# REPORT OF THE STUDY ON THE ABUNDANCE AND UTILIZATION OF *MORINGA OLEIFERA* LAM. FOR FOOD, WATER TREATMENT, MEDICINES AND FARM FORESTRY/AGROFORESTRY IN THE COAST PROVINCE, WITH PARTICULAR REFERENCE TO GOSHI, GANDA AND JILORE LOCATIONS OF MALINDI DISTRICT, KENYA

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**Cover photograph:** Moringa trees managed (pollarded) for leaf vegetable production in the backyard of a grower in Ganda location, Malindi district, Coast province, Kenya

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**SUMMARY**

The Farm Forestry and Natural resources Conservation Project around Arabuko-Sokoke-Goshi, Coast Province of the Republic of Kenya (B7-6201/2000-02), hereafter referred to as 'the project', commissioned the study on the abundance and utilization of *Moringa oleifera* (hereafter referred to as moringa) for food, water treatment, medicines and farm forestry/agroforestry around the project area of Goshi, Ganda and Jilore locations of Malindi District, Kenya.

The purpose of the study was to provide and generate information relating to the extent of cultivation, uses, production, marketing and socio-economics of moringa growers within the coastal area with special emphasis to the project area.

The study approach and methodology included; consultations and discussions with the project leader and team members, collection of relevant information and literature, reconnaissance of the project area, interviews with farmers and other stakeholders, and data collection, management, analysis and writing and presentation of the report.

The major findings were:

- About 53% of households interviewed within the project area cultivated moringa, with one the oldest living growers having established his moringa trees in 1961. The number of moringa saplings or trees ranged from one to 100, with an average of 12 per household. Ganda location had the greatest extent and number of moringa growers, followed by Goshi and then Jilore locations.
- The most common utilization of moringa was found to be its leaves, used mainly to blend with the traditional vegetables. Other uses that were mentioned included; water clarification and medicinal purposes.
- Moringa was mainly propagated using seed and the trees were managed by coppicing, pollarding or pruning.
- There was no evidence of markets and marketing activities of moringa products within the project area and the nearby Malindi and Kilifi towns. The only

exception was one grower who on very rare occasions sold moringa leaves as fresh vegetables in the neighbourhood. The nearest markets were in Mombasa, which received its moringa products (green pods) from moringa growers living around the town and nearby Likoni area.

- Most of the households were poor subsistence farmers, but owned their lands or households. Land ownership in the project area ranged from one to 33 acres per household. Majority of the households (80%) were male headed. The males also made the day to day decisions.
- Although a number of Government Departments, Non-Governmental Organizations (NGOs) and Community Based Organizations (CBOs) operated within or around the project area, none was found to have activities related to the domestication of moringa. Nonetheless, these organizations have between them a wealth of human resource base in relevant disciplines and capacity which could be tapped to enhance the promotion, cultivation, production, utilization and marketing of moringa products within the project area.

In conclusion, the information generated from this study with respect to the extant biophysical performance, profitability, feasibility and acceptability indicated a high potential for adoption of moringa technologies in the project area. However, a detailed diagnostic and appraisal survey will be required in the near future to establish the extent of adoption since dissemination of moringa technologies in the project area has only just been initiated by the project in earnest. In order for the present initiative on moringa cultivation to be sustainable, an equally proactive initiative should be undertaken to empower the moringa growers within the project area to be self reliant on information and information gathering regarding the appropriate cultivation and management practices, production, product development, and market and marketing strategies for their moringa products.

**LIST OF ACRONYMS**

| | |
|---|---|
| ACP | African, Caribbean and Pacific States |
| AFLP | Amplified Fragment Length Polymorphism |
| AliSEi | Associazione per la Cooperazione Internazionale e l'Aiuto Umanitario |
| CBOs | Community Based Organizations (CBOs) |
| CDE | The Centre for the Development of Enterprise |
| CTA | The Technical Centre for Agricultural and Rural Development |
| CWS | Church World Service |
| DFID | Department for International Development |
| DNA | Deoxyribonucleic acid |
| FADA | Forest Adjacent Dwellers Association |
| FAO | Food and Agriculture Organization of the United Nations |
| FOB | Free on Board |
| KARI | Kenya Agricultural Research Institute |
| KEFRI | Kenya Forestry Research Institute |
| Masl | Metres above seal level |
| NGOs | Non Governmental Organizations |
| PMO | Product Market Opportunity |
| PROPAGE | The Association for the Promotion and Propagation of Arid and Semi-arid Lands Plants |
| RAPD | Randomly Amplified Polymorphic DNA |
| TOR | Terms of Reference |

# 1. INTRODUCTION

## 1.1. About the species

*Moringa oleifera* Lam. (syn. *M. pterygosperma* Gaert.) also popularly known as the annual drumstick or the horseradish tree, belongs to a monogeneric family of trees and shrubs, the Moringaceae (Ramachandran *et al.*, 1980; Jahn *et al.*, 1986, Muluvi *et al.*, 1999, Olson 2001). There are at least 13 species of *Moringa* within this family. Although a native of the sub-Himalayan regions of north west India, *Moringa oleifera* (hereafter referred to as moringa) is now widely naturalized in many countries of Africa, Arabia, South East Asia, the Pacific and Caribbean Islands and South America (Verdcourt, 1985), and is also the only species within the family Moringaceace that has been accorded much attention. The common names; the 'horseradish' tree arise from the taste of the condiment prepared from the roots, and the 'drumstick' tree arise from the shape of the pods. Moringa has a host of other country specific vernacular names, an indication of the importance of the tree around the world wherever it has been introduced. The highly valued fruit and seed products of moringa have perhaps been the most important factors which have been responsible for its rapid dispersal from its origin to many parts of the tropical world over the last century.

There is an immense amount of botanical literature relating to its description and ecology. Briefly, the tree ranges in height from 5-15 m with an open, umbrella shaped crown, straight trunk (10-30 cm thick) with corky, whitish bark. The tree produces a tuberous tap root which helps explain its observed tolerance to drought stress. The evergreen or deciduous foliage (depending on climate) has leaflets 1-2 cm in diameter, the flowers are pleasantly fragranced. White or cream coloured and are borne profusely in axilliary drooping panicles 10-25 cm long. The fruits or pods are initially light green, slim and tender eventually becoming dark green and firm up to 120 cm long depending on genotype or variety. The pods turn brown when dry. Fully mature, dried seeds are round or triangular in shape, the kernel surrounded by a lightly wooded shell with papery wings (Verdcourt, 1985; Morton, 1991; Beentje, 1994; Ram, 1994).

Originally considered a tree of hot, semi-arid regions (annual rainfall 250-1500 mm) it has also been found to be well adapted to hot, humid, wet conditions with annual rainfall in excess of 3000 mm (Ram, 1994). The tree was originally considered suitable for lowland cultivation at altitudes less than 600 mm. However, the adaptability of the tree has been demonstrated by the discovery of naturalized stands at altitudes of 1200 m in Mexico (Jahn, 1986), and recently by my collaborators, in excess of 2000 m in Zimbabwe. In Kenya, moringa grows productively (flowers, fruit and seed production) in a variety of soil types and at altitudinal range from 0 to 1450 m above sea level (Maundu *et al.*, 1999; Odee et *al.*, unpubl.). Moringa can also grow in a variety of soil conditions. Although preferring well drained sandy or loamy soils, heavier clay soils will be tolerated although water logging should be avoided. The tree is also reported to be tolerant to light frosts and can be established in light alkaline soils up to pH 9 (Valia *et al.*, 1993).

**1.2. Moringa distribution in Kenya**

The history of moringa cultivation in Kenya dates back well over a century when it was brought into the country mainly by the indentured workers from the Indian sub-continent during the construction of the Mombasa-Kisumu railway. As the main port of entry during that time, Mombasa and the coastal strip, including Malindi where the project is located, was naturally the first choice of cultivation areas. Cultivation then extended upcountry slowly with the construction of the railway. The earliest record of introduction of this species in Kenya is graphically documented by Cockar (1926). Here is a telltale excerpt about the early establishment and utilization of moringa at Makindu Railway Station, Kenya:

"Many trees with drum sticks here. These trees with edible drumsticks were planted by railway Asians early in 1900. The white flowers of these trees are very tasty if cooked in any salad oil. You will like to have them daily" (sic).

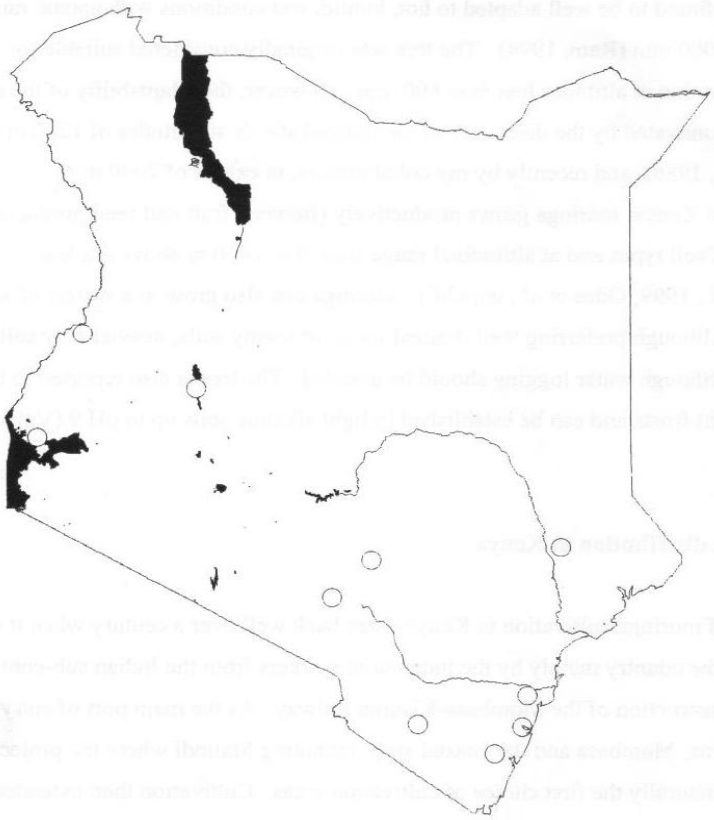

**Fig. 1.** Major domestication areas of moringa in Kenya (marked with open circles)

These early establishments of the species were largely dictated by the appropriate climate and soil type, hence lack of continuity of moringa along the railway transect, especially in the highlands of Kenya. The present day moringa cultivation and distribution have remained restricted in those areas of early establishment. Figure 1 shows the distribution in Kenya, ranging from coastal lowlands of Mombasa, Kwale, Malindi and Taita Taveta districts to upcountry Makueni, Kitui and Kibwezi in districts of North Eastern Province. There are also small pockets of old moringa establishments in western Kenya near the

towns of Kisumu and Kitale. The proliferation of moringa has largely been due to increased awareness and curiosity about its litany of potential of uses by Government, NGOs and other charitable organizations from within and international interest as whole. Among the many organizations involved in the domestication of moringa in the country, the Kenya Forestry Research Institute (KEFRI) has and still continues to provide leadership in research and development of the species, providing valuable technical information to others who are involved in the dissemination of the species both locally and internationally.

### 1.3. Purpose of the study

The project has recognized that the full potential of moringa, as a multipurpose farm forestry or agroforestry tree species, has not yet been fully realized in the coastal region of Kenya. One of the main objectives of the project is to encourage sustainable use and conservation of natural forests and to uplift the living standards of the local communities living within the project area by enhancing food security and income generation. By encouraging on-farm cultivation of fast growing multipurpose agroforestry species to the local communities, it is expected that the pressure exerted on the natural forests by extractivists may be reduced.

This study was, therefore, commissioned by the project to provide and generate information relating to the extent of cultivation, uses, production and socio-economics of moringa in the coastal area with special emphasis to the project areas of Ganda, Goshi and Jilore locations in Malindi District, Kenya.

### 1.4. Objectives of the study

The objectives of the study designated on the Terms of Reference (see appendix 1) are:

- To determine the extent of domestication of moringa in terms of cultivation, management, production and utilization and relate these information to the socio-economic status of households within the project area (TOR 1, 2, 3, ,4 & 5);
- To appraise the status of markets and marketing of moringa products, and provide technical information on markets and marketing, cultivation and production, logistical and financing that will enhance adoption for sustainable production and utilization in the project area (TOR 6, 7, 8, 9 & 10); and
- To identify stakeholders and potential collaborators within the project area, and provide any other relevant information and recommendations regarding the research and development of moringa (TOR 11, 12 & 13).

### 1.5. Approach and methodology

The study was carried out mainly in the project area in Ganda, Goshi and Jilore locations of Malindi district. Although outside the project area, parts of Gede (Mijomboni and Dabaso sub-locations) and Watamu (Jimba) locations were also covered because of their proximity to KEFRI's Gede Regional Forest Research Centre. Urban areas, namely Malindi, Kilifi and Mombasa were also visited for the market information study.

A participatory approach was used to collect data and information. The study was broken into three parts:

- Introduction and discussions with the project leader and other team members
- Collection of information and literature relevant to both the study area and the context of the study
- Reconnaissance of the project area
- The main survey study and data collection
- Data analysis and draft report preparation

Visual observations and exploratory consultations were made during the reconnaissance of the project area to determine the location and sample size for the main survey and data

collection. According to the 1999 population and Housing Census[1], Ganda location has 2013 households, Goshi has 2000 households, and Jilore has 1400 households. Our study sample size was Ganda location, 28 households; Goshi location, 25 households; and Jilore location, 24 households. The sample size, therefore, represented a proportion of about 1.4 - 1.8% of the total population of households in the three locations. The study covered the key sub-locations and villages namely; Ganda, Msabaha and Mere within Ganda location, Kakuyuni, Mongotini and Mmangani within Goshi location, and Jilore and Kakoneni within Jilore location. Outside the project area, only 16 and 2 households were interviewed in Gede and Watamu locations, respectively.

In the main field survey, three formal questionnaires were used (appendix 2). The first one was designed for farmers' socio-economic survey which covered background of households, land tenure, resources, knowledge, management and utilization of moringa, marketing of moringa products, and organizations or group affiliations. The second questionnaire was designed to generate market information for moringa products from local urban businesses or entrepreneurship. The last questionnaire was targeted at Government Departments, NGOs, and CBOs working in the project area.

Data and information generated from the farmer socio-economic survey was analyzed using the statistical package SPSS version 8.0 for Windows.

### 1.6. Structure of the report

The report is structured around the objectives, which in turn, are derived from the Terms of Reference for this study. Chapter one gives a brief background about the species distribution, purpose and objectives of the study and approach and methodology used. Chapters two, three and four provide narratives and discussions of the results of the study regarding cultivation, management, production utilization, markets and marketing and socioeconomics of moringa. Chapters five and six provide useful technical information

[1] The 1999 Population and Housing Census: Counting Our People for development, Volume 1, January 2001.

and stakeholders and potential collaborators, while conclusions and recommendations are presented in chapter seven.

## 2. DOMESTICATION AND SOCIO-ECONOMICS OF MORINGA

### 2.1. Extent of cultivation

Moringa growers were found in the project area namely Ganda, Goshi and Jilore, as well as well as Gede and Watamu locations. The number of moringa saplings or trees on growers' farms ranged from 1-100 and with a mean of 11.5 ± 8.1 (standard deviation, $n$ = 39) per household. Slightly more than half (52.7%) of farmers were found to grow moringa on their farms in the project area with moringa growers in Ganda location accounting for the highest proportion, followed by Goshi and Jilore (Table 1). Within each location, only Ganda had a greater proportion of moringa growers (80%) than no-growers. Other locations had less moringa growers than non-growers. Therefore, Ganda location seems to be the region with the highest cultivation rate of moringa. When data from Gede-Watamu locations were included in the analysis, 54.4% of all farmers interviewed were moringa farmers, with Ganda still having the highest proportion (22.2%) followed by Goshi and Gede-Watamu combined (11.1%), and Jilore (10%).

**Table 1.** Proportion of moringa growers and non-growers in the project area

| | | Proportion (%) | | |
|---|---|---|---|---|
| **Location** | **Partition** | **Growers** | **Non-growers** | **Total (%)** |
| Ganda | Within location | 80.0 | 20.0 | 100.0 |
| | Within growers | 51.3 | 14.3 | 33.8 |
| | Total | 27.0 | 6.8 | 33.8 |
| Goshi | Within location | 40.0 | 60.0 | 100.0 |
| | Within growers | 25.6 | 42.9 | 33.8 |
| | Total | 13.5 | 20.3 | 33.8 |
| Jilore | Within location | 37.5 | 62.5 | 100.0 |
| | Within growers | 23.1 | 42.9 | 32.4 |
| | Total | 12.2 | 20.3 | 32.4 |

The on-farm moringa trees were either isolated or scattered and following no discernible pattern. In a few farms, they were clustered or localized at particular areas of the homesteads in a manner resembling woodlots.

### 2.2. Wealth categorization

Some studies[2] have been carried out characterizing the wealth status of farmers and how they relate to other socio-economic elements of the project area. Interestingly, moringa as an on-farm or agroforestry tree species is hardly mentioned in these studies, which on the surface may suggest that it is not as highly valued as other tree species in the project area namely, mango, cashew nuts, coconuts, neem, citrus trees (orange and lemon) and guava. Nonetheless, just as shown in the wealth zonation studies, the results of the present study as derived from both visual observations and the responses to the indicator elements of the questionnaires, majority of moringa growers, as well as non-growers, are indeed poor smallholder subsistence farmers.

### 2.3. Marital status

Moringa growers were predominantly male and married (Table 2). As would also be expected, the majority of the households were male headed (80%); female headed households occurred as a result of absentee husbands (in employment, away from home) and widowed wives. It was therefore no surprise that the day to day decisions of household matters was also from the male head accounting for 82% of moringa growers.

### 2.4. Land ownership and source of labour

Most of the moringa growers owned their own farms (85%), although there was also a significant proportion who were squatters as was more frequent in Ganda than Goshi and Jilore locations. Another interesting observation on land ownership was that a good

[2] Zonation (stratification) and typology (recommendation domains) of the farm forestry project area. First and second reports of the formal survey conducted within the project area in December, 2001.

proportion (62%) of moringa growers had an additional land elsewhere, even beyond their own administrative location. For example, a young farmer in Ganda also owned another piece of land in Goshi location. Most of these additional farms were bought (46%) rather than inherited (18%). The family was the main source of labour.

**Table 2.** Socio-economic background of moringa growers in the project area ($n = 39$)

| Parameter | Variable | Frequency (*n*) | Proportion (%) |
|---|---|---|---|
| Sex of farmer | Male | 33 | 84.6 |
| | Female | 6 | 15.4 |
| Marital status of farmer | Married | 36 | 92.7 |
| | Single | 3 | 7.7 |
| Household head | Male headed | 31 | 79.5 |
| | Female headed, absent husband | 7 | 17.9 |
| | Female headed, no husband | 1 | 2.6 |
| Settled farm ownership | Farmer owned | 33 | 84.6 |
| | communal | 2 | 5.1 |
| | Squatter | 4 | 10.4 |
| Source of farm labour | Family | 35 | 89.7 |
| | Hired/casual | 1 | 2.6 |
| | Family and hired | 3 | 7.7 |
| Division of family labour | Husband/male head | 16 | 41.0 |
| | Female/female head | 12 | 30.8 |
| | Children | 2 | 5.1 |
| | All contribute equally | 9 | 23.1 |

The number of adults (16+ years old) resident per farm or household ranged from 1 to 8 for male and 0 to 7 for female.

