BASELINE SURVEY

POST-HARVEST FOOD CHAIN LOSES, WASTAGE AND CURRENT ENERGY DEMAND FOR HIGH MOISTURE CONTENT VEGETABLES IN KENYA

EXECUTIVE SUMMARY

The world globally is upbeat over the escalating environmental degradation concerns as a result of the continued vicious cycle of unsustainable resource extraction. The earth's natural ecosystem cleaning mechanism has failed terribly due to the unorthodox resource use activities. The exploitation and use of fossil energy resources for transport, tillage, harvesting and postharvest processing in agriculture has continued to uncover the long buried carbon, releasing it to our troposphere which is home to ground-level ozone and others. The unsustainable use of forests for wood fuel (over 80% in Eastern Africa for example) and other applications, agricultural malpractices and deficiencies and the low uptake of solar energy for example have continued to deny the world an opportunity to contain this carbon dioxide imbalance. The United Nations predicts that the world's population will reach 9.5 billion by 2050 and this will pose enormous challenges in sustainable food production, water and energy supply. The World Health Organization (WHO) estimates that nearly 60% of the world population is malnourished and unless serious measures are taken to address this then the situation will be significantly exacerbated in the near future. A lot of effort has quite rightly focussed on increasing food production but this is dependent on increased use of valuable resources.

Minimisation of losses in the food chain will not only increase the quantity and quality of produce but also reduce energy, water and land use. Losses in the food value chain are approximately a third of the total world yield and are estimated to range from about 15% for cereals up to 50% for fresh fruits and vegetables in some developing countries [2]. The losses occur during harvest, processing, storage, transportation, retail and use of a range of foods. Significant losses are a result of a number of factors which include insufficient drying, inadequate storage, insufficient cooling and poor transport , all of which rely on high levels of energy input.

The goal of this survey was to provide factual baseline information on the aspects and impacts surrounding the processing of high-moisture-content vegetable production and the extent and potential of renewable energy use by Kenyan farmers. This aims at providing practical insights which will inform the research team on the actual issues on the ground so as to appropriately strategise for the identification, selection and analysis of the best renewable energy solutions for intenvention.

Through the stakeholder workshop held in JKUAT on 20th March 2014, the participants highlighted and prioritized the high moisture content vegetables which could be investigated and best sites for the survey. The survey used questionnaires and interviews to collect primary data. Structured quantitative questionnaires were used and these were administered by RE4Food project members and trained research assistants. The questionnaire sought information on household demographics, livelihood activities, crop farming, vegetable farming practices, post-harvest handling, production and marketing. The quantifiable answers from the questionnaires were analysed to establish frequencies and percentages of beneficiaries and levels of benefit. The questionnaires captured both qualitative and quantitative data. The qualitative data was used to compliment the quantitative results and was analysed thematically. Expert opinion was sought from the County Directors' of Agriculture and Kenya Agricultural Research Institute (KARI-Kisii). The opinion supplemented the information gathered from all the other methods listed above. A total of 249 respondents were interviewed from Kisii (103), Kiambu (107) and Kirinyaga (39). The

information gathered from the field was analysed using the SPSS software package and forms the basis of this report.

The bio-data gathered from the three counties indicate that the population of male respondents was higher in Kiambu and Kirinyaga at 84.6% and 79.4%, respectively, while the female respondents were higher for Kisii at 62.1%. In terms of the age distribution, majority of the respondents were the middle aged (36-59 years) followed by the youth (< 36 years). Generally, the marital status of the households ranged between 76.6 and 92.3% for the three counties surveyed and most of the households are male headed as expected in the African culture. Majority of households (69.1%) in Kirinyaga had a family size of 1-4 members whereas most households in Kiambu County had family sizes of 1-4 (44.2%) and 5-8 (41.3%) members. In Kisii County, a greater majority (69.2%) of households comprises of 5-8 members. In all the surveyed counties, the level of education is relatively low, with majority of the respondents having had some level of formal education at primary (44.2%) and secondary (69.2%) levels. Land ownership is predominantly by men (over 75%) in the three (3) Counties and virtually all the land under cultivation is owned by the respondents. The sizes of land parcels were also relatively small with most of the land sizes being less than five (5) acres. Various forms of livelihood activities were carried out, the main ones being livestock rearing (> 89%) and cultivation of various crops (> 51% for cereals).

Income was mainly drawn from various economic activities namely; livestock production (rearing and selling animals and animal products), crop faming (cereal foods, root crops, pulses, fruits and vegetables) and employment. Kiambu County recorded the highest mean total income (Ksh 278,362.8 p.a) per house hold, the only county with mean income higher than the aggregate mean for the entire study area. Further, the results show that less than 30% of the respondents farmed family land, and that a significant portion of farmers in Kisii (20.4%) and Kiambu (37.4%) farm rented land. From the survey a large proportion of the farmers (> 84%) grow vegetables in less than one (1) acre of land. However, 16.0% of farmers in Kiambu grow vegetables in more than one (1) acre and this is attributed to the access of forestland where they are able to rent from the government under the shamba system of farming.

In addition, the results show that Kisii and Kirinyaga have a good mixture of both indigenous and exotic vegetables with Kisii having 58.8 and 41.3% of indigenous and exotic vegetables, respectively, and Kirinyaga having 45.5 and 54.5%, respectively. Generally, in all the three (3) counties a large proportion (77.1-90.6%) of the vegetables is grown both for market and domestic consumption. Apart from Kirinyaga County with less than 50% growing vegetables by rain water, Kiambu and Kisii predominantly rely on rain fed vegetable growing with 81.7 and 73.0%, respectively. Various technologies are used for both weeding and pest control, with manual weeding being predominant in all the three counties at 94.2% for Kisii, 74.8% for Kiambu and 84.6% for Kirinyaga. In Kirinyaga, 14.7% of respondents practise irrigation and the proportion of the water sources are 43.0, 30.0 and 26.7% from rivers, piped and boreholes, respectively.

In general, losses during harvesting are less than 10% in all the three counties although in some instances the losses of more than 50% were reported. Minimal losses were encountered during transportation of vegetables at less than 10%. Handling losses were reported in the market during handling with more than 67% of the respondents experiencing losses of less than 10%. Vegetable value addition activities are quite minimal in all the counties. Majority of the respondents 83.7, 78.3 and 63.7% in Kisii, Kiambu and Kirinyaga, respectively, recorded losses of less than 10% during processing (viz., drying, boiling, grading and cleaning). The most common storage method for vegetables is under shade before transportation to the market, with response rates of 94.1, 48.0 and 75.8% in Kisii, Kiambu and Kirinyaga, respectively.

Respondents were aware about renewable energy technologies available, with 94.9 and 27.6% in Kiambu and Kirinyaga, respectively, confirming having knowledge on biogas. Mostly, manual labour is utilised in most of processing operations. This indicates that there is great potential for promotion of renewable energy use in processing of high moisture content vegetables. In Kisii 15% of the respondents sell their vegetables directly to other farmers while in Kiambu 20% of the respondents market their vegetables through middlemen.

The main challenges to marketing as isolated out by the respondents include; poor infrastructure, low prices, lack of markets, surplus produce, high taxation, poor storage, exploitation and lack of capital. The suggested interventions and solutions include; training, ready market, technology for value addition and production, quality seeds, affordable capital and good infrastructure. Some of these solutions could be overcome through use of renewable energy based value addition technologies; such would enable farmers get better prices, provide ready market for products, avoid price fluctuations, improve incomes thus provide needed capital for improved seeds and production and avoid the challenge of poor infrastructure.

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CHAPTER 1 : INTRODUCTION

1.1. Motivation to Move into Green Energy

The world globally is upbeat over the escalating environmental degradation concerns as a result of the continued vicious cycle of unsustainable resource extraction. The earth's natural ecosystem cleaning mechanism has failed terribly due to the unorthodox resource use activities. The exploitation and use of fossil energy resources for transport, tillage, harvesting and postharvest processing in agriculture has continued to uncover the long buried carbon, releasing it to our troposphere which is home to ground-level ozone and others. The unsustainable use of forests for woodfuel (over 80% in Eastern Africa for example) and other applications, agricultural malpractices and defficiencies and the low uptake of solar energy, for example, have continued to deny the world an opportunity to contain this carbon dioxide imbalance. These and many other cumulative, intertwined and sub-sequential activities have resulted in the blanketing of sun's heat over our heads commonly refered to as global warming. As a result, over the years we have experienced accelerated drying up of our water catchments, stretching of the deserts, melting of the ice caps at the poles, increased sea water levels and so on.

With the acknowledged diminishing of the unevenly distributed and over-relied fossil fuel resource base coupled with the environmental factsheets, governments, researchers, experts and other stakeholders are quickly retracing their steps into new alternatives including the long forgotten fuel systems that existed long before the peak oil – Renewable energy. It has become evident that no single primary energy resource can comfortably and sustainably meet the entire end-use energy service needs for a nation or region. Some of the avenues being sort to conserve energy include development of more efficient processes, systems and/or equipment and fuel supply switch to renewable energy systems.

Africa in general, is deficient in the fossil resource base and also lacks the technological capacity to exploit the little resource that there is. The better part of Africa, being in the tropics is however rich in renwable energy resources. This serves as a basis for increasing

and/or up-scaling renewable energy related projects in order to provide the needed energy for food processing and thereby improve livelihoods.

1.2. Problem Statement for the Baseline Survey

1.2.1. Background Information

Out of the total Kenya's land (580,367 km^2), only about 16% is arable and out of this, farming takes only 31%, grazing 30%, forests 22% while game parks, urban centres, markets, homesteads and infrastructure take up 17%. The rest of the 84%, as shown in Figure 1.1, consists of arid or semi-arid lands of which insignificant per centage is irrigable.

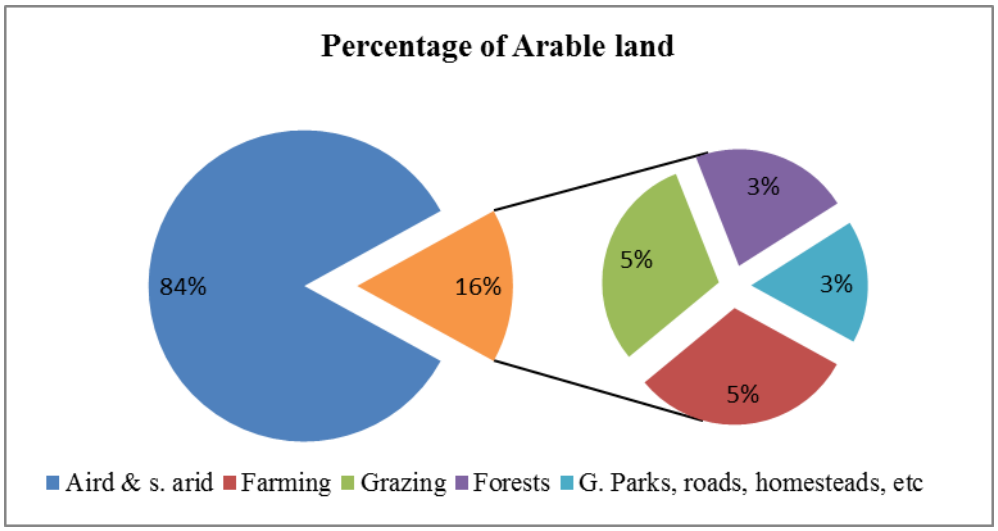

Figure 1.1: Share of arable land as compared to dry land in Kenya

Agriculture, the mainstay of Kenya's economy, currently contributes 26% of the GDP directly, and another 25% indirectly. The sector also accounts for 65% of Kenya's total exports and provides more than 18% of formal employment. Furthermore, more than 70% of informal employment is in the rural areas and is supported by agriculture[1]. The agricultural sector comprises six subsectors namely the industrial crops, food crops, horticulture, livestock, fisheries and forestry.

The United Nations predicts that the world's population will reach 9.5 billion by 2050 and this will pose enormous challenges in sustainable food production, water and energy supply. The World Health Organization (WHO) estimates that nearly 60% of the world population is malnourished and unless serious measures are taken to address this then the situation will be significantly exacerbated in the near future. A lot of effort has quite rightly focussed on increasing food production but this is dependent on increased use of valuable resources.

Minimisation of losses in the food chain will not only increase the quantity and quality of produce but also reduce energy, water and land use. Losses in the food value chain are approximately 1/3 of the total world yield. These losses are estimated to range from about 15% for cereals up to 50% for fresh fruits and vegetables in some developing countries [2]. The losses occur during harvest, processing, storage, transportation, retail and use of a range of foods. Significant losses are a result of a number of factors which include insufficient

drying, inadequate storage, insufficient cooling and poor transport, all of which rely on high levels of energy input.

In sub-Saharan Africa losses are predominantly at the producer end of the food chain and reducing these losses is often beyond the means of individual producers, who are predominantly subsistence farmers [3]. Sub-Saharan Africa (SSA) is the least electrified region of the world, with rural electrification levels of less than 5% in many countries. A majority of the population are dispersed in rural settlements, with the transmission and distribution costs of grid electricity to dispersed households being high. Thus more viable alternatives to provide a range of decentralised energy technologies that better match the dispersed nature of the SSA's rural population are required. Developing countries too have high population growth and are increasingly using significant volumes of fossil fuels within their food production to meet growing demands, particularly as their export markets start to grow [3][4]. Energy input is required across the entire food chain and it is estimated that 7-10 calories are required in the production of 1 calorie of food. This is primarily from fossil fuels which will increasingly become more expensive and post-harvest losses indirectly contributing to increased greenhouse gas emissions and climate change [4]. It is therefore essential that technologies and practices adopted to reduce post-harvest losses are energy efficient and integrate effective renewable energy solutions, such as biomass, solar PV, solar thermal, wind turbine, and micro-/pico-hydropower sources [5].

Plate 1: Kale and Cabbage farming in Kinale, Kiambu County, Kenya

The use of a range of integrated renewable energy solutions is vital and can combine a range of options from wind power, solar PV and solar thermal for heating and cooling, and to use tri-generation (combined cooling, heating and electrical power), the use of bio-gas/syngas produced by anaerobic or gasification food processing residues and wastes, are all possible solutions. The food processing and renewable energy mix will be dependent on the particular food chains, resource availability, and may incorporate additional bio-mass and waste streams from other local sources to enhance the bio-gas/syngas production. In addition in the direct energy use in the food processing chains there may also be the potential to produce excess energy (electricity and biogas) which can be sold to the local population.

Decentralised food processing systems, supported by distributed energy supplies do not only improve food security but also increase employment and income generation in rural communities. The local processing of food enables better storage and easier transportation, longer shelf-life, reduced seasonal supply effects, and produces products with added value. Additional benefits include social entrepreneurship, environmental management and nutritional health [7]. In Kenya, agriculture accounts for about 24% of the GDP with an estimated 75% of the population depending on the sector and 66% of the manufacturing sector is agro based and it has the most developed horticultural sector in East Africa [8].

Plate 2: Indigenous vegetables growing in area e.g Nyambane area, Kisii County, Kenya

1.2.2. Description of the Assignment

Whereas it is common knowledge that there are post-harvest challenges facing most of the rural small-scale farmers in Kenya, factual data to support and/or inform this thought for an informed course of action is lacking. This particular survey therefore sought to provide information on the prevailing post-harvest conditions and/or cahllenges in vegetable growing within the selected regions in Kenya. The survey was informed by the already concluded desk-top study report, which singled out high moisture content vegetables as the products of high proirity.

Based on the spacial and product population distributions, and the information gathered from focus group discussions and expert opinions, the team found it paramount to evaluate the impacts, losses and the extent of renewable energy use on these products by the concerned farmers. This was accomplished through:

[1] Development of field survey tools for administering to the survey regions.
[2] Establishement of the demographic structures of the concerned families or farmers.
[3] Identification of the key livelihood activities and trends.
[4] Determination of the economic status, contributions and impact from the concerned crop.
[5] Determination the most common vegetable farming practices and sources of raw/feedstock materials.
[6] Characterisation post-harvesting handling practices by farmers and the associated losses in vegetable farming.

[7] Identification of the production and marketing challenges faced by the vegatable farmers.
[8] Evaluation of the extent of renewable energy use in post-harvest processing of vegetables.
[9] Determination of the resource potential characteristics of the available renewable energy sources in the study regions.

CHAPTER 2 : DESIGN OF THE RE4FOOD PROJECT

2.1. Project Implementation Structure

The RE4Food project is a collaborative three year project addressing research challenges associated with increasing food security and reducing reliability on fossil fuels. The project which commenced on 1st July 2013 has an international focus and involves international academic institutions (viz., Newcastle University, United Kingdom; University of Kassel, Germany; Kwame Nkrumah University of Science and Technology, Ghana; Jomo Kenyatta University of Science and Technology, Kenya; Njala University, Sierra Leone; and Stellebosch University, South Africa) as well as British Non-governmental Organisations (NGOs) based in Sub Saharan Africa (i.e., Practical Action Consulting-East Africa, Kenya; and Environmental Foundation for Africa, Sierra Leone).

The day to day management of the project is the responsibility of Prof. Tony Roskilly (Newcastle University) as the PI and is supported by the work package leaders to coordinate their area of research expertise in the project. The collaborating organisations are represented on the Management Committee (MC) which is chaired by Prof.Roskilly and the MC provides operational direction, oversee the general running of the project, monitor delivery of the research outputs and the user engagement strategy and is accountable for the overall performance of the consortium against the agreed milestones. The initial kick-off meeting of the MC was held in Kenya on 5th July 2013. In addition the MC holds virtual meetings every three (3) months using WebEx (or a similar system). This regular review provides an 'early alarm' system if any slippage occurs allowing time for mitigation. The academic leads from each organisation take overall responsibility for the research work and RA supervision at their organisation.

The project is supported by internal Energy Efficient Rural Food Processing Utilising Renewable Energy to Improve Rural Livelihoods SWAN personnel who have experience in project and financial management of international research projects and supports the effective operation of the MC. The consortium partners are already members of several consortia and fully familiar with operating the appropriate administrative arrangements, information exchange techniques, and stakeholder partnership strategy. A Multi-stakeholder Network (MSN) has been established and it includes all project partners as well as representatives from farmers, food processors, energy suppliers, regulators, policy makers, SMEs, and all potential users of the research outcomes. The MSN on-going engagement throughout the project is via email correspondence but in addition plans to hold three (3) physical knowledge gathering meetings at the beginning of the project and three (3) knowledge dissemination meetings near the end of the project.

2.2. Goals, Aims and Objectives

The goal of this survey was to provide factual baseline information on the aspects and impacts surrounding the processing of high-moisture-content vegetable production and the extent and potential of renewable energy use by Kenyan farmers. This aims at providing practical insights which will inform the research team on the actual issues on the ground so as to appropriately strategise for the identification, selection and analysis of the best renewable energy solution/s for intenvention. The specific objectives of this study were;

i. To assess and identify a product which has overlap and common potential benefit to livelihoods.
ii. To analyze post-harvest food chains, for example looking at handling, cleaning, drying, transport, storage, and assess waste and losses.
iii. To evaluate current energy inputs across various stages along the food chain for each of the products.
iv. To assess the extent of rural food processing, the technologies utilised, the energy mix and level of inputs currently required.
v. To identify the potential for various forms of renewable energy and assess existing deployments in rural regions.

Plate 3: Kales in Kinale,Kiambu County, Cowpeas in Amariba area, Kisii County,

2.3 Survey Scope and Boundaries

The scope of this report is limited to the evaluation of the post-havest vegetable production chains and the associated impacts, and the exent of renewable energy use in the post-harvest processing of the crop. It does not highlingt the selection criteria of the concerned crop earlier covered in the desktop study report which preceeded this report. Further this report does not entirely conclude on the prospective usage of renewable energy resources in rural areas especially for food processing but rather gives a face-value insight of the gaps in, and potential of various renewable energy resources.The survey was conducted in three counties in Kenya namely Kiambu, Kirinyaga and Kisii (Figure 2.1).

