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Community knowledge, perceptions and use of seed-oil plants: The case of Letlhakeng, Kubung and Mahetlwe villages in Kweneng District. Botswana

Gagoitseope Mmopelwa[1,*], Raban Chanda[2], Donald. L. Kgathi[3], Keotshephile Kashe[4]

[1,2]University of Botswana. P/Bag UB 00704, Gaborone Botswana
[3,4]University of Botswana, P/Bag 285, Maun, Botswana
*Corresponding author

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Abstract— *The world over, there has been increasing concern over the use of fossil fuels due to their finite availability, increasing prices and negative environmental impacts. The aim of the study was to determine the potential socio economic impacts of locally available or indigenous oil seed plants as biodiesel feedstocks. A household survey and a focussed group discussion were conducted in village of Letlhakeng and two settlements (Mahetlwe and Kubung), respectively, in Kweneng district in Botswana, to study residents' knowledge, perceptions, use of and willingness to grow local seed-oil plants which could support biodiesel production: A number of indigenous oil seed plants, including Ochna pulchra, Pappea capensis, Ximenia caffra, Ziziphus mucronata, Mimusops zeyheri and Bauhinia petersiana were identified as potential biodiesel feedstocks. The reported seed-oil plants were generally perceived to be abundant where they grow. Generally, respondents expressed a willingness to commercially gather the seed-oil plants as well as grow the plants in own farms or in marginal land under community based natural resources management (CBNRM) arrangement to supply biodiesel production. The willingness stemmed from the perceived socio-economic and environmental benefits that include employment creation, diversification of income sources, enhanced resource value and conservation and sustainable use of resources.*

Keywords*— *seed-oil plants; cultivation, biodiesel production, respondent, trees

I. INTRODUCTION

Fossil fuels have been the dominant sources of energy for a long time, however concerns on climate change, energy security and economic development have compelled the global community to search for alternative sources of energy (Raju et al., 2010; Sekoai & Yoro, 2016; The Royal Society, 2008; Thondhlana, 2014; Hussein, 2010; Günther Fischer et al., 2009). Their use as sources of energy has largely been blamed for contributing significantly to the global emissions of greenhouse gases which result in average global temperature increases (Duvenage et al., 2013; Shah et al., 2012). As they drive many economic activities, their cumulative effect has been significant. Transport sector for instance, is the largest contributor of carbon dioxide emissions in many economies (The Royal Society, 2008; Demirbas et al., 2016). Growth in population and industrialization have exacerbated their demand leading to increase in the price of oil (Sekoai & Yoro, 2016; Singh et al., 2016).

As fossil fuels are produced from non –renewable and unsustainable sources, (Raju et al 2010; Singh et al., 2016), their uncertain and finite availability and fluctuating prices threaten energy supply security of nations dependent on them (Shah et al., 2012; Sekoai & Yoro, 2016; Duvenage et al., 2013). The factors affecting the price and supply of fossil fuels are also beyond control of the importing countries.

Biofuels, which are solid, liquid and gaseous renewable fuels that can be produced from food biomass (first generation fuels such as corn), and non-food biomass (second generation fuels such as non-edible plants), have increasingly been viewed as potential replacements of conventional sources of energy as they can address climate change concerns, contribute to socio-economic development and reduce reliance on imported fossil fuels (United Nations 2008; Thangaraj & Solomon, 2020; Chhetri et al., 2008; Singh et al., 2016; Gandure & Ketlogetswe, 2011). The environmental benefits of biofuels stem from their contribution in reduction of greenhouse gases. It has been established that the CO_2 that these plants absorb for photosynthesis neutralises that which is emitted when biofuels burn (Hanaki & Portugal-Preira 2018). Sustainable Development Goal 13 advocates for taking urgent action to combat climate change and its impacts, and therefore biofuel development is one way of contributing to the achievement of this goal. The socio-economic benefits of biofuels include enhanced rural livelihoods as they generate employment opportunities for rural communities who participate in biofuel development projects (Raju et al., 2010; Thondhlana, 2014).

The development of biofuels is also in line with Botswana Vision 2036, especially Pillar 3 (Sustainable Environment) which advocates for a low carbon foot print as the society increasingly becomes aware of the consequences of climate change. The Vision also aspires for a Botswana that will be energy secure with diversified, safe and clean sources (Government of Botswana, 2016). In support of the country's Vision 2036, the National Energy Policy of Botswana seeks to direct sustainable economic development and sustainable environment by ensuring optimal usage of locally available energy resources (Government of Botswana, 2021). To attain energy self-sufficiency and increased security of supply, the Ministry of Mineral Resources, Green Technology and Energy Security will bring new and renewable energy sources into the country's energy mix. Among the initiatives aimed at achieving Vision 2036 are the identification and development of local biodiesel feedstock through research and development. According to Gandure & Ketlogetswe (2016), biodiesel which can be derived from many sources can be blended with conventional sources and used in diesel engines. Gandure et al. (2014) have demonstrated that high quality biodiesel can be produced from some of edible and non-edible indigenous oil seeds in Botswana. The plants are also readily available and require minimal management during growth (Thangaraj & Solomon, 2020). It is however, noted that the use of edible plants or crops as feedstock for biodiesel may lead to food shortage and subsequent price increases on food (Shaa et al., 2021).

