PRACTICAL ACTION

JOMO KENYATTA UNIVERSITY OF AGRICULTURE AND TECHNOLOGY
TECHNOLOGY FOR DEVELOPMENT

PROGRESS REPORT ON WORK PACKAGE 1

POST-HARVEST FOOD CHAIN, LOSES, WASTAGE AND CURRENT ENERGY DEMAND ANALYSIS (LEAD: JKUAT)

T1.1. Assess and identify a product which has overlap and common potential benefit to livelihoods (Ghana; Sierra Leone; Kenya)

VEGETABLE, FRUIT AND ROOT CROPS PRODUCTS THAT HAVE OVERLAP AND COMMON POTENTIAL BENEFIT TO LIVELIHOODS IN KENYA

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1.0 Introduction

Work Package 1 looks at post-harvest food chain, losses, wastage and current energy demand analysis. This report presents an analysis of Task 1.1 on assessing and identification of vegetable and fruit products that have overlap and common potential benefit to livelihoods in Kenya. The results presented in this report are based on a desk research and will form the basis for field work to verify and select the final crops.

Several crops in Kenya have potential, overlap and common potential to livelihoods in Kenya. This report reviews the crops based on priority crops identified in the post-harvest analysis. Most farmers in Kenya grow crops on less than two acres of land hence most are small scale farmers.

1.1 Market Opportunities and constraints

This section analyses market opportunities and constraints inherent within identified fruits and vegetables value chains for the purposes of understanding the value to livelihoods for farmers. These vegetables and fruits play important role in food security, nutrition, and income generation for resource-poor farmers and consumers in Kenya. The crops typically have certain characteristics;

- Poorly stored fruits and vegetables can be a source of contamination since they are highly perishable.
- In Kenya fruits and vegetables are an essential part of people's diet.
- Contamination of fruits and vegetables occurs during production, transport, processing and handling

This review analyses the benefits of the following identified crops;

a) Root crops
b) Leafy Vegetables
c) Fruits

2.0 Crops Analysis

2.1 Root Crops/tubers

Roots and tubers crops are the second most important food crops after cereals; with potential to contribute significantly to food security needs and livelihood improvement in Kenya. Major root crops grown principally for human consumption in Kenya include; irish potatoes, cassava, sweet potatoes, and cocoyam. These crops are an important source of food and play a key role in ensuring food security. They are grown across a wide range of agro-ecological zones including ASALs. Root crops and tubers have a wide range of uses; food, animal feed, resins and serves as raw materials for industry. Their exploitation for these uses is still low due to lack of focus on their development. In addition, these crops are at various levels of commercialization.

2.1.1 Cassava

a) Background Information

Scientifically cassava is known as *Manihot esculenta* and Mhogo in Kiswahili. Cassava grows as a shrub. It is a traditional starch crop grown virtually throughout Kenya. However, the Western, Coastal and the semi-arid Eastern regions of Kenya have the highest production (*Karuri E. E. et al, 2001*). The root/tuber is the main food product from the plant. Traditional utilization of the fresh tuber in Kenya is limited to roasting and boiling for consumption in all the growing areas. It is an important crop in subsistence farming, as it requires minimum production skills or inputs. It is drought tolerant and produces reasonable yields under adverse conditions. Most important is its ability to remain in the soil as a famine reserve. Other factors that make cassava popular with small-scale farmers, particularly in Kenya, are that it requires little labour in its production and there are no labour peaks because the necessary operations in its production can be spread throughout the year, and its yields fluctuate less than those of cereals.

While cassava production demands few external inputs, labour and planting materials consists the main costs of production. As a root crop, cassava requires a lot of labour to harvest. Cassava production is dependent on supply of good quality stem cuttings. The multiplication rate of these vegetative planting materials is very low, compared to grain crops that are propagated by true seeds. Postharvest deterioration of cassava is of major concern. Cassava stem cuttings are bulky and highly perishable, drying up within a few days. Consequently, roots must be processed into a storable form soon after harvest. Farmers recognize postharvest loss as a major risk factor in cassava production. Nevertheless, the rapid postharvest perishability might lead to comparative disadvantages for small-scale producers linked to small-scale processing units. Furthermore, many cassava varieties contain cyanogenic glucosides, and inadequate processing can lead to high toxicity. Various processing methods, such as grating, sun drying, and fermenting, are used to reduce the cyanide content.