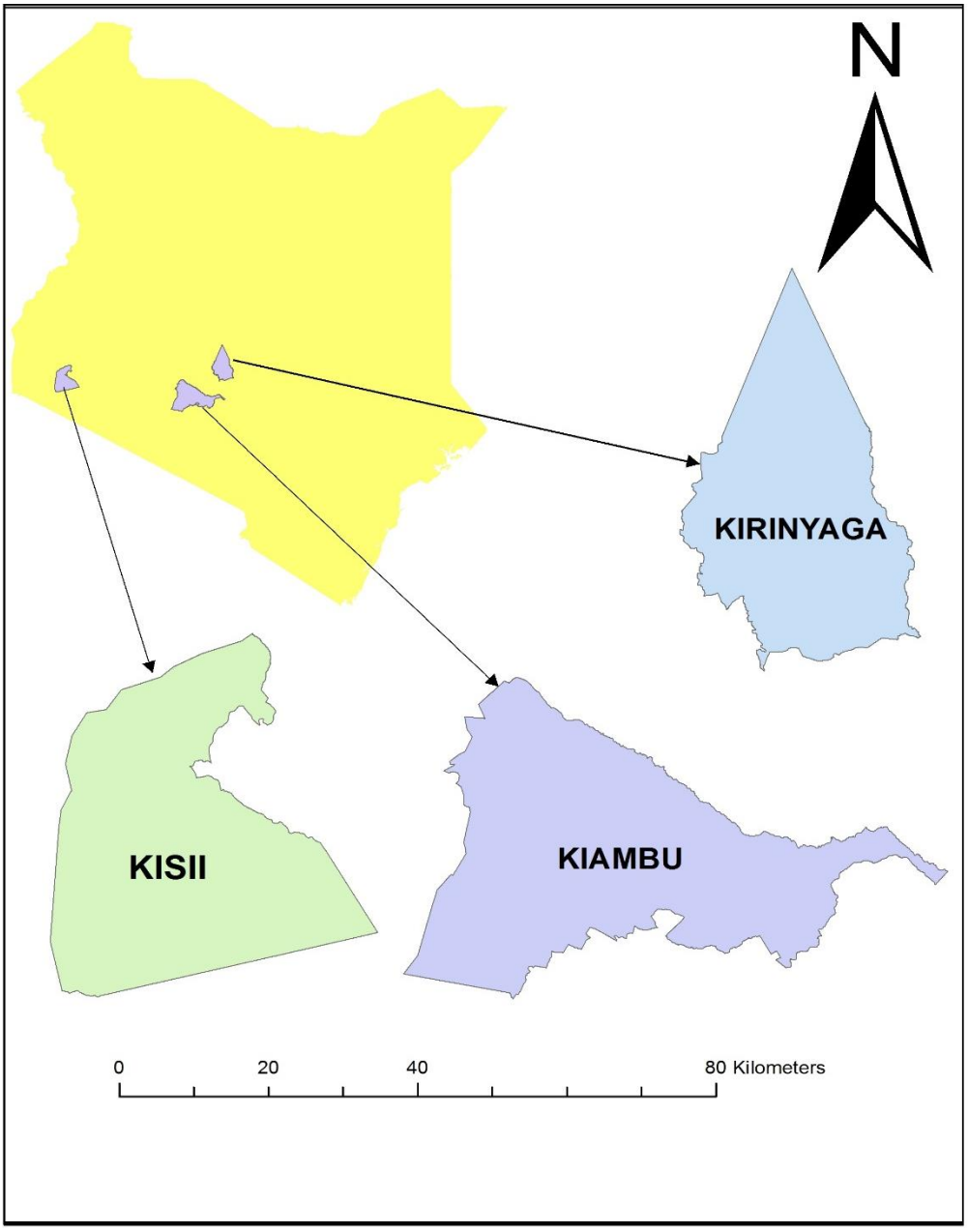

Figure 2.1: Map showing the location of the three counties namely Kisii, Kiambu and Kirinyaga on the Kenyan map, where the survey was conducted

2.4 Survey Implementation Plan

The survey was carried out in the month of May 2014. The strategy employed here to inform the survey was to approach the existing farmer groups or cooperatives to provide information on the their repsective practices and experiences. The approach was to engage those directly involved in vegetable production. One interesting aspect about Kenyan small scale farmers is that virtually all of them usually team up in form of a small groups within a reasonable geographical region to voice their concerns or promote their products communally. As such, engaging farmers through these small groups becomes the best and easest avenues of getting in touch with individual farmers.

Team members consulted the County government offices, other local authorities and some earlier identified stakeholders to establish a rapport with the concerned groups. A follow up on the representative groups from the two (2) study regions was made by the team members in colaboration with the stakeholders. Different rural groups were identified and individual respondents meetings arranged prior to the visits. These activities were undertaken in the better part of the month of May 2014. Project team members sub-divided into two (2) groups and the group were dispatched to the respective sites to interact and collect information from the farmers for a period of five (5) days in each region. Questionnaires were used to guide and record the gathered information, some of which was confirmed by observation.The information was collated and analysed in the month of June and July 2014.

CHAPTER 3 : METHODOLOGY AND DESIGN

3.1. Introduction

The survey used various tools and methods to collect data. Secondary data was collected from available literature and documents. Through the stakeholder workshop held in JKUAT on 20th March 2014, the participants highlighted and prioritized the high moisture content vegetables which could be investigated. They also prioritized the best representative sites where the survey could be conducted for the various high moisture content vegetables. Questionnaires were developed and tested before use in the field. Two teams were constituted comprising of five (5) members from the RE4Food project, both JKUAT and PAC East Africa. The teams were also assisted by enumerators in the field and county extension staff from the Ministry of Agriculture especially on linkage, mobilization and group organization. The two teams simultaneously visited the field where they administered questionnaires to group members and held group discussion on post-harvest losses along the value chains. In total 103 questionnaires in Kisii, 107 in Kiambu and 39 in Kirinyaga were administered, totalling to 249.

The data used in this report is from the workshop, secondary sources in addition to field interviews conducted in three Counties in Kenya, namely; Kisii, Kiambu and Kirinyaga Counties. The data was collected through structured quantitative questionnaires, expert opinion from directorates of agriculture in respective counties and observation on how vegetables are handled from the farm to the market.

Plate 4: Briefing session at Kimicha village in Kirinyaga County, Kenya

3.2. Criteria for Sites Selection

Data was collected from three Counties (Kisii, Kiambu and Kirinyaga) based on the types of vegetables grown. In Kisii the focus was on indigenous vegetables, while in Kiambu and Kirinyaga the focus was on exotic vegetables. The selected priority sites for the baseline survey are shown in Table 3.1.

Table 3.3.1: Selected priority sites for the baseline survey

Code/S.No	Village	County
		Kiambu
1	Kaguongo	
2	Kiandutu	
3	Kinale	
4	Magana meri	
5	Matimbei	
6	Mukeu	
7	Murengeti	
8	Roromo	
		Kirinyaga
9	Kathiga	
10	Kianjogu	
11	Kimicha	
12	Kombuini	
13	Mahuti-ini	
14	Mbeti	
15	Nyangati	
		Kisii
16	Amariba	
17	Boronyi	
18	Chinche	
19	Nyaguta	
20	Nyambache	
21	Amariba	
22	Boronyi	
23	Chinche	

3.2.1. Kiambu County

Kiambu County which is in the central region of Kenya and comprises of seven Sub Counties: Lari, Kikuyu, Limuru, Kiambaa, Githunguri, Ndeiya and Karai. (Figure 3.1) The district covers an area of 1,324 square kilometers with 90% being high agricultural potential land[1]. Rainfall is reliable and ranges from 1,500mm in the highlands to 500mm in the semi-arid areas of Ndeiya and Karai[1]. These two divisions are vulnerable to drought. Reliable rainfall makes the county potential for fresh vegetables production through rain fed agriculture. The survey took place in Lari Sub County, which is a major supplier of Kales and cabbages to the Nairobi and Mombasa markets.

[1] http://www.kenyampya.com/index.php?county=Kiambu

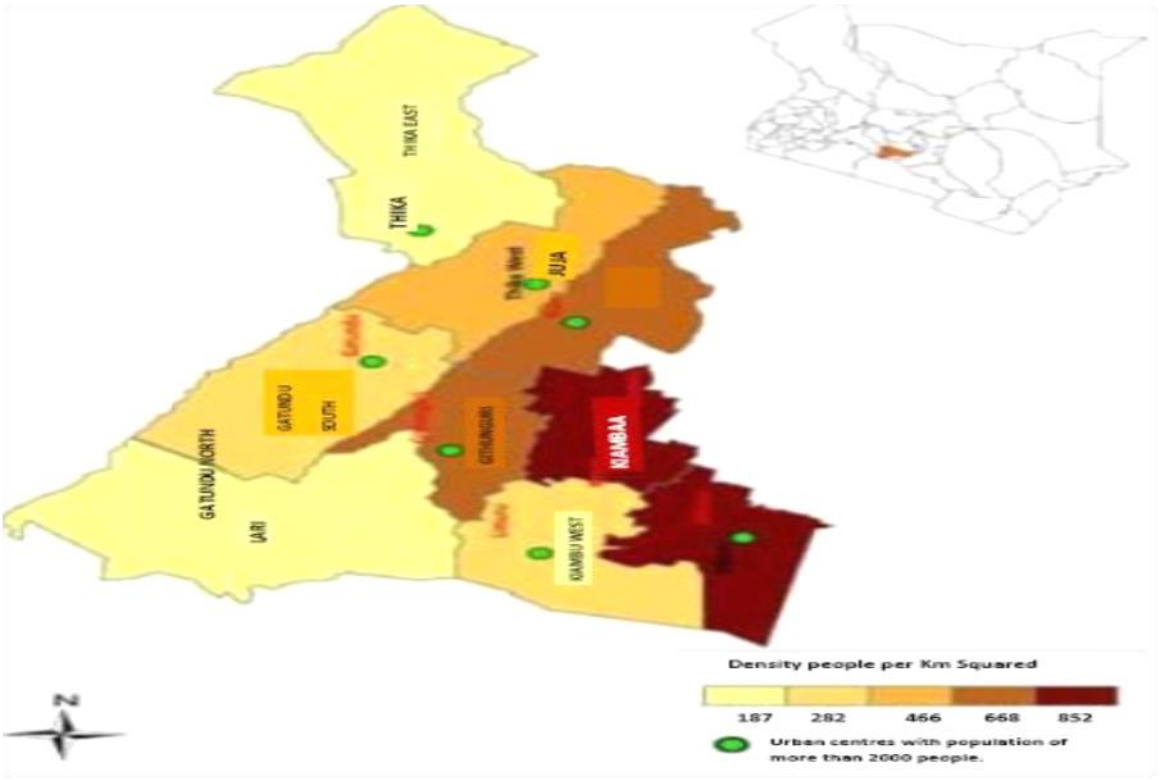

Figure 3.1: A map of Kiambu County, Kenya

3.2.2. Kisii County

Kisii County is located to the south east of Lake Victoria and is bordered by six counties with Narok to the south, Migori to the west, Homa Bay to the north west, Kisumu to the north, Bomet to the South East and Nyamira to the East (Figure 3.2). The county is composed of Masaba, Gucha, Gucha South, Kisii South, Kisii Central and Kitutu Chache Sub Counties. The County covers an area of 1,317 km^2 with a total population of 1,152,282 and a population density of 874.7 people per square kilometre contributing 2.9% to the national per centage. By the year 2009, the County had an annual growth rate of 2.75%. With 51% of its population living below the poverty line with an age dependence ratio of 100:94 (National population census 2009)[2]. The county has equatorial climate receiving rainfall almost throughout the year and an average annual rainfall of 150cm-200cm. Kisii County enjoys favourable climatic conditions that favor agriculture. This sector thus provides the veins that keep the county economy productive. The sector employs over 80% of the county's workforce; is a source of household income raw materials for agro-based industries; assists in environmental conservation. Agriculture is mainly small scale with production of food crops using non-mechanized techniques. The county is a major producer of vegetables especially the indigenous ones like amaranth, black nightshade etc.

[2] http://statistics.knbs.or.ke/nada/index.php/catalog/55

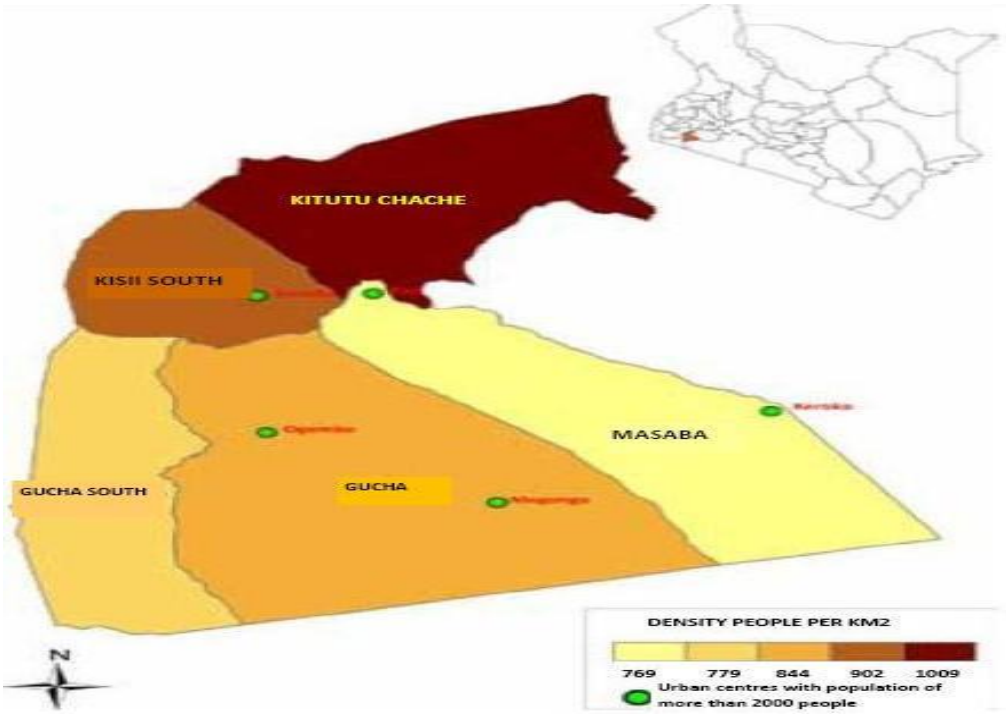

Figure 3.2: A map of Kisii County, Kenya

3.2.3. Kirinyaga County

Kirinyaga County is a county in the Central region of Kenya, with population of 528,054 and 154,220 households (Figure 3.3). It covers an area of 1,479.1 square kilometers. The Population density is 357 people per square kilometre. 25.6% of the population live below the poverty line[3]. The county economic base is agriculture with many horticultural crops grown through irrigation for both local market and export. Tomatoes are a major horticultural crop grown in this region mostly for supply to Nairobi and Mombasa. According Horticultural Crops Development Authority (HCDA) 2012-2013 report the area under tomatoes was 18,612 ha. The total production for the country was 397,000 MT with a value of Ksh 12.8 Billion. Tomato was majorly produced in Kirinyaga (24%), Kajiado (9%) and Taita Taveta (7%)[4] In Kirinyaga Tomato is produced under Mwea irrigation scheme.

[3] http://statistics.knbs.or.ke/nada/index.php/catalog/55

[4] HCDA 2012-2013 annual report

Figure 3.3: A map of Kirinyaga County, Kenya

3.3. Description of Tools and Approaches Used

The study used mainly structured quantitative questionnaires that were administered by RE4Food project members and trained research assistants. As a tool for data collection, structured open and closed ended questionnaires were developed and used. The questionnaire (see appendix) sought information on household demographics, livelihood activities, crop farming, vegetable farming practices, post- harvest handling, production and marketing. The quantifiable answers from the questionnaires were analysed to establish frequencies and per centages of beneficiaries and levels of benefit. The questionnaires captured both qualitative and quantitative data. The qualitative data was used to compliment the quantitative results and was analysed thematically. Expert opinion was sought from staff at the County Directors' of Agriculture, Kenya Agricultural Research Institute (KARI-Kisii) as well as other stakeholders. The opinion supplemented the information gathered from all the other methods listed above.

Plate 4: Data collection session at Roromo village in Kiambu County, Kenya

3.4. Sampling

Multi-stage sampling was used in this study. Three Counties (Kisii, Kiambu and Kirinyaga) were selected based on;

i. The type of high moisture vegetables grown in the area includes exotic vegetables like kales, cabbage and traditional vegetables like black nightshade, spider flower. Traditional high value vegetables like black nightshade are grown in Kisii while Kirinyaga and Kiambu Counties grow mostly exotic vegetables like cabbage and kales.
ii. The geographical location also determined the County selected. Kirinyaga (134 Kilometres from Nairobi) and Kiambu (16 kilometres from Nairobi) are close to Nairobi where market for vegetables is huge therefore the chances of post-harvest losses are different from Kisii (369 kilometres) which further away.
iii. These Counties have well-developed and mature farming practices that offers valuable lessons on how they can be helped to reduce post-harvest losses.
iv. Kisii being a major source of indigenous high moisture vegetables was selected to represent indigenous vegetables value chain.
v. Kirinyaga represented tomato value chain, being a major producer and supplier of the commodity in cities like Nairobi and Mombasa.
vi. Kiambu county is a major supplier of high moisture exotic vegetables like cabbages and kales hence it was identified as representative of that segment.

In total respondents from 20 villages in the three counties were interviewed.

Plate 5: Data collection session at Nyambache in Kisii County, Kenya

At the County level in consultation with the County Directors of Agriculture, we selected Sub-Counties from which we further selected villages where there is widespread vegetable farming. Most vegetable farmers at the village level are organised in groups. The groups were assembled at a particular location, where they hold group meeting and interviewed. There were two survey teams during data collection each comprising of five (5) members as presented in Table 3.2. The detailed schedules for the baseline survey are shown in Tables 3.3 and 3.4.

Table 3.2: Team members

Kisii County	Kiambu and Kirinyaga Counties
Prof. Joseph Mailutha	Prof. Christopher Kanali
Dr. Joseph Mungatu	Dr. Urbanus N. Mutwiwa
Victor Esendi	Dr. (Eng.) Gareth Kituu
Francis Njoka	Ezra Tonui
Livingstone Mulamu	Michael Kamwere

Table 3.3: Detailed schedule for the Baseline survey for Kisii County

Date	Time	Activity	County
27thMay 2014	09:00-10:00 AM	Briefing meetings at the County Agricultural office	Kisii county
	10:00-12:00 PM	Briefing the Boronyi group	
	12:00-05:00 PM	Administering the questionnaire	
	05:00-05.30 PM	Finalizing on filling the questionnaire and winding up	
28thMay 2014	09:00-10:00 AM	Consultation at KARI Kisii	
	10:00-12:00 PM	Briefing the Nyambache group	
	12:00-05.30 PM	Administering the questionnaire	
	05:00-05.30 PM	Finalizing on filling the questionnaire and winding up	
29thMay 2014	09:00-11:00 AM	Briefing the Chinche group	
	11:00-05:00 PM	Administering the questionnaire	
	05:00-05.30 PM	Finalizing on filling the questionnaire and winding up	
30th May 2014	09:00-11:00 AM	Briefing the Nyaguta group	
	11:00-05:00 PM	Administering the questionnaire	
	05:00-05.30 PM	Finalizing on filling the questionnaire and winding up	
31st May 2014	09:00-11:00 AM	Briefing the Amariba group	
	11:00-05:00 PM	Administering the questionnaire	
	05:00-05.30 PM	Finalizing on filling the questionnaire and winding up	

Table 3.4: Detailed schedule for the baseline survey for Kiambu and Kirinyaga Counties

Date	Time	Activity	County
27th May 2014	09:00-10:00 AM	Briefing meetings at the sub county Agricultural office	Kiambu county
	10:00-12:00 PM	Briefing the Roromo/Kaguongo groups	
	12:00-05:00 PM	Administering the questionnaire	
	05:00-05.30 PM	Finalizing on filling the questionnaire and winding up	
28th May 2014	09:00-11:00 AM	Briefing the Kinale/Kiandutu groups	
	11:00-05:00 PM	Administering the questionnaire	
	05:00-05.30 PM	Finalizing on filling the questionnaire and winding up	
29th May 2014	09:00-11:00 PM	Briefing the Magana Meri/Murengeti group	
	11:00-05:00 PM	Administering the questionnaire	
	05:00-05.30 PM	Finalizing on filling the questionnaire and winding up	
30th May 2014	09:00-11:00 PM	Briefing the Kimicha/Kathiga/Kombuini group	Kirinyaga county
	11:00-05:00 PM	Administering the questionnaire	
	05:00-05.30 PM	Finalizing on filling the questionnaire and winding up	
31st May 2014	09:00-11:00 AM	Briefing the Kianjogu/ Mahuti-ini/ Mbeti/ Nyangati group	
	11:00-05:00 PM	Administering the questionnaire	
	05:00-05.30 PM	Finalizing on filling the questionnaire and winding up	

CHAPTER 4 : RESULTS AND DISCUSSION

4.1. Demographic and Socio-Economic Analysis

4.1.1. Demographic Analysis

A total of 249 respondents were interviewed from Kisii (103), Kiambu (107) and Kirinyaga (39). The bio-data results from the baseline survey showed that the population of males were higher in Kiambu and Kirinyaga at 84.6% and 79.4%, respectively, while the females were higher for Kisii at 62.1% as shown in Figure 4.1. The reason for the differences in gender distribution was because of the varieties of vegetables grown in the three (3) regions. Kisii predominantly grows indigenous vegetable varieties, while Kiambu and Kirinyaga grow exotic ones. The marketing strategies for these varieties vary with indigenous types being more favourable to women. Exotic varieties have a more modernised structure in Kiambu and Kirinyaga, which favour more men. The indigenous varieties were also being promoted by local research institutions such as KARI which had encouraged the involvement of women.