## 2.5. Gender demographics

The age of moringa growers ranged from 16 to 70 with a mean of 48 years. The gender age distribution is shown in Table 3.

**Table 3**. Gender and age distribution within moringa growers' households

| Parameter | *n* | Min | Max | Mean |
|---|---|---|---|---|
| Full time adults (16+ years) male farm residents | 39 | 1 | 8 | 3.08 |
| Full time adult female farm residents | 39 | 0 | 7 | 3.51 |
| Full time children (<16 years) farm residents | 39 | 0 | 15 | 6.85 |

## 2.6. Off farm income generating activities

Nearly 62% of moringa growers were also engaged in some form of income generating activity or paid jobs outside the farm activities. This is well above the district level of about 49% based on the recent census data. The income generating activities were partitioned as follows: formal employment, 33%; self employment, 21%; and 8%, temporary or casual employment. In Mombasa, Kwale and Taita-Taveta districts only 30% or less of moringa growing households were found to engage in off-farm income generating activities (Odee *et al.*, unpubl.).

## 2.7. Groups and affiliations

Only 23% of moringa growers (respondents) belonged to a social group. There was only one respondent in Goshi who belonged to a women's group. Other group affiliations were youth groups, 4; religious groups or faiths, 3; and savings and credit associations, 2. Such a low rate of group affiliation may be explained by the fact that most of the CBOs are still in nascent or emerging stages[3] and have therefore not attracted much membership.

[3] Report on the Organisational Capacity Assessment of Community Based Organisations within the project area (Ganda, Goshi and Jilore locations), January 2002, the project project, European Commission.

## 2.8. Domestication in the project area

### 2.8.1. Early introductions

The earliest record of moringa planting by living farmers dates back to 1961 in Ganda, although a female farmer told us that she recalls her father tending moringa as a young girl during the Second World War. The earliest record of moringa planting in Jilore and Goshi were 1968 and 1980, respectively. Most growers (76%) in Ganda location had planted their own moringa crop, whereas it was less than 30% for Goshi and Jilore locations. This finding makes Ganda as the main region of moringa domestication within the project area. Less than 4% of the farmers either inherited or bought their land already planted with moringa by the previous owners.

### 2.8.2. Planting

The main type of planting material in the project area was seed, just has been found in Taita-Taveta and Makueni districts (Odee *et al.*, unpubl.). Others were seedlings, wildlings and cuttings. The key source of planting material was obtained from neighbours, hence the characteristic clusters of moringa growing villages or locations. Other mentioned sources of planting material included the Forest Department, relatives and a shopping centre.

### 2.8.3. Management

Moringa appeared to grow much better in Ganda and Goshi locations than in Jilore. Although the main reason for this was the more favourable biophysical conditions, management may also have played a major role in this observation. Several management practices were mentioned across the project area namely coppicing, pollarding, and pruning and coppicing, but the proportion of those growers who practiced any of the above-mentioned management techniques were higher in Ganda and Goshi (36% and 32%, respectively) than in Jilore (only 8%).

## 3. CURRENT PRODUCTION SYSTEMS AND UTILIZATION OF MORINGA BY THE LOCAL COMMUNITIES

### 3.1. Production systems

As previously mentioned more than half the number of households in the project area cultivating moringa are practicing farm forestry, and are technically agroforesters. The most common farming system observed in the project area was smallholder subsistence farming with little modern machinery, such as tractors, involved. They are largely mixed farming systems which besides growing of food and tree crops, also keep livestock such as cattle, goats, poultry, sheep and rabbits.

Several tree and crop species were observed on farms namely; coconuts, bananas, mangoes, citrus (orange and lemon), vegetables cashew nuts, moringa, maize, pawpaw, sugarcane, sorghum, cassava etc. Consistent with visual observations, analysis of on-farm crop ranking indicated that mango tree was the most frequently top listed crop (44%) followed by banana (18%) and then moringa (10%). This observation indicates that moringa is also highly rated among the several crops that are grown in the project area. However, it is highly rated mainly as a vegetable (leaves), but other crops such as mango are more important because of their potential for on-farm income generation. For example, nearly 80% of the respondents (growers and non-growers of moringa) sold their mango fruits as compared to only less than 3% who sold the vegetables, which included moringa leaves. As a matter of fact, only two farmers in Ganda reported selling fresh moringa leaf vegetable, this mainly to the neighbours.

The farm sizes of the interviewed farmers ranged from 1-33 acres (Table 4). Farm sizes, therefore, ranged from small- to medium-scale. On average, the farm holdings of moringa growers in the project area are similar to other coastal moringa growing regions of Kwale and Taita-Taveta districts but smaller than in the more marginal areas in Makueni district of Eastern Province (Odee *et al.*, unpubl.).

**Table 4.** Total farm sizes owned per households (in acres)

| Location | *n* | Range | | Mean ± SD |
|---|---|---|---|---|
| | | Min | Max | |
| Ganda | 25 | 2 | 33 | 10.92±7.67 |
| Goshi | 25 | 1 | 26 | 8.24±7.53 |
| Jilore | 24 | 4 | 22 | 11.21±6.05 |

### 3.2. Local uses

The most common use of moringa was as a vegetable (Fig. 2), accounting for nearly 85% of the households of moringa growers in the project area. It is mainly the leaves of moringa that are used as a vegetable, and flowers for only a very small proportion of households. It is important to emphasize the importance of moringa leaves in the culinary culture of the communities in the project area. The Giriama, the predominant ethnic group within the project area, refers to it as *muzungi; muzungwi* and *muzumbwi* are other variations. They mix moringa with other traditional vegetables (this study, also Maundu *et al.*, 1999), especially those which are acidic or bitter in taste. Examples of blending vegetables mentioned include; *thalakushe/talakushe* (*Asystasia gangetica*), *Kimbiri* (*Oxygonum salicifolium*), *Mutsunga* (*Launaea cornuta*), *mnavu* (*Solanum nigrum*), *mchunga* (*Sonchus sweinfurthii*) and *logatsi* (*Amaranthus graecizans*).

Other local uses include medicinal from roots and leaves, and fuelwood from stems and branches. Only one respondent used moringa seed for water clarification, although more than half (56%) of them were aware of its use for this purpose. Interestingly, none were aware of the multiple uses of the species in particular the use of moringa seed as a source of cooking oil and its potential use in apiculture.

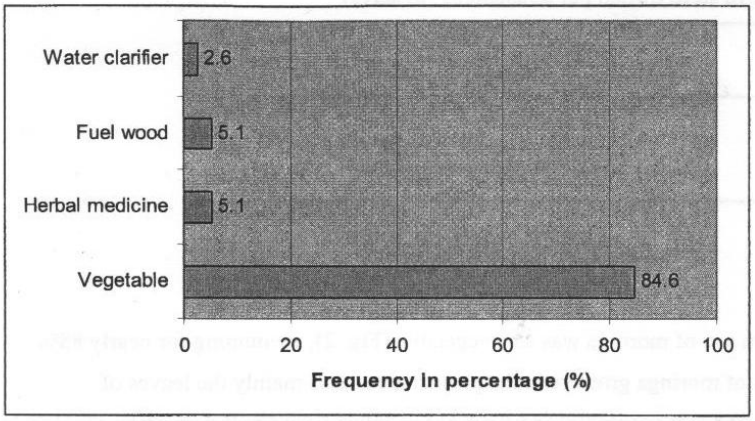


**Fig. 2.** Uses of moringa in the project area

### 3.3. Opportunities for diversified utilization

3.3.1. Edible oil

Moringa seed kernel contains up to 42% oil by weight and the fatty acid profile of the oil shows it contains a rage of 66 - 76% oleic acid, which means that its quality approaches that of olive oil (Fuglie, 2001; Foidl *et al.*, 2001; see also appendix 6). The oil is pale-yellow in colour with a pleasant, nutty flavour. It can be used as any other vegetable oil for salads or in cooking. With appropriate training, dissemination and facilitation, the households or communities within the project area can be made to be self sufficient in quality cooking oil and any surpluses sold to the markets.

3.3.2. Water clarification and treatment

Moringa seed contain between 30-42% oil and the presscake obtained as a by-product of the oil extraction process contains a very high level of protein. Some of these proteins (approximately 1%) are active cationic polyelectrolytes having molecular weights between 7-17 K Dalton (Foidl *et al.*, 2001). The cationic polyelectrolytes neutralize the colloids in muddy, turbid or dirty water since the majority of these colloids have a negative electrical charge. This protein can therefore be used as a non-toxic natural

polypeptide for sedimenting mineral particles and organics in the purification of drinking water. The process of household water purification or clarification with moringa seed is simple and straightforward. Dried seeds are crushed and sieved using the same traditional techniques used to produce maize flower. The finely crushed seed powder, when mixed with water, yields water soluble proteins with a net positive charge (Folkard and Sutherland, 1996; Folkard *et al.*, 2001; Foidl *et al.*, 2001). The proteins are considered to act similarly to synthetic, positively charged polymer coagulants. When added to raw (untreated) water the proteins bind to predominantly negatively charged particles and grow in size to form the flocs, which may be left to settle by gravity or removed by filtration. This process will also remove 90-99.9% of bacteria and algae attached to the solid particles, as well as clearing the water (Folkard *et al.*, 2001; Foidl *et al.*, 2001). Dosing solutions of about 1-3% act as a natural cationic polyelectrolyte (coagulant) during treatment (Sutherland *et al.*, 1990). A good proportion of households in the project area largely source their water from the highly turbid river and ponds or lakes dotting the Jilore and Goshi locations. Increased cultivation, accompanied by technology dissemination and advocacy, will therefore raise awareness and utilization of moringa for household or domestic water clarification and/or treatment (see appendix 7 for household level water clarification protocol). Utilization of moringa seeds in the treatment of water at community or reasonably sized treatment works have also been shown to be more cost effective than chemical (alum and soda ash) treatment, and having the advantage that the effectiveness is, in general, independent of the pH of raw water, nor does treatment alter the pH of treated water (Folkard *et al.*, 2001).

### 3.3.3. Moringa for a healthy nutrition

Leaves, flowers, roots and immature pods of the moringa tree are edible and form a part of traditional diets in many countries of the tropics and sub-tropics. There are numerous dishes whose recipes vary from country to country some of which can be found in literature (e.g. Fuglie, 2001) and the internet. Moringa leaves probably rank as one of the best tropical vegetables in terms of nutritional contents containing high concentrations of vitamins A and C, B-complex, iron, calcium, protein, zinc, selenium and essential amino acids (Fuglie, 2001). Although moringa growers in the project area utilize the leaves,

dissemination of the information on the nutritional benefits, by recruiting new users, would have a positive health and nutritional impact and hence improve the health status especially of the children. Although moringa is a valuable source of nutrition to people of all ages, children aged 1-3 years receiving a serving of 100 grams of fresh leaves would meet their daily requirements of calcium, about 75% of iron, 50% of protein need, as well as important supplies of potassium, B–complex vitamins and all the essential amino acids (Fuglie, 2001).

3.3.4. Other uses

There are a multiple of other uses of moringa. For example, leaves can be used as fodder and are readily eaten by cattle, sheep, goat, pigs and rabbits. It has also been referred to as a medical pharmacopoeia due to its numerous medicinal properties (Fuglie, 2001); every part of the tree is widely used to make a wide variety of traditional medicines for numerous conditions. It has been demonstrated to have the following effects: hypocholesterolemic effect (Ghasi *et al.*, 2000), hypotensive activity (Faizi *et al.*, 1994), the anti-fertility activity (Shukla *et al.*, 1988), anti-ulceronic activity (Akhtar and Ahmad, 1995), and anti-tumor effects (Guevara *et al.*, 1999).

Other uses include; honey production (apiculture), honey clarification, fertilizer (seed cake) or green manure, gum, pulp, tannin, live fences, alley cropping, biogas production, ornamental etc.

### 3.4. Potential for adoption of moringa

Franzel *et al.* (2002) have provided a framework for assessing the adoption potential of an agroforestry technology through participatory on-farm trials. In this framework, several factors are cited within which key questions are asked to provide a gauge for assessing the adoption potential. Most of these factors and questions are also pertinent to moringa technology. The most relevant questions can also be adapted for moringa as follows:

- Biophysical performance; soil type, climate etc. Are they suitable for moringa cultivation?
- Profitability: Is moringa cultivation profitable to the farmer as compared with alternative crops
- Feasibility and acceptability: Do the farmers have the required information and resources, and are they willing to and be able to cope with problems that occur? Do farmers perceive significant advantages in growing moringa?
- Boundary conditions: Under what circumstances (e.g. biophysical, household, community characteristics, and market conditions) is moringa cultivation likely to be profitable, feasible and acceptable to farmers?
- Lessons for effective dissemination (extension and policy): What does farmer feedback suggest will help interest farmers in moringa cultivation? What type of extension support do they need most? What types of changes in institutional arrangements, public investments or market conditions would enhance the adoption potential of moringa cultivation?

Some of the questions above have been answered in this study. Nonetheless, most of the unanswered questions will require detailed diagnostic and appraisal surveys since this is the first time that moringa technology is being disseminated in earnest.

The general picture within the confines of this study indicates that there is potential for adoption by subsistence farmers to facilitate sustainable production and utilization of moringa in the project area if complemented with a good support system in terms of dissemination, policy and capacity building in all spheres of moringa development (e.g., information on production, utilization, processing, markets and marketing of products). The species is not new in the project area, that there is already some tradition of moringa cultivation and utilization spanning over a period of at least 40 years to date.

The most encouraging evidence from this study, besides the fact that the species was highly ranked among other crops, was that nearly all the farmers, growers and non-growers, indicated that they would be willing to grow moringa. Those who already grow

it were eager to increase more plantings and non-growers were eager to obtain planting material. Secondly, there were almost an equal proportion of growers to non-growers, which suggests that a doubling of moringa growers should be expected in the near term.

Another positive observation was that land ownership (or tenure) was not a problem or constraint. Most farmers owned their land and the land space was not exhausted, notwithstanding the fact on-farm cultivation of moringa is traditionally agroforestry and not monoculture. Furthermore, the type of agroforestry production system found within the project area is amenable to introduction or re-planting of moringa without deleterious effect to other trees and crops. There are also no cultural barriers on growing the crop. There is young to middle-aged family labour force which is readily available to support any intensive or expansive programme for moringa cultivation and production. Only < 8% engaged in casual or temporary labour outside their farms, and is therefore unlikely to abandon their farming activities. About 33% of households have persons who are engaged in formal employment, potentially a source of capital for farm inputs and also to sustain hired labour. With increased awareness and training on utilization and opportunities for income generation, moringa may become as visible as the mango tree in the project area. A good case in point for potential of adoption with increased awareness is that of a recent seminar (*Baraza*) held by the project; some of our respondents had attended the seminar and are presently awaiting to seize the perceived opportunities by growing moringa.

### 3.5. Expected problems and drawbacks

Besides the existing moringa crop established over the years in the project area, the project has supplied thousands of seedling in the last long rainy season. This initiative, together with the growing awareness will expand the moringa acreage to substantial magnitudes. The expansion programme will also bring the obvious problem of over-supply and possible wastage if other measures are not taken to advise on utilization and marketing of products. As a fast growing species, the recently cultivated crop will flower, fruit and seed within the year leaving most growers, especially the newly

recruited ones, without knowing how to use or even sell their products. This may have a negative effect especially after such an excellent initiative by the project. The need for raising awareness on utilization and markets and marketing of moringa products can therefore not be over-emphasized at this time.

Another potential drawback is that of pests and diseases. As the acreage of cultivated moringa and application of management practices which are geared towards increased production are intensified, so will be the risks of outbreaks of pests and diseases. We have noted several pests (mainly those in the insect Order Lepidoptera), which may cause considerable defoliation and damage when moringa populations increase, more so in a monoculture setting. Our earlier study in the major moringa growing areas have shown that farmers in the agro-ecologically similar districts of Mombasa and Kwale experienced severe pest attacks during the rainy season, while those in Taita-Taveta and Makueni districts experienced such attacks during the dry season (Odee *et al.*, unpubl.). Some of these potential pests and diseases are mentioned in chapter 5.

## 4. MARKETS AND MARKETING OF MORINGA PRODUCTS

### 4.1. Moringa markets

#### 4.1.1. Present status in Kenya

As stated in the historical perspective of moringa, the vegetable green pod was the driving force behind its domestication in other parts of the tropics outside its native distribution in the sub-Himalayan tracts. The main users have the green pods are first and foremost communities from the Indian sub-continent (Asians). The communities migrated in many parts of the world, largely as British indentured labour force in several colonies during the later part of 19$^{th}$ and early 20$^{th}$ centuries. These communities, who are now naturalized in many parts of the world, including Europe and North America, remain the main market for the green pods. However, the extent and stability of this market has not been clear, if anything, a very guarded secret among those involved, which may give the wrong impression that it's either very competitive or just not big enough to allow many players in the production, distribution and export of the products.

In Kenya, the green pod production also targets the communities of Asian origin, who are largely living in urban areas of Nairobi, Mombasa and Kisumu. There was no evidence of pod production in the project area for local or export markets. The moringa growers in Ganda, Goshi and Jilore mainly utilized its leaves as a household vegetable, and only sold it occasionally. In this study, only one major moringa grower, Mzee Saro of Mabaoni village, Ganda location, sold fresh moringa leaves to neighbours at about KShs 5 per *Kifungu* (Swahili: small measure). Presently, market outlets for moringa pods seem to be limited; our study revealed no trading at all of the pods in Malindi and Kilifi towns even though all the interviewed traders had seen or were aware of moringa products and their uses. I also observed isolated fruited moringa trees on farms and shopping centres along the Malindi – Mombasa highway/road.

Although this study did not provide any evidence that linked domestication of moringa in the project area with the early days of trade in green pods, it is most likely that this was probably the case as has been established in the other major growing areas in the Coast and Eastern provinces. The nearest market outlet was in Mombasa at the City Market and also in the fresh produce sections of some of the supermarkets. There was only one trader of moringa pods at the huge city market, who was supplied by an Asian vegetable grower from nearby Likoni using irrigation technology. The pods sold for ~ KShs 60 per kg and the turnover were about 14-70 kg per week at the city market. Another trader, Shree Ganesh, with a fresh produce stall strategically located under the roof of Likoni "Nakummatt" supermarket, produced his own moringa pods and also supplied the "Nakumatt" supermarket at Bombolulu, selling at KShs 2 per pod (approximately KShs 100 per kg). This trader has farmed moringa since 1934. I also learnt that some of the moringa produced in Mombasa are exported to Nairobi; information on quantities was not available.

