UNIVERSITY OF NAIROBI

SUSTAINABLE ENERGY AND WATER USE FOR HORTICULTURAL PROCESSING BY MICRO, SMALL AND MEDIUM ENTERPRISES IN KENYA

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DECLARATION

This thesis is my original work and has not been submitted for the award of a degree in any other university:

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DEDICATION

To Jane Dolly Obiero the wind under my wings; to Kayla Ayimba and Elana Ayimba for teaching me the true meaning of resilience. To Andrew Ayimba thank you for your patience, support and encouragement while I was undertaking this journey in pursuit of knowledge.

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ABBREVIATIONS AND ACRONYMS

DTB	Disinfection by-products.
EEMs	Energy Efficiency measures
EPRA	Energy Petroleum and Regulatory Authority
EPT	Energy and Petroleum Tribunal
ERC	Energy Regulatory Commission
EU	European Union
FFV	Fresh-cut fruits and vegetables
FFVP	Fresh-cut fruits and vegetable products
FIs	Financial Institutions
GDP	Gross Domestic Product
GHGs	Greenhouse gases
ISIC	International Standard Industrial Classification
KAP	Knowledge, attitude and practice
KEBS	Kenya Bureau of Standards
kJ	kilojoules
kW h	Kilowatt hour
LCA	Life Cycle Assessment
MSMEs	Micro, Small and Medium Enterprises
MJ	MegaJoule
NPEA	Nuclear Power and Energy Agency
RERAC	Renewable Energy Resource Advisory Committee
REREC	Rural Electrification and Renewable Energy Corporation
SCP	Sustainable Consumption and production
THM	Therm

USD United States Dollar

WSSD World Summit on Sustainable Development

10-YFP Ten-Year Framework of Programmes

ABSTRACT

Horticulture is the third foreign exchange earner and is mostly undertaken by smallholder farmers. Processing of horticultural produce involves the intensive usage of water and energy which subsequently results in the generation of huge amounts of waste. The current trends of sustainability in energy and water use practices among horticultural processing micro, small and medium enterprises (MSMEs) are poorly documented. There is insufficient knowledge on the amount of water and energy utilised including whether there is sustainable use of these resources in the different phases of processing by horticultural MSMEs. This study was conducted to assess sustainable energy and water use practices for resource efficiency by horticultural processing MSMEs in Kenya in order to generate the much-needed information on the amount of energy and water used by the horticultural processing MSMEs to help in improving resource use efficiency thereby leading to sustainable use of energy and water for processing in the horticultural sector as envisaged in SDG 12 as well as establishing the level of knowledge of MSMEs. The current study employed cross-sectional and longitudinal research designs with mixed methods approaches. Additionally, a reconnaissance study was done to test the practicability of the objectives and 122 MSMEs were surveyed. Purposive sampling was used to select a representative sample size of 39 MSMEs. Data was gathered using partially-structured questionnaires, interviews along with observations. Quantitative data was displayed using descriptive statistics such as frequencies, standard deviation and means. Qualitative data on the other hand was analysed using thematic analysis.

The results showed that the MSMEs had a high level of knowledge, however this did not motivate them to adopt the environmental practices geared at resource efficiency. The high level of knowledge could be attributed to the training that had been held on sustainable consumption and production (SCP). The MSMEs needed additional motivation to adopt sustainable practices aimed at resource use efficiency. A non-significant relationship was established between attitude and practice. Multiple linear regression indicates age affects knowledge, attitude and practices (R^2=0.272, F=4.238, P=0.012). An increase in age is associated with an improvement in knowledge, attitude and practices on energy and water use for processing. The other variables which are type of MSME, education level, frequency of processing and gender did not have a significant effect on knowledge, attitude and practices of the MSMEs. There is weak enforcement of energy and water use efficiency measures. In addition, more emphasis has been placed on energy management than on water management. Green training had a beneficial influence on the implementation of energy and water efficiency measures by the MSMEs. However, the focus of the MSMEs has been on the implementation of short-term measures on energy and water use efficiency. About the quantification of energy used for horticultural processing, the results indicate that in the processing plants where there is energy intensive processing for instance pasteurization processes, there is intensive consumption of energy compared to plants that only package the produce. Similarly, on quantification of water for horticultural processing, it was noted that there was minimal water use in plants where there was minimal processing and packaging of produce compared to plants where there was washing and further processing of produce. Sub-metering was largely lacking thus hampering the collection of detailed and specific data that would help the MSMEs identify hotspots of energy and water consumed. The study recommends the use of incentives such as subsidies and rebates to encourage MSMEs to adopt practices aimed at energy and water use efficiency, additional training is also needed to enhance awareness of MSMEs on the need for energy and water use efficiency. There is also a need for enforcement of energy and water efficiency measures by the relevant government entities.

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

The agro-food sector utilizes huge amounts of energy and water for processing fruits and vegetables (Nikmaram and Rosentrater, 2019). Water is a very important resource for the food processing industries because it is not only an ingredient but also a major processing constituent (Flörke *et al*., 2013; Nikmaram and Rosentrater, 2019). The fruits and vegetable agro-processing sector is among the main sub-sector of the food sector that consumes water intensively (Asgharnejad *et al*., 2021; Fusi *et al*., 2016; Nikmaram and Rosentrater, 2019; Walker *et al*., 2018). Hence sustainable utilization of water is a huge environmental as well as economical problem for the fruits and vegetables processing industries (Ölmez, 2017).

It's further projected that there will be an increased need for water to be used in the production of food and this demand might get to about 10 to 13 trillion cubic meters yearly by mid of century. This translates to between 2.5 to 3.5 times more than the entire fresh water withdrawals for anthropogenic use currently (Institution of Mechanical Engineers (IME), 2015). Large quantities of water are utilised in processing fresh vegetables, removal of dirt from skinned vegetables, cleaning, rinsing as well as chilling vegetables that have been processed in addition to washing the various environmental surfaces in the manufacturing factories. The washing activities together with activities related to cleanliness are a significant concern in the reduction of the entire water consumed within the fruits and vegetables manufacturing sector (Lehto *et al*., 2014).

Reduction of the water footprint of the cleaning operation poses a setback to the fresh fruits and vegetables (FFV) industries together with food scientists (Manzocco *et al*., 2015). In the recent past, there has been heightened concern about the ecological sustainability aspect of the FFV industry (Manzocco *et al*., 2015; Ölmez, 2017). These concerns are mostly attributed to the processing stage

(Raffo and Paoletti, 2022). Utilization of the best available technologies as well as application of a structured water management strategy could bring about a decrease of about ninety percent in the demand for freshwater due to the reuse of water used for processing (Ölmez, 2017).

The food industry globally utilizes approximately 200 exajoules of energy annually (EIA, 2017; FAO, 2017). The ultimate specific use of energy demand by the agri-food sector worldwide is approximately a third of the global entire ultimate demand for energy. In high gross domestic product (GDP) nations, close to 45 % of the end-use energy demand is utilised in food processing (Sims *et al*., 2015). The agri-food manufacturing sector needs energy for cooling, heating, along with lighting (Abolarin *et al*., 2014; FAO, 2011a).

Given that production of food is predicted to rise by 25% between now and 2030, sustainable sourcing of energy is gradually becoming a huge concern (Institution of Mechanical Engineers (IME), 2015). It is approximated that the entire quantity of energy required for processing is about 50 – 100 MJ per kilogram of the total food products that are retailed (FAO, 2011b). Within Kenya, the manufacturing sector is amongst the major consumers of energy. The proportion of consumption of electricity by this sector for instance in 2019 was 50.16% whereas fuel was at 12% (KNBS, 2020).

Adoption of efficient energy and water use practices by horticultural processing Micro, small and medium enterprises (MSMEs) in Kenya will lead to sustainable consumption and production, resource use efficiency and reduction of the economic and environmental burden exerted by the horticultural processing MSMEs. When all MSMEs are lumped together and their environmental impacts analysed, it has been established that they have significant environmental as well as social impact (Revell *et al*., 2011) and therefore these enterprises should begin to adopt additional sustainable behaviours together with a long-term vision to formulate organizationally and environmentally sustainable procedures (Shankar *et al*., 2017).

1.2 Statement of the Problem

Processing of horticultural produce entails the intensive use of large amounts of water and energy which are scarce resources. MSMEs are increasingly processing horticultural produce to increase the shelf life of the highly perishable horticultural produce and for exportation to far-off markets thereby addressing the problem of food loss and wastage. It is estimated that a third of the food produced for global consumption is either lost or wasted (FAO, 2011c). A recent report has estimated that 17% of global food production may be wasted (United Nations Environment Program, 2021). Further, in East Africa, it has been projected that about 30% to 80% of fruits and vegetables produced are lost consequently leading to substantial revenue losses to both the farmers and governments in these east African countries (Wakholi *et al*., 2015).

This challenge will likely escalate in the years to come due to the intensification of the demand for the fresh-cut fruits and vegetable products (FFVP) in developing countries. The washing phase during the processing of the horticultural produce consumes about 90% of water. Even though the reuse of water amongst the different processes is done, there remains a large amount of wastewater that is produced. There is also inadequate data on the amount of water needed during the various stages of processing thus resulting in unsustainable water use.

Various studies have been undertaken, for example, Manzocco *et al.* (2015) focused on the high consumption of water resources during the washing operations and the toxic disinfection by-products (DTB) produced from water reuse and Lehto *et al. (*2014) studied water utilization and wastewaters produced during the processing of FFV. The focus of these studies was the consumption of water, toxic DTB and the high amount of wastewater generated. Water is widely used during food processing operations by horticultural processing MSMEs, however, there is limited available data on consumption volumes thus the existence of knowledge gaps in Kenya.

The data on energy consumed for the processing of food and dispensation is debatable because the available data does not include all nations. United Nations Statistics Division (UNSD) statistics indicate that the overall agri-food energy from the processing of food remains the same as the entire amount consumed within the primary manufacturing sector. Nevertheless, this is perhaps due to underestimation as a result of missing country information as well as the failure to include energy resources utilised in the many informal small-scale, food processing ventures that take place in emerging economies or republics and are excluded in the food and tobacco industry statistics (Sims *et al*., 2015).

There is insufficient information on the amount of energy and water used by MSMEs for horticultural production; when this valuable information is lacking the MSMEs can't undertake efficiency measures that would enable them to achieve sustainable development goal (SDG) 12 that puts emphasis on sustainable consumption and production; the goal here being increased production while using fewer resources in addition to minimising the environmental impact of the processed products. MSMEs cannot reduce their resource use when they don't know how much they are consuming in the first place. The aim of this study was to cogenerate knowledge with the horticultural processing MSMEs so as to ensure resource use efficiency and inform policy.

1.3 Research Objectives

1.3.1 General Objective

The general objective was to assess sustainable practices for energy and water resource use efficiency by horticultural processing MSMEs in Kenya.

1.3.2 Specific Objectives

This study was directed by these four specific research objectives :

1. To establish knowledge, attitude and practices of energy and water use by horticultural processing MSMEs in Kenya.
2. To examine the influence of legal frameworks on energy and water use by horticultural processing MSMEs.
3. To assess the effect of green training on sustainable energy and water use by horticultural processing MSMEs.
4. To analyse the amount of energy and water consumed by horticultural processing MSMEs.

1.4 Research Questions

The study was steered by these subsequent research questions:

1. Why do knowledge, attitude and practices affect energy and water use by horticultural processing MSMEs?
2. What is the influence of legal framework on energy and water use practices by horticultural processing MSMEs?
3. Why does green training affect energy and water use by horticultural processing MSMEs?
4. How much energy and water are consumed by horticultural processing MSMEs?

1.5 Justification of the Study

Presently many farms in addition to the specific plants or factories have spread out their operations from farming to processing FFVPs. There is insufficiency of knowledge concerning the water usage in the different phases of processing the FFVPs. There is therefore a need for obtaining information on the various waters produced during the different stages of processing of the horticultural produce (Lehto *et al*., 2014). Additionally, if an enterprise is to advance its energy and water use efficiency, the preliminary vital phase is to establish the quantity of energy and water that is consumed, the particular point of consumption and where energy as well as water are required by various pieces of equipment in the company's manufacturing system (Mousavi *et al*., 2016).

According to Olmez (2013), monitoring water usage and measuring water quality helps to reduce the quantities of water utilised and to improve on the quality of water. Therefore, acquiring information on water usage is vital for identifying the critical phases of processing requiring further studies, management of risks and appraising the need for prior treatment of waste water before using it (Lehto *et al*., 2014). This study will therefore be useful in generating the much-needed information on the amount of energy and water used by the horticultural processing MSMEs to help in improving resource use efficiency thereby leading to sustainable use of energy and water for processing in the horticultural sector as envisaged in SDG 12 as well as establishing the level of knowledge of MSMEs.

1.6 Scope and Limitation

The focus of the study was on horticultural processing MSMEs in Kenya and how their knowledge, attitude and practice, legal framework and training influence sustainable energy and water use for processing. The study employed cross sectional and longitudinal research design. The field work was conducted between October 2019 to December 2021 with breaks in between due to disruption from the covid 19 pandemic. Following the declaration of Covid 19 as a global pandemic, cessation of movement and curfews ensued thus delaying data collection; in addition, several MSMEs closed shop following the poor prevailing economic conditions due to Covid 19 pandemic. The study used purposive sampling whereby only horticultural processing MSMEs were targeted thus leading to selection of a small sample size

The finding will inform policy on resource use and also will be vital in decoupling economic growth from environmental deterioration thereby leading to sustainable development

1.7 Organization of Thesis

The format adopted for writing this thesis is the paper format. In this format, the various chapters starting from chapter three contains complete manuscripts which have either been published, are in press or are being prepared for publication. The thesis is structured into seven chapters. Chapter one contains an introduction, the background of the study, research problem, objectives, scope and limitation as well as the significance of the study. Chapter two comprises the literature review. Chapter three contains findings on knowledge, attitude and practice of horticultural processing MSMEs. Chapter four presents finding on influence of legal frameworks on energy and water use by horticultural processing MSMEs. Chapter five presents findings on the influence of green training on energy and water use efficiency by horticultural processing MSMEs. Chapter six is on analysis of the amount of energy and water utilized by horticultural processing MSMEs. Chapter seven is a summary of the findings, general conclusions and recommendations of the study then a bibliography and appendages.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

This chapter examines works relevant to this study and how they influence energy and water use practices by MSMEs in Kenya**.** The theoretical and conceptual frameworks are also contained in this section.

2.1 History of Sustainable Consumption and Production (SCP)

The history of SCP can be traced back to the Earth Summit that was held in Rio de Janeiro whereby consensus was reached that the degeneration of the environment was intertwined with unsustainable trends of consumption and production (UN, 1992). This consensus was reaffirmed in 2002 at the Johannesburg Summit (UN, 2002). During that summit, SCP was acknowledged to be a "central objective and an essential requirement for sustainable development". SCP strategies and programmes have more and more turned out to be significant with countries acknowledging the importance of delinking resource utilization plus degradation of the environment from economic progression (Statistics Sweden, 2016).

Humanity is faced with intertwined economic, environmental and social crises emanating largely as a result of the present unsustainable patterns of consumption and production, in addition to causing great harm to human progression. Mankind is presently consuming increasingly more resources than before both for every individual and in totality thereby surpassing greatly the earth's regenerative capacity. Resource consumption all over the world keeps on rising whilst pollution and waste raise, additionally the disparity between the wealthy and the underprivileged continues to widen (UNEP, 2012a).

The Oslo Symposium of 1994 defined sustainable consumption and production as "*the use of services and related products, which respond to basic needs and bring a better quality of life while minimizing the use of natural resources and toxic materials as well as the emissions of waste and pollutants over the life cycle of the service or product so as not to jeopardize the needs of further generations"*. Societies must undergo a transformation in the manner in which they consume and produce if global sustainable development is to be attained (UNEP, 2014).

Over the last 20 years, sustainable consumption and production (SCP) have become the prime concern of governments as the globe adapts to the more economical, environmental and socially sustainable sequence of development (UNEP, 2014). Unsustainable patterns of consumption and production have been acknowledged to be the major reason for the degradation of the environment. This was also confirmed in the Rio Summit of 1992 and all other subsequent sustainability meetings ever since. SCP aims to change these patterns thus it's a policy agenda for tackling the underlying causes of humanity's ecological dilemma while also providing for human well-being and prosperity (Akenji and Bengtsson, 2014).

Changing to increasingly sustainable trends of consumption and production is embedded in sustainable development thus international collaboration is important to achieve this change. The Johannesburg Plan of Implementation (JPOI) of the World Summit on Sustainable Development (WSSD) in 2002 was cognisant of the fact that SCP is an all-embracing objective of, and a significant precondition for sustainable development and further pressed on all interested parties to give support in addition to nurturing the advancement of Ten-Year Framework of Programmes (10-YFP) that supports both regional and nationwide strategies that hasten the move to SCP patterns that encourage economic as well as social progression within the ecosystems' carrying capacity (UNEP, 2012b).

The WSSD that occurred in 2002 in its Johannesburg Plan of Implementation (JPOI) stated the need for the establishment of a worldwide 10-YFP on SCP to hasten the move in the direction of sustainable consumption and production as well as encourage economic and societal advancement inside the confines of' carrying capacity of ecosystems. This led to the initiation of the Marrakech Process on SCP launched in Marrakech, Morocco in 2003. The Marrakech Process was a bottom-up and multi-stakeholder process which supported the execution of SCP policies and initiatives and contributed to the development of a global 10-YFP on SCP (UNEP, 2012b).

Globally, multilateral environmental agreements regularly either indirectly or directly promote SCP by encouraging transformation in production and consumption trends. The Montreal Protocol for example has fruitfully availed monetary aid to pay for industrial change and other actions that safeguard the ozone layer. Nationwide SCP policies encompass specific SCP strategies or sustainable development strategies that clearly address SCP (UNEP, 2012a). Such strategies have been or are being established in several countries including Colombia, Burkina Faso, Croatia, Cote d'Ivoire, Czech Republic, Ecuador, Dominica, Finland, Ghana, Indonesia, Mali, Kazakhstan, Mauritius, Poland, St. Lucia, Senegal, Tanzania, Uganda, Zambia and the United Kingdom. Nationwide strategies also include thematic policies such as forestry programs and integrated waste management programs which similarly support the change to SCP (UNEP, 2012a).

Regionally, the European Union had implemented an SCP action plan. The Arab region, Africa, Latin America together with the Caribbean areas have also established SCP action plans with the Marrakech Process. These action plans have been ratified by the appropriate regional intergovernmental bodies (UNEP, 2012a). Africa has been ahead of other regions in executing SCP and the initiation of the African 10-YFP on SCP illustrates Africa's commitment to execution of SCP activities on the continent. The establishment of national and local SCP programs in various African nations has laid the foundation for placing emphasis on the significance of SCP in realisation of sustainable development in Africa (UNEP, 2012b).

Partnership is very essential in the realization of sustainable development and alleviation of poverty in Africa as exemplified by the Marrakech Task Force on Cooperation with Africa which provides support for promoting SCP on the African continent (UNEP, 2012b). SCP can be described as having two objectives that are wide-ranging and interconnected i.e. attainment of well-being for all persons and confining adverse impacts on the environment as a result of social and economic actions in the Earth's carrying capacity (Akenji and Bengtsson, 2014). SCP has been recognised to have a wide scope. The fourth chapter of Agenda 21 begins by recognizing that given that the issue of changing consumption patterns is wide, it is given due attention in numerous sections of Agenda 21 more so those addressing energy, wastes and transportation (UN, 1992).

SCP is an all-inclusive approach that uses a life cycle perspective therefore it takes in to consideration the entire utilization of materials plus the resultant discharges, waste and effluents; targeting at minimising harmful impacts on the environment as well as encouraging all-encompassing welfare. It focuses on the sustainable as well as effective managing of resources in the entire phases of the value-added chains of goods and services incentivizes the advancement in methods which utilise lesser materials in addition to producing fewer waste including hazardous waste while producing ecological gains and regularly productivity and pecuniary benefits. Such enhancements can similarly enlarge the competitive advantage of businesses, converting resolutions for challenges in sustainability into export, employment along with business prospects. SCP likewise supports obtaining plus recycling or reusing valued materials thus converting waste streams into useful streams (UNEP, 2012a).

The execution of SCP as a consolidated tactic aids in realization of overall development goals, lessening of future social, environmental, and economic costs, intensifying fiscal competitiveness plus reduction in poverty. SCP focuses on promotion of energy and resource efficiency, better quality of life, green jobs and sustainable infrastructure (UNEP, 2012b). The globe in 2015 approved the 17 globally recognised Sustainable Development Goals (SDGs). Connected to the 17 goals are the 169 targets and SCP was singled out as a separate SDG as well as a fundamental constituent of the numerous other goals and targets agreed to (Statistics Sweden, 2016).

2.2 Sustainable Consumption and Production in Kenya

Research focusing on progression of SDG 12 which puts emphases on SCP is scarce due to the reason that this is a comparatively new area of research that is yet to be well structured and its confines are also not well defined (Chan *et al*., 2018). A number of nations have developed strategies towards achievement of SCP; for instance, the Government of Sweden outlined a strategy for SCP whose focus was on action point by the Government whilst collaborating with businesses, municipalities as well as civil societies so as to aid consumers to consume in a more sustainable way (Chan *et al*., 2018). A national strategy and action plan for Jordan on SCP for the period 2016 – 2025 has been implemented (Ministry of Environment of Jordan, 2016).

Kenya on the other hand is still lagging behind when it comes to analysing her present trends of consumption and production and translating the same into national blue prints that will lead to the attainment of SCP (Makworo and Kasiva, 2021). The reason why Kenya could be still lagging behind is due to insufficient relevant and detailed data on energy and water consumption trends by the manufacturing industry. This present study has established that there is inadequate knowledge on where, why and what energy and water is used for in horticultural processing yet this information will help the Government of Kenya in formulating strategies that will lead to the actualization of SCP. However, all is not lost for Kenya since she supports SCP as declared in the Eighteenth Session of the Commission on Sustainable Development (Republic of Kenya, 2010).

2.3 Global Horticultural Production

Over the last 20 years, horticultural produce which includes vegetables, cut flowers as well as fruits exports from developing nations have soared immensely. Horticultural exports from Latin America have raised three-fold over the last 20 years whereas exports from Asia and Africa have increased fourfold. This advancement has led in horticulture becoming the most significant product group in overall agro-food exports for all emerging countries (Vandenbroeck and Maertens, 2016). Within the whole emerging areas exportation of cut flowers, vegetables plus fruits raised immensely during the last 20 years. Within Africa, exports from horticulture raised from 3.75 billion USD in 1995 to 16 billion USD in 2014 and this translates to a mean yearly increase of 7.5%. Within Asia together with India as well as China, exports from horticulture grew from 14.7 billion USD in 1995 to 66.5 billion USD in 2014 which led to a yearly incremental rate of about 7.8% (Vandenbroeck and Maertens, 2016).

In America, horticultural exports increased averagely by 6.3% yearly from 11.8 billion USD in 1995 to 40 billion USD in 2014. Consequently, horticultural exports are the most significant agricultural food exports in America, Africa and Asia. Nations like Kenya, Peru, South Africa, Mexico, China, Thailand, Ethiopia and Chile have become vital suppliers of cut flowers, fruits as well as vegetables in the global marketplace. The bigger percentage of produce from horticulture exported from emerging nations is intended for developed nations (Vandenbroeck and Maertens, 2016). India is a major fruit and vegetable basket of the world (Dastagiri, 2017; Neeraj *et al*., 2017). India is ranked second after China with respect to both vegetables and fruits in terms of production. India produces 88.98 million tonnes of fruits from an area of 7.21 million hectares and produces annually 162.89 million tonnes of vegetables from an area of 9.39 million hectares (Neeraj *et al*., 2017).

According to a Global Competitiveness Study (USAID-KHCP, 2013), the international market share for Kenya fell to 1.28% in 2012 due to over reliance on flowers and tea export in addition to poor export value per hectare. Kenya also relies on two or three markets thus there's need for diversification. The report further states that Kenya is the largest exporter to European Union (EU) with a 16% market share. Egypt, South Africa and Ghana export more to the Middle East depicting the over reliance of Kenya on EU. In spite of Kenya's ranking as the biggest horticultural exporter in Sub Saharan Africa, arid nations located in the Middle East and North export more per capita and are also ahead of Kenya with respect to export value per hectare (USAID-KHCP, 2013).

Israel which is an arid country exported horticultural produce valued at 559 USD per capita. Morocco and Egypt which are both arid countries exported horticultural produce worth 69 USD and 132 USD per capita respectively whereas Kenya only produced horticultural produce valued at 8 USD. Onions, passion fruits and French beans export quantities declined because of competitiveness from Latin America together with local erratic supply (USAID-KHCP, 2013). Further the Global Competitiveness Report indicates that in spite of the big potential in passion fruits and avocado exports specifically in Europe where the crop doesn't grow due to the weather patterns, growing of these two crops is dominated by small-scale farmers whose magnitude of production can't be of benefit to the value chain (USAID-KHCP, 2013).

Agriculture is considered as the main economic sector in Kenya because of the contributions it makes towards the economy. It contributes 26% to the GDP, employs 70% of the total Kenyan population and creates employment opportunities for 40% of the populace in countryside regions. It has been projected that in 2018, approximately 198,000 and 185,000 hectares of land was used for production of vegetables and fruits respectively (NIRAS-LTS *et al*., 2021).

The horticultural sector is the second biggest source of forex earnings in the agricultural sector next to tea. It is responsible for about 36% of agriculture's portion of GDP and has continued to expand. The horticultural segment provides a lot of opportunities globally, regionally as well as to the local markets (Matui *et al*., 2016). Kenya is the biggest supplier of vegetables to the European Union exporting peas, green beans, Asian vegetables together with avocados. Nationally, horticulture is the second biggest foreign exchange earner after tea in Kenya contributing to 21.4% of the entire value of its exports (KNBS, 2018).

The quantities of export of unprocessed horticultural produce raised marginally by 1.8% from 322.6 thousand tonnes in 2018 to 328.3 thousand tonnes in 2019. However, it is anticipated that the growth of the horticultural sub sector will be restricted by the effects of the corona virus which has suppressed external demand and heightened production costs due to operational challenges. The weak global economy will most probably affect negatively exports from Kenya especially horticultural products and the tourism sector (KNBS, 2020). More than 80% of farms engaged in horticulture are MSMEs. These MSME farmers targ*et al*l segments in the market, either as persons, in cooperatives or as out growers for big export farmers. Big farms chiefly target export markets for Asian vegetables, beans, peas, vegetables, avocados, nuts and flowers, medicinal and aromatic plants. The characteristic of big farms includes high investment and high input in comparison to MSME farmers, who frequently suffer deficiency in knowledge and capital (Muriithi and Matz, 2015).

According to Kenya Revenue Authority and Kenya National Bureau of Statistics, it is estimated that in 2019 Kenya produced 467,602 metric tons of horticultural produce worth 1,145 million USD while in 2018 497,416 million metric tonnes was produced valued at 1,157 million USD (KNBS, 2020). The tropical and temperate climatic condition in Kenya is favorable for horticultural production and development (Embassy of the Kingdom of Netherlands, 2017).The domestic value of horticultural production in 2016 was 2,481.969 billion USD in comparison to 1,935.525 billion USD in 2015(AFA and HCD, 2017). Export earnings of horticultural products increased by 7% to 342,989.3 million USD in the first quarter of 2019 thus becoming the leading foreign exchange earner (HCD, 2019). The output and corresponding value of horticultural production from 2015 to 2019 is displayed in

Figure 1. The statistics used in plotting figure 1 were gotten from the Kenya National Bureau of Statistics (KNBS, 2020) and the author then plotted the horticultural production output and the corresponding values of the output in USD.

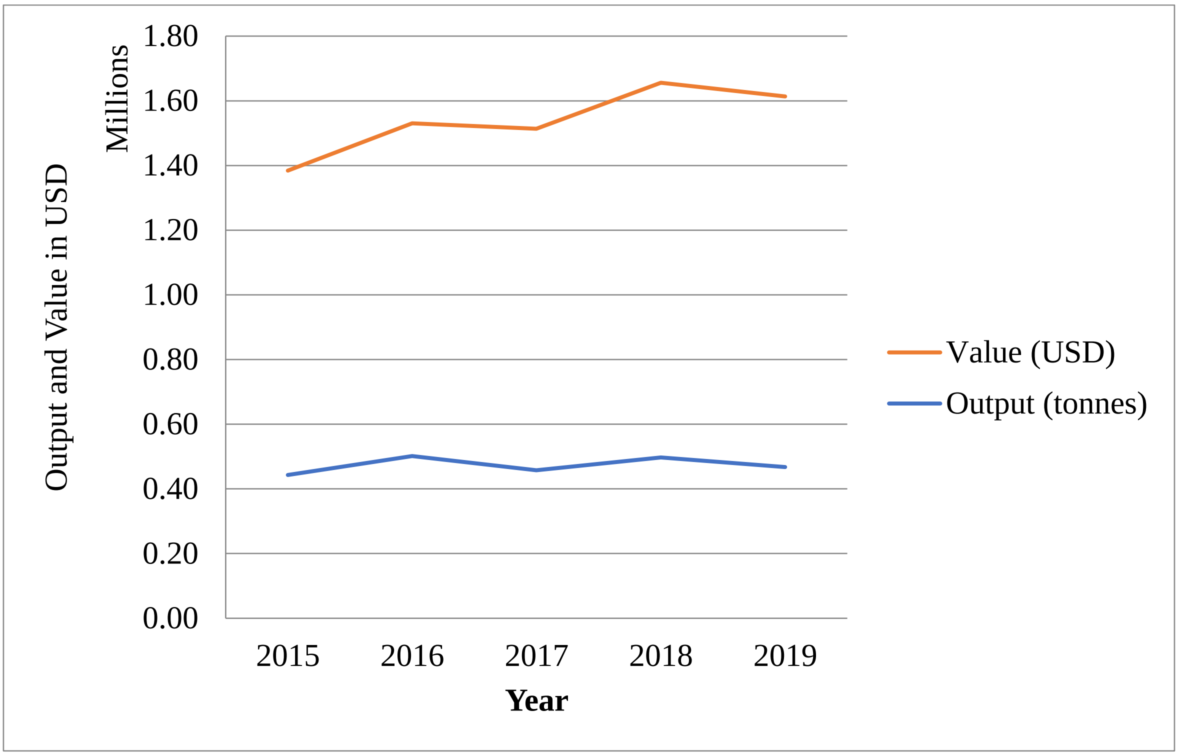

Figure 1 Horticultural Production in Kenya and its Value in USD

Source: Author's calculation, 2022

Horticultural subsector comprises of five produce that is fruits, vegetables, nuts, flowers as well as medicinal and aromatic plants (MAPS) (RSA, 2015). The contribution of the focal sectors are as follows: Asian vegetables, African leafy vegetables as well as exotic vegetables (36% of the domestic value); fruit (30%); nuts (5%); flowers (26%) and MAPS (2%). Approximately 95% of the horticultural produce especially vegetables and fruits are consumed in the local market whereas the remaining 5% which includes French beans and flowers ends up in the export market (Matui *et al*., 2016).

The major fruits grown are avocados, mangoes, passion fruits, pineapples, bananas, paw paws plus watermelon (Embassy of the Kingdom of Netherlands, 2017); whereas vegetable include tomatoes, kales, cabbages, onions, potatoes, French beans, chilly, sugar-snaps, snow-peas, baby-corn, runner-beans, Asian vegetables, garden-peas, herbs plus spices (RSA, 2015). These fruits and vegetables are grown over an extensive array of ecological zones from the high to mid rainfall regions to the semi-arid and arid areas in Kenya (Embassy of the Kingdom of Netherlands, 2017).

It's estimated that between 2.5 to 4.5 million persons are working in the horticultural sector and a majority of these people are small holder farmers who grow nearly 80% of the horticultural produce (fruits and vegetables). Vegetable production is practiced in the rural areas as well as within Nairobi City (Lans *et al*., 2012). Horticultural production is faced with land scarcity therefore to sustain demand and crop productivity, it is imperative that the land remains fertile throughout the year hence the intensive use of fertilizers and pesticides (GOK, 2012; Wainwright *et al*., 2014).

Horticultural production is a key income earner for sub-Saharan African countries (Jayne *et al*., 2021; USAID and AFFA, 2014). Horticultural production in Kenya dates back to the pre-independence period and has continued to thrive both in production and value addition in post-independence period (Hortiwise, 2012). In the agricultural sector, horticultural production is the second highest income earner in Kenya after tea (Ulrich, 2014), reserving its integral position in Kenya's economy. Horticultural production in the country is done both in small scale and plantations yielding an employment capacity of over 8 million people both directly and indirectly within the country as well as provision of food security and raw material for agro-processing (GOK, 2012; Mashindano *et al*., 2013).

Horticultural production is significantly carried out by smallholder farmers under rain-fed systems although some farms utilise elaborate green-house technologies together with irrigation in largescale farms. Fresh fruits along with vegetables are mainly exported to Europe while the rest are consumed domestically. This has seen production carried out under strict Good Agricultural Practices

(EurepGAP) in order to ensure compliance to standards. Although the increasing export market and competitiveness has put pressure on local horticultural producers in terms of quality of product (Yabs and Awuor, 2016).

Kenya has gradually executed traceability strategies that have encompassed the progression of internationally recognized local standards, such as KFC Silver Standard, HEBI Base Code, KenyaGAP along with others, with effective certification actions. This has however, resulted to hiccups due to high costs required to meet food safety standards resulting to threatened sustainability of production as some smallholder farmers withdraw due to non-compliance failures (Agriculture and Food Authority, 2016; Asfaw *et al*., 2010; GOK, 2012).

2.4 Overview of Horticultural processing globally

Fruits as well as vegetables are a major player in the economic sector with respect to revenue generated together with employment opportunities created. The covid 19 pandemic had had widespread repercussion within the fruits and vegetable supply chain and has brought about new obstacles and costs to deal with. These new costs are due to a myriad of factors such as inefficient operations due to the imposed social distancing measures in packhouses and orchards, increased logistical costs, additional safety measures and delays (OECD, 2020). Globally, more than 50 percent of fruits and vegetables are grown on farmland which are less than 20 hectares in size while in developing countries the figure is over 80 percent across Asia, China together with Sub-Saharan Africa. Exports of fresh and processed fruits and vegetables from Sub-Saharan Africa to the rest of the globe have increased between 2002 and 2017 (COLEACP, 2021).

FFVs are extremely fragile thus they need special care for their safety and quality to be maintained through proper processing which improves on their shelf life, tastiness, availability, nutritional quality, attractiveness as well as minimizing wastage and losses. A wide range of technologies for processing have allowed FFV to be well-preserved and changed into a wide array of plant-based foods which have been delivered to consumers either for immediate consumption or stored for consumption in the future (X. Liu *et al*., 2022). Some FFVs are widely traded goods such as apples, juices, citrus and tomatoes whilst others are specialties with limited production and markets such as blackcurrants whereas some are local preferences in between for instance Kimchi in Korea, apricot and strawberry jam in France, plum and berry juice in Poland among others (X. Liu *et al*., 2022). Processed FFVs market size surpassed USD 260 billion dollars in 2019 (GMI, 2020) and is projected to expand at over 7 percent compound annual growth rate between 2020 and 2026 (COLEACP and OECD, 2021).

It is estimated that about 30% to 80% of fruits and vegetables produced are lost thus leading to significant income losses not only for the farmers but the governments as well in East Africa. A number of endeavors have been attempted by various stakeholders to establish plans and actions that will lessen on such losses. Researching as well as execution of technology and equipment to aid in managing along with processing fruits and vegetables so as to extend the lifespan of horticultural products is some of the strategies put forth to reduce post-harvest loss (Wakholi *et al*., 2015).

Processed fruits are sold as concentrates, canned fruit or derivative products such as jam and juices. Some of the derivative products from fruit processing exported from Kenya include canned pineapples, mango, orange and passion fruits juices, jellies, jams, pastes, pickles, marmalades and preserves (Federal Ministry for Economic Cooperation and Development, 2016). The processed products are sold canned, frozen, bottled, dehydrated, solar dried or preserved in brine. In Kenya, semi-industrial thermal processing techniques such as fruits and vegetable solar driers and biomass fired driers are also used (Kanali *et al*., 2017). Studies have recommended traditional drying techniques such as solar drying and sun drying and mechanized techniques such as freeze, vacuum and infrared drying as possible value addition techniques for African leafy vegetables such as amaranth (Ambuko and Wilson, 2017).

Approximately 95% of the entire horticultural production is utilised or used locally whereas the residual 5% is sold to other countries overseas (RSA, 2015). The export quantities for fruits and vegetables have been steadily increasing from 2009 to 2013 though in 2011 there was a slight decline. Analysis that has been done in the recent past have brought out grave concerns that poses a threat to the future of the horticultural sector in Kenya. The analysis focused on two particular areas that is developing a comprehensive list of combinations of either crops or markets that are very tactical for exporters from Kenya in the foreseeable future and benchmarking Kenya's competitiveness against key international competitors (USAID-KHCP, 2013). Kenya's export volume of vegetables reached over 6.6 thousand metric tonnes in December 2021. The highest export volume of 9.8 metric tonnes was recorded in January 2019 as depicted in figure 2. Low export volumes was recorded in 2020 and this was attributed to the disruption by covid 19 pandemic which affected many countries globally(Statista, 2022).

