EFFECTS OF DIGITAL SYSTEMS AND CLIMATE SMART AGRICULTURE ON DOMESTICATION AND PRODUCTIVITY OF CAPE GOOSEBERRY *(Physalis peruviana L.)* AMONG FARMING FAMILIES IN BARINGO COUNTY, KENYA

JONATHAN CHEBOR KANDAGOR

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DECLARATION AND RECOMMENDATION

Declaration

This thesis is my original work and has not been presented in any other University for the award of a degree.

Signature……………………………………Date…………**10-11-2024**……..….……...

Jonathan Chebor Kandagor

Ed23/15543/19

Recommendation

This thesis has been submitted with our approval as University supervisors.

Signature…………… …..….Date…………**10-11-2024**……..….……...

Prof. Fredrick U. Ngesa, PhD

Department of Agricultural Education and Extension

Egerton University

Signature……………________________……….Date………..…**10-11-2024**……..….……...

Dr. Maurice O. Udoto, Ed.D

Department of Agricultural Education and Extension

Egerton University

Signature…………… …….Date…………**10-11-2024**……..….……...

Dr. Daniel O. Pande, PhD

Department of Biological Sciences and Biomedical Science & Technology

Laikipia University

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DEDICATION

I dedicate this work to my wife Dorcas Cheptumo, and our children; Linda, Marion, Ryan and David for their encouragement and support. To my parents; Andrew Chesang and Florence Kandagor for their guidances and support.

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ABSTRACT

Cape Gooseberry fruit has documented nutritional, medicinal and industrial values. In Kenya, the level of domestication of the crop is low, despite the fact that it grows naturally in many parts of the country, including Baringo County. The purpose of this study was to introduce the crop in Baringo County for cultivation, and determine its acceptance levels. The study, also, documented the eco-physiological characteristics of the crop in situ. The study examined the deployment and use of documentary audio-visuals, online training and mobile app on Cape Goosberry productivity. In addition, the study incorporated climate smart agriculture, the selected practices being organic manure and intercropping with beans. The research designs used were quasi-experimental and participatory learning and action research. The sample size for the study was 120. Three Sub-Counties in Baringo County were purposively selected. From each Sub-County, one ward was, also, purposively selected. The sample was distributed equally among the three wards. Random sampling was used to select 40 farming families from each ward. Within each ward, sampled farming families were assigned to four treatments as follows: The first group received crop technologies through digital systems and incorporated climate smart agriculture; the second group received technologies through digital systems; the third group incorporated climate smart agriculture and relied on regular extension services; and the last group relied on regular extension services. The farming families grew the crop and at maturity, they harvested and weighed the fruits. The data collection instruments used were interview schedules, observation schedules and crop productivity templates. Experts examined the validities and reliabilities of the instruments and the recommended improvements effected. Triangulation and KR-21 were used in determining the instrument reliabilities, which yielded a reliability coefficient of 0.94. Productivity data were analysed to determine the effects of digital systems and climate smart agriculture. Content analysis, descriptive and inferential statistics were used in analysis. The inferential statistics used were t-tests and analysis of variance. The tests were at 0.05 level of significance. The major findings are that: Cape Gooseberry performs well under clay loam soil; farmers in Baringo County are willing to engage in production of the crop; and productivity levels improved when technologies were disseminated using digital systems in combination with climate smart agriculture. The conclusions from the study are that: Cape Gooseberry is a viable crop for Baringo County. The study recommends provision of training of extension staff on integration of digital systems and climate smart agriculture on extension systems.

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LIST OF ABBREVIATIONS AND ACRONYMS

CA	Communication Authority
CABI	Centre for Agriculture and Bio-science Information
CSA	Climate Smart Agriculture
DFID	Department for International Development
FAO	Food and Agriculture Organization
FGDs	Focus Group Discussions
GOK	Government of Kenya
ICT	Information Communication Technology
IFPRI	International Food Policy Research Institute
KALRO	Kenya Agricultural and Livestock Research Organization
KCSAP	Kenya Climate Smart Agriculture Project
KNBS	Kenya National Bureau of Statistics
KOAP	Kenya Agricultural Observatory Platform
NACOSTI	National Commission for Science, Technology and Innovation
PlAR	Participatory Learning Action Research
TV	Television
UNDP	United Nations Development Programme
USAID	United States Agency for International Development

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Cape Gooseberry *(Physalis peruviana L.)* is native to the South American nations of Peru, Chile, Venezuela, Bolivia, Colombia and Ecuador, from where it was introduced in other continents (Barirega, 2014). In Africa, the crop was first introduced in South Africa during the 1770s (Pulles, 2021), from where it spread to other countries in the continent, including Kenya (Kioko, 1987; National Research Council, 1989).