The development of biodiesel from local or indigenous renewable sources is therefore expected to have many benefits including creating an opportunity to diversify current and future energy sources, increasing the security of supply of biodiesel, reducing the country's import bill of fossil fuel as well as diversifying job opportunities for the rural people whose main source of livelihood is agriculture. It is against this background that a baseline survey and focused groups were carried out to determine and evaluate the potential socio-economic impact of local biodiesel feedstock in Botswana. The specific objectives of the study were: 1) To capture respondents' knowledge of the presence and distribution of potential seed-oil plants; 2) To identify uses of indigenous seed-oil plants which potentially could also be harvested for biofuel production; 3) To study community's perceptions on social, economic and environmental impacts of commercial gathering of oil components and 4) To investigate local community's willingness to engage in commercial gathering of seeds for oil extraction.

Description of study sites

This study was conducted in Kweneng district, in the villages of Letlhakeng, Mahetlwe and Kubung (Figure 1). The choice of study villages was based on a prior survey that was carried out in Kweneng, Ngamiland, Chobe and Southern districts to identify oil seed plants used or known by communities. Letlhakeng village is situated about 60 km from Molepolole, the capital of Kweneng district. Geographically, Letlhakeng village is located 24° 5' 39.9" S 25° 1' 47.2" E. Mahetlwe village is situated about 25 kilometres north east of the village of Molepolole (24° 14' 19.9" S 25° 40' 31.4"E), while Kubung is located about 31 kilometres south west of Molepoplole (24° 37' 58.9"S 25° 18' 31.3" E). The 2011 Population census estimated Letlhakeng population at 7229, with a male and female population of 3362 and 3867, respectively, while that for Mahetlwe and Kubung was estimated at 1060 and 1085, respectively (Statistics Botswana, 2011).

The mean annual rainfall in the area is about 420 mm (McLeod, 1995) with most of the rainfall occurring in summer. The minimum temperature of 7.4^0C occurs in July and the maximum temperature of 36^0C occurs in January. The villages are situated in the sandveld area and the soils in the area are deep, acidic and red-brown in colour (McLeod, 1995). The vegetation can be generally described as tree and savannah dominated by small-leaved tree species especially acacia species. Economic activities include subsistence agriculture. Cattle and goat rearing are important livelihoods while crop production is affected by poor soils (McLeod, 1995).

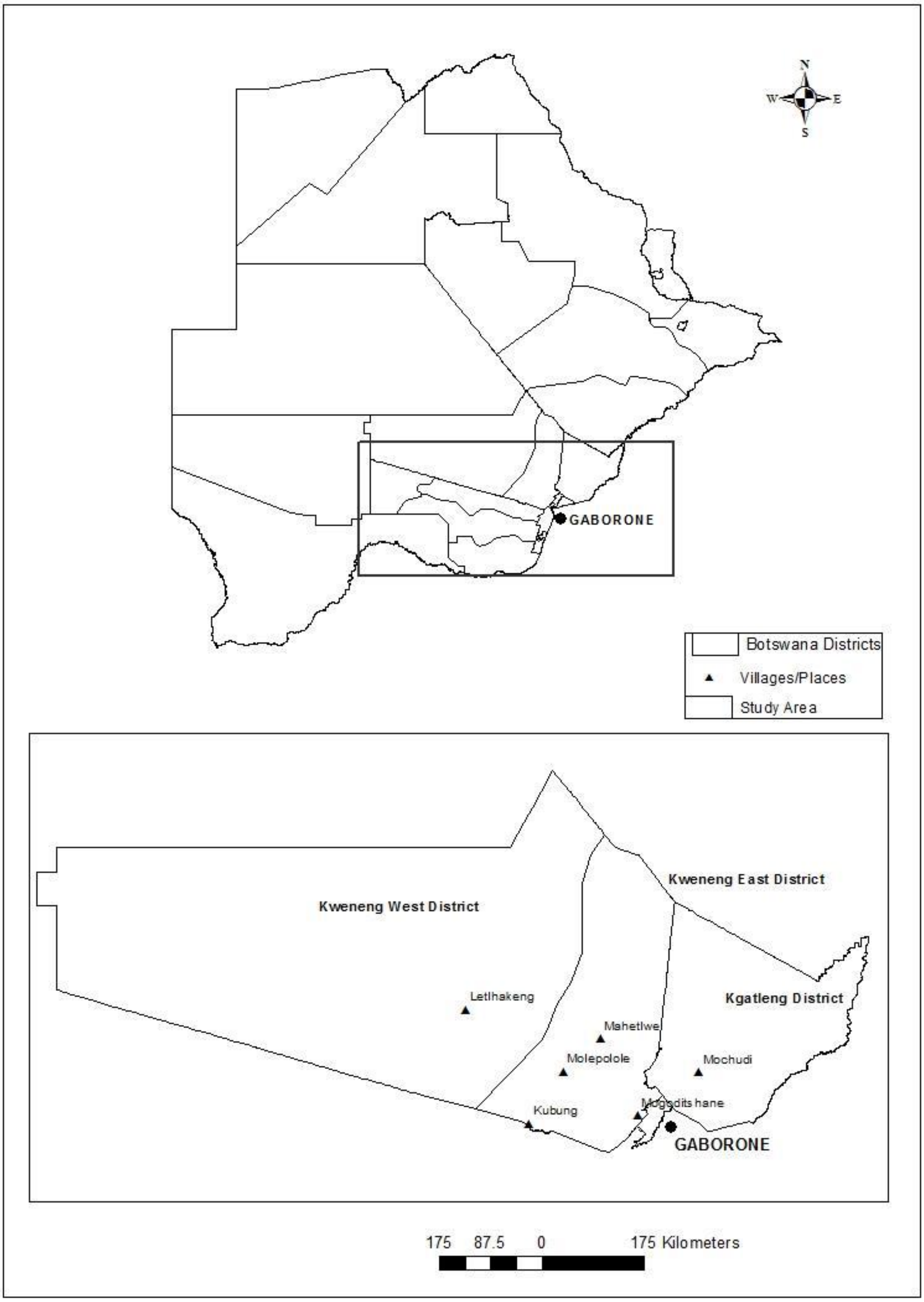

Fig.1: Location of study sites

II. RESEARCH METHODOLOGY

Data collection and Sampling

Two methods of data collection were employed: household interviews using a semi- structured questionnaire and focussed group discussion. The household interviews were conducted in Letlhakeng village, while focussed group discussions were conducted in both Mahetlwe and Kubung villages.