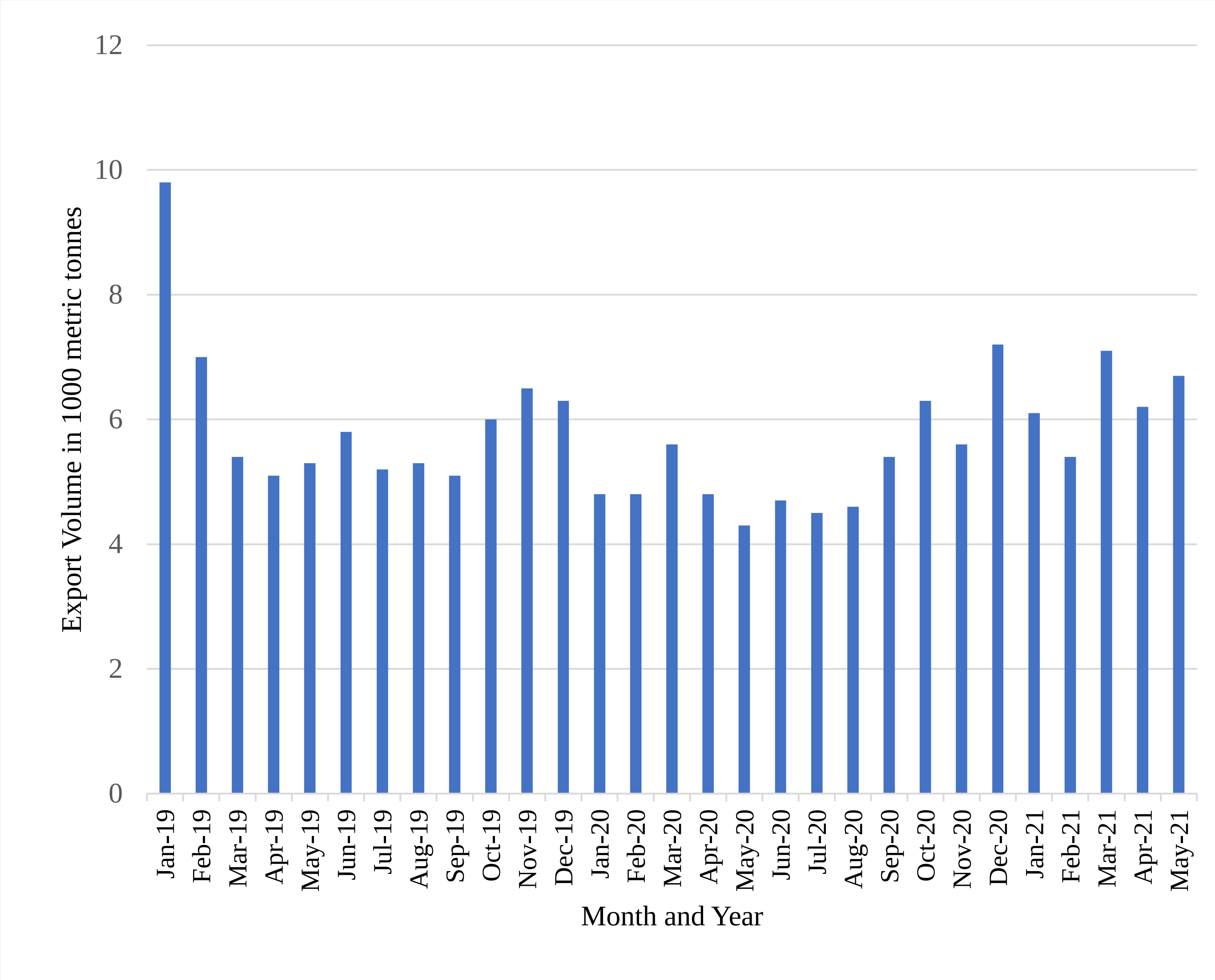

Figure 2 Export volume of vegetables from Kenya between January 2019 and May 2021 (in 1,000 metric tons) (Source: Statista, 2022)

2.5 Energy use for processing of fruits and vegetables

Efficient use of energy is among the basic necessities for sustainable agriculture especially with the growth in the global population, it is essential to increase global food production, which depends on utilization of energy that is majorly gotten from fossil fuels (Bajan *et al*., 2021). Energy is used universally in the provision of services of all types related to energy. These include the provision of electricity, industrial processes such as refining and manufacturing, transportation, cooling, heating, lighting among others (Rosen, 2021). The food processing sub sector will be compelled to increase food production by 70% so as to feed the growing global population which is estimated to have reached 9.5 billion by 2050; this implies that water and energy use needs to increase as well by close to 40% and 50% respectively grounded on the present rate of consumption (FAO, 2017). Manufacturing of vegetables and fruits consists of numerous unit operations that are done depending on the kind of product to be produced. For instance, in the processing of juice, the raw materials (that is vegetables or fruits) have to undergo crushing while to obtain powdered form of a product it has to undergo drying and grinding operations (Patel *et al*., 2019).

Processing of food consumes considerable amount of energy, labor as well as machinery to transform comestible raw materials into food products that are of higher value (Wang, 2014). The food industry globally utilises 200 exajoules (EJ) of energy annually. This intensity in energy consumption is associated with huge amounts of greenhouse gas emissions and declining resources (FAO, 2017). Hence sustainable consumption and production is important in the agro-industry so as to minimise consumption of energy for processing of fruits and vegetables. Energy used for powering machines on the farm, in the storing and processing amenities, in the direct usage of fuel in automation of field operations together with transporting of produce increases the total energy which presently represents approximately 3.1% of worldwide consumption of energy yearly (Institution of Mechanical Engineers (IME), 2015).

The food and drinks sector is a major consumer of resources for instance energy, water as well as packaging materials thus faces immense pressure from national governments as well as global organizations to improve on usage of resources (Wu *et al*., 2013). It is therefore imperative for this sector to reduce on the consumption of resources to ensure sustainability of this sector. It is estimated that close to 68% of energy is consumed by fuel fired boilers as well as direct heating systems for processing and heating of spaces. A further 16% of electrical energy is utilised by electric motors, 8% taken up through electric heating, 6% consumed by refrigerators and 2% by air compressors (Wu *et al*., 2013).

FFV need to be stored in cold conditions ranging from 0 to 5^{o}C and temperatures should be controlled during the preliminary stages of processing so as to avoid spoilage. Temperature should be maintained at around 0^{o}C (Bansal *et al*., 2015). Energy which is a prerequisite in the food processing industry is used for running machines, heating, cooling and lighting. The whole demand for energy for food processing is about thrice the direct energy utilised behind the farm gate. Additionally, energy is entrenched in the packaging which can be comparatively energy-intensive due to the usage of plastics and aluminium (FAO, 2011b).

Temperature has an important function in determining the shelf-life of processed fruits and vegetables due to the fact that it determines not only the postharvest quality of the produce but also has a direct influence of growth of spoilage microorganisms (James and Zikankuba, 2017). Both low and high temperatures are used in the processing of fruits and vegetables. Heat treatment includes dipping in hot water, hot water rinse with brushing, saturated water vapor and hot dry air blanching. Heat treatment can either last for a brief time for instance an hour long or can be lengthy taking one to four days at 37 – 55^{o}C or below a minute in sweltering water of about 63^{o}C. Chilling temperatures lie between 1–4°C, whereas frozen temperatures scope is 18 − 35°C (James and Zikankuba, 2017).

Most of the energy usage transpires during transporting of raw materials and other products, powering various processes, heating of buildings (where applicable), sterilization and in other unit operations. In order to achieve higher energy efficiency in the food processing industries, adoption of two essential operations can play important functions that is non thermal processing such as high-pressure processing and membrane processes (Nikmaram and Rosentrater, 2019). The initial cooling, processing and cold storage of fresh fruits and vegetables is among the most energy demanding subdivision of the food industry. Significant levels of refrigeration and heating are required to decelerate spoilage whilst maintaining pre-harvest freshness and flavour or ripe fruits and vegetables.

The refrigerant systems specifically for the food processors typically operate at the heaviest load during day time hours when electrical costs and outdoor temperatures are the highest (Hackett *et al*., 2005). This calls for utilization of alternative sources of green energy to reduce the environmental burden of cooling and heating phases during horticultural processing.

An immense amount of energy is normally consumed in converting raw materials into higher value food products and this is dependent on the type of product being produced. For instance, to evaporate 1kg of water from products, an average of 6 MJ of heat will be required all through the drying process; on the other hand, to reduce the temperature of products below –20^{o}C, 1 MJ or 0.3 kWh of electricity will be needed all through the freezing processes. Thus, heating processes are the most energy intensive type of unit operations utilised in the food industry and at times include, dehydration, pasteurisation drying, evaporation and sterilization (Nikmaram and Rosentrater, 2019).

Processed potato products utilize a lot of energy (Ladha-Sabur *et al*., 2019). Drying, for instance, utilizes huge amounts of energy because of the high initial water content in the raw material (Wu *et al*., 2013). Potatoes crisp are dried till a water content of 2% is achieved and since the final water content of potato flakes is lower than that of French fries, their production is thus much more energy intensive (Ladha-Sabur *et al*., 2019). Figure 3 summarizes the amount of energy utilized to process fruits and vegetables with potato-based products consuming the highest quantities of energy due to the initial high-water content of the raw materials. Ketchups, jams and marmalades consume relatively lower amounts of energy compared to potato products.

Production of French fries exerts a lot of burden on the environment due to the huge amount of energy that is consumed, use of solar energy or any other form of green energy will help in minimising the environmental burden. There is therefore need to rethink the heating phase during processing and this could be in terms of equipment or process redesign so that minimal energy is consumed during heating of the product; most of the MSMEs are using outdated inefficient equipment which end up consuming energy intensively.

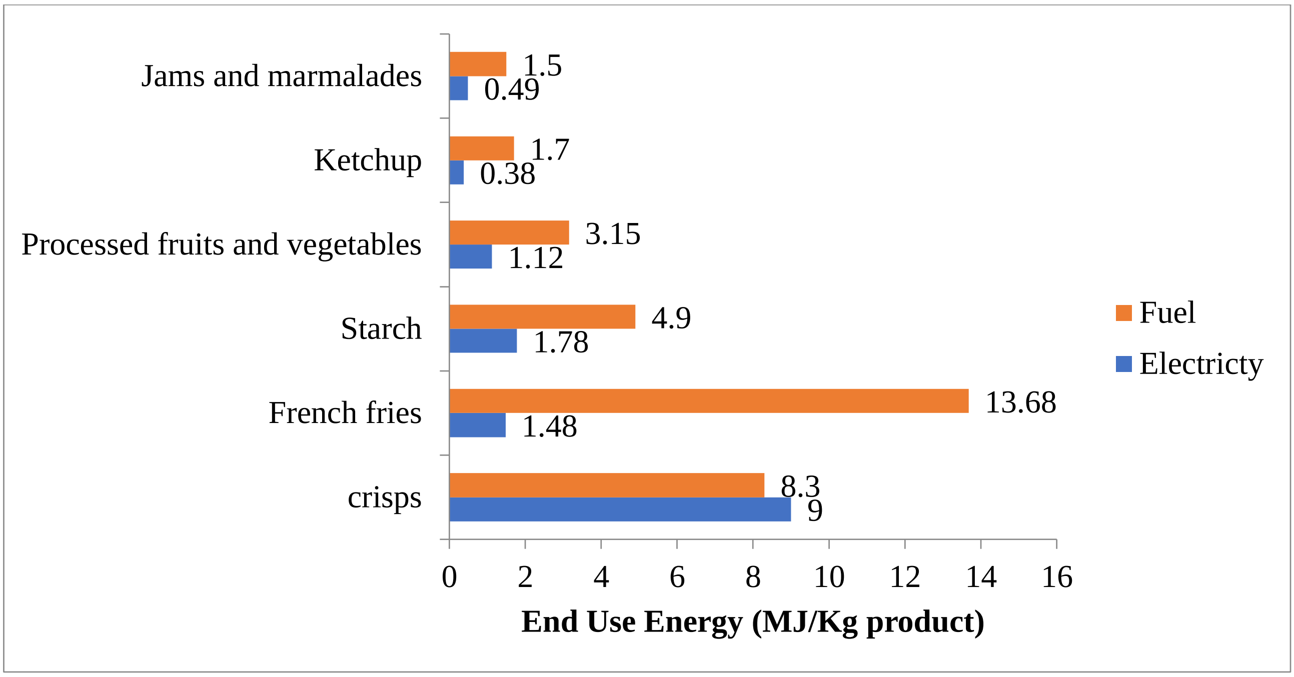

Figure 3 Energy consumed to process fruits and vegetables
Source: Ladha-Sabur *et al*. (2019)

2.6 Energy Efficiency Measures (EEMs) in Horticultural Processing MSMEs

Globally there's raising concern over energy due to two major factors that is the need for the reduction of greenhouse gases emissions or reduction of the environmental impact of production as well as usage of energy; and the need for better usage of the scarce energy resources. The most promising viable solution entails deploying renewable energy resources and energy efficiency that is in some way the best available renewable energy source (Cagno *et al*., 2010). Improving energy efficiency is deemed as an essential approach for reducing greenhouse gas emissions particularly in the short and medium term (Fleiter, Schleich, *et al*., 2012). MSMEs view investment in energy efficiency as low priority projects, allocate less resources to energy management and exhibit lower adoption rates for energy efficiency measures (EEMs) (Cagno *et al*., 2010).

It has been estimated that the potential for energy efficiency of industrial MSMEs in the European Union to be between twenty and twenty five percent (Thollander and Palm, 2013). Presently, this potential is still unexploited in spite of the fact that a number of energy efficiency investments are sustainable financially and demand minimal capital spending. A myriad of financially limiting factors including low profitability, high fixed costs and capital constraints as well as barriers which are not financially related such as inadequate skills and information accounts for lack of adoption of EEMs. A number of policy tools have been developed to prevail over the barriers to information and foster the uptake of EEMs in large firms together with MSMEs. The Energy Efficiency Directive have rallied for energy audits as an important tool for addressing the information asymmetry in existence by creation and disseminating knowledge on options for technology together with the associated savings in energy cost (European Commission, 2016).

Such knowledge can aid in forecasting consumption of energy in parallel to aid designing strategies in energy saving and the related measures (Kalantzis and Revoltella, 2019). Performing an energy audit is an initial step in energy consumption optimization (Backlund and Thollander, 2015). An energy audit can be defined as a procedure whose aim is to evaluate how a plant or a building uses various forms of energy, identification of opportunities and reduction in potential consumption (Kalantzis and Revoltella, 2019). Approximately 30% of the energy demanded by MSMEs may possibly be reduced by cost effective EEMs for instance energy management software and this would result in energy savings. Energy efficiency can be of immense assistance to MSMEs in monumental ways such as cutting costs thus freeing up resources to invest in more productive activities as well as becoming increasingly resilient, innovative and competitive. If MSMEs were to implement EEMs to their full potential, it would result in savings of over 20% of their energy bills; this is a measure that MSMEs in Europe and beyond cannot afford not to do (DEXMA, 2016).

According to (Kalantzis and Revoltella, 2019), energy audits seem to be of more benefit to smaller firms concerning decisions related to investment. The projected outcome of energy audits on the choice to invest and after on the quality of buildings' energy efficiency standards and state of the art equipment and machinery is positive and statistically significant for almost all firm sizes. This impact declines with firm size in relation to investment decisions in EEMs thus indicating that information on energy audits is of higher importance for smaller MSMEs compared to larger MSMEs. For larger MSMEs, the information asymmetry could be lesser, and this might possibly explain why their adoption rate is higher compared to smaller MSMEs irrespective of the extant of an energy audit program (Kalantzis and Revoltella, 2019).

Governments as well as policy makers have been strongly committed to reach a common environmental and energetic policy. In order to be fully effective, Governments should take measures while taking into consideration that MSMEs are usually less efficient than large enterprises, they account for 99% of the total number of industries in most countries globally and consume approximately 40% of the total energy for the industrial sector (Cagno *et al*., 2010). Further, the source of funding chosen by firms to finance investment projects plays a major part in the decision they make on whether to invest in EEMs. Research findings indicate that firms that are dependent on solely internal sources of funding are highly unlikely to invest in EEMs more so in the processes related to production. In addition, the findings reveal that for these firms, the positive outcome of energy audits on the choice to invest in EEMs is lessening and even becomes negative (Kalantzis and Revoltella, 2019).

Attention towards MSMEs is needed for several reasons: MSMEs don't have an internal structure capable of focusing on energy consumption and doesn't have a chance to (Cagno *et al*., 2010). In MSMEs, the entrepreneur has to play a number of roles such as operations, sales, marketing, safety, planning, administration and he or she may also be employed within the factory. Thus, energy is just one of the issues and there is no specified focus on it (Cagno *et al*., 2010; DEXMA, 2016). Another reason is that the time allocated for energy efficiency activities is usually quite limited. MSMES also lack the knowhow of energy management and practices. Financial barriers especially pay back times of more than two to three years are regarded as limiting to MSMEs whereas large enterprises are able to afford investments for even more than eight years (Cagno *et al*., 2010).

According to (Sims *et al*., 2015), the energy demand of a system can be minimised through the usage of more efficient technologies such as membrane processing and non-thermal processing (Nikmaram and Rosentrater, 2019), changes to behaviour as well as development of generally energy management systems. Such EEMs not only minimise the costs but can also minimise greenhouse gas emissions where combustion of fossil fuel is reduced. Combining improved energy efficiency with renewable energy can help in keeping the energy costs low. Solar heat can also be used for drying fruit or grain either naturally in the open air or in solar heated facilities. Heat recovery can be one of the most cost effective efficient EEMs in food processing plant. It entails usage of waste heat from one process for another useful purpose (Sims *et al*., 2015).

Due to equipment or process inefficiency, a significant amount of waste heat is released and lost by the sector annually. The UK industry produced approximately 11.4TWh/year of recoverable waste heat of which 2.8 TWh is from the food and drink manufacturing process (Chowdhury *et al*., 2018). Utilization of this waste heat can reduce CO_2 emissions by 541.08 ktCO2e and save 89 million USD every year. Unlike the heat source from the iron and steel industry, the waste heat from food and drink processing is majorly low-grade energy whose energy is typically below 260^{o}C. In the food and drink manufacturing industry, approximately 64% of the energy is used for low temperature processes (Chowdhury *et al*., 2018).

(Sims *et al*., 2015) further states that prior to investment in heat recovery systems, it's advisable to look into if the waste heat can be minimised in the first place through improved energy efficiency. A majority of the processing operations produce considerable amounts of waste heat while at the same time another section of the plant or process requires heat. The energy intensity of various food processing factories may be more than 50% higher than necessary because of low energy efficiency systems when bench marked against the best available technologies. The low energy efficiency of small sized food processing plants in a majority of developing countries allow for the use of enhanced technologies and processes to bring about significant environmental and economic benefits even though energy bills accounted for only 5% to 15% of the total factory costs (Sims *et al*., 2015).

Good housekeeping refers to various realistic methods that a company can adopt right away on their own to advance productivity, realise cost-savings, and lessen the environmental impacts of their operations; advance organizational procedures and safety at the work place (DEC, 2015; Zohir, 2010). Therefore, it's a tool for the management of the environment, cost and change in the organization. When these areas are sufficiently taken into consideration, a triple win i.e., economy, environment and organization can be achieved as well as a thriving method for the establishment of continual advancement in the organization. The gains of good housekeeping can be regarded as a triangle with synergistic effect that enables companies to tap into the triple win options which can lead to a process of continual improvements (Zohir, 2010).

Simple housekeeping or general maintenance measures on older, less efficient processing equipment can often yield energy savings of 10% to 20% for little or no capital investment (EuroChambers, 2010; Sims *et al*., 2015). Medium cost investment measures for instance optimising combustion efficiency, recovering the heat from exhaust gases and selecting optimum size of high efficiency motors can result in energy savings of 20% - 30% for minimal or no capital investment. Higher savings are possible but usually demand greater capital investment in new equipment (Sims *et al*., 2015).

Energy efficiency can be attained in various ways for instance improvement of efficiency of equipment plus unit processes, recovery of heat and assimilation of processes (Wu *et al*., 2012). The focus of management in food processing is inclined towards quality of the product instead of usage of energy. This can be changed into an advantage if management is urged to re-examine critically the technical processes and control systems used as well involvement of staff in this activity (Sims *et al*., 2015).

2.7 Water use efficiency measures in Horticultural Processing MSMEs

Water is a resource which cannot be replaced in processing industries however many companies have failed to fully exploit the hidden potentials that can be gained from optimizing its operations as well as their water system. European countries waste between 20 to 40 percent of its available fresh water resources by failing to deploy technological improvements which alone can account for up to 40% improvement by enhancing the water productivity by volume (Kurle *et al*., 2017). Further, it has been recognized by the United Nations that there is a gap in knowledge especially in manufacturing sector related to the amount of water withdrawals and consumption utilised in the manufacturing transformation processes and production needs (WWAP (World Water Assessment Programme), 2012). This represents the missed potential to improve on water efficiency in the manufacturing sector; lack of knowledge on how much was supplied versus how much was consumed is a huge deterrent to water efficiency efforts.

Water efficiency is a viable economical way to improve on water security in many situations. Water efficiency is a worthwhile strategy even in circumstances where water security has not been prioritised as a goal; water efficiency can expand the accessibility of water for economic, cultural, aesthetic, spiritual and environmental uses (AWA, 2012). Therefore, water efficiency measures are key to solving the challenges of water scarcity and should be prioritized in the manufacturing industries to enable them check their consumption at an early stage. According to Institution of Mechanical Engineers (IME), 2015), in the last century, the abstraction of fresh water for use by mankind has increased by more than double the demographic growth rate. Presently, human beings use approximately 3.8 trillion m^3 of water annually; about 70% of this is utilised by the agricultural sector worldwide (Institution of Mechanical Engineers (IME), 2015) while a further 20% is utilised in the production and processing industries leaving just 10% for domestic usage (IChemE, 2014) and the level of usage will keep on rising in the decades to come.

Reduction of pressure on water resources is imperative through development of new resources and in dealing with inefficient utilization of water. Being water efficient implies taking simple steps towards the reduction of water use and using water saving technologies that will result in both energy and monetary savings (CIWEM, 2016). A range of measures exist that are essential to the establishment of improved water efficiency such as metering and sub metering, usage of tariffs which are well designed, installing water saving fixtures or products, water efficient labelling, among others (CIWEM, 2016). Water efficiency refers to the group of policies and practices that make the most of the advantages obtained from every unit of water used (AWA, 2012).

Water is essential to a majority of manufacturing activities and processes thus its efficient use should be prioritised so as to ascertain that scarcity of water and increased water tariffs shall have a minimal effect on production. Identification of opportunities to improve water use efficiency involves the employment of various water management strategies such as water audits, utilization of advanced water treatment technologies as well as process integration. Water management strategies gives insightful understandings into possibilities of changes in processes that could lead to increased water use efficiency and ultimately water savings (Agana *et al*., 2013).

2.8 Water use for processing of fruits and vegetables

The International Fresh-Cut Produce Association (IFPA) defines fresh-cut fruit and vegetable products (FFVP) as fruits or vegetables that have been trimmed, peeled or cut into a 100% usable product that has been packaged to offer consumers high nutrition and flavour whilst maintaining its freshness (Jideani *et al*., 2017). Control of water use is a significant constituent of sustainable fresh cut vegetable production due to inadequate water resources as well as controlling the waste water reused for vegetable processing or for irrigation of cultivated land (Lehto *et al*., 2014).

Nikmaram and Rosentrater (2019) state that all through food processing operations, water is utilised in various unit operations and functions as well as, an ingredient, a preliminary and intermediary cleaning source or as an efficient transportation mechanism for some raw materials and is an essential resource used for sanitization of plant equipment and areas. Water utilization will probably carry on being an essential part of the food industry but it has become a target for efficiency and reduction endeavours (Nikmaram and Rosentrater, 2019).

According to a study by (Lehto *et al*., 2014), it was established that utilization of water was highest in the plants in which vegetables were processed and lowest in the plants where vegetables were washed and packed. In the plants studied the total water consumption varied from 1.5 to 5.0 $m^3 t^{-1}$ of finished product as shown in Table 1.

Table 1 Total Water Consumption in Different kinds of Processing Plants

Plant	Operation of the Plant Examined	Total amount of raw material treated	Range of volume m^3t^{-1} (finished product)
A	Washing of root vegetables	6000 t of carrots, 3000 t of potatoes	1.5 – 3.0
B	Washing and processing of carrots	5000 t washed and packaged, 5000 t washed and processed	2.0 – 5.0
C	Processing of vegetables	6500 t of carrots and other root vegetables washed and peeled	3.5 – 5.0
D	Production of vegetable salads	500 t of lettuce and small amounts of other vegetables washed and cut	2.2 – 3.2

Source: (Lehto *et al*., 2014)

It is estimated that the water consumption and wastewater volumes lie in the scope of 2.4 – 11m^3 and 11 – 23m^3 respectively per tonne of produce for the FFV processing sub-sector. Thus sustainable water usage is a huge environmental as well as economic problem for the FFV processing sub-sector (Manzocco *et al*., 2015; Ölmez, 2017). This signifies huge wastage of water plus energy due to the reason that these wastewaters are cooled at refrigeration temperatures to meet fresh-cut processing requirements. The water used for processing is discharged to surface water hence exacerbating the global water scarcity challenge (Manzocco *et al*., 2015).

The fruit and vegetable processing industry consist of manufactures of bottled as well as canned produce, sauces, concentrates, dried vegetables and fruit products (Smith *et al*., 2010). Categorization of the water use in a conventional fruits and vegetable processing plant is as displayed in figure 4. Processing operations consume the largest amount of water that is 78% of the water supplied to the processing plant with auxiliary usage accounting for the least amount of the water consumed in a fruit and vegetable processing plant.

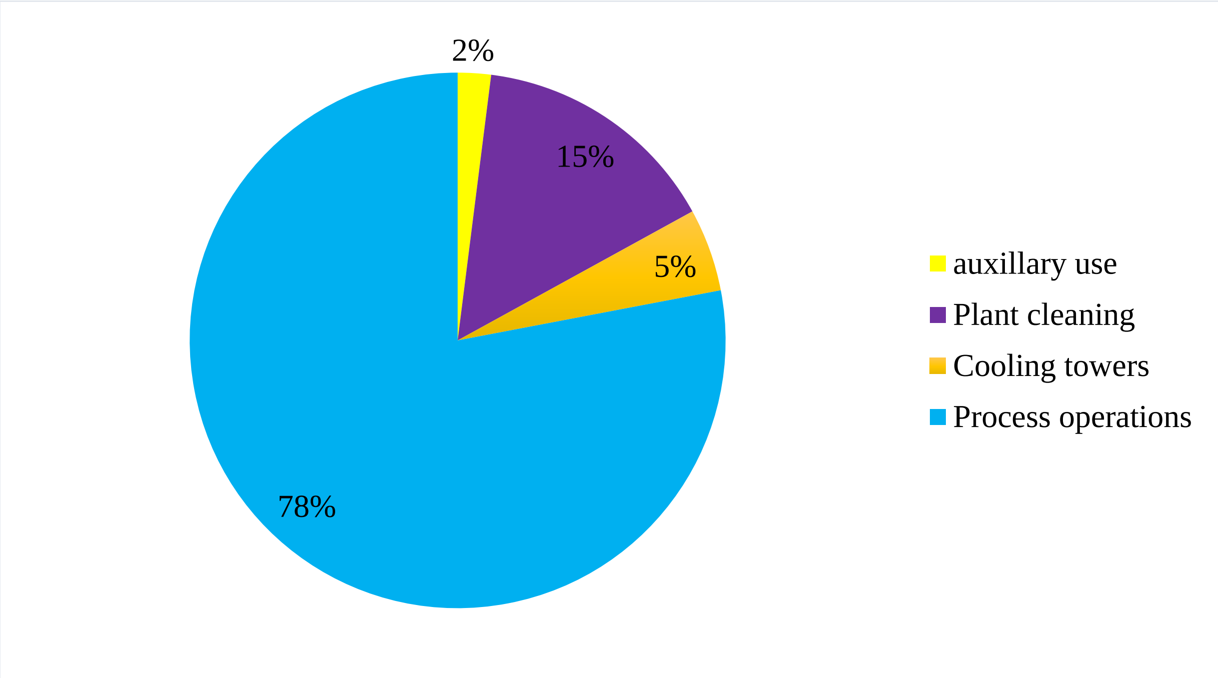

Figure 4 Categorization of water use in a conventional fruit and vegetable processing Plant
(Source: Smith *et al*., 2010)

From figure 4 above it is clear that the bulk of the water that is supplied to a fruits and vegetable plant is consumed during the processing phase. Reuse and recycling of water will help in minimizing fresh water consumption during consumption. The codex Alimentarius has allowed for reuse of water in the fruits and vegetables sector. What is required is the frequent monitoring of the quality of the water reused to ensure that it is of acceptable standard and free of pathogens. In addition, the Government of Kenya needs to come up with a water reuse policy for the manufacturing industries to reduce consumption of potable water. Kenya has already been classified as a water scarce country and thus such policies will ensure sustainability in the horticultural processing sector by providing a framework for sustainable utilization of resources.

2.9 Energy conservation in horticultural processing MSMEs and the environment

Energy conservation refers to any behaviour that leads to decreased usage of energy. Energy conservation encompasses changes in behaviour for example utilization of daylight to minimise the need for artificial lighting, switching off machines when not in use, turning down thermostats and switching off lights (Abolarin *et al.*, 2013). Improvement in energy efficiency (EE) is amongst the most crucial targets in the United Nations Sustainable Development Goals with the objective to increase by twofold the global rate of improvements in EE by 2030 (United Nations, 2015).

MSMEs in totality are significant energy consumers (Fawcett and Hampton, 2020; Henriques and Catarino, 2016). Several studies in the recent past have established that the possibility for advancement in energy and resource efficiency in manufacturing companies ranges from 10% to 40% in relation to possible energy savings (S Thiede *et al.*, 2013; Sebastian Thiede, 2012). MSMEs directors are solely focused on their day-to-day business activities as well as resolving problems thus have insufficient time to advance knowledge outside the basics consequently disregarding lucrative efficiency opportunities (European Commission, 2014).

The International Energy Agency has estimated that micro, small and medium enterprises (MSMEs) consume over 13% of the total global energy (IEA, 2015). On the other hand, there is limited information on the energy consumption of MSMEs as a proportion of national or industrial and/or commercial energy usage (Fawcett and Hampton, 2020). This limited information could be attributed to the nature of MSMEs. These MSMEs operate in all geographical locations, some are registered while others are not. It is thus difficult for the Government to track energy consumption for the MSMEs given that there are those who are not registered while others do not have business premises.

Further, the MSMEs, do not know how much energy is consumed in the different phases of processing due to lack of metering and sub metering of equipment so as to monitor the energy consumption.

According to (Thollander *et al*., 2015), it is important to study the industrial sector in relation to energy efficiency improvements since its amongst the main energy consuming sectors and accountable for a major share of carbon dioxide emissions. Bottom-up data on energy end use on a collected level is scarce. However, data for total energy supply such as natural gas, coal, oil and electricity are available but the data from bottom to top of the particular processes that these energy sources are used for as well as where the major potential for implementation of energy efficiency measures (EEMs) exists is less prevalent. This is especially with reference to small and medium enterprises (MSMEs) thus making formulation of policy and design for industry a huge challenge (Thollander *et al*., 2015). Uptake of energy audits is quite low in MSMEs yet these audits will provide valuable information on potential for energy savings and improvement thereby improving on their energy efficiency while informing policy as well.

Industry is accountable for approximately 50% of global consumption of energy (Trajer *et al*., 2021). Adoption of energy efficiency and implementation of conservation measures may lead to considerable energy savings. Some companies don't turn off heavy energy consuming equipment when not in use especially during breaks. Every motor that has been left on regardless of its size leads to wastage of a large amount of energy when considered over a long duration (Abolarin *et al*., 2014). Practices such as not turning off energy consuming equipment can be linked to lack of knowledge and awareness of energy efficiency measures. Therefore, green trainings are instrumental in raising awareness of the company employees so that they know practices like the ones highlighted by these authors are highly inefficient and lead to high energy consumption. These green trainings should be regularly carried out to raise awareness on the need for adoption of simple practices such as turning off idle equipment, installing energy efficient machines, switching off lights when not in use (Zohir, 2010) further puts forth that Housekeeping measures is amongst the no cost or little cost measures for energy conservation opportunities and can be described as an exceptional starting point for improvement of methods of operation. Maintenance programs incorporate simple, common sense and practical measures. These measures can be used to save energy, minimise production cost as well as reduce loss of raw materials, reduce waste, conserve water and lessen environmental impact. Implementation of these practices is not only easy but also entails minimal costs. Additionally, regular training of employees in charge of operation of major energy efficiency equipment ought to be carried out to increase energy efficiency (Zohir, 2010).

Several energy saving opportunities have been identified with reference to the present practices within the medium scale manufacturing company to enhance productivity. The opportunities for energy management that have been identified includes monitoring electrical loads to reduce peak demand, replacement of inefficient drive belts on large motors wit energy efficient cog belts, replacing incandescent bulbs with energy efficient bulbs, installation of banks of capacitors to increase power factor of the motors and turning off equipment when not in use. These energy efficiency measures have been suggested to bring about expected energy savings when the highlighted recommendations are implemented (Abolarin *et al*., 2014).

There are two significant areas in which energy conservation can bring about positive gains; the first area is in conserving water. Energy management can help in identification of areas where water specifically heated water can be reused without causing harm to the manufacturing process. This can be achieved through return of hot steam condensate to the boiler and reusing hot water streams to meet lower temperature heating or preheating requirements. The second area is in relation to environmental protection. Energy conservation is inherently a “clean” source of energy. Application of energy management principles will be of help in reducing pollution emissions from a plant or minimizing the fuel related emissions by helping to minimize the amount of fuel used in the plant (Zohir, 2010)

Energy efficiency can be attained in various ways for instance improvement of efficiency of equipment plus unit processes, recovery of heat and assimilation of processes (Wu *et al*., 2012). The focus of management in food processing is inclined towards quality of the product instead of usage of energy. This can be changed into an advantage if management is urged to re-examine critically the technical processes and control systems used as well involvement of staff in this activity (Sims *et al*., 2015).

MSMEs when considered individually do not consume a lot of energy but when observed in totality, their consumption can't be overlooked since it is quite significant and has been estimated by International Energy Agency (IEA) to be approximately over 13% of the entire quantity of energy demanded (IEA, 2015). When the energy efficiency of MSMEs is improved, it increases not only their competitiveness but profitability as well (Henriques and Catarino, 2016). The outcome of enhancing MSMEs energy efficiency will be seen in value increase not only to the MSMEs but also to societies and economies. Energy efficiency brings about a number of benefits with respect to the economy, society, environment as well as playing a crucial part in combating climate change (IEA, 2015).

Thus, for the continual growth and sustainability in this sector, energy and water conservation is vital (M. Compton *et al*., 2018). It's estimated that the food industry globally utilises 200 exajoules of energy annually. This consumption causes decreasing resources and large levels of greenhouse gas emissions. Energy conservation opportunities lie in use of renewable energy. Energy conservation measures will only be adopted by MSMEs if they are cost effective (Wang, 2014). MSMEs are estimated to represent 57 % of electricity and 50 % of gas demand (DEC, 2015).

It has been projected that 46% of potential energy savings can be attributed to a number of energy management programs. These programs are categorised into three groupings and there's gradual increment in their complexity. Plant energy management measures include basic conservation measures for instance preventive maintenance, system operator training and using utility incentives (M. Compton *et al*., 2018). Energy project management is a bit advanced and includes identification and prioritization of capital projects, usage of system optimization tools and practices of important operations as well as assigning an energy engineer. The third grouping is integrated plant energy management programs that comprise of autonomous authentication of energy savings together with execution of an energy management plan that consists of policies, accountability plus system/department level target goals (M. Compton *et al*., 2018).

Even though MSMEs in entirety are very important consumers of energy, there is an inadequate understanding of their energy use and the potential for energy savings. In addition, there is lack of agreement on MSMEs decision making process on energy, and consequently how policy can be best designed to encourage their choices. Considering their heterogeneousness in business sectors, types of buildings occupied, equipment used, forms of organisation, and so on, using empirical evidence on MSMEs to improve understanding and policy design is fundamentally hard (Hampton and Fawcett, 2017). This calls for the need for formulating policies that specifically target MSMEs. These enterprises are unique in nature and need to be specifically targeted by governments so as to obtain relevant information on their energy consumption and the potential for savings.

2.10 Water use in horticultural processing MSMEs and its effect on the environment

Water efficiency is a multidimensional concept that signifies "doing more and better with less" through getting increased value with the resources which area available, through reducing consumption of resources and reduction of pollution and environmental impacts of water utilization for the production of goods and services at every phase of the value chain as well as provision of water services (UNEP, 2014). Food processing is rated amongst the biggest water intensive industries with an important part to play in the implementation of sustainable development goals (SDGs). Water intensive industries like the food processing industry poses a severe risk to the inadequate fresh water resources thus several efforts are being made to advance and apply innovative strategies for management of water in these industries (Asgharnejad *et al*., 2021).

It has been predicted that water scarcity will intensify in the coming years (Piesse, 2020). Scarce water resources for anthropogenic activities have contributed to the usage of unconventional water resources like saline water, waste water and rain water (Ajami *et al*., 2014). Use of water will probably continue being an essential part of the food industry however it has become a target for efficiency and reduction efforts (Nikmaram and Rosentrater, 2019). The food industry cannot do away without water since it is a vital resource necessary for resources; however, concerted efforts need to be made to ensure minimal water use for processing given the high demand for potable water in this sector.

In the recent past, there has been heightened concern on the environmental sustainability of the fresh cut fruits and vegetables industry (Manzocco *et al*., 2015; Ölmez, 2017). These concerns are mainly attributed to the processing phase (Raffo and Paoletti, 2022). Processing of fruits and vegetables has a substantial effect on the environment because of the consumption of considerable quantity of water. Water has a myriad of functions during the processing of fruits and vegetables; it's an energy carrier, used as a raw material, washing raw materials, maintenance of production hygiene and hydro transportation. The products produced from the processing of fruits and vegetables include fruits and vegetables concentrates, frozen fruits and vegetables as well as fruit juices and drinks (Trajer *et al*., 2021).

Processing of fruits and vegetables has a notable environmental impact because of its utilization of a considerable quantity of water. Consumption of water is largely dependent on the kind of production and the technology employed. Water has several functions in fruits and vegetables processing industries such as it is a raw material, used for maintenance of production hygiene, energy carrier, washing raw materials as well as hydro transport (Trajer *et al*., 2021). Sustainable consumption of water is an enormous economical as well as environmental challenge for the horticultural processing industries (Ölmez, 2017). Sustainable use of water in this industry will lead not only to economic benefits in terms of reduction of costs associated with consumption of water but also environmental benefits in terms of minimal use of water resources to the horticultural processing sector.

Proper management of water in the fruits and vegetable industry is mostly reliant on pecuniary motivations as governed by regulation. The dispersed nature of the MSMEs in the food industry depicts diminished capability for setting up their own waste water treatment system thus heightening the significance of effective water management given that water is a scarce resource (Sánchez *et al*., 2011). Case in point is Botswana whereby the government has executed policies such as Botswana National Water Policy (BNWP) that aims at promoting sustainability, equity and efficient usage of water as a crucial resource (Botswana National Water Policy, 2012). Water recycling and raising water conservation awareness are examples of some other measures that have been put in place to decrease water scarcity (Farrington, 2015).

MSMEs viewed in entirety have a significant environmental as well as social impact (Revell *et al*., 2011) and therefore these enterprises should begin to adopt more sustainable behaviours and a long-term vision to design environmentally and organizationally sustainable processes (Shankar *et al*., 2017). Utilization of the best available technologies as well as application of a structured water management strategy could bring about a decrease of about ninety percent in the demand of fresh water due to the reuse of water used for processing (Ölmez, 2017).

2.11 Role of MSMEs in Attainment of Sustainable Development

Sustainable development has advanced into a concept that is transformational (Bruntland, 1987) thus constantly indicating its capacity to reform the manufacturing industries globally regardless of their industrial affiliation, location and size of these enterprises (Despeisse *et al*., 2012). For manufacturing enterprises, the concept of sustainable development is concerned with ensuring that manufacturing systems as well as practices respond to the requirements of the three components of sustainability that is ecological or planet, social or people and economic or profit (Elkington, 1997). Sustainable energy is one of the guiding principles of sustainable development with reference to consumption of energy by humanity (Bruntland, 1987).

The academic literature has categorised the sustainable energy approaches into efficient methods of energy consumption and cleaner methods of energy consumption (Sáez-Martínez, Lefebvre, *et al*., 2016). Since the recognition of the sustainable development concept globally, it is only the large manufacturing enterprises that have contributed albeit scantily to the mere environmental dimension of sustainability (Petrini and Pozzebon, 2010; Schoenherr and Talluri, 2013). MSMEs in contrast have continued to lag behind in the adoption of holistic approaches geared at sustainable production as well as reporting (Kurapatskie and Darnall, 2013). This lagging behind can be attributed to lack of knowledge and resources to enable MSMEs adopt the approaches that will lead to sustainable production therefore MSMEs will largely adopt short term approaches that will require minimal capital investment and shy off from adopting long term approaches which has long term benefits but require capital investment.