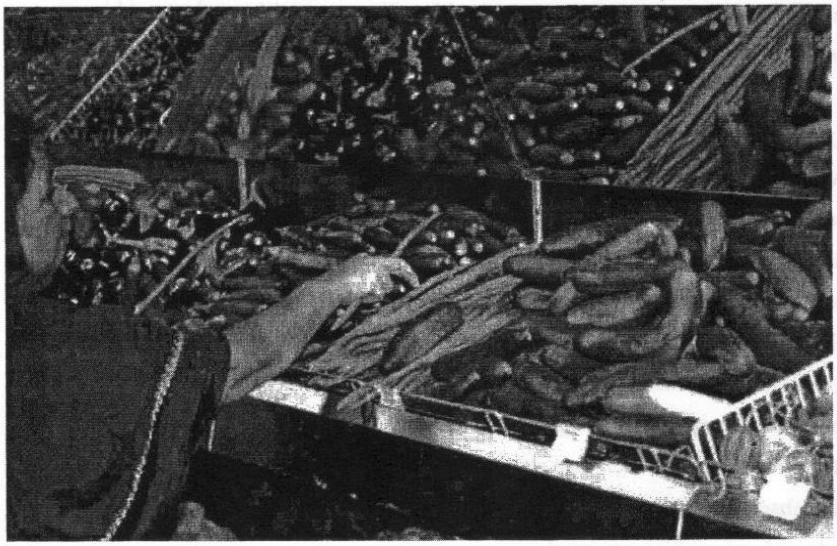

**Plate 1.** A shopper picking moringa pods from the fresh produce section in a Nairobi supermarket

However, the bulk of imports into Nairobi originate from Mbololo, near Voi in Taita-Taveta District, and Makueni District in Eastern province. The major markets for pods in Nairobi are the "Uchumi" Supermarket (Sarit Centre and Ngong Road Hyper) and the City Park Market in Parklands. The shelf prices in these markets range from KShs 80-120 per kg depending on the season. The Nairobi traders report, on average, a weekly turn over of about 50 kg. In all these outlets, the targets or buyers are of Asian origin.

4.1.2. Past market situations

A socio-economic survey[4] carried out between 1995 and 1998 in moringa growing areas of Mombasa (Mtongwe-Likoni), Taita-Taveta and Makueni districts revealed that the early pod trade, which was the engine for on-farm moringa cultivation, had declined. The buying price from farmers by middlemen in and around Mombasa ranged between KShs 6-15 per kg (exchange rate at the time: 1 USD = KShs 65). The price in Taita-Taveta and Makueni ranged from KShs 7-17 per kg. There was also a short market spell for moringa seed from Taita-Taveta in the neighbouring Tanzania when Optima of Africa Ltd was establishing plantations in Arusha. Seeds were sold by farmers at a price of KShs 11-15 per kg depending on the quality. The study also established that on-farm moringa cultivation or domestication in these areas started around the 1950s, presumably when demand in the local and international markets started to grow and hence its value as a cash crop.

Cultivation of moringa was at its peak in the 1980s when farmers fetched about KShs 6 per kg of fresh pods at the time when the strength of the Kenya shilling was at least five-fold its current value. However, despite the apparent decline in the market value for moringa pods, farmers maintained and managed the crop on their farms because of its other attributes namely fodder, vegetable and its compatibility with other food and cash crops. The observed market fluctuations could be as a result of lack of market research and organized production and export systems analysis. Notwithstanding some growers concerns about the markets for their pods or other products, there is a potential benefit for

[4] Final Report of the EC Project Contract No. TS3*CT94-0309 (DG 12 HSMU) (1994-1997) entitled "Development of *Moringa oleifera* and *Moringa stenopetala* tree to provide valuable products: coagulants for water/wastewater treatment and vegetable oil".

large scale production, if accompanied by appropriate market analysis and product value adding (see other section on technical information).

The widespread use worldwide by Asian populations has a small but ever-expanding export market for fresh and tinned moringa pods. The pods can be obtained fresh in a number of cities in Europe, imports being received from suppliers said to be in Kenya and other African countries. The moringa pods are most likely from the coastal areas of production (Mombasa and Taita-Taveta), where they are transported to Nairobi then air-freighted to Europe. There is now an international airport in Mombasa, where moringa pods may be directly air-freighted to European destinations. This approach could cut costs of transportation and hence make the products from the coast, including the project area, to be more competitive. Although the growers do not receive substantial amounts of money for their produce, in long-term, the tree remains a valuable cash crop because, once established, minimal inputs are required, e.g. management, to ensure sufficient production over several years. At present, tinned pods are currently exported only from India and Sri Lanka. Other countries like Kenya can also get into tinning since the market exists; the spin off would result in reducing the huge losses which occur due to long distance transportation and smaller or more competitive fresh produce markets.

4.1.3. Markets for oil

The market for edible oil appears to be a mixed bag. In general, oilseed production has an important socio-economic role in the rural areas of Kenya and many other developing countries. Sub-Saharan Africa is a net importer of edible vegetable oil, protein cake and meal required for dairy, poultry and pork industries. It is now generally accepted that the national Kenyan requirements for edible oil and protein cake can be met by engaging smallholder farmers in the production of oilseeds. Since on average, 80% of population is rurally located, the small-scale rural based oilseed enterprises have a better market niche by sheer volume than the large scale urban based crushers and processing industries, which mainly supply the urban markets. Such production would make full use of the capacity of the domestic processing industry. Kenya has depended on locally hydrogenated fats from imported palm oil, at a cost of USD 60 million for 80% of its

vegetable oils and fats, prompting the Government of Kenya with other partners to promote oilseeds, mainly soybean[5]. The entry of private-sector interests into post-liberation economies of African countries has highlighted the importance of production of annual oilseeds. However, the oil processing industries rely heavily on cheaply imported palm oil. The mid 1980s saw large surplus quantities of palm becoming available from the Far East. The international price of palm oil dropped from a high of USD 750 per ton to below USD 300. The impact on the local Kenyan edible oil industry was a drastic reduction in the farm gate price being offered to sunflower farmers. The knock on effect was that the number of small scale farmers cultivating sunflower plummeted from 80,000 to around 8,000 in a period of 2-3 years (Oilcrops Development, Ltd, Nakuru, Kenya). At the same time, many small to medium scale crushers, suppliers to giant refiners, saw their throughput and workers jobs curtailed in similar scales as the refiners switched sourcing of raw vegetable oil from indigenous plants to importing cheaper palm oil from abroad, effectively rendering the local oilseed producers less competitive. Since then, and despite the non-competitiveness of the local oilseed production, the majority of rural oilseed producers are optimistic that rural economy would prosper in the long run if production remained an integral part of national agricultural policy and strategy.

Notwithstanding the availability of land and conducive biophysical conditions for moringa cultivation and its potential as a source of edible oil, it is hardly mentioned alongside the annual oil-bearing crops of most importance to sub-Saharan Africa namely sunflower (*Helianthus annuus*), sesame (*Sesamum indicum*), safflower (*Carthamus tinctorium*), groundnut (*Arachis hypogea*) and rapeseed (*Brassica rapa* and *B. napus*). There are several oil vegetable processing industries in Kenya who can be targeted during market opportunity analysis to determine the competitiveness of moringa oil against the traditional annual oilseeds. The composition of moringa oil is stable. A study carried out by Jan Dekker International on oxidation tests showed that moringa oil was stable at 100°C for up to 80 hours, as compared to sweet almond oil which would be 5 hours and virgin olive oil for 40 hours (Le Poole, 1995). This quality of oil is of interest for

[5] Oilseeds: post-harvest operations; www.fao.org

cosmetic manufactures such as Optima of Africa Ltd based in Arusha, which could be a value added market for local moringa oil production. What would be required is to establish links with such companies to determine the market potential and carry out feasibility studies on village or local level extraction facilities. Enterprises like Optima in Tanzania, Pronatex in Madagascar and Horti Nursery in India have developed plantations and contracted farmers to produce moringa seeds that they process into oil. Horti nursery of India sells moringa oil to space agencies and has made contacts with a Japanese lubricant extender manufacturer (De Saint Sauveur, 2001). Nevertheless, oil for cosmetic use is generally a low volume high value market.

In developing countries edible oil production is controlled by a few large scale producers normally based in the urban centres. As a consequence, when vegetable oil reaches the rural market additional costs due to transport and retailer's profit tend to push the price beyond that of poor subsistence populations. A good example to support localized or decentralized small scale oil processing of moringa oil is exemplified by a case study in Zimbabwe. In 1988 the Intermediate Technology Development Group in Zimbabwe (IT Zimbabwe) began a programme to establish small scale oil processing enterprises using expeller technology introduced from India. Since its inception, more than 17 such enterprises were established, 12 in rural areas and 5 in urban centres in a period of less than 7 years (Sunga and Wittby, 1995). The Church World service (CWS) has designed a hydraulic press specifically for moringa, although the press will also work for groundnut, shea nuts and other oil seeds (Fuglie, 2001). Similar types of small scale oil seed extraction systems are also locally available in Kenya[6] and therefore can be tried and tested for the rural market. They have the highest chance of success as a rural intervention to initiate small off-farm enterprises, and a start for the evolution of more value added domestic activities. However, on a slightly greater scale such as the groups or NGOs operating the small scale rural based extractors attest to a number of technical problems of oil extraction. Problems such as jamming due to immature seeds (seeds in a pod are not all in the same state of maturity), polymerization, very low productivity, low

[6] Appropriate technologies for enterprise creation (APPROTECH), P.O. Box 64142, Nairobi, Kenya. Tel.: +254 2 783046/787381/796278; e-mail: aprotech@aprotech.org; http:/www.aprotech.org

extraction yield, long and cumbersome filtering process etc, only lead to high production costs as a result of tediously produced low volumes that at present may only be of interest to the cosmetic industry.

The production of moringa as a large scale commercial edible oil for processing industries has a number of teething problems. Firstly the oil comes into competition with vegetable oil from the traditional annual oilseeds named above, and would have to compete on prices already drastically dropped by the cheap palm oil imports. According to Sutherland *et al.* (2001), the current FOB price for palm oil is about USD 0.32 per kg , and hence would require a great deal of expanded moringa oil production to at least match that price. Secondly, as new oil that has not been previously offered for sale as an edible product, its acceptance will depend very much on the consumer and how the product is marketed. A major obstacle to commercial scale marketing will also have to pass the conservative regulatory authorities to approve it for sale to the general public.

Moringa oil produced in India attracts a price tag of ~ USD 150-550 per litre, whilst oil from 'Binga Tree' in Zimbabwe exported to South Africa fetches USD 15 USD per kg (Anbarassan *et al.,* 2001). Nonetheless, the fast growing, high yielding moringa, estimated to produce about 4.9 tonnes of seed per hectare against average yields of sunflower and groundnut of 2.0 and 0.5 tonnes per hectare, respectively, and the drought tolerant nature of the tree makes it particularly suited in the marginal areas where the costs associated with the cultivation and harvesting of other oil crops make them uneconomic.

4.1.4. Water treatment products

The development of moringa species as a whole has been driven by the fact that its seeds or presscake (obtained following oil extraction) contain natural water treatment properties. However, to date these products are largely confined to the household level with little venture into the market world. Optima of Africa Ltd has invested in the development of a process whereby a concentrated product (Phytofloc™) could be cost effectively produced on a commercial scale (Sutherland *et al.*, 2001). However, the

acceptance and utility of this product has not yet been tested in the public domain. Nonetheless, pilot water treatment plant trials using moringa seed have been shown to give comparable results to those obtained with commercial chemicals (alum and ash) at a fraction of the cost (Folkard *et al.*, 2001). The authors have also estimated that if the water utility established and maintained a plantation of moringa trees for oil production/presscake coagulant, a net profit could be achieved. The presscake left following oil extraction may also be utilized as a fertilizer or even animal feed, adding value to the by-product.

4.1.5. Market for moringa leaves

Moringa leaves as a source of fresh vegetable or dried, and as health food could be of great potential with proper advocacy and marketing. Already, the growers in the project area use fresh leaves to blend with other local vegetables known to be acidic or bitter in taste. It should be easy to produce and process. There is a potential to expand the local market in the project area, district and even beyond, and thus be made to become another *sukuma wiki* (kales), the ever-present vegetable in most Kenyan green grocer stalls. A good example of what advocacy and awareness can do to encourage the use of moringa leaves as an alternative vegetable source is exemplified by a case study by "Trees for Life", an organization that enable people around the world to help plant fruit trees in developing countries[7]. In 1996, the organization conducted a campaign to identify replicable methods for motivating people to increase their dietary use of nutrient-rich moringa leaves. The campaign was conducted in 20 villages of Orissa, India. Twelve months after the completion of the campaign, an independent team surveyed the change in knowledge, attitudes and practices of the local people. Results of the survey showed that the proportion of people who included moringa leaves in their diets three to four times a week had increased from 30% in the baseline study to 84% one year after the campaign. This is a remarkable achievement for communities who have been nurtured most of their lives to eat moringa pods. A similar awareness creation and advocacy

[7] Trees for Life, 3006 W. St Louis, Wichita, KS 67203-5129, Te.: +316 945-6929, Fax: +316 945-0909; website: www.treesforlife.org.

would not only increase the number of households utilizing moringa but also expand the market for the product in the project area and the region as whole.

Moringa leaves (and pods) could also be marketed alongside other traditional vegetables as an African delicacy, which with its health food status could be a major tourist attraction in the Malindi tourist hotels[8]. The tourism industry is currently struggling; including vegetables such as moringa on hotel menus and marketing it as a health food among others could attract a different kind of tourist to come to Kenya while at the same time establishing a long-term market for moringa producers within the project area and the coast in general. There is a growing interest in the western world for moringa leaf products, because of its status as a medical pharmacopoeia, but this interest has not really translated into viable markets.

Other countries, especially within the Sahelian belt rely on moringa as a major source of vegetable. In Niger, leaves (and not pods) are sold fresh or sun-dried and stored for off-season (Bonkoungou, 2001). Women play an important role in the commercialization of moringa in Niger. Consumption of the leaves is part of a culinary tradition in Niger, especially among the Hausa and Djarma ethnic groups (De Saint Sauveur and Hartout, 2001). During the wet season, moringa leaves are abundant and are sold for an average of 750 CFA (one USD) per sack; women traders may take up to 60 sacks per person. During the dry season, especially in the month of Ramadan, the price for one sack of leaves can reach 2,500 CFA (USD 3), but with fewer leaves available women will go to the market with only 5-6 sacks.

[8] The Hotel Keepers Association Office/Secretariat, Malindi should be consulted on this potential. I spent nearly half a day trying to talk to someone in this office as well as Eden Roc Hotel but to no avail.

### 4.2. Markets and marketing strategies

The market is the overall *demand* for a *product* at a given price and time, under specific standards and conditions (FAO, 1996). Therefore, *to market* means to actively promote product or market development or product sales. *Demand* or the needs and wants of customers, can change for any product as circumstances change, and *price* is the variable that reflects these changes and insures that the supply of a product equals the demand. Product refers to a combination of a physical product and services attached to it. For example, moringa leaves can be sold as picked in the town markets; or it can be cleaned, dried, ground and packaged with information about species and use, and sold through specialized food or medicine shops.

Moringa markets, as for any other products, can be divided into consumer and industrial markets. Consumer markets consist of individuals and households who buy products for their direct consumption, while industrial markets buy products for further processing. Presently, in Kenya and other international markets, moringa products (mainly vegetables) are largely targeted towards the consumer markets.

Marketing, on the other hand, is the process of identifying, stimulating, and satisfying customer's demands. It requires the collection and analysis of information to identify markets and learn what consumers need and want. Marketing also involves the physical delivery of goods to the customer. Marketing also suggests to producers what to produce and directs the product development efforts of the processing industry. It informs the customers about the availability, quantity, quality, price, service, and distribution of products. Marketing of moringa products in Kenya appears to be oversupplied especially with the green pod trade. This is mainly as a result of a poor market understanding and information base. I have personally noted the trend of seasonality in the supply and distribution of moringa in supermarkets ranging from abundant certain times of the year to non-existent at other times, e.g., July to Septembers). Secondly, since the domestication of the species in the country, the markets have been confined to the green pod vegetable production and distribution, targeting only the Asian communities.

Perhaps this lack of marketing information has contributed to the non-realization of the full potential of moringa products as a major income earner for the rural growers. Effective marketing of moringa products will be required to help farmers maximize their income and also keep a stable and predictable income over time. Sound marketing strategies can also reduce the risk of oversupplying the markets. Many subsistence farmers have limited access to markets and marketing information. This means that when they produce more than the household or family uses, they have difficulty selling it. This appears to be the present scenario with moringa growers in the project area, as well as the others in Mombasa, Kwale and Taita-Taveta in Coast province, and Makueni district in Eastern province.

Therefore, if moringa growing and product development is to be promoted, a strong and concerted effort has to be put in place for developing the capacity of the farmers to access or generate their own market information to use in marketing their products. I observed in this study and a previous socio-economic study in the major moringa growing areas that moringa production can grow very fast in a given area so long as the agro-ecological conditions, and most importantly, the farmers' perception of market opportunities. However, the apparent poor performance of moringa products as shown from these studies is indicative of lack of information on markets, market development and opportunities by the producers and marketing agents of moringa products in the major producing areas in Kenya. There has never been a single focused study aimed at establishing successful marketing for moringa products in the country. At the onset of production, the producers should be armed with the following pieces of information:

- What is the market?
- What products does the market want?
- When does the market want the product?
- How much does the market want?
- Where is the market?
- What is the appropriate distribution channel?
- How does the market want the goods delivered?

- What is the market price?
- Is the market aware of the supply?
- Who are the competitors?
- How is the information needed for successful marketing gathered?
- How is all this information used?
- Who is involved in implementing operational plans?

Information generated from the above will constitute a marketing information system. Some pieces of information have been generated by this study, but it has only involved a fraction of the populace in a small geographical area in market and marketing terms. The exercise for market information system should be dynamic and embrace not only the local area, but national and international markets. This information should, therefore, guide seasonal production, help determine production investments, identify promotional needs, and in general help production adjust to demand. It should provide reliable information on demand, supply, products, channels, promotion, prices, competition, and their trends. If properly presented and made available to producers in a clearly understood manner, this information will help avoid over-production. Higher level strategies can then follow, such as market opportunity analysis, which is an investigation into the feasibility of a specific product for a specific market for a specific producer or group of producers. According to van Lieshout *et al.* (1997), it is best described as a product market-opportunity (PMO). A PMO classification is based on objective characteristics of products and markets. It aims at distinguishing existing products from new ones and existing markets from new ones, as shown in Table 5. In my opinion, the following four strategic options (and in order of priority) can be derived for moringa products:

- Develop new markets for existing products
- Improve existing products for existing markets
- Diversify production by developing new products for existing markets
- Develop new products for new markets

Local markets for existing products are hardly exhausted; the apparent market saturation or fatigue is largely as a result of lack of market information systems to producers. At the project area level, as well as other producing areas, there is room for market penetration for both the unprocessed (e.g., leaves and pods), which can be easily achieved by creation of awareness and marketing to other households and communities and indigenous Kenyans to take on moringa as a major part of their healthy diet.