For purposes of sampling in Letlhakeng, a map of the village with plot numbers was obtained from Statistics Office in Gaborone. An existing traffic circle at the centre of the village was used as the starting point from where the sampling was carried out. Starting from this traffic circle, the entire village was divided into 6 clusters. All the plot numbers in the each cluster were listed and counted (Table 1). All undeveloped and business (commercial) plots were excluded from the sampling. The total number of plots counted was 3740 and the targeted sample size was 200 households. Using proportional sampling, the number of plots in each cluster was determined. The plots were then selected using random numbers. Due to the high number of selected respondents that were not present during the survey, the number of respondents interviewed were 156.

Table 1. Clusters and number of sampled households in Letlhakeng

Cluster	Households in each cluster	Proportionate sample
1	1237	66
2	702	38
3	578	31
4	362	19
5	190	10
6	669	36
Total	3740	200

The face-to-face interviews were directed to heads of households. Data was collected on the following aspects: demographic characteristics of respondents, respond's knowledge of seed-oil plants in the area (including plant species, occurrence and abundance, uses of different plant parts, purpose of oil extraction (if any), respondents' local willingness to commercially gather plants parts for oil extraction, respondents' perceptions on social, economic and environmental impacts of commercial gathering of seed-oil plants. The questionnaire was administered by well-trained research assistants.

In the villages of Mahetlwe and Kubung, data was collected by conducting a focussed group discussion in each village. Prior to conducting the group meetings, the research team visited the village leaders and members of the Village Development Committee to inform them about the project and to request them to assist with selection of community members who could form part of the discussion groups. The criterion of selection or inclusion in the group included mainly elderly people with at least 35 years of age with possible knowledge of these plants. The research team desired to have at least 10-12 members in a group, however the decision to participate in the discussion rested with the suggested individuals. In Mahetlwe village the focussed group comprised 3 males and females, while in Kubung village the group comprised 9 males and 5 females. A range of issues were discussed including the following: seed-oil plants used currently and in the past, availability of seed-oil plants and other general uses of these plants, taboos associated with the use of seed-oil plants, extraction and uses of oil, views on commercial gathering of seeds for oil extraction and growing seed-oil plants on existing arable or new land. Each discussion lasted about 2 hours.

Data Analysis

Data collected from the household survey was entered into SPSS and both descriptive and inferential analyses were done. Descriptive analysis was done using summary statistics (e.g. mean and standard deviation) and the data was presented in the form frequency tables, table of proportions/percentages and different graphs. Inferential analysis was carried out using Chi square test and binary Logistic regression. The Chi-square was used to test for independence or association between categorical variables. For the logistic regression analysis, the dependent or response variable was willingness to engage in contract farming for the cultivation of seed-oil plants (*Yes = 1; No = 2*). The independent or predictor variables were Gender (*Male = 1; Female = 2*), Land ownership (*Own land = 1: Does not own land = 2*), Head of household (*Yes = 1; No = 2*); Size of the household, and Preference of cultivation of seed-oil plants on new land (*Yes = 1; No = 2*). The data collected from the focussed group discussions was presented thematically and the results were compared with those in the household survey and existing literature.

III. RESULTS AND DISCUSSION

Socio-demographic characteristics of respondents

The socio-demographic variables of the respondents are presented in Table 2. The respondents comprised more females than males, and their age ranged from 18 to 89 of age years old (*mean* = 51 years; *sd* = 16 years)). Respondents pursue diverse livelihoods, including formal and self-employment, Ipelegeng (Government drought relief programme), arable farming, livestock farming, old-age pension scheme, Government grants- food basket, and menial jobs. Government Drought Relief Programme has become the main source of temporary employment for many rural households. Livestock farming is still regarded as an important economic activity but was not ranked as highly as other activities. Infact it was found that a high number of households do not own cattle, with most of the households being female-headed (Figure 2). It is noted however, that traditional cattle rearing in Botswana is a male-associated activity. Other livestock in the area include cattle, goats, sheep, donkeys, and chickens. In terms of arable farming, more than half of the respondents (59.6%) own land with a mean size of 2.0 hectares/farmer (*sd = 6.60 hectares*). Crops grown include sorghum, maize, beans, watermelons, sweet-reed, groundnuts and lab-lab as cattle feed.

Table 2. Socio- demographic variables of respondents in Letlhakeng

Variable		
Gender	Male	32.7%
	Female	67.3%
Age	Maximum	18 years
	Minimum	89 years
Household size	Maximum	25 persons
	Minimum	1 persons
Livelihood source	Main	Ipelegeng
	Least	Menial Jobs
Household income	<BWP 530	60.3%
	BWP530	1.3%
	BWP 500-1000	21.8%
	BWP2000-2500	0.6%
	>BWP3000	1.3%
Size of land	Maximum	37 hectares
	Minimum	2.0 hectares
Education	No formal education	39%
	Primary education	22%
	Junior secondary education	30%
	Senior secondary education	5%
	Tertiary education	6%

Most of the respondents (60.3%) in the survey also reported that they do not receive a regular monthly income. Only 13.5% of the respondents reported to earn an income of less than P530, which is the level set by government for the old-age pension scheme, while 23.1% of the respondents receive an income between P500 and P1000. Only one respondent (0.64%) reported to earn an income of between P2000 and P2500, while 2 respondents (1.3%) reported to earn at least P3000.00.