Figure 1: Cassava Tubers

b) Market potential for Cassava

Cassava is highly perishable; farmers in dry regions can only get full benefits of cassava by practicing value addition that includes processing. According to the Food Friday Program report televised by the Nation Media Group - Kenya on 15th February 2013 at 9.40pm, the current cassava production in the country is estimated at 500,000 tonnes per annum. Processed cassava can make a variety of products including cassava ugali, chapati, mahamri, doughnuts, cake, crisp and chips as well as porridge. Cutting cassava into chips is one of the best methods of value addition and reducing the perishability of the produce. However, a recent study by the Kenya Agricultural Research Institute (KARI) shows that

most farmers were likely to stick to selling fresh cassava roots due to poor buying prices of chips.[1]

There is huge market potential for this food crop for both human consumption and animal feed. The market potential lies in capitalizing on cassava's utility as a source of products such as animal feed, glue, bio-fuel, and glucose syrup. New varieties with higher yields, less cyanide and better resistance to drought and disease are greatly increasing the market fortunes of cassava. Main constraints in processing and value addition to cassava in Coast and Eastern regions are; lack of appropriate equipment, capital, lack of knowledge and insufficient cassava volumes.[2]

2.1.2 Irish Potatoes (Solanum tuberosum)

In Kenya, potato is the second most important food crop after maize. Its ability to grow in the high altitude areas where maize does not do well, and its high nutritive value, make it an important food and cash crop for people living in these areas. Kenya is the fifth biggest potato producer in Sub-Saharan Africa, with an output of 790,000 tonnes in 2006 (FAO 2008)[3]. In Kenya, the crop is second most important staple food crop after maize (MoA, 2005)[4]. For the approximately 800,000 potato growers in the country, annual production of the crop is worth about Ksh. 10 billion at farm gate prices. This crop is very important due to its usage in both fast food outlets and in homes. Despite the high potential to contribute in improving welfare of many Kenyans, potato industry has faced a number of challenges ranging from production, processing,

trading and wholesaling and marketing. Potato marketing in particular is poorly structured and farmers generally get very low marketing margin compared to other actors in the value chains. The industrial processing of potatoes is restricted to the production of snack type foods such as crisps and other types of snacks specifically for Asian consumers. There are more than twenty crisps enterprises located in Nairobi. However, the number could be higher since some processors are operating in private homes and may not be registered. The larger potato crisp makers' use on average of one metric ton of potatoes per day. The level of production depends on amount ordered by their customers, who are mainly the major supermarkets, hotels, and clubs in Nairobi and other major towns.

2.1.3 Sweet potato

[1] Kiura, J.N., Ndung'u J.M. and Muli B.M (2010): "Processing Cassava into Chips in Coastal Kenya; Commercial Potential is in the Future," Kenya Agricultural Research Institute (KARI).

[2] Kiura, J.N., Ndung'u J.M. and Muli B.M (2010); ibid

[3] Food and Agriculture Organization of the United Nations. International Year of the Potato, 2008. www.potato2008.org

[4] Ministry of Agriculture (2005). National Policy on Potato industry. Policy and Reforms in the industry to improve production, Research ,marketing and regulatory framework

After Irish potato and cassava, sweet potato is the third most important root/tuber crop in Kenya in terms of production. They are widely grown in arid and semi arid areas where there are long periods of droughts. They require very little investments and inputs such as pesticides, fungicides and limited usage of fertilizers. Therefore, sweet potatoes are ideal for improving food security, especially for the poor segments of the population. Sweet potato production also contributes to gender integration as 75% of the activities in sweet potato production are done by women. Furthermore, sweet potato is a cover crop, protecting the soil against erosion and contributing to soil fertility. Sweet potatoes are also increasingly becoming an important cash crop for smallholder farmers, especially in areas that have been devastated by the cassava mosaic virus. Sweet potatoes can be boiled, roasted, fried, creamed or baked in their skins. They are easily combined with both sweet and savoury dishes and are mostly grown on small scale in compound gardens (*Rono, S.C.et al; 2006*).

A six year summary of production is as shown in the table below according to Ministry of Agriculture and FAO.

Table 1: Sweet potato production

Year	2005	2006	2007	2008	2009	2010	AV
Sweet potato	671,709	724,646	811,531	894,781	1,034,204	820,971	826,307

(Figures adopted from Economic review for Agriculture 2010, FAO)

2.1.4 Carrot

Carrot is a popular vegetable grown in Kenya mostly in the cooler highlands. The roots are consumed raw or cooked, alone or in combination with other vegetables to make stew, as an ingredient of soups, sauces and in dietary compositions. Young leaves are sometimes used as fodder. Carrots are an important source of vitamin A in human diets. Vitamin A deficiency can lead to blindness and especially for children to a greater risk of dying from ailments such as measles, diarrhea or malaria. The produce is readily sold in urban and rural markets by farmers and middlemen

2.1.5 Summary on roots and tubers

Cassava, sweet potatoes, Irish potatoes and carrots are very important root crops and tubers grown in different parts of Kenya both for direct consumption with little processing and also as a raw material for value added products. Irish potatoes are generally used in various forms such as crisps, chips and stew. Cassava on the other hand is used for making industrial starch and for processing composite flours. All these root crops exhibit high postharvest losses if proper postharvest management is not put in place. The study will therefore establish the most critical post-harvest handling points where technology can be used to drastically reduce these losses.