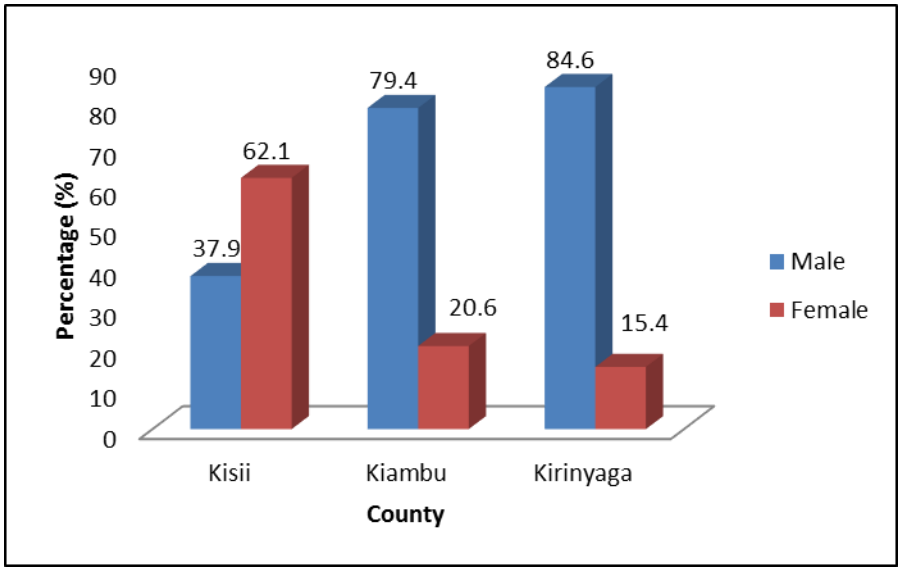

Figure 4.1: Gender distribution of the respondents of the baseline survey in Kenya.

In terms of the age distribution, majority of the respondents were the middle aged (36-59 years) followed by the youth (<36 years) as presented in Figure 4.2. However, there were a lot of youth engaged in the vegetable growing in Kiambu compared to other regions. This was due to the readily available market for the products and easier access to 'free land' from the neighbouring forest around Kinale village by the youths. In Kirinyaga, a lesser number of youths were interviewed. Some were attending training on the date of the interview and were represented by the relatively older group members.

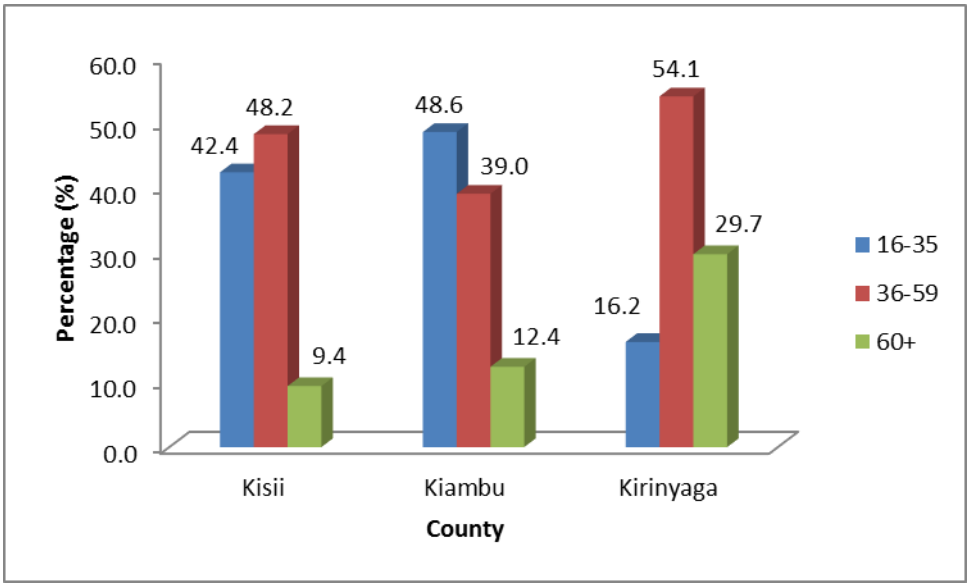

Figure 4.2: Age distribution of the respondents of the baseline survey in Kenya.

Generally the marital status (married) of the households ranged between 76.6 and 92.3% for the three counties surveyed (Figure 4.3). Most of the households are male headed as expected in the African culture (Figure 4.4).

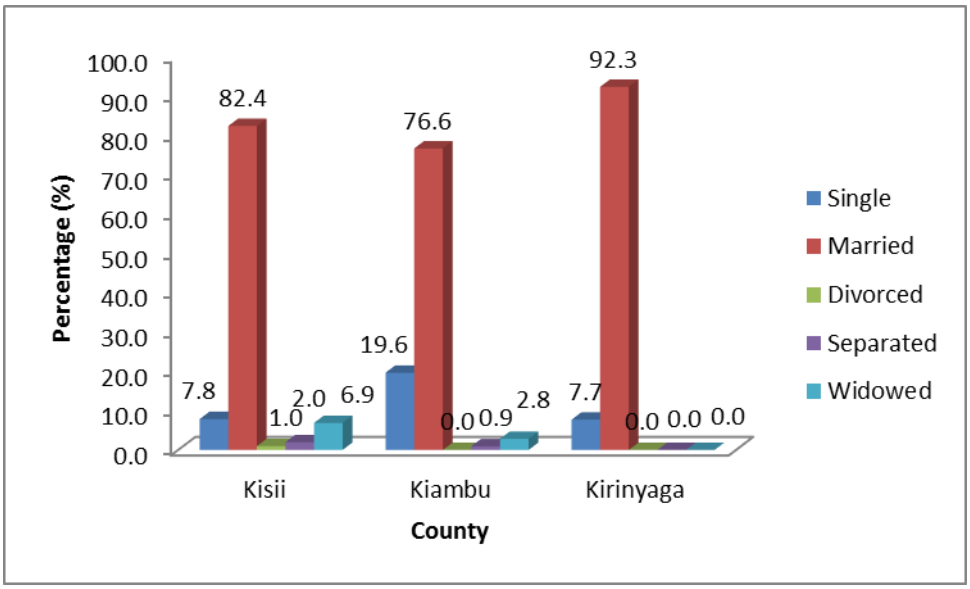

Figure 4.3: Marital status of the respondents of the baseline survey in Kenya.

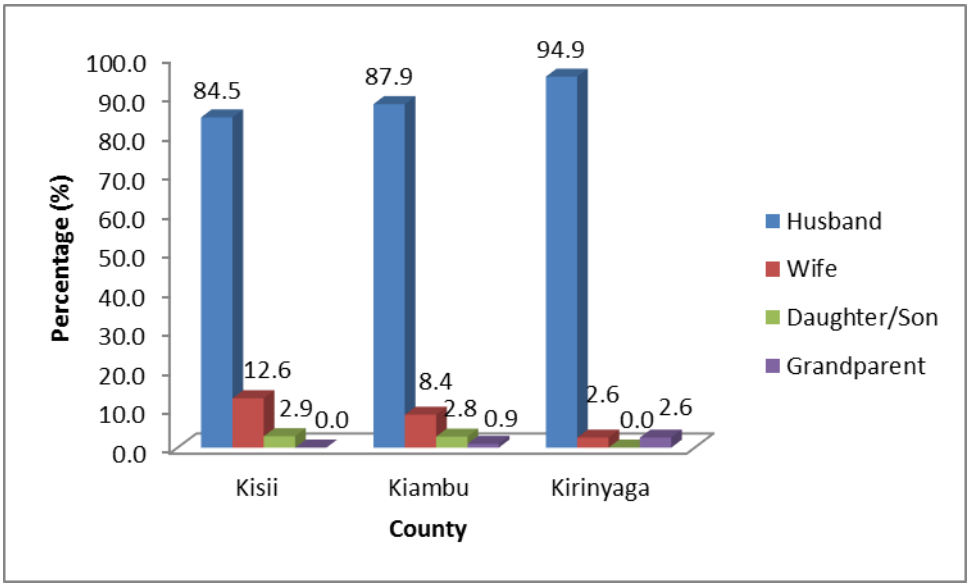

Figure 4.4: Household headship of the respondents of the baseline survey in Kenya.

Majority of households (69.1%) in Kirinyaga had a family size of between 1-4 members whereas most households in Kiambu County had family sizes of 1-4 (44.2%) and 5-8 (41.3%) members. In Kisii County, a greater majority (69.2%) of households had 5-8 members (Figure 4.5). Households in Kisii and Kiambu Counties suggest that more labour force can be available for farming activities as compared to Kirinyaga Country.

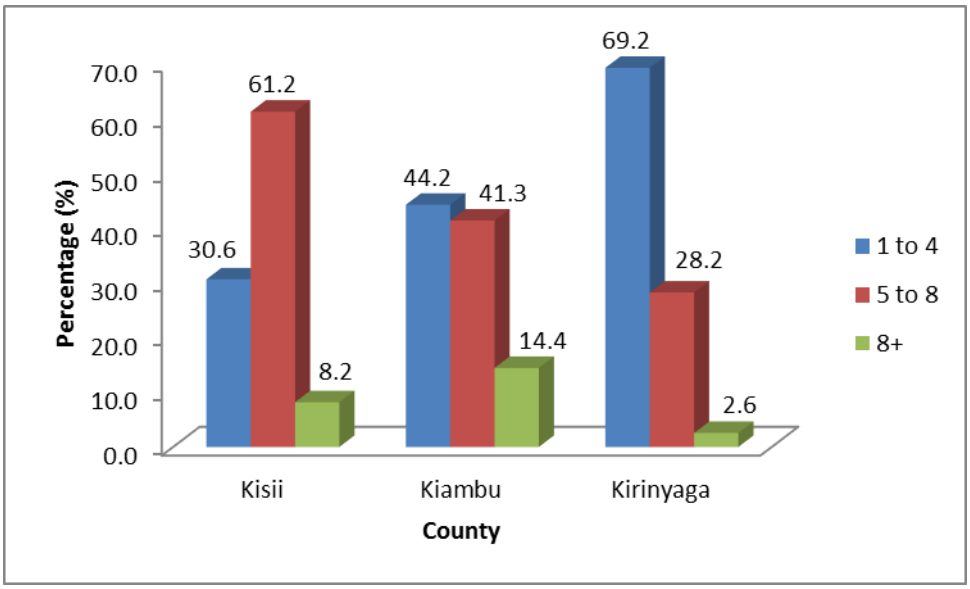

Figure 4.5: Households sizes of the respondents of the baseline survey in Kenya.

In all the surveyed regions, majority of the respondents had some level of formal education at primary and secondary level (Figure 4.6). This indicates that dissemination and adoption of new farming and processing concepts can be cascaded to the local communities with ease.

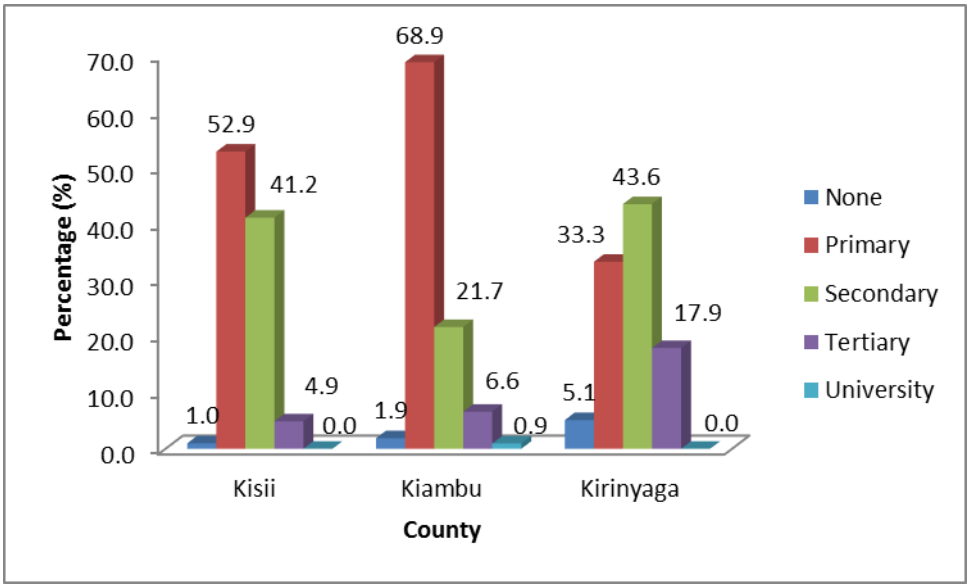

Figure 4.6: Highest level of education reached by the respondents of the baseline survey in Kenya.

4.1.2. Socio-economic analysis

Land is also predominantly owned by men in the three (3) Counties (Figure 4.7) and virtually all the land under cultivation is owned by the respondents. A meagre 5.7% of respondents in Kiambu County, however, have rented from their neighbours.

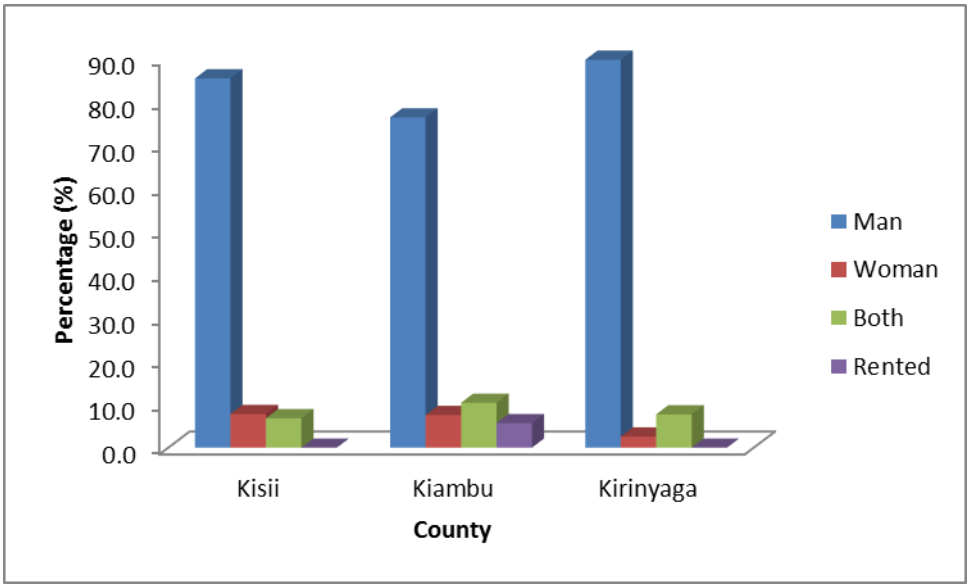

Figure 4.7: Land ownership by gender of the baseline survey in Kenya.

The sizes of land parcels were also relatively small in the three (3) counties with most of the land sizes being less than five (5) acres (Figure 4.8). This indicates that the potential for small scale decentralised commercial activities is high across the three counties.

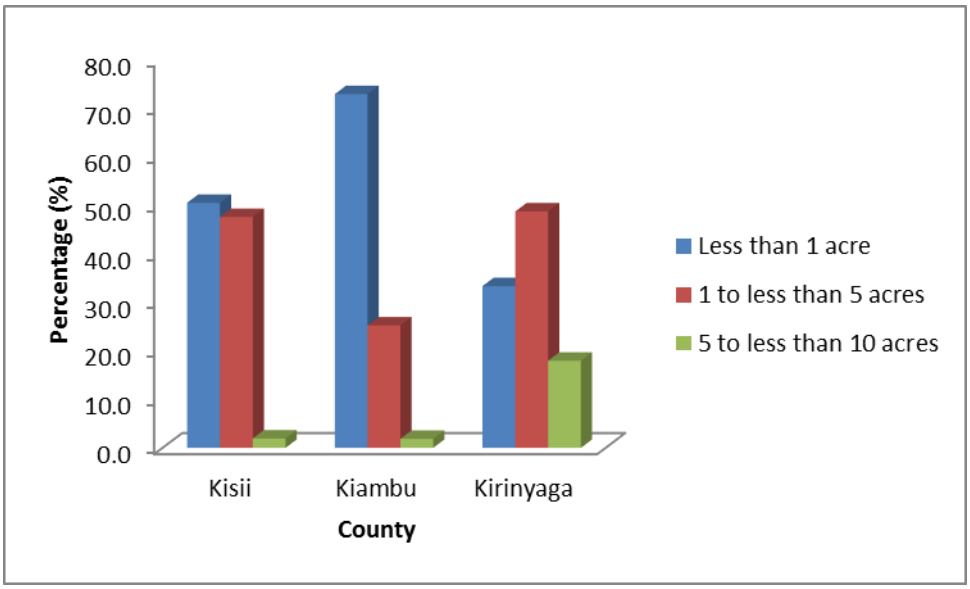

Figure 4.8: Land size distribution for the respondents of the baseline survey in Kenya.

4.2. Livelihood Activities

4.2.1. Consolidated Livelihood Activities

The farmers who participated in the survey were involved in various livelihood activities as presented in Table 4.1. The results show that rearing animals is a major economic activity in all the three counties with Kisii leading with 96.1%. Livestock is used as a form of a bank by most rural folks since it can be easily disposed in case there is need for emergency financial needs. Cereal production is a major economic activity with Kisii recording 100.0% followed by Kirinyaga with 91.7%. However, cereal farming is low in Kiambu (51.4%) with farmers giving vegetable production more emphasis due to quick income and easy access to the market. Root crops are grown across the three counties with Kiambu leading with 82.2%. However, the varieties grown are quite different in each county, with Kisii growing sweet potatoes, Kiambu irish potatoes and Kirinyaga cassava. Cassava is grown in the dryer parts of Kirinyaga especially by farmers who have no access to irrigation water for vegetable farming. Pulse production is mostly done in Kisii (89.3%) and Kirinyaga (74.4%) counties. The low production of pulses in Kiambu is attributed to unfavourable weather conditions for pulses.

Fruit production is not a major economic activity in Kiambu (15.0%) partly because of land sizes and unfavourable weather. However, in Kisii and Kirinyaga fruit farming is a major economic activity with the 98.1% and 97.4%, respectively. Vegetable farming is a major

economic activity in all the three counties with all of them recording more than 70%. This is because most farmers value it as an income generating activity and a source of quick income by the youth. In all the three counties the percentage of people engaged in salaried job was less than 3%. A high percentage (60.7%) of respondents in Kiambu are engaged in casual jobs apart from farming.

Table 4.1: Livelihood activities in the three counties

County	Kisii	Kiambu	Kirinyaga
	n =103	n =107	n =39
Activity		Percent	
Rearing animals	96.1	91.6	89.7
Cereal food crops	100.0	51.4	97.4
Farming root crops	59.2	82.2	61.5
Farming pulses	89.3	23.4	74.4
Farming fruits	98.1	15.0	97.4
Farming vegetables	99.0	89.7	71.8
Salaried job	1.9	1.9	2.6
Casual/ non-salaried	54.4	60.7	46.2

In the table: n = size of sample

4.2.2. Animal Rearing

Different kinds of animals are reared within the three counties with all showing a strong preference for cattle, which is 44.4, 67.0 and 48.1% for Kisii, Kiambu and Kirinyaga, respectively (Figure 4.9). This indicates that there is potential for biogas production using the waste from the cattle.