The Cape Gooseberry crop belongs to the family *Solanaceae,* and is grouped under berries (Bakshi et al., 2015). Because of its nutritional, medicinal and industrial uses, the crop has attracted interest (Bravo & Osorio, 2016). Published reports show that the crop has essential vitamins and minerals which have both nutritional and medicinal values (Demİr et al., 2014; Puente et al., 2011). According to Petkova (2021), Cape Gooseberry is a natural source of phytonutrients such as protein, lipids and sugars. It is also rich in dietary fibers such as pectin, cellulose, natural pigments, macro and micro-elements, especially K, Mg, Cu, and Zn. In addition, Cape Gooseberry fruit contains bioactive compounds, making it functional food and proving its antidiabetic, antioxidant, anti-inflammatory, anticholesterolemic, and immunomodulatory activities (Eken et al., 2014; Hassanien, 2011; Lal et al., 2019; Pinto-Muñoz et al., 2011; Singh et al., 2019). The industrial uses include processing of jam, juice and raisins (Ramadan & Moersel, 2007), besides, cosmetic products as indicated by Popova et al. (2021).

Ecologically, Cape Gooseberry fruit crop requires well-drained soils, and moderate to high amount of rainfall during the early stages of growth (Puente et al., 2011). It, however, needs low rainfall when the fruits are maturing (Morton, 1987). According to El-Tohamy et al. (2009), high soil fertility favours vegetative growth over production of Cape Gooseberry fruits, leading to low yields and poor quality fruits. The plants become dormant when there is droughts, and does not withstand freezing temperatures (Morton, 1987). It is an annual crop in temperate regions but a perennial crop in the tropical regions.

In Kenya, there have been attempts to grow the crop in the counties of Machakos, Makueni and Busia. In Machakos, it was grown by farmers contracted to the Kenya Orchards Limited (KOL) in early 1980s (Kioko, 1987; National Research Council, 1989). With regard to

Makueni, Del Monte grew the crop in Kibwezi between 2004 and 2006. KALRO in partnership with United States Agency for International Development (USAID) in 2016 trained farmers in Busia County and distributed Cape Gooseberry seedlings for production (FarmBiz Africa, 2018; Wasilwa et al., 2021), but there is no documentation on the uptake of the crop. The crop, however, grows in the wild in forest areas of Mount Elgon, Mount Kenya, Timboroa Forest, Kakamega Forest, Coastal regions of Kenya and Koibatek Forest in Baringo County (KALRO, 2021; Wasilwa et al., 2021).

Although the crop has been growing naturally in Baringo County, it has not been taken up by farmers. The possible reasons for failure of farmers to take up Cape Gooseberry could be: Insufficient awareness of the benefits of the crop, limited promotion and documentation of recommended crop husbandry practices, and bias in research and development in favour of commercial crops (KALRO, 2021). The problems associated with limited domestication of Cape Gooseberry in Baringo County are weak linkages between extension staff and farmers, low extension personnel, farmer ratios, low soil fertility, pest and disease infestation, and high cost of inputs. These problems could be addressed using digital systems in dissemination of approved Cape Gooseberry technologies and incorporation of climate smart agricultural practices.

Digital system include radio and television programmes, websites, information kiosks, blogs, video-conference, farmer call centers, social media, digital villages, documentary audio-visual aids, online training and mobile apps (Asenso & Mekonnen, 2012). This study purposively selected documentary audio-visual aids, online training and mobile app, since they are effective and efficient in creating awareness and interest, and preparation of the farmers to undertake the crop husbandry practices and availability of reference resources for management of the crop (Hassan, 1995; Oakley & Garforth, 1985; Rogers 2003; Sani et al., 2021; Santucci, 2005).

Documentary audio-visual aids refers to items, events and activities captured using cameras and presented through various media, including smart phones, televisions, screens and computers (Bentley et al., 2015). Audio-visual aids are useful in creating awareness and interest among farmers in new agricultural technologies and enterprises. The other benefits of using audio-visual aids in agricultural extension include: Promotion of retention of the content presented, communication of similar subject matter to different groups of people at different times, reaching a lot of people, summarizing events and activities which have been captured over a period, and allowing documents to be presented within a short time (Jasmin, 2018; Maredia et al., 2018; Moriarty, 2005; Newbury et al., 2014).