2.2 African Leafy Vegetables

African Leafy Vegetables (ALVs) provide an avenue to meet the food security, nutritive needs and income for resource poor communities. In Kenya the most common and popular ALVs are the Solanumnigrum (black nightshade locally known as “managu”), Vigra ungliculata (cowpea locally known as kunde), Amaranthus spp (amaranthas locally known as terere) and Cleome gynandra (spider flower locally known as “Sageti”).

Table 2: Summary of African leafy vegetables found in Kisii and Transmara

Local name of ALV	Common name	Scientific name
Lisabebe	Pumpkin leaves	*Curcubitae spp.*
Omutere	Jute	*Corchorus olitorius*
Enderema	Vine spinach	*Basella alba*
Rinagu	Black nightshade	*Solanum nigrum complex*
Emboga	Amaranth	*Amaranthus spp.*
Amato ye miogo	Cassava leaves	*Manihot esculenta*
Amato ye amabuoni	Sweet potato leaves	
Chinsaga	Spider flower	*Cleome gynandra*
Egesare	Cow peas/Kunde	*Vigna unguilata*
Mitoo		Crotararia brevidens
Rise	Stinging nettle	*Urtica massaica*
Rikongiro	Wondering jew	*Commelina* spp.

Demand for indigenous vegetables has grown tremendously in recent years. This is in part attributed to recognition of their high nutritive value. For example, black nightshade is rich in protein and methionine. The other leafy vegetables are high in iron, calcium and vitamin A when compared to commonly consumed vegetables like cabbage and kales. ALVs were considered weeds before. Apart from ability to meet food needs of households in communities, ALVs have potential of becoming cash crops to many small-scale farmers.

2.2.1 Grain Amaranth

Amaranth is known in local language as Terere (Kikuyu), muchicha (Kiswahili, Ngiriama), Lidodo, (Luhya), alika (Luo). Amaranth is a “pseudo-cereal” (a non-grass cereal)” because of its flavour and cooking similarities to grains) that has high nutritional and medicinal value. There are more than 60 species and between 4000 – 6000 varieties. These species are divided into Grain, Vegetables, Ornamental and Weeds

Grain amaranth is an important crop because it is an inexpensive and can be grown by the rural

poor. It is early maturing and produces many grain/seed that are easily harvested. Grain Amaranth is highly tolerant to drought, making it a suitable crop for the arid and semi-arid regions. Grain Amaranth is also highly nutritive with high quality proteins (lysine and methionine) and high levels of vitamins and dietary fibres. The grain is highly palatable and can be used raw, cooked, popped or milled to flour. White or golden coloured grains are recommended for consumption. Other uses include green leaves as vegetables, amaranth oil extract, making starch and animal feed.

2.2.2 Black nightshade and spider flower

Locally known as Managu and Sageti respectively; these plants are grown in large-scale in Osinoni location of Kilgoris district of greater Transmara. The wider Kisii County also grows black nightshade and spider flower. Large scale growing of the two vegetables includes Mosocho, Ogembo and Nyamonyo village.

a) Production and land size

The average landholding size is 3.7 acres in Kisii with 3.2 acres under cultivation. Most farmers grow ALVs alongside other crops like maize and beans. The land allocated to the pure stands is often small compared to other crops. It is however difficult to estimate the actual acreages since most farmers scatter the vegetables on the farm.

b) Seed availability

The seeds for planting in Kisii and Transmara County can be obtained from Kenya Agricultural Research Institutes Centres like Kakamega, Kisii and Kitale. However, the Kisii Centre provides most of the seeds for field demonstration. Other source of the seeds is the Kenya Seed Company. Farmers are encouraged to plant seeds that are clean, free of disease and pests. Despite the above sources of seeds, farmers still largely depend on their own seeds from the farm, some buy from the market and private companies. Farmers also get their seeds from friends and neighbours. Apart from where there are demonstration farms, very few farmers get their seeds either from ministry of Agriculture or research institutions.

2.2.3 Cow peas

Cowpea (*Vigna unguiculata* L. Walp.) is an annual legume believed to have originated in Africa and is widely grown in Africa, Latin America, and Southeast Asia and in the southern United States. It may also be identified as *Vigna sinensis* (L.) in some older references. The crop is mainly used as a grain crop (fresh shelled or dry), animal fodder, cover crop or as a vegetable. In Kenya it is mainly grown for its grain and as a leafy vegetable. The history of cowpea dates to ancient West African cereal farming, 5 to 6 thousand years ago, where it was closely associated with the cultivation of sorghum and pearl millet.