In terms of education, most of the respondents (38.5%) had no formal education while the least number of respondents (5%) were those who had senior secondary as their highest level of education (Table 2).

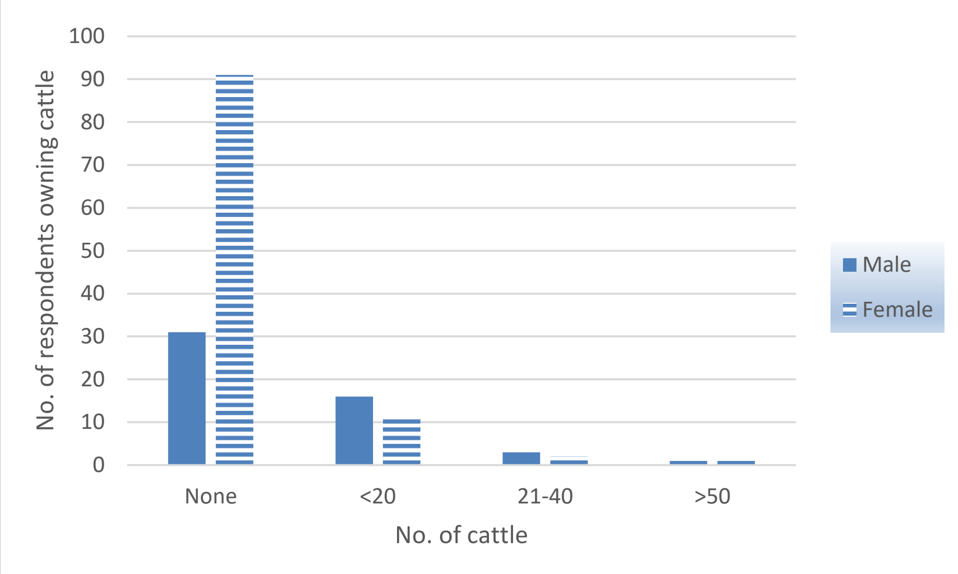

Fig.2. Male and female ownership of cattle in Letlhakeng

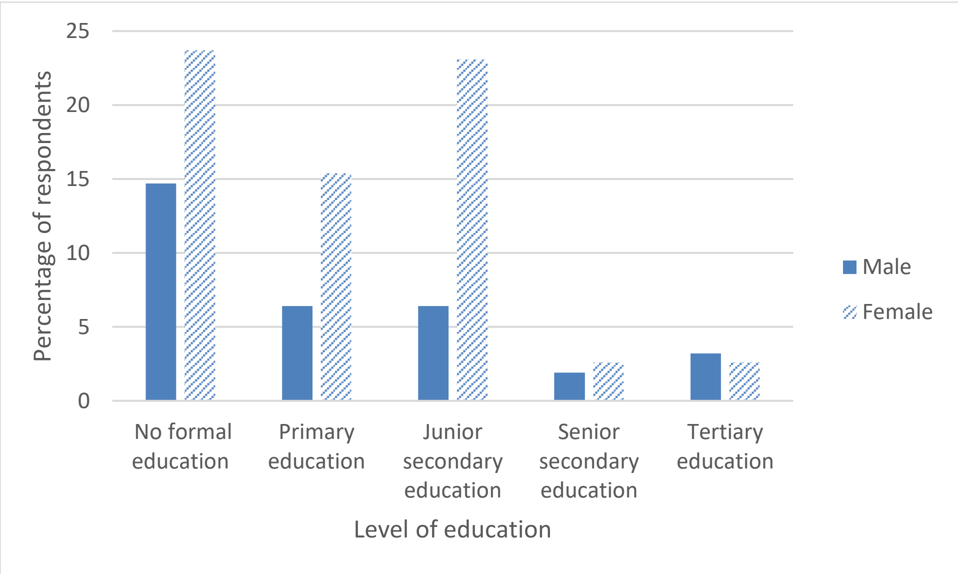

Fig.3: Respondents' level of education in Letlhakeng

Respondents knowledge of potential oil plants in the area

Prior to asking respondents in Letlhakeng about their knowledge of potential seed-oil plants, they were first asked to indicate how long they have lived in the area, and when they first saw the particular tree/shrub species. Most of the respondents indicated that they were born and raised in Letlhakeng and had seen these plants growing around. Table 3 shows the tree/shrub species reported by the respondents. It seems that *Ximenia caffra* is a commonly growing species in the area as it was reported by all respondents. This is followed by *Ochna pulchra*

Table 3. Seed-oil plants growing in and around Letlhakeng

Plant Species	**Local Name**	**English Name**	**Seen since childhood (%)**	**Never seen the plant (%)**
Ochna pulchra	Monyelenyele/Monamane	Pealing buck ochna	63.4	36.6
Pappea capensis	Mopenewena	Jacket plum	14.10	85.9
Ximenia caffra	Moretologa	Wild plum,	100	0
Ziziphus mucronata	Mokgalo	Buffalo thorn	9.0	99.1

In the village of Mahetlwe the focussed group listed the following seed-oil plants: Morama bean (*Tylosemm esculentum*), Mositsane (*Elephantorrhiza goetsei*), Marago a bahumagadi (*Grewia avellana),* Morula (*Sclerocarya birrea),* Moretologa (*Ximenia caffra*), Mokgalo (*Ziziphus mucronata*), Mmopudu (*Mimusops zeyheri*) and various melon seeds (*Citrullus lanatus, Citrullus vulgaries*). In the village of Kubung, the following plants were listed: Morula (*Sclerocarya birrea),* Morama (*Tylosemm esculentum*), Moretologa (*Ximenia caffra*), Mositsane (*Elephantorrhiza goetsei*), Mogose (*Bauhinia petersiana*) and various seeds of melons (*Citrullus lanatus*, *Citrullus vulgaries (mokapane)*. A member of the focussed group in Kubung stated that of the known seed-oil plants in the area, *Ximenia caffra* had the highest oil yield.