**Table 5.** Classification of market opportunities

| **Classification of strategic options** | | **PRODUCER OPPORTUNITIES** | |
|---|---|---|---|
| | | **Existing products** | **New products** |
| **MARKET OPPORTUNITIES** | **Existing markets** | Penetration (strengthening position) | Product development |
| | **New markets** | Market development | Total diversification of market products |

The first logical entry for developing local capacity for market information gathering would be to work with CBOs or other farmer organization, such as cooperatives. A first step is to have members of such organizations meet together to decide what to do and identify opportunities and problems, where the producers take their own solutions and make them into a plan of action. Although mostly in emergent stage, there already exist 13 CBOs in the project area, comprising of locational environment committees and local community groups[9]. It was also evident that these groups or organizations have not really taken root since only a small proportion of farmers were affiliated to any of them. These organizations need to be empowered by appropriate training to enhance their capacity for marketing, especially of moringa products. Extension workers, NGOs, community leaders, and even the project can then be the vehicles for introducing and imparting marketing skills to the moringa producers. By working at the organizational level, members can gain bargaining power with traders and middlemen so that they maximize their incomes, while reducing the farmers' risks.

[9] Report on the Organisational Capacity Assessment of Community Based Organisations within the project area (Ganda, Goshi and Jilore locations), January 2002, the project, European Commission.

### 4.3. Opportunities for adding value to moringa products

The scope for farmers to add value to their produce is considerable. They can increase the market value of their produce at the farm level and through direct involvement in marketing activities, either as individuals or as members of a group. Mgale (1997) has described three levels of opportunities namely; opportunities at the farm level, opportunities arising from farmer integration in the food chain and opportunities arising from direct involvement in marketing. At the farm level, opportunities for adding value to moringa products include improving marketable yields through good agronomic practices such as choice of variety or genotype. There already exist several ecotypes or provenances, varieties and genotypes with specific product attributes, but a selection and improvement research and development component will be necessary as guided by type and quality of products required by the identified markets.

Another opportunity is the need to carry out basic processing, such as oil products instead of seed, or grading, preparing, preserving and tinning green pods to avoid wastage and extend shelf life of the product as well as allowing easy shipment to markets. To take advantage of these opportunities, farmers need advice and information on gauging their output to market demands and on identifying sales opportunities at both the domestic and export levels. Some of these strategies regarding market information have already been described above. Linked to farm level opportunities is also the farmer integration in the food chain. As competition increases, it is possible that farmers may become involved in group marketing and make contracts with wholesale traders or supermarket chains or even processors. Such collaboration, arrangements and agreements will ensure stability of production and market outlets. Finally, a critical but rather less accessible process of value adding activity in developing countries such as ours is that attained through financing. Products cannot pass through the marketing system without financial support. The producer at any stage must either sacrifice the opportunity to use his/her capital elsewhere or he/she must borrow the necessary capital from other sources. Farmers will therefore need financial capital for the phase during which they are in possession of their produce and awaiting sale or payment. Because of limited credit facilities, farmers have

to rely on mobilization of local resources, savings and self-help, which emphasize the need to work with groups rather than individuals. Therefore, support of NGOs such ActionAid as should be sought as they have means to help farmers organize themselves.

## 5. TECHNICAL INFORMATION FOR MORINGA CULTIVATION

### 5.1. Introduction

Moringa is increasingly becoming an important agroforestry tree species in pan-tropical areas. It is an ideal woody species for both the small-scale resource-poor farmer in developing countries and, for the plant enthusiast in the developed world due to its litany of uses. The Kenya Forestry Research Institute, in collaboration with European and North American Research Groups, has in the past 5 years been undertaking research to conserve and develop valuable products to add value for on-farm moringa cultivation.

Therefore, the information presented below are from hands on experiences both from our own work and from indigenous knowledge of Kenyan farmers and other stakeholders who have cultivated and maintained moringa since it was introduced in Kenya more than a century ago. I have also borrowed relevant information from other workers.

### 5.2. Moringa genotypes, provenances, ecotypes varieties: which type to use?

Most of the germplasm that originated from the Indian sub-continent in the early part of last century have evolved in their new environments to genetically distinct populations different from the sources. This is because moringa is highly cross-pollinated, which leads to variability of growth, productivity and many other traits. Therefore, numerous genotypes exist in ecologically and geographically diverse sites around the world that can be harnessed for improvement programmes. For example, we have 3 major provenances in Kenya (Mbololo, Kibwezi and Likoni provenances), showing traits that vary in growth, pod length and yield, seed yield and longevity between themselves and the Indian populations. Results of our growth trials at Marigat has revealed that the Kibwezi provenance has the greatest growth rate, attaining a height of about 7 m followed by Mbololo in two and a half years of growth. The coastal genotype, Likoni, showed the lowest growth rate (Odee *et al.*, unpubl.). However, it should be noted that the growth rate in the slightly more favourable agro-ecological conditions such as found in Ganda

location is expected to be a lot higher than Marigat. Recent molecular characterization of the major Kenyan populations has reaffirmed the occurrence of genetically distinct populations (Muluvi *et al.*, 1999). The molecular characterization used Randomly Amplified polymorphic DNA (RAPD) and Amplified Fragment Length Polymorphism molecular markers to determine population genetic structure of the Kenyan moringa populations. These marker techniques, used for the first time on moringa, showed that most of the genetic variation is found between populations. The practical implication of this finding is that provenance collection is recommended for Kenyan moringa populations. The results also suggest that high genetic gains may be realized through selection within individual provenances than between provenances for the various important attributes or products. Studies in India have also shown high variability of seedling population in a number of traits including number of flowers per inflorescence, pod weight and number of pods per plant (Suthanthirapandian *et al.*, 1989). These differences in growth and productivity are important in making decisions on which type of planting material to use. It will also depend, of course, on the end product of interest.

Despite this inherent phenotypic variability, there has been very little work on selection and breeding genotypes, mainly because nearly all the material found around the world had been selected prior to dispersal for fruit and seed production. Some breeding work has been carried out in India, more so for pod quality and aesthetics (Rajangam *et al.*, 2001). There are only a few named varieties. A type named "Jaffna" grown in parts of South India produces fruits about 60-90 cm and with soft flesh and good taste. Another type is "Chavakacheri murungai" producing fruits of 90-20 cm long. Another distinct type is "Chemurungai" (red tipped fruits) which flowers throughout the year and yields heavy crops, while 'Kadumurungai' is a wild type producing small inferior quality pods (Mohideen and Shanmugavelu, 1982). The "Annual Drumstick", grown in parts of Ramanpuram district of Tamil Nadu state of India (Mohideen and Shanmugavelu, 1982), bear some resemblance in flowering and fruiting attributes with plants which were established at Kitui, Ramogi and Gede. However, comparisons with the Indian ecotypes, provenances or varieties should be treated with caution as the Indians have specifically selected their germplasm for fruit as a vegetable. For instance, the Horticultural College

and Research Institute of Tamil Nadu Agricultural University has released two annual moringa varieties for vegetable pod production for commercial cultivation (Rajangam *et al.*, 2001). The varieties are PKM-1, which is dwarf to medium height and produces 50-54 tonnes of green pods per hectare; and PKM-2, which is medium to tall height and produces about 98 tonnes of green pods per hectare.

### 5.3. What growing conditions does moringa prefer?

Moringa grows well in warm to hot climates. However, it can also survive light frosts, although not productively. It thrives in lowlands and even at elevations of up to 1200 masl. Our best growth, and seed and pod yield data have been recorded in elevations of between 1100-1200 masl. These areas have mean annual temperature ranges of 21 to 32°C, and mean annual rainfall of 450-1100 mm. The drought tolerance of moringa (largely because of its tuberous root which also acts as a water storage organ) is exemplified by its establishment and growth in Kenyan conditions receiving less than 600 mm of annual rainfall occurring in one week, such as Marigat near Lake Baringo.

### 5.4. Seed collection and storage

Seeds are normally collected from matured fruits with pale brown colour. It is critical to collect the seeds before pods dehisce (open). A large proportion of seeds can be lost from mature fruits that overstay on the tree. Furthermore, the seeds risk being infested by pests such as weevils. The seeds are light and can be carried to some considerable distance from the progenitor especially when the fruit dehisces. One kilogram contains about 4,000-5,000 seeds of moringa. A standard sack/gunny bag can contain a range of 25-30 kg of impure seeds, but this also depends on the drying state (moisture content) of the seeds at the time of harvest. Moringa trees can grow tall thus making the exercise of fruit/seed collection rather precarious unless special implements such as extendable secateurs are used to harvest fruits high up the tree. Most growers in Taita-Taveta and Makueni districts get around this problem by managing their crop, for example, by regular pruning so that they do not grow so tall. They have also improvised long

harvesting wooden sticks with hooks at the far end to harvest fruit (pods) and seed. There are also short stem varieties of moringa, for example the Indian PKM1, which do not grow so tall. Management techniques such as pollarding, coppicing and lopping are frequently used to promote branching, increase production (pod and seed) and allow easy harvesting of products. Seeds should be stored in a cool dry place. Viability tests have shown that freshly collected seeds of moringa are highly viable, attaining germination rates of up to 70% within 12 days and maxima of 90% in 19 days (Boera, 1999). The seed viability is maintained at germination rates of 80% even after storage of up to 6 months at room temperature, 3°C and -20°C. Therefore, seeds collected for the purposes of cultivation can be stored in any of these conditions for periods of up to 6 months without significant loss of viability. We have not observed any serious pest attack of seeds stored under cool or room temperatures.

### 5.5. Nursery practice

#### 5.5.1. Pre-sowing

This practice is necessary when direct sowing in the field is deemed futile such as occurs in very dry conditions with unpredictable rainfall pattern.

To hasten germination the seed capsule or husk is removed after de-winging although sowing without de-winging is also commonly practiced. The capsule cover breaks down and sprouting starts after seven days. Although we have not found it necessary, Fuglie and Sreeja (2001) also recommends soaking in water overnight before sowing to encourage rapid germination.

#### 5.5.2. Sowing/nursery mixture

A nursery mixture containing forest soil and sand is ideal. However, ordinary soil can be used where forest soil is not available. We use a ratio of 3:1 soil and sand. The sand improves drainage and aeration for seedlings. Only plant one seed in each tube. Keep

moist but not too wet. Moringa does not like too much water. Seed may dampen and rot. Even after germination, seedling may dampen off. Established seedlings, saplings and trees often react by yellowing and subsequent shedding of leaves, which can be mistaken for nutrient deficiency.

A polythene tube of size 5" × 9" or approximately 13 cm × 23 cm (flat dimensions) has given us satisfactory results for nursery period of not more than 2 months. Larger tubes may also be used to allow root and tuber development where seedlings are expected to stay longer in the nursery.

Tubes are filled with the mixture leaving a portion at the top for layering after sowing. The tubes should have holes (3 - 6) at the bottom to facilitate excess water drainage and also allow the roots to emerge. If the tubes do not have drainage holes, you can create them by puncturing the bottoms with a sharp-pointed implement.

After sowing the seed is layered with soil (about 2 cm deep) and then some light dry grass is placed at the top to cool down the direct heat from the sun in hot conditions, if not under shade. Tubes are watered twice a day - mornings and evenings until commencement of germination which occurs between 4 - 7 days. After germination watering intensity is reduced. Water reduction should be more pronounced just before out-planting as a way of hardening the seedlings. Hardening is started from week 6 - 7 of growth in the nursery prior to planting in the field in the 8$^{th}$ week.

5.5.3. Direct seeding

If water is available, as in irrigated fields, trees can be seeded directly and grown anytime during the year. Prepare planting pit first, water, and then fill in the pit with top soil mixed with compost or manure before planting seeds. Rain fed or rain dependent planting should be seeded directly at the onset of rainy season.

5.5.4. Growing from cuttings

Moringa can also be raised from cuttings. Propagation by cuttings is particularly attractive when the mother plant (stock plant) or elite tree has a desirable trait requiring to be re-produced as true to type (cloning). Use hardwood (not green) for cuttings. Cuttings should be 45 cm to 150 cm long and 10 cm to 16 cm thick (Fuglie and Sreeja, 2001; Rajangam *et al.*, 2001). For production of large numbers of cuttings, the elite trees are cut down or hedged, leaving a head of about 90 cm height from which several shoots are allowed to grow. From these shoots, cuttings of about 100 cm long and 4 to 5 cm in thickness are selected and used as planting material (Seemanthini, 1964; Peter, 1978).

Cuttings may also be planted into tubes or directly to field. When planting directly, plant the cuttings in light sandy or loamy soil. Most soils in the project area have sandy to loamy texture (Mwendwa *et al.*, 2001), hence favourable for moringa propagation. Plant one-third of the length in the ground, i.e., if cutting is 150 cm long, plant the proximal end 50 cm deep. When the cuttings are planted in the nursery, the root system may be slow to develop. Cuttings planted in the nursery can be out planted after 2- 3 months (Fuglie and Sreeja, 2001). However, our experience indicates that plants raised from cutting are normally unstable and vulnerable to wind.

**5.6. Land preparation and planting techniques**

5.6.1. Bush Clearing

Bush clearing should be commenced early enough to allow subsequent operations to be completed before on-set of rainy season. Complete clearing is recommended to minimize competitions for scarce nutrient and water from the weeds.
We have not experienced any competition effects of moringa on associated food crops or other trees when spaced at a distance of 3 m × 3 m apart.

### 5.6.2. Site fencing

Appropriate fencing of newly out planted sites is absolutely essential where wildlife or free roaming livestock are expected. This is the time when moringa is most vulnerable and considerable investment should be considered to protect the saplings. This is particularly important in the rangelands.

### 5.6.3. Ground Preparation

Deep ploughing is particularly important in soil profiles with hardpan. A second round of ploughing is done to open up new furrows at a spacing of 2.5 - 3.0 m. The depth should be approximately 50 cm. Further pitting of the planting holes at 30 - 50 cm on both side of the furrow is carried out. This is to prevent convergence of excess water at basal zone.

Excess moisture at the basal part of the trunk can promote fungal infection (root-rot). It is therefore important that holes for planting in irrigated land are pitted beside the furrow.

### 5.6.4. Transplanting

As mentioned earlier, seedlings are kept in the nursery for a period of 8 weeks, and watering regime reduced a week or two prior to planting. Care should be taken when transporting seedlings to out-planting sites. For instance, seedlings should be in upright position and shielded from strong wind during transportation.

Planting should be done later in the afternoon to avoid mid-day sun. Freshly transplanted seedlings should be staked where necessary to prevent seedling bending or breakage. The nursery seedling tube should be removed prior to planting by cutting it length-wise with a razor blade.

In less harsh conditions, seeds may be directly sown in pits or furrows. However, you require planting at least 5 seeds per hole and later thinned to cover for potential losses due to lack of germination, opportunistic pests and unpredictable weather conditions.

5.6.5. Irrigated planting

Because of the very erratic and unpredictable nature of rainfall in certain dry areas, it may be necessary to irrigate newly planted seeds or seedlings. We have successfully established some of our trials located in drylands receiving less than 400 mm of rainfall using irrigation by gravity (canals). After establishment, irrigation has only been necessitated during prolonged (unusual) drought and when we needed to induce flowering.

5.6.6. Spacing

For intensive or agroforestry type systems of intercropping, a spacing of 3 m between trees in a row and 10 m between rows is recommended (Fuglie and Sreeja, 2001). In a monoculture system, any spacing is appropriate and depends on the end product. In our trial at Marigat, we found a spacing of 2.75 m × 2.75 m to be superior to 2 m × 2 m, 2.5 m × 2.5 m and 3 m × 3 m in terms of height growth (Odee *et al.*,unpubl.). Optima of Africa, whose main interest in moringa cultivation is in seed production, has recommended a moringa monoculture spacing of 2.5 m × 2.5 m × 6 m in a double row configuration giving some 800 trees per hectare (Creighton, 2001).

## 5.7. Plantation management and production tips

5.7.1. Pinching the terminal tips

When the seedlings/saplings attain a height of about 60-75 cm, pinch the terminal growing tip 10 cm from the top. This can be done using fingers or shears or knife blade.

Secondary branches will begin to appear on the main stem below then cut soon after (about a week or so later). Cut the branches back to 10 cm when they reach 20 cm. Tertiary branches will appear in the same manner. This pinching, done 3-4 times before flowering will encourage the tree to become bushy and produce pods or fruits, and subsequently seed within easy reach. Pinching also helps the tree to develop a strong frame for maximizing yield and hence reduce breaking of branches or falling over due to the weight of the fruit or simply prevent breakage due to heavy wind. Ratooning (or coppicing or pruning) may also be done with mature trees, by cutting at about 30 cm-100 cm just before or at the onset of the proper rainy season.

### 5.7.2. Use of fertilizers

Moringa normally grows well without fertilization. We have not found the necessity in the diverse agro-ecological zones of Kenya where we have established our trials located in Kibwezi, Kitui, Ramogi (western Kenya), Marigat (Rift valley) and Gede, which is also most similar to the project area of Ganda and Goshi. However, some moringa growers in other countries use manure or compost mixed with the soil for filling the planting pits. Nitrogen based fertilizers (e.g., NPK) are applied as top dressing at first flowering stage, especially after pinching (Suthanthirapandian *et al.*, 1989; Rajangam *et al.*, 2001). Research done in India has also shown that applications of 7.5kg farmyard manure and 0.37kg ammonium sulphate per tree can increase pod yields threefold (Ramachandran *et al.*, 1980). Nitrogen fertilization encourages leaf biomass production, whereas phosphorus will encourage root development (Fuglie and Sreeja, 2001).

### 5.7.3. Flowering and fruiting

*Moringa oleifera* saplings may flower as early as 3 months after transplanting into the field. Thereafter, flowering and fruiting follow the seasonal patterns of the region. In western Kenya, there is all year flowering with peak periods. In other parts, such as Kenya's Rift valley, flowering is highly seasonal, closely linked to the little annual short

spelled rainfall. In areas with bimodal rainfall, up to 2 crops of fruit may be harvested. Fruit development and maturity may spread over a period of 2 - 5 months.

### 5.7.4. Time to harvest fruit and seed

If the main product of interest is fruit (pod), then harvest should start as soon as the right texture and size are observed. Mature pods for seed should be harvested before the beginning of rainy season to prevent losses due to rotting.

### 5.7.5. Yield Range

Seed yield and general productivity depends on the variety, spacing and environmental conditions prevalent at the out planting site. The pod and seed yield is generally low in the early harvests under two years after transplanting. Mature stands (+3 years) can yield on average 2 tonnes of seed per hectare based on estimates derived from our trials in western Kenya with the Mbololo provenance. However, as mentioned above there is often great genetic variability on plants raised through unimproved seed sources. Significant gains can, therefore, be made on growth and productivity through genetic selection and appropriate management strategies. In India, the fruit or pod yield is reported to be low (80-90 fruits/tree) in the first year and then increases to 500-600 fruits/tree/year by the fourth year (Rajangam *et al.*, 2001). Others have reported fruit yields of up to 1,600/tree/year by the third year (Fuglie and Sreeja, 2001).