Uses

Cowpea seed is a nutritious component in the human diet as well as livestock feed. The protein in cowpea seed is rich in the amino acids, lysine and tryptophan. Cowpea can be used at all stages of growth as a vegetable crop. The tender green leaves are an important food source in Africa and are prepared as a pot herb, like spinach. Immature snapped pods are used in the same way as snap beans, often being mixed with other foods. Green cowpea seeds are boiled as a fresh vegetable, or may be canned or frozen. Dry mature seeds are also suitable for boiling and canning.

2.2.4 Kales (Brassica oleracea var acephala)

Kales (sukuma wiki) are a widely consumed vegetable in Kenya mainly as a side dish with other foods like ugali or chapati. The main producing areas include Central (Kiambu, Nyeri, Nyandarua), Nyanza (Kisii, Migori and Bondo), Rift valley (Molo, Nakuru, Bomet, Narok). Notable varieties include Collards, Sukuma Siku, and Marrow stem. Production and value increased by 11.9%, 40.7% and 3.3% respectively in 2010(HCDA, 2010)**Error! Bookmark not defined.**. Despite the 40.7% increase in production volume the value did not increase proportional due to the low price per kilogram. Its consumption is usually when its fresh and little processing if any is going on as at now. Its consumption is both in rural and urban areas where it's sold as fresh vegetable by retailers. However drying when there is glut of the product in the field can ensure steady supply and availability throughout the year and also earn the farmers better returns.

2.2.5 Cabbages (Brassica olereceae var capitata)

Cabbages *(Brassica olereceae var capitata)* are important vegetables grown in Kenya for the local fresh market and little is exported. It is one of the most consumed vegetables in the urban centres in Kenya. It is grown by both small scale and medium scale farmers and marketed in rural and urban areas. It is grown under rain fed and irrigated conditions and its best suited for cooler temperatures. In addition it can tolerate hard frosts, but severe freezes can be damaging. Cabbage flavor improves with cooler temperatures because plant cells are working to convert starches to sugars to protect the plant against the cold. The result is a sweet, fresh taste that surpasses that of store-bought greens. Cabbage is mainly used for cooking and as a salad. It is also dehydrated and can also be used as a livestock feed. Main losses in cabbage product chain include insect-pest damage, rotting, over-maturity, physical damage, leaf crushing, head bursting, soft rotting and wilting (*Thongsavath, C. et. al; 2012*). During the rainy seasons many farmers plant the crop hoping to reap good incomes but end up losing due to oversupply. Some of the cabbages goes to waste in the farms due to poor prices and is fed to livestock though that was not the intended purpose. All these losses amount to about 30% for both domestic and export products. From FAO's estimates, cabbage production was 784,786 tonnes in the year 2010.

2.2.6 Tomato

In the past decade, tomato has gained importance as an income generating crop in high potential and peri-urban areas. It is a highly valued vegetable-cum-spice in Kenya and extensively used in cookery more than any other ingredient. It is grown in almost all counties at altitudes of between 1150 and 1800 m above sea level. In 2011, area under production was 19,000 ha, from which 600,000 MT valued at KES 14.2 billion were produced (HCDA, 2010)[5]. The most common varieties include; Cal.J, Fortune maker, Rio-grande, Roma VF, Anna F1, plumty, bravo, chonto, Money maker among others. In 2010 the area under the crop increased by 10.5% whereas production volume and value increased by 12% and 17.7% respectively (HCDA, 2010)**Error! Bookmark not defined.**. This was attributed to improved weather conditions from the previous drought conditions. During the peak harvesting period a lot of the tomatoes go to waste due to excess volumes and poor prices hence farmers become reluctant even to harvest in order to avoid incurring more losses. However with coming up with various value addition methods, this waste can be avoided and farmers can earn even more income from their sweat.

[5] HCDA, 2010. Horticultural crops report

2.2.7 Summary on vegetables

Five leafy vegetables namely green amaranth, cowpeas, black nighshade, kales and cabbage will be studied among them three traditional vegetables and two exotic ones. Vegetables form a key part of a balanced diet for daily body demand for a healthy person. However, vegetables are very seasonal mostly following the rain season pattern when they are abundant and very scarce during the dry season. Technologies can therefore be identified to reduce wastage during the abundant production periods and hence provide constant supply and availability even during the dry period. The study will also identify other possible postharvest loss and waste gaps along the value chain which can be addressed.

2.3 Fruits

Underutilized fruits are those species with under-exploited potential in contributing to food security, health, income generation and environmental services.[6] These fruits have potential to contribute to food security and poverty alleviation including the value addition aspects to diversify use and shelf-live.