Online training is a learning experience which is delivered or enabled by electronic technologies including transmissions through open broadcasts, wireless communication devices, audio-visual conferencing and graphics (Bonk, 2002). It involves digital transmission of contents for the purpose of learning and sharing information (Andres & Woodard, 2013). Through online training platforms, physical distance and isolation among farmers and extension officers is reduced, this allows farmers to have real time interactions with their colleagues, researchers and extension specialists (Nakasone et al., 2014; Newbury et al., 2014; Stacey, 1999).

Mobile app is a platform on which data, information, knowledge and illustrations are loaded and can be shared in an interactive manner with other users (Bentley et al., 2015). It is designed to run on smart phones, tablets and computers (Serrano et al., 2013). Mobile app platforms facilitate interactions between the content developers, intermediaries and end users (Bentley et al., 2015; Mittal & Mehar, 2012). In dissemination of agricultural technologies, the primary actors are researchers, extension specialists and farmers. Mobile apps can, thus, be used to promote storage and interactions of recommended agricultural technologies.

Climate smart agriculture is a technique for transforming and reorienting agricultural systems to support food security under the new realities of climate change (Lipper et al., 2014). There are varied climate smart agricultural techniques which include crop rotation, minimum tillage, sub-soiling, mulching, water conservation, integration of organic manures and incorporation of legumes (Barzman et al., 2015; Moswetsi et al., 2017; Sullivan et al., 2013; Swanton & Murphy, 1996). Climate smart agriculture has the potential to improve soil health and quality, increase agricultural productivity, reduce production costs, control pest and disease infestation, and promote sustainability of production (FAO, 2010; Lipper et al., 2014). The study incorporated organic manure and intercropped Cape Gooseberry with beans. Organic manure was used to improve the soil conditions, while beans were used to fix nitrogen to improve soil fertility.

When domesticating a crop, it is important to understand its science and ecology. The science of a crop focuses on its external structure, internal structure and the functional processes (Buckleyl et al., 1997; Collins et al., 1985; Martinková et al., 2014; Singh et al., 2016).

Ecology is the science of interactions of organisms to the surrounding habitats, and includes both organic and inorganic conditions of existence which force the organism to adapt (Schulze et al., 2005).

The current study sought to document and analyze the effects of disseminating approved Cape Gooseberry technologies using digital systems, and incorporating climate smart agricultural practices during its domestication and management. Finally, the study documented and analysed the performance of the crop in terms of domestication and productivity due to the interventions. In addition, the study determined the botanical characteristics of Cape Gooseberry and ecological conditions which favour its growth and survival in the wild in Baringo County.

1.2 Statement of the Problem

Cape Gooseberry plants grow naturally in Baringo County, and despite their documented nutritional, medicinal and industrial values, farmers have not taken up the crop for cultivation. This study, therefore, sought to introduce the crop and support the farmers by providing the crop technical knowledge since the farmers were not familiar with the recommended agronomic practices of the crop. Therefore, the problem and gaps being addressed by the study is failure by farmers to adopt the crop for production and the need to support the production of the crop under inadequate agricultural extension services, since there is documentation that there is limited number of agricultural extension staff in Baringo County. In this study, therefore, the crop was introduced to farming families in the county and assisted to raise the crop to harvesting. In addition, customized digital system was used to promote adoption of the crop. Also, because of the current thinking with regard to sustainable agricultural production systems, the study incorporated climate smart agricultural practices.

1.3 Purpose of the Study

The purpose of this study was to introduce Cape Gooseberry plant and support farming families in Baringo County to grow the crop to harvesting. To support the farmers with the technical knowledge, a digital system was used to disseminate approved crop technologies to the farmers. To determine the levels of Cape Gooseberry productivity by interventions, the yields in kilogrammes per acre were ascertained.