Sustainable development has been studied but with a bias towards large enterprises whilst research on MSMEs has garnered minimal attention (Johnson and Schaltegger, 2016; López-Pérez *et al*., 2018). In addition, with reference to the MSMEs collective effect on the environment, social and economic areas, they are crucial to progressing the SDGs established by the United Nation (UN)

(Khattak, 2019). The contribution of MSMEs towards the economy cannot be ignored, they are a source of employment thereby providing livelihoods to the many people employed by MSMEs either directly or indirectly, contributes to the GDP of a country and can either impact the environment positively or negatively while interacting with the environment to obtain raw materials required to undertake its business activities.

MSMEs are key in attainment of SDGs goals 1 (no poverty), 2 (zero hunger), 8 (decent work and economic growth) and 12 (sustainable consumption and production). MSMEs contribute about 50% of global gross value added and from 16% to about 80% of GDP depending on a country's economic structure (IEA, 2015). MSMEs are key in processing of horticultural products to minimise wastage and loss thereby increasing the shelf life of products and contributing to food security. MSMEs are a source of employment to not only the urban population but also the rural population thereby contributing to economic growth as well as sustainable livelihoods. In addition, MSMEs contribute to attainment of SCP through minimising use of resources (in this case energy and water) thus attainment of resource use efficiency.

The principle of sustainable energy according to the Brundtland report definitions is based on three criteria for determining the sustainability of an energy source that is environmental (minimizing hazardous waste generation as well as greenhouse gas emissions), economic (energy cost and impact of jobs related to energy production) and socio-culture (long-term availability of energy, energy security) (Bruntland, 1987; Prashar, 2019). Energy sustainability encompasses the utilization of energy throughout all its facets in a way that supports the varied aspects of sustainable development. Therefore, energy sustainability is an all-inclusive concept that goes beyond the usage of sustainable energy resources thus can be deemed as a constituent of the general sustainability. There is no globally recognized definition for energy sustainability; however, various authors have put forth various definitions that can be used.

Thus, a general definition can be advanced by widening definitions of sustainable development or sustainability (Rosen, 2021). For instance, according to (Karunathilake *et al*., 2019), sustainability in energy is defined as energy that is produced and utilized in a manner that it "meets the needs of the present generation without compromising the needs of the future generations to meet their own needs". According to (Rosen, 2021), energy sustainability is defined as the provision of energy related services for all persons presently as well as in the future in a way that is sustainable that is sufficient to meet the basic needs, not detrimental to the environment overly, affordability by all persons as well as acceptable to people together with their communities. From these two definitions, a key aspect of energy sustainability is ensuring provision of energy related services to the present generation as well as the future generation, also access, affordability, environmental safety and acceptance are key aspects of energy sustainability. The three components of sustainability that is economy, social and environment are reviewed in relation to MSMEs.

2.11.1 Economical aspect of sustainability in relation to MSMEs

Industrial MSMEs account for over 99% of the total number of companies in a majority of countries globally. In the EU, about 7 million employment opportunities have been created by 23 million MSMEs. Thus, industrial MSMEs are not only energy intensive but they are also the major economic drivers with respect to innovations, growth of GDP, exports, employment and investments (Thollander and Palm, 2013). In a majority of the developing and emerging economies, small and medium enterprises have a huge contribution to the employment for instance in a majority of developing and emerging economies, over fifty percent of the overall jobs created in the private sector can be credited to the MSMEs with less than one hundred employees (ILO and GmbH, 2013). MSMEs are an integral part of economies worldwide thus increasing their energy efficiency will bring about a lot of value to societies, economies as well as to the enterprises themselves (Henriques and Catarino, 2016).

Small and Medium Enterprises (MSMEs) have been acknowledged as the largely significant business section in developing countries mostly due to their numbers, collective size and responsibility in sustaining economic stability through provision of employment opportunities for its citizens (Ayyagari *et al*., 2014). MSMEs account for over ninety percent of businesses globally in Europe (European Commission, 2019) as well as ninety nine percent of the private sector business (Jamali *et al*., 2017). Micro, small and medium enterprises (MSMEs) are regarded as a source of job creation, economic progression and social change (KNBS, 2016). This exemplifies the crucial role played by MSMEs in the economy with respect to creation of employment opportunities and contribution towards the GDP of a country. In the absence of these MSMEs the economies of many countries will be adversely affected.

According to the MSME survey carried out by the Kenya National Bureau of Statistics in 2016, approximately 14.9 million people are employed in these enterprises. Generally micro enterprises accounted for the 81.1% of jobs reported in the MSMEs. Kenya has a total of 7,410,700 MSMEs (both licensed and unlicensed) and out of this 874,000 MSMEs are classified in the manufacturing division. A further breakdown of selected top economic activities at 2-digit International Standard Industrial Classification (ISIC) division indicated that 38,120 MSMEs are classified as involved in the manufacture of food products (KNBS, 2016).

Manufacturing includes either the chemical or physical alteration of substances, materials or components. The components, or materials or substances altered are raw materials that are products of agriculture, forestry, fishing, mining, quarrying and products of other manufacturing activities. Considerable transformation, reformation or rebuilding is commonly deemed as manufacturing. Processing of fruits and vegetables falls under division 10 of ISIC that is manufacture of food products (United Nations, 2008).

There are more than two hundred fruits and vegetables exporters in Kenya and the majority of these comprise of micro, small and medium enterprises and approximately 20% of large companies (Embassy of the Kingdom of Netherlands, 2017). An MSME is defined as enterprises that employ less than 250 persons and have an annual turnover not more than Euro 50 million and/or an annual balance sheet that doesn't surpass Euro 43 million. An MSME with 1 – 9 employees is categorised as a micro enterprise, 10 – 49 employees as a small enterprise and 50 – 250 as medium enterprise (European Union, 2015). The detailed definition of MSMEs is provided in Table 2.

Table 2 Definition of MSMES according to European Union

Indicator	Size class		
	Micro	**Small**	**Medium**
Head count	<10	10<50	50<250
Annual turnover	≤ 2.2 million USD	≤11 million USD	≤ 55 million USD
Annual balance sheet total	≤ 2.2 million USD	≤ 11 million USD	≤ 47 million USD

Source: European Commission 2015

Organization for Economic Cooperation and Development (OECD) defines small and medium enterprises as non-subsidiary, independent companies that hire less than a defined number of employees. This number varies across countries globally; in the European Union it is 250 employees, in New Zealand the upper limit is 20, in China 1000, in the US it is 500 (IEA, 2015) and in Kenya it is 100 (KNBS, 2016).

MSMEs are significant drivers of economies globally. In the European Union, they create 1.1 million new employment opportunities yearly and 30% of the GDP generated can be attributed to them. In spite of scarce resources, they also propel innovation by carrying out close to 20% of research and development (R and D) in the European Union as well as United States; in some OECD countries like Poland, Norway, Portugal and Iceland over half of R and D can be attributed to them (OECD, 2013). In Africa, 90% of businesses can be attributed to MSMEs and they contribute close to 50% of GDP. In Kenya, MSMEs create 50% of the new employment opportunities, 80% of the labour force is attributed to them and contribute 40% of the GDP (Kamunge and Tirimba, 2014).

A number of studies have further established that enterprises have an inclination towards activities leaning towards sustainable development but only if its's favorable to them and not disadvantageous to their financial interests (Woo *et al*., 2014). The major significant factor to enterprises that helps them in making a decision on whether to be proactive enterprises are the financial implication of obtaining new technology, new facilities and processes essential for environmental activities (Cheruiyot and Tarus, 2016; De Clercq and Voronov, 2011). Even in light of the benefits that can be enjoyed by MSMEs when they implement environmental measures, they are still hesitant to implement these environmental activities due to insufficient resources (Wilson *et al*., 2012). Other researchers have established that MSMEs often face challenges in adopting environmental practices due to both limited awareness of the benefits from adoption of the practices and insufficient resources (Brammer *et al*., 2012).

2.11.2 Social aspect of sustainability in relation to MSMEs

Energy sustainability is a major point of deliberation in relation to anthropogenic activities as well as the progression of society and further widely civilization (Rosen, 2021). The business-as-usual approach in use of energy has notable effects on not only people but the environment as well (United Nations, Department of Economic and Social Affairs, 2015). Some of these effects include:

dependency on energy together with its security and political implications; effects on the environment which includes pollution as well as the subsequent effects on public health in addition to climate change as a result of anthropogenic activities. Noteworthy factors which have an influence on the advancement of the use of energy are the constantly urbanizing and increasing global populace, accompanied by rising standards of living (United Nations Environment Program, 2020).

The services provided by energy create a conducive environment for not only good standards of living but also supports development of societies (Rosen, 2021). Majority of nations presently utilize energy in a way that is not sustainable (Baleta *et al*., 2019). Significant economic, environmental and social challenges are linked to energy. There is need for these challenges to be addressed sufficiently as part of attaining sustainable energy use even though the process can be challenging as well as complex. Some of the noteworthy challenges relate to social inequality, excessive consumption of resources, climate change together with the ecological and environmental effects of other emissions in addition to limited affordability of energy. Further, standards of living and wealth, culture, level of urbanization and population many a times vary among countries thereby additionally influencing energy sustainability (Rosen, 2021).

2.11.3 Environmental aspect of sustainability in relation to MSME

Energy resources are gotten from the environment. Some energy resources are renewable whilst others are non-renewable because they are finite in quantity. Energy systems in a majority of nations today are majorly spurred by fossil fuels however, utilization of renewable energy is on the rise (Karunathilake *et al*., 2019). Conservation and efficiency are key constituents of energy sustainability. The concept of sustainability encourages every generation to meet its energy needs without compromising the energy needs of the future generations. The focus of energy sustainability is long term energy policies and strategies that will ensure sufficient energy to meet the needs for today and tomorrow (Abolarin *et al*., 2013). Some of the benefits that are linked to energy conservation and efficiency include reduction in operating cost, energy consumed, duration of replacement of lighting fixtures, improvement in energy performance of buildings and the heat generated by the incandescent bulbs (Halonen *et al*., 2010). Others include contribution to the fight against greenhouse gases and participation in the global energy (Abolarin *et al*., 2013).

Even though there are immense economical paybacks as a result of manufacturing, this sector exerts huge amounts of stress on the environment due to its significant dependency on energy and materials from the environment. For example, the air is polluted with greenhouse gases (GHG) whenever combustion of fossil fuels occurs so as to produce energy or resource as well as indirectly when fossil fuels are used to generate the electricity (Duflou *et al*., 2012). Further there has been increased pressure on the manufacturing sector to minimize energy use and consequently the harmful effects that energy as well as the utilization of materials or resources have on the environment (Bunse *et al*., 2011).

It is imperative that the manufacturing sector accepts the responsibility for exerting increased pressure on the environment. This sector has a huge environmental burden linked to it; the sector is characterized by consumption of both non-renewable and renewable resources for example water and fossil derived materials together with notable quantities of energy thereby causing considerable stress on the environment (Duflou *et al*., 2012).

2.12 Legal and Regulatory Framework Globally

2.12.1 Energy efficiency policies for Micro, Small and Medium Enterprises globally

In a number of countries, small and medium sized enterprises (MSMEs) account for over 99% of the number of companies and 60% of employment (DEXMA, 2016; Thollander *et al*., 2019). Therefore, this sector consumes energy, is a significant player in the economy with respect to GDP, exports, innovations as well as creation of employment opportunities. Even though MSMEs are significant in the economy, they haven't gotten a great deal of consideration in the energy policy activities of most countries (Thollander *et al*., 2019).

MSMEs are widely acknowledged as difficult for energy policy and this is because of their diverse nature; they operate virtually in all sectors, in every property type and vary from one-person operations without a business premise to manufacturers with up to 250 employees. Furthermore, their energy usage isn't understood well; evidence on why, how much and where it's used is insufficient (Hampton and Fawcett, 2017). A recent study by International Energy Agency (IEA, 2015) estimated that MSMEs collectively use over 13% of the energy globally and that significant opportunities exist for implementing (EEMs) with a potential saving of up to 30%. However, in many priority areas such as energy efficiency and low carbon heat, MSMEs are poorly addressed by existing policies (Committee on Climate Change, 2016).

In Japan, subsidies for energy efficient investments have been implemented since the late 1990s and the total budget for energy efficiency investment subsidies is roughly USD 2 billion in recent years (Kimura, 2017). Amongst them, the largest program for industrial and commercial sectors is named 'Support program for enhancing energy efficiency investments' which was started way back in 1998 and its budget recently is approximately between 400 and 500 USD million. The program subsidizes energy efficiency projects which install new or improves existing industrial equipment and systems for instance boilers, furnaces, cogeneration systems as well as energy management systems. Projects that qualify are subsidized by one third up to one half of their investments while they are required to achieve energy savings of more than 1% of the firm's energy consumption or more than 10.8 GWH, that is 1,000 kiloliters on crude oil equivalent compared to the baseline (Kimura, 2017).

Energy audit programs are the most common policies used in industrial MSMEs and non-energy intensive industries while for large and energy intensive industries long term agreements (LTAs) or voluntary agreements (VAs) are more common (Bertoldi *et al*., 2005). Selected countries in the European Union (EU) member states, that is Germany, Italy, Ireland and Sweden that were studied by (Thollander *et al*., 2019) apply some form of investment subsidy to promote uptake of industrial EEMs that form a backbone of industrial energy policy.

Italy which is among the countries studies also relies on a 'white certificate scheme' whereas Japan relies on both the energy Conservation Law and the VAP Keidran. All the studied countries apply separate energy audit policy schemes for industrial MSMEs and two countries, Sweden and Germany, also apply energy efficiency implementation networks as key policy programs for the sector (Thollander *et al*., 2019). Notably energy efficiency networks as a form of energy management support for industrial MSMEs seem to only be present in two countries, that is Germany and Sweden (Durand *et al*., 2018; Carlén *et al*., 2016).

If results of the energy efficient networks as indicated by the energy efficiency policy program initiatives are as good as the current research states, i.e., about twice as high a degree of improved energy efficiency compared with a stand-alone energy audit program, such a policy initiative is suggested to also be used as an argument for undertaking pilot studies in other parts of the world as well.

2.12.2 Water efficiency policies for Micro, Small and Medium Enterprises globally

MSMEs which are actively involved in the agriculture's value chain have the potential to contribute to water savings through increment of productivity of food crops, improvement of water management practices as well as technologies, implementation of sustainable practices in agriculture as well as growing of lesser crops which are water intensive crops. Capacity building and awareness raising for businesses and farmers is essential to changing these practices (DESA, 2019).

Water efficiency standards present a key unexploited opportunity globally for promoting resource efficiency policies, addressing water scarcity and mitigating carbon dioxide emissions thereby playing a main part in the advancement of sustainable development (CLASP, 2021). In the European Union, the member states are bound by Article 9 of the European Water Framework Directive that requires the implementation of pricing policies that incentivize users to use water efficiently. The directive further requires that resource costs and environmental costs are included to comply to the 'polluter pays principle' so that the true value of water is reflected. This means that all person who put a demand on the water environment including domestic consumers are required to pay for the full cost of these services to ensure sustainable management of water resources in the long term. (CIWEM, 2016).

Kenya could borrow a leaf from this directive from the European Union so that water is truly valued in Kenya and ensure that what consumers pay commensurate to the true value of water. There is quite a huge pricing discrepancy between energy resources and water leading to the underpricing and under valuation of water resources thus even in the manufacturing industry more effort has been put towards EEMs compared to water efficiency measures.

In England, the Water Act 2014 has placed a new primary duty of resilience on the Water Services Regulatory Authority and requires it to "*promote measures to manage water sustainably and reduce demand so as to reduce pressure on water resources*"(Government of United Kingdom, 2014). Subsequently the Water Services Authority's strategy to setting prices of water as well as incentives for water companies has recently been amended. In Wales, the Government published recently the Water Strategy for Wales and plans to evaluate as well as consult on options that will encourage decrease in water consumption and further carry out investigation into the costs together with benefits of metering (CIWEM, 2016). Again, such policies can be replicated to Kenya whereby the Water Resources Authority can be tasked to ensure that all consumers of water adopt water efficiency measures that will help in reducing the burden on water resources. Metering and sub metering should also be made mandatory to allow for effective monitoring of water use.

In Botswana the government, has put in place policies such as Botswana National Water Policy (BNWP) (Botswana National Water Policy, 2012) that purposes at encouraging equity, sustainability and efficient usage of water as a crucial resource (Selelo *et al*., 2017). Policies that specifically target water efficiency measures should be formulated and enforced as in the case of Botswana National Water Policy so as to encourage minimization and efficiency in water consumption.

2.13 Legal and Regulatory Framework in Kenya

There are a number of policies that have been formulated and documented and these give a framework and guidance to the agro-food chain in Kenya. It's noteworthy that some of these policies have not been gazetted yet even though they are largely used as reference in the horticultural sector. This research will review only policies which are most relevant to energy and water use practices by horticultural processing MSMEs.

2.13.1 Water Act 2016

Water Act, 2016 came into law in October 2016 after the 2014 Water Bill was assented into law thereby repealing the Water Act, 2002. The Act states that its essential function is to regulate, manage as well as develop water resources, water supply and sewerage services and related purposes.

This Act gives direction on regulation, managing and improvement of water resources in line with the Constitution. The Act establishes the Water Resources Authority (WRA), the National Water Harvesting and Storage Authority (NWHSA), the Water Services Regulatory Boards (WSRB), the Water Sector Trust Fund (WSTF) and the Water Tribunal. WRA is a regulatory authority with the mandate of issuing permits among other functions. The Act further states that all water resources are bestowed on the national government and held in trust for its citizens.

The WRA which was established in Section 11(1) of the Water Act 2016 is mandated to serve as an agent of the national government, regulate the management and usage of water resources. The function of WRA include formulation and enforcement of standards, procedures and regulations for the management and use of water resources; enforcement of regulations enacted under this act, receiving water permit applications for water abstraction, water use and recharge; determine, issue vary water permits and enforce conditions of those permits; collection of water permit fees as well as water use charges, determine and set permit and water use fees among others.

2.13.2 The National Water Policy (NWP) 1999

The NWP acknowledges that the insufficient advancement of reuse infrastructure as well as the health risks are the major barriers to the adoption of water reuse in Kenya. "*There have been various technologies in use within the water sector. Some of these technologies have proved to be unsustainable in the long run. Many water supply and reuse schemes are currently non-operational while others are operating at a very low level. It is quite evident that among the reasons for this state of affairs is the choice of the wrong technology, which the beneficiaries or those charged with the responsibility of operating the water supplies do not understand"* (Sessional Paper No. 1 of 1999 on The National Water Policy on Water Resources Management and Development, 1999).

In relation to water reuse, it is evident that the policy environment in Kenya generally recognises the importance of water reuse (Wakhungu, 2019). However, this is not enough. The Government of Kenya needs to go a step further and come up with a comprehensive framework that provides guidelines on water reuse especially for manufacturing industries. The mere presence of statements related to water reuse is quite ambiguous in that it is upon the manufacturing industries to decide on whether to reuse water or not.

The existence of a comprehensive policy framework on water reuse will provide guidance to industry, ensuring their compliance as well as appointing institutions in charge of overseeing water reuse to ensure adherence to water reuse quality standards. The comprehensive water reuse policy should also contain subsidies and incentives to encourage the manufacturing industries to invest in water reuse infrastructure.

2.13.3 The National Environment Policy (NEP) 2013

The National Environment Policy (NEP) proposes a wide range of measures and actions that seek to address important environmental challenges and issues such as unsustainable trends in consumption and production, environmental degradation, high rate of population growth among others. The environment together with its natural resources are valued national assets that necessitate sustainable management for not only the present generation but the future generation as well (Republic of Kenya, 2013).

Majority of the provisions for reuse of water in Kenya falls under the environment and natural resources together with the water and irrigation sectors (Wakhungu, 2019). The NEP in its policy statement recognizes the need for ensuring the quality of the reused water to avoid risks to human health. '*Ensure safe water for all through prevention and minimization of health risks related to a water source, drinking water, recreational water, wastewater and water reuse*'.(Republic of Kenya, 2013). This framework therefore provides for reuse of water in the horticultural sector so as to reduce on unsustainable consumption of water resources for processing; what is needed is frequent and regular tests and checks to ensure the quality of the water for reuse. Water reuse should therefore be enforced in the horticultural processing sector given that this sector intensively consumes water yet Kenya has been classified as a water scarce country.

2.13.4 Energy Act, 2019

The Energy Act, 2019 came into effect on March 28, 2019 thereby repealing the Energy Act, 2006 (the repealed Energy Act), the Geothermal Resources Act, 1982 and the Kenya Nuclear Electricity Board Order No. 131 of 2012. This act consolidated all the laws related to energy in Kenya. The new act contains several amendments to the repealed Energy Act that are meant to consolidate all the laws related to energy in Kenya, to effectively define functions of the national and devolved levels of government with respect to energy, to provide for the utilization of renewable energy sources, supply as well as use of electricity plus other forms of electricity, regulation of midstream and downstream petroleum and coal activities.

The new act is cognisant of the changing environment of energy regulation in Kenya by acknowledging the different sources of renewable energy as well as creating the corresponding licensing and regulatory agencies in addition to a dispute resolution tribunal. The new entities created are Energy and Petroleum Regulatory Authority (EPRA), the Energy and Petrol Tribunal (EPT), the Rural Electrification and Renewable Energy Corporation (REREC) and the Nuclear Power and Energy Agency (NPEA).

The EPRA succeeded the Energy Regulatory Commission (ERC) which previously exerted regulatory control over the energy sector. The EPRA will continue to hold regulatory control over the whole of the energy sector save for licensing of nuclear facilities and regulating downstream petroleum. The Energy and Petroleum Tribunal (EPT) which succeeded the Energy Tribunal has a wider mandate. The new act provides that EPT can hear and resolve disputes and appeals related to energy and petroleum that might crop up from the Energy Act as well as any other written laws. The new act also provides a comprehensible legislative framework which was lacking before that guides EPTs conduct of its business procedures.

REREC replaced Rural Electrification Authority. In addition to rural electrification, REREC has the added mandate of renewable energy that sets it at the core of policy formulation, promotion of renewable energy use among the local population, global collaboration as well as research and development. Renewable Energy Resource Advisory Committee (RERAC) is an inter-ministerial committee meant to give advice to the cabinet secretary in charge on issues to do with allocating renewable energy resources, management of water towers plus catchment areas, issuing licenses to renewable energy resource areas, management as well as development of renewable energy resources and development of multipurpose project like dams and reservoirs.

The Nuclear Power and Energy Agency (NPEA) succeeded the Kenya Nuclear Electricity Board. NPEA has been mandated to continue with the Board's mandate of developing and implementing Kenya's nuclear energy programme. The new Act has further adopted the proposal put forth in the bill that all renewable and energy resources to be vested in the national government. Considering these resources are not equally spread out in the country, it's deemed appropriate to have them vested in the national government so that they can develop them to the advantage of all Kenyans and not just the regional county governments and communities where the resources are located.

Section 75 on renewable energy states that the cabinet secretary shall promote the development and use of renewable energy technologies including but not limited to biomass, biodiesel, bio-ethanol, charcoal, fuel wood, solar, wind, tidal waves, hydropower, biogas and municipal waste. Section 166 of the Act has established a system for penalising electricity suppliers and compensating consumers for unnecessary power outages or for their provision of inconsistent or poor-quality electricity that results into damages to consumers' properties, monetary losses or even loss of life.

Given that the Act has been passed into law, it is up to the diverse government stakeholders to take the lead in operationalizing the Act. The new sector entities established that is the EPRA, EPT, RERAC and NPEA transitioned and took over the entities replaced. The transition entailed renaming and giving a new title to themselves as well as adoption of their new mandates as contained in section 225 of the New Act and the Fourth Schedule to the Act. The Act further clearly defined the functions of the national and the county governments with respect to energy infrastructure.

The Act is cognisant of the need for energy efficiency and has outlined measures for industries to follow to help them attain energy efficiency. The Act has recognised the importance of energy audits and has outlined this in the act and has made a provision that if thought essential to energy use efficiency and subsequently its conservation, any designated consumer should ensure that an energy audit is performed by energy auditors who are accredited and submitted to the Authority. The designated user should also provide the Authority with the remedial action taken to comply to the accredited energy auditor's recommendations. Energy audits are essential to energy efficiency efforts therefore it is imperative that the entities charged with this mandate enforce this requirement of the Energy Act.

The functions of the national governments comprise energy regulation plus licensing, national policy formulation, operation and development of energy infrastructure specifically for natural resources-based energy. On the other hand, the roles of the county government consist of county energy planning together with regulation of energy operations like biogas and biomass licensing, production of charcoal, gas reticulation among others.

2.13.5 Kenya National Energy Efficiency and Conservation Strategy (NEECS)

One of the essential foundations of sustainable development in Kenya is Energy efficiency and conservation thus the Government of Kenya has regarded it as amongst the priority areas for improvement in her endeavours to improve the quality of life for her people. There are numerous benefits that Kenya will reap from improvement of energy efficiency and conservation such as improvement in energy security, reduction in expenditure of foreign currency, minimizing the strain on national grid during peak hours and lowering cost externalities linked to emissions.

The NEECS was developed to advance continuing efforts through provision of a road map that targets setting and achieving energy efficiency goals. The strategy has set two targets for the agricultural and industrial sector. There is expectation that this sector will increase the number of energy audits that is presently being carried out from 1,800 to 4,000. Execution of the recommendations of the audits is important to enable achievement of efficiency targets. Further there is expectation that this sector will implement the recommended energy conservation strategies so as to save 250 million liters of heavy fuel, 9 million liters of industrial diesel oil and 100MW of power demand in comparison to the current baseline of 51 million liters of heavy fuel, 1.8 million liters of industrial diesel oil and 20 MW of power demand saved (Republic of Kenya, 2020).

In order for the agricultural and industrial sector to achieve these targets, they should have 5 registered energy service companies (ESCOs) and 120 licensed energy auditors as well as from the baseline of 0 and 7 respectively (Republic of Kenya, 2020). This strategy has therefore placed an emphasis on the need of energy audits in the agricultural and industrial sector for the attainment of energy efficiency. Enforcement of energy audits in this sector is therefore crucial and plays a big role in the realization of energy efficiency in this sector. The first step towards energy efficiency is carrying out energy audits and then implementing the action plans as contained in the energy audit reports.

2.14 Theoretical Framework

2.14.1 Triple Bottom Line Theory (TBL)

The study was grounded on the Triple Bottom Line Theory which was advanced by John Elkington in 1994. Sustainability is becoming more and more an essential prerequisite for anthropogenic activities thus making sustainable development a key objective in human development. At the centre of sustainable development is the opinion that environmental, economic and social concerns ought to be dealt with concurrently and holistically in the development process. Making manufacturing sustainable demands an equilibrium and integration of economic as well as environmental societal objectives, supportive practice and policies (Rosen and Kishawy, 2012).

There is a growing need by businesses to give to the society both environmentally and socially as well as upholding financial profitability and these three components has slowly turned into a focal point for businesses. This concept which has been defined as sustainability has for a long time been linked to the TBL which aims to put in sync the environmental, social and financial outcomes of a business (Gupta and Kumar, 2013). This points to the increased awakening of businesses towards sustainability issues. The focus of businesses is no longer solely profits rather it is to ensure that their profitability is in tandem with the environment and society as well and this will lead to sustainability of such businesses.

The concept of sustainable development can be traced back to 'Our common Future' which was published in 1987 following the World Commission on Environment and Development and the UN Conference on Environment and Development (UNCED) which was held in Rio de Janeiro in 1992 whereby sustainability was defined as "*development that meets the needs of the current generation without compromising the needs of the future generation to meets its own needs*". This concept entails integration of environmental thinking into all aspects of economic, political and social activities and has turned out into a focal point of the environmental debate (Bruntland, 1987).

Sustainability has repeatedly been cited as an aspiration of businesses, non-profits and governments in the last ten years however, gauging the extent to which an organization is sustainable or in pursuit of sustainable growth might be complex. Spreckley in 1981 pioneered the idea of TBL in a paper in which he particularly outlined what enterprises or "socially responsible enterprises" should include in their performance assessment. In 1994, John Elkington invented the phrase "triple bottom line" in his book *Enter the Triple Bottom Line* (Sitnikov, 2013). It has become more evident that businesses have to take up a fundamental responsibility in attaining the goals of sustainable development strategies (Elkington, 1994). The concept of "Triple Bottom Line" was introduced by John Elkington whereby he expounded on the notion that sustainability for a company entails adopting a triple objective that is being socially beneficial, environmentally responsible and economically viable, and everything is cantered on a win-win-win situation for environment, society and business (Elkington, 1994).

TBL is an accounting framework that includes three measures of performance that is social, environmental and financial hence is different from the conventional methods of reporting since it incorporates ecological or environmental and social measures which may be hard to allot suitable ways of quantification. The TBL dimensions are often referred to as people, planet and profits i.e. 3Ps. The triple bottom line (TBL) went past the habitual determination of profits, return on investment and shareholder value and went on to include environmental as well as social dimensions (Francisco and Moura, 2017; Slaper and Hall, 2011).

TBL accounting has widened the traditional reporting structure to take in ecological and social performance on top of economic performance. In addition, the idea of TBL underlies companies that have a duty to its shareholders as well as broader array of stakeholders plus the environment. Stakeholder in this context refers to any person or group whom might be affected either indirectly or directly by the activities of the company. TBL is related to the manner in which an organization is interested with and keeps records on all its progress and outcomes in appreciation of the people, planet and profits. There is no distinctive commonly recognized definition of TBL reporting, it can be generally described as corporate contact with stakeholders and this portrays the strategy of the company in managing the economic, environmental and social scope of its actions (Sitnikov, 2013).

(Sitnikov, 2013) goes to further state that given that it's also deemed as corporate social responsibility even though others prefer to refer to it as sustainability. Before the introduction of the sustainability concept as "triple bottom line" by Elkington environmentalists had been grappling with quantification and structures of sustainability. The 3Ps don't have a universal measurement unit. There's neither a generally acceptable standard for calculation of the TBL neither is there a universal acceptable standard for the three components that encompass each of the three TBL categories. This may be regarded as a strong point since it permits users to customize the broad structure to the needs of different entities that is businesses or non-profit organization, various projects or policies; or diverse geographic boundaries (cities, regions or countries) (Slaper and Hall, 2011).

According to (Evans *et al*., 2017), economic value forms consist of profits, investment returns, financial sturdiness, long term viability and business security. Social value forms include labour standards, equity and diversity, community development, secure livelihoods, health and safety and well-being while environmental values comprise of reduced emissions, minimal waste utilization of renewable energy, pollution deterrence and biodiversity. The TBL and its core value of sustainability have become compelling in the world of business because of growing informal or unscientific proof of greater long-term profitability. For instance, reducing waste from packaging can consequently result into reduced costs (Slaper and Hall, 2011).

People (human resources/capital) is linked to proper plus favourable business conventions for employees, community and the locality in which a business undertakes its activities. A TBL company devises a matching social structure whereby the wellbeing of labour, corporate and other stakeholders are mutually beneficial, it aims at benefitting many groups and not to cause harm to any groups. Planet (natural resources/capital) is linked to sustainable environmental conventions. A TBL company tries to profit the natural setting to the maximum while ensuring no or minimal damage so as to decrease the environmental effect. A TBL approach will reduce its ecological footprint by efficient use of energy and non-renewable resources, reducing production waste plus converting waste into less toxic form before its disposal in safe and regulated way (Francisco and Moura, 2017; Sitnikov, 2013).

Profit is the economic value produced by the company after deducting the costs of all the materials and it includes the cost of the capital invested. It is the visible economic effect the company has on its economic location and is often confused with being related to the internal revenue generated by the company (Francisco and Moura, 2017; Sitnikov, 2013). Thus, an original TBL approach can't be described as just traditional corporate accounting revenue plus social and environmental impacts unless the "profits" of the other bodies are included and understood as social benefits. The three measures of TBL stand for society, economy and environment. The community is dependent on the economy whereas the economy is dependent on the global ecosystem (Sitnikov, 2013).
The TBL concept is presented in the Figure 5.

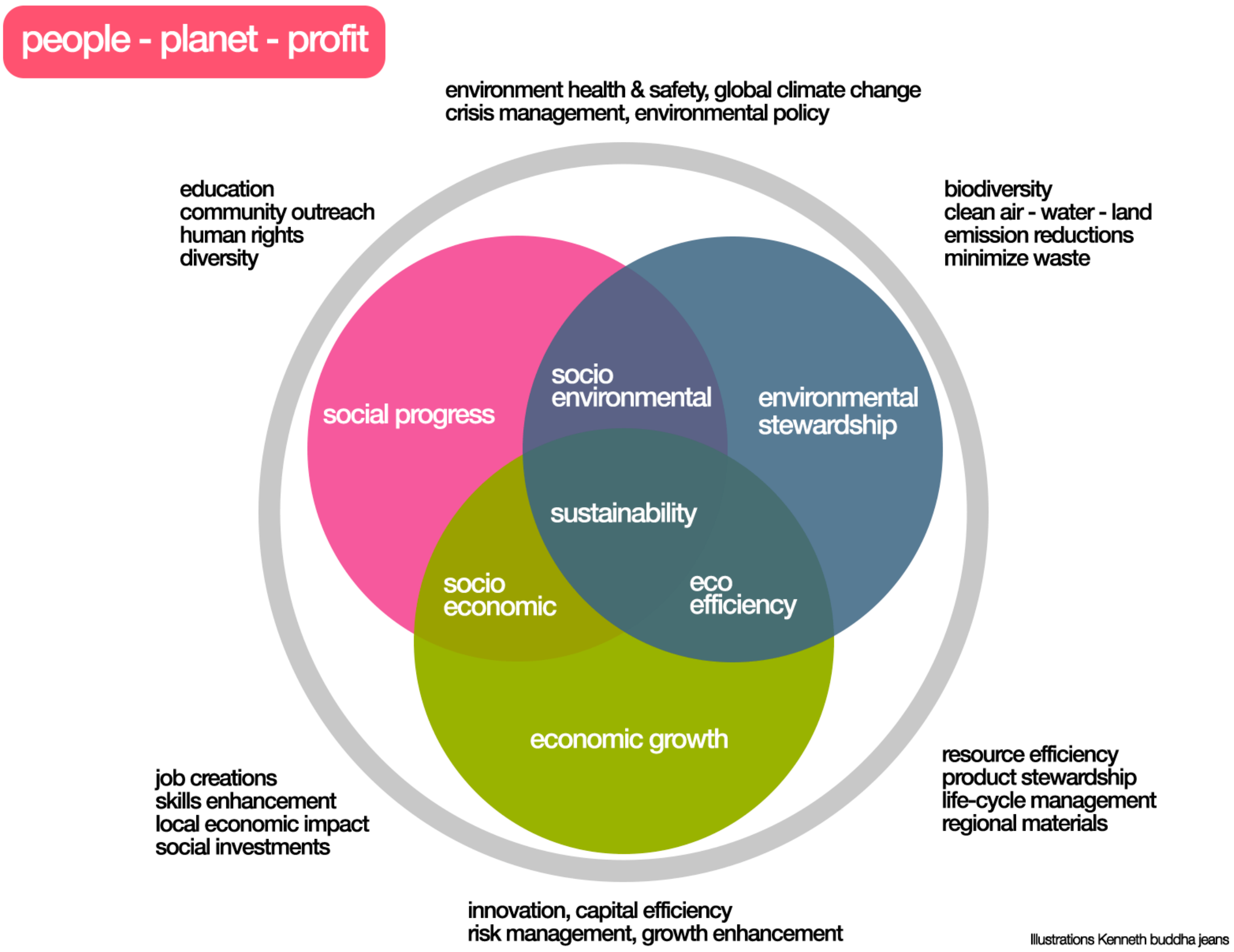

Figure 5 Triple Bottom Line Sustainability Accounting (Adapted from Lyngaas, 2013)

The triple bottom line provides a comprehensive framework of how businesses should refocus and expand on their priorities. It is no longer sustainable for business to only focus on their financial profitability, but also take into consideration how their businesses activities impact on the environment and society as well. The businesses depend on the environment for raw materials and location for its business. The society is dependent on the business for employment and economic growth while the economy is dependent on businesses for growth and prosperity. When one of the components is operating sub optimally the other two components will be negatively affected. Therefore, it is important that a business takes into consideration the society and environment and this it can do by incorporating these two as part of its corporate social responsibility.

2.14.2 4Ps (People, Planet, Profit and Practices)

Based on the triple bottom line sustainability model the researcher has modified this model to come up with quadruple bottom line sustainability model or the 4Ps that is People, Planet, Profit and Practices. The researcher recommends that practices be added to the triple bottom line sustainability accounting model because without sustainable practices the industries will not be able to achieve energy and water use efficiency and thus sustainable consumption and production will not be achieved. Sustainable practices are the fourth component that needs to be incorporated into this model to ensure sustainability of the horticultural processing MSMEs.

In this proposed new model, Sustainability will be achieved when the 4Ps that is People, Planet Profits and Practices interact. Adoption of sustainable environmental practices will lead to environmental stewardship in that the activities of the MSMEs will have minimal environmental impacts, economic growth will be delinked from environmental degradation because of these sustainable practices that will enable MSMEs to integrate environmental concerns into their business activities. Further, there will be social progression as a result of sustainable livelihoods that will have minimal adverse impacts on the environment. Sustainable practices will enable horticultural processing MSMEs to sustainably consume resources (in this case energy and water resources) while producing horticultural products to meet the needs of the people thereby leading to sustainable consumption and production not only for the present generation but also for the future generations.

There is increased pressure from society and governments for businesses to be more sustainable as well as being responsible socially (López-Pérez *et al.*, 2018). Addition of practices into this model will enable MSMEs to integrate environmentally, socially while at the same time sustaining financial profitability thereby minimizing environmental, social and financial negative impacts of the businesses in their area of operations. The concept of the 4Ps sustainable accounting model is depicted in figure 6.