Respondents in Letlhakeng were also asked to indicate their perceptions regarding the abundances of the seed-oil plants (Table 4). *Ximenia caffra* was perceived to be abundant by 63% of the respondents. Most of the respondents could not state whether *Ochna pulchra*, *Pappea capensis*, *Jatropha curcas and* Ziziphus *mucronata* were abundant or not.

Table 4. Respondents views on plant species occurrences and abundance in Letlhakeng (%)

Tree species	**Abundant (many)**	**Not abundant (Few)**	**Don't know**
Ochna pulchra	34.6	25.6	37.8
Pappea capensis	2.6	1.3	82.7
Ximenia caffra	63.1	34.0	1.9
Jatropha curcas	0	0	100
Ziziphus mucronata	10.3	0	89.2

Focussed group discussions in Mahetlwe and Kubung also revealed that *Ximenia caffra* is one of the abundant tree species in the area despite its many uses that can threaten its populations. They further indicated that *Ximenia caffra* seemed to be quite drought resistant. With regard to *Sclerocarya birrea*, they noted that the tree is not abundant in their area and occurs sporadically. According to BirdLife Botswana (2017), *Sclerocarya birrea* occurs mostly in the eastern, south-eastern, and northern parts of the country. In Kubung *Tylosemm esculentum* was regarded as more abundant is Kweneng west region than in other regions. According to Travolos and Karamanos (2008), *Tylosemm esculentum* grows under a wide range of environmental conditions, avoiding drought by storing water in its tubers and reducing water losses through stomatal movement.

Uses of different plant components

Seed-oil plants, in addition to producing oil, have many other uses (Table 5). The uses were revealed by respondents based on their actual use of the plants or general knowledge possessed by the villagers, especially the elderly. Woody plant components such as branches and stems are generally used for fencing, construction, carving, making traditional implements and as sources of fuelwood. Leaves of most plants are browsed by livestock, especially small stock, and are also used as traditional medicines. The roots and barks for certain plants are used mainly for treatment of various ailments or conditions including blood pressure, muscle pains or spasm, toothaches, chest pains and stomach ailments.

The use of *Ochna pulchra* seeds as a source of oil has also been reported by other researchers (e.g. Mogotsi & Ngwako, 2015; Leger, 1997). The oil extracted from the berries is used for cooking purposes, and according to

Leger (1997), the oil is extracted by first cooking the fruits to separate the oil from the kernel which is then skimmed off. Mogotsi & Ngwako (2015) and Magwede et al. (2019) reported that *Ochna pulchra* is used for curving purposes and as a source of fuelwood.

Pappea capensis, a well distributed tree in Africa is also a tree of economic importance as the fruits are commonly eaten by humans (Rafiri, 2010). According to Rafiri (2010), the seeds of *Pappea capensis* contain a high concentration of oil with a potential to be used for biodiesel production. Du Toit el al. (2011) reported that the oil from seeds of *Pappea capensis* was found to be suitable for biodiesel production in South Africa as B5 blend. For other uses of *Pappea capensis*, Tajuddeen et al. (2021) reported that leaves have traditionally been used for the treatment of malaria by the Masia and Kikuyu people of Kenya, the Venada of South Africa and the Gumuz of Ethiopia. The stem, bark, leaf and oil of *Pappea capensis* have also been traditionally used for the treatment of ringworms, nosebleed, baldness, chest complaints, eye infection (Ngai et al., 2017). In their study to determine the anti-diabetic activity of dichloromethane (DCM), Nagai et al. (2017) found that the leaves and bark extracts of *Pappea capensis* were effective against anti-diabetic activity and recommended the parts be considered in the development of herbal products for the treatment of diabetes.

Respondents in the household survey were asked if they have ever extracted oil from any of the plants mentioned. *Ximenia caffra* was the only plant that was mentioned (15.4% of the respondents) in this regard. None of the respondents mentioned any biodiesel production related uses. The mentioned uses of oil were treating/tanning leather, treatment of wounds and the skin (ointment). Some of the mentioned of uses of *Ximenia caffra* oil are similar to those reported in some parts of Angola where the oil has been used for preventing sunburn, softening the skin, preventing stretch marks as well as conditioning the hair (Satoto et al., 2019; Urso et al., 2013). In Ethiopia *Ximenia caffra* oil is extracted from the fruit kernel and used to treat human and animal diseases (Kefelegn & Desta, 2021), while in Kenya the oil has been used to supplement kerosene when blended with kerosene in the ratio of above 10% (Kibuge et al., 2015). Nair et al. (2013) reported many uses of *Ximenia caffra* including nutritional, comestic, biofuel and medicinal. According to these authors the fruit of *Ximenia caffra* is a rich source of protein, potassium and vitamins, while the extract from the plant is used to treat sexually transmitted diseases. Bultosa et al. (2020) found that *Ximenia caffra* contains 59.4% of oleic acid, while *Mimusops zeyheri* (Mmupudu) contains 55.7% of oleic acid which is a component of human diet having many health benefits such as reduction of cholesterol, improving human health and immune system.