1.4 Objectives of the Study

The following were the specific objectives of the study:

i. To establish the levels of awareness of Cape Gooseberry crop among farming families in Baringo County.
ii. To determine the eco-physiological characteristics of Cape Gooseberry that make it thrive naturally in Baringo County.
iii. To determine the levels of Cape Gooseberry adoption in Baringo County.
iv. To determine the effects of disseminating approved Cape Gooseberry technologies to farming families through digital systems on productivity levels of Cape Gooseberry in Baringo County,
v. To determine the effects of receiving information on Cape Gooseberry husbandry practices through regular extension services and incorporating climate smart agricultural practices in Baringo County on Cape Gooseberry productivity levels among farming families,
vi. To determine the effects of disseminating approved Cape Gooseberry technologies through digital systems and incorporating climate smart agricultural practices in Baringo County on Cape gooseberry productivity levels among farming families,
vii. To determine the difference in Cape Gooseberry productivity levels when the crop technologies are disseminated through the use of digital systems, use of regular extension services and climate smart agricultural practices, use digital systems and climate smart agricultural practices, and use of regular extension services.

1.5 Research Questions

i. What are the levels of awareness of Cape Gooseberry crop among farming families in Baringo County?
ii. What are the eco-physiological characteristics of Cape Gooseberry in Baringo County?
iii. What are the levels of Cape Gooseberry adoption in Baringo County?

1.6 Hypotheses

$H0_1$: There is no statistically significant difference in Cape Gooseberry productivity levels when the crop technologies are disseminated to farming families through digital systems, and when farming families receive the technologies from regular extension services during the crop production.

$H0_2$: There is no statistically significant difference in Cape Gooseberry productivity levels when farming families receive information on the crop technologies through regular extension services in combination with incorporation of climate smart agricultural practices during Cape Gooseberry production, and when the farming families receive the crop technologies from regular extension services during the crop production.

$H0_3$: There is no statistically significant difference in Cape Gooseberry productivity levels when farming families receive the crop technologies through digital systems in combination with incorporation of climate smart agricultural practices during the crop production, and when the farming families receive the crop technologies from regular extension services during the crop production.

$H0_4$: There is no statistically significant difference in Cape Gooseberry productivity levels when the crop technologies are disseminated through the use of digital systems, combined use of regular extension services and climate smart agricultural practices, digital systems and climate smart agricultural practices are combined, and regular extension services are used.

1.7 Significance of the Study

This study provides empirical data, information and knowledge on the use of digital systems in dissemination and adoption of agricultural technologies by farmers. The study, also, provided data regarding the levels of acceptability of Cape Gooseberry by farming families in Baringo County, and the levels of the crop productivity. By integrating climate smart agricultural practices, the study presents the empirical data on effects of using the practices with regard to productivity levels in Cape Gooseberry production. The information and knowledge obtained from this study should be useful to agricultural extension practitioners since it highlighted benefits of integrating digital systems in agricultural extension services. Also, it is useful to agricultural development agencies promoting sustainable agricultural development since it has highlighted the benefits of incorporating climate smart agricultural practices on crop productivity. The findings of this study are of use to policy makers at the Department of Agriculture, Livestock and Blue Economy in Baringo County when formulating policies on agricultural extension. The findings regarding the eco-physiological characteristics of the crop, forms a foundation for successor studies directed at development of appropriate husbandry practices for the crop.

1.8 Scope of the Study

The study involved documentation and analysis of data and information regarding the introduction and production of Cape Gooseberry crop by farming families in Baringo County. Digital system was used to disseminate the crop husbandry practices to two groups of farming families. The system comprised use of Cape Gooseberry documentary audio-visual aids during the crop awareness creation and interest stimulation phase; use of online training to disseminate approved Cape Gooseberry technologies, while Cape Gooseberry mobile app enabled the farming families receive approved crop production reference materials.

In Baringo County, there is one agricultural extension officer per Ward. Therefore, at the beginning of the study, three extension officers from the three selected Wards where the study was conducted were trained on Cape Gooseberry husbandry practices. The extension officers were to provide information on Cape Gooseberry husbandry practices to two groups of farming families. In addition, the farming families in the two groups were free to seek information on the crop husbandry practices from other sources such as agrovets, research stations and other Non-Governmental Organizations supporting agricultural development activities in their Wards. With the use of digital system and regular extension services, the farming families grew the crop. Climate smart agricultural practices of organic manure and intercropping with beans were incorporated during the growing of the crop. During the crop production process, the study documented and analysed data regarding the levels of Cape Gooseberry domestication and productivity in kilograms per acre.

The use of digital system and regular extension services in dissemination of the crop husbandry practices, and incorporation of climate smart agricultural practices, was analyzed as the independent variables. Cape Gooseberry adoption and productivity levels were the dependent variables. Indicators in the dependent variables were the levels of adoption in number of new farming families who joined in growing Cape Gooseberry and the crop productivity in kilograms per acre.