### 5.7.6. Pests and diseases

There are many reports of pests and diseases of moringa around the world but most of them are not of economic importance. Pests and diseases may also be injurious in one and not in another region. It is reported that a budworm, *Noordia moringae*, causes considerable damage. A scale insect, *Diaspidotus* sp., has severely infested trees and

greatly reduced the fruit crop in Madras State, India. In Kenya, a green leaf caterpillar, *Noorda blitealis*, is highly destructive in Marigat (Rift valley province), Makueni (Eastern province) and in Mbololo (Coast province). The pest manifests itself by mining or defoliating leaves and flowers, and debarking stems, branches, twigs and fruit capsules. The infestations occur at the onset of rains and peak just after the rains, subsiding with the start of the dry season. Although infested moringa trees are resilient and often recover, the damage can be so severe that the aboveground biomass production of the socio-economically important products such as leaves, flowers, fruits and seed can be reduced to between 2 – 4% (Odee *et al.*, 1999). Moringa farmers in Taita-Taveta and Makueni districts use ash or remove affected plants to control the pests (Odee *et al.*, unpubl.). We have not found this pest in the coastal strip of Malindi and Mombasa district but it may be just a matter of time when there will be large crop of moringa established. In India, the caterpillar is not considered a serious pest. Spraying with commercial pesticides may help control most pests.

A root-rot fungus, *Diploidia,* commonly occurs in wet or waterlogged conditions. Management practices that reduce or exclude excessive retention of water around the root collar of seedlings, saplings and trees are thus crucial towards prevention of this fungus. KEFRI's pest and disease control unit is spearheading a research programme: an integrated pest management, including biological control, to develop effective and sustainable pest control measures.

5.7.7. Other tips

- Sow seeds or transplant seedlings just before the rains especially in very dry conditions
- Constant weeding (spot or complete) is necessary to keep away weeds
- Dry or broken stems are pruned to allow re-growth
- Early deaths at transplanting are replaced (beaten up) in the first month

- Heavy pod fruiting branches are reinforced to prevent breaking or splitting of branches or trunks that may be easy entry points for insect pests and diseases
- Dry brown pods are harvested promptly to avoid loss of seed or infestation by weevils

**5.8. Cost estimates of moringa cultivation**

It is difficult to provide an accurate cost of moringa cultivation in an agroforestry system such as is common in the project area and indeed other parts of the country. However, we have attempted to provide an estimate in an entirely experimental moringa monoculture setting of our growth and production trials located in Marigat station, near Lake Baringo in Rift valley province. We arrived at an estimate of KShs 110,494 (about USD 1400, present exchange rate but study carried out more than 5 years ago) per hectare, based on actual records collected from raising seedlings in the nursery, transplanting, management, maintenance up to first harvest of pods for seed in the first year of the crop. There was some input of mechanical land preparation using tractors (see appendix 8). This estimate can reduce substantially if labour is entirely manual, fencing is excluded and planting is through direct seeding. However, such exclusions are driven by the specific factors on the ground. I envisage a drastic cost reduction in the project area compared to Marigat due to the favourable socio-economic and agro-ecological conditions.

Creighton (2001) of Optima of Africa Ltd has also made a forecast for one hectare of moringa seed production under Tanzanian conditions on the basis of 800 trees per hectare (appendix 9). They estimated approximately USD 497 in the first year to cover establishment costs (tractor disc ploughing, marking out, hole digging, manure, hole filling, sowing seeds), and maintenance costs (two hand weedings and 2 hand slashings, 3 prunings and first ratooning, harvesting and ginning). These costs are therefore nearly a third that of Kenya but such a comparison should be made with caution since the conditions and parameters for costing are not necessarily similar.

## 6. STAKEHOLDERS AND POTENTIAL COLLABORATORS

To the best of my knowledge and on the basis of this study, there is no single organisation with similar (moringa) activities that is presently located in the project area, except for KEFRI, which is part of the project. A number of NGOs are involved with planting of moringa among other tree species as part of agroforestry and on-farm tree planting, especially in the marginal areas such as the semi-arid and arid lands. However, none is really focussing on moringa as a commodity such as does the project, which makes this initiative uniquely challenging and a great likelihood for success, if anything, for the simple reason that there is no foreseeable risks resulting from competition in the area. Already, the project has rejuvenated moringa planting in the project area using participatory approaches, and by collaborating with farmer groups and other CBOs such as FADA; these should be pursued. Other government or quasi-government organisations such as the Ministry of Agriculture and Livestock Development and KARI have on-going activities in the project area, as is the case nationwide, but none is directly dealing with moringa, not even in research and development. However, these institutions have a wealth of human resource and experience with other commodity crops, which should be tapped in order to enhance moringa production, utilisation, product development and marketing in the project area and beyond.

The most visible NGO within the vicinity of the project area is ActionAid (Coast province) Kenya, with Jilore location being closest to their activities. ActionAid's key programmes are education, water, food, health, credit, security, and policy research and advocacy. The broad activities embraced within these programmes are pertinent to the domestication, development and utilization of moringa. For instance, the water programmes aim at ensuring safe and reliable sources of potable water for 60% of all poor households in all operational areas, building the capacities of water associations to manage their own water projects in a participatory and democratic manner and enshrine the right to water in the national constitution. According to the 1999 census, about 52% of households in Malindi district have access to clean (piped) water. This proportion may be a lot lower, especially within the project area, as the census was inclusive of

households even within the urban centre of Malindi. Moringa may have a role as nearly half the households will probably have access to turbid and clinically unsafe water from ponds, dams, lakes and rivers such as is common in some parts of Goshi and Jilore locations. Similarly, other ActionAid's programmes have direct impact on moringa. Therefore, collaborating with ActionAid would benefit the moringa initiative from its established capacity in the areas of dissemination, community mobilization and advocacy and hence drive the development and marketing of moringa in the project area and beyond because of its wider geographical reach. Another NGO, Heifer International, based in Malindi can also be a potential partner, especially in the area of promoting and developing moringa as a another source of animal fodder.

Perhaps the most useful contact in terms of production, commercialization and marketing of moringa products would be found south of the boarder in Dar es Salaam, Tanzania. Established in 1995, Optima Africa[10] and a subsidiary of Optima Environment S.A. (Swiss company), is focused on the development of products available from moringa. The company has a large network of farmers (>10,000) in Tanzania growing moringa and reputes itself as the only one in the world involved in large scale production of moringa oil. Optima of Africa Ltd is now producing and marketing moringa by-products, all containing moringa oil. The range of products is marketed locally in East Africa, and international companies specialized in the cosmetic industry. There are three cosmetic oils at present, all composed of 100% natural products using moringa oil blended with other plant oils, and marketed as massage, skin care, sports oil, and soap. This would be a vital first line stop outside the Kenyan coastal region as the market for either raw or processed products from the project area, as well as a source of information on the opportunities and constraints pertaining to the intensive and extensive cultivation, production, product development and marketing processes of moringa products.

Globally, there are literally hundreds of organisations working with moringa, which cover diverse research and development issues pertaining to moringa. The profiles and

[10] Optima of Africa Ltd, 255 Vikawe Street (Regent area), Dar es Salaam, Tanzania. Tel/fax: +255 270690, website: www.optimaworld.com.

activities of most of them can now be obtained in the internet. However, Leicester University (UK) Engineering Department[11], Church World Service (CWS)[12], and the Moringa Homepage[13] deserve special mention and their websites should be visited for general information on biology, water treatment, oil products, cultivation and production, medicinal, nutritional and many other miscellaneous uses.

[11] Leicester University Engineering Department: www.le.ac.uk/engineering
[12] Church World Service: www.moringatrees.org
[13] Moringa Homepage: www.mobot.org

## 7. CONCLUSIONS AND RECOMMENDATIONS

Moringa is a multipurpose tree species with a potential for greater adoption and utilization within the project area. Its many attributes, which include valuable products and an array of uses coupled with its ability to flourish in a range of conditions and compatibility with other trees and intercrops, make it an ideal tree for promotion and inclusion in the farm forestry and agroforestry initiative of the Farm Forestry and Natural Resources Conservation Project.

This study has shown that there is a long history of moringa cultivation and utilization within the project area, albeit inexhaustibly, which needs to be re-invented by way of appropriate moringa technology dissemination and empowerment of growers in order to catalyze its adoption and maximal exploitation. The way forward is to build on the indigenous knowledge of moringa cultivation and utilization and avail all the other options and support systems that will help drive a sustainable adoption process. By enhancing its adoption and utilization, the expectation is that the communities within the project area will improve their nutrition, health, have safe drinking water and generate income from the valuable products. Additionally, by providing basic products and services normally extracted from the adjacent Arabuko-Sokoke forest, the pressure on this unique natural resource will be reduced and hence help conserve it.

On the basis of information generated by this study, the following key recommendations are outlined herewith to facilitate sustainable production and utilization of the species in the project area:

- There is an urgent need to use appropriate germplasm and management strategies for moringa cultivation targeting specified products and services, as will be determined by the needs and priorities of the communities within the project area. Production, utilization and marketing of products should be supported by appropriate technical information, so that the right germplasm is used as dictated by the needs and priorities identified by the growers or producers. It is

recognized that there has been very little selection and improvement work carried out to date except for the production of the green pod vegetable. If other products will arise from the needs and priority assessments, then there should be a parallel investment towards research and development of such products.

- Presently, the only moringa product in some kind of use is the fresh leaves as a blend for other traditional vegetables. There is need to advocate and diversify utilization of moringa in the project area. This can be achieved by dissemination and technology transfer mechanisms such as participatory approaches and extension agencies to specifically inculcate the uses and how to use moringa as a source of edible cooking oil, water clarification and treatment, health and nutrition, fodder, medicinal, apiculture and many others.

- Markets and marketing of moringa products were found to be wanting in the project area and the coastal region. As a vital precursor to trade and subsequent income generation to growers, markets and marketing of moringa products could determine whether the new initiative on moringa cultivation, production and utilization would be sustainable or not. There is, therefore, an urgent need to empower the local moringa growing communities through capacity building so that they are able to target production, and to understand and develop markets for their products.

- Last but not least, there is need to strengthen and consolidate partnerships and collaborations with other Government Departments, NGOs, CBOs, who although are not necessarily carrying out activities pertaining to moringa in the project area, may have relevant human and infrastructural resource base that can be tapped to complement the efforts of the project consortium to help enhance adoption for sustainable production and utilization of the species.

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## APPENDICES

**Appendix 1.** Terms of reference

The consultant is expected to design viable questionnaires to address the following:

1. extent of cultivation of *Moringa oleifera* especially in the project area
2. main social groups (e.g. women headed households, women groups, large families, youth groups) involved in cultivating *Moringa oleifera*
3. socio-economics of cultivating households (poor, average or rich)
4. current utilization information (common uses by local communities in the project area especially for water treatment, food, medicines, apiculture, farm forestry)
5. regions with a lot of cultivation of the species (especially those within the project area i.e. Goshi, Ganda and Jilore
6. Marketing information (main products, markets, market needs versus supply)
7. financial, logistics, and technical information about cultivation and marketing of produce
8. potential for large scale export oriented production of oil and pods within and outside Kenya
9. potential for adoption of the species by subsistence farmers to facilitate sustainable production and utilization of the species in the project area
10. any expected drawbacks if the species is widely cultivated in the area
11. names and activities of other projects, NGOs or research organizations involved in similar work
12. possible collaborators in the field of study, and
13. any other relevant information on the study

**Appendix 2.** Questionnaires used in the study

**MORINGA OLEIFERA**

**FARMER SOCIO-ECONOMIC SURVEY**

**DISTRICT**_____ **DIVISION**_____

**LOCATION**_____ **VILLAGE**_____

**BACKGROUND**

1. Name of farmer:_____ Age:_____

Sex 1. Male 2. Female

Marital status 1. Single 2. Married

2(a). Who heads the household?

1. Male headed household.
2. Female headed household (absentee husband)
3. Female headed household (no husband)

2(b). Who makes most of the day-to-day decisions about running the farm?

1. Husband/male head
2. Wife/female head
3. Farm couple
4. Other (specify)

3. How many people (full time residents) live on the farm?

1. Adult men (16+)_____
2. Adult women (16+)_____
3. Children (<16)_____

**LAND TENURE**

4. Who owns the farm you live in?

1. Own
2. Rental
3. Communal
4. Others (specify)

5. What is the approximate size of your farm? (specify acreage/hectare)_____

6. Do you own any other piece of land other than this one?

1. Yes
2. No

7. If 'Yes', how did you get it and what is its acreage?

1. Bought
2. Inherited
3. Others (specify)

Acres/hectare_____

**RESOURCES [This section to be complemented by visual observations]**

8(a). Are you engaged in any other off farm income generating activities?

1. Yes
2. No

8(b). If 'Yes', what's the activity?

1. Formal employment
2. Self employment/business
3. Casual labour
4. Others (specify)

9(a). Where do you obtain labour for your farming activities?

1. Family labour
2. Casual/paid labour
3. Communal labour
4. Others (specify)

9(b). If it is family labour, who works most of the farm?

1. Husband/male head
2. Wife/female partner
3. Children
4. Others (specify)

10. If you hire labour, what is the mode and rate of payment?_____

11. What crops are grown on the farm? (List in order of importance)

1._____ 2._____ 3._____

4._____ 5._____ 6._____

12. What type of livestock do you keep on the farm? (List in order of importance).

1._____ 2._____ 3._____

4._____ 5._____ 6._____

13. Do you sell any of the farm products listed above?

1. Yes
2. No

14. If 'Yes' name the products

_____ _____

_____ _____

_____ _____

15. What farming implements/tools do you own?(List)
1._____ 2. _____
3. _____ 4. _____

**KNOWLEDGE, MANAGEMENT AND USE OF MORINGA TREE**
**[This section is for Moringa growers]**

14. What is the local name of the Moringa tree? _____

16. Does this name have any significant meaning (If yes state the meaning)?

17. What is the estimated number of Moringa trees/stems/saplings on the farm?_____

18(a). Who planted the trees that are present on your farm?
1. Planted them yourself
2. Inherited/bought with the farm
3. Others (specify)

18(b). If you planted them yourself, what year was that?_____

19. Where did you get your first planting material?_____

**MANAGEMENT:**

20. How do you make new plantings of Moringa?
1. Natural regeneration/wildings
2. Seed
3. Seedling
4. Cuttings
5. Others (specify)

21. How do you manage the crop?
1. Not at all
2. Coppicing
3. Pruning
4. Lopping
5. Pollarding
6. Others (specify)

**UTILISATION AND MARKETING**

22. How do you utilize moringa tree or its products? (List in order of importance uses and/or parts of tree)
1._____ 2. _____
3. _____ 4. _____

23. Are you aware of the many other uses not listed above (Mention other uses not listed above of the key uses namely, food, cooking oil, water clarification, medicinal, apiculture, mulch etc.)? (YES/NO)

24. Now that you are aware of the many potential uses of Moringa, would you like to increase or grow more Moringa trees in your farm? (YES/NO)

25(a). Do you sell any of the tree products?

1. Yes
2. No

25(b). If yes, list the products, unit prices, quantities sold and buyers or customers. Also indicate if products are taken to market outlets or bought straight from your farm.

| Product | Unit price | Quantity sold p.a. | Market or farm sold | Buyer(s) |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

26. What problem(s) do you encounter in selling or marketing of Moringa products?

1. _____ 2. _____
3. _____ 4. _____

**KNOWLEDGE AND UTILISATION OF MORINGA**
**[This section is for non-moringa growers]**

27(a). Have you heard or seen the Moringa tree or its products? (Display Moringa poster/photos)

1. Yes
2. No

27(b). If yes, do you use any of its products?

1. Yes
2. No

27(c). If yes, where do you get or buy the products? (Name the place or locality)

1. Neighbours
2. Market
3. Shop
4. Hawkers
5. Others (specify)

28. Are you aware of the many potential uses of this tree? (mention the key uses namely, food, cooking oil, water clarification, medicinal, apiculture, mulch etc.)

1. Yes
2. No

29. Now that you are aware of the many potential uses of the Moringa tree, would you plant it in your farm if provided with seeds/seedlings even at minimal cost?
YES/NO

**GROUP/INSTITUTIONAL LINKAGES**

30(a). Do you belong to any affiliations/organizations?

1. Yes
2. No

30(b). If yes, which group/s do you belong to? (Provide names where available)

1. Women's group
2. Religious or faith group
3. Youth group
4. Savings + Credit Associations

31(a). Have you been involved in any other project which encourages or advocates growth and utilization of Moringa tree?

1. Yes
2. No

31(b). If yes, what type of project/activity was it and when?

| Year | Activity |
|---|---|
| | |
| | |
| | |
| | |

32. Have you ever participated in any externally initiated development activity?

1. Yes
2. No

33. If yes, name the agency/institute responsible (e.g. MoALD, KWAP, CARE, KEFRI, KARI, FD etc.) and the type of activity you were involved in.

| Agency, institute, etc. | Activity |
|---|---|
| | |
| | |
| | |
| | |

34(a). Are there any cultural barriers against anyone (e.g. women, children, men) planting or cutting down the trees?

1. Yes
2. No

34(b). If yes, explain

**MORINGA OLEIFERA**

**MARKET INFORMATION FOR MORINGA PRODUCTS**

**DISTRICT**_____ **DIVISION**_____

**LOCATION**_____ **TOWN/CENTRE**_____

1. Name and address of Moringa dealer/buyer:
Name:_____
Address:_____

2. Category of business (e.g. retailer, stall, hawker, exporter etc.)_____

3. What types of Moringa products do you deal in?
   1._____ 2._____
   3._____ 4._____

4. Where do you get your Moringa products?_____

5. How do you source or get your Moringa products?
   1. Direct from farm(s)
   2. Middlemen
   3. Other means (specify)

6(a). Do you experience any problems in sourcing Moringa products?
   1. Yes
   2. No

6(b). If yes, list them in order of importance
   1._____ 2._____
   3._____ 3._____

7. Which Moringa products do you process before selling?
   1._____ 2._____
   3._____ 3._____

9. Who buys your Moringa products?
   1._____ 2._____
   3._____ 3._____

10. List the products and quantities you sell and type of buyers

| **Product** | **Unit price** | **Quantity sold per week, month or year** | **Buyers (e.g., individuals, market vendors, supermarkets** |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |

11(a). Do you export any products upcountry or abroad?

1. Yes
2. No

11(b). If yes, list products and destination

| Product | Unit price | Quantity exported per week, month or year | Destination |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |

12. How has the market for your Moringa products behaved in the past 20 years to date?

1. Increased
2. Decreased
3. Fluctuated
4. Remained constant

13(a). How do you see the present demand for your Moringa products?

1. Increased
2. Decreased

13(b). If increased, is the present supply sufficient?

1. Yes
2. No

13(c). If yes, is it reliable or guaranteed?