It is interesting to note that none of respondents in the study mentioned to have extracted oil from *Jatropha carcus*, whose fruits are well known rich sources of oil. *Jatropha carcus* was seen in most of respondents' yards during the survey and discussions with respondents indicated that they are not aware of its oil properties except for using it as an ornamental plant and to provide shade. *Jatropha curcas* has been identified as one of the potential substitutes for conventional sources of energy as the oil from the fruit can be used in biodiesel production (Firdaus & Husni, 2012). It is also well known for its properties of thriving in marginal lands, maturing early and producing a significant amount of oil from its seeds (Aigba et al., 2021; Chhetri et al., 2008).

Table 5. Reported known uses of plants' parts

Plant species	**Plant part and uses**				
	Leaves	**Stem/Branch**	**Root**	**Fruit**	**Seed/oil**
Ochna pulchra	Animal browse	Carving Fencing Firewood	Traditional medicine	Animal browse Edible	Animal browse
Pappea capensis	Animal browse	Firewood Costruction		Edible	
Ximenia caffra	Animal browse	Firewood; Construction	Traditional medicine	Edible	Oil for leather treatment
Ziziphus mucronata	Traditional medicine	Building Carving	Traditional medicine	Edible	

Focussed group members in MahetLwe and Kubung villages mentioned that the oil from seeds of *Ximenia caffra* and *Ziziphus mucronata* were generally used for tanning the skins. They explained that the seed cake of these two plants is usually mixed with animal brains (goats or sheep), and then applied uniformly on the dry skin. Mangalo et al. (2020) reported that the bark for *Ziziphus mucronata* has been used in the treatment of various infections such as sexually transmitted infections and sores. For *Elephantorrhiza goetsei*, the red coloured extracts from the tuber is applied on the skin to give it a brighter colour. The use of plant oil for these purposes is similar to what other studies have found in other parts of Botswana. For instance, in Hukuntsi sub-district of Kgalagadi District, Koloka & Moreki (2011) found that *Elephatina elephantorrhiza* (mositsane) and *Terminalia cericea* (mogonono) were used vegetable tanning agents with *Elephatina elephantorrhiza* (mositsane) being the commonest.

With regard to the use of *Sclerocarya birrea*, the discussions revealed that human consumption of fresh fruit was the main use of the tree. Elsewhere and in other parts of Botswana country, the oil extracted from the kernel of *Sclerocarya birrea* is used for cosmetic purposes, massaging and as a base for soap making (Vermark et al., 2011). The fruit is also used to make traditional beer as well as juice that is high in vitamin C (Mojeremane & Tshwenyane, 2004; Motlhanka & Makhabu, 2011; Rossiter et al., 1997). With regard to the use of oil from *Sclerocarya birrea* for biodiesel production, Gandure and Ketlogetswe (2011) carried out an assessment of oil from this tree and that from *Tylosemm esculentum* and *Ximenia caffra* and found that *Sclerocarya birrea* has a good energy content of 48.4 MJ/kg, reflecting that it can support biodiesel production. For *Tylosemm esculentum and Ximenia caffra,* Gandure and Ketlogetswe (2011) established that their oil acidity were below 0.8KOH which indicates that they can be used in diesel combustion engines. For the Morama bean plant (*Tylosemm esculentum*), the focussed group discussions revealed that the seeds of this plant are roasted and eaten by humans. The various uses of these plants species clearly present a case of food-oil conflict especially when the demand for their oil for biodiesel production increases.

Another important tree species mentioned during the focussed group discussions in Kubung is *Bauhinia petersiana*. The discussions revealed that the seeds (nuts) of *Bauhinia petersiana*, often contained in brownish pods, are commonly roasted and eaten by humans. Vengesai et al. (2021) also reported that the seeds can be boiled in oil and water and eaten as relish. Studies conducted elsewhere, e.g. Amonsou et al. (2014) have established that seeds of *Bauhinia petersiana* contain significant amounts of potassium, phosphorus, magnesium and calcium, zinc and iron. According to Brinc & Belay (2006), the seeds of *Bauhinia petersiana* are also grounded and used as coffee, and that a mixture of boiled leaves and roots is used to treat the common cough and wounds.

One of the important sources of vegetable oil mentioned during the focussed discussions is the melon seeds. It was explained that the melon seeds are pounded and mixed with traditional foods to make relish or improve the taste of traditional food. For instance, the crushed seeds of common water melons and cooking melons are often mixed with edible traditional vegetables to improve their taste. In Namibia, Cheikhyoussef et al. (2017) reported that the oil extracted from *Citrullus lanatus* is used for commercial, healing, massaging and as well as cosmetic purposes. Cheikhyoussef et al. (2017) also estimated the oil content of *Citrullus lanatus* to be 40.16±3.45%. In Nigeria Sani et al. (2018) investigated the physico-chemical properties of biodiesel from *Citrullus lanatus* blended with 5% (B5), 10% (B10), 15% (B15), 20% (B20) and 25% (B25) of petro-diesel and found that the properties to be within the American Society for Testing and Materials (ASTMs) standards for biodiesel. Various tests done earlier by Ogunwole (2015) also showed that biodiesel from *Citrullus lanatus* was within the ASTM diesel, and therefore an alternative for diesel engines.