The study, also, documented and analyzed the botany of the crop, and determined the ecological characteristics which favor its growth in the wild in Baringo County. The characteristics that were studied include rainfall levels, temperature requirements, altitudinal conditions and soil quality, in addition to the edaphic characteristics, associated plants, pests and diseases.

1.9Assumptions of the Study

The study made the following assumptions:

i. There was no contamination of data and information due to interactions between the farming families since the study zoned the farming families based on the interventions and the desired distance of not less than five (5) kilometres between the groups.

ii. The education levels of the farming families did not affect domestication and the crop productivity because of random sampling of the farming families who participated in the study.

1.10 Limitations of the Study

The potential limitations of the study were:

i. The farming families did not raise the Cape Gooseberry seedlings. This is an important husbandry practice in Cape Gooseberry production. The farming families were provided with Cape Gooseberry seedlings for transplanting. The limitation was, however, addressed through establishment of demonstration fields where nursery establishment and management practices were carried out with the farming families in each group per Ward.

ii. Two groups of farming families received Cape Gooseberry production reference materials through mobile app freely downloadable from Google play. There is no restrictions on who downloads and uses the app. The limitation was, however, addressed through zoning of the farming families based on the study interventions and distance of not less than five (5) kilometers between the groups to minimize interactions.

1.11 Operational Definition of Terms

A number of terms in the thesis are critical in its understanding. For the terms, constitutive and operational definitions of terms have been provided.

Awareness: The term refers to knowledge and understanding that something is happening or exists (Gafoor, 2012; Merriam-Webster, n.d). In this study, it was the familiarity of Cape Gooseberry plants, husbandry practices and related economic importance as a source of livelihood among the farming families.

Climate Smart Agriculture: The term refers to an approach that helps guide actions to transform agri-food systems using practices that are sustainable to improve soil health, agricultural productivity and resilience (Lipper et al., 2014). In this study, climate smart agricultural practices refer to the use of organic manure and intercropping Cape Gooseberry with beans during the crop production.

Digital Systems: The term refers to deployment of hardware, software and networks in an integrated manner to transform data into digital solutions (Digital Technologies Hub, 2021). In this study, it refers to the use of Cape Gooseberry documentary audio-visual aids, online training and mobile app to allow farmers receive approved technologies on Cape Gooseberry production.

Documentary Audio-Visual Aids: These are instructional devices and materials which help in learning process through the use of both audio and visual formats (Lexico, 2021; Padhi, 2021). In this study, it was the use of Cape Gooseberry audio-visuals through Zoom meeting.

Domestication: The term refers to placing humans in control of crop and livestock production, and responsibility for their care to meet specific and well-defined objectives. Through domestication, successive generations of domesticated crops and livestock become integrated into human societies and production systems (Zeder, 2006). In this study, Cape Gooseberry crop was introduced in Baringo County for cultivation to maturity by farming families. If the farmers successfully adopt the crop, then vertical and horizontal scalling will be needed.

Effect: This term refers to influence or to cause someone or something to change (Cambridge University Press, 2021). In this study, it was the difference in Cape Gooseberry productivity means in kilogrammes per acre based on different study inteventions, and the levels of adoption in number of farmers participating in Cape Gooseberry domestication as a result of receiving approved technologies through digital systems, and incorporation of climate smart agriculture during its production, in addition to the number of new farmers who joined during the crop domestication process.

Farming Families: The term refers to agricultural holdings which are managed and operated by a family and predominantly reliant on family capital and labour (FAO, 2024). In the study, it was the sampled farming families who took part in Cape Gooseberry domestication from the beginning to the end of the study.

Mode of Production: The term refers to various approaches in which societies produce goods and services they need for them to survive or prosper (Cohen & Eames, 1982). In the study, it was the sources of information on Cape Gooseberry husbandry practices and the agricultural practices incorporated by the farming families during Cape Gooseberry production.

Productivity: The term refers to quantitative measure of crop yields in a given measured area of land (Reynolds et al., 2015). In this study, it was the measurement of harvested Cape Gooseberry fruits in kilograms per acre for a period of three months.

Regular Extension Service: The term refers to the provision of technical advice to farmers to develop their knowledge, skills and practices and improve their livelihoods (CGIAR, 2012). In this study, it was the receiving of technical advice on Cape Gooseberry production by farming families from agricultural extension staff from Baringo County, and through other sources of agricultural information they have been using on other crops which included agro-vets, farmer to farmer, group learning, radio and television programmes. In addition, regular extension services refered to the use of conventional agricultural practices.