2.3.1 Tree tomato (Tamarillos)

The tree tomato (*Solanum betaceum or Cyphomandra betacea)* can reach up three meters of height and belongs to the Solonaceae family, which is the same family of potato and tomato. Its fruits are fleshy, oval or elliptic shaped and yellow, orange or purple color with a pleasant-tasting, slightly acidic, aromatic pulp, rich in vitamins and minerals. Two varieties of Tamarillos are most popular. The first is golden orange with yellow flesh while the second varies between burgundy and purple and has orange flesh. The thin, bitter, non-edible skin of the Tamarillo is shiny and smooth. The flesh is full of little seeds that look a lot like tomato seeds. With its particular acidic yet aromatic taste, the Tamarillo is used as a fruit just as well as a vegetable.

Market potential

In Kenya the market potential for tree tomato has not been exploited, it is still not widely cultivated despite its immense benefits. The tree tomato is an excellent source of antioxidants because it contains a type of flavonoid known as anthocyanins. Furthermore, and more importantly it contains the carotenoids lycopene and beta carotene.

[6] Haq, N. and A. Hughes (2002). Fruits for the future in Asia, Southampton, UK

2.3.2 Passion fruit

Passion fruit is among the most important fruit crops produced commercially in Kenya ranking third in export fruits. Two species are commercially grown. The purple passion fruit (*Passiflora edulis* f*edulis*) is grown in the Kenyan highlands mainly for the fresh market due to its aromatic taste and flavor while the yellow passion fruit (*Passiflora edulis* f. *flavicarpa*) is grown in the coastal lowlands mainly for juice extraction due to its high acidity.

Production of passion fruit in Kenya is challenged by factors such as inadequate technical knowledge on crop management, poor post-harvest handling, pests and diseases. Passion fruit is a highly suitable crop for small-scale farmers due to its high market value and short maturity period. However, its production is constrained by lack of technical knowledge on crop pests and diseases and high capital investments.

Kenya-Agricultural Research Institute (KARI) has developed 3 new varieties of passion fruit in Kenya. The new varieties are KPF4, KPF11 and KPF12. The new varieties have potential of lifting economic status of smallholder framers while increasing passion fruit production in the country. These new varieties of passion fruit are drought tolerant, more suited to the fresh market and processing. While they are similar to passion fruits grown in Coast lowlands; the new varieties are superior quality because they are larger, juicier and more tolerant to soil and foliar diseases

Market potential

Passion has huge potential for both local and export market because it only takes one year to mature. The new varieties of passion fruit have huge potential for revenues to farmers. The table below gives potential costs in the production of passion fruit.

2.3.3 Mango

Mango production has been on the increase in Kenya. There has been rapid growth of 24 percent each year between 2006 and 2009. Mango production in Kenya is differentiated according to the production system; these are traditional mango growing and commercial/market-oriented mango production. The Coastal region in Kenya produces the bulk of mangoes consumed in Kenya.