Taboos and use of seed-oil plants

The use of certain tree species is associated with social taboos, which are prohibitions to do certain practices within a society (Angsongna, 2016). The taboos are passed from generation to generation and it is believed that they help shape or instil correct behaviour within members of the society. Some of the taboos associated with the use of certain species in this study include the strict non-use of some of the tree species as sources of fuelwood and prohibition of cutting certain tree species during certain seasons of the year, especially the dry season. It is believed that the breaking of these taboos could lead to one falling sick, experiencing bad luck, being stricken by lightning, etc. The effectiveness of upholding the taboos is with regard to protecting or conserving plants known to support livelihoods, plants threatened by overuse or those considered to be sacred by the community (Colding & Folke, 2019; Angsongna et al., 2016). For example, it is prohibited to use plants such as *Diospyros lycioides* as sources of fuelwood because of the unique medicinal properties that the plant possesses. Besides, there are several woody species that are more suitable sources of fuelwood.

Respondents local willingness for any commercial gathering of plants parts for oil extraction

Respondents were presented with a hypothetical scenario whereby a local company would be engaged in extraction of oil for biodiesel production. They were then asked if they would be willing to participate in commercial gathering of feedstock (seeds) from the wild. Majority of the respondents 139 (89.1%) indicated that they would be willing to participate in commercial gathering of seeds, while 16 (10.3%) would not. Those willing to participate in the project indicated that a project of this nature would have positive socio-economic and environmental benefits. First, respondents indicated that local availability of and free access to seed-oil plants would make their participation easier as they would be able to continue with their normal lives. Second, the use of plant feedstock for biodiesel production would enhance knowledge and value of local plants. Knowledge and awareness of the potential social and economic values of local plants would inevitably, lead to conservation and sustainable use of seed-oil plants. Third, the project would provide employment and sustainable income for many people in poverty. Employment of young people by the project would keep them away from engaging in deviant behaviour as well as reduce their dependency on government. Furthermore, expansion of the project into other areas or districts is expected to stimulate local infrastructure development. The project would also have the potential to improve local economic diversification leading to increased livelihood options. Lastly, production of biodiesel from such feedstock will generate the necessary foreign exchange and improve energy security.

Notwithstanding the perceived benefits of the projects, respondents that would not be willing to participate in the project expressed the fear that the project may possibly restrict access to local resources by introducing strict regulations on them. Some of the respondents feared that the project would have negative environmental impacts. For instance, they explained that the use of open access resources to promote commercial endeavours would result in local conflicts and unsustainable use of these resources leading to loss of certain plant species.

Some of the positive and negative impacts of the perceived biodiesel project are similar to those of small and large scale jatropha projects undertaken in some parts of Africa. Such projects include those that were evaluated by Maltitz et al. (2016) in Malawi and Mozambique. The evaluation entailed assessing the impact of jatropha plantation projects on ecosystem services, local human well-being, and poverty alleviation. In Mozambique, a large plantation commercial company, Niqel, cleared large tracts of land for purpose of cultivating jatropha, while in Malawi, a private company, BERL, involved small scale farmers in contract farming to grow jatropha as hedges between their farms where the company would purchase seeds from the farmers (Maltitz et al., 2016). In terms of benefits, Nigel provided employment to 230 full-time farmers and 85-150 seasonal workers, improved road infrastructure in the area and injected cash in the area. In Malawi the return to labour for BERL was estimated at US$1.36 per 8 hour day. The negative impacts of these projects especially Niqel, included the conversion of large area of woodland to commercial uses that was formally used for other activities such as grazing. The clearing of land also displaced some farmers from their land.

Respondents perceptions on cultivation of seed-oil plants

An alternative scenario to commercial gathering of seeds from the wild was also presented to the respondents. In this scenario, respondents were asked if they would consider engaging in contract farming to cultivate seed-oil plants to support biodiesel production. A majority (93.2%) of the respondent indicated a willingness to engage in contract farming. However, engaging in contract farming will depend on the availability of two important production inputs, namely, land and labour. Respondents were then asked if they would devote all or part of their land to cultivation. Most of them indicated that they would prefer using part of their arable land for the cultivation of seed-oil plants (Table 6). Notwithstanding these responses, the decision to use agricultural land for the cultivation of seed-oil plants is generally discouraged as this may lead to reduced food availability (Rosillo-Calle, 2012; Thondhlana, 2014). It is also important to note that while farmers expressed the desire to use part of their land for the cultivation of seed-oil plants, majority of them owned only a small amount of land. The results of Chi-square analysis did not show evidence of any association between size of land and the decision to use part of the land for seed-oil plants cultivation ($X^2 = 91.125; P = 0.064$), which means that they disregarded the size of land and the opportunity cost of such a decision. Some members of the focussed groups in Mahetlwe and Kubung also expressed the desire to engage in contract farming. In Mahetlwe village the discussions revealed that a number of fields had lain fallow for several years' mainly due lack of rainfall. They indicated that such fields could be used for the cultivation of oil seed plants.

Table 6. Respondents views on land for the cultivation of seed-oil plants (%)

Response	**Devote all land to cultivation**	**Use part of family land to cultivation**
Strongly Agree	22.4	72.4
Agree	10.3	9.6
Neither Agree nor Disagree	8.3	4.5
Disagree	48.1	7.7
Strongly disagree	10.9	5.8
TOTAL	100	100

The results of logistic regression for the household survey results in Letlhakeng showed that the willingness to engage in contract farming was influenced by gender ($p < 0.05$) and preference for cultivation of seed-oil plants on new land ($p < 0.05$) (Table 7). Thus, men were more likely to engage in contract farming than women. Other variables such as Ownership of land, Household size, Head of household were not significant. The signs for the coefficients for Own land, House size and Gender are negative, implying that respondents who own land, respondents with bigger-sized families and males respondents, were not likely to engage in contract farming.