Sustainable Production: This term refers to the production of goods and services using processes and systems that conserve resources and preserves the regenerative capacity of the environment (Rosen & Kishawy, 2012). In this study, sustainable production involved the use of locally available organic manure from livestock waste and intercropping with beans when growing Cape Gooseberry.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter presents documentation and analysis of relevant literature. The review was guided by the study objectives and to improve the understanding of the following: Background of Cape Gooseberry crop; ecology and biology of Cape Gooseberry; domestication and husbandry practices of Cape Gooseberry; agricultural extension and information communication technology, and climate smart agriculture. In addition, the theoretical and conceptual frameworks that guided the study are presented.

2.2 Background of Cape Gooseberry Crop

The background of Cape Gooseberry crop includes the origin and distribution of the crop, significance of the crop, and biology and ecology of the crop. The presentation of the origin and distribution of Cape Gooseberry covers literature on global, regional and local Cape Gooseberry production.

2.2.1 Origin and distribution of Cape Gooseberry

Cape Gooseberry has its origin in the South American countries of Peru, Chile, Venezuela, Bolivia, Colombia and Ecuador, but it has since been introduced in other countries of the world (Barirega, 2014; Cárdenas et al., 2023). Globally, Colombia, is the largest producer and exporter of Cape Gooseberry (Demİr et al., 2014; Puente et al., 2011). The crop has, also, been grown in England, India, China, Malaya and Australia (Deng et al., 2016; Morton, 1987; Sengupta, 2018). According to Mayorga et al. (2001), Colombia is one of the leading producers and exporter of Cape Gooseberries in the world, and the crop is the second most exported crop int the country after banana fruit.

In Africa, the crop was introduced in South Africa in 1770s by settlers (Pulles, 2021). The crop is currently cultivated throughout South Africa, with its fruits being used in jam manufacturing (Barirega, 2014). Western Cape Province is the largest producer of Cape Gooseberry in South Africa (Pulles, 2021). From South Africa, the crop production has spread to other African countries, including Kenya (Kioko, 1987; National Research Council, 1989; Puente et al., 2011).

The crop mainly grows in the wild in Kenyan forests and is known differently in local dialects. There are records of attempts to grow the crop in parts of Kenya particularly in

Machakos, Makueni and Busia Counties. In Machakos, it was grown by farmers contracted to Kenya Orchards Limited (KOL) in early 1980s (Kioko, 1987; National Research Council, 1989). With regard to Makueni County, Del Monte company grew the crop in Kibwezi between 2004 and 2006 (Wasilwa et al., 2021). In Busia County, KALRO in partnership with USAID trained and distributed Cape Gooseberry seedlings to farmers (FarmBiz Africa, 2018; Wasilwa et al., 2021).

According to Kioko (1987), over production of Cape Gooseberry fruits in Machakos in 1986, discouraged farmers from growing the crop in the subsequent years. This is after Kenya Orchards Limited which contracted the farmers purchased only five tonnes and rejected three tonnes of ripe Cape Gooseberries. With regard to Makueni and Busia Counties, despite all the attempts to grow the crop, there is no documentation on sustained uptake of the crop.

In 2010, Kenya Agricultural and Livestock Research Organization (KALRO) identified Cape Gooseberry as an underutilized and listed it among 100 crops for commercialization (KALRO, 2021). This was driven by the fact that the crop is found growing naturally in forest areas of Coastal region, Mount Elgon, Mount Kenya, Kakamega, Timboroa and Koibatek (Wasilwa et al., 2021). In Baringo County, the crop is found growing in Koibatek forest. According to KALRO (2021), the crop, however, has not been domesticated despite its benefits.

2.2.2 Significance of Cape Gooseberry crop

Cape Gooseberry crop has industrial, nutritional and medicinal benefits (Agudelo et al., 2023; Hassanien, 2011). The fruits are raw materials for industrial processing (Sheikha et al., 2010). Some of the products that have been produced along the Cape Gooseberry value chain include jams, raisins, chocolate covered-candies and juice (Barirega, 2014; Ramadan & Moersel, 2007). In addition, Cape Gooseberry fruits are used in the cosmetic industry. This is due to its richness in vitamins, calcium, iron and phosphorous (Carvalho et al., 2015; Ivanova et al., 2021; Rodrigues et al., 2009; Soliman et al., 2019).