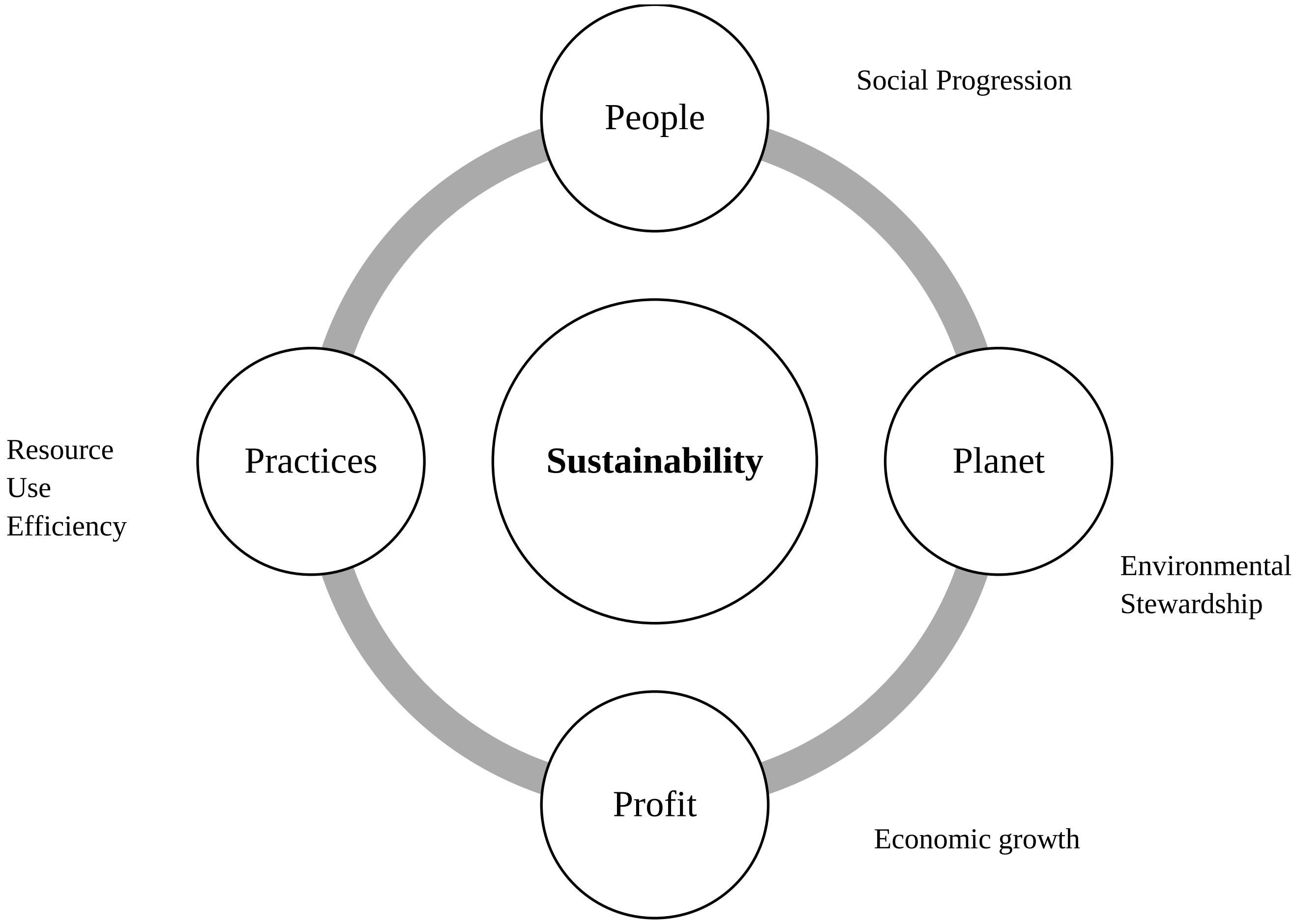

Figure 6 4Ps Sustainability Accounting Model
(Source: Researcher, 2022)

Larger enterprises as well as MSMEs produce social, environmental and economic impacts on the environment. The accumulation of these impacts is quite substantial in the immediate local environment where these enterprises undertake their business activities (Sarango-Lalangui *et al*., 2018). Therefore, sustainable practices are the key to minimizing adverse impacts from businesses thereby ensuring sustainability in the long run. Adoption of sustainable practices in the case of horticultural processing MSMEs will lead to resource use efficiency (water and energy) consequently leading to sustainable consumption and production and ultimately sustainability in the manufacturing sector. It's imperative to note that sustainability is instrumental in not only non-economic development of nations but also economic development as well due to the fact that it is a source of employment, creates new companies, improves processes and products as well as changing the lives of people (Szopik-Depczyńska *et al*., 2017). Therefore, nations should aspire to attain sustainability due to the many benefits it brings.

A typology of business sustainability has been proposed by (Dyllick and Muff, 2016) contingent on the exercised development level. In an ideal world, this would goad companies to alter the game by shifting from an inside out approach that is how businesses are making a contribution to some or none sustainability issues; to an outside in approach that is how companies are effectively making a contribution towards solutions to global problems (Tsvetkova *et al*., 2020). The typology makes use of the "*Business-as-usual: The Current Economic Paradigm as a starting point: Business Sustainability 1.0: (Refined Shareholder Value Management), Business Sustainability 2.0: (Managing for the Triple Bottom Line), Business Sustainability 3.0: (Truly Sustainable Business)"* (Dyllick and Muff, 2016).

Based on this typology developed by (Dyllick and Muff, 2016), Tsvetkova *et al.*, (2020) developed a matrix for the stages for sustainable development. This matrix contains four quadrants that is the capitalist model which is the initial point whereby sustainability is not looked at as the responsibility of the company; the sole focus is economic progression. The second quadrant has been identified as the situational development because of the companies practice of moving in the direction of sustainability whenever potential economic outcomes is dependent on this shift; in addition it is deemed relevant to adopt such an intitiative or strategy depending on demands from valued stakeholders. In the third quadrant, companies are intentional about development of their sustanability practices. These practises are intended to incorporate environmental concerns, economic prosperity and social issues or what is referred to as TBL in their day to day activities. The fourth quadrant which is radical development is deemed by (Dyllick and Muff, 2016) to be the game changer whereby sustainability is not only executed but is also regarded as important for business.

This is not to say that economic prosperity has been neglected but rather that by focusing on SDGs of the UN then it will result in financial viability.

The above exemplifies the importance of incorporating sustainable practices in business. When sustainable practices are incorporated into a business, economic, social and environmental benefits will automatically follow thus leading to sustainability of a business. Just like in the fourth quadrant which looks at sustainability as important for businesses, in the proposed model of 4Ps sustainable accounting model, sustainable practices constitute the fourth component needed to make a shift to sustainability of businesses. The other three components that is economic, social and environmental progression will automatically be achieved by incorporating sustainable economic, social and environmental practices in the daily routine or activities of a business.

It has been reported by increasingly more executives that the advantages of taking into consideration sustainability ensue to the society, environment and also to the individual companies in the form of intangible benefits such as increased competitiveness, increased brand reputation and increased attractiveness to talent/employees as well as tangible benefits such as minimised risks and costs of doing business (Kiron *et al*., 2013). If horticultural processing MSMEs were to adopt the 4Ps sustainable accounting model, they will reap benefits such as reduced energy and water bills, increased competitiveness due to sustainable consumption and production as well as green consumerism, in addition they will be able to attract the best human resource who can further their sustainability agenda.

2.15 Conceptual Framework

The conceptual framework represents the concept of resource use (energy and water) efficiency practices by horticultural processing MSMEs and the influencing factors that will determine the attainment of SCP practices. The independent variables in the study are resource use efficiency (energy and water use efficiency). Knowledge, attitude and practices, green training and analysis of energy and water used for horticultural processing are the dependent variables that will determine energy and water use efficiency practices. Knowledge, attitude and practices will determine the MSMEs energy and water use practices for horticultural processing; if they are knowledgeable and aware about the existence of such practices then they are likely to make use of these practices. Efficient use of energy and water will lead to efficient resource use and reduction of environmental impact of horticultural processing on the environment. Horticultural processing is energy and water intensive.

The intervening variables are organizational culture, awareness as well as availability and access to financial resources. There are measures that can be adopted by MSMEs at little or no cost for energy and water use efficiency in the short term. However, for gains to be made in the long term, access to and availability of financial resources is necessary to enable MSMEs make capital investments in either equipment or green technology, processes or building design so as to reap energy and water use efficiency in the long term thus ensuring sustainability in this sector. Further an organization's culture/awareness will also be instrumental in attainment of sustainable consumption and production. If an MSME is aware about the importance of resource use efficiency, it will put mechanisms and strategies in place to help it achieve SCP. Awareness or organizational culture can be seen in a company's environmental policy whereby the company is seen to have included measures that will help it to minimise adverse environmental impacts as it undertakes its economic activities. There are other variables that will affect the study. The decision by the MSMEs on whether to adopt resource use efficiency measures can be cited as the moderating variable

Efficient energy and water use practices (SCP) is the independent variable. Efficient use of energy and water will lead to a green economy that is an economy with lessened environmental risks and ecological scarcities and that targets sustainable development without posing harm to the environment. In such an economy economic growth will be delinked from environmental degradation. This means that industries can pursue their economic activities without negatively affecting the environment in which they operate in. The society will also be enjoying green employment opportunities and social progression as a result of the sustainable horticultural processing MSMEs who will also be able to give back to the society positively. The conceptual framework is illustrated in Figure 8.

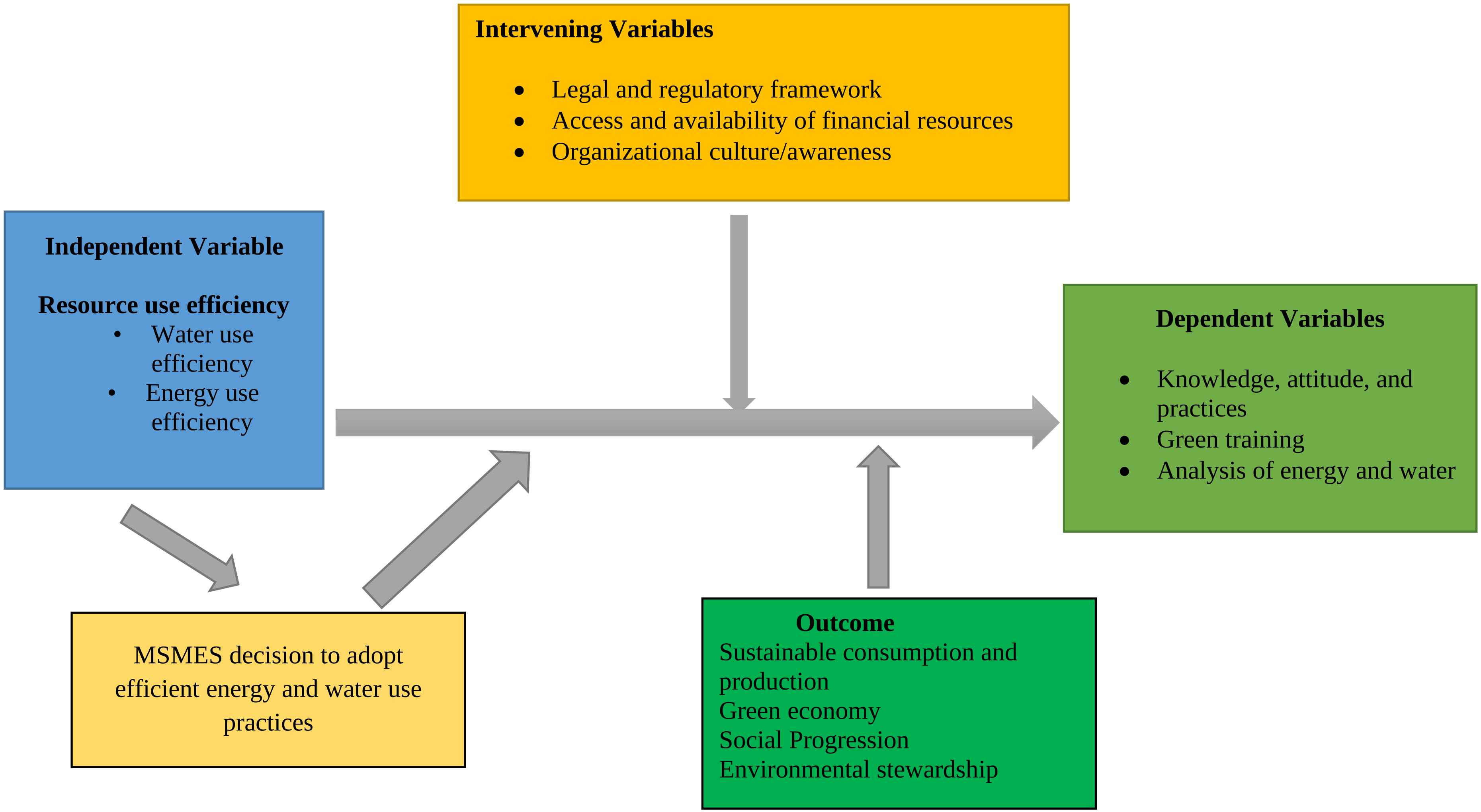

Figure 7 Conceptual Framework
(Source: Researcher, 2022)

2.16 Research Gaps

In the scholarly work on resource use efficiency in Kenyan horticultural processing MSMEs, there is scanty literature on energy and water use efficiency. Several studies have been done on the horticultural processing industry on consumption of energy and water for processing but there still remains a gap on sustainable energy and water use for horticultural processing. There is inadequate documentation of the energy and water use consumption patterns of horticultural processing MSMEs. The significant usage of energy and water together with its environmental impacts are less studied (Sanjuán *et al*., 2014). The energy use by MSMEs is not well understood, documentation on why, how much and where energy is used is inadequate (Hampton and Fawcett, 2017). Insufficient information on the energy cost can be a noteworthy hindrance to improvement on energy efficiency for a company (Mickovic and Wouters, 2020).

The major problem facing the horticultural industry is the inadequate data on the amount of water consumed at the particular phases of the processing line (Olmez, 2013). In order for an organization to improve on its energy and water efficiency, the initial crucial step is to determine how much, when and where energy as well as water are needed by different pieces of equipment in the company's manufacturing system (Mousavi *et al*., 2016). This information is crucial for the horticultural processing MSMEs to know the starting points where to start implementing energy and water use efficiency measures.

Performing an energy audit is an initial step in energy consumption optimization (Backlund & Thollander, 2015). Such knowledge can aid in forecasting consumption of energy in parallel to aid designing strategies in energy saving and the related measures (Kalantzis & Revoltella, 2019) Identification of opportunities to improve water use efficiency involves the employment of various water management strategies such as water audits. Water management strategies gives insightful understandings into possibilities of changes in processes that could lead to increased water use efficiency and ultimately water savings (Agana *et al*., 2013). Uptake of energy and water audits is quite low in MSMEs yet these audits will provide valuable information on potential for energy and water savings and improvement thereby improving on their resource use efficiency while informing policy as well.

This study evaluated the influence of the legal framework on energy and water use efficiency practices. The policy framework on energy efficiency is quite elaborate but enforcement on energy efficiency is lacking. Similarly, when it comes to water efficiency measures, the policies are not as quite elaborate and it is left to the industry to decide how to implement the water reuse practices. There is need for a water reuse policy to guide the industries in reusing water thus leading to sustainable consumption and production.

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CHAPTER THREE

ASSESSMENT OF KENYAN HORTICULTURAL PROCESSING MICRO, SMALL AND MEDIUM ENTERPRISES' KNOWLEDGE, ATTITUDE AND PRACTICES ON ENERGY AND WATER USE

Abstract

Horticultural processing involves intensive consumption of water and energy. It's unknown whether the current energy and water use practices by Micro, Small and Medium enterprises (MSMEs) are sustainable. This study was conducted to investigate knowledge, attitude and practices on energy and water use by horticultural processing MSMEs in Kenya. A cross sectional research design was adopted and purposive sampling was used to select 39 horticultural processing MSMEs. Data were collected using a structured questionnaire. The study found that the MSMEs had excellent knowledge on energy and water use efficiency. The study further found out that 75% of the respondents had a positive attitude towards the environment. Over 80% of the respondents had adopted simple housekeeping practices geared at conserving energy and water. Multiple linear regression indicates age has an effect on knowledge, attitude and practices (R^2=0.272, F=4.238, P=0.012). The other variables had a non-significant effect on knowledge, attitude and practices. Despite the high level of knowledge possessed by the MSMEs, they still have not adopted long term practices that will lead to sustainability in the long run. In addition, the findings from this study reveal that MSMEs are not sufficiently motivated to move from positive attitude towards energy and water use practices. Subsidies and rewards could help MSMEs adopt practices that will lead to sustainability in this industry in the long run.

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3.1 Introduction

The food processing industry is amongst the prime consumers of water and energy in the manufacturing sector (M. Compton *et al.*, 2018; Nikmaram and Rosentrater, 2019; Walker *et al.*, 2018). This industry is characterized by intensive consumption of water due to the various types of processes and unit operations which involves usage of water such as cleaning, cooling, pasteurizing among others. Moreover, good quantity and quality of water is crucial for food processing (Sánchez *et al.*, 2011). The major environmental issue to be resolved is the high rate of consumption of potable water. Adoption of a systematic method towards management of water could lead to 30% – 50% reduction in the total amount of water used in this sector (Ölmez, 2013).

In Europe the agro-food industry constitutes the major manufacturing industry and it accounts for 14% of the overall turnover which amounts to over 836,000 million euros. This industry is made up of over 30,000 companies within the European Union (EU) with the majority MSMEs with less than 250 workers. These MSMEs are a source of employment to about 2.7 million persons and constitute 48.5 percent of the overall production of the agro-food industry in the EU. In Spain, the agro-food industry is the lead industry in the industrial sector (Sánchez *et al.*, 2011). In low- and middle-income countries, the food processing and beverages is regarded as the most important subsector in the agro-industry and it accounts for over 50% of the total formal agro processing sector (Woldemichael *et al.*, 2017).

Demand for water globally is expected to exceed supply by over 40 percent by 2030 and by more than 50 percent in the developing countries especially in sub–Saharan Africa (Chellaney, 2013). A country is classified as water stressed if the per capita water availability is less than 1700 m^3 yearly. Kenya is amongst the countries regarded as severely water scarce globally with per capita availability below 1000 m^3 per annum (Jones, 2014). The continual growth of the population in Kenya's urban areas as well as the continued rapid urbanization of the rural areas has led to increased demand for water for industrial, domestic, as well as agricultural uses (Kibuika and Wanyoike, 2014).

In Kenya, electricity and petroleum are the major drivers of the economy whereas biomass is mostly consumed in the rural areas and a small section of the urban population. Nationally, wood fuel as well as other biomass account for close to 68% of the total primary energy consumption, followed by petroleum at 22%, electricity at 9% and other fuel sources as well as coal at 1%. Solar energy is mainly utilized for drying, heating and lighting (Government of Kenya, 2021).

The food industry globally utilizes approximately 200 exajoules annually (EIA, 2017; FAO, 2017). The various unit operations through which fruits and vegetables pass in order to obtain the final processed product require input of energy. This industry needs energy for heating, cooling and lighting (FAO, 2011a). Drying is an energy intensive process, heating and pasteurization operations require production of steam, large amount of electrical energy is needed for operation of electric motors as well as air compressors; boilers, sterilizers and heat exchangers operate at high temperatures whereas freezing and cooling operations demand extremely low temperatures (Patel *et al*., 2019). To perform these unit operations large amounts of electricity are needed and this translates to high operating costs for the MSMEs.

The energy use by MSMEs is not well understood, documentation on why, how much and where energy is used is inadequate (Hampton and Fawcett, 2017). The major problem facing the fresh cut industry is the inadequate data on the amount of water consumed at the particular phases of the processing line (Ölmez, 2013). In order for any shift towards sustainability be successful, it is imperative to comprehend the knowledge, attitude and practices (KAP) associated with sustainability in various populaces. The KAP model associates cognitive, affective and behavioural elements that are subject to interventions from communicative actions that intensify the level of knowledge, changes attitudes as well as improves practices (Salas-Zapata *et al*., 2018).

Generally, knowledge is deemed as an essential pre-requirement of someone's behaviour (Gifford and Sussman, 2012). Attitude refers to the evaluation of an object, concept or behaviour along a dimension of favour or disfavour, good or bad, like or dislike (Ajzen and Fishbein, 2000). Environmental attitude refers to caring about environmental issues or the concern for the environment and is also referred to as pro-environmental behaviour (Gifford and Sussman, 2012). Practices refers to particular activities that are directly associated with processes that are cognitive (knowledge) and affective (attitudes) to the extent that all human acts are consistent with their, beliefs, values, culture, understanding, and other socialization processes (Heimlich and Ardoin, 2008).

(Sáez-Martínez, Díaz-García, *et al*., 2016) studied factors encouraging environmental responsibility in European MSMEs. The focus of (Hoogendoorn *et al*., 2015) was what drives environmental practices of MSMEs. Attitude and awareness towards Environmental Management and its impact on Environmental Management Practices have been studied (Cassells and Lewis, 2011; Weerasiri and Zhengang, 2012) but the authors did not consider knowledge. Studies have been carried out on employees' pro-environmental behaviour in MSMEs (Banwo and Du, 2019; Fatoki, 2019); the focus of these two studies was an employee perspective. Environmental sustainability practices of MSMEs have been conducted (Domínguez-A. *et al*., 2015; Yusliza *et al*., 2020). (Ouma *et al*., 2021) studied knowledge, attitude and practices of MSMEs but their focus was on waste management. KAP study of energy conservation at workplace among employees has been carried out though of university employees (Seniwoliba and Yakubu, 2015) and not MSMEs.

The current study is unique in that to the author's knowledge, there is no study that has so far been done on knowledge, attitude and practices of horticultural processing MSMEs on energy and water use efficiency in Kenya. The study thus lays a foundation for other similar studies in Kenya and the rest of Africa.

3.2 Materials and Methods

3.2.1 Study area

The study was conducted in Kenya in Nairobi, Kiambu, Nyeri, Makueni, Laikipia, Nakuru, Murang'a, Embu, Meru, Kisumu, Homabay, Uasin Gishu and Vihiga counties and the study targeted horticultural processing MSMEs. Horticultural processing MSMEs refers to the MSMEs involved in the postharvest activities related to fruits, vegetables, medicinal, aromatic and ornamental plants including preservation, transformation and preparation of agricultural production for intermediary or final consumption. The study areas marked in red dots are shown in Figure 1.

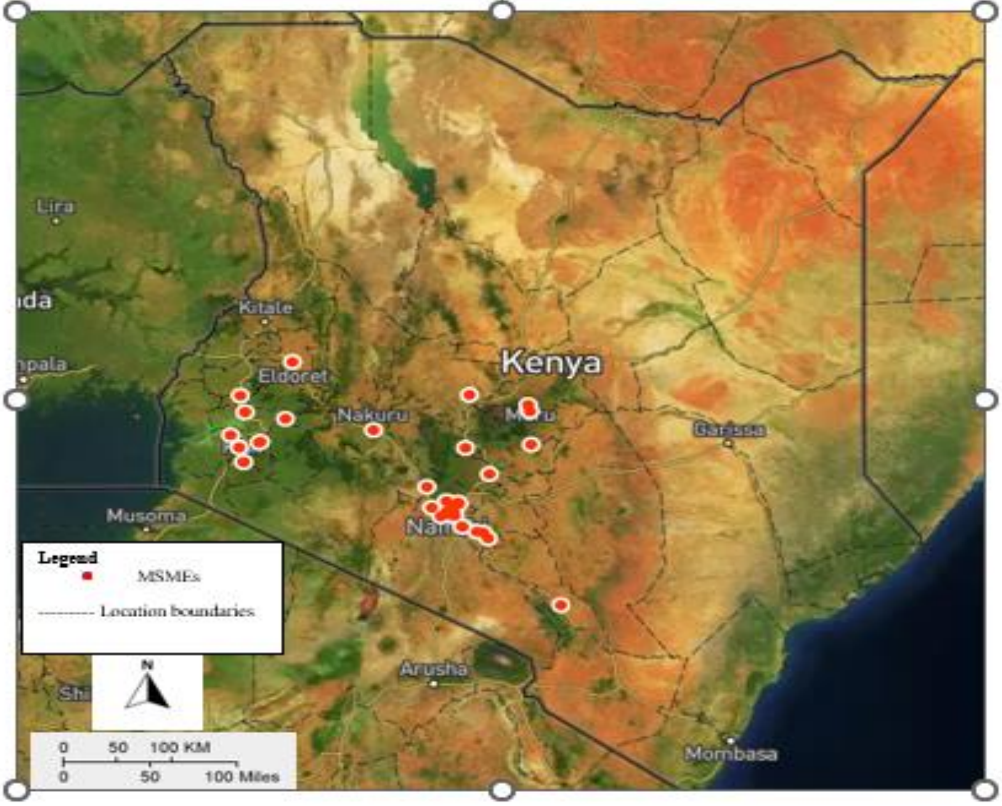

Figure 8 Map of Kenya showing the study areas marked in red dots
Source: ©Mapbox ©OpenStreetMap, 2022

3.2.2 Research Design

This study employed a cross sectional research design that enabled the researcher to collect data on knowledge, attitude and practices on energy and water use by horticultural processing MSMEs over a short period of time that may be regarded as a single point in time.

3.2.3 Sample size and sampling procedure

A baseline survey was conducted to establish the feasibility of this research work. Three hundred (300) MSMEs who met the prescribed criteria were identified from a sampling frame obtained from Kenya Bureau of Standards (KEBS) and trained on sustainable consumption and production practices on energy use efficiency, water use efficiency as well as waste management. These MSMEs were located in Nairobi, Western and Central regions of Kenya. After the training, site visits assessments were made to ascertain the existence of these MSMEs as well as for monitoring and evaluation purposes. MSMEs were mapped and thereafter the prescribed criteria for their inclusion in this study were applied. The prescribed criteria included having: a Company registration, Kenya Bureau of Standards Certification, Public Health license, at least three years in horticultural processing, regular frequency of processing – at least twice a week and desire to attain Environmental Management System (EMS) certification. Out of the 300 MSMEs that had been identified and trained, only 122 MSMEs met the criteria and were assessed during the baseline survey. After the baseline survey only 61 MSMEs were identified to proceed to the next level. Further screening was done and only MSMEs able to provide data on energy and water used for processing were selected. Thirty-nine (39) MSMEs met the prescribed criteria and were purposively selected to be interviewed.

Data on knowledge, attitude and practices on energy and water use efficiency for horticultural processing was collected through face-to-face interviewing of MSME representatives. The selection of the interviewee was further based on their expertise, that is, only MSME personnel with three years of experience within the selected MSME, in addition to having information on operations and financial status of the MSME were interviewed. Face to face interviews were preferred so as to establish an atmosphere of trust through the ensuing discussion. Data was collected from December 2019 to March 2021. All the 39 questionnaires were correctly completed and returned, providing a response rate of 100%.

3.2.4 Data collection and analysis

Primary data was obtained using a questionnaire, structured interviews and observations. The questionnaire contained both open and closed ended questions. Interviews were also used and entailed using prearranged questions and standardized methods of recording (Kothari, 2004). Secondary data was collected from various sources including published reports, journal articles and research project reports among others. Data was collected using ODK software.

Data was edited, coded, entered and classified. Pearson correlation and linear correlations were used to determine the relationship between knowledge, attitude and practice and energy and water use efficiency. Descriptive statistics such as frequencies and percentages were also determined.

3.2.5 Methods of scoring

3.2.5.1 Knowledge

The section on knowledge comprised multiple-choice questions to enable the researcher establish the general knowledge of MSMEs on efficient energy and water use for processing. This section had 10 questions on knowledge on efficient energy use as well as 10 questions on knowledge on efficient water use. One mark was assigned for every correct answer and no mark was given for a wrong answer. Total score ranged from 0 to 20; this was then converted into a percentage and classified into the three levels of knowledge. The overall knowledge score was categorized using Bloom's cut off point as high if the score was between (80% -100%), moderate (60 – 79%) and poor level of knowledge if the score is less than 60% (Feleke *et al.*, 2021).

3.2.5.2 Attitude

This section of the questionnaire contained 29 statements that tested MSMEs attitude towards energy and water bills incurred by the MSMEs, efficient use of energy, efficient use of water, role of science in solving energy and water crisis in Kenya and general perception of the respondents towards the environment. The respondents were asked to choose a response based on a 5-point Likert scale.

A mean score of 3 was computed through addition of the weighted points of the likert scale and dividing it by 5 that is 1+2+3+4+5 equals 15 then 15 divided by 5 equals to 3. Therefore, a response was considered positive if it scored a mean score that was equal to or greater than 3 and it was considered negative if the mean score was less than 3 (Jatau, 2013).

3.2.5.3 Practices

The MSMEs were asked to select the practices they have been adopted in their enterprises towards energy and water use efficiency. There were two sub-sections on practice; the first sub-section was on energy conservation practices while the second sub-section was on water conservation practices. The MSMEs were required to indicate either yes or no on each question posed on practices. The response yes denotes the practice that has been adopted by the MSMEs while the response 'No' indicates that the MSMEs has not taken up this practice yet.

3.3 Results

3.3.1 Demographic characteristics of MSME representatives

The MSMES surveyed were located in Nairobi, Kiambu, Nyeri, Makueni, Laikipia, Nakuru, Murang'a, Embu, Meru, Kisumu, Homabay, Uasin Gishu, Machakos, Makueni and Vihiga counties. Table 1 indicates the demographic characteristics of the MSMEs representatives interviewed (respondents). More than half of the respondents were males, that is, 61% whereas females constituted 39%. A majority (46%) of the MSMEs representatives interviewed fell under the age group 36 – 50 years. Most (82%) of the MSMEs representatives interviewed had completed tertiary level of education whereas 15% and 3% had completed secondary and primary level of education, respectively. Majority (51%) of the MSMEs indicated that they have been processing for 3– 5 years, 36% indicated 5 – 10 years, 8% indicated 10 – 15 years while 5% of the MSMEs surveyed had been in processing for over 15 years.

The MSMEs were further asked to indicate the frequency of processing of horticultural produce. A majority of them (41%) indicated they process daily, 20% process 2 – 3 times a week, 10% process weekly, 3% process fortnightly, 3% process monthly while 23% indicated that they process depending on demand and availability of raw materials and market. Most of the MSMEs (44%) were micro enterprises, 41 percent were small enterprises while 15% were medium enterprises. Table 3 summarizes the socio-demographic characteristics of the respondents.

Table 3 Socio Demographic Characteristics

Socio Demographic Characteristics	Variable	Frequency	Percentage
Gender	Male	24	61
	Female	15	39
Age (years)	18 – 35	15	38
	36 – 50	18	46
	51 – 60	5	13
	61 and above	1	3
Education Level completed	Primary	1	3
	Secondary level	6	15
	Tertiary	32	82
Frequency of Processing	Daily	16	41
	2 – 3 times a week	8	20
	Weekly	4	10
	Fortnight	1	3
	Monthly	1	3
	On demand	9	23
Number of years in Processing	3 – 5 years	20	51
	5 – 10 years	14	36
	10 – 15 years	3	8
	Over 15 years	2	5
Responsibility in the company	Owner	15	38
	Hired manager	24	62
MSME type (source: European Commission 2015)	Micro (1 – 9)	17	44
	Small (10 – 49)	16	41
	Medium (50 – 250)	6	15

3.3.2 Knowledge, Attitude and Practices

3.3.2.1 Knowledge

The MSMEs representatives were asked questions to test their knowledge on energy use as well as water use for processing of horticultural produce. All of the 39 MSMEs were rated as having high level of knowledge as shown in Table 4. The high level of knowledge of the MSMEs can be attributed to the capacity building training that the MSMEs had undergone. This means that the MSMEs are fully aware and knowledgeable on measures that can be adopted by the enterprises that will help them attain efficiency with respect to energy use and water use during processing of horticultural products not only in the short term but also in the long term thus leading to sustainability of these enterprises.

Table 4 Level of Knowledge of horticultural processing MSMEs in Kenya on energy and water

Level of Knowledge	Score	Frequency	Percentage
High level (80 – 100%)	16 – 20	39	100
Moderate level (60 – 79%)	10 – 15	0	0
Low level (less than 59%)	0 – 9	0	0

The MSMEs were asked how use of excessive electricity affects their business and 91% got the answer correctly that it results in high electricity bills, they were further asked if there is a direct relationship between over-consumption of electricity and decreasing water resources and 91% got the question correctly indicating their high level of knowledge. They were further asked if the use of daylight during the day results in considerable savings in the electricity bills and 88% of the MSMEs got the answer correctly while 12% did not. Regarding question on the use of machines and equipment efficiently results into low electricity bills, 94% got the answer correctly implying a high level of knowledge on energy efficiency. The MSMEs responses to questions testing their knowledge on efficient use of energy is shown in Table 5.

Table 5 Kenyan Horticultural Processing MSMEs Knowledge on Efficient Use of Energy

QUESTION	Correct (%)	Incorrect (%)
There is a direct relationship between over consumption of electricity and decreasing water resources: true	91	9
How does excessive use of electricity affect your business? High electricity bills	91	9
Efficient use of machines and equipment results into low electricity bills	94	6
The use of daylight during daytime leads to significant electricity savings: True	88	12
Use of worn-out appliances causes high energy consumption: true	97	3
Use of renewable energy can lead to a reduction in cost of energy: true	97	3

The MSMEs were further asked questions to assess their knowledge on efficient use of water for processing of horticultural products. The findings indicate that 97% of the MSMEs were aware that reusing of water leads to reduction in the amount of water consumed, 79% were aware that water recycling helps in minimising the amount of fresh water consumed and inspection of faulty valves and fittings helps in preventing water loss.

The MSMEs responses to questions testing their knowledge on efficient use of water is shown in Table 6. The high level of knowledge of the MSMEs shows that the Hortigreen project which has been holding capacity building workshops and trainings had improved the knowledge and awareness of MSMEs on energy and water use for processing.

Table 6 Kenyan Horticultural Processing MSMEs Knowledge on Efficient Use of Water

QUESTION	Correct (%)	Incorrect (%)
Water used for processing must be safe to drink or to use in food preparation	97	3
Reuse of water leads to: reduced amount of water consumed	97	3
Installation of meters and sub meters helps to monitor and reduce on water consumption	97	3
Inspection and replacement of faulty valves and fittings leads to: avoiding wastage of water	70	30
Water recycling helps to: reduce fresh water consumption	79	21

3.3.2.2 Attitude

Out of the 29 statements posed on attitude, 22 statements scored a mean score equal to or greater than 3 meaning the responses were considered positive while 7 statements had a mean score of less than 3 hence the responses were considered negative. This information is presented in Table 7.

The findings indicate that 76% of the respondents had a positive attitude towards the environment. The MSMEs displayed a pro environmental behaviour as deduced from their responses. About 90% of the MSMEs representatives interviewed disagreed that saving energy is the responsibility of the company and not theirs, 93% disagreed that saving water is responsibility of the company and not theirs, 93% disagreed that they use water as they please when it is adequately available, 97% indicated that they were willing to conserve water and energy, 89% agreed that water will eventually be scarce if it is not conserved, 71% agreed that they were concerned about the high electricity bill incurred by their respective companies. About 81% further agreed that human beings were over exploiting the earth.

Table 7 Kenyan Horticultural MSMEs Attitude towards energy and water use for processing

NO	QUESTIONS	MEAN	STANDARD DEVIATION
1.	Saving water is the company's responsibility and not mine	1.53	0.788
2.	Saving energy is the company's responsibility and not mine	1.38	0.638
3.	I use water as I please when it's adequately available	1.50	0.707
4.	I use energy as I please when it's adequately available	1.50	0.826
5.	I am willing to conserve water	4.59	0.783
6.	I am willing to conserve energy	4.59	0.783
7.	Water will eventually be scarce if we don't conserve it	4.38	0.853
8.	Energy will soon be in short supply if we don't use it Efficiently	4.24	1.046
9.	I am concerned about the high electricity bills incurred by the company	3.97	0.937
10.	I am not bothered about the high-water bills incurred by the company	2.12	1.274
11.	I care about the company's environmental image	4.50	0.896
12.	I do all I can to efficiently use water	4.56	0.786
13.	I do my best to efficiently utilize energy	4.56	0.790
14.	I am willing to reuse water for environmental reasons	4.50	0.788
15.	I am willing to recycle water for environmental reasons	4.56	0.561
16.	I care for the environment	4.56	0.660
17.	I think that Kenya is a water scarce country	3.29	1.115
18.	I think that there is an energy crisis in Kenya	3.06	1.043
19.	Human beings are over exploiting the environment	4.24	0.781
20.	Human beings are meant to rule over nature	3.29	1.315
21.	The earth has sufficient resources only if we use them efficiently	4.29	0.836
22.	Plants and animals have as much right as human beings	4.24	0.923
23.	The environment is sacred	4.38	0.739
24.	Renewable energy is good for the environment	4.41	0.701

Table 7 Cont.

No	Questions	Mean	Standard Deviation
25.	The solution to the energy problem lies in science	2.91	0.996
26.	Science holds the solution to the water crisis in Kenya	2.88	1.008
27.	Making the company energy efficient is good for the environment	4.26	0.828
28.	I worry that the company doesn't have enough money to pay electricity and water bills	3.24	1.208
29.	Use of efficient equipment saves energy as well as water	4.26	0.828

3.3.2.3 Practices

The different energy conservation practices were read out and the MSMEs representative indicated which one they had adopted and which one they had not yet adopted. Table 8 summarises the responses from the horticultural Processing MSMEs representatives who were interviewed on the energy conservation practices that they have adopted.

Table 8 Energy Conservation Practices of Kenyan Horticultural Processing MSMEs

No	Energy Conservation Practices	Yes (%)	No (%)
1.	Regular preventive maintenance of equipment	91	9
2.	Proper loading and operation of equipment	91	9
3.	Replacement of older components and equipment with higher efficiency models	82	18
4.	Use of signage and guides to remind staff on good practice	74	26
5.	Conducting regular energy audits	53	47
6.	Using renewable energy: a. Biogas b. Wind power c. solar energy	27	73
7.	Process control and optimization to ensure production operations are running at maximum efficiency	88	12
8.	Implementation of energy management systems that ensures involvement of management and staff towards efficient use of energy	91	9
9.	Reusing hot water	41	59
10.	Regular training of staff on energy use efficiency	82	18
11.	Channelling back steam condensate to the boiler	21	79
12.	Installing energy efficient electric motors	77	23
13.	Turning off idle motors	85	15
14.	Installing correctly sized equipment	88	12
15.	Use of energy efficient bulbs	85	15
16.	Reusing cooling water	32	68

In reference to energy conservation practices, the findings indicate that all of the enterprises have adopted most of the simple housekeeping measures to achieve energy and water use efficiency. About 89.3% of the MSMEs practice regular preventive maintenance of equipment, 89.3% indicated that they practice proper loading and operation of equipment, 71.4% use signage and guides to remind staff on good practice, 86% use energy efficient bulbs. When asked if the MSMEs switch off lights when not in use, they all indicated that they do. However, switching off lights when not in use was observed in 92% of the MSMEs that were visited.

Regarding water conservation practices, the MSMEs gave their responses as follows: 97% turn off taps when not in use, 79% reuse water where possible, 82% use dry cleaning methods to clean equipment and surfaces, 86% indicated that they inspect and replace faulty valves and fittings, 82% inspect water connection points for leakages and promptly repair any identified leakages. Majority (53%) of the respondents indicated that they carry out water audits. The various water conservation practices that have been adopted by the Kenyan Horticultural Processing MSMEs on efficient water practices are presented in Table 9.

Table 9 Water Conservation Practices of Kenyan Horticultural Processing MSMEs

No	Water Conservation Practice	Yes (%)	No (%)
1.	Proper and regular maintenance of equipment	94	6
2.	Raising staff awareness on need for proper maintenance of equipment	97	3
3.	Installation of a condensate water reuse system	21	79
4.	Turning off taps when not in use	97	3
5.	Implementation of a strategic water management program that ensures involvement of management and employees towards efficient water use	88	12
6.	Water recovery from the various operations	35	65
7.	Reusing water where possible	79	21
8.	Using dry cleaning methods to clean equipment and surfaces	82	18
9.	Conducting regular water audits	53	47
10.	Water recycling	18	82
11.	Inspection and replacement of faulty valves and fittings	88	12
12.	Installing water meters on equipment to enable monitoring and reduction of water consumption	68	32
13.	Inspection of all water connections for leakages with prompt repair of leakages	85	15
14.	Keeping spray nozzles free of dirt and scale	56	44
15.	Installing water efficient building fixtures	59	41
16.	Pre-soaking floors and equipment before cleaning	71	29

Pearson correlation analysis was done to find out if there was any relationship between knowledge, attitude and practices. The results of the analysis are presented in Table 10 and it indicates a positive moderate correlation, r=0.32 between knowledge and attitude and statistically significant (p=0.05). A weak positive relation, (r=0.25), exists between attitude and practices; and practices and knowledge (r=0.038) however, this relationship isn't statistically significant, (p=0.13) and (p=0.82) respectively.