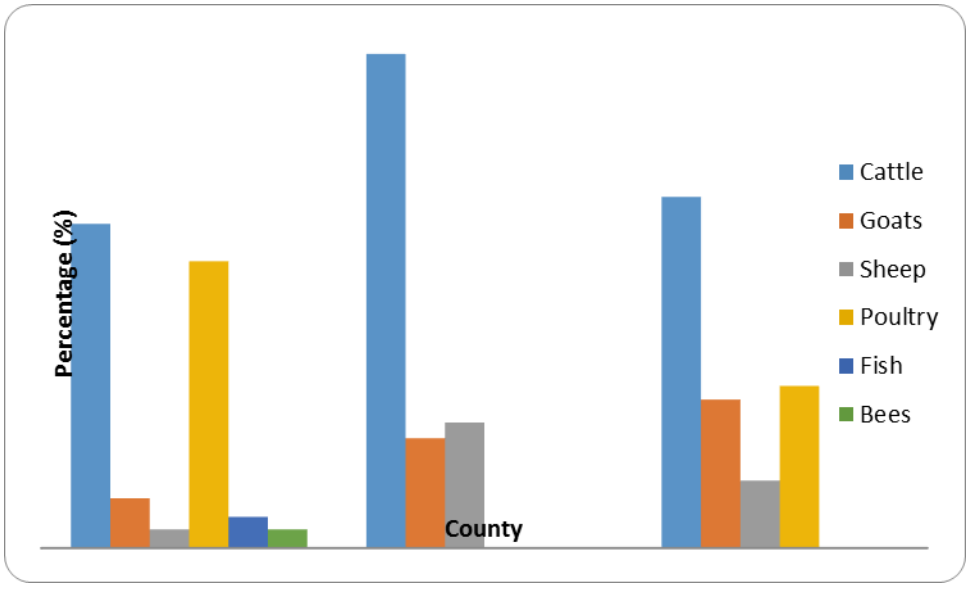

Figure 4.9: Animal rearing in the three counties of the baseline survey in Kenya

4.2.3. Cereal Production

Maize production cuts across as a major crop in all the counties with Kiambu leading at 97.4% (Figure 4.10). However, in Kisii farmers are engaged in farming other cereals like millet (14.9%), sorghum (11.6%) and wheat (1.7%). The cereals form the stable food in all the three counties, hence, the emphasis given in the three counties.

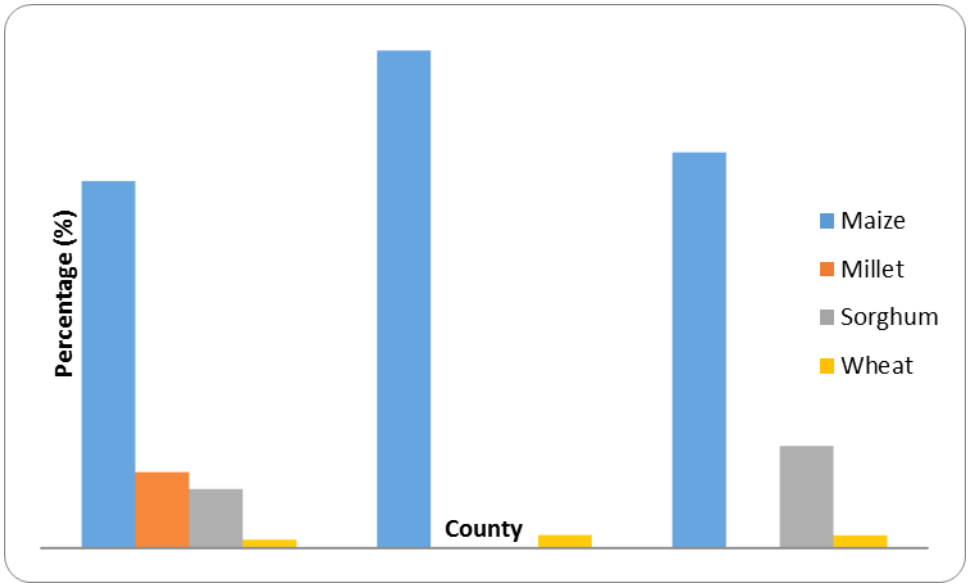

Figure 4.10: Cereal production in the three counties

4.2.4. Root crops

Root crops are very distictive in the areas they are grown (Figure 4.11). Kisii and Kirinyaga counties lead in sweet poatao production with 83.9 and 76.2%, respectively, while Kiambu has the highest production of Irish potatoes (95.6%). Most of the other root crops are grown in small quantities (<15%) in all the three counties.

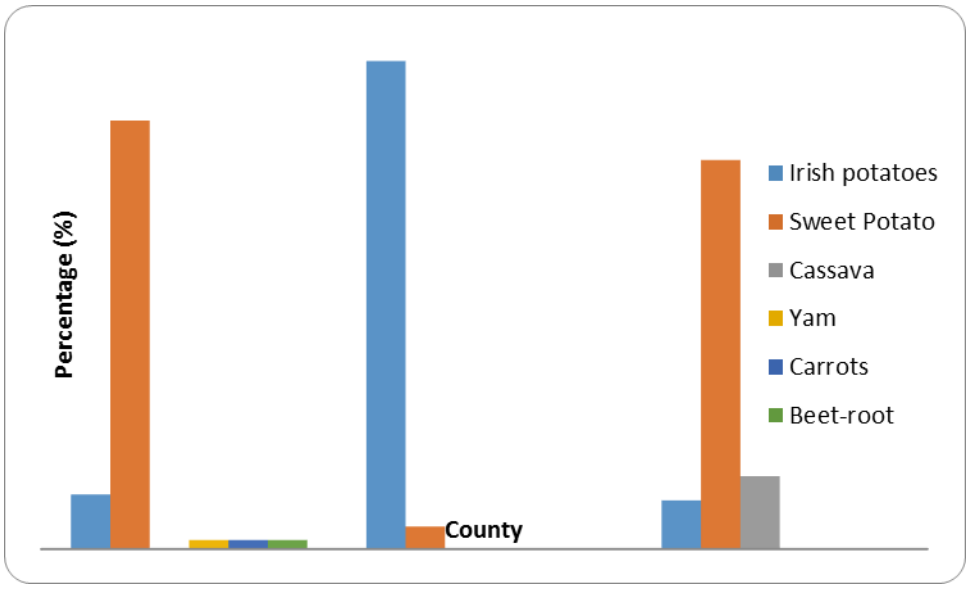

Figure 4.11: Root crops grown in the three counties of the baseline survey in Kenya

4.2.5. Pulses

Pulses are very popular in all the counties due to their utilisation in making various food recipes across the various communities in Kenya. Kisii leads in production with a response rate of 74.8% while Kiambu and Kirinyaga have rates of 71.8 and 66.8%, respectively. Cowpeas are produced in relatively good proportion at rates of more than 20% in all the counties (Figure 4.12). Cowpea is popular both for its tender leaves which is used as a vegetable and for the grain which is a good source of proteins.

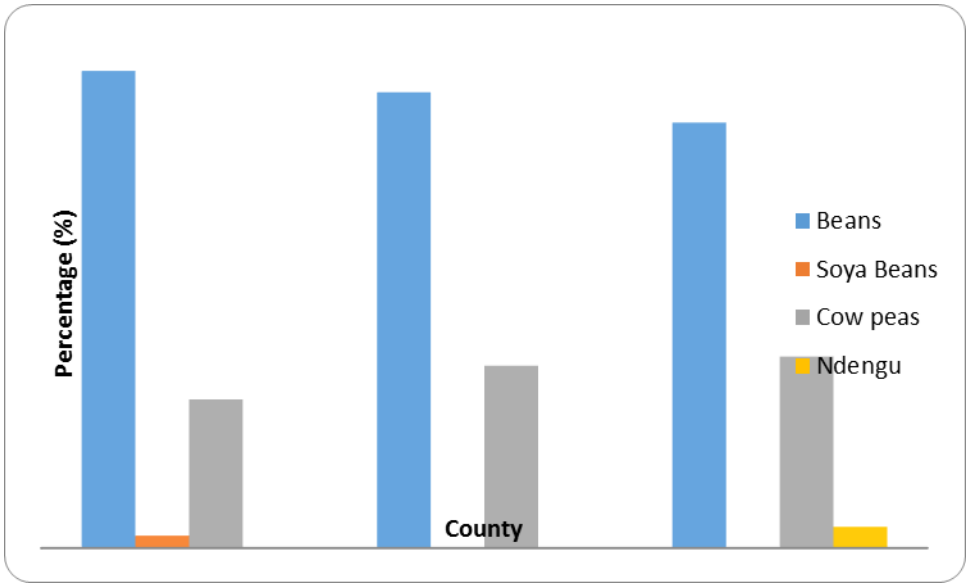

Figure 4.12: Pulse production in the three counties of the baseline survey in Kenya

4.2.6 Social Economic Status

The social economic status of the sampled households was derived from the various activities they engaged in at the time of the survey. Total income was drawn from livestock production (rearing and selling animals and animal products), crop faming (cereal foods, root crops, pulses, fruits and vegetables) and employment income. From Table 4.2 Kiambu County recorded the highest mean total income (Ksh 278,362.8 p.a) per house hold, the only county with mean income higher than the aggregate mean for the entire study area. Kirinyaga and Kisii followed in that order. This is in line with KIPRA (2013) who reported that Kiambu had lower poverty levels as compared to Kisii and Kirinyaga.

Table 4.2: Social economic Status

County		Total Annual Income	School Fees Per Term	Food Expenditure Per Month	Medical Expenses Per Month	Other Utility Bills	Total Annual Expenditure	Total Annual Deficit
Kisii (n=103)	Mean	**79,862.1**	15,485.4	3,291.3	1,932.0	1,233.0	123,932.0	**-44,069.9**
	Std. Deviation	142,277.1	10,970.4	1,948.5	1,789.2	941.5	55,124.0	146,557.6
Kiambu (n=107)	Mean	**278,362.8**	11,822.4	4,738.3	2,532.7	1,953.3	146,158.9	**132,203.9**
	Std. Deviation	981,557.9	10,242.2	2,250.1	2,450.7	1,610.0	68,338.2	982,803.7
Kirinyaga	Mean	**148,364.1**	13,974.4	4,948.7	2,230.8	1,564.1	146,846.2	**1,518.0**

(n=39)	Std. Deviation	270,830.8	11,423.6	2,655.2	2,083.3	1,447.2	66,990.0	260,469.7
Total (n=249)	Mean	**175,890.8**	**13,674.7**	**4,172.7**	**2,237.0**	**1,594.4**	**137,072.3**	**38,818.6**
	Std. Deviation	663,207.3	10,825.3	2,315.4	2,150.6	1,379.6	63,685.6	662,503.0

Note: The table gives money in Kenya Shillings where the exchange rate was US$ 1=Ksh 86.5. School term=3 months.

These mean income levels were significantly different (F=2.418, p-value=0.091) at 5% level of significance. The expenditure on school fees, food, and other utility bills (water, rent, electricity) did not vary significantly (F=3.073, p-value=0.048 for school fees, F=14.215, p-value=0.0 for food and F=7.541, p-value=0.001 for other utility bills) at 5% level of significance implying that the life styles do not vary considerably. Although medical expenses were significantly different (F=2.065 and p-value=0.129), the overall expenditure was not affected, and so the three counties did not have significant variation (F=3.826 and p-value=0.023) in terms of their annual spending on basic needs. However, a deficit was observed in Kisii but this can be explained by failure to capture remittances into the counties which is a sizeable source of finance to them. Therefore, once captured, the surplus in the other counties will be increased considerably.

4.3 Crop Farming

4.3.1. Land Ownership

Traditionally land has been owned by men in the African culture set up as is well depicted in by the results of this survey (Figure 4.13). Kirinyaga leads with 89.7% followed by Kisii and Kiambu with 85.4 and 76.4%, respectively. This means that whatever enterprise is to be done on the land, men have to give consent since they own the land. A small proportion (< 8%) of the land is owned by women while less than 11% is co-owned by the both genders. More than 80% of the farmers' farm owned land in all the three counties (Table 4.2). The results further show that less than 30% of the respondents farm family land, and that a significant portion of farmers in Kisii (20.4%) and Kiambu (37.4%) farm rented land.

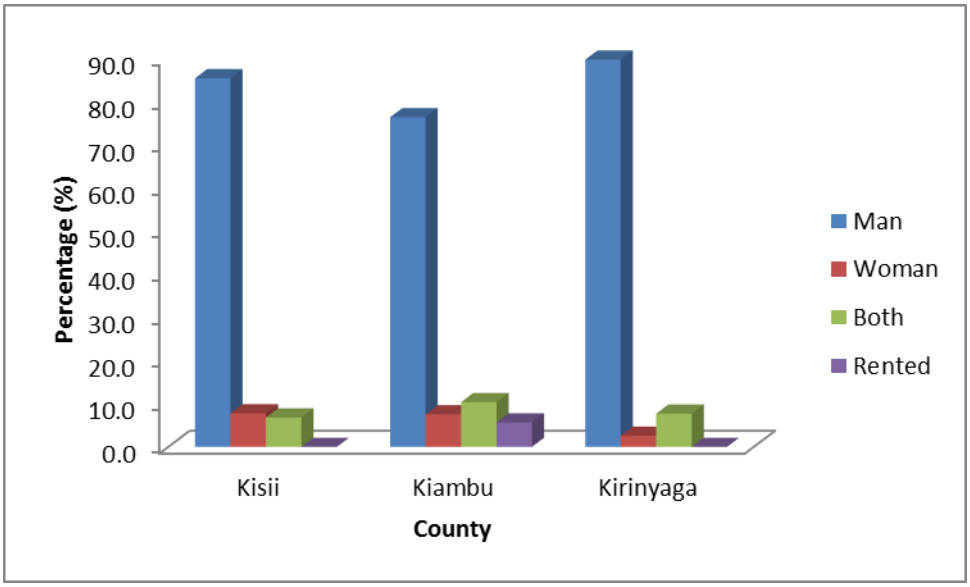

Figure 4.13: Land ownership

Table 4.3: Ownership of farmed land

Farmed land	County		
	Kisii	Kiambu	Kirinyaga
	n=103	n=107	n=39
		Percent	
Farmed own land	83.5	65.4	82.1
Farmed family/community owned land	6.8	18.7	28.2
Farmed rented land	20.4	37.4	7.7
Farmed free access to someone's land	2.9	3.7	0.0
Gave land to someone for free	1.0	9.3	0.0

4.3.2. Vegetable Farming

From the survey a large proportion of the farmers (> 84%) grow vegetables in less than one (1) acre of land (Table 4.3). However, 16.0% of farmers in Kiambu grow vegetables in more than one (1) acre and this is attributed to their access to forestland where they are able to rent under the shamba system of farming.

Table 4.4: Land under vegetables

County	Kisii	Kiambu	Kirinyaga
		Percent	
Size of land under vegetables	n=103	n=107	n=33
Less than 1 acre	90.3	84.1	97.0
1 to less than 5 acres	9.7	15.9	3.0
Total	100.0	100.0	100.0

The survey established that Kisii and Kirinyaga have a good mixture of both indigenous and exotic vegetables with Kisii having 58.8 and 41.3% of indigenous and exotic vegetables, respectively, and Kirinyaga having 45.5 and 54.5%, respectively (Figure 4.14). In Kiambu

County, most of the emphasis is on exotic vegetables partly due to unfavourable weather for indigenous vegetables and also due to a readily available market (viz., Nairobi and Mombasa) for the exotic vegetables.

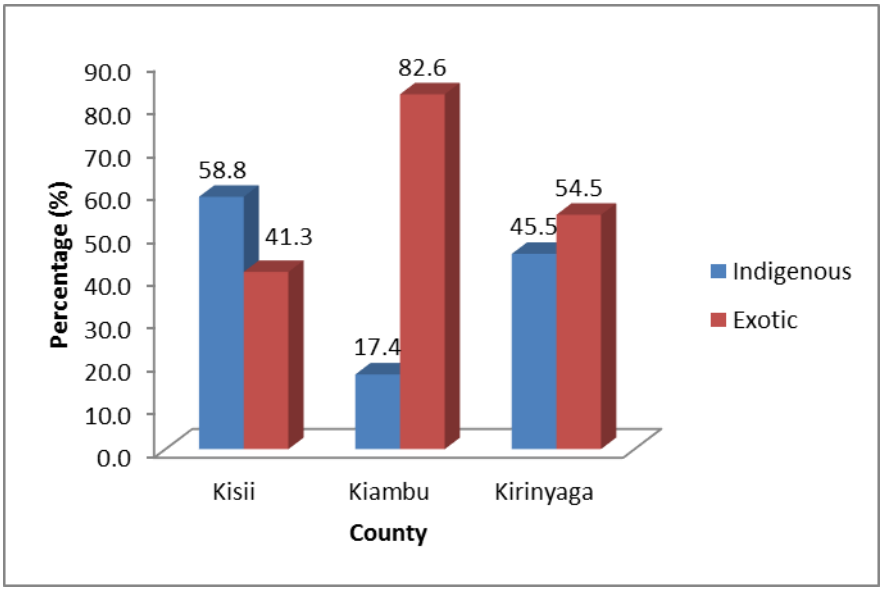

Figure 4.14: Vegetables grown the three counties

4.3.3. Reasons for Growing Vegetables

a) Kisii County

In Kisii, the vegetables are preferred because of their good prices and are fast maturing, hence, are able to fetch money faster for the farmers (Figure 4.15). Indigenous vegetables grown are preferred because favourable weather and soil conditions.

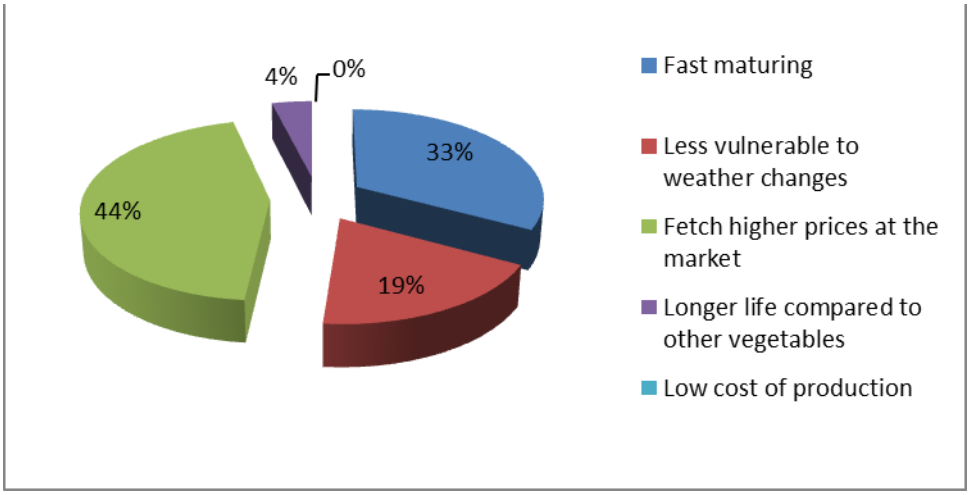

Figure 4.15: Reason for growing vegetables in Kisii

b) Kiambu County

In Kiambu County, exotic vegetables grown are preferred since they are less vulnerable to the prevailing climate (38%), are fast maturing (28%) and they fetch high prices (27%). Kiambu's proximity to Nairobi city gives it a good advantage for marketing the vegetable (Figure 4.16). The farmers, therefore, have less worry on where to sell their produce. The rest is transported to other markets like Mwembe Tayari in Mombasa.

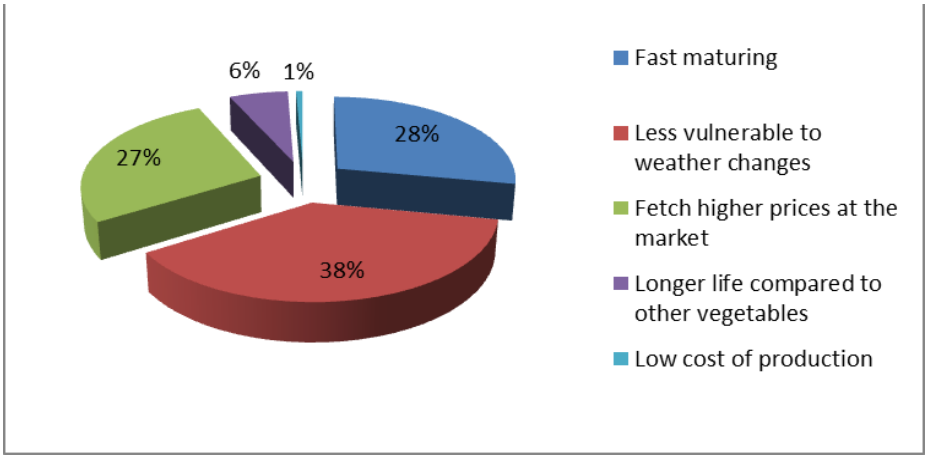

Figure 4.16: Reason for growing vegetables in Kiambu

c) Kirinyaga County

Vegetables in Kirinyaga are grown due to their fast maturing nature (37%) and fetch high prices (35%) especially the exotic varieties (Figure 4.17). The preferred vegetables are less vulnerable to weather changes thus farmers are always sure of a good harvest.