Nutritionally, research has shown that Cape Gooseberry fruit has several polyunsaturated fatty acids, carbohydrates, vitamins A, B, B1, B3, C, D, E, and K, and essential minerals including phosphorus, calcium, iron, potassium, and zinc (Carvalho et al., 2015; Demİr et al., 2014; Hemalatha et al., 2018; Puente et al., 2011; Rodrigues et al., 2009). These nutrients help in boosting body immunity. Its richness in vitamin C, is, also, good for the skin, while vitamin A improves the eye sight (Sengupta, 2018). Healthwise, Cape Gooseberry fruits reduce blood sugar levels and hypertension (Anand, 2016; Darwish et al., 2020). The fruits, according to Pinto et al. (2009), can be used to supplement overall dietary management of diabetes. In addition, its richness in nutritional fiber content is important, because the fruit has polysaccharide pectin which acts as an intestinal regulator, thus preventing constipation (Ramadan & Mörsel, 2003).

Cape Gooseberry fruits are used in manufacturing of beauty care products due to their richness in vitamins A, B1, B3, C, Calcium, Iron and Phosphorus which are beneficial to the skin and the body. Vitamin A helps in reducing wrinkles and brown spots as well as smoothening the skin. It has properties that enhances weight loss since it has lesser calories (Anand, 2014). In the European markets, Cape Gooseberry fruits are used as ornaments in meals, desserts, salads and cakes (Ramadan, 2011). All these attributes, make Cape Gooseberry a potential crop for biomedical research and commercial purposes (Hassanien, 2011). Besides, these characteristics have boosted its distribution globally (Enciso-Rodrı´guez et al., 2020).

2.2.3 Biology and ecology of Cape Gooseberry crop

Proper understanding of crop biology and ecology is a pre-requisite condition for successful domestication of wild crops. Therefore, this section provides detailed information covering Cape Gooseberry biology and ecology.

Cape Gooseberry is a herbaceous, perennial plant that grows to a height of between 0.9m and 1.8m, and can spread up to 4 metres wide. The leaves are 6-15 cm long and 4-10 cm wide, and are velvety, heart-shaped, have pointed tips and serrated margins (Ramírez et al., 2013). The crop has bell-shaped, nodding flowers, which are approximately 2 cm wide. The flowers are yellow in colour, with 5 black purple brown spots. After flowering, the calyx forms the straw-colored husk enclosing the fruit (CABI, 2019; Hassanien, 2011). The berry is spherical, approximately 2cm wide, with smooth, orange-yellowish skin and juicy pulp having numerous yellowish seeds. When fully ripe, Cape Gooseberry fruit is sweet but with a pleasing grape-like tang. The husk is bitter and inedible (CABI, 2019; González-Locarno et al., 2020; Hassanien, 2011).

The crop reproduces naturally by seed (Morton, 1987). Use of stem cuttings can, also, be a viable means of propagation. Flowering of Cape Gooseberry occurs all year-round, 3 months after sowing. The flowers are pollinated by both insects and wind (CABI, 2019; Lagos et al., 2008). Under cultivation, Cape Gooseberry single crop may yield up to 300 fruits per season, with each fruit weighing about 5g (Morton, 1987). Crop scientists such as Ayala (1990); Tyagi and Sahay (2016), have found that Cape Gooseberry plant can sustain fruit production between 12 – 24 months.

Chemical aspects such as the taste of the fruit which is related to the maturity ratio (total soluble solids) (TSS) / titratable total acidity (TTA) and the pH are the main important factors considered for commercial quality of Cape Gooseberry fruits (Herrera et al., 2011). High quality Cape Gooseberry fruit has a total acid concentration by volume of between 1.6 and 2.0% (Herrera, 2000), which Abhilasha (2016), and Tyl and Sadler (2017) noted that, it is an important variable in the process of ripening and flavour of fruits, as well as influencing the industrial processing costs.

Ecologically, Cape Gooseberry adapts well to a wide range of altitudes within the tropical climate. However, it does not withstand freezing temperatures. Long duration of direct sunshine favours the fruit development and maturation in terms of the size, quality and ripening of the fruits. High amount of rainfall after dry season causes fruit cracking (Fischer & Melgarejo, 2020). In addition, the crop does not tolerate water logging, and soil flash during heavy rains contaminates the fruits causing mucor rot disease (Dennis, 1983).

