* fruits was a form of cultural identity that is always attached to the species by the rural people as they had grown up eating the fruits. Some of the respondents argued that eating of the fruits is part of their tradition with all respondents perceived *O. ficus-indica* to have been there before they were born. Interviews with respondents revealed that processes of gathering and processing *O. ficus-indica* result in important social benefits as local people cooperate in these activities and these activities and interactions can be the basis for community-based systems for managing plant resources. A small proportion of the respondents (1.5%) argued that there is need to highlight the fact that *O. ficus-indica* is an invasive alien species in need of monitoring, control and there is need to participate in integrated clearing programme of the species that is coordinated Working for Water organization (Table 2). These respondents argued that the Working for Water Programme significantly increased public awareness about alien plant species in the Eastern Cape, including *O. ficus-indica*. During focus group discussions (FGDs), the respondents argued that *O. ficus-indica* was inextricably linked to local peoples' food needs, nutrition, health, culture and landscape in a number of fundamental ways. Discussions with respondents during FGDs also revealed that *O. ficus-*

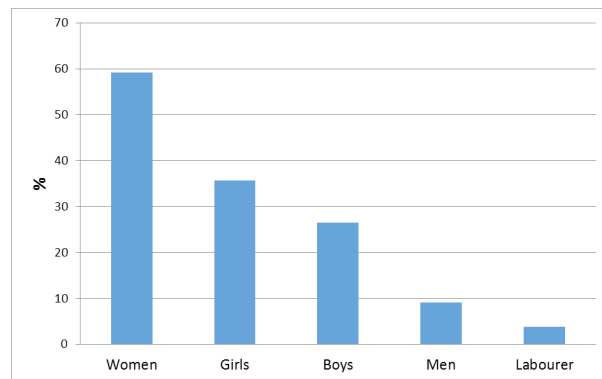
**Table 2.** People's attitudes or reasons of using *O. ficus-indica* in Makana, Ngqushwa and Raymond Mhlaba Local Municipalities in the Eastern Cape (n= 132). Some respondents indicated more than one response.

Major reason and specific components	(%)
Supplementary role (as fodder, food, hedge, fence, beer brewing, herbal medicine, homemade soap and source of income)	88.6
Livelihood needs (as fodder, food, hedge, fence, herbal medicine and source of income)	84.1
Aesthetic role (hedge, live fence, ornamental and garden plant, and an important component of the Eastern Cape province landscape)	8.3
Cultural role (as herbal medicine, beer brewing, fruits donated to neighbours and used as gifts to relatives and neighbours)	6.1
An invasive alien species in need of monitoring and control	1.5



*indica* help to diversify the household economy, providing seasonal source of income between December and March every year. This small-scale processing and trade of *O. ficus-indica* make up an important part of the rural economy in the Eastern Cape province. Interviews with the respondents revealed that the income generated through selling *O. ficus-indica* fruits is used for livelihood needs such as buying electricity, groceries, clothing, school fees and uniform.

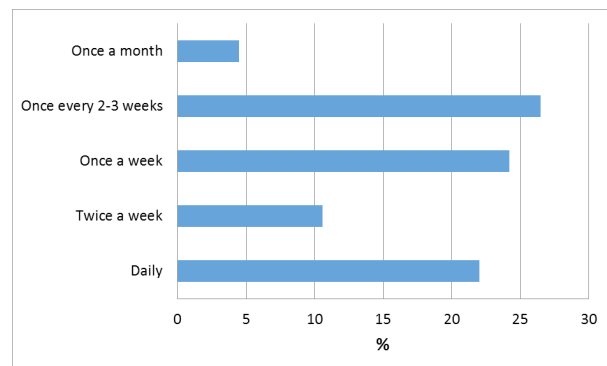
Discussions with respondents revealed that collection of *O. ficus-indica* was performed mainly by children and women (Figure 3). To collect *O. ficus-indica*, most people (42.4%) travel long distances exceeding 15 km (Table 3), hence fruits were collected daily, once a week or once every 2-3 weeks (Figure 4).



**Fig. 3.** Proportion of participation (%) by household members and labourers in *Opuntia ficus-indica* harvesting (n = 132). Some respondents indicated more than one use.