Table 10 Correlation between Knowledge, Attitude and Practice

Level	**Pearson correlation**	**P value**
Knowledge – Attitude	0.32	0.05
Attitude – Practices	0.25	0.13
Practices – Knowledge	0.04	0.82

Multiple linear regression analysis was further done to test for any significant relationship between education level, frequency of processing, gender, age, type of MSME against the knowledge, attitude and practices variable. From the analysis done as displayed in Table 11, age is the only variable that has an effect on the knowledge, attitude and practices on energy and water use of MSMEs. An increase in age is associated with an improvement in knowledge, attitude and practices on energy and water use for processing (R^2=0.272 F=4.238 P=0.012). The older the age of the horticultural processing MSME representative the higher the chances of a positive improvement in knowledge, attitude and practices.

Table 11 Multiple Linear Regression

Variables	Knowledge			Attitude			Practices			
	Coefficient	Std Error	P value	Coefficient	Std Error	P value	Coefficient	Std Error	P value	
Education level	-0.010	0.136	0.941	-0.069	0.035	0.060	0.007	0.024	0.762	R^2=0.337 F=1.451 P=0.245
Frequency of processing	0.293	0.365	0.428	0.058	0.095	0.544	0.018	0.065	0.780	R^2=0.048 F=0.573 P= 0.637
Gender	-0.043	0.089	0.634	-0.022	0.023	0.348	0.012	0.016	0.466	R^2=0.051 F=0.608 P=0.614
Age	-0.308	0.122	0.066	0.090	0.032	0.008	0.015	0.022	0.493	R^2=0.272 F=4.238 P=0.012
MSME type	0.017	0.152	0.911	0.042	0.040	0.295	-0.058	0.027	0.041	R^2=0.128 F=1.665 P=0.193

3.4. Discussion

Environmental knowledge is described as possessing and comprehending issues related to the environment. Environmental knowledge places emphasis on the awareness of individuals on issues connected with collective responsibility as well as environmental appreciation and influence (Kim *et al*., 2018). The findings from the study established that all the MSMEs had high level of knowledge on efficient use of energy and water. It is difficult for an individual to care and be aware about environmental issues or act pro environmentally responsible if they lack knowledge about the environment (Paillé and Boiral, 2013). This means that possessing knowledge is the first step to acting or caring about environmental issues such as energy and water conservation. (Kim *et al*., 2018) put forth that environmental knowledge promotes awareness and leads to positive attitude towards nature. This is in line with the present study where the relationship between knowledge and attitude was statistically significant.

According to (Blankenberg and Alhusen, 2019), possessing environmental knowledge increases the prospects of environmentally responsible behaviour. The present study agrees with this finding. This means that for MSMEs to be able to efficiently use energy and water for processing, they must be knowledgeable about environmentally responsible energy and water use practices. It has further been established that there is a positive association between environmental knowledge and energy saving behaviours (Pothitou *et al*., 2016). Measurement of knowledge as well as attitude of human beings with respect to a specified intervention in the course of the implementation phase of a program may not yield accurate information concerning behaviour change but maybe useful in measuring potential impact (Wasonga *et al*., 2014). The present study gives an insight on the influence of a sustainable consumption and production intervention program concentrating on MSMEs knowledge, attitude and practice towards energy use as well as water use in horticultural processing MSMEs.

However, knowledge does not always essentially mean sustainable practices. The findings of this study indicate non-significant relationship between knowledge and energy and water use efficiency practices of MSMEs. This means that despite the MSMEs possessing good level of knowledge on energy and water use efficiency, it doesn't automatically lead to adoption of best practices aimed at energy and water use efficiency. The findings of this current study resonate with the findings from (Ahmad *et al*., 2015) in a study which sought to establish the environmental knowledge, attitude, practice and communication of university students. The study established that even though students had a good level of knowledge, it didn't spur them to take up the correct ecological practices. Although environmental knowledge does not have visible effect on pro environmental behaviours or practices, it has significant indirect effects on pro-environmental behaviours with environmental attitudes as an intermediary (P. Liu *et al*., 2020).

(Besar *et al*., 2013) also found out that despite young civil servants in Malaysia possessing good level of knowledge and positive attitudes towards the environment, the practices adopted were only moderate. Notwithstanding the excellent knowledge possessed by the MSMEs on water and energy use efficiency, a number of the MSMEs surveyed don't apply this knowledge in practice. Though the MSMEs are aware that practices such as switching off the lights during the day leads to energy savings, a number of them leave lights on during the day and idle machines are not plugged off. In addition, in spite of the high significance of costs of energy to MSMEs they largely lack the resources or time to dedicate to this area (EuroChambers, 2010).

The findings of the present study further indicate that only 53% of the MSMEs conduct energy audits as well as water audits regularly yet conducting energy and water audits regularly results in notable cost savings. According to research conducted by (Fleiter, Schleich, *et al*., 2012) it has emerged that technical methodology is many a times employed when carrying out energy audit programs and this method leads to errors by MSMEs as they try to manage their energy resources. Energy audits are frequently done by professionals mostly with a background in engineering (Fleiter, Schleich, *et al*., 2012) and handed over to MSMEs which might lack a comparable background knowledge thus making it hard for the MSMEs to understand the results of the audit (Palm and Backman, 2020). Insufficient knowledge is thus a barrier to MSMEs implementing the audit findings.

An MSME must aggressively process information within the organization, in turn its personnel are obligated to control their individual learning processes by choosing and arranging fitting information and constructing connections to existing knowledge (Thollander and Palm, 2015). Thus, the prime aim of policy programs should be to support MSMEs to progress their knowledge skills and then assist them utilize these skills to conceptualize useful knowledge in appropriate areas (Mayer, 1992). The Government should also mount additional educational programs geared at enhancing the knowledge of MSMEs on pro-environmental behaviour given that possession of environmental knowledge is the first step towards acting in a pro environmental manner. MSMEs cannot adopt best practices in energy and water use if they lack the knowledge on these practices.

Despite MSMEs positive attitude towards environmental issues, they don't participate in environmental issues (Weerasiri and Zhengang, 2012). This point is further expounded by a study by Tilley in 1999 on MSMEs environmental behaviour and attitudes which established that MSMEs do not have sufficient motivation to transit from pro environmental attitude to behaviour (Tilley, 1999). Thus, positive attitude towards environmental issues in this case energy and water use efficiency doesn't translate into adoption of best practices that will help MSMEs achieve sustainability in energy and water use. The present study established that the MSMEs had a positive attitude towards energy and water use efficiency however more intervention is needed for these MSMEs to adopt sustainable energy and water use practices.

Further the findings of the present study indicate a moderate but positive relationship between attitude and energy and water use practices of MSMEs. Thus, to some extent attitude influences the energy and water use practices of MSMEs. This finding is in line with a finding by (Weerasiri and Zhengang, 2012) whom established that there is little or no significant relationship between attitude and practices. This means that MSMEs attitudes appear to remain positive even where there is inadequate implementation of best environmental practices

Majority of the MSMEs (91%) have implemented a strategic energy management program that ensures involvement of management and employees towards efficient energy use; on the other hand, only 88% of the MSMEs have implemented a strategic water management program that ensures involvement of management and employees towards efficient water use. According to (Sachidananda *et al.*, 2016), less effort has been placed on management of water as compared to management of energy. Water minimization strategies range from adoption of good housekeeping measures, conducting water audits to process and product redesign.

Housekeeping measures are among the measures to achieve energy conservation opportunities and incurs absolutely no or little cost; these measures can be described as a brilliant starting point for advancing methods of operation. These measures can be employed to conserve energy, lessen production costs, curtail wastage of raw materials, reduce waste, save water and alleviate environmental impact (Zohir, 2010). Abolarin *et al*., (2014) established that adoption of practices such as monitoring of energy consumption, turning off equipment when not in use and replacement of incandescent bulbs with energy saving bulbs results in energy savings. Given the diminishing energy supplies, it's imperative that energy conservation practices be adopted as a preliminary measure and increase uptake of energy efficient technologies as a long-term measure (Mills and Schleich, 2012).

3.5 Conclusions

The findings from this study indicate that the MSMEs have high level of knowledge on energy and water use for processing and to some extent knowledge affects attitude. However, this high level of knowledge has not spurred the MSMEs to adopt long term sustainable consumption and production practices such as energy and water use efficiency practices that will ensure sustainability in the horticultural processing industry in the long run. Further, the findings from the study indicate that the MSMEs are not adequately motivated to transition from positive attitude towards energy and water use to practices.

3.6 Recommendations

The study thus recommends government subsidies and rewards to encourage MSMEs to adopt efficient energy and water use practices. Further the study recommends regular and structured training on energy and water use efficiency and setting up model companies that MSMEs can learn from then replicate in their enterprises.

CHAPTER FOUR

INFLUENCE OF LEGISLATIVE FRAMEWORK IN EFFICIENT USE OF ENERGY AND WATER BY HORTICULTURAL PROCESSING MSMES IN KENYA

Abstract

The food processing industry is a water and energy intensive industry; however, these two finite resources cannot be substituted in this industry. MSMEs are lauded globally for being a major source of employment and drivers of innovation, however, their energy and water usage is not well understood given their unique characteristics and their scope of operation. MSMEs range from those with business premises to those without thus regulation of this business type poses a challenge to governments globally. Data was collected through cross sectional research design using a structured questionnaire. Quantitative data was analysed using thematic analysis and pivot tables. It emerged from the study that majority of the MSMEs had complied with the statutory requirements needed to operate a business in Kenya. However, on the legal requirements in terms of energy efficiency, a majority of the MSMEs were neither aware that energy efficiency is enforced nor of the government body mandated to enforce energy efficiency. Further most of the MSMEs do not carry out energy audits as required by the law. Over half of the MSMEs have initiated energy conservation actions to reduce on the energy consumed due to the high electricity bill they incur and not due to the legal requirements. Water is deemed a cheap resource thus most MSMEs have not really put in place measures to help them attain water efficiency. In conclusion, enforcement by the government was largely lacking despite policies and strategy in place to help industries achieve energy and water use efficiency.

4.1 Introduction

Micro, small and medium enterprises (MSMEs) represent 99% of enterprises, provide approximately 60% of employment and are a crucial part of economies globally (IEA, 2015). The food processing industry utilizes huge amounts of energy and water (Trajer *et al.*, 2021). The collective energy usage by MSMEs and carbon emissions are often disregarded by policies on energy efficiency. MSMEs account for over half of commercial as well as industrial energy usage however the details of their energy usage and savings potential is not well understood (Fawcett and Hampton, 2020). Knowledge on where and how energy is consumed together with identifying existence of available opportunities may provide good support for developing the most effective policies (Thollander *et al.*, 2015).

In some countries, government programs and policies aim to assist industry to improve competitiveness through increased energy efficiency. Nevertheless, usually only scarce financial as well as technical resources for improving energy efficiency are available especially for MSMEs (Hasanbeigi and Price, 2010). Investment subsidies, energy networks, sector guidelines and benchmarking have been recommended as policies which are relevant for consideration for industrial MSMEs (Thollander, Zubizarreta-Jiménez, *et al.*, 2014). Further according to (Thollander, Cornelis, *et al.*, 2014) the major policy means that targets medium sized companies as well as energy intensive industrial MSMEs are Voluntary Agreements (Vas) together with law enforcement followed by energy audit programs as well as energy efficiency networks.

For small companies which are not energy intensive, the most favourable policy choices are energy audit programs preferably anchored at the local or regional level followed by energy efficiency networks also anchored at the local or regional level (Thollander, Cornelis, *et al.*, 2014). Barriers to improvements in industrial energy efficiency more so in developing countries are more noticeable because of a multitude of aspects such as weak information systems, weak energy policy frameworks, financial constraints among others (Apeaning and Thollander, 2013). Even though the existing industrial energy efficiency barriers in developing countries are akin to those in developed countries, poor energy infrastructure, the lack of adequate policy frameworks, fragile economies just to mention but a few make the presence of these barriers more distinct in developing countries (M. E. Compton, 2011).

In Kenya, the Government has set targets for the industrial and agricultural sector to aid them in attaining energy efficiency. There is expectation for the sector to increase the number of energy audits from currently 1800 to 4000. Further there is expectation from this industry to implement the recommended energy conservation measures so as to save 9 million litres of industrial diesel oil, 250 million litres of heavy fuel oil and 100 MW of power demand (Republic of Kenya, 2020). Energy efficiency together with taxes imposed on emissions are effective drivers for energy policy that have been utilized by governments globally to encourage energy efficiency in firms (Apeaning and Thollander, 2013). Management of energy and water resources efficiently depends majorly on the economic incentives as provided for by the law (Obiero *et al*., 2021).

When defining energy efficiency regulations as well as programs, it’s imperative to take into consideration the political backing of measures and legislation or its opposition or indifference because of the role played by government representatives in making pressure for energy efficiency (Langlois-Bertrand *et al*., 2015). Sustainable utilization of water is a matter of concern globally given that industries today are made up of large multinational companies which have factories worldwide thus since policies and legislations concerning management of water varies across nations, it is important that the industry cooperates with governments as well as local authorities to ensure sustainable water use management (Ölmez, 2014). There is need for policy instruments that encourage acceptance of water reuse for instance public involvement programs and awareness creation in the policy framework for Kenya (Wakhungu, 2019)

4.2 Materials and Methods

4.2.1 Study area

The study was conducted in Kenya specifically in Makueni, Kisumu, Homabay, Nairobi, Vihiga, Nyeri, Kiambu Laikipia, Murang'a, Embu, Meru, Uasin Gishu and Nakuru counties whereby the focus of the study was on MSMEs processing or adding value to horticultural produce that is vegetables, fruits, medicinal, aromatic as well as ornamental plants.

4.2.2 Research design

A cross sectional research design was employed and this was instrumental to the researcher to collect data on influence of regulatory framework on energy and water use efficiency by MSMEs processing horticultural produce in Kenya. Cross sectional research design allowed the researcher to choose the respondents on the basis of the exclusion and inclusion guidelines as described by the study. Further this design enabled the researcher to collect data from many respondents at a single point in time (Setia, 2016).

4.2.3 Sample size and sampling procedure

A detailed step by step explanation on how the sampling was done and how the sample size was arrived to has already been explained in chapter section 3.2.3. Refer to this section for the sample size and sampling procedure.

4.2.4 Data collection and analysis

Primary data was obtained using a questionnaire, structured interviews and observations. The questionnaire contained both open and closed ended questions on influence of legal and regulatory framework on energy and water use for horticultural processing. The questionnaire contained two different sub sections on legal and regulatory framework on energy and water use.

Data was edited, coded, entered and classified. The qualitative data obtained on the role of regulatory framework on efficient energy and water use for processing was analysed through thematic analysis with the help of pivot tables. Data was presented using graphs. Quantitative data obtained was analysed with the help of SPSS software

4.3 Results

4.3.1 Demographic characteristics

Out of the 39 MSMEs interviewed, 45% were micro, 42% small while 13% were medium enterprises. Majority (26%) of the MSMEs were located in Nairobi, 10% were located in Homa bay, 10% were located in Kiambu and Machakos, 8% were located in Kisumu, 5% were located in Kisii, Makueni, Meru and Uasin Gishu counties, 3% of the MSMEs interviewed were based in Embu, Laikipia, Murang'a, Nakuru, Nyeri and Vihiga counties as is displayed in Figure 9. To further break down these numbers in terms of the specific number of MSMEs located in the various counties, Embu, Laikipia, Nakuru, Nyeri, Vihiga and Murang'a have 1 MSME each, Homa Bay, Machakos and Kiambu have 4 MSMEs each, Uasin Gishu, Kisii, Makueni and Meru have 2 MSMEs each, Kisumu 3 MSMEs, 10 MSMEs were located in Nairobi. The MSMEs were further asked to indicate the number of years that they have been processing horticultural products. Over half (53%) indicated that they had been processing for between 3 to 5 years, 37% indicated that they have been processing for between 5 to 10 years, 5% for between 10 – 15 years while 5% have been processing for over 15 years. Further 44% of the enterprises surveyed were micro, 41% small and 15% were large enterprises.

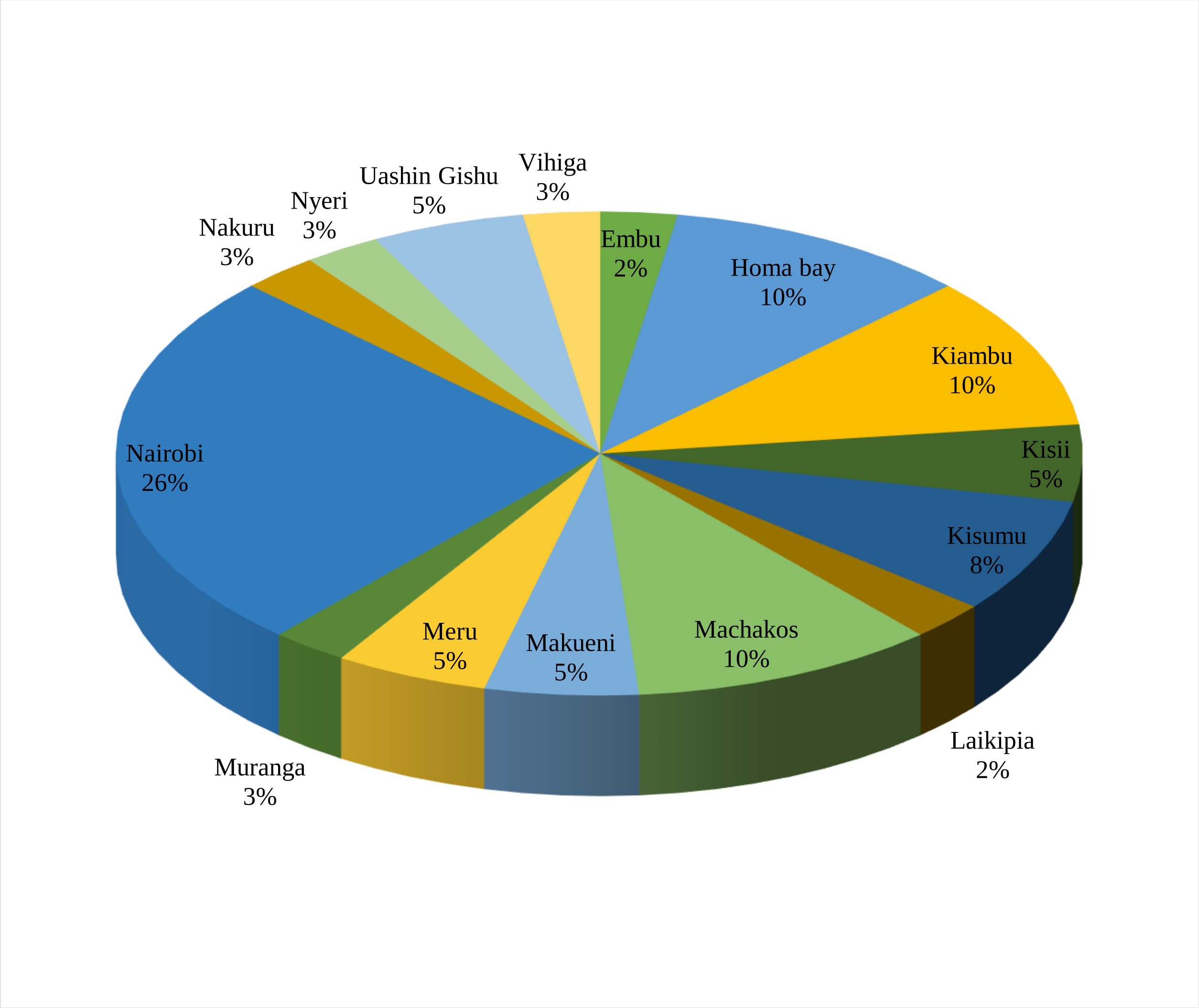

Figure 9 Geographical Distribution of the Surveyed Horticultural Processing MSMEs in Kenya (Source: Researcher, 2022)

4.3.2 Energy use for processing and legal and regulatory framework

The MSMES were asked various questions related to legal and regulatory framework governing energy use in Kenya. Regarding the use of electricity, the study found out that 5% of the MSMEs use electricity for lighting purposes, 8% use electricity to power equipment, 85% use electricity for lighting purposes and to power equipment while 2% don't use electricity.

It was further reported that there are a number of measures that have been adopted by these MSMES so as to conserve energy. A majority of them (54%) indicated that they practice simple housekeeping measures such as use of natural light during the daytime, switching off lights and equipment when not in use, 11% indicated that they use renewable energy so as to reduce reliance on fossil fuels, 10% of the MSMEs conserve energy through installation of efficient motors and equipment, 7% of the MSMEs indicated that they regularly maintain their equipment to ensure their energy efficiency and also a further 7% indicated that they train their staff in efficient operation of equipment. A small percentage (5%) practice bulk processing to conserve energy, 4% record and monitor energy consumption while only 1% reuse cooling water to conserve energy.

The findings of the study reveal that 44% of the MSMEs carry out energy audits while 56% don't. Out of the 44% of the MSMEs that carry out energy audits, 41% undertake energy audits once a year while 3% carry out energy audits twice a year. In addition, of the 44% that carry out energy audits they were further asked if they had submitted a detailed audit report and only 5% had submitted an audit report while 39% had not. The study further established for the 56% of the MSMEs that don't carry out energy audits the reasons cited were lack of adequate knowledge on the need for carrying out energy audits, the benefits realized by firms when they carry out energy audits as well as inadequate financial resources to carry out the audits.

More than half (82%) of the MSMEs were not aware that energy efficiency compliance was enforced by Energy Petroleum and Regulation Authority (EPRA). Only 18% were aware that EPRA is tasked with enforcing energy efficiency compliance. It also emerged that only 3% of the MSMEs had been issued with an energy savings certificate by EPRA pointing to intensive energy usage in this sector as well as lack of enforcement.

The MSMEs were further asked if county government inspectors had visited their enterprises and their responses were as follows: 39% indicated that yes, county government inspectors had visited their enterprises to inspect equipment and appliances while 62% indicated not, only 23% confirmed that a county government inspector had visited their enterprise to check the production process so as to ascertain the energy standards and norms, 36% reported that a county government inspector had visited the organization to take stock of their equipment while only 18% reported that a county government inspector had visited their premises to record the statement of employees which was deemed useful for efficient use of energy and its conservation. The summary of the responses received in relation to the county government inspectors are as displayed in figure 10.

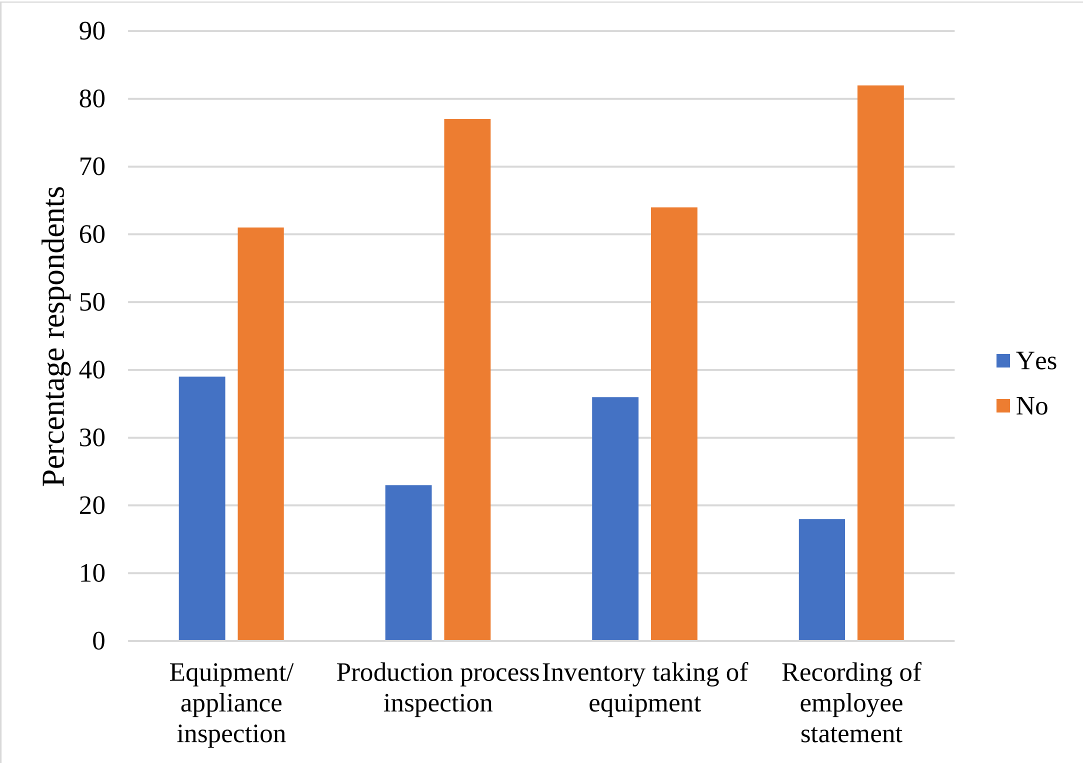

Figure 10 County Government Enforcement of Minimum Energy Efficiency (Source: Researcher, 2022)

It emerged that 10% of the MSMEs at times use energy over and above the prescribed limits while 90% indicated that they did not. For the MSMEs who consume energy over and above the prescribed limits the reasons cited for over utilization of energy are: 20% said it was due to bad practices by employees whereby they forget to switch off lights and appliances, 20% indicated that it was due to old inefficient equipment that led to overconsumption of electricity, 40% indicated that it was due to overproduction due to peak seasons hence the machines and staff work for longer hours and 20% indicated that during cold seasons the solar driers don't get sufficient energy from the sun thus they have to rely on electricity for processing thereby leading to over consumption of electricity.

The findings from this current study further indicate that only 3% of the MSMEs submitted a remedial plan of action outlining measures to be taken by the enterprise to reduce over consumption of electricity. The remedial measures include training staff on energy use efficiency, purchasing of energy efficient equipment, preventive maintenance of equipment, reusing boiling water and switching off lights when not in use as well as idle machines.

The MSMES were asked if their businesses had been registered by the county governments. A majority of them (95%) had been registered by the county governments while 5% had not. The study established that the 5% that had not been registered cited the following reasons: the enterprise is located in a government trade zone whereby the only requirement is a public health license and the business is a cottage industry. The MSMEs were further asked if they had complied to the statutory requirements. Their responses are captured in figure 11.

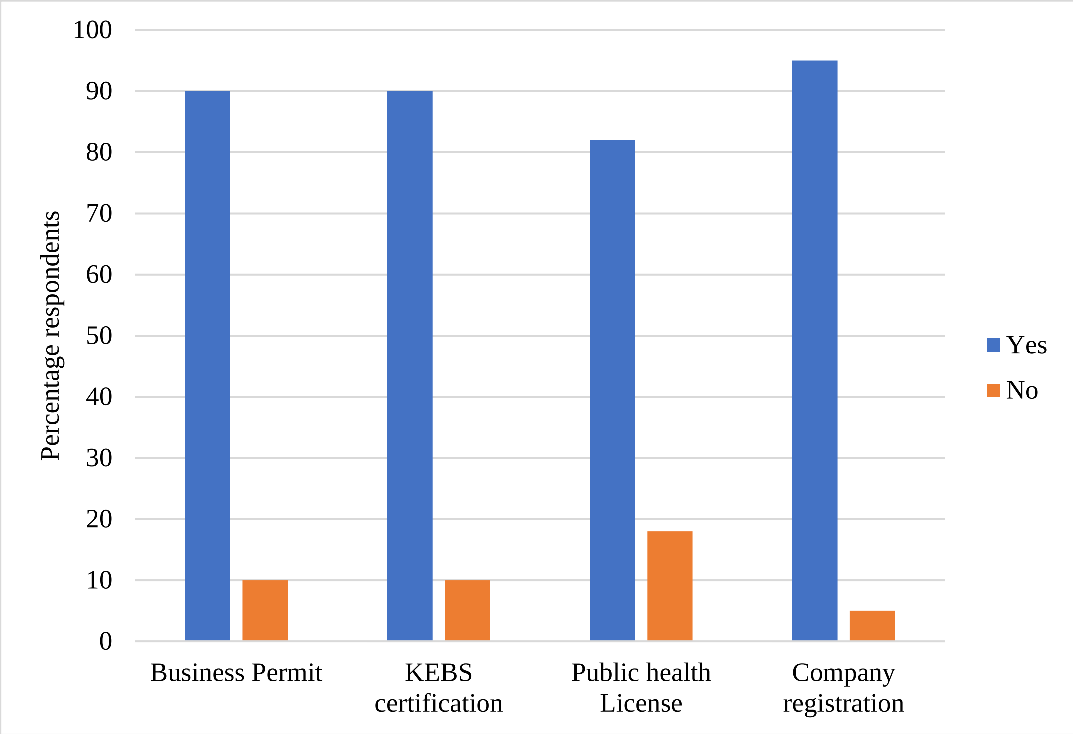

Figure 11 Compliance of Kenyan Horticultural Processing MSMEs to statutory requirements (Source: Researcher, 2022)

Over half of the respondents (59%) agreed that the laws and regulations are stringently enforced, 23% strongly agreed, 3% strongly disagreed while 15% disagreed. Further, 13% of the MSMEs indicated that they had faced challenges complying to the laws and regulations while 87% did not face any challenges. The challenges faced include bureaucracy (57%), high cost of the permits and licenses (29%) and corruption (14%).

4.3.3 Water use for processing and legal and regulatory fframework

The findings from this study indicate that 13% of the MSMEs abstract water from a natural resource while 87% do not. Only 7% have a water permit allowing them to abstract water. Further, 85% of the MSMEs pay charges for the use of water while 15% do not because the water charges are included in their rent charges. The MSMEs were asked on their frequency of paying for the water charges and 69% indicated that they pay for the water charges monthly, 3% purchase water daily since they lack a constant water supply, 10% indicated that they only purchase water occasionally when their water reservoir runs out since they rely on rain water, 3% don’t have a water meter thus are unable to pay for water.

The MSMEs were asked if they at times extract water in excess of its needs and 3% confirmed that they do while 97% indicated that they do not extract water in excess of its needs. The reason cited for over consumption of water is during peak season where the company has increased orders to fulfill thus leading to overconsumption of water. Regarding the issue of any challenges faced in complying to statutory requirements, 5% indicated that they faced a few challenges while 95% indicated that they faced no challenges. The challenges faced included bureaucracy which has led in delays in issuance of the required permits. The summary of the challenges faced is presented in Figure 12.

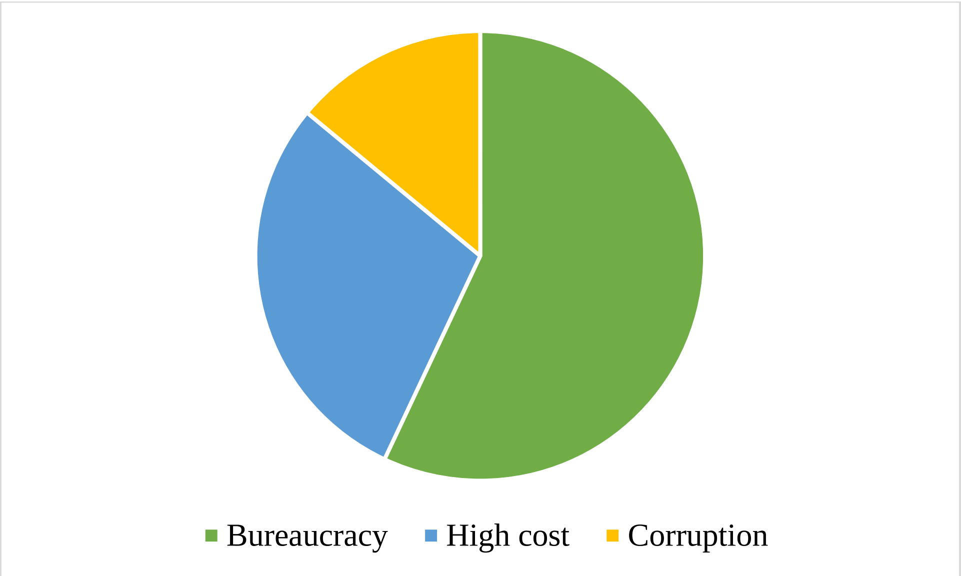

Figure 12 Challenges by Horticultural Processing MSMEs in Kenya when complying to statutory requirements

(Source: Researcher, 2022)

The study further established the top three strategies adopted by MSMEs to avoid wastage of water are monitoring water use (28%), reusing water (28%), adoption of simple housekeeping measures (21%) like turning off the tap when not in use, using dry cleaning methods. Other strategies used by MSMEs to avoid wastage of water are fixing faulty pipes and fixtures to avoid leakages (11%), rainwater harvesting (6%) and carrying out water audits (2%). The summary of the responses is presented in Figure 13.

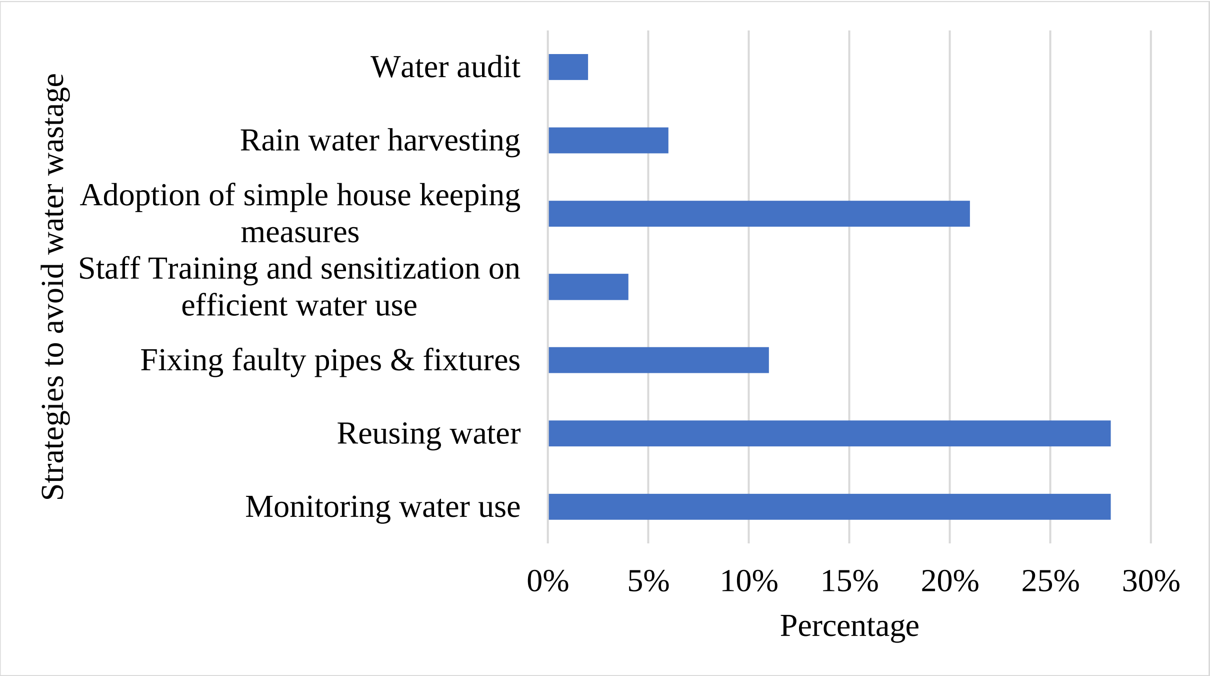

Figure 13 Strategies to avoid water wastage (Source Researcher, 2022)

4.4. Discussion

4.4.1 Influence of policies on energy for horticultural processing

Lack of focus on policy for MSMEs leads to low expectations of not only energy but also on carbon savings from MSMEs. MSMEs are tremendously diverse, are found in virtually all business areas, occupy all kinds of property types and range from service providers without business locations to manufacturing businesses operating transversely in numerous locations

(Fawcett and Hampton, 2020). This present study established that some MSMEs lacked business premises, they either operated from their homes or rented residential houses to set up their businesses. The distributed nature of this energy consumption of MSMEs that has been divided between thousands of individual businesses makes it a huge challenge to reach all the MSMEs (Southernwood *et al*., 2021). The 39 MSMEs that were surveyed were geographically dispersed pointing to their distributed nature and the difficulty faced by the Government in regulating them given that some (5%) of the MSMEs surveyed are not registered and have not complied to the statutory requirements for business registration and licensing.

It is therefore difficult for the government to regulate this sector yet collectively MSMEs consume a lot of energy. The government of the Republic of Kenya should tailor make policies that specifically target MSMEs so that they can contribute towards energy efficiency. (Macharia *et al*., 2021) posits that Kenya requires policies that stimulates energy efficiency in the manufacturing sector. In view of the multifariousness of driving forces of energy across the manufacturing sub sectors as well as forms of energy, the policies should not only be sector specific but energy specific too. The sector specific policies will enable the MSMEs attain energy efficiency since it will address the factors barring MSMEs presently from adopting energy efficiency practices.

The MSMEs further cited financial barriers as one of the reasons that deterred them from undertaking energy audits thus formulation of policies that subsidize energy audits would be a step towards encouraging horticultural processing MSMEs in Kenya to adopt energy efficiency measures (EEMs). This is in line with research findings by (Kalantzis and Revoltella, 2019) where the authors established that firms that generally used their money finance their investments were highly unlikely to invest in EEMs after an energy audit. According to (Fleiter, Gruber, *et al*., 2012) governments should consider subsidizing energy audit programs for companies as a common policy in order to overcome the energy efficiency gap even though it may lead to some issues of free riding. Free rider in this case refers to an MSME who would have paid for energy efficiency measures even because of the benefits they stand to gain from implementing the energy efficiency measures but ends up receiving a subsidy or rebate and doesn't pay for the EEMs. The issues of free riding might result in increased expenditures for the government thereby rendering such energy policies that sought to subsidise EEMs unsustainable thus negatively impacting energy subsidy programs.

Thollander and Palm (2015) suggests that local energy programs that take into consideration the actual needs of MSMEs are deemed to be more successful as opposed to a generalized model that targets all companies in a similar way. In the European Union, member states are required to formulate programs for MSMEs that encourages them to not only carry out energy audits but also to implement the energy efficiency measures that have been identified (Southernwood *et al*., 2021). Kenya can borrow from this and go a step further to develop policies that specifically target MSMEs rather than enforcing the Energy Act on large as well as small enterprises yet their mode of operations are quite different as well as the factors barring them from adopting EEMs. The drivers for uptake of energy efficiency are different across the MSMEs thus specific policies targeting horticultural processing MSMEs will yield more results.

A number of studies in countries globally have confirmed that considerable opportunities in energy efficiency lie in the industrial sector and many of these opportunities are cost effective. Even so industries are unaware of potentials for improvements in energy efficiency. Carrying out energy audits is an initial step in the identification of these potentials but many industries are devoid of the proficiency to carry out an effective energy audit (Hasanbeigi and Price, 2010). This finding is in line with the finding of the present study that established that majority of the MSMEs (56%) do not carry out energy audits and the major reason they cited was lack of knowledge to carry out the audits and also, they didn't know the importance or purpose of energy audits. Further, in the Kenya National Energy Efficiency and Conservation Strategy (Republic of Kenya, 2020), the government has clearly provided timelines for conducting energy audits, which is at least once a year but this is not adhered to as was established by the findings of the study.