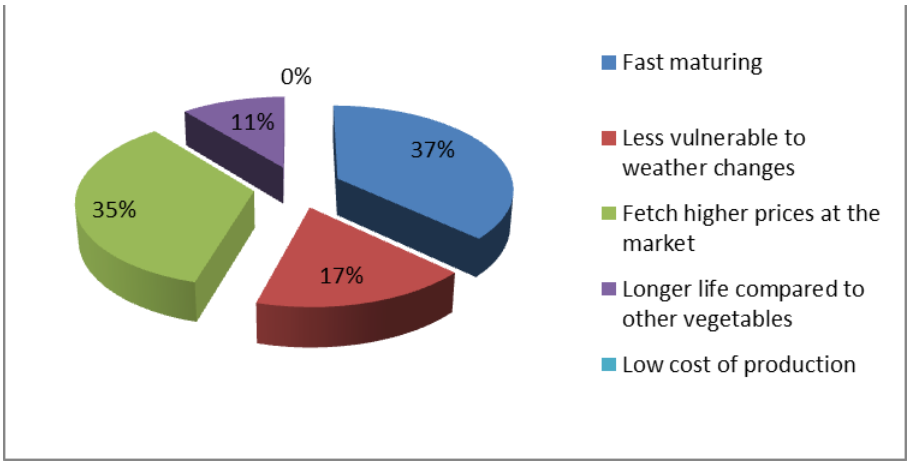

Figure 4.17: Reason for growing vegetables in Kirinyaga

4.3.4 Purpose for growing vegetables

Generally, in all the three (3) counties a large proportion (77.1-90.6%) of the vegetables is grown both for market and domestic consumption (Figure 4.18). However, a small proportion (< 18%) of the vegetables is grown purely for sale. This implies that whatever is not suitable for market is consumed at the farm level.

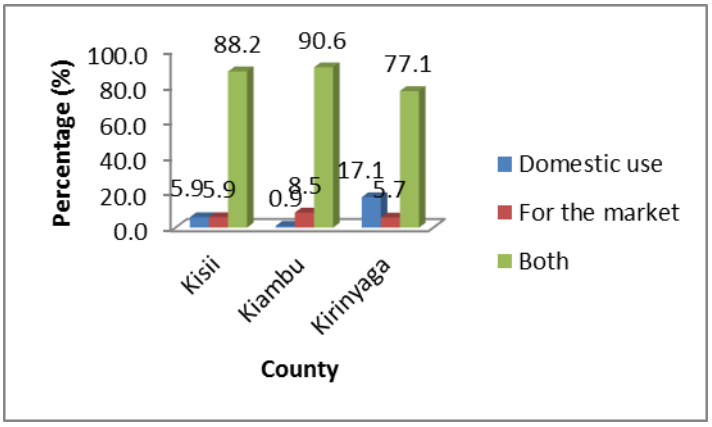

Figure 4.18: Purpose for growing the vegetables

4.4. Vegetable Planting Practices

4.4.1. Vegetables grown

Apart from Kirinyaga county with less than fifty percent (<50%) growing vegetables by rain water, Kiambu and Kisii are predominantly reliant on rain fed vegetable growing with 81.7 and 73.0%, respectively (Figure 4.19). This means there is great potential to promote irrigation technology in these counties in order to have production all year round. Kirinyaga have higher percentage of irrigation due to various irrigation schemes in the area for rice farming. This water for rice irrigation is diverted by farmers to grow vegetables during the offseason for rice farming.

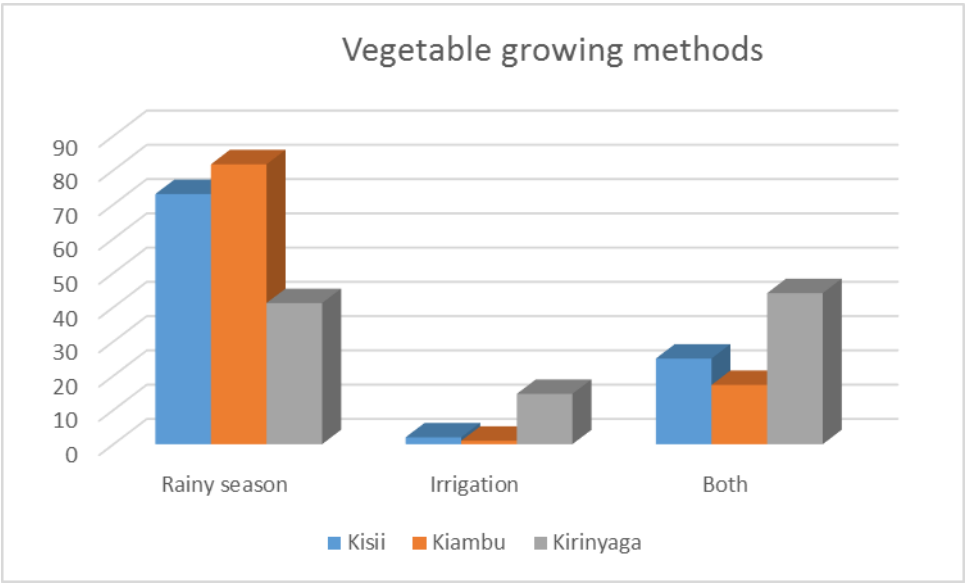

Figure 4.19: Vegetable growing methods

4.4.2. Technologies Used for Weeding and Pest Control

Various technologies are used for both weeding and pest control, with manual weeding being predominant in all the three counties at 94.2% for Kisii, 74.8% for Kiambu and 84.6% for Kirinyaga as presented in Figure 4.20. Pest control is done mostly using chemicals although

some farmers practice organic farming in order to control pests with Kisii, Kiambu and Kirinyaga registering 48.6, 19.6 and 12.8%, respectively.

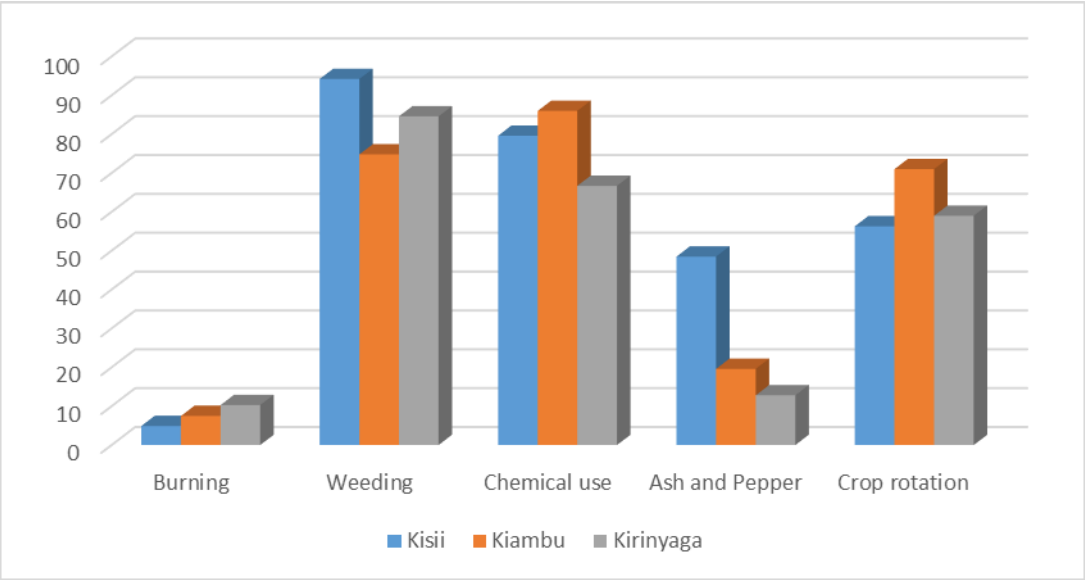

Figure 4.20: Methods of weed and pest control

4.4.3. Source of Water for Irrigation

Irrigation water is from various sources as shown in Figure 4.21. In Kirinyaga, 14.7% of respondents practise irrigation and the proportion of the water sources are 43.0, 30.0 and 26.7% from rivers, piped and boreholes, respectively. This distribution gives the farmers a wide choice of irrigation methods to use in their vegetable production unlike the other counties of Kiambu and Kisii where they are largely dependent on rain and shallow wells/boreholes.

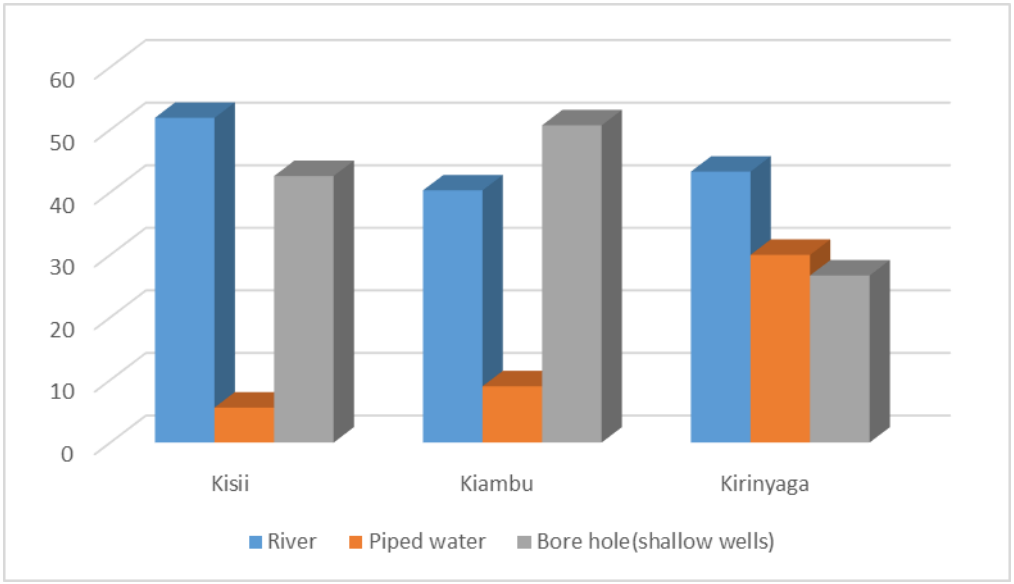

Figure 4.21: Source of irrigation water

4.4.5. Method of Irrigation

a) Kisii

Half (50.0%) of the farmers practising irrigation in Kisii use sprinklers while 26.3% use subsurface irrigation method (Figure 4.22). The rest use either drip, surface or bucket irrigation.

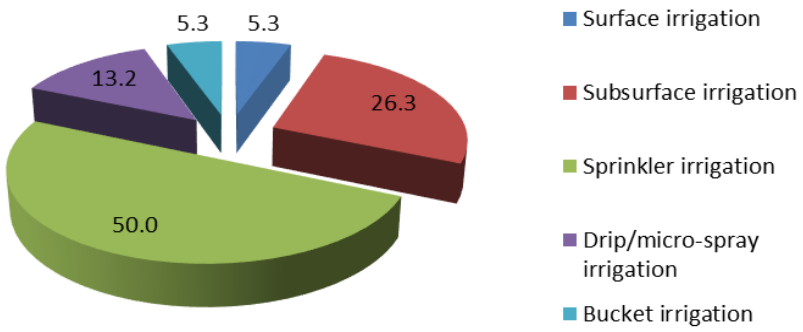

Figure 4.22: Irrigation methods in Kisii

b) Kiambu

Most of the water for irrigation in Kiambu is sourced from boreholes hence necessitating the use of bucket irrigation (85.5%) as shown in Figure 4.23. The water is pulled to the surface using a bucket before being transferred to a watering can and applied to the vegetables.

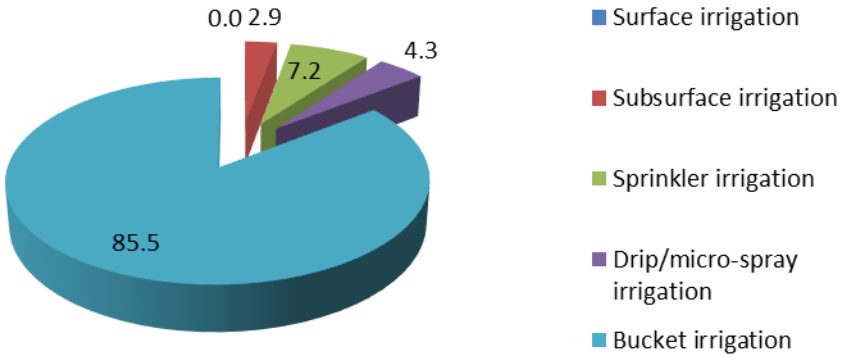

Figure 4.23: Irrigation methods in Kiambu

c) Kirinyaga

In Kirinyaga, water for irrigation is mainly sourced from rivers and irrigation canals meant for rice farming (see Figure 4.21 above), hence, water is pumped using motorised engines to irrigate vegetables through overhead sprinklers (62.1%) as shown in Figure 4.24. Other farmers use surface irrigation (31.0%) especially when growing vegetables like tomatoes which is predominant in the area.

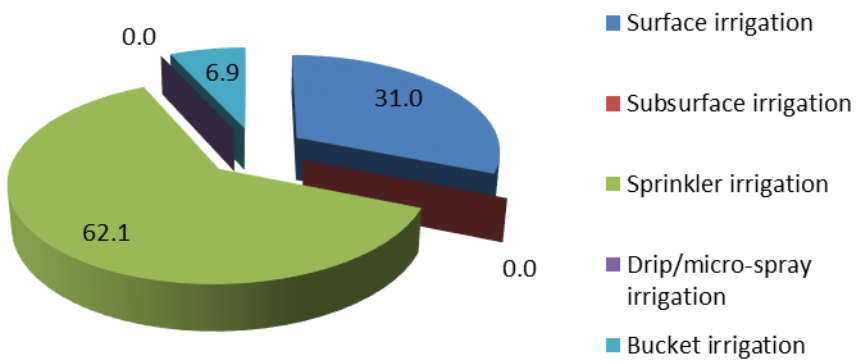

Figure 4.24: Irrigation methods in Kirinyaga

4.4.6. Duration of Planting to Harvesting Vegetables

The survey established that kales generally take more than four (4) weeks before harvesting in all the counties with response rates of 71.6, 86.5 and 57.7% in Kisii, Kiambu and Kirinyaga, respectively (Figure.4.25). However, in Kirinyaga and Kisii a good proportion of the respondents, 38.5 and 28.4%, respectively, harvest the vegetables between 2-4 weeks. Cabbages, unlike kales whose leaves can be plucked and sold two (2) weeks after planting, have to wait until they are mature before harvesting. In Kirinyaga and Kiambu, 83.3 and 97.8%, respectively, of the respondents indicated that it takes more than 4 weeks to harvest cabbages (Figure 4.26).

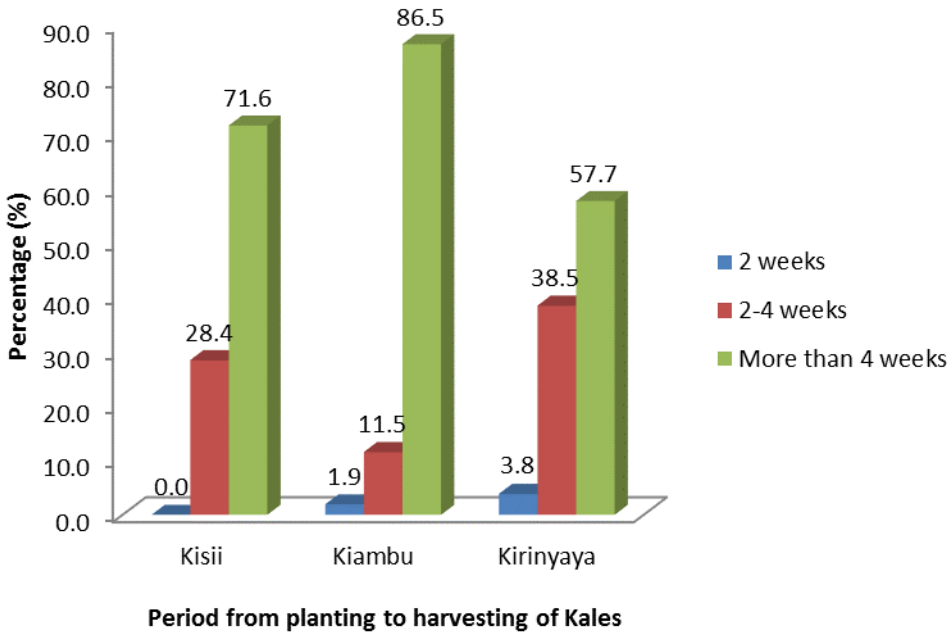

Figure 4.25: Period from planting to harvesting kales

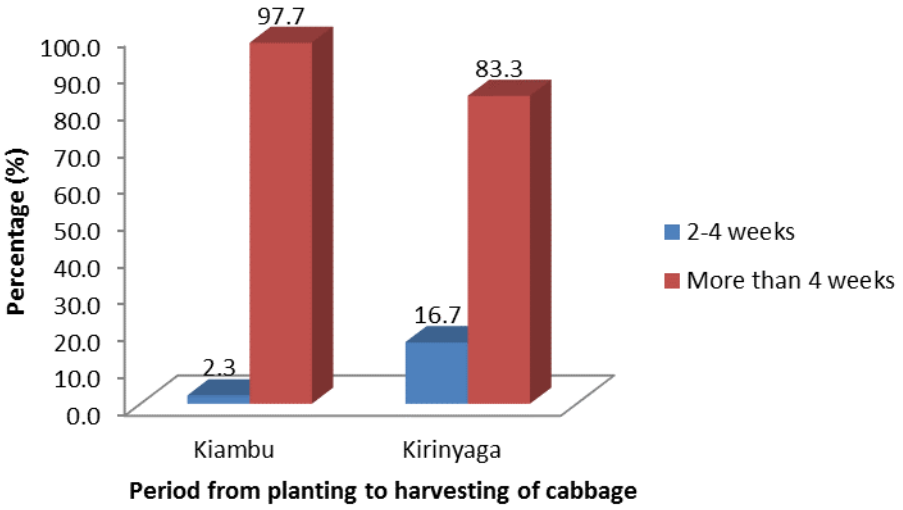

Figure 4.26: Period from planting to harvesting cabbages

4.5. Post-Harvest Handling

4.5.1. Losses During Post-Harvest Handling

In general, losses during harvesting are less than 10% in all the three counties although in some instances the losses of more than 50% are reported (Figure 4.27). This is during the rainy season when there's excess production. Losses of less than 10% during sorting was reported in all the three (3) counties (Figure 4.28). This is because the farmers do selection during harvesting and therefore quality that's not suitable for the market is left in the farm.

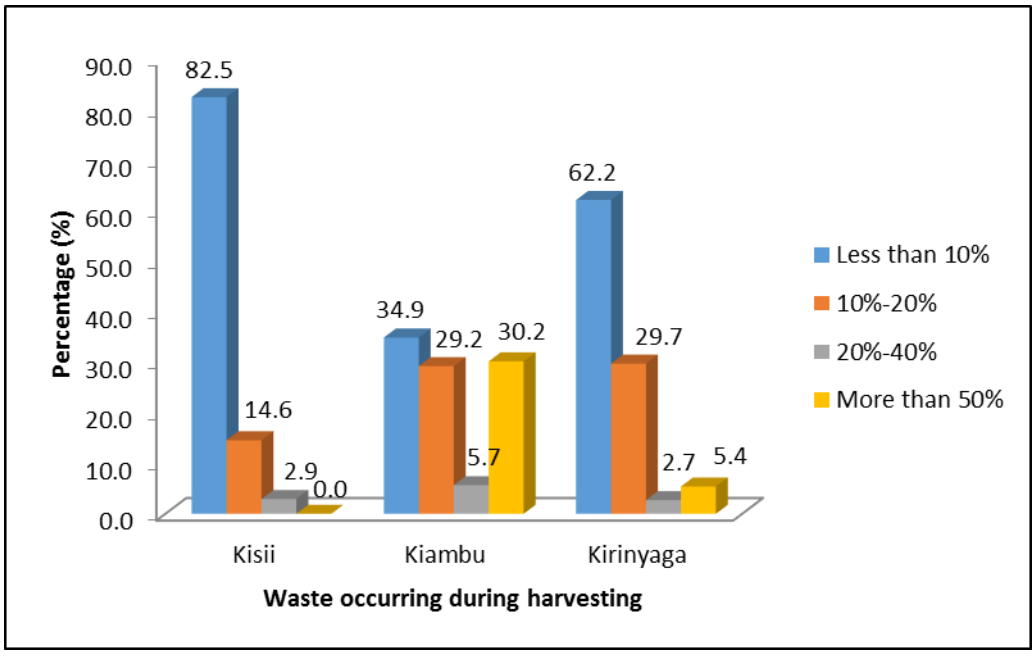

Figure 4.27: Losses during harvesting for high moisture content vegetables

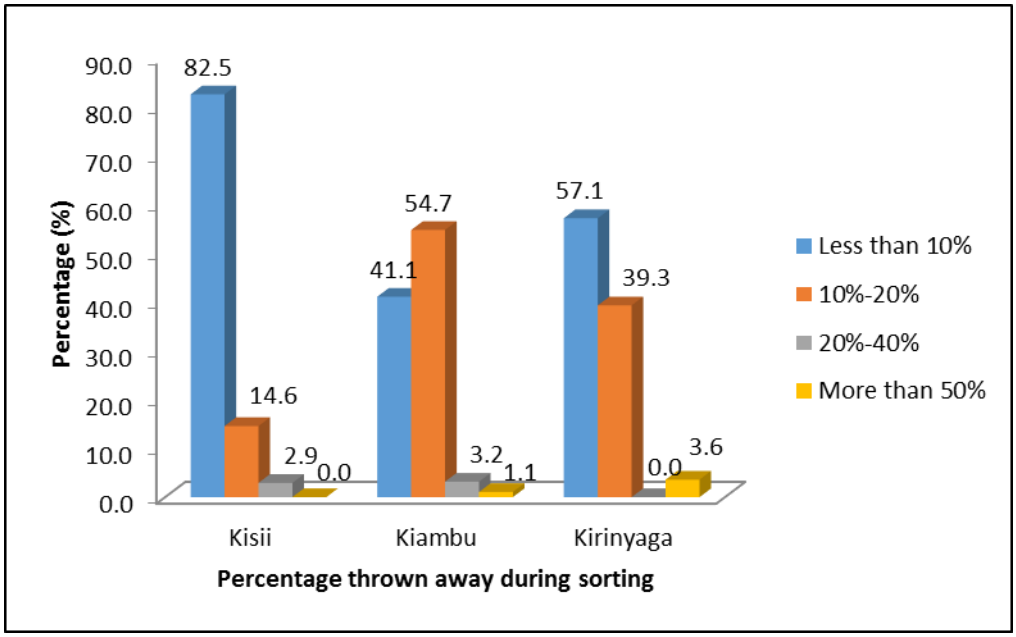

Figure 4.28: Wastage during sorting for high moisture content vegetables

Minimal losses are encountered during transport with all the three counties mainly exhibiting losses of less than 10% as shown in Figure 4.29. However, instances of losses of between 20-30% are reported with 17.3, 10.8 and 21.2% in Kisii, Kiambu and Kirinyaga, respectively.