1. Yes
2. No

14. What other issues would you like to be addressed concerning marketing of your Moringa products?

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____

**MORINGA OLEIFERA**

**GOVERNMENT DEPARTMENTS, NON-GOVERMENTAL ORGANISATIONS (NGOs), COMMUNITY BASED ORGANISATIONS, PROJECTS ETC. UNDERTAKING SIMILAR ACTIVITIES IN THE AREA**

**OPERATIONAL LOCATION:**
**NAME**_____

**ADDRESS**_____

**TELEPHONE/FAX/EMAIL**_____

1. What is your sectoral interest?
    1. Agriculture or livestock development
    2. Agroforestry
    3. Health
    4. Micro-finance/credit facilities
    5. Others (specify)

2. What are your key activities?
    1. _____
    2. _____
    3. _____
    4. _____
    5. _____

3. What is your geographical coverage or reach?
    1. Goshi
    2. Ganda
    3. Jilore
    4. Others (specify)

4. What is your target group(s)? Provide names where applicable.
    1. Farmers
    2. Women's group
    3. Youth
    4. Others (specify)

5(a). Is domestication and utilization of the moringa tree among your activities?
    1. Yes
    2. No

5(b). If yes, what is your aim or goal in advocating domestication of Moringa trees by farmers?

6. Would you like to collaborate with the project "**Farm Forestry and Natural Resources Conservation Project**" on domestication, utilization and dissemination of Moringa technologies in the area?
    1. Yes
    2. No

**Appendix 3.** List of farmers interviewed

| Name | Location | Sub-location | Village |
|---|---|---|---|
| Dama Kazungu | Ganda | Ganda | Ganda |
| Samuel Kenga | | Ganda | Ganda |
| Sudi Omari | | Ganda | Ganda |
| Alii Omar Kambaa | | Ganda | Mtatazi |
| Koi Harrison | | Msabaha | Kasimbiji |
| Charo Kithi | | Msabaha | Mkaomoto |
| Tsoemoyo | | - | Mkaomoto |
| Jua Kali | | - | Mkaomoto |
| Dudu | | - | Mkaomoto |
| Kitsoa Hinzano | | - | Mkaomoto |
| Nasibu Yusufu | | - | Mkaomoto |
| Kasumuni Alii | | - | Mkaomoto |
| Harrison Mkutano | | Msabaha | Mkaomoto |
| Said Karisa | | Msabaha | Kasimbiji |
| James Charo | | Msabaha | Msabaha |
| Chengo Kijomo | | Msabaha | Msabaha |
| Charo Kazungu | | Msabaha | Msabaha |
| Fidhini Ponda | | Msabaha | Msabaha |
| Bongo Khonde | | Msabaha | Msabaha |
| Kahindi Mwavuo | | Mere | Mere |
| Bakari Omar | | Mere | Mere |
| Salim Katete | | Mere | Mere |
| Sidi Nyongoro | | Mere | Mere |
| Mariamu Yusuf | | Mere | Ganda |
| Rehema Julius | | Mere | Mere |
| Mwanaisha Idiwa Alifali | | Ganda | Mabaoni |
| Mzee Saro | | Ganda | Mabaoni |
| Ismail Bakari | | Ganda | Mabaoni |
| Ponda Hinzano | Goshi | Kakuyuni | Madunguni |
| James Kenga | | Kakuyuni | Madunguni |
| Raphael Ziro | | Kakuyuni | Kavonyalalo |
| Charo Kombe | | Kakuyuni | Madunguni |
| Jumwa Ngowa | | Kakuyuni | Madunguni |
| Sidi Jefwa | | Kakuyuni | Madunguni |
| Daniel Kenga | | Kakuyuni | Kanyalalo |
| Gona Hare | | Kakuyuni | Madunguni |
| Charo Mole | | Mongotini | Mongotini |
| Isaya Kenga | | Mongotini | Jilore |
| Kaingu Kalume | | Mongotini | Jilore |
| Harrison Kaingu | | Mongotini | Jilore |
| Kahindi Charo | | Mongotini | Mongotini |
| Joseph Kenga | | Mongotini | Mongotini |
| Abraham Katana | | Mongotini | Mongotini |
| Lawrence Ngumbao | | - | Mumangani |
| Karisa Chengo | | Mongotini | Mongotini |
| James Gohu | | Mongotini | Mongotini |
| Reuben Ngonyo | | Mumangani | - |
| Stephen Gia | | Mmangani | - |
| Thomas Kitsao | | Mmangani | - |
| Albert Chome | | Mmangani | - |
| Katana Thethe | | Mmangani | - |
| Majale Mumba | | Mmangani | - |
| Kahandi Ngao | | Mmangani | - |

| Name | Location | Sub-location | Village |
|---|---|---|---|
| Kenneth Gushe | Jilore | Jilore | - |
| Paul Kaingo/Priscilla Menza | | Jilore | Jilore Vitunguni |
| Sulubu Matete Ngiro | | - | Jilore Vitunguni |
| Ngumbao Kadenge Tsaro | | Jilore | - |
| Arthur Gona | | Jilore | - |
| Katana Bi Kanga | | - | Jilore |
| Richard Ruwa | | Jilore | - |
| Kitsao Chanzera | | Jilore | - |
| Kahindi Koi | | Jilore | Jilore |
| Raymond Kadenge | | Jilore | - |
| Andrea Baloni Mulewa | | Jilore | Jilore Vitunguni |
| Edson Raymond Kitsao | | Jilore | - |
| Mwanza Ruwa | | Kakoneni | Majengo |
| Karisa Samuel | | Kakoneni | Majengo |
| Katana Mlanda | | Kakoneni | Majengo |
| Charles Kaingu | | Kakoneni | Majengo |
| Joseph K. Kahindi | | kakoneni | Majengo |
| Kadenge Charo | | Kakoneni | Majengo |
| Festus Karisa | | Kakoneni | Majengo |
| Katana Yaa | | Kakoneni | Majengo |
| Kithi Beja | | Kakoneni | Majengo |
| Shadrack Jilani | | Kakoneni | Majengo |
| Hannington K. Kithi | | Kakoneni | Majengo |
| Kalume Baya | | Kakoneni | Majengo |
| Rukia Nganda | Gede | Mijomboni | Arabuko |
| James Dino | | Mijomboni | Mabuwani |
| Katana Kiboni | | Mijomboni | Arabuko |
| George Ng'ambo | | Mijomboni | Mijomboni |
| Kitu Sumuni | | Mijomboni | Mabuwani |
| Katana Mramba | | Mijomboni | Mabuani |
| Shadrack Kenga | | Mijomboni | Mabuwani |
| Kombe Yeri | | Mijomboni | Mabuwani |
| Kahindi Kombe | | Mijomboni | Arabuko |
| Kahindi Gona | | Mijomboni | Arabuko |
| Katao Kombe | | Mijomboni | Arabuko |
| Karisa Hungwe | | Mijomboni | Mabuwani |
| Bonea Kauro | | Dabaso | Siita |
| Fundi Hamadi | | Dabaso | Dabaso |
| Joseph Sonkoro | | Dabaso | Dabaso |
| Kahindi Kaboga | | Madumadu | - |
| Abajila Dhidha | Watamu | Jimba | Mbarakachembe |
| Katana Charo | | Jimba | Jimba |

**Appendix 4.** List of traders interviewed

| Name | Type of business | Location/address |
|---|---|---|
| Sidi Kazungu | Hawker | Sokoni, Malindi |
| Sofia Mohamed | Hawker | Sokoni, P.O. Box 275, Malindi |
| Mwangi Kariuki | Hawker | Kwa Jiwa Supermarket, Malindi |
| Herman Njoroge | Hawker | Kwa Jiwa Supermarket, Malindi |
| Mrs Kahindi Chai | Hawker | Old Malindi Market Centre, Malindi |
| Abdulla | Grocer | Kilifi town centre, Kilifi |
| Mrs Kaingu John | Hawker | Market centre, Kilifi |
| M. Sheik | Grocer | Kilifi |
| Mrs Teresia Maingi | Grocer | Kilifi Market Centre, Kilifi |
| Samuel Deche | Grocer | Kilifi Market Centre, Kilifi |
| Dama Jembe | Green grocer | Mtwapa, Mombasa |
| Messrs Nakumatt | Supermarket | Bombolulu, Mombasa |
| Shree Ganesh | Fruits and vegetables market (green grocer) | Likoni, Mombasa |
| Abdu Mohamed | Green grocer | Mombasa Market, P.O. Box 18477, Mombasa |
| Ester Mkavita | Hawker | Kisimani, Mombasa |

**Appendix 5.** List of persons contacted from Government Departments, NGOs

| Name and title/position | Organization/Institution | Activity area |
|---|---|---|
| Chengo Safari, Irrigation Officer | Ministry of Agriculture and Livestock Development, Malindi | Water resources, soil conservation |
| Mwatsuma Kiti, Livestock Officer | Ministry of Agriculture and Livestock Development, Malindi | Livestock development |
| Athumani Mamu, Chairman | Forest Adjacent Dwellers Association (FADA) c/o Gede Forest Station | Sustainable conservation of the adjacent forest- on-farm tree farming |
| Lawrence Wesley Mwagwabi, Programme Co-ordinator | ActionAid Kenya | |

**Appendix 6.** Characteristics of moringa seed oil [sources: (1): Council of Scientific and Industrial Research 1962; (2): Ferrao and Ferrao 1970; (3): Dahot and Memon 1985; (4): Natural Resources Institute (NRI) 1993; (5): Technical Education Institute (TEI) 1995].

| **Properties** | | **Source of information** | | | | |
|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 |
| Specific gravity | | 0.8984 | | | | |
| Acid value | | 3.5 | 0.79 | 5.9 | | |
| Saponification value | | 182.2 | 187.9 | 187.4 | | |
| Iodine value | | 64.2 | 74.8 | 61.8 | | |
| Reichert miessel value | | 0.44 | | | | |
| Acetyl value | | 11.5 | | | | |
| Henher value | | 91.6 | | | | |
| Unsaponifiable matter | | 3.05 | | 1.58 | | |
| Vitamin E (mg/100g) | | | 10 | | | |
| B-carotene (mg/100g) | | | 14 | | | |
| **Fatty acids components (%)** | | | | | | |
| Myristic acid | C14:0 | | | 1.4 | 0.1 | |
| Palmitic acid | C16:0 | 9.3 | 6.7 | 3.5 | 5.9 | 6.9 |
| Palmitoleic acid | C16:1 | | | | 1.1 | 1.1 |
| Stearic acid | C18:0 | 7.4 | 4.3 | 8.3 | 5.1 | 8.3 |
| Oleic acid | C18:1 | 65.7 | 76.5 | 67.3 | 72.9 | 67.7 |
| Linolcnic acid | C18:2 | | 0.7 | 3.5 | 0.6 | 0.4 |
| Linoleic acid | C18:3 | | 0.7 | 3.5 | | |
| Arachidic acid | C20:0 | | 2.7 | 2.7 | 3.6 | |
| Eicosenoic acid | C20:1 | | | 2.3 | 2.6 | |
| Behenic acid | C22:0 | 8.6 | 4.6 | 5.6 | 7.3 | 7.4 |
| Lignoceric acid | C24:0 | | 1.1 | 3.2 | 1.0 | 0.4 |

**Appendix 7.** Household water treatment protocol (source: Folkard *et al.*, 2001)

Moringa seed solution may be prepared from either seed kernels or from solid residue (termed presscake) obtained following the extraction of seed oil. The steps of purifying turbid water at the household level are:

1. Seeds are allowed to mature and dry naturally to brown colour on the tree.
2. The seeds are removed from the harvested pods, and shelled.
3. The seed kernels are crushed and sieved (0.8 mm mesh or similar). Traditional techniques, such as mortar and pestle, used to produce maize flour have been found to be satisfactory for crushing the kernels.
4. The finely crushed seed powder is mixed with clean water to form a paste. To treat 20 litres of water, make a paste using about 2 grams (2 teaspoons) of seed powder. As a general rule of thumb use the powder from one kernel per litre of water when the water is very turbid, and per two litres of water is only somewhat turbid. Treatment experience will determine the optimum dosage.
5. Dilute the paste in a cup of clean water (i.e., in a sealed bottle) and shake the solution for five minutes in order to release the chemical in the powder.
6. Remove the insoluble material by filtering this solution through a muslin cloth or fine mesh screen into the bucket of water to be treated.
7. Stir the water rapidly for two minutes, then slowly for 10-15 minutes.
8. Leave the bucket to sit, without being disturbed, for 1-2 hours.
9. When the solid materials have settled to the bottom of the bucket, the clean water can be carefully poured off (decanted).
10. Boil or filter the water or add bacteria-killing substances such as chlorine or bleach (1-2 drops/litre) to make the water completely safe to drink.

NB. Solution containers should be cleaned between batches to remove insoluble seed material. Although the seeds or seed kernel powder can be stored for long periods, the paste for treating water should be prepared fresh each time.

**Appendix 8.** Costing of activities for moringa cultivation in the initial year of establishment at Marigat, Baringo district (source: KEFRI)

| ACTIVITY | AMOUNT (KShs) |
|---|---|
| **Nursery operations**. nursery soil mixture: a ratio of 2:1 (forest soil:sand); 2 tractor trailer loads of forest soil, one tractor trailer load of sand; tractor and trailer hire @ KShs 600 per trip, 3 trips | 1,800.00 |
| **Filling of nursery seedling tubes.** requires 8 man days × 56.65 ( one man day = 8 hours = KShs 56.65 per day minimum rate, Government of Kenya, 1996) | 453.20 |
| **Seed dewinging (cleaning)** and sowing of 2500 seedlings require 5 man days × 56.65 | 283.25 |
| **3000 seedlings tubes @ KShs 1** | 3000.00 |
| **Seed cost @ KShs 3,300 per kg** | 3,300.00 |
| **General maintenance** of seedlings in the nursery is assumed for a period of 90 days. The maintenance entails watering, pruning, thinning, pest control etc. Cost over a period of 90 days will be 6 × 90 × 56.65 | 3,823.88 |
| **Site preparation, transplanting, management and maintenance**. Bush clearing. On average 5 men will clear a hectare for 7 days = 5 × 7 × 56.65 | 1,982.75 |
| **Ploughing** a hectare by tractor (hire) | 1,000.00 |
| **Harrowing and ridging** a hectare by tractor | 8,000.00 |
| Pitting of holes 45 cm × 45 cm for transplanting @ KShs 10 | 25,000.00 |
| **Loading and unloading** seedlings from nursery to transplanting site = 3 man days × 56.65 | 169.95 |
| **Transplanting** 30 man days = 30 × 56.65 | 1,699.50 |
| **Fencing** (100 treated/durable posts @ KShs 120, 4 barbed wires @ KShs 1,800, 13 chicken wires @ KShs 1700, 10 kg of assorted nails @ KShs 50, 2 bags of corner post cement @ KShs 460, labour - pitting, consolidating, wire straining and binding = 10 man days × 56.65) | 43,286.50 |
| **Maintenance and management** to harvest (1 year) = 300 man days × 56.65 | 16,995.00 |
| **TOTAL ESTIMATED COST** | **KShs 110,494.03** |

**Appendix 9.** Costs and income forecasts for 1 hectare of moringa (source: Optima of Africa)

| **800 trees per hectare** | **Man days** | **Year 1** | **Year 2** | **Year 3** | **Year 4** |
|---|---|---|---|---|---|
| **COSTS** | | | | | |
| **Establishment costs** | | | | | |
| Tractor disc ploughing | 0 | 30,000 | 0 | 0 | 0 |
| Marking out | 9 | 9,000 | 0 | 0 | 0 |
| Hole digging | 23 | 23,000 | 0 | 0 | 0 |
| Manuring | 12 | 12,000 | 0 | 0 | 0 |
| Hole seeding | 6 | 6,000 | 0 | 0 | 0 |
| Sowing seeds | 4 | 4,000 | 0 | 0 | 0 |
| **Total establishment cost** | **54** | **84,000** | **0** | **0** | **0** |
| **Maintenance costs** | | | | | |
| Hand weeding 1 | 23 | 23,000 | 23,000 | 23,000 | 23,000 |
| Hand slashing 1 | 7 | 7,000 | 7,000 | 7,000 | 7,000 |
| Hand weeding 2 | 23 | 23,000 | 23,000 | 23,000 | 23,000 |
| Hand slashing 2 | 7 | 7,000 | 7,000 | 7,000 | 7,000 |
| Pruning 1 | 7 | 7,000 | 0 | 0 | 0 |
| Pruning 2 | 7 | 7,000 | 7,000 | 7,000 | 7,000 |
| Pruning 3 | 7 | 7,000 | 7,000 | 7,000 | 7,000 |
| Ratooning | 7 | 0 | 0 | 7,000 | 7,000 |
| Harvesting 1 | | 9,000 | 18,000 | 36,000 | 55,000 |
| Harvesting 2 | | 9,000 | 18,000 | 36,000 | 55,000 |
| Ginning | | 14,000 | 28,000 | 55,000 | 82,000 |
| **Total maintenance costs** | | **113,000** | **138,000** | **208,000** | **273,000** |
| **Other costs** | | | | | |
| Farmyard manure @ 2.4 tons/hect. | | 250,000 | 0 | 0 | 0 |
| Bags @ 250 each | | 1,000 | 6,000 | 12,500 | 16,500 |
| **Total other costs** | | **251,000** | **6,000** | **12,500** | **16,500** |
| **TOTAL ALL COSTS** | | **448,000** | **144,000** | **220,500** | **189,500** |
| ***SALES*** | | | | | |
| **Yield of seed in Kg** | | **160 Kg** | **960 Kg** | **2,000 Kg** | **2,640 Kg** |
| **Value of seeds @ 300/= per kg** | | **48,000** | **288,000** | **600,000** | **792,000** |
| ***MARGINS*** | | | | | |
| **Total sales less all costs** | | **-400,000** | **144,000** | **379,500** | **602,500** |
| **Equivalent in USD** | | **-444** | **160** | **421** | **669** |
| **Margin per kg** | | **-2,500** | **150** | **190** | **228** |

Note: costs do not include bush clearing, taxation, management or infrastructure

**Appendix 10.** Frequency tables of data derived from the questionnaires among growers within the project area (Ganda, Goshi and Jilore)

**Age of farmer (yrs)**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | 16 | 1 | 2.6 | 2.6 | 2.6 |
| | 24 | 2 | 5.1 | 5.1 | 7.7 |
| | 27 | 2 | 5.1 | 5.1 | 12.8 |
| | 28 | 1 | 2.6 | 2.6 | 15.4 |
| | 34 | 1 | 2.6 | 2.6 | 17.9 |
| | 35 | 1 | 2.6 | 2.6 | 20.5 |
| | 40 | 3 | 7.7 | 7.7 | 28.2 |
| | 42 | 2 | 5.1 | 5.1 | 33.3 |
| | 43 | 1 | 2.6 | 2.6 | 35.9 |
| | 45 | 4 | 10.3 | 10.3 | 46.2 |
| | 47 | 1 | 2.6 | 2.6 | 48.7 |
| | 48 | 1 | 2.6 | 2.6 | 51.3 |
| | 49 | 1 | 2.6 | 2.6 | 53.8 |
| | 50 | 1 | 2.6 | 2.6 | 56.4 |
| | 52 | 1 | 2.6 | 2.6 | 59.0 |
| | 54 | 2 | 5.1 | 5.1 | 64.1 |
| | 56 | 1 | 2.6 | 2.6 | 66.7 |
| | 58 | 3 | 7.7 | 7.7 | 74.4 |
| | 59 | 1 | 2.6 | 2.6 | 76.9 |
| | 60 | 3 | 7.7 | 7.7 | 84.6 |
| | 61 | 1 | 2.6 | 2.6 | 87.2 |
| | 62 | 1 | 2.6 | 2.6 | 89.7 |
| | 68 | 2 | 5.1 | 5.1 | 94.9 |
| | 70 | 2 | 5.1 | 5.1 | 100.0 |
| | Total | 39 | 100.0 | 100.0 | |