Presently, a small number of MSMEs have carried out an energy audit and even fewer have put in place measures to implement energy savings measures. This finding by (Southernwood *et al*., 2021) further supports the finding of this study that established 56% of MSMEs have not undertaken an energy audit yet an energy audit is the first step towards energy efficiency. An energy audit will not lead in energy savings but rather it aids in defining areas for bettering as well as the probable solutions for increased energy efficiency (Backlund and Thollander, 2015)

MSMEs need to undertake an energy audit at least once a year to help them know how much energy they are consuming and what measures they need to put in place to enhance energy efficiency in their enterprises. Through the recently established Kenya National Energy Efficiency and Conservation Strategy (NEECS), the Centre for Energy Efficiency and Conservation (CEEC) has targeted to increase the number of energy audits carried out in the manufacturing industry from 1800 to 4000 between 2019 -2025 (Republic of Kenya, 2020). This is a clear indication that the manufacturing industry are not undertaking energy audits as they are required by the law despite being intensive energy consumers yet energy audits will help horticultural processing MSMEs attain energy efficiency as well as environmental sustainability and increased profitability in the long run.

Voluntary Agreement Programmes (VAPs) is one of the major energy policies for industry and they are effective in motivating and encouraging industries to decrease their energy demand together with greenhouse gas emissions (Price, 2005). One of the key measures for raising the awareness of the energy efficiency potential and unveil opportunities for improvements in industries is through conducting energy audits. Energy audit policies have been established globally so as to encourage energy auditing in organizations (Johansson *et al*., 2019). This again exemplifies the importance of enforcement of energy audits so as to help horticultural processing MSMEs in Kenya attain energy efficiency. Energy audits are a prerequisite for the manufacturing industry in Kenya and they should be conducted at least once a year as outlined in the Energy Act of 2019.

4.4.2 Influence of policies on water for horticultural processing

Water is presently regarded as a crucial part of commercial sustainability strategies alongside energy and materials. Water reduction measures include undertaking water audits, adopting good housekeeping as well as redesigning product and process (Sachidananda *et al*., 2016). This is supported by the findings of this present study which established that all the MSMEs surveyed are practicing good housekeeping measures so as to ultimately attain water efficiency. The study further established that only 2% of the MSMEs carry out water audits. According to Sachidananda *et al*. (2016) minimal effort has been placed on management of water compared to management of energy. This statement is exemplified by the findings of the present study where it emerged that only 2% of the MSMEs undertake water audits. Water audit is a crucial tool for minimizing consumption of water.

Proper management of water in the food industry is dependent largely to a great extent on economic incentives controlled by legislature. Costs related to water supply and effluent discharge dictate decisions made concerning water management in companies. Environmental regulation must encourage company policies for treatment and saving that allows the sustainable availability of a limited resource such as water (Sánchez *et al*., 2011). Kenya is a water stressed country because of her per capita water availability which is below 1,000m^3 annually (Jones, 2014). There is therefore an urgency for developing countries to transit from present water management practices to sustainable ones such as water reuse (Wakhungu, 2019). From the present study, only 28% reused water. This proportion is quite low given the dire water situation in Kenya. Reuse of water will aid in reduction in fresh water withdrawals. There is need for a water recycling policy in Kenya that will encourage industry to reuse water after it has been treated.

Recycled water is often utilized for non-potable uses as industrial cooling processes, irrigation, general cleaning and flushing toilets. This study established that only 28% reuse water for cleaning, irrigation as well as flushing toilets thus reducing on their fresh water consumption. (Levine and Asano, 2004) established that such instances of reusing water have resulted in substantial achievements in the reduction of water supply in a number of countries. In North America and Europe, waste water management problems have been eased following reduction in production of waste water and water reuse initiatives in industrial, agricultural and domestic sectors (Seadon, 2010). This case pertinently validates the viability of water reuse but for this change to occur from existing water management practices to more efficient regimes like water reuse there is need for concerted efforts driven by public policy.

Public policy dictates the resources, goals, processes and strategies for these changes (Wakhungu, 2019). There is therefore a dire need for a water reuse policy in Kenya that will specifically target MSMEs to help them transit to sustainable water practices. Further there are a number of justifications as to why provisions for water reuse should be contained in a public policy. In reference to infrastructures and natural resources, policies alongside public institutions facilitate the establishment, maintenance, monitoring and enforcement of guidelines. These roles of policy are exemplified by social ecological systems model of (Anderies *et al*., 2004) which expounds on the associations between user, infrastructure and resources. Most notably, public policy rationalizes the addition of water use initiatives in monetary allocation. This is crucial for the uptake of water reuse in view of the high costs linked to the setting up and operation of water recycling technologies. Therefore, a policy environment that's intent on upscaling water reuse will be expected to create reserves that will fund public entities. In addition, this can be combined with incentives to lower the costs for the recycling of water by the private sector (Wakhungu, 2019).

Wakhungu (2019) further observes that the domestic, industrial and agricultural sectors which are the largest consumers of water in Kenya haven't sufficiently addressed the issue of water reuse. The National Water Policy of 1999 broadly discussed the challenges of insufficient infrastructure and its agenda was to encourage recycling of water as a source of water supply for industrial, agricultural and domestic sectors (Sessional Paper No. 1 of 1999 on The National Water Policy on Water Resources Management and Development, 1999); however, the National Water Strategy (NWS) for the years 2015 -2020 does not contain provisions that are connected to water reuse thus exemplifying the disconnect that exists between water reuse policy, planning and implementation . This finding further explains the reason for the low uptake of water reuse among the MSMEs that were surveyed in this study.

Schedule 8 of the Kenya's Water Act of 2006 outlines the microbial quality of waste water that can be reused for irrigation purposes, on the other hand, there lacks provisions for water quality for reuse in the industrial, domestic and commercial purposes. The Environmental Management and Coordination Act (EMCA 1999) has a provision for tax rebates for industries that recycle water (GoK, 1999). The failure to provide standards for industrial and domestic water recycling shows the inadequacy of the existing regulations. There is an urgent need for the formulation of these guidelines to aid water reuse thus leading to attainment of water use efficiency in horticultural processing MSMEs.

The law has placed more emphasis on conservation of energy than water as can be seen by the Energy act as well as Kenya National Energy Efficiency and Conservation Strategy which have clearly outlined responsibilities for the National and County governments in enforcing energy efficiency. Fines and penalties have also been clearly spelt out for industries that don't comply to the legal requirements; this is noticeably lacking in the water act. Also, the amount of money charged for use of water is quite minimal compared to energy use thus majority of the MSMEs have placed more emphasis on energy use efficiency compared to water due to the high electricity bills incurred on energy use.

4.5 Conclusion

Legal framework has little influence on energy and water use efficiency of horticultural processing MSMEs in Kenya. With respect to influence of legal framework on energy efficiency by horticultural processing MSMEs, the study established that despite the well-articulated policies on energy use efficiency, enforcement was largely lacking. More emphasis has been put on energy efficiency as opposed to water efficiency in view of the elaborate policies that have been formulated towards energy use efficiency.

4.6 Recommendations

It is imperative for the Government agencies to take up the role of enforcement that they are charged with so as to ensure energy and water use efficiency in the agro-processing industry. Use of incentives such as subsidies and rebates will go a long way in encouraging horticultural processing MSMEs to be more cautious in the use of these two resources. The government should also carry out education and awareness activities regularly to enlighten the horticultural processing MSMEs on their legal obligations towards energy and water use efficiency. The government should tailor make policies that specifically target MSMEs to encourage them to adopt the energy and water efficiency measures. Further the government should consider subsidizing audit programs to increase the uptake of energy and water audits in the agro-processing industry given that these audits will enable them adopt efficiency measures. However, these subsidies should be given with caution to avoid the free rider problem. Water reuse has been implied in various policies and legal instrument; however, this is not sufficient. The government needs to go a step further and formulate water reuse policies and guidelines that will guide the manufacturing industries on water reuse strategies. There is also need to appoint a government institution in charge of enforcing water reuse in industry and revising the water tariffs that will reflect the true cost of water.

CHAPTER FIVE

ROLE OF GREEN TRAINING IN ENERGY AND WATER USE EFFICIENCY IN HORTICULTURAL PROCESSING MSMES IN KENYA

Abstract

Processing of horticulture products involves intensive consumption of energy and water. Water and energy are a prerequisite for processing yet these two resources are increasingly becoming scarce owing to continued population growth and increased demand for products. Micro, small and medium enterprises individually consume less resources but when viewed in entirety their consumption trends cannot be ignored. MSMEs deem their activities as having minimal impact on the environment yet this is not true. Lack of information is a huge deterrent to the resource efficiency efforts by MSMEs. Cross sectional research design was used to undertake the study, structured questionnaire used to collect data from 39 MSMEs processing horticultural produce who had been purposively selected from a sampling frame obtained from Kenya Bureau of Standards (KEBS). The finding of the study indicate that the green trainings offered by the Hortigreen Project had a positive influence on the MSMEs. With regard to the influence of the green training on energy efficiency, 44% of the MSMEs surveyed were using renewable energy compared to before the training when only 39% were using renewable energy. Further 28% of the MSMEs carry out energy audits in comparison to only 8% before the training. It emerged that 74% of the MSMEs monitor their energy use after the training in comparison to 41% before the training. With reference to water efficiency, before the green training, only 15% of the MSMEs reused water, after the training, this figure changed to 59% pointing to the positive results of the training. Only 5% of the MSMEs monitored their water use before the training, thereafter the figure increased to 49% after the training. On water audits, only 5% carried out water audits and this figure increased to 26% even though it is still a minimal number.

However, it was interesting to note that the efficiency measures adopted are short term which will only lead to short term benefits. The MSMEs were not too keen on adoption of capital-intensive efficiency measures which would bring them immense benefits in the long term in spite of the information obtained from the trainings.

5.1 Introduction

Training or capacity development of employees results in improvement on performance of the organization (Esteban-Lloret *et al*., 2018) as well as quantity and quality of the employees' work (Nwankwo and Abumchukwu, 2010). Training is a significant component of a firm's operation as well as the environmental management research agenda (Sarkis *et al*., 2010) . Green training refers to "a type of training related to relevant environmental topics, which enables all staff to integrate the firm's performance with environmental issues". It is a process of continual education conceived to apprise the knowledge and skills of employees which is what is needed by both the employees and companies for sustainable development (Teixeira *et al*., 2016). Training is an essential function and resource in responding to the competitive pressures to adopt environmental practices and building the necessary capability.

Small and medium enterprises (MSMEs) have a significant part to perform in a majority of most economies especially in developing countries. MSMEs are responsible for most of the businesses globally and are a requisite for creation of jobs as well as economic development worldwide. Documentation indicates that MSMEs are responsible for over 50% of employment and account for 90% of businesses globally (World Bank, 2021). The food processing industry is amongst the biggest consumers of energy as well as water in the manufacturing sector. It is imperative that measures geared at conservation are implemented so as to reduce the consumption of electricity, water and fuel so that industries can attain growth that will be sustainable in the long term (M. Compton *et al*., 2018).

Earlier research has discussed information deficiencies as a major barrier to improved energy efficiency in MSMEs. Information deficiencies can be categorized into three categories: lack of information, cost of obtaining information together with accuracy of information (Golove and Eto, 1996), as well as a lack of training to process complicated and unfamiliar data. Other barriers faced by MSMEs that inhibit them from adopting energy efficiency measures include lack of internal capacity to develop and implement energy efficiency projects as well as inadequate information about how and where energy is utilized in their enterprises. Thus, energy efficiency is hardly regarded as a priority (Henriques and Catarino, 2016)

Inadequate knowledge on energy efficiency also heightens concerns that energy efficiency measures may lead to disruption of the production processes, cause losses in revenue or affect the quality of products in addition to reservations on cost savings (Olsthoorn *et al*., 2015). Such concerns will therefore be a significant constraint barring MSMEs from adopting energy efficiency measures. When MSMEs resolve to engage in energy efficiency projects, they might be forced to depend on parties external to the enterprises for technical as well as financial guidance. In the absence of this guidance, this barrier on lack of suitable skills is reinforced further (Henriques and Catarino, 2016).

Acquisition of knowledge and development of technical expertise is crucial for knowing what to decide and implement. Offering training as well as building capacity of MSMEs on SCP practices increases the probability of MSMEs to adopt SCP practices in their horticultural production (Aseto *et al*., 2022). The results of this present study will contribute to environmental research by focusing on the role of green training on energy and water use efficiency of horticultural processing MSMEs in Kenya.

5.2 Methodology

The study was conducted in Kenya specifically in Nairobi, Kiambu, Nyeri, Makueni, Laikipia, Nakuru, Murang'a, Embu, Meru, Kisumu, Homabay, Uasin Gishu and Vihiga counties where the study purposively targeted horticultural processing MSMEs. Thirty-nine (39) MSMEs were purposively selected to be included in the survey.

Green training was carried out between 2019 to 2021 whereby the selected MSMEs were invited for trainings. The trainings were done through lectures and case presentations whereby the MSMEs were able to learn best practices from enterprises that had incorporated efficiency measures in their operations. The focus of the training was sustainable consumption and production practices whereby the training focused on efficient use of energy for processing, efficient use of water for processing and waste management. Regarding efficient use of energy, emphasis was placed on adoption of housekeeping measures which will help the MSMEs reap benefits even with no capital investment involved; on efficient use of water, the MSMEs were taught about ways in which they can reuse water where possible, practice simple housekeeping measures such as turning off taps when not in use, prompt repair of leakages and practicing rain water harvesting where possible, emphasis was also placed on water audits to help them attain water use efficiency.

On waste management, the MSMEs were taught the importance of reducing, reusing and recycling waste so as to minimise on the waste generated. Further they were taught on importance of quantifying the amount of waste generated and how to safely dispose of the wastes. The MSMEs were also trained on environmental management systems in particular ISO140001 and this was done by Kenya Bureau of Standards. Further the MSMEs were taken through green financing so as to raise their awareness on green financing opportunities together with the Institutions that offer green financing to enable the MSMEs undertake projects or investments which are environmentally sustainable. The MSMEs were expected to implement the knowledge acquired in their enterprises. The project partner institutions represented included; the Fundacion SUSTALDE, University of Nairobi (UoN), Kenya Bureau of Standards (KEBS) and Consumer Information Network. The training registers are contained in appendix 2.

Data was collected using a questionnaire. The questionnaire had 10 questions on influence of green training on energy efficiency of horticultural processing MSMEs and 9 questions on influence of green training on water efficiency of horticultural processing MSMEs. The MSMEs representatives were asked to recall the practices of their enterprises on energy and water use efficiency before undergoing training and after being trained. Thematic analysis was done with the help of SPSS and descriptive statistics such as frequencies, and percentages determined.

5.3 Results

5.3.1 Demographic characteristics

All the MSMEs interviewed had undergone training on energy and water use efficiency. Out of the 39 MSMEs interviewed, 45% were micro, 42% small while 13% were medium enterprises. More than half (53%) indicated that they had been processing for between 3 to 5 years, 37% indicated that they have been processing for between 5 to 10 years, 5% for between 10 – 15 years while 5% have been processing for over 15 years.

5.3.2 Effect of green training on energy use efficiency of the horticultural processing MSMEs in Kenya

5.3.2.1 Relevance of green training

All the MSMEs (100%) indicated that they had received green training specifically on energy use efficiency. Over half of the MSMEs (64%) agreed that the training received was relevant to their energy use efficiency practices, 31% strongly agreed, while 5% disagreed that the training received was relevant to them. The 5% were further asked why they thought the training was not relevant to them; one responded that she thought the training on energy use efficiency was applicable to a medium enterprise and not a micro enterprise while another responded that the focus of the enterprise is sales and profit thus they don't have the time nor resources to apply the knowledge received from the training. All of the MSMEs indicated that they had shared the training with their fellow employees. The MSMEs were further asked if there has been notable savings in their energy bills. Over half of the respondents (80%) indicated that there had been no notable savings in their energy bills while 20% indicated that there had been notable savings in their energy bill. The savings in energy bill ranged from USD 7.23 to 649.09.

5.3.2.2 Energy conservation

The energy conservation practices among the companies were evaluated before and after the training and the results were as follows: according to the findings, 41% of the companies were practicing energy conservation measures even before the training, but the percentage increased to 74.4% after the training. This implies that the training led to an improvement in energy conservation among the companies. Companies that were practicing energy conservation before the training were doing it through switching off idle equipment, use of natural light and switching to equipment that consume less electricity for instance using a sealing machine that uses kerosene instead of electricity. Others ensured regular maintenance of equipment to ensure efficiency, using thermal oil which consumes less energy, use of solar drier for processing, reusing macadamia nut shells as fuel for the boiler as well as bulk processing.

After training, a number of the companies installed meters, started monitoring energy use and consolidating materials and products stored in different cold rooms especially during low season into one thus reducing the amount of energy spent in powering cold rooms. The companies also began replacing incandescent bulbs with energy saving bulbs, embraced bulk processing, replaced faulty or worn-out machines, replaced the thermal oil to a better alternative best suited for production, conducted capacity building of staff on energy use efficiency and used signage and guides to remind staff on good practices. The companies also held quarterly meetings to evaluate data collected on energy use and come up with strategies to minimize energy use if need be.

5.3.2.3 Reduction in uncontrolled use of energy

The MSMEs were asked to recall how there has been a reduction in uncontrolled use of energy before and after the training and it was established that 2.6% of the MSMEs indicated that their companies had noted reduction in uncontrolled use of energy before the training, however, this increased to 61.5% after the training. This shows that the training had an impact on the reduction in uncontrolled use of energy among the companies. After the training, the companies adopted simple housekeeping measures to help lower their energy bills. In addition, the MSMEs ensured better planning in production so that bulk processing is done. Other strategies used included staff sensitization that resulted in energy savings of up to 40%, using solar energy for drying hence minimizing cooking time and continuous batch processing which avoids having to reheat the oil when processing in small batches thus over consumption of electricity. The companies also ensured that energy records are taken on a daily basis and if consumption exceeded the expected limit remedial measures put in place as well as including energy saving in the company's environmental policy. In addition, sub-metering has helped the companies identify processes that are energy intensive and staff were appointed to monitor energy consumption.

5.3.2.4 Improved planning and control in energy use

The MSMEs were asked to indicate how there was improved planning and control in energy use before and after training and the findings indicate that improved planning and control in energy use increased among the companies from 5.1% before the training to 56.4% after the training. This implies that training led to an improvement in improved planning and control in energy among the companies. Before the training the enterprises ensured improved planning and control in energy use through bulk production as opposed to bit-by-bit processing, storing raw materials and products in the same cold room during low season to minimize energy use. In addition, data on energy consumption taken daily and with time the employees have understood the production process and knew the exact amount of energy required for processing thus no wastage.

After the training, the companies implemented bulk processing, solar drying to reduce processing time, staff sensitization, regular servicing of machines to ensure efficiency, solar drying of produce to minimize cooking time on gas and ensured production planning and optimal operation of machines. The companies were also storing raw materials and products in the same cold room during low season to minimize energy use. Further, an Environmental Management representative (EMR) was appointed and tasked with monitoring energy usage and submitting a report to inform decision making. Further, the floor manager switches off the power there is no production ongoing to avoid wastage of energy.

5.3.2.5 Use of renewable energy

The use of renewable energy among the companies before and after the training was evaluated and the results revealed that 38.5% of the MSMEs indicated that their companies were using renewable energy before the training. After the training, 43.6% of the participants indicated that their companies were using renewable energy, which implies that the training led to an improvement in the use of renewable energy among the companies. The MSMEs not using renewable energy cited cost as the major hindrance to them that inhibited them from investing in renewable energy.

5.3.2.6 Implementation of awareness and monitoring programs on energy efficiency

Regarding the implementation of awareness and monitoring programs on energy efficiency the MSMEs were asked to indicate if this was done before and after the training. It emerged that 7.7% of the participants indicated that their companies implemented awareness and monitoring programs on energy efficiency, which increased to 59% after the training. This implies that the training led to an improvement in awareness and monitoring programs on energy efficiency among the companies. Before the training, the companies conducted training and sensitization of employees on energy use and monitored energy consumption. After training, the management saw the need for investing in capacity building of staff, allowed staff to attend training externally when the opportunity arose, and conducted continuous internal training of staff. There was also basic sensitization of employees to remind and encourage them to adopt simple practices such as switching off lights and idle machines, appointed a committee tasked with monitoring energy usage, held quarterly meetings to report on their findings, enlightened employees on efficient energy use since it was part of the company's environmental policy as well as used signage and guides.

5.3.2.7 Change in how employees use energy

The MSMEs were asked to indicate if there was any notable change in how employees use energy before and after the training and the findings from the study established that there was no change in how employees use energy in all the companies before the training. However, this changed significantly after the training as 64.1% of the MSMEs indicated that there was a change in how employees use energy. This was due to the adoption of simple housekeeping measures and the training of employees on ways to minimize the use of energy. It was reported that after the sensitization and training of employees they remembered to switch off lights and equipment not in use unlike before when they forgot. In addition, the machines are powered only when they are ready to be used, the generator is switched on only when needed unlike before when it could be switched on in case of power outage even when there was no production ongoing. Also, signage reminded employees of good energy use practices while guides reminded staff on optimal operation of equipment to ensure efficiency. In addition, the employees were made aware of the importance of an efficient production process and efficient equipment in energy use efficiency.

5.3.2.8 Carrying out energy audits

The MSMEs were further asked if they carry out energy audits before and after the training. It emerged that only 7.7% of the companies were carrying out energy audits before the training, which increased to 28.2% after the training. This implies that the training led to an increase in the carrying out of energy audits among the companies. However, there is still room for improvement in energy audits. An energy audit is a powerful tool that can help MSMEs improve their energy efficiency.

5.3.2.9 Monitoring of energy use

The MSMEs were further asked to recall if monitoring of energy use was done before and after the training. The results showed that monitoring of energy use increased from 17.9% to 59% of the total companies, which implies that training led to improved monitoring of energy use among the companies. Before the training, the companies were comparing production against monthly energy bills, conducted a daily reading of energy consumption data, and conducted a physical inspection of machines to either replace worn-out ones or to carry out routine maintenance. After the training, the companies analysed energy bills to know the company's consumption trends, and temperature control to avoid wastage of energy. They were also comparing production quantity against energy consumption, conducted frequent meter readings and corrective action of consumption exceeding the expected amount, sub-metering of equipment to monitor energy use, and installed circuit breakers.

5.3.2.10 Implementation of Environmental Management System (EMS)

The implementation of EMS among the companies before and after the training was evaluated and the results were as follows: only 2.6% of the companies had implemented EMS, and this figure increased to 17.9% after the training. This implies that the training had a positive effect on the implementation of EMS among the MSMEs albeit minimally. Most of the MSMEs indicated that they were in the process of putting mechanisms in place to help them with implementing EMS.

5.3.2.11 Formulation of environmental policy

Regarding environmental policy, the MSMEs were asked to indicate if they had formulated an environmental policy for the company. The findings show that before the training only 5.1% of the companies had an environmental policy, which increased to 46.2% after the training.

This implies that the training had an impact on the formulation of environmental policies among the companies.

The results of the findings on the influence of green training before and after on energy efficiency measures by horticultural processing MSMEs in Kenya are presented in Figure 14 and Figure 15 respectively.

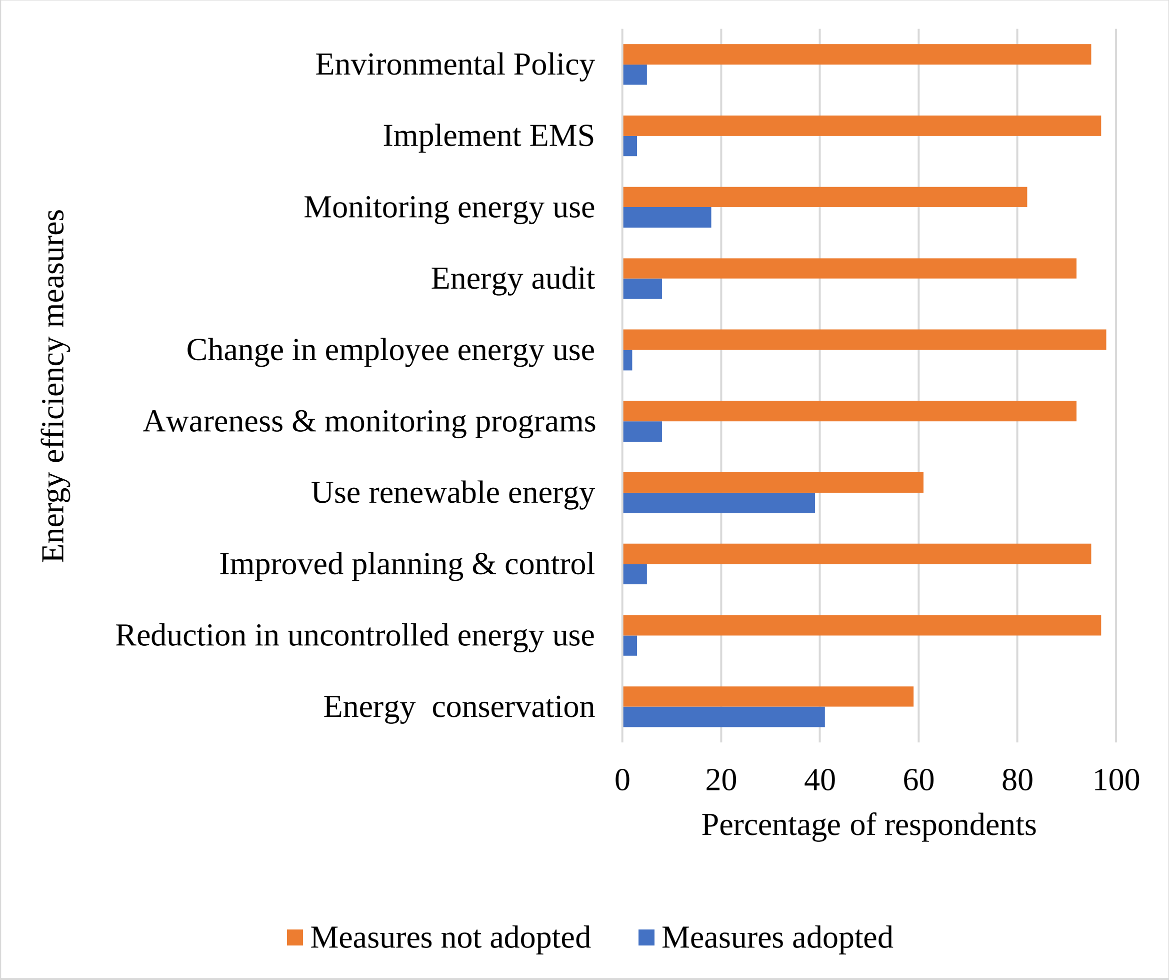

Figure 14 Energy Use efficiency of Horticultural Processing MSMEs in Kenya before training

(Source: Researcher, 2022)

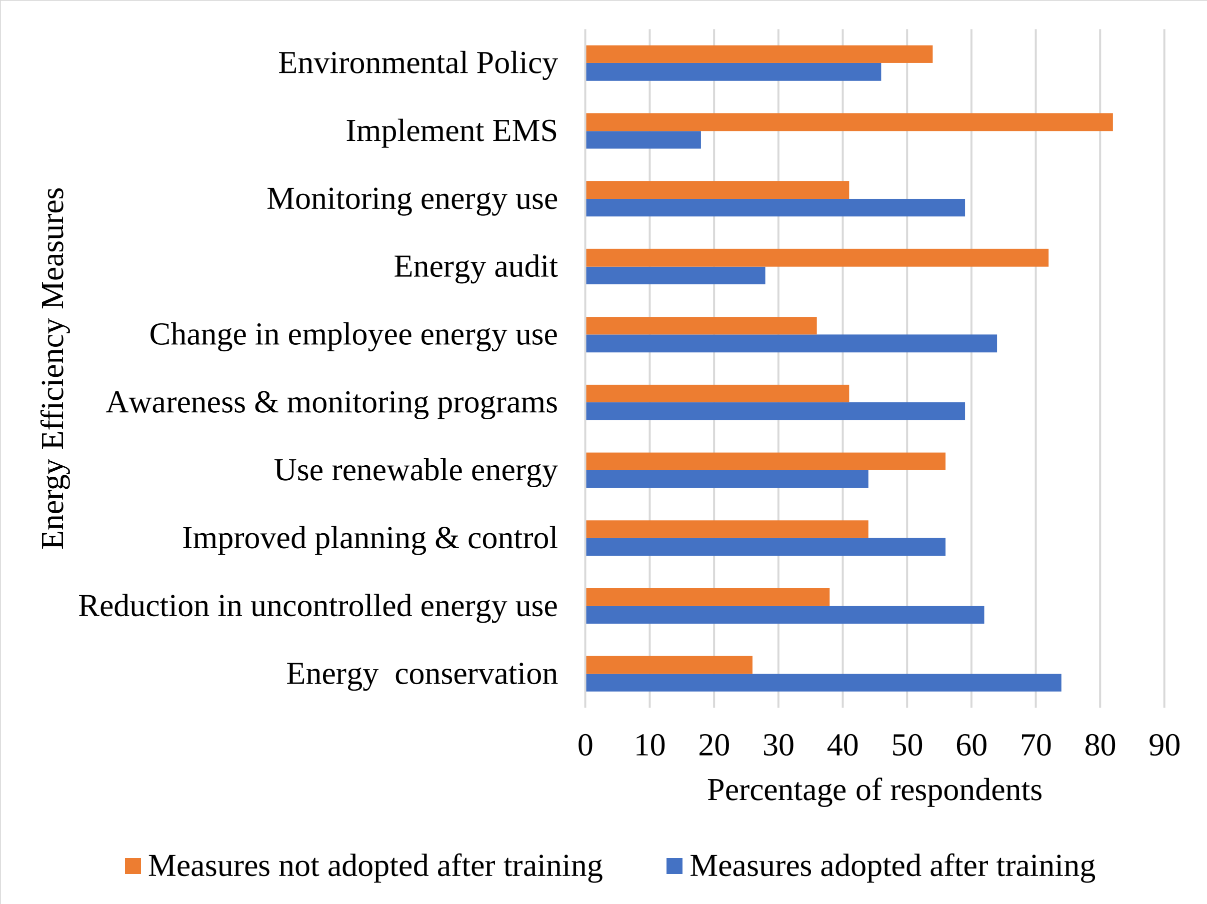

Figure 15 Energy use efficiency of horticultural processing MSMEs in Kenya after training
(Source: Researcher, 2022)

5.3.3 Relevance of green training to water efficiency

All the MSMEs surveyed indicated that they had attended the green trainings offered by the Hortigreen Project in conjunction with the University of Nairobi and other project partners. The MSMEs were asked if the training received was relevant to their water efficiency efforts and 67% indicated that the training was relevant while 33% said the training was not relevant to their enterprises. With regard to the 67% who said the training was relevant, they were further probed to explain why they thought the training was relevant and they indicated that the training raised awareness of the employees on the need of efficient resource use and they learnt about measures that they can adopt to ensure water efficiency. Those who thought the training was irrelevant were also asked to state why they thought it was irrelevant; the reasons cited include: the focus of the company is on increasing sales and making a profit, it being a microenterprise they have been struggling to stay afloat. Other reasons were that the water bill is quite minimal that is USD 2.13 per month thus there is no need to put in more resources towards water efficiency, water is adequately available from the borehole hence they didn't see the relevance of the training. Another respondent further indicated that very little is used for processing thus this training should have targeted larger enterprises with a bigger water footprint, due to lack of business premises the enterprise cannot implement what they have been taught and the company doesn't keep records on its water consumption since water bill is included in the rent. Only 7% of the MSMEs confirmed that there has been a notable change in their water bill while 93% indicated that they had been no change in their water bill. The noted change in the water bill ranged from USD 2.17 to USD 16.

5.3.3.1 Conservation of water

The MSMEs were asked to recall the measures used by the enterprises to conserve water before and after the training. It emerged that before the training, 41% of the participants indicated that their companies had measures in place to conserve water, while 59% indicated that there were no measures in place to conserve water. Measures used included closing water taps after use, rain water harvesting, using storage tanks, washing utensils in basins to minimize water use as well as recirculating water in boilers and regular maintenance of pipeline. The enterprises were also processing standard care products that require little water for processing, reusing water for cleaning purposes/ flushing toilets, installing foot-operated taps for efficiency as well as pre-soaking of utensils and equipment.

After the training, 71.8% of the participants indicated that their companies had measures in place to conserve water, but 28.2% indicated that their companies still had no measures in place to conserve water. Measures in place included turning off taps when not in use, rain water harvesting, storing water in tanks as opposed to fetching water directly from the tank, minimizing water usage, washing equipment immediately after processing to avoid excess usage of water to clean the equipment, installation of meters to monitor consumption, using dry cleaning methods, installed foot-operated taps to minimize wastage, educating/training employees as well as repairing of leakages and replacement of hosepipes. The enterprises were also ensuring the prompt repair of leakages and faulty valves, processing standard care products that consume little water for processing, installation of automatic taps to minimize wastage as well as signs and guides to remind staff on good practices. In addition, some MSMEs had done piping in the production area so that water is supplied directly to the production area to avoid wastage. Also, the enterprises were reusing water for cleaning purposes, irrigation, flushing toilets as well as recirculating water in the cooling tower. Further, some MSMEs had installed separate tanks for cleaning and processing purposes to effectively monitor water usage.

5.3.3.2 Reuse of water

The reuse of water among the companies before and after the training was evaluated and the results were as follows: according to the findings, before the training 15.4% of the participants indicated that their companies were reusing water while 84.6% were not reusing water. The enterprises were reusing water through recirculating cooling water in the boiler and/ cooling tower, irrigation, sanitation purposes (washing floors, flushing toilets).

After the training, there was a notable increase in the number of MSMEs reusing water. Over half of the MSMEs surveyed (59%) indicated that they were reusing water while 41% indicated that they were not reusing water. After the training, the MSMEs indicated that they reused water for cleaning purposes (cleaning floors, cleaning raw materials – final rinse used for the first wash, cleaning packaging material as well as flushing toilets), recirculating cooling water into the boiler, given to livestock and irrigation.

5.3.3.3 Recycling of water

The recycling of water among the companies was evaluated before and after the training and the results indicated that the number of companies (5%) that were practicing recycling remained the same. In addition, the majority of the companies (95%) were not practicing recycling. Before the training, charcoal and gravel was used to remove pollutants from water and reused for irrigation. Waste water was also channelled to a lagoon, held there as it undergoes purification and released to the environment after removal of pollutants. The same methods were used in recycling water after the training.

There was little change in the number of MSMEs practicing recycling of water due to the intensive capital investment required to set up a water treatment plant.

5.3.3.4 Reduction in uncontrolled use of water

The MSMEs were asked to recall how there had been a reduction in uncontrolled use of water before and after the training and the results indicated that, the reduction in uncontrolled use of water increased from 5.1% before training to 56.4% after the training. Before the training, strategies in place to ensure reduction in uncontrolled use of water was through bulk processing and reusing of recycled grey water, which minimized pumping of fresh water to the garden for irrigation.

After the training, it was established that the strategies in place to ensure reduction in uncontrolled use of water is bulk processing, replacement of faulty pipes and taps, use of signage and guides, closing taps after use, pumping water and storing it in a tank as opposed to consuming it directly from the tap to reduce on wastage, dry cleaning raw materials, education of staff to raise awareness on importance of efficient water use, installation of proper water piping system, sub-metering to monitor the amount of water used for production as well as prompt repair of faulty valves and fittings.

5.3.3.5 Improved planning and control in water use

Improvement in planning and control in water use was assessed before and after the training and the results were as follows:

The training led to an improvement in planning and control in water use from 5.1% of the MSMEs surveyed before training to 43.6% after the training. Before the training, planning and control in water use was implemented through bulk processing, pumping water only when required and some enterprises manufactured pulp once a month then pasteurized the pulp as a way of minimising bit by bit production that was turning out to be water-intensive hence reduction in water usage.

After training, there was improved planning and control in water use through bulk processing, rearranging the production area, staff sensitization (training), monitoring of departmental water usage, pumping water only when required, recording of water meter readings taken before and after production to monitor water use and sub-metering to monitor water use across departments. Other measures used include use of separate tanks for cleaning and processing to monitor usage and collecting data to inform them on their water usage trends. The companies had sub-metered the tank supplying the production area to monitor water use. Through monitoring water consumption, the companies were able to detect any excessive consumption and take remedial actions. Also, water audits and water action plans helped in planning how water should be used and reducing consumption.

5.3.3.6 Implementation of awareness and monitoring programs on water efficiency

The MSMEs were asked to indicate how the implementation of awareness and monitoring programs on water efficiency was done before and after the training. According to the findings, the implementation of awareness and monitoring programs on water efficiency among the companies increased from 10.3% before the training to 43.6% after training. Before the training, the implementation of awareness and monitoring programs on water efficiency was conducted through sensitization of staff on water use.

After the training, the implementation of awareness and monitoring programs on water efficiency was conducted through continuous sensitization of staff, monitoring water bills monthly, use of signage and guides, knowledge sharing on training received on water use efficiency, weekly meetings held with employees where data on water usage shared and measures taken to reduce on consumption. Other ways included formulating and implementing company's environmental policy.

5.3.3.7 Change in how employees use water

The MSMEs were asked to recall and indicate if there has been a change in employee water use practices before and after the training. Before the training, it was established that there was no change in how the employees had been using water. However, this changed after the training as 56.4% of the participants reported change in how the employees use water. After the training, the employees were more conscious and mindful in the way they use water, adopted simple housekeeping measures such as turning off taps when not in use, using dry cleaning methods, minimising water use and immediately reporting leakages.

5.3.3.8 Carrying out of water audits

Carrying out of water audits among the companies was assessed before and after the training and the results are as follows: Before the training, only 5.1% of the companies were carrying out water audits, but this increased to 25.6% after the training. This implies that training led to an improvement in the carrying out of water audits among the companies. The MSMEs realized the benefits of conducting water audits and started implementing this practice to ensure efficiency in water use. However, there is still need for improvement in this area; it will be hard for the MSMEs to conserve water yet they don't know how much they use. Carrying our water audits will help the MSMEs know how much water they consume and then put measures in place to minimise consumption.

5.3.3.9 Monitoring of water use

Monitoring of water usage among the MSMEs was assessed before and after the training. The findings indicate that before the training, only 5.1% of the companies were monitoring water usage, but this increased to 48.7% after the training. Before the training, a few companies had installed meters to monitor usage and reading from the water meter regularly taken. After the training, almost one half of the companies installed meters to monitor usage and reading of the water meters was done regularly (morning and evening). In addition, the companies installed separate water tanks for cleaning and processing to help in monitoring water usage, and sub-metering of water intensive equipment for instance the pulping machine to separate water use and effectively monitor processing phases that are water intensive.

The results of the questions on influence of the green training on water use efficiency measures of horticultural processing MSMEs is presented in Figures 16 and 17 before and after training respectively.