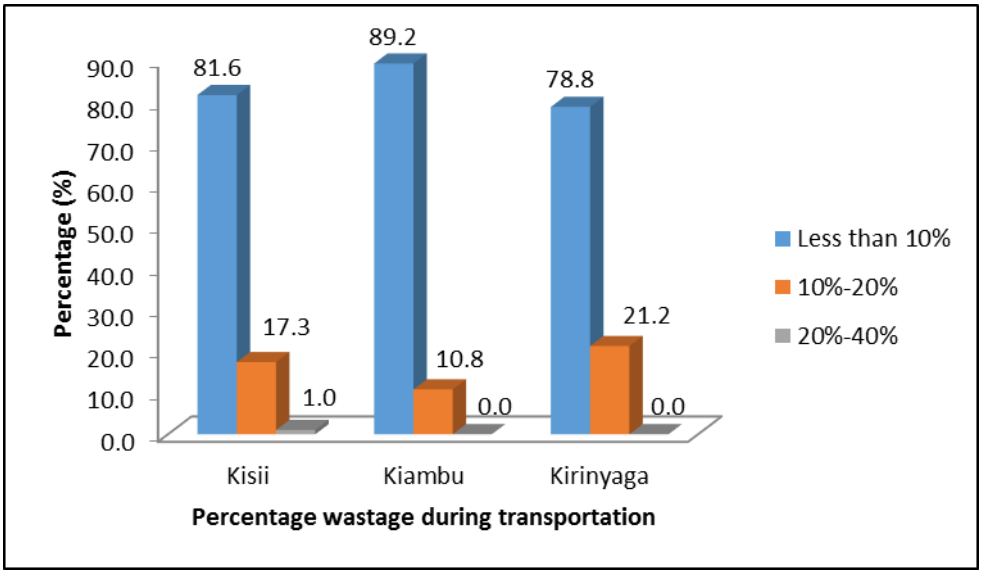

Figure 4.29: Wastage during transportation for high moisture content vegetables

Plate 5: Various modes of transport for kales in Kaguongo, Kiambu County

Handling losses do occur in the market during handling with the more than 67% of the respondents experiencing losses of less than 10% as shown in Figure 4.30. Based on these results, and from the face-value of the percentage losses in the five stages (harvesting, sorting, processing, transportation and marketing), it is quite clear that more that 50% of the raw produce goes to waste. A meagre 10% loss in each of the five stages means that half of the vegetables harvested is thrown away as waste at the end of the value chain. The respondents also affirmed the need for technology that can help them preserve their products for longer period as their response rates were above 96% in all the three counties (Table 4.5).

Vegetable value addition activities are quite minimal in all the counties. They basically involve drying, boiling, grading and cleaning. Majority of the respondents 83.7, 78.3 and 63.7% in Kisii, Kiambu and Kirinyaga, respectively, recorded losses of less than 10% during processing (Figure 4.31).

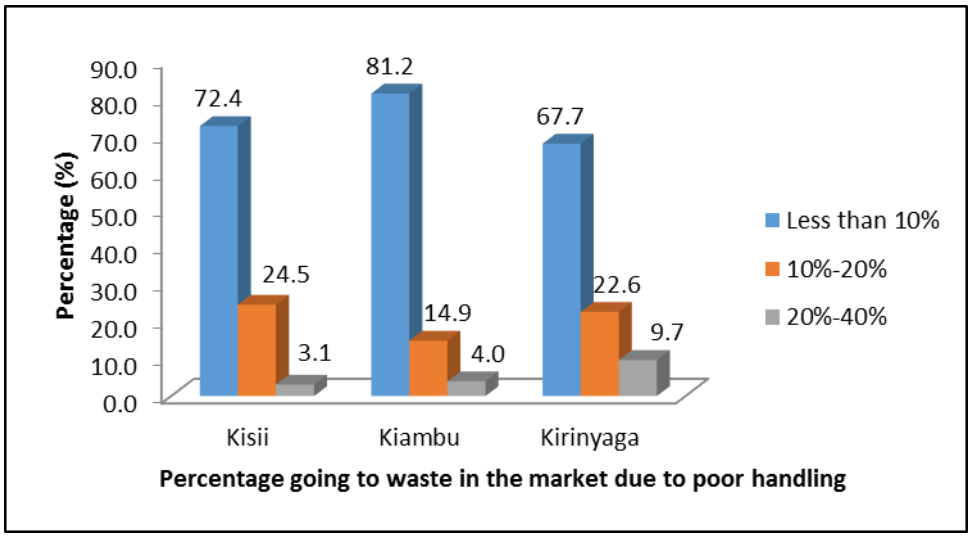

Figure 4.30: Handling losses in the market for high moisture content vegetables

Table 4.5: Need for technology for preservation of high moisture vegetables

	Kisii	Kiambu	Kirinyaga
Would you like technology to keep the vegetables longer for market	96.0	96.1	97.0

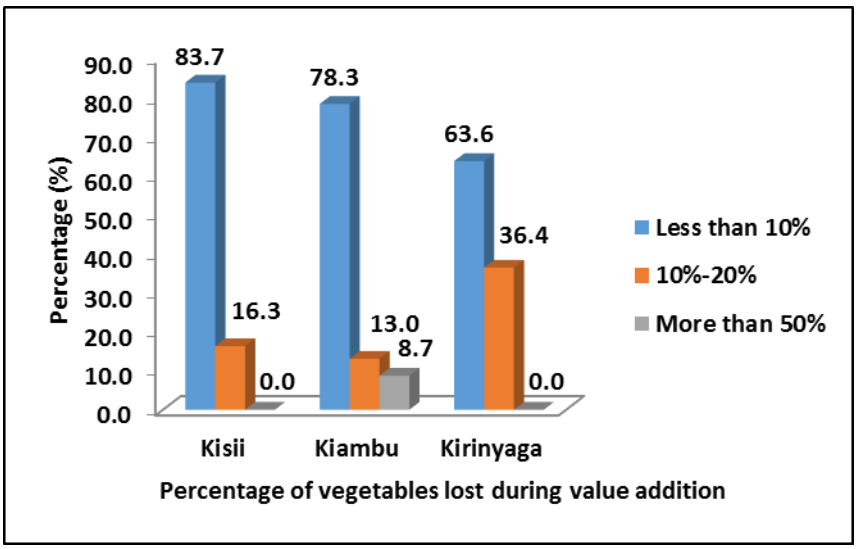

Figure 4.31: Losses during value addition for high moisture content vegetables

4.5.2. Storage Methods

There are quite a number of on-farm storage methods employed by farmers in the three counties. The most common one, however, being storage under a shade before transportation with response rates of 94.1, 48.0 and 75.8% in Kisii, Kiambu and Kirinyaga, respectively (Figure 4.32). Storage times vary from less than 3 hours to more than 6 hours in all the three counties. Farmers in Kiambu and Kisii mostly store their vegetables for less than 3 hours before sale unlike in Kirinyaga where vegetables have to stay for even more than 6 hours before sale as shown in Figure 4.33.

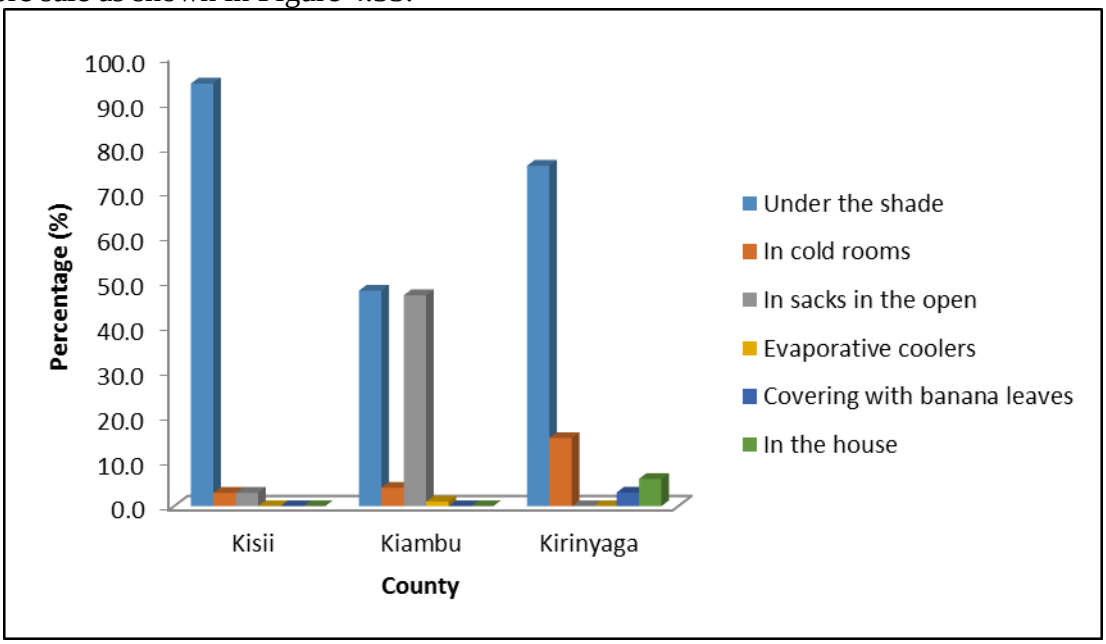

Figure 4.32: On-farm storage methods

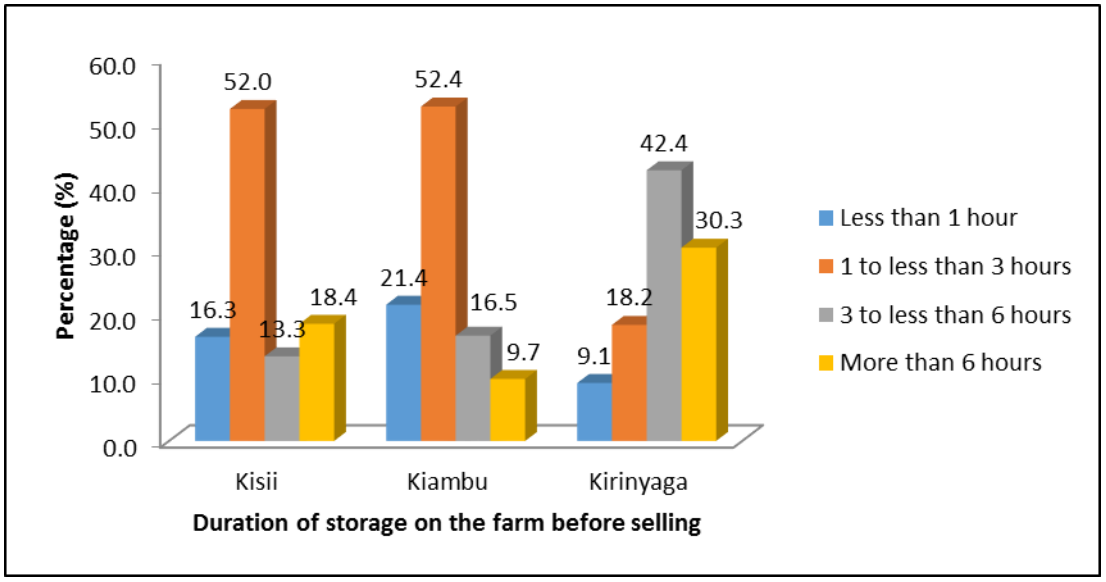

Figure 4.33: On-farm storage period

Plate 6: Kales under shade in Kiandutu, Kiambu

4.5.3. General Energy Use and Renewable Energy

Manual labour is the main source of energy for the vegetable production enterprise as shown in Figures 4.34 and 4.35 for all the three counties. More than 98% of the respondents perform harvesting and sorting, among other operations, manually in all the three counties.

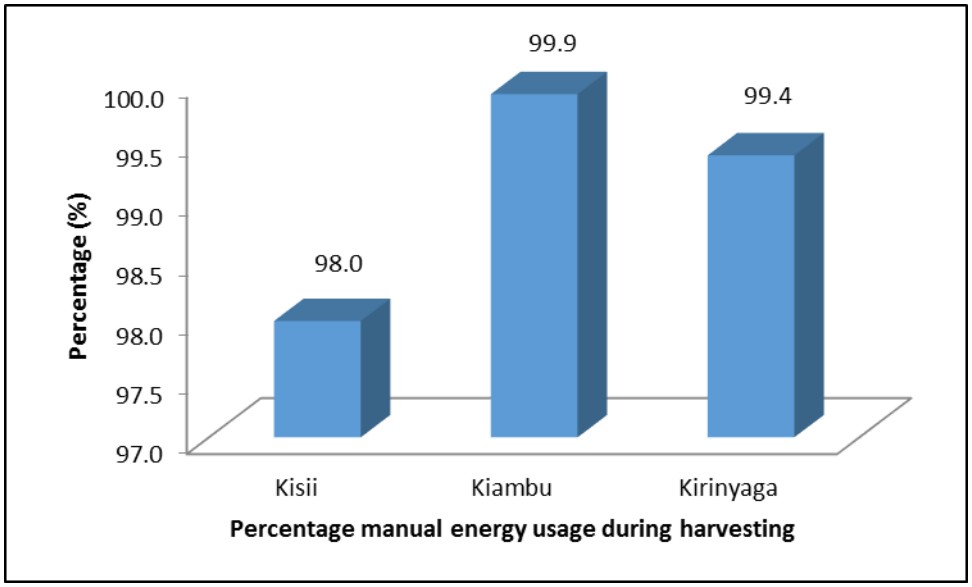

Figure 4.34: Manual energy use in harvesting high moisture content vegetables

From the survey data, respondents are aware about renewable energy technologies available, with 94.9% of the respondents from Kiambu confirming having knowledge on biogas and 27.6% in Kirinyaga (Figure 4.36). In Kirinyaga, 58.6% of the respondents are aware of solar energy technologies although it is mostly for domestic use in lighting and cooking. Among those familiar with the renewable energy technologies, 88.9% in Kirinyaga use solar while 64.5% in Kiambu use biogas as shown in Figure 4.37. Solar is mainly used for drying cereals while biogas and biomass is used for domestic cooking. The few vegetable value addition activities utilising renewable energy include drying (>50%) in the three counties, and boiling in Kisii 34.6% as shown in Table 4.6.

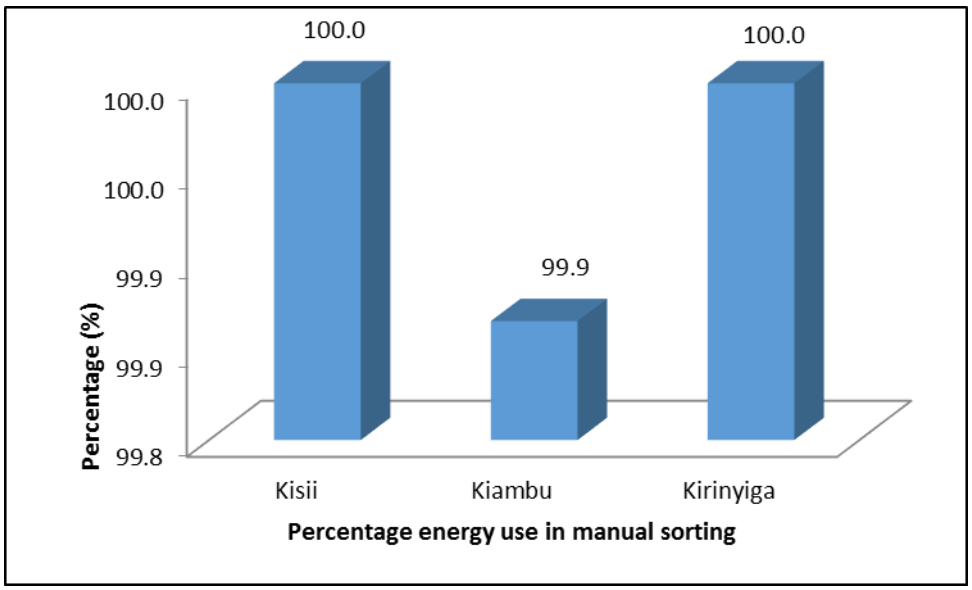

Figure 4.35: Manual energy use in sorting for high moisture content vegetables

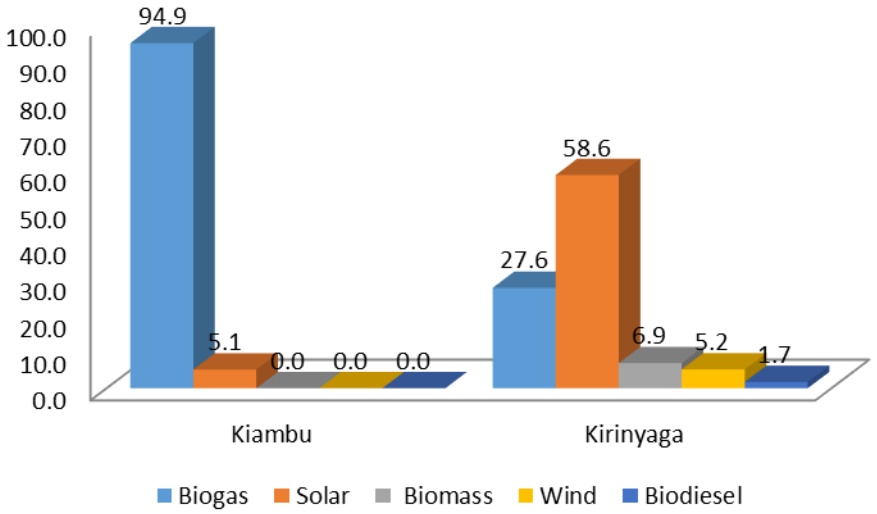

Figure 4.36: Knowledge of renewable energy

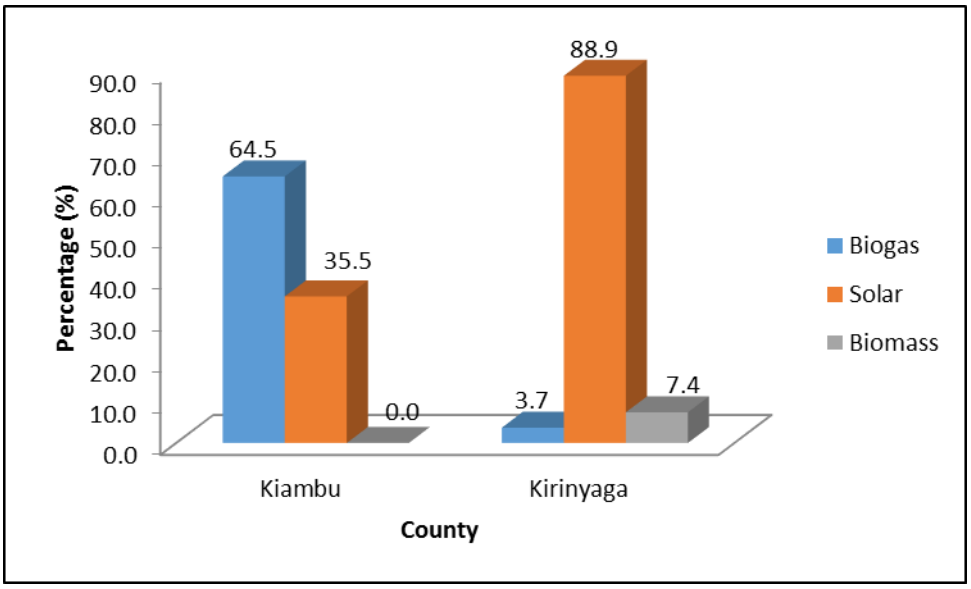

Figure 4.37: The proportion of renewable energy use among the respondents

Table 4.6: Methods of value addition for high moisture content vegetables

County	Drying	Paste	Jam	Ripening	Boiling and drying	Feed for animals	Grading and cleaning
Kisii (n=26)	50.0	3.8	11.5	0.0	34.6	0.0	0.0
Kiambu (n=17)	76.5	0.0	0.0	0.0	0.0	5.9	17.6
Kirinyaga (n=6)	66.7	16.7	0.0	16.7	0.0	0.0	0.0

In Table 4.7, a summary of the energy use in storage of vegetables in the three counties is given. The respondents showed very diverse uses of energy in the storage of the vegetables although none of the sources was extensively used. The degree of utilisation is between 50% and 100% among the respondents who are utilising a particular energy source. This shows

that there is a huge room for employment of various renewable energy resources in the three regions.