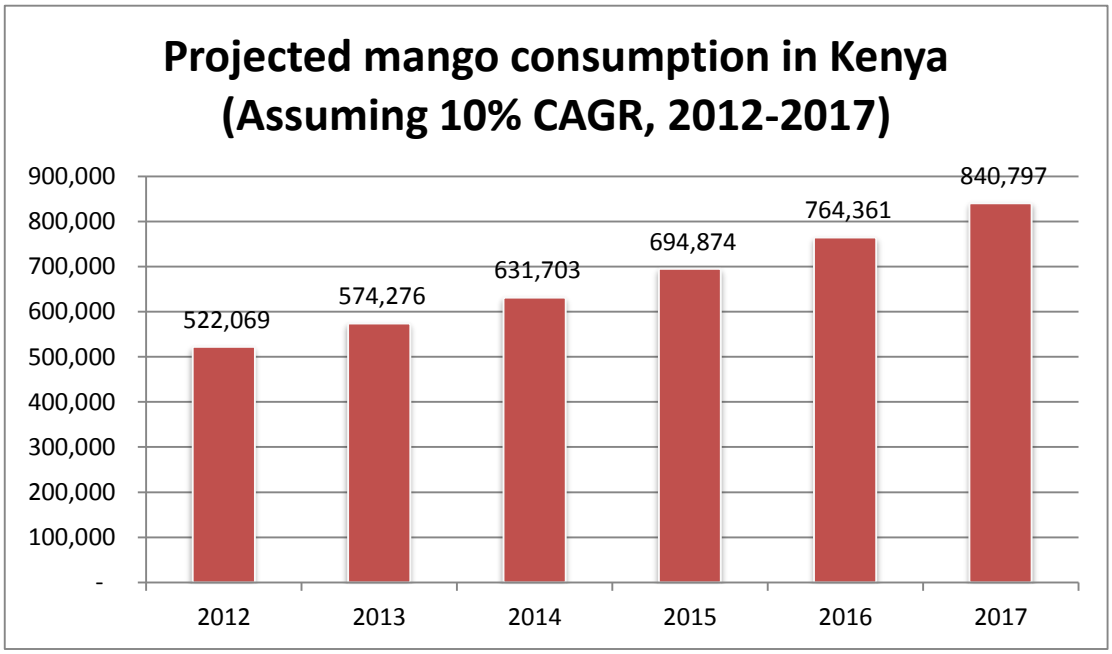


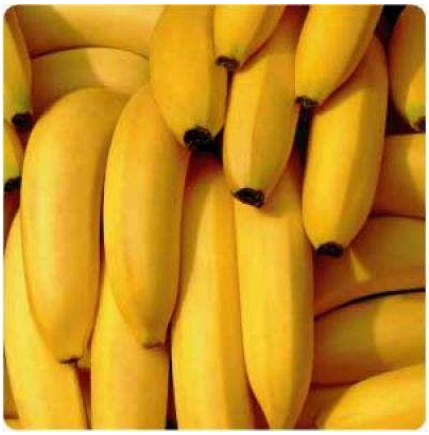
Figure 1: Projected mango consumption in Kenya.
Source: Compiled from Ministry of Agriculture, Kenya

Productivity depends on a number of factors, including quantity of previous crop, weather and soil conditions, altitude, control of pests and diseases, fertilization and cultivar. Even in the case of the same cultivar, yields vary greatly because mango is grown under widely varying agro climatic conditions and cultural practices[7].

2.3.4 Banana

Over the years banana has emerged as an important food crop and income earner in Kenya. There are two main types of banana grown in Kenya; the dessert and cooking varieties.

The banana originated in South Asia region to northern Australia and is popular with most communities in Kenya. Production is scattered all over the country.



Only a very small proportion of the Kenyan crop is exported. Most of it is consumed locally either ripe, as a dessert or cooked. Local cultivars in Kenya are 'Muraru', 'Kiganda', and 'Sukari' among others and they are adapted to various agro-ecological zones. Improved cultivars include Apple, Gross Michel, Kampala, Dwarf Cavendish, Giant Cavendish, Williams, Grand Nain, Valery, Poyo and Lacatan. Tall varieties are Poyo and Lacatan, while

[7] Griesbach J (2003). Mango growing in Kenya; ICRAF, Nairobi

medium varieties include Valery, Paz and Williams. The recommended banana varieties for export in Kenya are Apple (sweet Banana), Giant Cavendish, Lacatan, Sabaki, Valery, Red Banana (all dessert type), and Uganda Green (cooking type). In the year 2010, the total production stood at 1,439,584 tonnes (*Economic review for Agriculture*, *FAO*).
Giant Cavendish and Lacatan are resistant to Panama disease and have fruits with blunt tips. The bunch is irregularly shaped. Field heat and the subsequent transport and storage temperatures affect the length of the pre-climacteric period. Pre-cooled bananas are held at low temperature of 13°C. The optimum storage relative humidity is 85% to 90%. Below a temperature of 12°C, most banana cultivars suffer chilling injury. Both ripe and green bananas are susceptible to chilling injury although green ones are slightly more susceptible.

2.3.5 Avocado

Avocado is a universal fruit that thrives in subtropical climates and the temperate belt of the world. Africa Avocado Varieties are some of the finest in the world as the continent vaunts some of the finest varieties. The main avocado varieties in Kenya are:

1. Hass
2. Fuerte
3. Nabal, Puebla

As with the rest of the globe, avocado seasons fall into the better chunk of the year. Beginning early March to late November, the crop espouses extended harvest seasons when we have the highest supply. However there is a lot of losses incurred by farmers due to poor transport, poor roads network, poor storage at points of sale hence over ripening and rotting.

2.3.6 Water melon

Watermelon (Citrullus lanatus) is one of the most widely cultivated crops in the world (Huh et al., 2008)[8]. Its global consumption is greater than that of any other cucurbit. There are over 1,200 varieties of watermelon worldwide (Miles, 2004)[9] and a wide variety of watermelons have been cultivated in Africa (Zohary and Hopf, 2000)[10].Several of these varieties have been recommended for Kenyan range of climate.

These include Sugar baby Crimson Sweet 'Charleston Gray Chilean Black Congo Fairfax and 'Tom Watson' (Tindall, 1983)[11]. However, among these seven cultivars, only the first three are available in Kenyan markets with 'Sugarbaby' being the most popular (HCDA, 2006)[12].This makes demand of watermelon in Kenya to be higher than production resulting in the fruit being very expensive and only affordable to rich people. With local demand unsatisfied, its potential for export cannot be realized. To meet the local demand and may be create some surplus for export, production of watermelon in Kenya obviously needs to be increased (HCDA, 2006)12 Watermelons are not adapted to long storage. At low temperatures they are subject to various symptoms of chilling injury and loss of quality, and at high temperatures they are subject to decay. Between 10 and 15^{0}C is a good compromise. Watermelons should be consumed within 2 to 3 weeks after harvest, primarily because of the gradual loss of crispness. Quality hybrids are able to keep longer. The statistics below present details of both Water and Sweet/musk melons. Water melon is more preferred by local people unlike sweet melon that is grown for specific customers and has a short shelf life. The main production areas in the country are Coast (29,424 MT) and North Eastern (8,892 MT) Provinces.