**Sex of farmer**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | male | 33 | 84.6 | 84.6 | 84.6 |
| | female | 6 | 15.4 | 15.4 | 100.0 |
| | Total | 39 | 100.0 | 100.0 | |

**Marital status of farmer**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | single | 3 | 7.7 | 7.7 | 7.7 |
| | married | 36 | 92.3 | 92.3 | 100.0 |
| | Total | 39 | 100.0 | 100.0 | |

**Household head**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | male headed | 31 | 79.5 | 79.5 | 79.5 |
| | female headed husband absent | 7 | 17.9 | 17.9 | 97.4 |
| | female headed no husband | 1 | 2.6 | 2.6 | 100.0 |
| | Total | 39 | 100.0 | 100.0 | |

**Day to day decision maker on farm**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | male head | 32 | 82.1 | 82.1 | 82.1 |
| | wife/femal e head | 6 | 15.4 | 15.4 | 97.4 |
| | farm couple | 1 | 2.6 | 2.6 | 100.0 |
| | Total | 39 | 100.0 | 100.0 | |

**Number of full time adult male (16+) farm residents**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | 1 | 8 | 20.5 | 20.5 | 20.5 |
| | 2 | 10 | 25.6 | 25.6 | 46.2 |
| | 3 | 4 | 10.3 | 10.3 | 56.4 |
| | 4 | 11 | 28.2 | 28.2 | 84.6 |
| | 5 | 2 | 5.1 | 5.1 | 89.7 |
| | 6 | 3 | 7.7 | 7.7 | 97.4 |
| | 8 | 1 | 2.6 | 2.6 | 100.0 |
| | Total | 39 | 100.0 | 100.0 | |

**Who owns the farm the farmer lives in**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | own | 33 | 84.6 | 84.6 | 84.6 |
| | communal | 2 | 5.1 | 5.1 | 89.7 |
| | squatters | 4 | 10.3 | 10.3 | 100.0 |
| | Total | 39 | 100.0 | 100.0 | |

**Size of the farm in acres**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | 1 | 3 | 7.7 | 7.7 | 7.7 |
| | 2 | 3 | 7.7 | 7.7 | 15.4 |
| | 2 | 6 | 15.4 | 15.4 | 30.8 |
| | 3 | 3 | 7.7 | 7.7 | 38.5 |
| | 4 | 2 | 5.1 | 5.1 | 43.6 |
| | 5 | 1 | 2.6 | 2.6 | 46.2 |
| | 6 | 2 | 5.1 | 5.1 | 51.3 |
| | 7 | 2 | 5.1 | 5.1 | 56.4 |
| | 7 | 4 | 10.3 | 10.3 | 66.7 |
| | 8 | 3 | 7.7 | 7.7 | 74.4 |
| | 9 | 1 | 2.6 | 2.6 | 76.9 |
| | 10 | 3 | 7.7 | 7.7 | 84.6 |
| | 12 | 3 | 7.7 | 7.7 | 92.3 |
| | 14 | 1 | 2.6 | 2.6 | 94.9 |
| | 24 | 1 | 2.6 | 2.6 | 97.4 |
| | 25 | 1 | 2.6 | 2.6 | 100.0 |
| | Total | 39 | 100.0 | 100.0 | |

**Farm size in ranges**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | 0-2 acres | 12 | 30.8 | 30.8 | 30.8 |
| | 3-5 acres | 6 | 15.4 | 15.4 | 46.2 |
| | 6-10 acres | 15 | 38.5 | 38.5 | 84.6 |
| | 10-15 acres | 4 | 10.3 | 10.3 | 94.9 |
| | 15+acres | 2 | 5.1 | 5.1 | 100.0 |
| | Total | 39 | 100.0 | 100.0 | |

**Whether farmer owns other piece of land**

| | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|
| Yes | 24 | 61.5 | 61.5 | 61.5 |
| No | 15 | 38.5 | 38.5 | 100.0 |
| Total | 39 | 100.0 | 100.0 | |

**Size of the other piece of land acquired**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | 2 | 5 | 12.8 | 20.8 | 20.8 |
| | 3 | 1 | 2.6 | 4.2 | 25.0 |
| | 4 | 2 | 5.1 | 8.3 | 33.3 |
| | 5 | 1 | 2.6 | 4.2 | 37.5 |
| | 6 | 2 | 5.1 | 8.3 | 45.8 |
| | 8 | 1 | 2.6 | 4.2 | 50.0 |
| | 9 | 1 | 2.6 | 4.2 | 54.2 |
| | 9 | 1 | 2.6 | 4.2 | 58.3 |
| | 10 | 3 | 7.7 | 12.5 | 70.8 |
| | 12 | 6 | 15.4 | 25.0 | 95.8 |
| | 24 | 1 | 2.6 | 4.2 | 100.0 |
| | Total | 24 | 61.5 | 100.0 | |
| Missing | System | 15 | 38.5 | | |
| Total | | 39 | 100.0 | | |

**Total farm size**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | 1 | 2 | 5.1 | 5.1 | 5.1 |
| | 2 | 3 | 7.7 | 7.7 | 12.8 |
| | 3 | 1 | 2.6 | 2.6 | 15.4 |
| | 4 | 3 | 7.7 | 7.7 | 23.1 |
| | 5 | 2 | 5.1 | 5.1 | 28.2 |
| | 6 | 1 | 2.6 | 2.6 | 30.8 |
| | 8 | 4 | 10.3 | 10.3 | 41.0 |
| | 9 | 5 | 12.8 | 12.8 | 53.8 |
| | 10 | 2 | 5.1 | 5.1 | 59.0 |
| | 12 | 2 | 5.1 | 5.1 | 64.1 |
| | 13 | 1 | 2.6 | 2.6 | 66.7 |
| | 14 | 1 | 2.6 | 2.6 | 69.2 |
| | 17 | 3 | 7.7 | 7.7 | 76.9 |
| | 19 | 3 | 7.7 | 7.7 | 84.6 |
| | 22 | 1 | 2.6 | 2.6 | 87.2 |
| | 24 | 2 | 5.1 | 5.1 | 92.3 |
| | 25 | 1 | 2.6 | 2.6 | 94.9 |
| | 26 | 1 | 2.6 | 2.6 | 97.4 |
| | 33 | 1 | 2.6 | 2.6 | 100.0 |
| | Total | 39 | 100.0 | 100.0 | |

**Whether farmer is engaged in any other off farm income generating activity**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Yes | 24 | 61.5 | 61.5 | 61.5 |
| | No | 15 | 38.5 | 38.5 | 100.0 |
| | Total | 39 | 100.0 | 100.0 | |

**Off farm income generating activity the farmer is engaged in**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | formal employment | 13 | 33.3 | 54.2 | 54.2 |
| | self employment | 8 | 20.5 | 33.3 | 87.5 |
| | casual labour | 3 | 7.7 | 12.5 | 100.0 |
| | Total | 24 | 61.5 | 100.0 | |
| Missing | System | 15 | 38.5 | | |
| Total | | 39 | 100.0 | | |

**Source of labour for farm activities**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | family | 35 | 89.7 | 89.7 | 89.7 |
| | casual/paid | 1 | 2.6 | 2.6 | 92.3 |
| | family and paid | 3 | 7.7 | 7.7 | 100.0 |
| | Total | 39 | 100.0 | 100.0 | |

**Person who works most in family labour**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | husband/male head | 16 | 41.0 | 41.0 | 41.0 |
| | wife/female head | 12 | 30.8 | 30.8 | 71.8 |
| | children | 2 | 5.1 | 5.1 | 76.9 |
| | all work equally | 9 | 23.1 | 23.1 | 100.0 |
| | Total | 39 | 100.0 | 100.0 | |

**Does farmer sell farm products?**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Yes | 32 | 82.1 | 82.1 | 82.1 |
| | No | 7 | 17.9 | 17.9 | 100.0 |
| | Total | 39 | 100.0 | 100.0 | |

**Eggs sold by farmer**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | | 1 | 2.6 | 2.6 | 2.6 |
| | Yes | 1 | 2.6 | 2.6 | 5.1 |
| | No | 36 | 92.3 | 92.3 | 97.4 |
| | No | 1 | 2.6 | 2.6 | 100.0 |
| | Total | 39 | 100.0 | 100.0 | |

**Size of the other piece of land acquired**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | 2 | 5 | 12.8 | 20.8 | 20.8 |
| | 3 | 1 | 2.6 | 4.2 | 25.0 |
| | 4 | 2 | 5.1 | 8.3 | 33.3 |
| | 5 | 1 | 2.6 | 4.2 | 37.5 |
| | 6 | 2 | 5.1 | 8.3 | 45.8 |
| | 8 | 1 | 2.6 | 4.2 | 50.0 |
| | 9 | 1 | 2.6 | 4.2 | 54.2 |
| | 9 | 1 | 2.6 | 4.2 | 58.3 |
| | 10 | 3 | 7.7 | 12.5 | 70.8 |
| | 12 | 6 | 15.4 | 25.0 | 95.8 |
| | 24 | 1 | 2.6 | 4.2 | 100.0 |
| | Total | 24 | 61.5 | 100.0 | |
| Missing | System | 15 | 38.5 | | |
| Total | | 39 | 100.0 | | |

**Total farm size**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | 1 | 2 | 5.1 | 5.1 | 5.1 |
| | 2 | 3 | 7.7 | 7.7 | 12.8 |
| | 3 | 1 | 2.6 | 2.6 | 15.4 |
| | 4 | 3 | 7.7 | 7.7 | 23.1 |
| | 5 | 2 | 5.1 | 5.1 | 28.2 |
| | 6 | 1 | 2.6 | 2.6 | 30.8 |
| | 8 | 4 | 10.3 | 10.3 | 41.0 |
| | 9 | 5 | 12.8 | 12.8 | 53.8 |
| | 10 | 2 | 5.1 | 5.1 | 59.0 |
| | 12 | 2 | 5.1 | 5.1 | 64.1 |
| | 13 | 1 | 2.6 | 2.6 | 66.7 |
| | 14 | 1 | 2.6 | 2.6 | 69.2 |
| | 17 | 3 | 7.7 | 7.7 | 76.9 |
| | 19 | 3 | 7.7 | 7.7 | 84.6 |
| | 22 | 1 | 2.6 | 2.6 | 87.2 |
| | 24 | 2 | 5.1 | 5.1 | 92.3 |
| | 25 | 1 | 2.6 | 2.6 | 94.9 |
| | 26 | 1 | 2.6 | 2.6 | 97.4 |
| | 33 | 1 | 2.6 | 2.6 | 100.0 |
| | Total | 39 | 100.0 | 100.0 | |

**Whether farmer is engaged in any other off farm income generating activity**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Yes | 24 | 61.5 | 61.5 | 61.5 |
| | No | 15 | 38.5 | 38.5 | 100.0 |
| | Total | 39 | 100.0 | 100.0 | |

**Off farm income generating activity the farmer is engaged in**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | formal employment | 13 | 33.3 | 54.2 | 54.2 |
| | self employment | 8 | 20.5 | 33.3 | 87.5 |
| | casual labour | 3 | 7.7 | 12.5 | 100.0 |
| | Total | 24 | 61.5 | 100.0 | |
| Missing | System | 15 | 38.5 | | |
| Total | | 39 | 100.0 | | |

**Source of labour for farm activities**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | family | 35 | 89.7 | 89.7 | 89.7 |
| | casual/paid | 1 | 2.6 | 2.6 | 92.3 |
| | family and paid | 3 | 7.7 | 7.7 | 100.0 |
| | Total | 39 | 100.0 | 100.0 | |

**Person who works most in family labour**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | husband/male head | 16 | 41.0 | 41.0 | 41.0 |
| | wife/female head | 12 | 30.8 | 30.8 | 71.8 |
| | children | 2 | 5.1 | 5.1 | 76.9 |
| | all work equally | 9 | 23.1 | 23.1 | 100.0 |
| | Total | 39 | 100.0 | 100.0 | |

**Does farmer sell farm products?**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Yes | 32 | 82.1 | 82.1 | 82.1 |
| | No | 7 | 17.9 | 17.9 | 100.0 |
| | Total | 39 | 100.0 | 100.0 | |

**Eggs sold by farmer**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | | 1 | 2.6 | 2.6 | 2.6 |
| | Yes | 1 | 2.6 | 2.6 | 5.1 |
| | No | 36 | 92.3 | 92.3 | 97.4 |
| | No | 1 | 2.6 | 2.6 | 100.0 |
| | Total | 39 | 100.0 | 100.0 | |

**Milk sold by farmer**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | | 1 | 2.6 | 2.6 | 2.6 |
| | Yes | 1 | 2.6 | 2.6 | 5.1 |
| | No | 37 | 94.9 | 94.9 | 100.0 |
| | Total | 39 | 100.0 | 100.0 | |

**Cattle sold by farmer**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Yes | 5 | 12.8 | 13.2 | 13.2 |
| | No | 33 | 84.6 | 86.8 | 100.0 |
| | Total | 38 | 97.4 | 100.0 | |
| Missing | System | 1 | 2.6 | | |
| Total | | 39 | 100.0 | | |

**Poultry sold by farmer**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Yes | 7 | 17.9 | 18.4 | 18.4 |
| | No | 31 | 79.5 | 81.6 | 100.0 |
| | Total | 38 | 97.4 | 100.0 | |
| Missing | System | 1 | 2.6 | | |
| Total | | 39 | 100.0 | | |

**Goats sold by farmer**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Yes | 7 | 17.9 | 17.9 | 17.9 |
| | No | 32 | 82.1 | 82.1 | 100.0 |
| | Total | 39 | 100.0 | 100.0 | |

**Cassava sold by farmer**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Yes | 4 | 10.3 | 10.3 | 10.3 |
| | No | 35 | 89.7 | 89.7 | 100.0 |
| | Total | 39 | 100.0 | 100.0 | |

**Vegetables sold by farmer**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | yes | 1 | 2.6 | 2.6 | 2.6 |
| | No | 38 | 97.4 | 97.4 | 100.0 |
| | Total | 39 | 100.0 | 100.0 | |

**Fruits sold by farmer**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | yes | 31 | 79.5 | 79.5 | 79.5 |
| | No | 8 | 20.5 | 20.5 | 100.0 |
| | Total | 39 | 100.0 | 100.0 | |

**Jembe owned by farmer**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Yes | 38 | 97.4 | 100.0 | 100.0 |
| Missing | System | 1 | 2.6 | | |
| Total | | 39 | 100.0 | | |

**Panga owned by farmer**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Yes | 36 | 92.3 | 92.3 | 92.3 |
| | No | 3 | 7.7 | 7.7 | 100.0 |
| | Total | 39 | 100.0 | 100.0 | |

**Axe owned by farmer**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Yes | 14 | 35.9 | 35.9 | 35.9 |
| | No | 25 | 64.1 | 64.1 | 100.0 |
| | Total | 39 | 100.0 | 100.0 | |

**The project that the farmer was involved in**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | | 38 | 97.4 | 97.4 | 97.4 |
| | Alisei | 1 | 2.6 | 2.6 | 100.0 |
| | Total | 39 | 100.0 | 100.0 | |

**Whether the farmer belongs to any affiliations/organizations**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Yes | 9 | 23.1 | 23.1 | 23.1 |
| | No | 30 | 76.9 | 76.9 | 100.0 |
| | Total | 39 | 100.0 | 100.0 | |

**Group/affiliation farmer belongs to**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | women group | 1 | 2.6 | 12.5 | 12.5 |
| | religious /faith group | 3 | 7.7 | 37.5 | 50.0 |
| | youth group | 3 | 7.7 | 37.5 | 87.5 |
| | savings and credit associations | 1 | 2.6 | 12.5 | 100.0 |
| | Total | 8 | 20.5 | 100.0 | |
| Missing | System | 31 | 79.5 | | |
| Total | | 39 | 100.0 | | |

**How the other piece of land was acquired**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | bought | 18 | 46.2 | 72.0 | 72.0 |
| | inherited | 7 | 17.9 | 28.0 | 100.0 |
| | Total | 25 | 64.1 | 100.0 | |
| Missing | System | 14 | 35.9 | | |
| Total | | 39 | 100.0 | | |

**Person who planted moringa**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | self | 33 | 84.6 | 84.6 | 84.6 |
| | inherited/bought with farm | 3 | 7.7 | 7.7 | 92.3 |
| | spouse | 2 | 5.1 | 5.1 | 97.4 |
| | relative | 1 | 2.6 | 2.6 | 100.0 |
| | Total | 39 | 100.0 | 100.0 | |

**Year planted**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | | 1 | 2.6 | 2.6 | 2.6 |
| | 1961 | 1 | 2.6 | 2.6 | 5.1 |
| | 1968 | 1 | 2.6 | 2.6 | 7.7 |
| | 1978 | 2 | 5.1 | 5.1 | 12.8 |
| | 1980 | 1 | 2.6 | 2.6 | 15.4 |
| | 1985 | 2 | 5.1 | 5.1 | 20.5 |
| | 1990 | 3 | 7.7 | 7.7 | 28.2 |
| | 1994 | 1 | 2.6 | 2.6 | 30.8 |
| | 1995 | 1 | 2.6 | 2.6 | 33.3 |
| | 1996 | 1 | 2.6 | 2.6 | 35.9 |
| | 1998 | 2 | 5.1 | 5.1 | 41.0 |
| | 1999 | 8 | 20.5 | 20.5 | 61.5 |
| | 2000 | 8 | 20.5 | 20.5 | 82.1 |
| | 2001 | 6 | 15.4 | 15.4 | 97.4 |
| | 2002 | 1 | 2.6 | 2.6 | 100.0 |
| | Total | 39 | 100.0 | 100.0 | |

**Source of planting material**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | neighbours | 32 | 82.1 | 84.2 | 84.2 |
| | relatives | 2 | 5.1 | 5.3 | 89.5 |
| | forest station | 3 | 7.7 | 7.9 | 97.4 |
| | trading centre | 1 | 2.6 | 2.6 | 100.0 |
| | Total | 38 | 97.4 | 100.0 | |
| Missing | System | 1 | 2.6 | | |
| Total | | 39 | 100.0 | | |