Table 4.7: Summary of energy use in storage of vegetables

County	*Village*	*Energy source*					
		Open sun	***Shade***	***Solar system***	***Fuelwood***	***Diesel / petrol***	***Electricity***
		No.of Respondents and percentage of use					
Kisii	Boronyi	1 (90%)					
	Chinche	6 (50%)			4 (50%)		
	Nyamache	6 (50%), 1(100%)		2 (50%)	7 (50%)	1 (50%)	
Kiambu	Kinale	5 (100%)	6 (100%)	2 (100%)			
	Roromo		1 (100%)				
Kirinyaga	Mahuti-ini		3 (100%)				1 (100%)
	Kianjogu		1 (50%), 10 (100%)				
	Kimicha		10 (100%)				
	Mbeti		2 (100%)				

Manual and animal transport is mostly used especially to transport the produce to the market (Figure 4.38). Majority of the respondents, 76.5, 74.3 and 69.1% in Kisii, Kiambu and Kirinyaga, respectively, use manual energy for transport of the vegetables to the market. Others use lorries, small trucks and motor bikes, respectively, for transportation to far of markets.

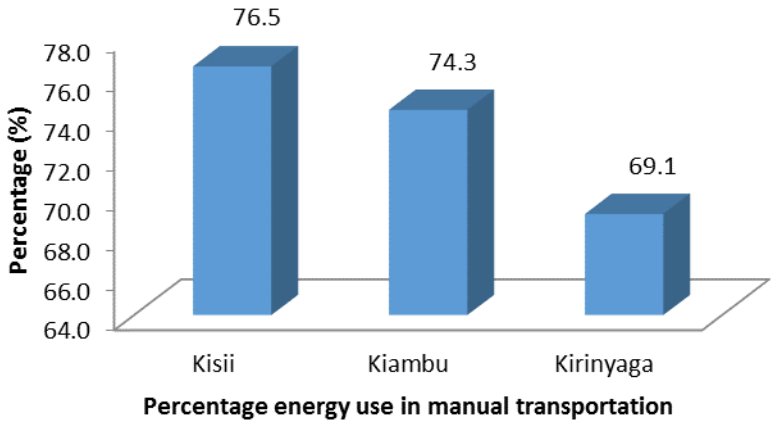

Figure 4.38: Manual transportation

Plate 7: Donkey cart transport in uplands market, Kiambu

The few farmers that process vegetables also use a variety of energy sources as summarised in Table 4.8. Mostly, manual energy is utilised in most of the processing operations. This indicates that there is great potential for promotion of renewable energy use in processing of high moisture content vegetables.

Table 4.8: Energy use summary in processing

County	***Village***	***Energy source***				
		Human	***Open sun***	***Fuel wood***	***Electricity***	***Others***
		No. of Respondents and percentage of use				
Kisii	Boronyi	8 (90%)	1 (90%), 1 (100%)	1 (50%), 2 (100%)		1 (10%)
Kiambu	Kinale	8 (100%)				29 (100%)
	Roromo	4 (100%)				
	Murengeti	1 (100%)				
Kirinyaga	Kiandutu				1 (100%)	

4.6. Production and Marketing

4.6.1. Market Linkages

In Kisii most of respondents (15%) sell their vegetables directly to other farmers while in Kiambu marketing is largely done through middlemen (20%) who then transport the produce to the market (Figure .4.39). Kirinyaga has a mixture of various methods whereby some farmers have formed a marketing cooperative for their produce in order to negotiate for better prices.

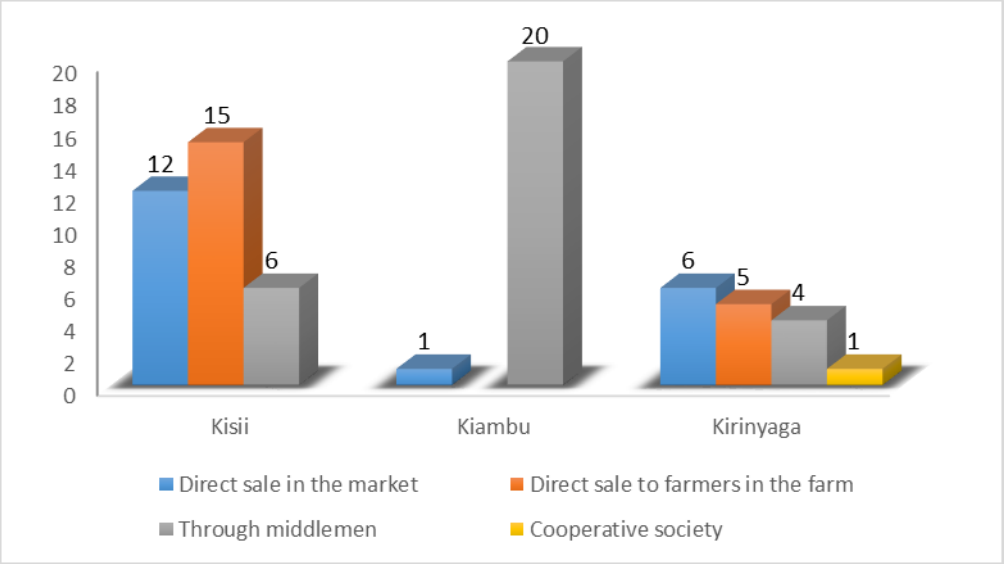

Figure 4.39: Marketing systems

4.6.2 Mode of Selling Vegetables

Vegetable marketing is done through various methods and from the survey data Kiambu has the highest number of farmers selling through middlemen with 67.0% and 10.0% in Kirinyaga (Figure 4.40). This is associated to the exotic vegetables grown in these areas namely kales, cabbage and tomatoes. In Kisii, marketing is predominantly in the local market (79.0%) since indigenous vegetables is mainly grown in the region.

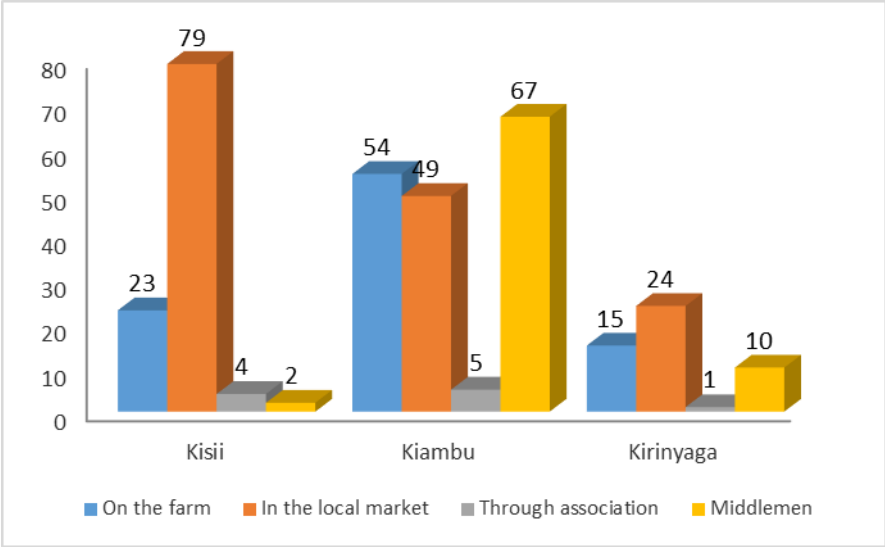

Figure 4.40: Vegetable marketing methods

4.6.3: Challenges in Marketing

a) Kisii

In Kisii, the major challenges in vegetable marketing emerge as poor roads, low prices and poor storage among others as shown in Figure 4.41. However, other issues like lack of finances, lack of market and price fluctuations recorded significant responses. It is worth noting that some of these issues raised like poor roads, pests and diseases and taxation regimes can be addressed by the county governments.

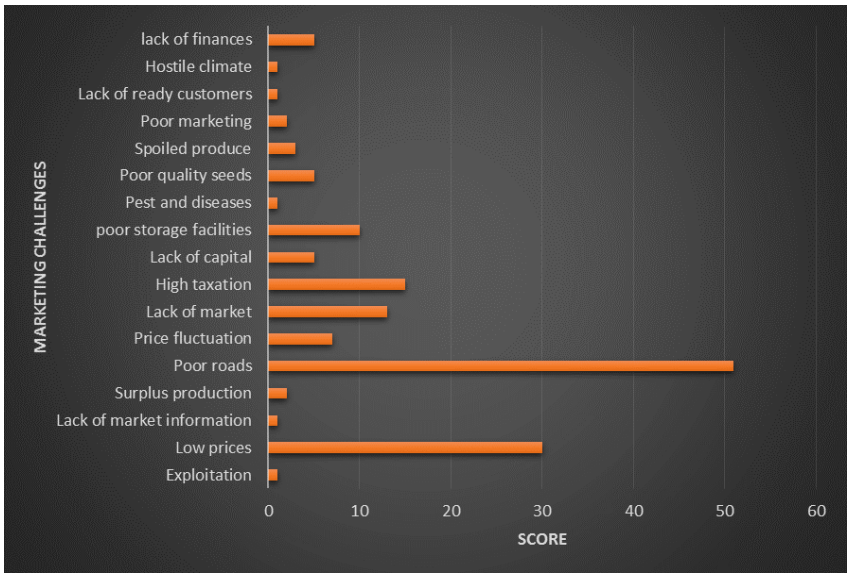

Figure 4.41: Marketing challenges in Kisii County, Kenya

b) Kiambu

Poor roads emerge as the main challenge in Kiambu just like in Kisii (Figure 4.42). Other challenges facing them are lack of market, low prices and poor storage methods for high moisture vegetable, among others.

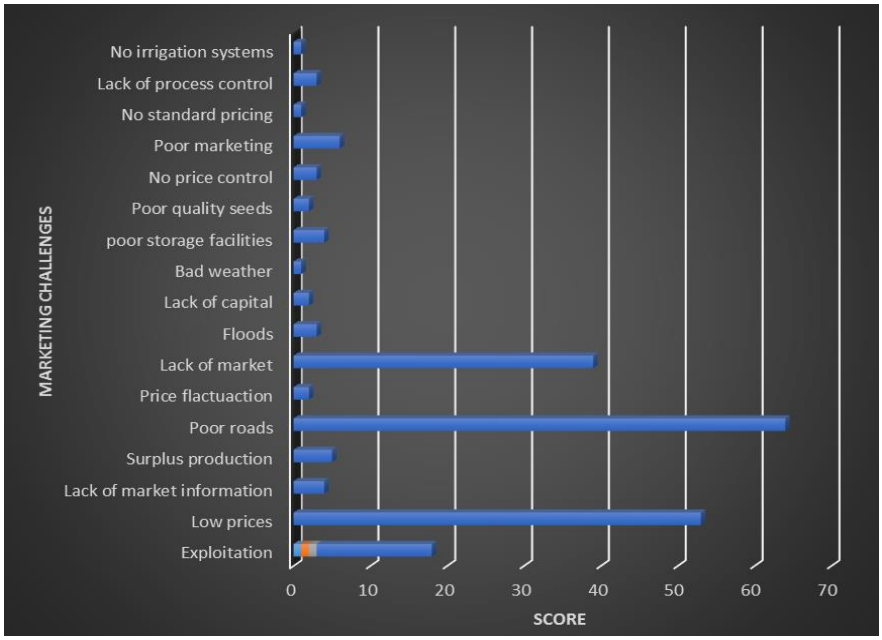

Figure 4.42: Marketing challenges in Kiambu

c) Kirinyaga

In Kirinyaga County, lack of market, poor prices and spoilt produce emerge as the main concerns for the respondents as shown in Figure 4.43. Surplus production and poor storage facilities are also challenges facing the respondents and hence, the need for various preservation and processing technologies for the surplus produce.

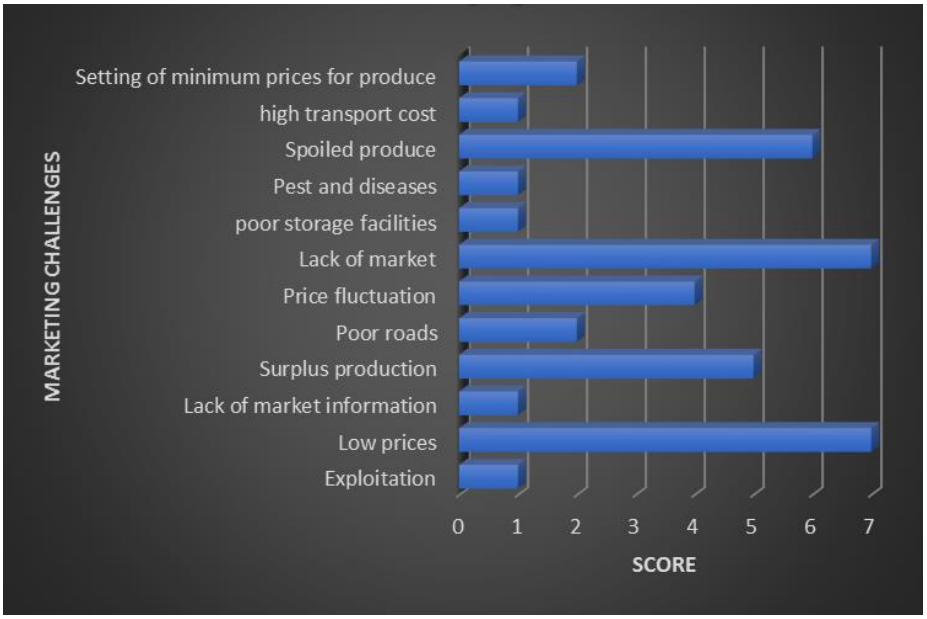

Figure 4.43: Marketing challenges in Kirinyaga

4.6.4. Suggested Solutions by Respondents

The respondent gave various suggestions on the way forward and how to solve the challenges facing them as shown in Figure 4.44. The respondents suggested capacity building through trainings and availability of appropriate technology as some of the ways to address the challenges facing them.

Figure 4.44: Suggested solutions

4.6.5. Suggested Interventions by respondents

Most of the respondents felt that capacity building through training would alleviate some of the problems and challenges they face in vegetable production and marketing (Figure 4.45). Also use of technology in processing was suggested as way of reducing the losses and a better way of giving them negotiating room for better prices and hence, increased incomes.

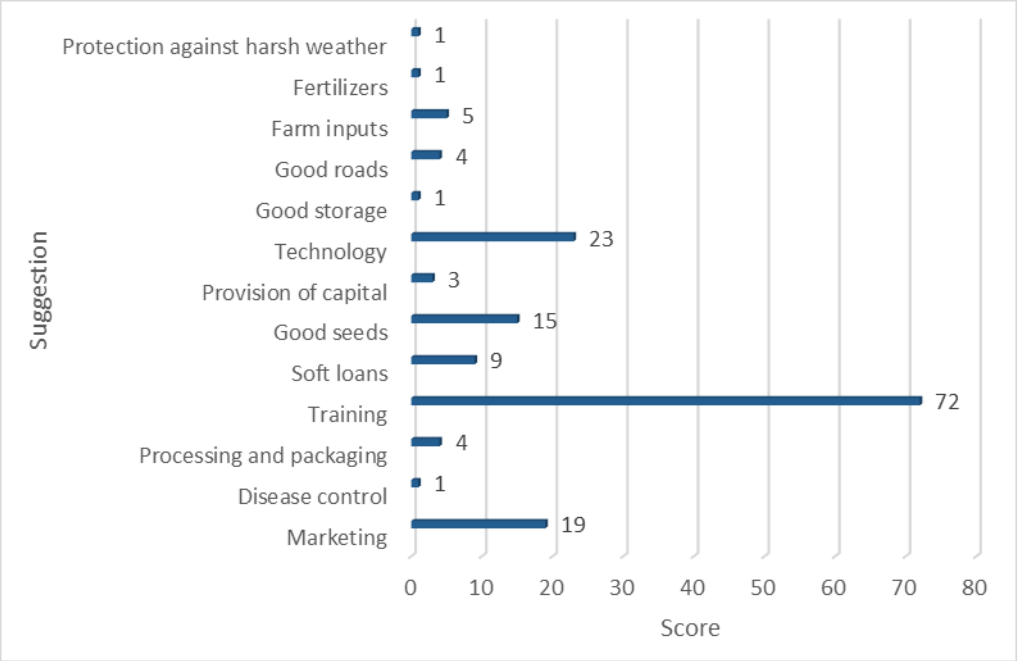

Figure 4.45: Suggested interventions

CHAPTER 5 : CONCLUSIONS AND LESSONS LEARNT

5.1. Conclusions

The survey provided factual baseline information on the aspects and impacts surrounding the processing of high-moisture-content vegetable production and the extent and potential of renewable energy use by Kenyan farmers. The survey has provided practical insights which will inform the Kenyan RE4 Food research team on the actual issues on the ground so as to appropriately strategise for the identification, selection and analysis of the best renewable energy solution for intenvention. The study covered three Counties (Kisii, Kiambu and Kirinyaga) based on the types of vegetables grown. In Kisii the focus was on indigenous vegetables while in Kiambu and Kirinyaga the focus was on exotic vegetables. The following conclusions can be drawn from the study:

1. The three counties have relativeley high population and popluation densities; with Kiambu having a population of 1.62 Million, Kisii 1.15 million and Kirinyaga, 0.528 million. The population densities are 638, 874 and 357 people per square kilometer, respectively. The average family sizes are highest in Kisii at 5-8 people per household while the other counties have 1-4 people per household. The three counties have high production of targeted horticultural crops; with Kirinyaga producing 24% of the national tomato production, while Kiambu is a major supplier of kales and cabbages to the Nairobi and Mombasa markets. Kisii County is a major producer of vegetables, especially, the indigenous ones like amaranth, black nightshade among others. Kisii and Kirinyaga have a good mixture of both indigenous and exotic vegetables with Kisii having 58.8 and 41.3% of indigenous and exotic vegetables, respectively, and Kirinyaga having 45.5 and 54.5%, respectively. In Kiambu, 82% of the farmers grow exotic vegetables. The main reason for selecting the respective type of vegetable are; prevailing climate, market prices and if fast maturing, with the former two being most influencing in Kisii and Kirinyaga, while climate was the most influencing factor in Kiambu. The crops are grown mainly for both domestic use and market. There is high participation of men in growing of the exotic vegetables compared to the traditional ones, with men constituing 84.6 and 79.4% of the surveyed population in Kiambu and Kirinyaga, respectively, while females were 62.1% of the surveyed population in Kisii. Kisii County grows more of the indigenous vegetables, while Kiambu and Kirinyaga grow mainly the exotic varieties.

2. The participation of the highly productive population in growing of vegatbles is high, with the middle aged population (36-59 years) particiapting more in vegetable production, followed by the youth (less than 36 years); however youth participation was the highest in Kiambu due to availabilty of market for the vegetables and free land from the forest. This indicates a long term capacity to produce. Dissemination and adoption of new farming and processing concepts can be cascaded to the local communities with ease given that the literacy levels are high in the three counties; no County had more than 6% of the surveyed population having no formal education. The need to promote high value

crops and improve incomes on existing production is there given the small land sizes. The sizes of land parcels were relatively small in the three counties with most of the land sizes being less than five acres. Most of these land (over 75%) is owned by men. There is likelihood that decisions on usage of these resource will be mainly made by men. There is need to continue promoting vegetable production in the counties since vegetables growing is one of the key economic activities in the three counties, with 99, 89.7 and 71.8% of the surveyed population in Kisii, Kiambu and Kirinyaga, respectively, engaging in vegetable production. Animal rearing is the most predominant economic activity. Other economic activities include; cereals, fruit, pulses and root crops growing. A number of farmers also engage in casual employment.