### Economic uses of *Opuntia ficus-indica*

Interviews with respondents revealed that *O. ficus-indica* is currently harvested from the wild with 73.3% of the respondents stating that the abundance of the species was decreasing while 26.7% said the



**Fig. 4.** *Opuntia ficus-indica* harvesting patterns by respondents in Makana, Ngqushwa and Raymond Mhlaba Local Municipalities in the Eastern Cape (n= 132). Some respondents indicated more than one use.

opposite and no one mentioned that the population of the species had remained unchanged. Those who stated that it has increased, attributed the increase to production of many cladodes and widespread collection of its fruits resulted in improved dispersal. The respondents who mentioned that the population of *O. ficus-indica* was decreasing, attributed this change to over-collection and loss of suitable habitat for the species due to urbanisation and agricultural activities. The quantity of *O. ficus-indica* collected per month by a household varied from a few kilogrammes to more than 25 kilogrammes (Table 4). Transect walks and interviews with respondents revealed that *O. ficus-indica* fruits were sold in a variety of settings including from home, door to door, along roads and highways and in informal markets. The fruits were sold in small plastic bags or 5 litre containers, with prices ranging from R15.00 (US\$1.07) to R20.00 (US\$1.43) per plastic bag or 5 litre container. The prize of each fruit was either R1.00 (US\$0.07) or R2.00 (US\$0.14). Incomes earned over the season from the sale of *O. ficus-indica* var-

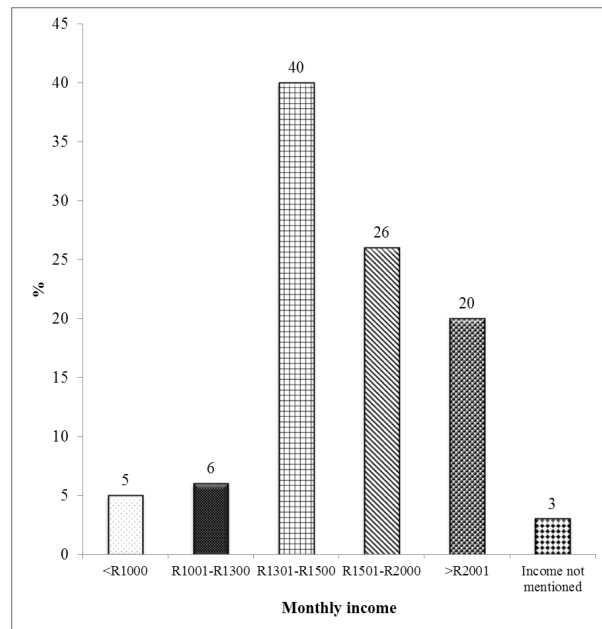
**Table 3.** The distance travelled by local people to collect *Opuntia ficus-indica* fruits in Makana, Ngqushwa and Raymond Mhlaba Local Municipalities in the Eastern Cape (n= 132). Some respondents indicated more than one response.

Distance travelled to get <i>O. ficus-indica</i> (km)	Makana	Ngqushwa	Raymond Mhlaba	Total	%
< 2	13	3	6	22	16.7
3-5	1	3	3	7	5.3
6-8	2	8	0	10	7.6
9-12	15	10	12	37	28
>15	19	16	21	56	42.4

**Table 4.** Amount of *Opuntia ficus-indica* harvested per household per month in Makana, Ngqushwa and Raymond Mhlaba Local Municipalities in the Eastern Cape (n= 132).

Amount harvested (kg)	Makana	Ngqushwa	Raymond Mhlaba	Total	%
<6	13	10	11	34	25.8
6-10	4	5	3	12	9.1
11-15	1	2	10	13	9.8
16-20	3	3	9	15	11.4
21-25	12	9	5	26	19.7
>25	17	11	12	40	30.3

ied from <R1000.00 (US\$71.43) to >R2000.00 (US\$142.86) per household (Figure 5).

**Fig. 5.** Monthly income earned by selling *Opuntia ficus-indica* fruits in Makana, Ngqushwa and Raymond Mhlaba Local Municipalities in the Eastern Cape