[8] Huh, Y.C., I. Solmaz and N. Sari. 2008. Morphological characterization of Korean and Turkish watermelon germplasm. 1 Cucurbitaceae 2008.Proceedings of the IXthEUCARPIA meeting on genetics and breeding of Cucurbitaceae. Pitrat M. (ed.). INRA, Avignon (France), May 21st-24th, 2008.

[9] Miles, C. 2004. Icebox watermelons. In: Crop Production, Vegetable Research and Extension. Washingston State University. Vancouver Research and Extension Center, Vancouver, USA. http://www.wsu.edu/watermelons. Date accessed: 18thJuly 2007.

[10] Zohary, D. and M. Hopf. 2000. Domestication of plants in the old world.Third edition. Oxford University Press, 2000. p. 193.

[11] Tindall, H.D. 1983. Vegetables in the tropics. The Macmillan Press Limited.London. Pp. 150-152.

[12] HCDA, 2006. Fruits and Vegetables. Horticultural Crops Development Authority Technical Bulletin.

2.3.7 Pawpaw

Pawpaw thrives in warm areas with adequate rainfall and temperature of 21^0-23^0C. They grow best in areas below 1000m.Cold weather delays fruit ripening and depressed fruit quality. Fruit tastes much better when grown during a warm sunny season with annual rainfall of 1200mm. It does well in light well drained soils rich in organic matter with soil ph 6.0-6.5.Pawpaw is tolerant to any kind of soil but very sensitive to water logging.

The papaws fruits are low in calories and high in potassium, vitamin A and C. Papayas enzymes promote digestion easing constipation and it is efficient in controlling colon infections and colon cancer. The plants are short living perennial trees whose economic life is about 4 years, although the plants have a lifespan of up to 10 years. This means that papaws need to be renewed every 4-5 years for maintenance of an economic orchard. There are three groups of papayas distinguishable by their flowers namely:-

- Female plants –These fruit trees grows female flowers only
- Male plants –These grows male flowers only.
- Hermaphrodites trees –These grows both male and female flowers. Therefore allow 4 plants per hole and later thin out to single trees when flowers appear.

Paw paw is mostly marketed locally with very little going for export.

2.3.8 Summary for fruits

Fruits are among the most perishable crops grown by farmers and have high potential for fetching good incomes. However, in most cases farmers do not realise good returns due to the perishable nature of these fruits.

2.4 Ranking of selected food products

Various types of the three food products (viz., fruits, root crops and vegetables) were ranked subjectively based on an agreed template for selected food products by the collaborating institutions. The ranking was based on economic factor (Table 3), technical and resource related factors (Table 4), and societal factors, including poverty impact (Tables 5). Using the economic factors the best five ranked food products were cabbage, banana, mango, Irish potato and kales, respectively. The best five food products were cabbage, Irish potato, kales, cowpeas and cassava based on technical and resource related factors while cabbage, mango, kales, banana, avocado were the best based on societal factors, including poverty impact. Overall, the best five ranked food products were cabbage, mango, kales, banana and avocado (see Table 5).

2.5 Conclusion

From the results of the evaluation, it is clear that there is a lot of potential for value addition in virtually all sub-sectors. There is need to improve the farm-gate quality of most of the produce.

The table below gives a summary of the potentials in the various sub-sectors and informed the team in their decision to focus their energies more on the vegetables sub-sector.

Table 6: Summary of evaluated product quantities in tonnes

Category	Type	Quantity	Category	Type	Quantity
Fruits	Banana*	1,439,584	**Vegetables**	Kales, peas & indigenous	2,527,284
	Mangoes	593,499		Cabbages	784,786
	Pineapple	257,623		Tomato**	539,151
	Paw paws	185,088	**Food**	Potatoes	2,725,936
	Fresh fruits	115,622		Sweet potatoes	826,307
	Citrus fruits	113,369		Cassava	500,000
	Oranges	107,735		Arrow roots	21,599
	Avocado	88,790		Yams	6,538