3. There is low usage of appropriate technologies for production. Irrigation usage is low in the three counties, with only Kirinyaga having about 50% of the farmers using both rain fed and irrigation farming. Manual weeding is common in all the three counties at 94.2% for Kisii, 74.8% for Kiambu and 84.6% for Kirinyaga, while in the three counties, crop rotation and chemical usage is practiced by over 60 and 70% of the farmer, respectively. Water is available mainly from rivers and boreholes; piped water is also available in the three counties. Most farmers can finance new technologies and investment given the relatively high incomes. The annual incomes were Kshs 278,362, Kshs 79,862 and Kshs 148,364 in Kiambu, Kisii and Kirinyaga, respectively. Currently, it is only in Kisii where deficit (after expenditure on food, medical expenses, school fees, etc.) is experienced; this is mainly due to the big sizes of household. Opportunities for usage of renewable energy source in for example irrigation exist; for example sprinkler usage is common in Kirinyaga and Kisii, with 62.1 and 50.0% of those using irrigation employing this technology, respectively. Use of buckets to draw water from boreholes is the most predominant technology; used by 85.5% of those employing irrigation in Kiambu. Other method used and where such energy can be used include; subsurface irrigation (used by 26.3% of irrigation farmers in Kisii), surface (used by 31% of farmer in Kirinyaga) and sprinkler (used by 13.2% of farmers in Kisii).

4. Overall, over 50% of the raw produce goes to waste along the value chain activities. Most losses are in the range of 0-20%. Losses during harvesting are mostly less than 10% in all the three counties, with 82.5, 34.9 and 62.2% of the farmers in Kisii, Kiambu and Kirinyaga, respectively, reporting this magnitude of losses. Harvesting losses in the range of 10-20% were reported by 14.6, 29.2 and 29.7% of the farmers in Kisii, Kiambu and Kirinyaga, respectively. Harvesting losses of over 50% were reported by 30% and 5.4% of the farmers in Kiambu and Kirinyaga ,respectively. This occurs during the rainy season when there is excess production. Sorting losses of less than 10% were reported by 82.5, 41.1 and 57.1% of the farmers in Kisii, Kiambu and Kirinyaga, respectively, while losses of 10-20% were reported by 14.6, 54.7 and 39.1% of the farmers in Kisii, Kiambu and Kirinyaga, respectively. Only 3.6% and 1.1% of farmers in Kirinyaga and Kiambu, respectively, reported sorting losses of more than 50%. Poor handling losses at the market also occur, with 72.4, 81.2 and 67.7% of farmers in Kisii, Kiambu and Kirinyaga,

respectively, reporting losses of less than 10 and 24.5, 14.9 and 22.6%, and losses of 10-20%, respectively. Value addition losses are also common with 83.7, 78.3 and 63.6% of farmers in Kisii, Kiambu and Kirinyaga reporting losses of less than 10 and 16.3, 13.0 and 36.4%, respectively, of the farmers reporting losses of 10-20%. No farmers reported sorting or value addition losses of more than 50%.

5. Various technologies for cooling vegetables exist at the farm level, and this can be replaced, analysed, improved or adopted for use to reduce on post-harvest losses. The most common method is use of shade (reported by 94.1, 48.0 and 75.8% in Kisii, Kiambu and Kirinyaga, respectively). Other technologies include use of sack in the open (reported by about 50% in Kiambu and less than 10% in Kisii), cold rooms (reported by over 10% in Kirinyaga and less than 10% in other Counties), in-house, evaporative coolers, and covering with banana leaves. Most of the system use renewable energy (shade, sacks, evaporative coolers, banana leaves) while the cold rooms use electricity.

6. Appropriate systems for storage in these area are those that could store product for less than 6 hours. Those who stored their vegetable for less than one hour were 16.3, 21.4, and 9.1% of the respondents in Kisii, Kiambu and Kirinyaga, respectively, while those who stored for 1-3 hours were 52.0, 52.4, and 18.21%, respectively. Storage for 3-6 hours is practiced by 13.7, 16.5 and 42.4 % of farmers in Kisii, Kiambu and Kirinyaga, respectively. Only 18.4, 9.7 and 30.3% of farmers in Kisii, Kiambu and Kirinyaga, respectively, would require systems to store for more than 6 hours. Renewable energy usage is low in the three counties with over 98% using manual energy in the post-harvest activities like sorting and harvesting. However, of those who use renewable energy 64.5 and 3.7% use biogas in Kiambu and Kirinyaga, respectively, while 35.5 and 88.9%, respectively, use solar energy. Knowledge on availability and usage of other forms of renewable such as biomass, wind and biodiesel is negligible. Areas where renewable energy can be applied and which farmers are currently practicing includes; drying, processing of jam and paste, ripening, boiling and drying and cleaning and grading. Currently 50.0, 76.5, and 66.5% of farmers in Kisii, Kiambu and Kirinyaga, respectively, are practicing drying, while 15.3 and 16.7% of farmers in Kisii and Kirinyaga are engaged in processing of jam or paste. Others value addition activities include; ripening (undertaken by 16.7% of respondents in Kirinyaga), feed preparation (by 5.9% of respondents in Kiambu) and grading and cleaning (by 17.6% of respondents in Kiambu).

7. Renewable energy can also be used in storage of vegetables. Current usage of renewable energy in vegetable storage varies but none of the sources was extensively used. The degree of utilisation is between 50 and 100% among the respondents who are utilising a particular energy source. The technologies used include solar system, shade, and direct sun. Electricity and diesel usage is also used and these could provide opportunity for renewable energy use.

8. Opportunities exist in use of renewable energy in transportation and processing of vegetables. Currently manual and animal transport is mostly used, especially to transport the produce to the market. Majority of the respondents, 76.5, 74.3 and 69.1% in Kisii, Kiambu and Kirinyaga, respectively, use manual energy for transport of the vegetables to the market. Others use lorries, small trucks and motor bikes, for transportation to far of markets. Processing also is mainly manual and renewable energy could be adopted here.

9. One of the major challenge in production of vegetables is lack of a well-defined marketing structure. There hardly exist any organised form of marketing, with majority of the farmers relying on middlemen, and direct sale at the farm and market; only 4, 5 and 1% in Kisii, Kiambu and Kirinyaga sell their produce through organised associations. In Kisii, indigenous vegetables are sold directly; sales at farm and local market is common with 23 and 79% of farmers using these channels respectively. In Kiambu 54 and 49% sell vegetables directly at the farm and local market respectively, while 67% sell to middlemen. In Kirinyaga no method is predominant; 15% sell direct at farm, 24% at the market and 10% to middlemen.

10. The main challenges to marketing as isolated out by the respondents include; poor infrastructure, low prices, lack of markets, surplus produce, high taxation, poor storage, exploitation and lack of capital. The suggested interventions and solutions include; training, ready market, technology for value addition and production, quality seeds, affordable capital and good infrastructure. Some of these solutions could be overcome through use of renewable energy based value addition technologies; such would enable farmers get better prices, provide ready market for products, avoid price fluctuations, improve incomes thus provide needed capital for improved seeds and production and avoid the challenge of poor infrastructure.

5.2. Lessons Learnt

1. Post-harvest loses that occur between the farmer and the consumer can be minimised by embracing value addition technologies.
2. Renewable energy have not been well utilised in value addition of vegetables and other crops. There is need for sensitisation and technologies suitable for the same.
3. The farmers need to be empowered so that they can negotiate better prices for their produce.
4. Marketing groups should be strengthened to offer economies of scale when marketing the farmers produce and running of cooling and storage infrastructure.
5. Simple cooling facilities should be built in the areas with vegetable production to offer prolonged period for vegetables before damage as the product awaits transportation to markets.

CHAPTER 6 : RECOMMENDATIONS AND REVIEW OPTIONS

1. There is need to minimise losses in the food chain in order to not only increase the quantity and quality of produce but also reduce energy, water and land use. The losses occur during harvest, processing, storage, transportation, retail and use of a range of foods. Significant losses are a result of a number of factors which include insufficient drying, inadequate storage, insufficient cooling and poor transport , all of which rely on high levels of energy input.

2. The results from this survey provide factual baseline information on the aspects and impacts surrounding the processing of high-moisture-content vegetable production and the extent and potential of renewable energy use by Kenyan farmers. Most farmers were aware about renewable energy technologies available, with manual energy being utilised in most of the processing operations. This indicates that there is great potential for promotion of renewable energy use in processing of high moisture content vegetables. Thus, it is necessary to develop farmer friendly yet efficient technologies for processing high moisture vegetables using renewable energy.

3. The development of the best renewable energy mix technologies for decentralised food processing systems will boost food security as well as increase employment and income of rural communities. Formation of agricultural commodity cooperatives/farmer groups will facilitate knowledge transfer, faster adoption of technologies developed as well as better prices for farm commodities. Thus, it is important to deliver focussed support to stakeholders through the formed network. Such a network should aim at among other things, facilitating engagement, dissemination of information/technologies as well as have a database for crop/energy specific information.

4. Although it is envisaged that there will be efficient and effective use of energy during postharvest operations at the farm level, the results indicates that most farms are too small to meet the costs of such technologies. This implies that it is paramount to ensure farmers form functional groups in order to pool their resources.

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ANNEXURE

Annex 1: Sample Questionnaire for the Baseline Survey

FARMER QUESTIONNAIRE				
Good morning/afternoon/evening, my name is _____ I am working for a project called RE4Food, an exciting collaborative project addressing research challenges associated with increasing food security and reducing reliability on fossil fuels. It has an international engagement focus and involves academics from Newcastle University and academic institutions in Germany, Ghana, Kenya, Sierra Leone and South Africa as well as British NGOs with bases in Sub Saharan Africa. Are you willing to be interviewed? YES➔**Continue** No➔**Terminate interview and move to next Farmer** Do you have any questions for me before we start?				
Enumerator Name		Enumerator Code		
Date of Interview (DD/MM/YY)				
Start Time		End		
County ----------		1= Kisii 2= Kiambu 3= Kirinyaga		
Sub-county----------		**Name:**	**Code:**	
Village----------		**Name only:**		
SECTION 1: HOUSEHOLD DEMOGRAPHICS				
1. Sex of respondent		1= Male 2 = Female		
2. How old are you?		1=16 to 35 2=36 to 59 3=60>		
3. What is your marital status?		1=Single 2=Married 3=Divorced 4= Separated 5=Widowed		
4. Who is the head of your household?		1=Husband 2=Wife 3=Daughter/son 4=Grandparent 5=Other_____		
5. How many members of your family currently reside in your household? *(Record number)*		1=1 to 4 2=5 to 8 3=8 and above		

6. What is your highest level of education	1= None 2= Primary 3= Secondary 4= Tertiary 5= University

SECTION 2: LIVELIHOOD ACTIVITY	7. Did anyone in your HH do this activity in the last year? (Circle one)	8. On average how much do you make
LIVESTOCK PRODUCTION		
Rearing & selling animals (e.g. camels, cattle, sheep,	1=Yes 2 = N0	
If yes, specify:		
CROP FARMING		
Cereal food crops (e.g. sorghum, maize, wheat,	1=Yes 2 = N0	
If yes, specify:		
Root crops (e.g. Irish potato, sweet potato)	1=Yes 2 = N0	
If yes, specify:		
Pulses (e.g. beans, cow-pea, chick-pea)	1=Yes 2 = N0	
If yes, specify:		
Fruits (e.g. mango, papaya, banana, orange, lemon,	1=Yes 2 = N0	
If yes, specify:		
Vegetables (e.g. kales, onion, tomato, cabbage,	1=Yes 2 = N0	
If yes, specify:		
EMPLOYMENT / LABOUR		
Salaried job (e.g. teacher, doctor, nurse)	1=Yes 2 = N0	
If yes, specify:		
Casual worker/non-salaried (e.g. farm, construction)	1=Yes 2 = N0	
If yes, specify:		

9. How much do you spend on the following?

Expenditure	**Amount** *(Pick code)*
School fees per term	1=Less than 10,000 2=10001 to 20,000 3=20,001 to 30,000 4=30,001+ 5= Others (specify)----------
Food per month	1=Less than 2000 2=2001 to 4,000 3=4001 to 6000 4=6001 to 8000 5=8001+ 6= Others (specify)----------
Medical bills per month	1=Less than 2000 2=2001 to 4,000 3=4001 to 6000 4=6001 to 8000 5=8001+ 6= Others (specify)----------
Utility bills (water, rent, electricity) per month	1=Less than 2000 2=2001 to 4,000 3=4001 to 6000 4=6001 to 8000 5=8001+ 6= Others (specify)----------

SECTION 3: CROP FARMING

10. Do you (or any other member of your household) own any land? *(Circle one)* 1= Yes

11. Who has the right of ownership of the land (title deed or any other legal document showing ownership of the land)?
    1= Man 2= Woman 3= Both
    4=Others(Specify)_____

12. What is the size of your shamba?
    1= Less than 1 acre 2= 1 to less than 5 acres 3= 5 to less than 10 acres
    4= More than 10 acres

13. Did you (or any member of your household) **farm** during the last farming season? *(Circle one)*
    1= Yes 2= No

14. If "**YES**", in13 above**,** please tell me about the land you used for farming.

Farmed own land	1= Yes	2= No
Farmed family/community owned	1= Yes	2= No
Farmed rented land	1= Yes	2= No
Farmed free access to someone's	1= Yes	2= No

15. Do you grow vegetables?	1= Yes	2=No

16. How much land is under vegetables?
    1= Less than 1 acre 2= 1 to less than 5 acres 3= 5 to less than 10 acres 4= More than 10 acres

17. Which vegetables do you grow?
    1=African leafy (managu, amaranth, stinging nettle, kunde, spider flower)
    2=Exotic(cabbage, kales, tomatoes)
    3=Others(specify)----------

18. Why do you grow the above vegetables?*(multiple responses)*
    1= Fast maturing
    2= Less vulnerable to weather changes
    3= Fetch higher prices at the market
    4= Longer life compared to other vegetables
    5=Others(specify)----------

19. For what purposes do you grow vegetables?
    1= Domestic use
    2= For the market
    3=Both domestic use and market
    4=Others(specify)----------

SECTION 4: VEGETABLE PLANTING PRACTICES

20. When do you plant your vegetables?
    1= During rainy season
    2=Through irrigation
    3= Both

21. Which technologies do you use for pest and weed control in vegetable production?	Yes	No

Burning	1	2
Weeding	1	2
Chemicals	1	2
Natural (ash and pepper)	1	2
Crop rotation	1	2
Others(Specify)		

22. If using irrigation, where do you get water?
    1=River
    2= Piped water
    3=Borehole
    4=Others(specify)_____

23. What method of irrigation do you use?
    1= Surface irrigation(flood, border and furrow) 3= Sprinkler irrigation
    2=Subsurface irrigation 4=Drip/micro-spray irrigation
    5= Bucket irrigation 6= Others (specify)_____

24. (a) How long does it take from planting to harvesting your kale vegetables?
    1=2 weeks
    2=2 to 4weeks
    3=More than 4 weeks

    (b) How long does it take from planting to harvesting your cabbage vegetables?
    1=2 weeks
    2=2 to 4weeks
    3=More than 4 weeks

    (c) How long does it take from planting to harvesting your other (specify) vegetables?
    1=2 weeks
    2=2 to 4weeks
    3=More than 4 weeks

SECTION 5: POST-HARVEST HANDLING

25. How do you harvest your vegetables *(Record all that apply)*

    1=Manually
    2=Using vegetable harvesting machines(specify)_____
    3=Others(specify)_____

26. What types of containers do you use when harvesting? (*Multiple responses)*
    1= Traditional baskets 2= Sacks 3=Trays 4=Timber crates
    5=Pliable plastic 6=Rigid plastic 7=Others(specify)_____

27. How much waste occurs in the farm during harvesting?
    1=Less than 10 per cent 2=Between 10 to 20 per cent 3=20 to 40 per cent
    4=More than 50 per cent

28. Do you sort your harvested vegetables? 1=Yes 2=No

29. If yes in 28 above, what percent of your harvested vegetables is thrown away during sorting?
    1=Less than 10 percent 2=Between 10 to 20 percent 3=20 to 40 percent
    4=More than 50 percent

30. How do you transport your vegetables from the farm to collection or selling point?
    1=Human transportation 2=Bicycle 3=Motorcycles 4=Mkokoteni/oxen cart
    5=Open pick-up 6=Close pick-up

31. What type of packaging do you use for transporting to the market?
1= Traditional baskets 2= Sacks 3=Trays 4=Timber crates
5=Pliable plastic 6=Rigid plastic 7=Others(specify)_____

32. What percentage gets wasted during transport to the market or collection point?
1=Less than 10 percent 2=Between 10 to 20 percent 3=20 to 40 percent
4=More than 50 percent

33. How do you store your vegetables on the farm after harvest?
1=Under the shade 2= In cold rooms 3=In sacks in the open
4=Others(specify)_____

34. How long do you store the vegetables on the farm before selling?
1=Less than 1 hour 2=1 to less than 3 hours 3=3 to less than 6 hours 4=More than 6 hours

35. What percentage of vegetables do you think go to waste due to poor handling at the market?
1=Less than 10 percent 2=Between 10 to 20 percent 3=20 to 40 percent
4=More than 50 percent

36. (a) Would you like technology to keep your vegetables longer for the market?
1=Yes 2=No
If yes, specify_____

(b) Which of the listed renewable energy resources do you know?

1= Biogas 2= Solar 3= biomass 4= wind
5= Biodiesel
6= Others (specify)_____

(c) Which of the renewable energy resources in 36(b) above have you used?
1= Biogas 2= Solar 3= biomass 4= wind
5= Biodiesel
6= Others (specify)_____

(d) For what purpose did you use the renewable resources in 36(b) above?

37. What type of value addition do you do to your harvested vegetables?
1=Drying 2=Paste 3=Jam 4=Others(specify)_____

38. Do you use drying of vegetables as a preservation method?
1=Yes 2=No
If yes, what type of drying methods do you use?
1=Open sun drying 2= Solar drying systems 3= Using electric dryers 4=Shade drying
5=Others(specify)_____

39. What per cent of the vegetables is lost during value addition process?
1=Less than 10 percent 2=Between 10 to 20 percent 3=20 to 40 percent
4=More than 50 percent

40. Indicate the proportions of total percentage energy use along the value chain listed below.

Chain stage	Percentage energy use										
	Man	Open	Solar	Bio	Bio	Wood	Diesel/p	Electri	Sha	Othe	Total=

	ual	sun	systems	gas	mas s	fuel	etrol	city	de	rs	100%
Harves ting											
Sortin g											
Storag e											
Transp ort											
Proces sing											

SECTION 6: PRODUCTION AND MARKETING

41. What are the major challenges you face in vegetable production? *(Multiple response)*
    1=Lack of good quality seeds
    2=Lack of capital to purchase good quality inputs
    3=Post-harvest losses
    4=Unpredictable weather patterns
    5=Lack of markets
    6=Poor infrastructure and transport system
    7=Inadequate knowledge

42. What are some of the solutions to the problems above?
    _____
    _____
    _____
    _____
    _____
    _____
    _____
    _____
    _____
    _____
    _____

43. How do you sell your vegetables? *(Multiple response)*
    1=On farm 2=In the local market 3=Through farmer associations 4=Through middle men
    5=I am a contract farmer

44. How do you link to the market?
    1=Directly 2=Indirectly
    Please explain answer
    _____
    _____
    _____
    _____
    _____
    _____

45. Are there marketing groups or any organised marketing system?
    1=Yes 2=No

46. If yes in 45 above, please explain
    _____
    _____
    _____
    _____

_____
_____
_____

47. Are the prices satisfactory?
    1=Yes 2=No

48. Do you make any profit from vegetable business?
    1=Yes 2=No

49. Do you add value to your harvested vegetables?
    1=Yes 2=No

50. Please explain answer in 50 above
    _____
    _____
    _____
    _____
    _____
    _____
    _____
    _____
    _____

51. Where do you sell your processed products?
    1=Locally 2=To middleman 3=Export market

52. What are the main challenges in marketing the vegetables?
    _____
    _____
    _____
    _____
    _____
    _____
    _____

53. Do you have any comments?
_____
_____
_____
_____
_____

THANK YOU