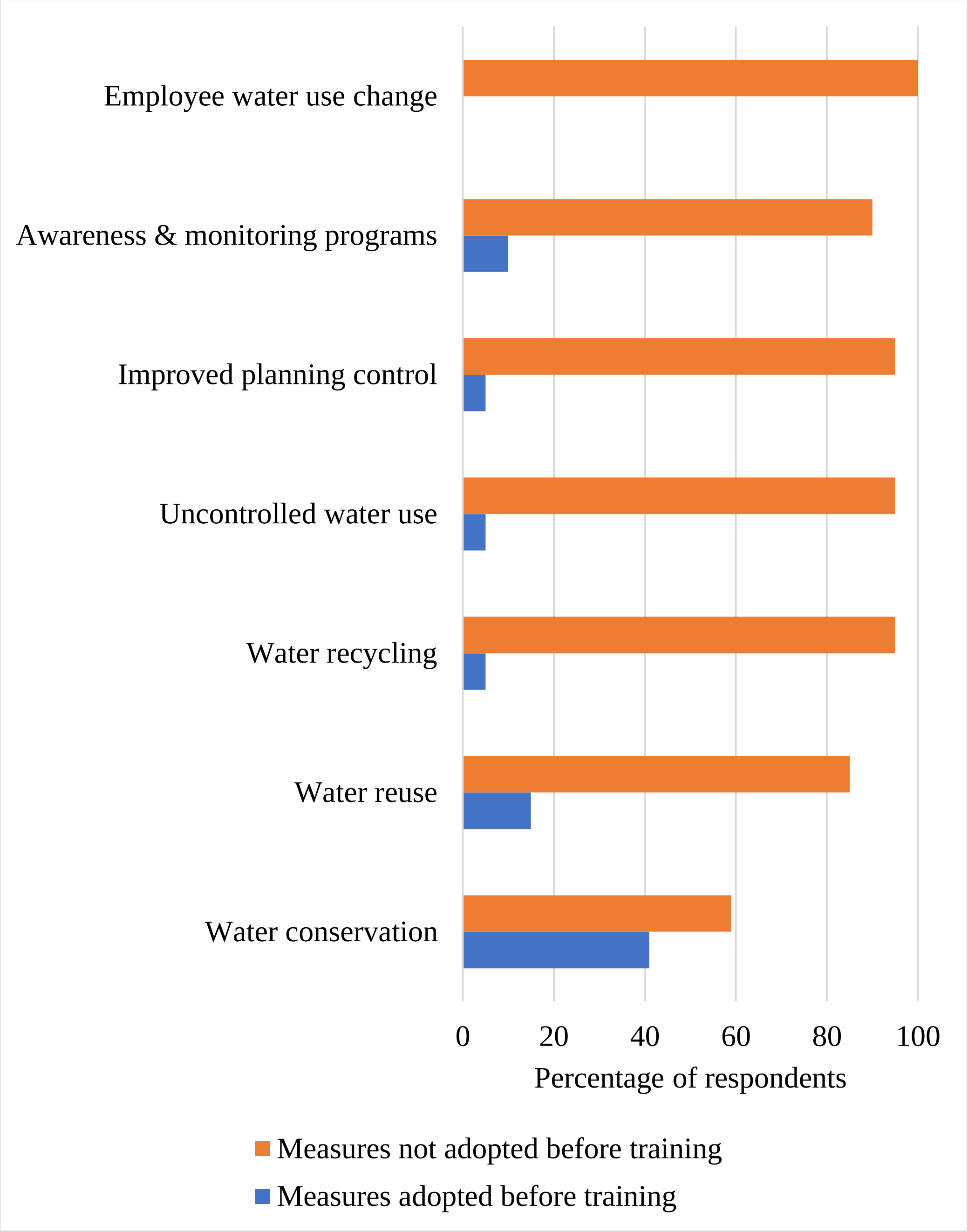

Figure 16 Water use efficiency measures of horticultural processing MSMEs in Kenya before the Green Training. (Source: Researcher, 2022).

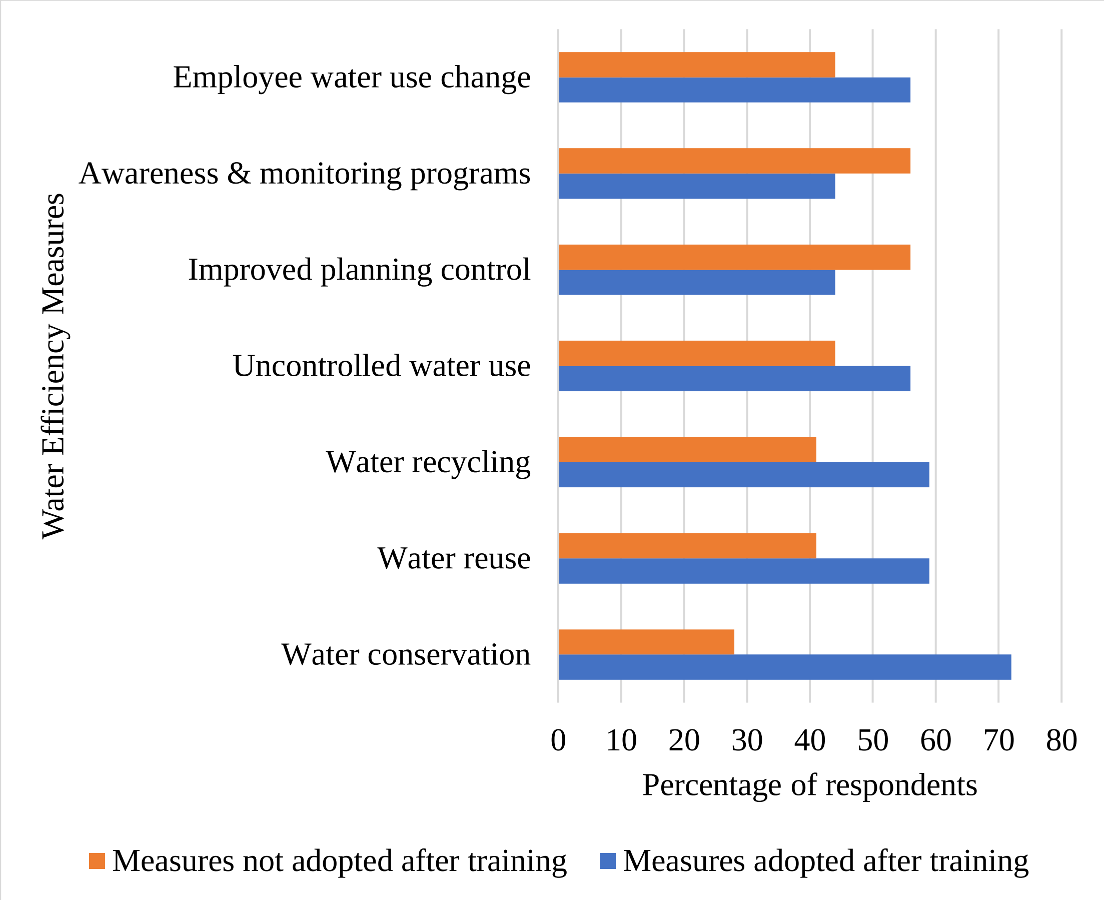

Figure 17 Water Efficiency Measures of Horticultural Processing MSMEs in Kenya after the Green Training (Source: Researcher, 2022)

5.4. Discussion

5.4.1 Influence of green training on energy efficiency of horticultural processing MSMEs in Kenya

A positive outcome is that all of the MSMEs surveyed implemented some form of energy efficiency improvements. When asked if the MSMEs practiced energy conservation, 74% of the MSMEs indicated that they do. Before the training only 41% of the enterprises practiced energy conservation measures. After the training the MSMEs discovered how much cost they were incurring from not monitoring their energy use. It emerged that the main motivating factor for the MSMEs to adopt energy efficiency measures was to reduce on their cost. The finding by (Southernwood *et al*., 2021) corroborates the findings of this present study.

According to these authors, the main motivation to implement energy efficiency actions is the reduction of cost, followed by the contribution to fighting climate change. The most common measures implemented are related to technical systems, i.e., lighting, ventilation, heating, cooling, and automation, which are lower risk and have quick payback, avoiding any risks to the production line or product quality (Southernwood *et al.*, 2021). Companies are increasingly confronted with perpetually increasing prices of energy, subsequently internal incentives also exist that minimize consumption of energy whilst increasing energy efficiency (Mickovic and Wouters, 2020).

MSMEs are focused on their day-to-day business actives as well as providing solutions to problems facing them thus, they have insufficient time to develop expertise beyond the essential business activities consequently ignoring the numerous opportunities in energy efficiency that would be profitable to them. According to the Observatory of European small and medium enterprises (MSMEs), it established that less than 30% of MSMEs in Europe had applied any measure geared at conserving energy and resources while only 4% had an extensive strategy towards energy efficiency (European Commission, 2014).

While there was a significant improvement in the energy efficiency measures applied by the MSMEs after the training, there is still a lot that the MSMEs can do to improve on their energy efficiency. The major energy efficiency measures carried out are short term in nature such as adoption of simple housekeeping measures like switching off the lights when not in use, switching off idle machines, bulk processing among others. These measures are cheap and easily adoptable by the MSMEs. However, when it comes to long term measures that has a financial implication, the MSMEs were hesitant to implement such measures. For instance, before the training only 39% of the MSMEs used renewable energy, after the training it emerged that 44% of the MSMEs were now using renewable energy. The larger proportion of the MSMEs (56%) not using renewable energy cited cost as a deterrent to them.

Even though most (72%) of the MSMEs surveyed have not undertaken energy audits, a majority of them that is 54% indicated that they have adopted simple housekeeping measures such as switching off lights during daytime, replacement of incandescent bulbs with energy efficient bulbs, switching off idle machines. Implementation of these measures are deemed ‘low hanging fruits that will enable the MSMEs reap cost savings on energy

Further the findings of this study reflect those of the resource-based view of the firm which posits that organizations will build the necessary capacities and capabilities so as to be able to compete more efficiently(Sarkis *et al.*, 2010). The study established that all the MSMEs (100%) had attended the green trainings so as to build the capacity of the staff thereby enhancing their capabilities and that there was indeed a difference before the training and after the training. There was a turn around by the MSMEs whereby they adopted environmental practices that they hadn’t been aware about so as to attain energy efficiency, reduce their costs and increase on their profitability.

In instances where information is available, MSMEs managers do not have the motivation nor time to obtain, process and act on it, consequently such enterprises are many a times unaware of the opportunities to advance efficiency as well as the cost and benefits of these opportunities (European Commission, 2014). Information measures like energy audits, case studies, webinars, technology demonstration projects, workshops, site visits, guides, lists of characteristic energy efficient projects, energy efficiency standards for equipment, clear marking of energy efficiency levels on equipment and fact sheets may aid MSMEs to improve on their energy efficiency (Henriques and Catarino, 2016). Before the training MSMEs were not aware of the importance and benefits of carrying out an energy audit thus only 8% of the enterprises conducted energy audits before the training. After the training, the number increased to 28% which was still minute in view of the benefits that can be achieved by MSMEs that implement energy audits.

For MSMEs to effectively respond to environmental issues they must demonstrate a comprehensive understanding of the environmental issues associated with the industry as well as the supporting law (Seroka-Stolka and Jelonek, 2013). However, various past studies have established that MSMEs lack knowledge on how to react to environmental issues. For instance, majority of MSMEs are unlikely to undertake programs on environmental improvement compared to large firms. This includes having a written environmental policy, to implement a formal environmental management standard or to perform environmental audits (Walela, 2020). This finding is in line with the findings of the present study which established that before the training only 5% of the MSMEs had an environmental policy, this improved after the training to 46% but a larger proportion of the MSMEs (54%) did not have an environmental policy even after they had undergone training. Regarding implementing an EMS, only 3% of the MSMEs had implemented an EMS even before the training; after the training only 18% took up the training received and implemented an EMS.

(Williams and Schaefer, 2013) put forth that a number of MSMEs presume that the impact caused on the environment as a result of their business activities is minimum thus, they don't fully comprehend the extent to which environmental legislation affects them. Consequently, many MSMEs are responsive than proactive when it comes to addressing matters related to the environment. This finding is in line with findings of this present study which established that the MSMEs had majorly adopted simple housekeeping measures as a strategy to achieve energy efficiency and avoided any measure that had heavy financial implication.

5.4.2 Influence of green training on water efficiency of horticultural processing MSMEs in Kenya

Potable quality water isn't needed for each single operation in a food processing facility thus waste water generated in some processes could be recycled in others either with or without additional treatment depending on the water quality requirements for the specific reuse. Those streams should be well defined with respect to water quality parameters, microbial load and chemical composition (Meneses *et al*., 2017). To reduce their water consumption 59% of the MSMEs were reusing water in their enterprises. Before the training only 15% of the MSMEs practiced water reuse. The MSMEs indicated that they reused water for sanitation purposes, washing raw materials (water used in the final rinse used for first wash) as well as for irrigation purposes.

Within the food processing industry, a few sectors have been allowed to use reclaimed water in their manufacturing practices including vegetables and fruits industry (Codex Alimentarius, 2013). What is required is continual monitoring, audits and frequent sampling of the water. Kenya has been a member of the codex since 1969, implementation of these standards by horticultural processing MSMEs in Kenya will aid in minimizing fresh water consumption and enhancing the environmental sustainability of this industry. The MSMEs surveyed only reused water for sanitation purposes and/or irrigation but not for processing.

The study established that there was no change in the number of MSMEs who practiced water recycling before and after the training. This number remained at 5%. The reason for the small number of the MSMEs who practice water recycling can be explained by the results of a study by (Meneses *et al.*, 2017) which established that the food industry specifically at the food processing phase is very sensitive to the concept of water recycling due to the adverse nonscientific based perceptions about the characteristics of the reused water as well as the potential risks for contamination. The authors go on to argue that if more science-based information was availed, then this risk perception might be less biased. Regrettably there are few publications concerning the consequences of utilizing reconditioned water in food processing scenarios. In addition, the cost for setting up a water treatment plant is a deterrent to many MSMEs.

According to (Kurle *et al.*, 2015), a number of manufacturing companies are unable to take advantage of hidden potentials in optimizing their water operations. This study established that little effort had been put in by MSMEs to attain water use efficiency. Before training only 5.1% of the MSMEs ensured that there was improved planning and control in water use. After the training, this figure changed to 44% meaning that concerted efforts hadn't been put in to ensure efficient use of water. Regarding water audits only 5.1% undertook water audits before training; after training the figure increased to 26% which is still minimal. Over half of the MSMEs that is 74% were still not carrying out water audits after the training in spite of the knowledge they had gained from the green trainings attended.

One vital resource that has historically been neglected when it comes to considering resource consumption in industry is water. This finding by (Kurle *et al.*, 2015), further corroborates the findings of this study. The MSMEs were asked if they monitor their water usage, before the training 5% of the MSMEs monitored their water use and after the training it was established that 49% of the enterprises were monitoring their water use. On further probing, it emerged that the 51% who don't monitor their water use indicated that they felt their water bill was minimal hence no need for monitoring, others indicated that the water bill was included in their rent thus no need for monitoring since there will be no difference in the cost. Over half of the MSMEs that is 56% were still not implementing monitoring and awareness programs aimed at water use efficiency even after the training. This explicitly shows that water is deemed a cheap resource and is often neglected by industries in their pursuit of resource efficiency. According to (Sachidananda *et al*., 2016), less effort has been placed on management of water as compared to management of energy.

Australian Government conducted a survey on manufacturing groups and established that through application of basic interventions for instance behavioral change, recycling without reconditioning treatment as well as monitoring, savings on the total quantity of water used of up to 25%, 30% and 60% respectively can be attained (Australian Department of agriculture, 2007).

It was interesting to note from the study that the MSMEs are willing to focus on ad hoc measures such as energy and resource efficiencies rather than strategic measures that have long-term impact such as formulating environmental policy, adoption of EMS, water and energy audits. Their main focus has been on simple housekeeping measures such as turning off taps when not in use, reusing water, prompt repair of leakages among others. Little effort has been put in long term strategies such as water recycling and water audits. This confirms findings of previous studies (Revell *et al*., 2011) which highlight the short-term strategies towards efficiency adopted by MSMEs.

The study reveals the importance of day-to-day behavior of employees in achievement of savings in energy. The studied enterprises valued measures related to behavior as similarly important as technical measures. The results suggest that energy efficiency should be imbedded in the corporate strategy, use of broad spectrum of different practices as well as the involvement and empowerment of employees as major drivers in establishment of energy efficiency within MSMEs. Additionally, the findings reveal external influences on shaping the meanings of energy efficiency for the MSMEs by raising attention for energy efficiency in the enterprises and making energy decisions more likely (König *et al*., 2020).

(Aseto *et al*., 2022) established that through mounting training as well as strengthening the capacity of MSMEs on SCP, MSMEs were increasingly likely to integrate SCP practices in their horticultural production. This finding mirrors the findings of the present study which established that after the green training were offered all the MSMEs picked one form or another of the SCP practices and started implementing them. Further, the probability of encouraging MSMEs to adopt and continue implementing SCP practices is dependent on access to reliable and stable markets that permits them to recover their initial investments for integrating SCP practices. Improving access to financial and capital tools might enable MSMEs to prevail over barriers that make adoption of SCP practices unattractive for instance lack of production equipment and machinery as well as huge upfront investment.

The MSMEs were unable to adopt green energy due to the huge capital investment involved thus the continued reliance on electricity which is not only environmentally unsustainable but also financially unsustainable in the long run due to the high cost of electrical energy used for manufacturing. (Aseto *et al*., 2022) stresses on the need for availing financial support to MSMEs and enabling them to access finance from financial institutions or any other incentive can be amongst the highly effective means of making an impact on the sustainability of MSMEs. Lack of collateral is the major challenge faced by MSMEs that prevent them from accessing credit, thus necessitating the need for the establishment of a fund that will help in guaranteeing MSMEs thus minimizing their financial risk and making them attractive to the financial institutions.

Further the formation of cooperatives can enable MSMEs to consolidate resources thereby enhancing their access to formal credit. Governments can also support horticultural MSMEs by establishing targeted policies that aim to address the challenges faced by MSMEs when it comes to accessing finances, providing financing which is affordable through the local financial institutions (FIs) consequently creating an enabling environment that minimizes the risk of FIs advancing loans to MSMEs thus enabling them to provide loans which are affordable to MSMEs (Aseto *et al*., 2022).

5.5 Conclusions

The training equipped the MSMEs with the knowledge needed to attain efficiency in energy and water use. However, more emphasis was placed by the MSMEs on implementing energy efficiency measures as opposed to water efficiency measures due to the high electricity bills incurred. There is need for additional frequent and structured training to help the MSMEs shift from adoption of short-term efficiency measures to long term efficiency measures which has more capital gains.

5.6 Recommendations

There is need for more education and sensitization for the MSMEs to fully understand the need for prioritizing water efficiency measures as well. There is also need for subsidization of renewable energy equipment to enable MSMEs switch from energy sources like electricity and fuel onto sustainable forms of energy like solar or bioenergy. The high costs of installing renewable energy prohibits MSMEs from fully adopting them. It will be interesting to study in the future if the MSMEs will be willing to invest in long term improvements towards efficiency once they have fully reaped and exploited the benefits gotten from the so-called ‘low hanging fruits.’

CHAPTER SIX

ANALYSIS ON THE AMOUNT OF ENERGY AND WATER USED BY KENYAN HORTICULTURAL PROCESSING MICRO, SMALL AND MEDIUM ENTERPRISES

Abstract

Energy and water are resources which are a prerequisite for horticultural processing. Accurate and detailed information on the costs related to energy and water consumption by horticultural processing MSMEs in Kenya is necessary to inform decision making on resource use efficiency and for sustainability purposes in this sector. It is against this background that the study was carried out to quantify energy and water used by horticultural processing MSMEs in Kenya. The study used longitudinal research design whereby quantification data on energy use was obtained from 11 industries while quantification data on water use was obtained from 14 industries. The MSMEs were given electricity and water meters for submetering and monitoring how much energy and water was used for processing. The MSMEs were required to take readings of the energy and water meters before and after production, weigh the raw materials before production as well as weigh the final output and provide this data on a monthly basis. The findings of the study indicate that the major source of energy for horticultural processing was electricity from the national grid and that the MSMEs were faced with ever increasing energy bills. Energy consumption was high in MSMEs that used intensive energy processes such as cooling for example specific energy consumption for snow peas was 21,120 KJ/kg. The study revealed that water use was high in companies that processed their products and low in companies that only did packaging of produce that is 30,000 litres in plant K where there was minimal processing compared to plant L where 13,000,000 litres of water was consumed in processing tomato sauce. About 25% of the MSMEs didn't know the cost of water consumed because their source of water was private boreholes or that their water bills was

included in the rent. In the absence of this detailed energy and water cost information, it is difficult for MSMEs to make decisions that will eventually lead to energy and water use efficiency. The cost information will be of value to not only Kenyan MSMEs but also the manufacturing sector as a whole and can be used in improving energy and water efficiency in the horticultural sector.

6.1 Introduction

Presently, efficient use of energy and water is an issue of increased focus to industry because of increasing prices of energy, scarcity of quality water as well as the environmental concerns of governments together with the public in general. In order for an organization to improve on its energy and water efficiency, the initial crucial step is to determine how much, when and where energy as well as water are needed by different pieces of equipment in the company's manufacturing system (Mousavi *et al*., 2016). Information on the level of energy costs of the various departments as well as the finished product is an essential tool for management of energy (Aflaki *et al*., 2013); on the other hand, insufficient information on the energy cost can be a noteworthy hindrance to improvement on energy efficiency for a company (Mickovic and Wouters, 2020).

Continual growth in the global population and rising living standards necessitate growing demand for new products as well as an increase in the consumption of resources. In view of the world's contemporary situation with respect to resource consumption per capita, the population today has surpassed the earth's natural carrying capacity or bio capacity (Evans *et al*., 2009; Rockström. *et al*., 2009). It is expected that this trend will continually go up resulting in a heightened demand for energy as well as water by 40% over the next 20 years if there are no major changes in policy. It has been approximated that there will be a 4-fold to 10-fold increase in resource efficiency necessary by 2050 (European Commission, 2011; World Business Council for Sustainable Development, 2010).

It has been acknowledged by the United Nations that there is existence of a gap of knowledge especially in manufacturing concerning the amount of water withdrawal and consumption used for the intended manufacturing transformation and production needs (WWAP (World Water Assessment Programme), 2012). This issue is of high relevance for small, medium and large manufacturing enterprises alike given that this gap in knowledge results in enterprises missing out on the starting points for efforts geared at minimising water use (Redmond *et al*., 2008).

The initial step towards water reduction is to establish the various stages in processing where water isn't required or at least not in the amounts currently used (Meneses *et al*., 2017). Limited publications in this field give numerical values of water unit consumption indices (Trajer *et al*., 2021). Water is utilised through the food production chain at diverse phases including irrigation, processing, heating, cooling as well as cleaning. Although the percentage of water consumption in the food processing industry is relatively small, it's important to note that food processing industries use only potable water for processing and are often situated near urban areas thus competing with the community for the scarce natural resources (Meneses *et al*., 2017).

It is worth noting that research has been carried out on impacts of agriculture linked to growing of food (Canning *et al*., 2010); the significant usage of energy and water together with its environmental impacts are less studied (Sanjuán *et al*., 2014) . There is paucity of information with this regard from the US food processing industry; whereas EU has availed a detailed document that gives quantified detailed data on energy and water utilization (Santonja *et al*., 2019). Such studies are extremely useful for identification of how water reuse can lead to a notable reduction in depletion of fresh water. This study was therefore carried out to analyse the amount of energy and water used by horticultural processing MSMEs in Kenya.

6.2 Methodology

Longitudinal research design was used to collect data on amount of energy and water used for processing over a period of time. Data on energy and water consumption was collected from December 2019 to September 2021; the data was standardised and only data for one-month portraying consumption of energy and water for horticultural processing was used. It was quite a challenge obtaining data from the MSMEs on their energy and consumption trends due to inadequate records kept on the cost of consumption of energy and water for processing. According to (Bos-Brouwers, 2010) MSMEs provide scarce information concerning their financial performance and strategies thereby contributing to them being studied less. Purposive sampling was used to select 39 MSMEs involved in processing of horticultural produce. Inclusion and exclusion criteria were developed to purposively select horticultural processing MSMEs.

Three hundred MSMEs were trained on SCP practices specifically energy use efficiency, water use efficiency together with sustainable waste management practices. The 300 MSMEs were from Nairobi, Western and Central regions whom were purposively selected. Snow balling sampling was also used until the sample size of 300 MSMEs was attained.

The first inclusion and exclusion criteria were developed and applied. And this entailed having a registered company with a business premise, processing fruits, vegetables as well as MAPS and have some records on energy and water consumption. Monitoring and evaluation were done of the SCP practices that the MSMEs had been trained on through site visits assessments to confirm the existence of these companies, verification of the processing activities as well as monitoring and evaluation of the SCP practices adopted. After the application of the criteria, only 122 MSMEs qualified and moved to the second stage. A baseline survey was conducted in 2018 to inform the study and all the 122 MSMEs were purposively selected and surveyed.

The criterion was further refined after the baseline survey and a second inclusion and exclusion criterion developed. This second criteria involved possession of a company registration certificate, compliance to Kenya Bureau of Standards Certification, possession of a Public Health Licence, at least three years' experience in processing horticultural products (fruits, vegetables, MAPS), consistent regularity in horticultural processing (at least twice a week), having records on energy and water consumption and finally the aspiration to attain ISO 14001 Environmental Management Standard.

The second criterion was applied and only 61 MSMEs were eligible to proceed to the next stage. Further screening was done based on availability of energy and consumption data and only 39 MSMEs met the prescribed criteria; purposive sampling was applied and all the 39 MSMEs were surveyed.

Due to insufficient data and lack of proper and detailed records on energy consumption, only 11 MSMEs were used for quantification because they were able to provide data on their energy consumption; with regard to water, fourteen (14) MSMEs who were able to provide information on the costs associated with water consumption for horticultural processing were surveyed.

The following information was collected from the MSMEs: location and of the MSMEs, date of data collection, processes involved that consumed energy and water, sources of energy and water used in processing of horticultural produce, description of processed product, amount of energy and water consumed per kg of processed product as well as the cost of energy and water consumed every month (energy and water bills).

6.3 Results

6.3.1 Analysis of energy used for horticultural processing by Kenyan MSMEs

The MSMEs were asked if they use energy for processing horticultural produce and all of the MSMEs indicated that they use energy. The MSMEs were further asked to indicate all forms of energy that they use. Majority (50%) of the MSMEs indicated that they use electrical energy while 13% indicated that they use solar energy. The various sources of energy utilised by horticultural processing MSMEs in Kenya are presented in Figure 18.

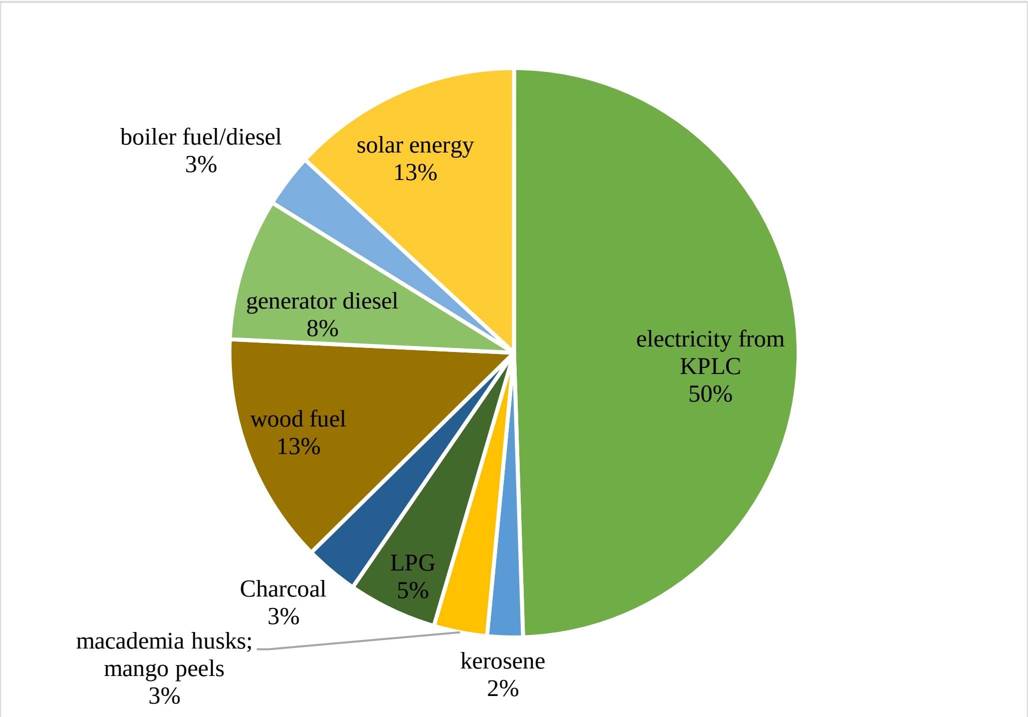

Figure 18 Sources of energy for horticultural processing MSMEs in Kenya (Source: Researcher, 2022)

The MSMEs were required to take meter readings before and after production so as to record the amount of energy consumed in processing of horticultural produce. The electrical fuel energy consumption data for ten (10) MSMEs and wood fuel energy consumption for 1 (one) MSME was collected and summarised in Table 12 and Table 13 respectively.

Table 12 Analysis on Electricity used for horticultural processing by MSMEs in Kenya

Plant	Product	Total Energy consumed for processing (kJ)	Total Cost per month (USD)	Production Per Day (Kg)	Total Quantity (kg) of Products	Specific Energy Consumption in kJ	Cost of Electrical Energy Per Kg
A	Stinging nettle	393,840	23	1.3	40	9846	0.57
B	Mango pulp	128,213,000	8,754	2,053	123,200	1040.69	0.07
C	Baobab powder	115200	4.3	100	100	1152	0.04
	Baobab seed oil	23400	2.3	5	5	4680	0.46
D	cocktail juice	4,698,000	168.38	988	29,649	158.45	0.01
	mango juice	4,600,800	161.75	948	28,462	161.65	0.01
	Passion juice	5,043,600	185.22	1085	32,608	154.67	0.01
	Orange	4,082,400	143.31	840	25,224	161.85	0.01
	Pineapple	2,073,600	72.72	426	12,800	162	0.01
	Lemon	19440	0.68	10	120	162	0.01
E	Sweet potato flour	138600	5.6	3.3	100	1386	0.02
F	Banana flour	236880	23	70	280	846	0.08
G	French beans	25,344,000	947	1,000	24,000	1056	0.04
	snow peas			400	1,200	21,120	0.79
	Sugar snap			130	4,000	6336	0.24
	baby corn			110	3,300	7.68	0.03
H	banana flour	3,092,000	40	50	15,000	206.13	0.003
I	Banana crisps	2,304,000	94	16	477	4830.19	0.20
	Banana wine			144	4,333	531.73	0.02
	Banana flour			3	87	26483	1.08
	Banana chips			72	2,167	1063	0.04
	Banana fiber			14	433	5321	0.22
J	Mango crisps, pineapple crisps, plantain crisps	894240	34	100	1,600	558.9	0.02

Only one MSME indicated that it relied on wood fuel to process. The MSME further indicated that it spent USD 194 per month to purchase wood fuel for horticultural processing as indicated in Table 13.

Table 13 Analysis of Wood Fuel Used by Horticultural Processing MSME in Kenya

Plant	Product	Total Energy consumed for processing(kJ)	Total Cost per month (USD)	Production per day (kg)	Total quantity of products processed in the month (kg)	Specific Energy Consumption (kJ) per kg of processed product	Cost of energy per kg of processed product (USD)
A	Mango Crisps, banana and pumpkin flour	33,210,000	194	52	1,560	21288.46	0.12416

The MSMEs were further asked to indicate how much money was spent per month towards paying for their energy bills. About 7% of the MSMEs indicated that they didn't spend any money in paying for energy bills; this was either because the MSMEs were fully reliant on solar energy or because they had not received their energy bills from Kenya Power and Lighting Company (KPLC). Generally, the monthly energy bills for the 39 MSMEs ranged between 1.72 USD to 11, 125.36 USD per month as shown in Table 14.

Table 14 Cost of electrical energy used for horticultural processing per month

Electricity bill per month (USD)	Percentage (%) Respondents
11,125.3	8.0
5,134.79	2.0
4,278.99	8.0
3,851.09	2.0
941.38	2.0
890.03	2.0
684.64	5.0
395.81	2.0
342.32	2.0
256.74	2.0
213.95	3.0
192.55	5.0
183.14	5.0
171.16	8.0
145.49	3.0
128.37	5.0
102.70	3.0
85.58	3.0
68.64	3.0
68.46	3.0
42.79	3.0
34.23	3.0
25.67	3.0
21.39	3.0
11.12	3.0
8.56	2.0
4.28	2.0
1.71	3.0
0	2.0

Specific energy consumption of all the processed products was calculated to provide an overview of how much energy was consumed when producing one kilogram of the processed product. This value was obtained by dividing total energy consumption in kilojoules (KJ) by total amount of products produced in the month. The data obtained on specific energy consumption is displayed in Figure 19.

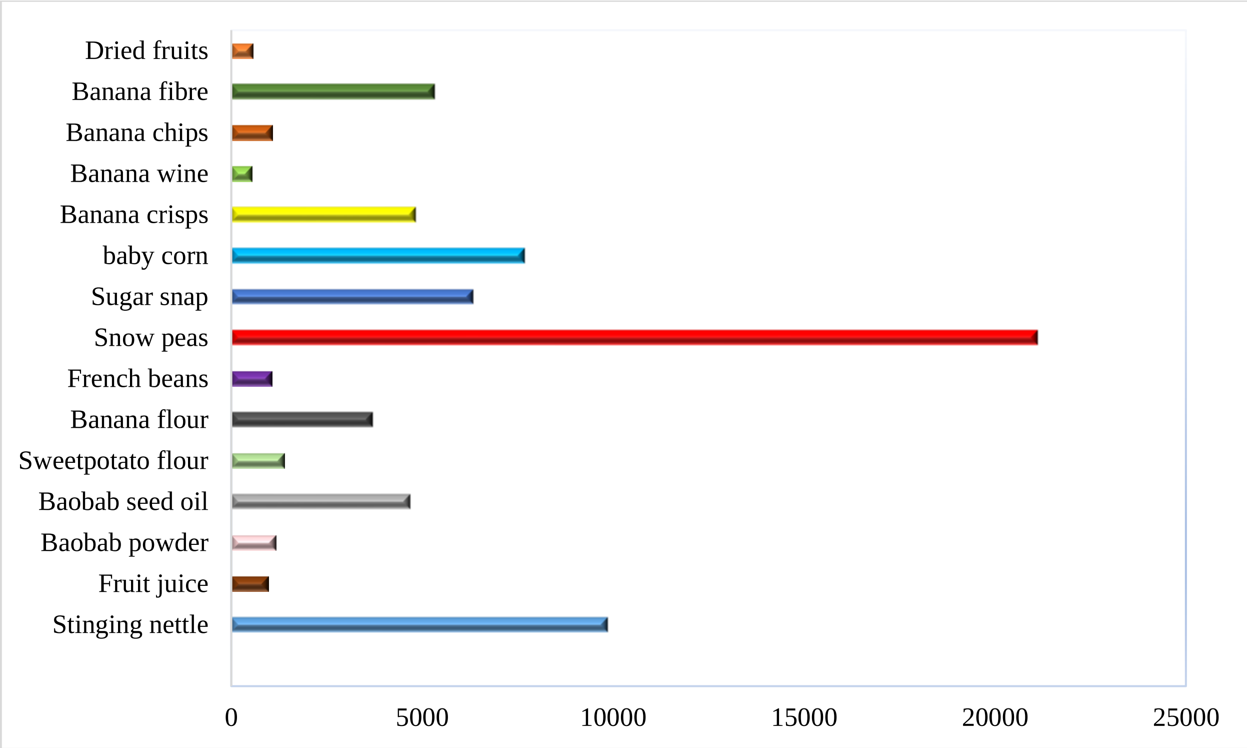

Figure 19 Specific energy consumption (kJ/kg) for horticultural processing by MSMEs in Kenya (Source: Researcher, 2022)

Snow peas had the highest specific energy consumption due to the refrigeration process which is an intensive energy consumption process followed by stinging nettle which undergoes drying to obtain the powder. These two products consumed 21,120 kJ/kg and 9,846 kJ/kg of processed product respectively. The end-use electrical energy consumption for baby corn, sugar snap and banana crisps were 7680, 6336, and 4830 respectively per KJ/kg of the processed products.

6.3.2 Analysis of Water used for horticultural processing by MSMEs in Kenya

The MSMEs were asked to indicate the sources of water that they used for processing. Some MSMEs relied on multiple sources of water where as some got water from a single source. The major sources of water are tap water (55%), borehole (21%), rainwater harvesting and purchasing water from water vendors (10%). The sources of the water used are summarised in Figure 20.

The processes examined in this study where water was consumed in these horticultural processing MSMEs are either washing the raw materials, rinsing of raw materials and or during the processing phase.

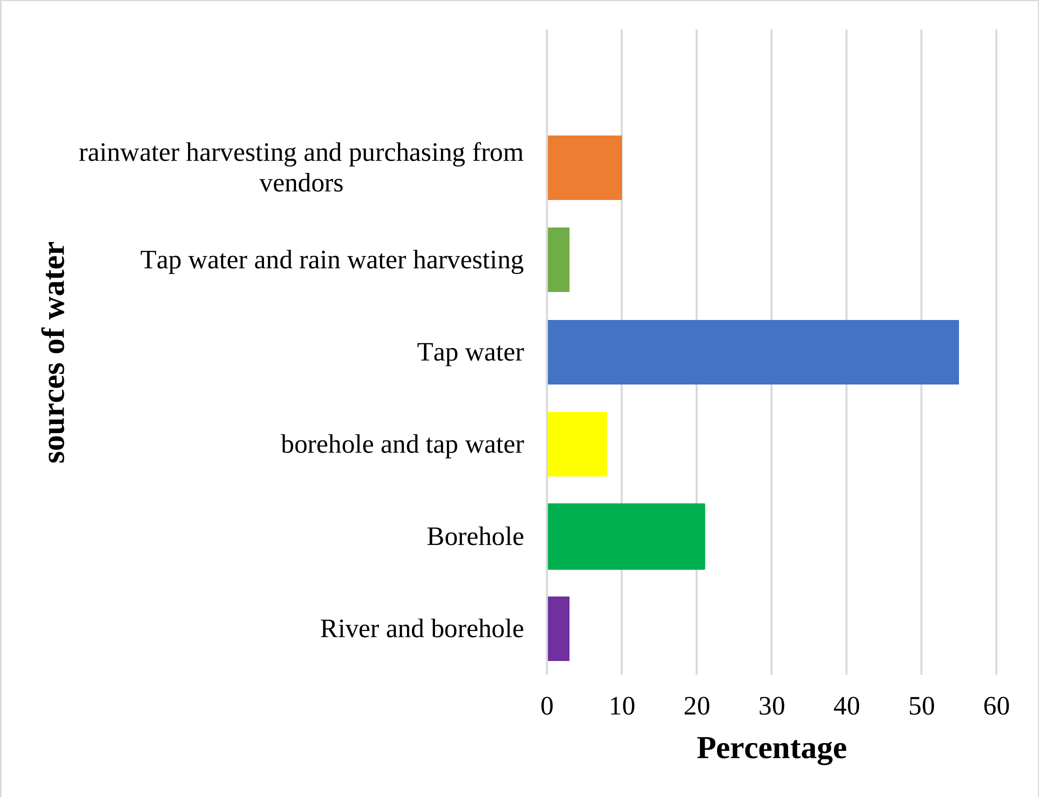

Figure 20 Sources of water used for horticultural processing by Kenyan MSMEs
(Source: Researcher, 2022)

The MSMEs were asked to indicate how much their water bill was per month. The findings indicate that 5% of the MSMEs didn’t pay for their water bills because they didn’t have water meters thus it was hard to quantify how much water they consumed, 6% drew water from their boreholes thus didn’t incur water bills. It also emerged that these boreholes are not metered thus posing a challenge to the quantification of the amount of water consumed by MSMEs in the different phases of horticultural processing. Further 3% of the MSMEs indicated that their water bill was included in the rent they pay thus they had no way of ascertaining how much water was utilised per month while there were those who were abstracting water from their private borehole hence didn’t incur any cost. The monthly water bills incurred by the MSMEs ranged from 1.72 USD to 1289 USD. The water bill incurred by the MSMEs per month is summarized in Table 15.