## Discussion

A significant number of respondents (88.0%) emphasized the importance of *O. ficus-indica* to the livelihood needs of local people in Makana, Ngqushwa and Raymond Mhlaba Local Municipalities. Local communities have incorporated *O. ficus-indica* into their livelihoods which resulted in respondents not knowing that the species is an alien. To the local communities in Makana, Ngqushwa and Raymond Mhlaba Local Municipalities, *O. ficus-indica* is categorized like any other useful plant species in the province. Such a perception was observed by dos Santos *et al.* (2014) who argued that there is often no

differentiation by local communities between invasive alien species and native species as local communities often focus on the ecosystem goods and services provided by such species. Research findings from the current investigation corroborate previous studies which showed that invasive alien plant species may also have positive economical, social and ecological significance and these uses need to be taken into account when assessing the costs resulting from invasions by alien plant species (Semenya and Maroyi, 2018). There is now a large body of evidence supporting human dependency on invasive alien plant species for food, shelter, ecosystem services, aesthetic enjoyment and cultural identity (Semenya and Maroyi, 2018). Nuñez *et al.* (2012) argued that it may be possible to control or eradicate certain invasive alien species by harvesting them as food sources. The same authors argued that using invasive alien species as an economic resource may trigger the local community to protect these species and facilitate their incorporation into the local culture. Borokini and Babalola (2012) argued that economic exploitation of invasive alien species is usually labour intensive and menial jobs are usually created while providing additional means of income for local communities. Similarly, Sladonja *et al.* (2018) argued that invasive alien plants can be used as catalysts for ecosystem restoration, source of bioenergy, honey, fibre, ornamental plants and herbal medicines.

Interviews with respondents revealed that *O. ficus-indica* is sold in local markets offering an important source of cash income. Local community members, especially poor households in Makana, Ngqushwa and Raymond Mhlaba Local Municipalities would derive much of their household income through selling *O. ficus-indica* earning approximately between <R1000.00 (US\$71.43) to >R2000.00 (US\$142.86) per month (Figure 5). For some households, selling and marketing of *O. ficus-*

*indica* is their only source of income. Previous research by Shackleton and Shackleton (2006) in the Eastern Cape province showed that many poor and unemployed households in Kat River Valley because of the absence of formal job opportunities in the area, they harvest plant products for marketing generating about R1800.00 per month. Therefore, extraction, processing, and trading of plant resources is often the only employment available for households in remote and marginalized rural and peri-urban areas (Dash and Behera, 2013). In many situations, such plant products do not generate much income for people, as recently noted in a report on community forestry in northern part of the Democratic Republic of the Congo (Ingram *et al.*, 2012) but sustainable collection, use and commercialization of these products are the main drivers in the promotion of plant resources for community development, poverty reduction and livelihood improvement and sustainable forest management (Ahenkan and Boon, 2011). This requires scientific documentation of these resources, the details of species-specific information on distribution and availability, their potential use and market frontiers (Ahenkan and Boon, 2011; Dash and Behera, 2013).

The relationship between local people and *O. ficus-indica* in the present study shows wealth of indigenous knowledge on the different aspects of plant utilization in the study area. In Makana, Ngqushwa and Raymond Mhlaba Local Municipalities, *O. ficus-indica* plays a supplementary role (88.6%) and required to meet the livelihood needs (84.1%) of some households, as the species is used to meet some parts of their nutritional, health, forage, cultural and household income (Table 2). For the poor households, collection of *O. ficus-indica* is a means of coping with food-supply, nutrition and cash income needs. Households living near suitable habitats for *O. ficus-indica* are typically most dependent on the species and these people are the most active collectors of *O. ficus-indica* in the study area. In several villages within Makana, Ngqushwa and Raymond Mhlaba Local Municipalities, the collection and gathering of *O. ficus-indica* was used as means to manage poverty and to empower local community development in different ways including community engagement, income-generating activities and cultural diversity. This high dependency on *O. ficus-indica*, particularly by the poor-income group, is indicative of their importance in the improvement of livelihoods, nutrition, and health. Not

only do *O. ficus-indica* supplement vitamins, proteins, minerals, and the nutritional requirements of the communities, they also diversify their diets and enhance their seasonal food balance (Brown *et al.*, 2011). Unfortunately, the extraction of *O. ficus-indica* from natural habitats has limited potential for improving food security and nutrition of households since this is obviously unsustainable. Interviews with participants revealed that there is a decline in the availability of *O. ficus-indica* mainly due to both anthropogenic (over-collection, land clearing for settlement and cultivation, destructive collection practices and excessive commercial harvesting) and natural drought. There is no doubt that the production of *O. ficus-indica* on a permanent basis will enormously help create more sustainable employment and income-generation opportunities, enhance food security, and improve the nutrition and health of poor households, enabling these households to continue to exploit the full potential of the species. The results of this study, therefore, calls for a review of the socio-economic benefits of exotic plants to local communities in South Africa before blindly advocating for their eradication. In addition, the extensive use of exotic plants is seen as imperative for their ultimate control and should ultimately form part of their management strategy.

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