The focussed group discussions in Mahetlwe and Kung villages suggested that seed-oil plants should be grown on new land under a plantation managed by farmers under common property arrangement.

Table 7. Logistic regression analysis for households in Letlhakeng

Variable	(β)	SE	Wald	df	Sig	EX(β)
Own_land	-2.159	1.0509	2.045	1	0.53	0.115
HH_Size	-0.114	0.157	0.526	1	0.468	0.892
HH_Head	2.449	1.630	2.257	1	0.133	11.574
Gender	-5.013	2.370	4.473	1	0.034	0.007
New_Land	2.888	0.841	11.807	1	0.001	17.959
Constant	-2.928	3.026	0.936	1	0.333	0.054

Respondents in the household survey were also asked how they would allocate hired and family labour under contract farming. Figure 4 shows that respondents were almost indifferent about using family or hired labour in the cultivation of seed-oil plants. A Chi-square analysis showed evidence of a highly significant association between willingness to engage in contract farming and using family labour in the cultivation ($X^2 = 52.970; P = 0.000$). The analysis also showed a highly significant association between willingness to engage in contract farming and using company hired labour in the cultivation ($X^2 = 36.401; P = 0.000$), implying that it did not matter to the respondents whether hired or family labour was engaged in the cultivation of seed-oil plants.

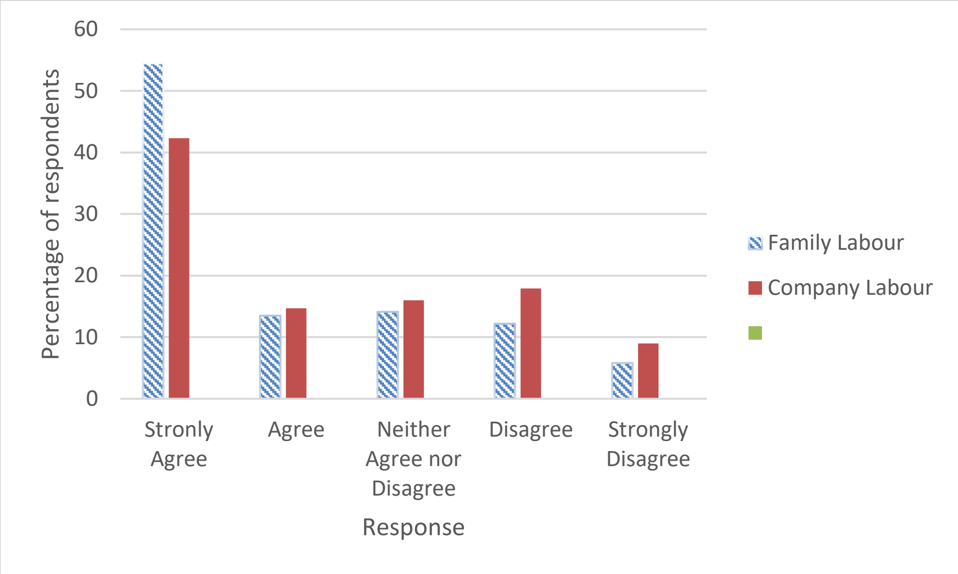

Fig.4: Respondents views on labour use under contract farming

IV. CONCLUSIONS

This study provided some insights about potential seed-oil plants in Kweneng district. The seed-oil plants identified included *Ximenia caffra*, *Sclerocarya birrea*, *Bauhinia petersiana*, *Mimusops zeyheri*, *Tylosemm esculentum*, *Ziziphus mucronata*, *Citrullus lanatus* and *Citrullus vulgaries.* The general perception of the respondents is that seed-oil plants growing in the study area, especially *Ximenia caffra*, are still abundant. The respondent had good knowledge of the general uses of plant parts such as leaves, roots, wood and bark. The various uses include construction, fencing and treatment of several body ailments from extracts of leaves, roots or bark. The reported uses of these plants' parts are consistent with what has been reported in literature where some of these plants are exploited for subsistence and commercial purposes. The study revealed that respondent's knowledge of the use of extracted oil from the seeds of these plants was limited to only traditional uses such as cooking and treatment of body ailments. None of the respondents had any knowledge of the use of oil for biodiesel production. Furthermore, the fruit or seed of almost all of the seed-oil plants mentioned is edible, implying that the use of the seed for biodiesel production will potentially affect the availability of food for those dependent on wild foods for their nutritional needs. There is therefore need to screen non-edible oil seeds in other parts of the country for their potential as biodiesel feedstock and to investigate their economic oil yield. For example, the biodiesel production potential of non-edible plants such as *Jatropha carcus* is not known in the study area, and the plant is used for ornamental purposes and to provide shade.

The results of the study also revealed respondents' willingness to engage in commercial collection or gathering of seeds from the wild. The willingness stemmed from the perceived socio-economic and environmental benefits of using the seeds of these plants as biodiesel feedstock. The perceived benefits included employment creation, diversification of income sources, enhanced resource value, conservation and sustainable use of the resources. The perceived benefits further generated willingness of the communities to cultivate seed-oil plants either on unused (fallowed) agricultural land under contract farming or on new land under a plantation model managed through a community trust. It is recommended that the decision to grow seed-oil plants under this model be based on scientific studies that would have demonstrated economic viability of such projects. Important considerations would include determination of economic or sustainable oil yield of the identified oil-seed plants under different scenarios.

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