**both food and fruit; **vegetable cum spice*

Table 3: Ranking of selected food products base on economic factors

	Fruits						Root Crops					Vegetables				
	Mango	**Banana**	**Avocado**	**Passion fruit**	**Pawpaw**	**Watermelon**	**Cassava**	**Arrowroots**	**Carrots**	**Irish potato**	**Sweet potato**	**Amaranth**	**Black nightshade**	**Kales**	**cabbage**	**cowpeas**
Economic growth	5	5	5	4	4	4	3	3	3	5	3	3	3	5	4	4
Market demand and growth potential (evidence of strong demand, unmet demand)	4	5	4	4	4	4	3	3	4	4	3	4	3	5	5	4
Existing and potential markets	4	5	4	4	3	4	3	4	4	3	4	4	4	4	5	4
Small producers competitiveness (current and potential)	4	5	4	4	3	3	3	4	4	4	4	3	4	4	5	4
Potential for pre-processing/value addition close to source	5	4	4	4	3	4	4	3	2	5	4	4	4	4	4	4
Technological level of production and access to resources (financial, knowledge, infrastructure, etc.)	3	3	2	3	2	2	3	3	3	4	3	3	2	3	4	3
Potential to expand the production	5	4	3	4	4	4	3	4	3	4	4	3	4	3	5	3
Total score	**30**	**31**	**26**	**27**	**23**	**25**	**22**	**24**	**23**	**29**	**25**	**24**	**24**	**28**	**32**	**26**
Ranking	**3**	**2**	**6**	**6**	**14**	**9**	**16**	**11**	**14**	**4**	**9**	**11**	**11**	**5**	**1**	**7**

Table 4: Ranking of selected food products base on technical and resource related factors

	Fruits						Root Crops					Vegetables				
	Mango	**Banana**	**Avocado**	**Passion fruit**	**Pawpaw**	**Watermelon**	**Cassava**	**Arrow roots**	**Carrots**	**Irish potato**	**Sweet potato**	**Amaranth**	**Black nightshade**	**Kales**	**cabbage**	**cowpeas**
volume and value of the crop	4	4	3	3	3	3	3	3	3	4	3	3	2	4	4	4
losses (preference to products with high losses)	4	2	4	2	3	4	4	4	2	3	2	3	4	4	5	3
Potential for reduction of losses	4	4	4	3	3	4	4	3	3	3	3	4	4	4	5	3
Volume of by products produced	2	2	3	3	2	3	3	3	3	4	2	3	2	2	3	4
Achievable level of utilisation of waste	2	3	3	3	2	2	3	3	2	4	2	2	3	3	3	4
Energy intensity of production steps, both theoretically and in real terms	3	2	2	3	2	3	3	3	3	4	2	2	3	3	4	3
Level of renewable energy sources	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Potential for use of renewable energy resources	3	4	3	2	2	2	3	3	2	3	3	3	4	4	4	3
Appropriateness of process technology suggested	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total score	**22**	**21**	**22**	**19**	**17**	**21**	**23**	**22**	**18**	**25**	**17**	**20**	**22**	**24**	**28**	**24**
Ranking	**6**	**10**	**6**	**13**	**15**	**10**	**5**	**6**	**14**	**2**	**15**	**12**	**6**	**3**	**1**	**3**

Table 5: Ranking of selected food products base on societal factors, including poverty impact

Attribute	Fruits						Root Crops					Vegetables				
	Mango	Banana	Avocado	Passion fruit	Paw paw	Watermelon	Cassava	Arrow roots	Carrots	Irish potato	Sweet potato	Amaranth	Black nightshade	Kales	cabbage	cowpeas
Geographical location and outreach	5	4	4	4	3	4	3	4	3	4	4	4	4	4	4	4
Representation of women/youth in sub sector	4	4	4	5	4	4	4	3	4	3	4	4	4	5	5	4
Number of businesses in the sector (current and potential outreach	4	4	4	3	2	2	3	3	2	2	3	2	2	4	3	3
Number of enterprises for each type of firm in the value chain (including farm size, average salary per employee)																
Better wages for people who are in employment	4	3	4	4	3	3	3	3	3	2	3	3	3	4	4	3
Potential for employment generation (reduction of unemployment)	4	3	4	4	3	4	4	3	3	2	3	3	3	4	4	4
Making work more enjoyable	4	3	4	3	3	3	3	4	3	2	2	3	3	3	4	5
Potential for reduction of stunting through increase of nutritional value of food stuffs	5	4	4	4	4	4	4	3	4	3	4	4	4	4	4	3
Total score 3	**30**	**25**	**28**	**27**	**22**	**24**	**24**	**23**	**22**	**18**	**23**	**23**	**23**	**28**	**28**	**26**
Ranking 3	**1**	**7**	**2**	**5**	**15**	**8**	**8**	**10**	**15**	**10**	**10**	**10**	**10**	**2**	**2**	**6**
Overall Score	**82**	**77**	**76**	**73**	**62**	**70**	**69**	**69**	**63**	**72**	**65**	**67**	**69**	**80**	**88**	**76**
Overall Ranking	**2**	**4**	**5**	**7**	**16**	**9**	**10**	**10**	**15**	**8**	**14**	**13**	**10**	**3**	**1**	**5**