Table 15 Cost of Water Used by Horticultural Processing MSMEs per month in USD

Water bill per month (USD)	Percentage (%) Respondents
1289.21	2
550.06	2
214.87	2
214.87	2
77.35	2
67.04	2
60.16	3
34.38	5
30.08	5
25.78	3
20.63	3
13.75	3
12.89	5
10.02	3
8.59	5
5.16	3
4.3	3
4.3	8
3.44	3
2.15	5
1.72	5
0.0	26

Further data was collected from MSMEs to analyse how much water was used for horticultural processing. The MSMEs were asked to measure the amount of water they used in the different phases of processing. This data is displayed in Table 16.

Table 16 Analysis of Water used for horticultural processing by MSMEs in Kenya

Period	Processing Phase	production per day (Kg)	Water consumed (L)	Product	Total quantity of processed product per month (kg)	Specific water consumption (L/kg)
A	Washing	165	85	Sweet potato puree	138	0.61594
B	Washing	300	150	Sweet potato puree	250	0.6
C	Washing	4	3000	Stinging nettle powder	120	25
D	Pulping	6160	825000	Juice	520,000	1.58654
	Washing	1500	1000	French beans	30,000	0.03333
	Washing	500	500	Snow peas	4,000	0.125
E	Pulping	2950	119000	Juice	28,462	4.18101
F	Pulping	450	53760	juice	12,800	4.2
G	Pulping	1055	105000	juice	25,224	4.1627
H	Pasteurization	400	13,000,000	Tomato sauce	12,000	1083.33
I	Washing	6	4,800,000	Dried mango crisps	180	26666.7
J	Washing	9	8,640	Banana flour	280	30.8571
K	Washing	1000	30,000	Packed French beans	23000	1.30435
	Packaging	200	0	Packed sugar snap	6000	0
	Packaging	500	0	Packed snow peas	15,000	0
	Packaging	100	0	Packed baby corn	3000	0

Period	Processing Phase	production per day (Kg)	Water consumed (L)	Product	Total quantity of processed product per month (kg)	Specific water consumption (L/kg)
L	Washing	63	300	Banana flour	756	0.39683
	Washing	75	1040	Banana crisps	1950	0.53333
	Washing	85	1040	Banana flour	2210	0.47059
	Washing	350	2600	banana chips, fibre and wine	9,100	0.28571
M	pulping	208	1800	Juice	6250	0.288
	Pasteurization	67	300	Jam	2000	0.15
N	Washing	53	3200	Dried mangoes	1600	2
	Washing	50	3200	Dried pineapple	1500	2.13333
	Washing	17	1000	Banana crisps	500	2

6.4 Discussion

6.4.1 Analysis of energy used for processing by Kenyan horticultural MSMEs

Half (50%) of the MSMEs surveyed relied on energy from the national grid. This is in line with the findings of a study that established that usually MSMEs bought energy from the national grid whereas self-generation such as combined heat and power was more common for bigger establishments (Aflaki *et al*., 2013). Energy from the national grid is characterised by perpetually increasing costs. In addition, MSMEs tend to have insufficient information concerning their costs of energy thereby underestimating the pecuniary potential of investments in energy efficiency (Mickovic and Wouters, 2020).

The study further established that sub-metering of machines had not been done by the MSMEs in instances where the plants were processing multiple products. For example, in plant J 894,240 kJ was utilised in processing mango crisps, pineapple crisps and plantain crisps. Similarly, in plant I, 2,304,000 kJ was consumed in processing banana crisps, wine, flour, chips and fibre. The same situation of lack of sub-metering was observed also in plant G where 25,344,000 kJ was utilised in processing French beans, snow peas, sugar snap and baby corn. Previous studies have also established that sub-metering was particularly deficient in MSMEs (Apeaning and Thollander, 2013; Bunse *et al*., 2011; Thollander *et al*., 2015).

Further it has also been noted that practical circumstances might complicate gathering of information for instance in developing countries (Apeaning and Thollander, 2013). Sub metering is a tool that if employed by the horticultural processing MSMEs will help them identify processes that are more energy intensive and take remedial actions that will ensure energy efficiency in the future.

With regard to the cost of the energy utilization, 2% of the MSMEs surveyed didn't know how much their cost was and this was due to not receiving their monthly bills from KPLC. This therefore inhibits such MSMEs from knowing the true cost of their energy consumption or taking any measures that will aid them in reduction of these costs. This finding is collaborated by findings from another study that established that many processing enterprises seem to turn to inaccurate approaches for calculating as well as allotting costs of energy in addition they seem to lack the essential information for management of energy (Mickovic and Wouters, 2020). Thus, these MSMEs that don't know the cost of their energy consumption will face a challenge in implementing energy efficiency measures given that they don't have the detailed information on the energy hotspots in their companies as well as the different production phases.

The results further indicate that consumption of energy was high in plants which did pulping due to the pasteurization process which is quite energy intensive for example in plant B and D which processed juice their electrical energy consumption was quite high that is 128,213,000 kJ and 20,517,840 kJ respectively. This finding mirrors the findings of another study that established that despite the economic benefits that accrue from the manufacturing sector, this industry exerts huge amounts of stress on the environment due to its notable dependence on energy and materials (Duflou *et al*., 2012). There is mounting pressure on this sector to reduce usage of energy and subsequently the effects that energy as well as the consumption of materials exert on the environment (Mousavi *et al*., 2016).

In the horticultural processing industry, the processes which consume energy intensively are the ones which need cooling and refrigeration through use of cold storage refrigerating equipment; which consume over 20% of the total electrical energy for the processing of the final product. The other energy intensive processes are those which need thermal energy for heating specifically in drying horticultural products for industrial transformation as well as pasteurization of jam, canned fruits and vegetables, canned tomatoes together with fruit juices; and these consume over 70% of total energy needed (Latini *et al*., 2016). This finding is in line with the findings of the present study which established that energy consumption was high for products like snow peas, sugar snap, baby corn due to the refrigeration stage; fruit juice also consumed a lot of energy due to the pasteurization process. Further, in facilities that process juice, heating of juice (pasteurization) is amongst the processes which are major consumers of thermal energy whereas refrigeration is the biggest consumer of electricity (Walker *et al*., 2018).

Cost of energy was quite a concern for the MSMEs as depicted by the amount of money spent to settle energy related bills incurred by the enterprises on a monthly basis. The MSMEs indicated that their monthly energy costs ranged from 1.71 USD to 11,125 USD which was quite high. Business entities are faced with ever increasing prices in energy thus internally in the organization, there exists incentives to encourage reduction of consumption of energy thereby increasing energy efficiency. One of the key factors that will aid in achievement of energy efficiency is sufficient information on the cost of energy to the company and not just in terms of the overall amount of energy consumed but also at a more comprehensive level (Mickovic and Wouters, 2020). The information obtained by MSMEs as they monitor their energy use will help them in making decisions that will not only minimise their energy related costs but also put in place energy efficiency measures to bring down their energy costs.

6.4.2 Analysis of Water used for Processing by Kenyan Horticultural MSMEs

Detailed information on the various phases of processes requiring water was lacking especially in terms of washing of raw materials, quantity of raw materials cleaned, water used in the machines, for hydro transportation of raw materials or for washing of the facility and or equipment. Most of the MSMEs relied on one water meter thus sub metering of water intensive equipment was not done. Sub-metering would have helped the MSMEs identify the water hotspots during processing in their facilities and put in place remedial measures. Similarly, other MSMEs completely lacked water meters.

According to (Walker *et al*., 2018), lack of metering hinders regulation of water consumption. Consumption of water tend to be not regulated therefore it is a challenge to account for water that has not been utilised for a specific piece of equipment or for a regulated activity such as day to day or monthly cleaning if the flow of water has not been metered. Further according to

(CIWEM, 2016), installation of water meters should be made mandatory especially in areas where there is a lot of pressure on water resources so as to encourage minimal consumption of water. Therefore, given that the horticultural processing industry consumes water intensively, the government of Kenya should make it mandatory for all manufacturing industries to have water meters as well as do sub metering to enable effective monitoring of water use and therefore implementation of strategies that will lead to reduction in water consumption.

Results from this study indicate that in plants where there was minimal processing and packaging of products, water consumption was minimally consumed. In plant M where there was only packaging of snow peas, baby corn and sugar snap, there was minimal water consumption as compared to the processing of French beans in the same plant that consumed 30,000 litres of water in washing 1000kg of French beans. This result is supported by the findings of a study that was conducted in 2014 whereby the authors established that water use was at its peaks in plants where processing was done and lowest in plants where only washing and packaging was done. The authors further state that simple washing of raw materials compared to washing and peeling of root vegetable use up to $3.0m^3$ and $5.0\ m^3$ of water per tonne of products respectively (Lehto *et al*., 2014).

About 28% of the MSMEs surveyed didn't know the amount of water consumed since they did not receive their water bills at the end of the month. The reasons cited for not receiving water bills is that some MSMEs had sunk their own boreholes thus they didn't incur any cost in consumption of water (23.1%), a further 2.6% indicated that their water bill was included in their rent thus they had no idea how much cost was incurred as a result of consumption of water. This poses a challenge towards quantification of water used in horticultural processing by the Kenyan MSMEs.

In order to evaluate the efficacy of any strategy targeted at the reduction of the amount of water consumed, it is essential that the quantity of water currently consumed in the various food processing sector and where practicable in each of the processing stages within the agro-food processing sector be established (Meneses *et al*., 2017). In the absence of this information on the amount of water consumed, this will be a hindrance to the water efficiency efforts in the horticultural processing sector in Kenya given that a proportion of the MSMEs surveyed that is 25.7% are unaware of the amount of water consumed during processing as well as the water bill incurred at the end of the month. It is thus hard to minimise consumption of water yet some of the MSMEs don't know how much water is consumed.

6.5 Conclusions

Analysis of energy and water used for horticultural processing by MSMEs in Kenya is important so that the MSMEs know the specific quantity of resources that are used for processing and also to aid these enterprises in identification of any hotspots for energy and water consumption so that they can take remedial actions that will enable them attain resource use efficiency. However, data on energy and water used for processing is inadequate and thus there is need for regular awareness and trainings on need for keeping detailed records as well as trainings on how to collect and record this data will be of immense benefit to the MSMEs. Metering and sub metering will also help the MSMEs attain energy and water efficiency due to the information that they will be able to collect from monitoring the energy and water consumption of the various machines or processes.

6.6 Recommendations

There is need for the establishment of a database on specific energy and water consumption for processing horticultural products. Such a database will be of use to MSMEs to help them identify areas where there is intensive use of energy and water as well as help them identify the starting point for resource use efficiency measures. The database will also be of use to policy makers. The MSMEs should be encouraged to install meters and sub meters for effective monitoring in energy and water use.

CHAPTER SEVEN

GENERAL DISCUSSION, CONCLUSIONS AND RECOMMENDATION

7.1 Discussion

This study sought to assess the sustainability of energy and water use practices by horticultural processing MSMEs in Kenya. The findings from the study indicated that all the MSMEs surveyed had a high level of knowledge. According to (Kim *et al.*, 2018) possession of knowledge fosters awareness and results in a positive attitude towards the environment. Paillé and Boiral (2013) further established that it is hard for a person to be aware and care for the environment when they have insufficient knowledge concerning the environment.

The study further established that attitude influences energy and water use practices of MSMEs to a small extent. This finding mirrors the finding by (Weerasiri and Zhengang, 2012) who found out that there is no significant relationship between attitude and practices meaning that MSMEs attitude will remain positive despite insufficient adoption of best environmental practices.

The study also established the existence of a non-significant relationship between knowledge together with energy and water use efficiency practices of horticultural processing MSMEs in Kenya. This meant that in spite of the MSMEs being in possession of high level of knowledge on energy use efficiency and water use efficiency, it didn't spur them to adopt the best practices. This finding is consistent with the findings of Ahmad *et al.*, (2015) where the authors established that in spite of the students having a high level of knowledge it didn't prompt them to take up practices in favour of the environment. Besar *et al.*, (2013) conducted a study on the level of knowledge, attitude and environmentally friendly practices among young civil servants in Malaysia where they discovered that even though young the civil servants had good level of knowledge and positive attitude towards the environment, the environmental practices adopted were only minimal.

Lack of policies tailor made for MSMEs yields low expectation of energy as well as carbon savings of MSMEs (Fawcett and Hampton, 2020). The findings of this study indicate that it is difficult for the Government of Kenya to regulate energy and water use consumption in this industry due to the dispersed nature of these enterprises. The Energy Act has outlined comprehensive measures geared at enhancing energy efficiency but enforcement is largely lacking.

The Water Act, 2016 is not as explicit as the energy act when it comes to outlining water conservation strategies. This has led to the continual neglect of water resources thus leading to minimal water conservation measures. The National Water Policy of 1999 and the National Environmental Policy contain some sentences on water reuse; however, this has not been expounded further to guide the manufacturing industry. The National Water Policy of 1999 formed the basis for the formulation of the Water Act of 2002 yet there is no mention of water reuse in the Water Act. Kenya is a severely water scarce country and more efforts should be made towards recycling and reusing water so as to reduce of consumption of fresh water.
According to (Kurle *et al*., 2015; Sachidananda *et al*., 2016) negligible attempts have been put towards the management of water compared to the management of energy.

Further, there are many energy saving potentials that have not been exploited. Energy audit is one of the energy saving measures that has not been fully exploited. The study established that only 28% of the MSMEs carry out energy audits and the reason cited by 72% of the MSMEs that don't undertake energy audits is lack of knowledge of the benefits of carrying out the audit as well as lack of the capacity to undertake the audits. This agrees with previous studies (Fleiter, Schleich, *et al*., 2012; Hasanbeigi and Price, 2010; Southernwood *et al*., 2021). Most MSMEs lack the technical knowledge to undertake energy audits and have to rely on technical personnel to undertake the audits, unfortunately when they received the audit reports its normally written in a technical language which most of the MSMEs don't understand thus they are unable to implement the recommendations of the audit reports.

Effective management of water in the food industry is majorly reliant on to a huge extent the economic incentives as regulated by law (Obiero *et al*., 2021). Costs associated to water supply influence decision making on water management in companies. Environmental regulation must encourage policies for treatment and saving that will ensure sustainable availability of scarce resources such as water (Sánchez *et al*., 2011). The study established that MSMEs look as water as a cheap resource and do not take concerted effort in its conservation. Economic incentives might be a starting point for MSMEs to start managing the water resources at their disposal effectively.

A positive result as a result of the green trainings is that all the MSMEs interviewed executed some form of energy efficiency measures. The main motivation that spurred the MSMEs towards the adoption of the energy efficiency measures was to reduce on the costs incurred. This finding tallies with other studies where the authors established that the major reasons for implementation of energy efficiency measures is the reduction of costs followed by contribution to fight against climate change (Southernwood *et al*., 2021).

The study further noted the diversity of the efficiency measures in energy and water use adopted by the MSMEs. The practices that the MSMEs are engaged in are simple housekeeping measures such as switching off the lights and idle machines, bulk processing, replacement of incandescent bulbs with energy saving bulbs, turning off taps when not in use, prompt repair of leakages and faulty pipes, reusing water, dry cleaning methods and sensitization of staff in resource efficiency measures. (Brammer *et al*., 2012) noted that most MSMEs are involved in one form or the other of environmental activities however there was noteworthy heterogeneousness in the initiatives that the MSMEs had engaged in.

There is still inadequate information on the amount of energy and water required for processing or the specific amount of energy and water consumed by the machines during the various processing phases. It is hard for the MSMEs to adopt energy and water efficiency measures yet they do not know how much they are consuming in the first place this is as a result of lack of metering and sub-metering to allow for effective monitoring of their consumption trends. This finding agrees with findings from earlier studies that also established that submetering was particularly deficient in MSMEs (Apeaning and Thollander, 2013; Bunse *et al*., 2011; Thollander *et al*., 2015).

7.2 Conclusion

The following conclusions can be made from the current study:

Knowledge is important but not a sufficient determining factor towards adoption of energy and water efficiency measures. There is need to motivate MSMEs to encourage them to adopt practices that will lead to resource use efficiency. Positive attitude does not necessarily translate into adoption of energy and water use efficiency practices.

Enforcement of energy efficiency in industry is quite low. The Energy Act has created an institution mandated to enforce energy efficiency that is EPRA as well as mandated county government officials to enforce energy efficiency as well at the county level yet this has not been fully enforced.

Access and availability of funding affects a company's adoption of EEMs and this is because adoption of these EEMs requires substantial capital investment. MSMEs are willing to implement long term energy and water efficiency measures but lack sufficient resources thus their major focus is on short term efficiency measures that doesn't require huge capital investment.

Green training positively influences energy and water use efficiency practices and should be carried out regularly. These trainings enable a company to incorporate environmental considerations into their business activities thereby leading to resource use efficiency and sustainability of such businesses.

Management of water resources has not been given due consideration. Water is viewed as a cheap resource and there is also the misconception that it is abundance yet Kenya has been classified as a severely water scarce country. More emphasis has been placed on management of energy as opposed to water.

7.3 Recommendations

This study recommended the following:

Regular and structured training is needed by MSMEs to enhance their knowledge and improve the uptake of resource efficiency measures in this industry.

The use of subsidises and rebates by the government to encourage resource efficiency efforts in the horticultural processing industry.

More effort should be placed on management of water resources given that it is a scarce resource and for the formulation of water reuse policy for the manufacturing industry in Kenya.

Metering and sub metering of water and energy processes and equipment should be made mandatory to enable collection of water and energy consumption data that will inform water and energy efficiency strategies.

Regular energy and water audits are needed to improve resource use efficiency measures in the horticultural processing industry.

7.4 Recommendations for Further Research

There is need for further research on the impact of energy and water audits in horticultural processing MSMEs on resource use efficiency.

Long term studies on investment in energy and water use efficiency measures are needed to analyses the effect of horticultural processing MSMEs on the environment.

Economic valuation of water resource to reflect its true cost and the subsequent impact on water use efficiency efforts.

There is need for further research on the willingness of MSMEs to invest in long term improvements towards energy and water use efficiency once they have completely enjoyed the merits derived from the ‘low hanging fruits.’

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APPENDICES

APPENDIX 1

QUESTIONNAIRE ON ASSESSING SUSTAINABLE ENERGY AND WATER USE FOR PROCESSING BY MICRO, SMALL AND MEDIUM ENTERPRISES (MSMEs)

Introduction and Consent to participate in Interview

My name is Linda Maryanne Obiero, a PhD student at Wangari Maathai Institute for Peace and Environmental Studies, University of Nairobi. I am undertaking a study on **assessment of sustainable energy and water use for processing by micro, small and medium enterprises in Kenya**. This study is under a project called Switch Africa Green Project titled, 'Inclusive Green Horticulture Processing Sector in Kenya' whose overall objective is to foster the adoption of Sustainable Consumption and Production practices in the Kenyan Horticultural Processing industry in order to support the transformation towards an inclusive green economy which generates growth, creates jobs and reduces poverty. The project is sponsored by the European Union and Implemented by University of Nairobi, Sustalde Fundacion, Kenya Bureau of Statistics, and Consumer Information Network.

The study will take approximately 1 hour of your time should you agree to it. Please fill this questionnaire as openly and honestly as possible. The information acquired will be treated with due confidence and will only be used for the purpose of this research study.
If consent declined, discontinue the survey.

Technical Notes

Definitions

1. **Efficiency** – producing optimal quantities using less resources
2. **Energy audit** – verification, monitoring and analysis of use of energy including submission of technical reports containing recommendations for improving energy efficiency with cost benefit analysis and an action plan to reduce energy consumption
3. **Energy efficiency** – using less energy to produce same service or output
4. **Energy efficient equipment** – uses less energy for same output and reduced CO_2 emissions
5. **Water Efficiency** – reducing water wastage by measuring the amount of water required for a particular purpose and the amount of water used or delivered.

SECTION 1: DEMOGRAPHIC CHARACTERISTICS

Name of Enterprise	Location	No of employees[1]	Number of years in Processing[2]	Gender of respondent[3]	Age of respondent[4]	Education level completed[5]	Frequency of processing[6]	Responsibility in the business[7]

Codes

1: 1=1 – 9 2=10 – 49 3=50 – 99

2: 1= 0 – 5 2=5 – 10 3=10 – 15 4=Over 15 years

3: 1 = Male 2= Female

4: 1= Youth (18 – 35) 2=36 – 50 Middle aged 3=upper middle aged (51 – 60) 4=Retired (61 and above)

5: 1 =No formal education 2=Primary 3=Secondary 4=Tertiary

6: 1=Daily 2=2 – 3 times a week 3=Weekly 4=Fortnight 5=Monthly 6= other (specify)

7: 1=owner 2=Hired manager 3=other (specify)

SECTION 2: KNOWLEDGE, ATTITUDES AND PRACTICES ON EFFICIENT ENERGY AND WATER USE

A: KNOWLEDGE ON EFFICIENT ENERGY USE

Please tick the correct answer.

1. There is a direct relationship between over consumption of electricity and decreasing water resources

   1. Yes 2. No

2. How does excessive use of electricity affect your business?

1. Increased production 2. High electricity bills 3. No effect 4. High profit

3. Efficient use of machines and equipment results into:
   1. High electricity bills 2. Low electricity bills 3. Low sales 4.Low profit
4. Minimizing use of electricity leads to energy use efficiency 1. Yes 2. No
5. Bulk processing of products as opposed to bit-by-bit processing is highly encouraged because it leads to energy use efficiency. 1. Yes 2. No
6. The use of daylight during daytime leads to:
   1. Excessive use of electricity 2. Significant electricity savings 3. High electricity bills 4. None of the above
7. Use of worn-out appliances causes high energy consumption. 1. Yes 2. No
8. Use of renewable energy can lead to a reduction in the cost of energy. 1. Yes 2. No
9. Agricultural waste can be reused to produce biogas energy
   1. Yes 2. No
10. Is it true that energy audits result in energy savings 1. Yes 2. No

B: KNOWLEDGE ON EFFICIENT USE OF WATER

1. Water used for processing must be safe to drink or to use in food preparation
   1. Yes 2. No
2. What benefit will be achieved when water is used efficiently?
   1. High water bills 2. Low water bills 3. Zero water bill 4. All of the above
3. Water audit leads to? 1. High water bills 2. Cost savings 3. Low profit 4. Low sales
4. Reuse of water leads to: 1. Increased amount of water consumed 2. Increased sales 3. Increased production 4. Decreased amount of water consumed
5. Adopting water-saving mechanisms improves the company's environmental image.
   1. Yes 2. No
6. Installation of meters and sub-meters helps to monitor and reduce on water consumption:
   1. Yes 2. No
7. Raising staff awareness is important in achieving water use efficiency 1. Yes, 2. No

8. Controlled use of water leads to 1. Cost-saving 2. High water bill 3. High electricity bill 4. None of the above

9. Inspection and replacement of faulty valves and fittings lead to: 1. Wastage of electricity 2. Avoiding water wastage 3. None of the above 4. All of the above

10. Water recycling helps to: 1. Reduce fresh water consumption 2. Increase fresh water consumption 3. Increase amount of waste water produced 4. All of the above

B: ATTITUDES ON EFFICIENT ENERGY AND WATER USE

Please tick appropriately. Use a scale of 1 to 5 whereby 1 = strongly disagree; 2 = disagree; 3 = neutral; 4 = agree; 5=strongly agree

No	Questions	1	2	3	4	5
1.	Saving water is the company's responsibility and not mine					
2.	Saving energy is the company's responsibility and not mine					
3.	I use water as I please when it's adequately available					
4.	I use energy as I please when it's adequately available					
5.	I am willing to conserve water					
6.	I am willing to conserve energy					
7.	Water will eventually be scarce if we don't conserve it					
8.	Energy will soon be in short supply if we don't use it efficiently					
9.	I am concerned about the high electricity bills incurred by the company					
10.	I am not bothered about the high-water bills incurred by the company					
11.	I care about the company's environmental image					
12.	I do all I can to efficiently use water					
13.	I do my best to efficiently utilize energy					
14.	I am willing to reuse water for environmental reasons					
15.	I am willing to recycle water for environmental reasons					
16.	I care about the company's environmental image					
17.	I care for the environment					
18.	I think that Kenya is a water-scarce country					
19.	I think that there is an energy crisis in Kenya					

20.	Human beings are overexploiting the environment					
21.	Human beings are meant to rule over nature					
22.	The earth has sufficient resources only if we use them efficiently					
23.	Plants and animals have as much right as human beings					
24.	The environment is sacred					
25.	Renewable energy is good for the environment					
26.	The solution to the energy problem lies in science					
27.	Science holds the solution to the water crisis in Kenya					
28	Making the company energy efficient is good for the environment					
29.	I worry that the company doesn't have enough money to pay electricity and water bills					
30.	The use of efficient equipment saves energy as well as water					

C: PRACTICES

Which of the flowing practices does the enterprise use to ensure proper use and conservation of water? (Please tick appropriately)

	Water Conservation Practice	**Yes**	**No**
1	Proper and regular maintenance of equipment		
4	Raising staff awareness on efficient water use		
5	Raising staff awareness on need for proper maintenance of equipment		
6	Installation of a condensate water reuse system		
7	Turning off taps when not in use		
8	Implementation of a strategic water management program that ensures water monitoring, target setting, employee involvement and continuous improvement		
9	Water recovery from the various operations		
11	Recycling and reconditioning treatments e.g. straining, filtration for water reuse		
12	Using dry cleaning methods to clean equipment and surfaces		
13.	Conducting regular water audits		
14.	Water recycling where feasible		
15.	Inspection and replacement of faulty valves and fittings		

16.	Installing water meters on equipment to enable monitoring and reduction of water consumption		
17.	Inspection of all water connections for leakages with prompt repair of leakages		
18.	Keeping spray nozzles free of dirt and scale		
19.	Installing water efficient building fixtures		
20.	Presoaking floors and equipment		

Which of the flowing practices does the enterprise use to ensure proper use and conservation of energy? (Please tick appropriately)

	Energy Conservation Practices	**Yes**	**No**
1.	Regular maintenance of equipment		
2.	Proper loading and operation of equipment		
3.	Replacement of older components and equipment with higher efficiency models		
4.	Use of natural light where possible		
5.	Use of signage and guides to remind staff on good practice		
6.	Raising staff awareness on need for proper maintenance of equipment		
7.	Switching off lights when not in use		
8.	Conducting regular energy audits		
9.	Using renewable energy: a. Biogas b. Wind power c. solar energy		
10.	Process control and optimization to ensure production operations are running at maximum efficiency		
11.	Implementation of energy management systems that ensures energy monitoring, target setting, employee involvement and continuous improvement		
12.	Reusing hot water		
13.	Regular training of staff on energy use efficiency		
14.	Integration and combination of heat and power systems where possible		
15.	Channeling back steam condensate to the boiler		
16.	Installing energy efficient electric motors		
17.	Turning off idle motors		

18.	Installing correctly sized equipment		
29.	Use of energy efficient bulbs		
20.	Reusing cooling water		

SECTION 3: QUANTIFICATION

3A: QUANTIFICATION OF ENERGY USED FOR PROCESSING

1. Do you use energy in processing of fruits and vegetables?

   1. Yes 2. No

2. Which of the following energy sources do you use?

   1. Electricity from KPLC
   2. Solar electricity
   3. Boiler fuel oil/diesel
   4. Generator diesel
   5. Wood fuel
   6. Charcoal
   7. Biogas
   8. Wind power

   If other, please specify………………………………………………………………………….

3. How much is your energy bill per month?

   ………………………………………………………….

4. How much energy is used in producing a kg of the processed product?

   ……………………..

   …………………………………………………………………………………………………
   …

5. What is the cost of energy used in producing a kg of processed product?

   …………………………………………………………………………………………………

   …………………………………………………………………………………………………

   ……………………

6. What is the average amount of money spent in paying for energy bills in the last 3 months?

………………………………………………………………………………………………………

…………

………………………………………………………………………………………………………

…………

7. Do you maintain a monthly energy consumption register?
    1. Yes 2. No
8. If yes complete the tables below for the period January 2018 – December 2018 and January 2019 – August 2019, showing on a month by month basis:

January 2018 – December 2018

Product	**Electricity**			**Wood fuel**		**Charcoal**		**Generator Diesel**		**Boiler fuel oil**		**Production per day (kg)**	**Total quantity of products**
	Energy (kWh)	Demand (kVA)	Cost Kshs	Quantity (kg)	Cost (Kshs)	Quantity (kg)	Cost (Kshs)	Volume	Cost	Volume	Cost		

January 2019 – August 2019

Product	**Electricity**			**Wood fuel**		**Charcoal**		**Generator Diesel**		**Boiler fuel oil**		**Production per day (kg)**	**Total quantity of products processed in the month**
	Energy (kWh)	Demand (kVA)	Cost Kshs	Quantity (kg)	Cost (Kshs)	Quantity (kg)	Cost (Kshs)	Volume	Cost	Volume	Cost		

10. If you generate biogas:

(a) What produces the biogas? 1. Cow dung 2. Plant waste 3. Both A and B

(b) Estimate the quantity of the raw material(s) in kg per day ________________________________

____

____

____

(c) What is the biogas used for? ____

____

__________(d) What quantity of the conventional fuel is saved per day by using biogas? ____________________

____

____

11. Do you produce hot water using solar energy? 1. Yes 2. No

If yes, how much hot water in liters per day and what is it used for? _____________________________

____

____

12. Do you generate solar electricity? 1. Yes 2. No

13. If you generate solar electricity:

(i) What is the maximum capacity in (a) kWh ____ (b) kWh per day ____

(ii) What is it used for? ____

3B: QUANTIFICATION OF WATER USED FOR PROCESSING

1. Do you use water in processing of fruits and vegetables?

    1. Yes 2. No

2. What is the source of water used?

    1. River 2. Borehole 3. Well4. Tap water

    If other, please specify……………………………………………………………………………….

3. How much is your water bill per month? ……………………………………………………….

4. How much water is used in producing a kilogram (kg) of the processed product?

    ……………………………………………………………………………………………………

5. What is the cost of water used in producing a kg of processed product? ………

6. What is the average amount of money spent in paying for water bills in the last 3 months? …… ……

7. Does the company carry out water audits 1. Yes 2. No

8. If yes why does the company carry out water audits? ………………………………………………

9. If no why doesn't the company carry out water audits? …………………………………………….

10. What is the frequency of the water audits? ……………………………………………………….

    1=Monthly 2=Bimonthly 3=Quarterly 4= every 6 months 4=Yearly 5=Others

    If other please specify

____

11. Do you maintain a monthly water consumption register?

1.Yes 2. No

12.If yes please fill in the table below

Fruit/vegetable	**Raw material (kg/day)**	**Product(s) – kg/day [Production per day (kg)]**	**Water (m^3) per month**	**Total quantity of products processed in the month**
Mangoes		1. Juice 2. Jam 3. Pulp 4. Dried mangoes 5. Other		
Pawpaw		1. Juice 2. Jam 3. Pulp 4. Dried pawpaw 5. Other		
Pineapple		1. Juice 2. Jam 3. Pulp 4. Dried pineapple 5. Other		
Oranges		1. Juice 2. Jam 3. Pulp 4. Other		
Spinach		1. Dried spinach 2. Flour 3. Other		
Kales		1. Dried Kale 2. Flour 3. Other		
Indigenous vegetables		1. Dried vegetables 2. Flour 3. Others		
Irish potatoes		1. Potato crisps 2. Whole raw peeled potatoes		

		3. Raw sliced potatoes 4. Ready to cook blanched potatoes 5. Sliced/cubed potatoes 6. Others		
Bananas		1. Banana crisps 2. Banana flour		

SECTION 4: TRAINING

4A: EFFECT OF TRAINING ON EFFICIENT ENERGY USE FOR PROCESSING BY HORTICULTURAL PROCESSING MSMES

	Practice	Before Training	After Training
1.	How do you conserve energy?		
2.	Has there been a reduction in uncontrolled use of energy?		
3.	How has there been improved planning and control in energy use?		
4.	Does the company use renewable energy?		
5.	Does the company implement awareness and monitoring programs on energy use efficiency?		
6.	Has there been cultural change in energy use?		
7.	Do you carry out energy audits?		
8.	How does the company monitor energy use?		
9.	Has the company implemented an environmental management system?		

10.	Does the company have an environmental management policy?		

4B: EFFECT OF TRAINING ON EFFICIENT USE OF WATER FOR PROCESSING BY HORTICULTURAL PROCESSING MSMES

	Practice	Before Training	After Training
1.	How do you conserve water?		
2.	How does the company reuse water?		
3.	How does the company recycle water?		
4.	How has there been a reduction in uncontrolled use of water?		
5.	How has there been improved planning and control in water use		
6.	What does the company do to implement awareness and monitoring programs on water use efficiency		
7.	How has there been a cultural change in water use?		
8.	Is water audit carried out?		
9.	How does the company monitor water use?		

SECTION 6: LEGAL and REGULATORY FRAMEWORK

SECTION A: ENERGY

1. Do you have a license permitting you to use electrical energy?

1. Yes 2. No

2. If yes, the license is valid from which period to which period? ______________________________

3. If no, why don't you have a license? ____

4. How do you use electricity in your company?

1. Lighting purposes 2. Power equipment 3. Both 1 and 2 4. None of the above 5. Others (specify) ______________________________________

5. How does the company conserve energy? - ____

6. Does the company carry out energy audits?

1. Yes 2. No

7. What is the frequency of the audits?

1=Monthly 2=Bimonthly 3=Quarterly 4= every 6 months 4=Yearly

5=Others

If other please specify ____

8. When is the last time an energy audit was carried out? _____________________________________

9. Has the company ever submitted a detailed audit report? 1. Yes 2. No

If yes did the company use an accredited energy auditor to write the report?

10. Has the company done an analysis of how much energy is consumed on a monthly basis?

1. Yes 2. No

11. If yes, how much energy is consumed? ____

12. Are you aware that energy compliance is enforced? 1. Yes 2. No

13. If yes how is it enforced? ____

14. Have you been issued with an energy savings certificate by the Energy and Petroleum Regulatory Authority? 1. Yes 2. No

15. If yes, when was the certificate issued? ____

16. How does the company consume the energy that it is supplied with? ________________________

17. Has the company ever purchased an energy savings certificate? 1. Yes 2. No

18. If yes why? - ____

19. Has a county government inspector been to your company to inspect the following:

i. Any equipment or appliance 1. Yes 2. No

ii. Any production process to ascertain the energy consumption norms and standards?

1. Yes 2. No

20. Has a County government inspector visited your company to make records of any equipment or appliance? 1. Yes 2. No

21. Has a county government inspector visited your company to record the statement of any employee which may be useful for, or relevant to, for efficient use of energy and its conservation?

1. Yes 2. No

22. Does the company sometimes consume energy over and above prescribed limits?

1. Yes 2. No

23. If yes why?

____

24. Did the company submit a remedial plan of action detailing measures to be taken to reduce energy consumption to acceptable limits? 1. Yes 2. No

25. Which measures does the company take to reduce energy consumption to acceptable limits?

26. Is your enterprise registered by the county government? 1.Yes 2. No

27. If no why

____

28. Have you complied with these laws and regulations?

Laws and Regulations	**Complied**	**Not complied**
Business permit		
KEBS certification		
Public health license		
Company registration		

29. Are the laws and regulations enforced stringently?

1 = Strongly disagree 2 = Disagree 3 = Neutral 4=Agree 5=Strongly agree

30. Have you faced any challenge in complying with these laws and regulations?

1.Yes 2. No

31. If yes, indicate the challenges faced-

____

SECTION B: WATER

32. Does the company have a water permit? 1. Yes 2. No

33. List the challenges if any experienced in obtaining the permit - ______________________________

- ____

34. How long did the company have to wait to obtain the permit after submitting its application to the authority?

1. 6 months 2. 6 – 12 months 3. 1 year 4. Over an year

35. Does the company pay charges for the use of water? 1. Yes 2. No

36. How frequently does the company pay these charges?

1. Weekly 2. Monthly

37. How often does the company apply for the renewal of the water permit? ____________________

____

38. When is the last time the company applied for renewal of the water permit? ____

39. How does the company maintain a clean and healthy environment?

____

40. Does the company at times extract water in excess of its needs?

1. Yes 2. No

41. If yes, what are the purposes for which this water is used? _________________________________

42. Have you faced any challenge in complying with these laws and regulations?

1. Yes 2. No

43. If yes, indicate the challenges faced- ____

44. How does the company conserve the environment? ___________________________________

45. How does the company ensure safety and health of the employees at the work place?

46. How does the company avoid wastage of water? _____________________________________

APPENDIX II

Monthly Energy Consumption Register

Name of Enterprise: ______________________________ Date: ______________________________

Period of consumption: ______________________________

Product	Electricity			Wood fuel		Charcoal		Generator Diesel		Boiler fuel oil		Production per day (kg)	Total quantity of products processed in the month
	Energy (kWh)	Demand (kVA)	Cost Kshs	Quantity (kg)	Cost (Kshs)	Quantity (kg)	Cost (Kshs)	Volume	Cost	Volume	Cost		

APPENDIX III

Monthly Water Consumption Register

Name of Enterprise: ________________________________ Date: __________________
Period of consumption: ______________________________________

Product	**Raw material (kg/day)**	**Product(s) – kg/day [Production per day (kg)]**	**Water (m^3) per month**	**Total quantity of products processed in the month**
Mangoes		6. Juice		
		7. Jam		
		8. Pulp		
		9. Dried mangoes		
		10. Other (specify)		
Pawpaw		6. Juice		
		7. Jam		
		8. Pulp		
		9. Dried pawpaw		
		10. Other (specify)		
Pineapple		6. Juice		
		7. Jam		
		8. Pulp		
		9. Dried pineapple		
		10. Other		
Oranges		5. Juice		
		6. Jam		
		7. Pulp		
		8. Other		
Spinach		4. Dried spinach		
		5. Flour		
		6. Other		
Kales		4. Dried Kale		
		5. Flour		
		6. Other		
Indigenous vegetables (specify)		4. Dried vegetables		
		5. Flour		
		6. Others		
Irish potatoes		7. Potato crisps		

		8. Whole raw peeled potatoes 9. Raw sliced potatoes 10. Ready to cook blanched potatoes 11. Sliced/cubed potatoes 12. Other		
Bananas		3. Banana crisps 4. Banana flour 5. Other		
Tomatoes		1. Tomato sauce		
French beans				
Snow peas				
Baby corn				

APPENDIX 1V

MSMEs Attendance Registers for the Green Training on Sustainable Consumption and Production Practices

GREEN Mbale Workshop

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CONTACT LIST OF PARTICIPANTS

ROJECT	Inclusive Green Horticultural processing sector in Kenya, HORTI-GREEN
PROJECT REF.	ENV/2017/391-363

DATE	29/04/2019
MEETING LOCATION	Boardpack Hotel–Malaga

MEETING PURPOSE
HORTI-GREEN MSMEs capacity building workshop

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PROJECT REF.	ENV/2017/391-383

DATE	29th April 2019
TIME SCHEDULE	0900-1530 Hrs
MEETING LOCATION	Broad Park Hotel, Mbale- Vihiga

MEETING PURPOSE
HORTI-GREEN MSMEs capacity building workshop

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