**How new plantings of moringa are made**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | natural regeneration/wildings | 5 | 12.8 | 13.2 | 13.2 |
| | seed | 27 | 69.2 | 71.1 | 84.2 |
| | seedlings | 3 | 7.7 | 7.9 | 92.1 |
| | cuttings | 3 | 7.7 | 7.9 | 100.0 |
| | Total | 38 | 97.4 | 100.0 | |
| Missing | System | 1 | 2.6 | | |
| Total | | 39 | 100.0 | | |

**How moringa is managed**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | not at all | 20 | 51.3 | 51.3 | 51.3 |
| | coppicing | 10 | 25.6 | 25.6 | 76.9 |
| | pruning | 2 | 5.1 | 5.1 | 82.1 |
| | lopping | 1 | 2.6 | 2.6 | 84.6 |
| | pollarding | 3 | 7.7 | 7.7 | 92.3 |
| | pruning and coppicing | 3 | 7.7 | 7.7 | 100.0 |
| | Total | 39 | 100.0 | 100.0 | |

**Utilize leaves and flowers as food**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | yes | 33 | 84.6 | 84.6 | 84.6 |
| | no | 6 | 15.4 | 15.4 | 100.0 |
| | Total | 39 | 100.0 | 100.0 | |

**Utilize seeds for purifying water**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Yes | 1 | 2.6 | 2.6 | 2.6 |
| | no | 38 | 97.4 | 97.4 | 100.0 |
| | Total | 39 | 100.0 | 100.0 | |

**Utilize roots and leaves as medicine**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Yes | 2 | 5.1 | 5.1 | 5.1 |
| | no | 37 | 94.9 | 94.9 | 100.0 |
| | Total | 39 | 100.0 | 100.0 | |

**Utilize stems as fuel wood**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Yes | 2 | 5.1 | 5.1 | 5.1 |
| | no | 37 | 94.9 | 94.9 | 100.0 |
| | Total | 39 | 100.0 | 100.0 | |

**Other uses known by farmer but not mentioned**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | yes | 26 | 66.7 | 66.7 | 66.7 |
| | No | 13 | 33.3 | 33.3 | 100.0 |
| | Total | 39 | 100.0 | 100.0 | |

**Water purification as other use known by farmer but not mentioned**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Yes | 22 | 56.4 | 84.6 | 84.6 |
| | No | 4 | 10.3 | 15.4 | 100.0 |
| | Total | 26 | 66.7 | 100.0 | |
| Missing | System | 13 | 33.3 | | |
| Total | | 39 | 100.0 | | |

**Apiculture as other use known by farmer but not mentioned**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | No | 26 | 66.7 | 100.0 | 100.0 |
| Missing | System | 13 | 33.3 | | |
| Total | | 39 | 100.0 | | |

**Cooking oil as other use known by farmer but not mentioned**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | No | 26 | 66.7 | 100.0 | 100.0 |
| Missing | System | 13 | 33.3 | | |
| Total | | 39 | 100.0 | | |

**Farmer willing to grow more moringa**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Yes | 25 | 64.1 | 96.2 | 96.2 |
| | No | 1 | 2.6 | 3.8 | 100.0 |
| | Total | 26 | 66.7 | 100.0 | |
| Missing | System | 13 | 33.3 | | |
| Total | | 39 | 100.0 | | |

**Farmer willing to grow more moringa**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Yes | 25 | 64.1 | 96.2 | 96.2 |
| | No | 1 | 2.6 | 3.8 | 100.0 |
| | Total | 26 | 66.7 | 100.0 | |
| Missing | System | 13 | 33.3 | | |
| Total | | 39 | 100.0 | | |

**Appendix 11.** Frequency tables of data derived from the questionnaires among growers and non-growers within the project area (Ganda, Goshi and Jilore)

**Age of farmer (yrs)**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | 16 | 1 | 1.4 | 1.4 | 1.4 |
| | 22 | 1 | 1.4 | 1.4 | 2.7 |
| | 24 | 2 | 2.7 | 2.7 | 5.4 |
| | 27 | 2 | 2.7 | 2.7 | 8.1 |
| | 28 | 1 | 1.4 | 1.4 | 9.5 |
| | 30 | 1 | 1.4 | 1.4 | 10.8 |
| | 33 | 2 | 2.7 | 2.7 | 13.5 |
| | 34 | 1 | 1.4 | 1.4 | 14.9 |
| | 35 | 1 | 1.4 | 1.4 | 16.2 |
| | 37 | 1 | 1.4 | 1.4 | 17.6 |
| | 38 | 3 | 4.1 | 4.1 | 21.6 |
| | 40 | 7 | 9.5 | 9.5 | 31.1 |
| | 41 | 1 | 1.4 | 1.4 | 32.4 |
| | 42 | 3 | 4.1 | 4.1 | 36.5 |
| | 43 | 1 | 1.4 | 1.4 | 37.8 |
| | 44 | 1 | 1.4 | 1.4 | 39.2 |
| | 45 | 6 | 8.1 | 8.1 | 47.3 |
| | 46 | 1 | 1.4 | 1.4 | 48.6 |
| | 47 | 2 | 2.7 | 2.7 | 51.4 |
| | 48 | 5 | 6.8 | 6.8 | 58.1 |
| | 49 | 3 | 4.1 | 4.1 | 62.2 |
| | 50 | 3 | 4.1 | 4.1 | 66.2 |
| | 52 | 3 | 4.1 | 4.1 | 70.3 |
| | 54 | 2 | 2.7 | 2.7 | 73.0 |
| | 55 | 1 | 1.4 | 1.4 | 74.3 |
| | 56 | 1 | 1.4 | 1.4 | 75.7 |
| | 58 | 3 | 4.1 | 4.1 | 79.7 |
| | 59 | 1 | 1.4 | 1.4 | 81.1 |
| | 60 | 4 | 5.4 | 5.4 | 86.5 |
| | 61 | 1 | 1.4 | 1.4 | 87.8 |
| | 62 | 3 | 4.1 | 4.1 | 91.9 |
| | 68 | 2 | 2.7 | 2.7 | 94.6 |
| | 69 | 1 | 1.4 | 1.4 | 95.9 |
| | 70 | 2 | 2.7 | 2.7 | 98.6 |
| | 105 | 1 | 1.4 | 1.4 | 100.0 |
| | Total | 74 | 100.0 | 100.0 | |

**Sex of farmer**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | male | 67 | 90.5 | 90.5 | 90.5 |
| | female | 7 | 9.5 | 9.5 | 100.0 |
| | Total | 74 | 100.0 | 100.0 | |

**Marital status of farmer**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | single | 6 | 8.1 | 8.1 | 8.1 |
| | married | 68 | 91.9 | 91.9 | 100.0 |
| | Total | 74 | 100.0 | 100.0 | |

**Household head**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | male headed | 65 | 87.8 | 87.8 | 87.8 |
| | female headed husband absent | 7 | 9.5 | 9.5 | 97.3 |
| | female headed no husband | 2 | 2.7 | 2.7 | 100.0 |
| | Total | 74 | 100.0 | 100.0 | |

**Day to day decision maker on farm**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | male head | 64 | 86.5 | 86.5 | 86.5 |
| | wife/femal e head | 8 | 10.8 | 10.8 | 97.3 |
| | farm couple | 2 | 2.7 | 2.7 | 100.0 |
| | Total | 74 | 100.0 | 100.0 | |

**Number of full time adult male (16+) farm residents**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | 1 | 15 | 20.3 | 20.3 | 20.3 |
| | 2 | 23 | 31.1 | 31.1 | 51.4 |
| | 3 | 8 | 10.8 | 10.8 | 62.2 |
| | 4 | 16 | 21.6 | 21.6 | 83.8 |
| | 5 | 5 | 6.8 | 6.8 | 90.5 |
| | 6 | 4 | 5.4 | 5.4 | 95.9 |
| | 8 | 1 | 1.4 | 1.4 | 97.3 |
| | 9 | 1 | 1.4 | 1.4 | 98.6 |
| | 10 | 1 | 1.4 | 1.4 | 100.0 |
| | Total | 74 | 100.0 | 100.0 | |

**Who owns the farm the farmer lives in**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | own | 65 | 87.8 | 87.8 | 87.8 |
| | communal | 5 | 6.8 | 6.8 | 94.6 |
| | squatters | 4 | 5.4 | 5.4 | 100.0 |
| | Total | 74 | 100.0 | 100.0 | |

**Size of the farm in acres**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | 1 | 4 | 5.4 | 5.4 | 5.4 |
| | 2 | 6 | 8.1 | 8.1 | 13.5 |
| | 2 | 9 | 12.2 | 12.2 | 25.7 |
| | 3 | 2 | 2.7 | 2.7 | 28.4 |
| | 3 | 4 | 5.4 | 5.4 | 33.8 |
| | 4 | 10 | 13.5 | 13.5 | 47.3 |
| | 5 | 2 | 2.7 | 2.7 | 50.0 |
| | 6 | 11 | 14.9 | 14.9 | 64.9 |
| | 7 | 2 | 2.7 | 2.7 | 67.6 |
| | 7 | 4 | 5.4 | 5.4 | 73.0 |
| | 8 | 3 | 4.1 | 4.1 | 77.0 |
| | 9 | 2 | 2.7 | 2.7 | 79.7 |
| | 10 | 1 | 1.4 | 1.4 | 81.1 |
| | 10 | 5 | 6.8 | 6.8 | 87.8 |
| | 12 | 5 | 6.8 | 6.8 | 94.6 |
| | 14 | 2 | 2.7 | 2.7 | 97.3 |
| | 24 | 1 | 1.4 | 1.4 | 98.6 |
| | 25 | 1 | 1.4 | 1.4 | 100.0 |
| | Total | 74 | 100.0 | 100.0 | |

**Farm size in ranges**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | 0-2 acres | 19 | 25.7 | 25.7 | 25.7 |
| | 3-5 acres | 18 | 24.3 | 24.3 | 50.0 |
| | 6-10 acres | 28 | 37.8 | 37.8 | 87.8 |
| | 10-15 acres | 7 | 9.5 | 9.5 | 97.3 |
| | 15+acres | 2 | 2.7 | 2.7 | 100.0 |
| | Total | 74 | 100.0 | 100.0 | |

**Whether farmer owns other piece of land**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Yes | 40 | 54.1 | 54.1 | 54.1 |
| | No | 34 | 45.9 | 45.9 | 100.0 |
| | Total | 74 | 100.0 | 100.0 | |

**Size of the other piece of land acquired**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | 2 | 8 | 10.8 | 19.5 | 19.5 |
| | 3 | 2 | 2.7 | 4.9 | 24.4 |
| | 4 | 5 | 6.8 | 12.2 | 36.6 |
| | 5 | 1 | 1.4 | 2.4 | 39.0 |
| | 6 | 4 | 5.4 | 9.8 | 48.8 |
| | 8 | 2 | 2.7 | 4.9 | 53.7 |
| | 9 | 1 | 1.4 | 2.4 | 56.1 |
| | 9 | 1 | 1.4 | 2.4 | 58.5 |
| | 10 | 5 | 6.8 | 12.2 | 70.7 |
| | 12 | 11 | 14.9 | 26.8 | 97.6 |
| | 24 | 1 | 1.4 | 2.4 | 100.0 |
| | Total | 41 | 55.4 | 100.0 | |
| Missing | System | 33 | 44.6 | | |
| Total | | 74 | 100.0 | | |

**Total farm size**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | 1 | 3 | 4.1 | 4.1 | 4.1 |
| | 2 | 6 | 8.1 | 8.1 | 12.2 |
| | 3 | 2 | 2.7 | 2.7 | 14.9 |
| | 4 | 9 | 12.2 | 12.2 | 27.0 |
| | 5 | 4 | 5.4 | 5.4 | 32.4 |
| | 6 | 7 | 9.5 | 9.5 | 41.9 |
| | 8 | 4 | 5.4 | 5.4 | 47.3 |
| | 9 | 5 | 6.8 | 6.8 | 54.1 |
| | 10 | 7 | 9.5 | 9.5 | 63.5 |
| | 11 | 1 | 1.4 | 1.4 | 64.9 |
| | 12 | 5 | 6.8 | 6.8 | 71.6 |
| | 13 | 2 | 2.7 | 2.7 | 74.3 |
| | 14 | 3 | 4.1 | 4.1 | 78.4 |
| | 16 | 1 | 1.4 | 1.4 | 79.7 |
| | 17 | 3 | 4.1 | 4.1 | 83.8 |
| | 19 | 3 | 4.1 | 4.1 | 87.8 |
| | 21 | 1 | 1.4 | 1.4 | 89.2 |
| | 22 | 3 | 4.1 | 4.1 | 93.2 |
| | 24 | 2 | 2.7 | 2.7 | 95.9 |
| | 25 | 1 | 1.4 | 1.4 | 97.3 |
| | 26 | 1 | 1.4 | 1.4 | 98.6 |
| | 33 | 1 | 1.4 | 1.4 | 100.0 |
| | Total | 74 | 100.0 | 100.0 | |

**Whether farmer is engaged in any other off farm income generating activity**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Yes | 40 | 54.1 | 54.1 | 54.1 |
| | No | 34 | 45.9 | 45.9 | 100.0 |
| | Total | 74 | 100.0 | 100.0 | |

**Off farm income generating activity the farmer is engaged in**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | formal employment | 19 | 25.7 | 48.7 | 48.7 |
| | self employment | 16 | 21.6 | 41.0 | 89.7 |
| | casual labour | 4 | 5.4 | 10.3 | 100.0 |
| | Total | 39 | 52.7 | 100.0 | |
| Missing | System | 35 | 47.3 | | |
| Total | | 74 | 100.0 | | |

**Source of labour for farm activities**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | family | 68 | 91.9 | 91.9 | 91.9 |
| | casual/paid | 1 | 1.4 | 1.4 | 93.2 |
| | family and paid | 5 | 6.8 | 6.8 | 100.0 |
| | Total | 74 | 100.0 | 100.0 | |

**Person who works most in family labour**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | husband/male head | 42 | 56.8 | 56.8 | 56.8 |
| | wife/female head | 16 | 21.6 | 21.6 | 78.4 |
| | children | 3 | 4.1 | 4.1 | 82.4 |
| | all work equally | 12 | 16.2 | 16.2 | 98.6 |
| | self (single lady) | 1 | 1.4 | 1.4 | 100.0 |
| | Total | 74 | 100.0 | 100.0 | |

**Does farmer sell farm products?**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Yes | 54 | 73.0 | 73.0 | 73.0 |
| | No | 20 | 27.0 | 27.0 | 100.0 |
| | Total | 74 | 100.0 | 100.0 | |

**Eggs sold by farmer**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | | 4 | 5.4 | 5.4 | 5.4 |
| | Yes | 1 | 1.4 | 1.4 | 6.8 |
| | No | 68 | 91.9 | 91.9 | 98.6 |
| | No | 1 | 1.4 | 1.4 | 100.0 |
| | Total | 74 | 100.0 | 100.0 | |

**Milk sold by farmer**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | | 1 | 1.4 | 1.4 | 1.4 |
| | Yes | 2 | 2.7 | 2.7 | 4.1 |
| | No | 71 | 95.9 | 95.9 | 100.0 |
| | Total | 74 | 100.0 | 100.0 | |

**Cattle sold by farmer**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Yes | 7 | 9.5 | 10.0 | 10.0 |
| | No | 63 | 85.1 | 90.0 | 100.0 |
| | Total | 70 | 94.6 | 100.0 | |
| Missing | System | 4 | 5.4 | | |
| Total | | 74 | 100.0 | | |

**Poultry sold by farmer**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Yes | 9 | 12.2 | 12.9 | 12.9 |
| | No | 61 | 82.4 | 87.1 | 100.0 |
| | Total | 70 | 94.6 | 100.0 | |
| Missing | System | 4 | 5.4 | | |
| Total | | 74 | 100.0 | | |

**Goats sold by farmer**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Yes | 9 | 12.2 | 12.2 | 12.2 |
| | No | 65 | 87.8 | 87.8 | 100.0 |
| | Total | 74 | 100.0 | 100.0 | |

**Cassava sold by farmer**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Yes | 9 | 12.2 | 12.2 | 12.2 |
| | No | 65 | 87.8 | 87.8 | 100.0 |
| | Total | 74 | 100.0 | 100.0 | |

**Sugar cane sold by farmer**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | yes | 1 | 1.4 | 1.4 | 1.4 |
| | No | 73 | 98.6 | 98.6 | 100.0 |
| | Total | 74 | 100.0 | 100.0 | |

**Vegetables sold by farmer**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | yes | 2 | 2.7 | 2.7 | 2.7 |
| | No | 72 | 97.3 | 97.3 | 100.0 |
| | Total | 74 | 100.0 | 100.0 | |

**Fruits sold by farmer**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | yes | 52 | 70.3 | 70.3 | 70.3 |
| | No | 22 | 29.7 | 29.7 | 100.0 |
| | Total | 74 | 100.0 | 100.0 | |

**Jembe owned by farmer**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Yes | 72 | 97.3 | 98.6 | 98.6 |
| | No | 1 | 1.4 | 1.4 | 100.0 |
| | Total | 73 | 98.6 | 100.0 | |
| Missing | System | 1 | 1.4 | | |
| Total | | 74 | 100.0 | | |

**Panga owned by farmer**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Yes | 70 | 94.6 | 94.6 | 94.6 |
| | No | 4 | 5.4 | 5.4 | 100.0 |
| | Total | 74 | 100.0 | 100.0 | |

**Axe owned by farmer**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Yes | 32 | 43.2 | 43.2 | 43.2 |
| | No | 42 | 56.8 | 56.8 | 100.0 |
| | Total | 74 | 100.0 | 100.0 | |

**The project that the farmer was involved in**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | | 71 | 95.9 | 95.9 | 95.9 |
| | Alisei | 3 | 4.1 | 4.1 | 100.0 |
| | Total | 74 | 100.0 | 100.0 | |

**Whether the farmer belongs to any affiliations/organizations**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Yes | 10 | 13.5 | 13.5 | 13.5 |
| | No | 64 | 86.5 | 86.5 | 100.0 |
| | Total | 74 | 100.0 | 100.0 | |

**Group/affiliation farmer belongs to**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | women group | 1 | 1.4 | 10.0 | 10.0 |
| | religious /faith group | 3 | 4.1 | 30.0 | 40.0 |
| | youth group | 4 | 5.4 | 40.0 | 80.0 |
| | savings and credit associations | 2 | 2.7 | 20.0 | 100.0 |
| | Total | 10 | 13.5 | 100.0 | |
| Missing | System | 64 | 86.5 | | |
| Total | | 74 | 100.0 | | |

**After having known the benefits; farmer willing to plant moringa**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Yes | 30 | 40.5 | 90.9 | 90.9 |
| | No | 3 | 4.1 | 9.1 | 100.0 |
| | Total | 33 | 44.6 | 100.0 | |
| Missing | System | 41 | 55.4 | | |
| Total | | 74 | 100.0 | | |

**How the other piece of land was acquired**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | bought | 27 | 36.5 | 65.9 | 65.9 |
| | inherited | 14 | 18.9 | 34.1 | 100.0 |
| | Total | 41 | 55.4 | 100.0 | |
| Missing | System | 33 | 44.6 | | |
| Total | | 74 | 100.0 | | |