Some of the pests affecting Cape Gooseberry fruit crop include: Fruit borer, red spider mite, white flies, stinkbug, stem borer, leaf borer, cutworms, soft brown scale and birds (Wasilwa et al., 2021). The potato tuber moth has, also, been observed infesting Cape Gooseberry crops when grown in the vicinity of potato fields. Birds feeding on ripe Cape Gooseberry fruits can be a serious pest problem (Wasilwa et al., 2021). The most common diseases affecting Cape Gooseberry crops are powdery mildew, fruit rot, dumping-off, root rots and viruses (CABI, 2019; Miyake et al., 2015; Wasilwa et al., 2021).

2.3 Cape Gooseberry domestication and husbandry practices

Globally, domestication of plants is continually being undertaken by rural communities to support their needs for food, industrial benefits, building materials, fibre and medicine (Shaukat, 2020). The first domestication of plants begun in Mesopotamia (Shaukat, 2020). The plant seeds were collected from wild plants, raised and managed until harvesting to provide the desired human needs (Shaukat, 2020).

According to Fernie and Yan (2019), domestication of neglected indigenous plants could help in solving an array of problems, including genetic and species diversification of farming systems, intensification of important ecosystem services provided by crops (Weißhuhn et al., 2017), and development of drought tolerant crop species (Zhang et al., 2018), which are adaptive to local ecological conditions (Fernie & Yan, 2019). Cape Gooseberry is one of the neglected wild fruits (Wasilwa et al., 2021), and despite its benefits, little is known about its domestication and husbandry practices, thus, affecting its market demands (Heywood, 2013; Ross-Ibarra et al., 2007).

Crop husbandry practices deals with various aspects of crops ranging from crop production, farm management, crop protection from pests and diseases (Shaukat, 2012). Crop production covers seed sowing, field operations, harvesting and storage (Shaukat, 2012). Under farm management, efficient utilization of farm inputs for maximum outputs, and record keeping are the guiding principles. Crop protection is more about pest and disease control and management. The weed science deals with the control of undesired weeds. Finally, soil science is about the soil quality in terms of nutrients it contains (Shaukat, 2012).

In Cape Gooseberry production, use of approved husbandry practices ensures that quality Cape Gooseberry fruits are produced which meets market demands and standards for industrial processing (CABI, 2019; Popova et al., 2021; Yilmaztekin, 2014). In addition, application of approved husbandry practices reduces incidences of pest and disease infestation leading to higher productivity and reduction of wastes through post-harvest losses (Miyake et al., 2015; Wasilwa et al., 2021). However, without proper agronomic practices, Cape Gooseberry plant can become invasive displacing other crops (CABI, 2019; Hassanien, 2011). There are various channels in which farmers can access information and knowledge on proper agronomic practices for various crops. The channels include agricultural extension services and use of digital platforms.

2.4 Agricultural Extension and Information Communication Technology

This section provides detailed information covering agricultural extension and integration of information communication technologies (ICTs) in agricultural extension. With regard to agricultural extension, its current status and recommendations for improvements by agricultural specialists are presented. On information communication technology, its benefits in dissemination of information and knowledge, as well as its integration in agricultural extension is discussed. Also, under this section, the use of audio-visual aids, online training and agricultural mobile apps in extension services are discussed in details.

2.4.1 Agricultural extension

Agricultural extension is the process of dissemination of agricultural technologies generated through scientific processes to farmers, to enable them utilize the knowledge to improve their farm productivity (Altalb et al., 2015). The functional objective of any agricultural extension service is sourcing for the best suitable agricultural solutions and the practical performance of these solutions in meeting the farmer agricultural needs (Rivera & Qamar, 2003). The sourced agricultural technologies and innovations must be good and superior to the old agricultural technologies used by farmers to promote its adoption (Muzari et al., 2012).

According to Schwartz (1994), the performance of government sponsored agricultural extension in developing countries has not been efficient in the transfer of improved agricultural technologies and innovations to the farmers due to inadequate number of extension staff; which has limited their effectiveness in promoting agricultural productivity (Msuya et al., 2017). Gichamba et al. (2017) noted that, the ratio of extension staff to farmers in Kenya is 1:1500, which is against FAO recommendation of 1:400 (Akuku et al., 2014). This has affected the quality of agricultural extension service delivery in the country (GoK, 2010), as indicated by Ochieng et al. (2017) who attributed low effectiveness in uptake of climate forecasts by farmers in Baringo County to weak extension structures. As a remedy to the limited number of agricultural extension service providers in Kenya, Gichamba et al. (2017), recommended the use of ICTs to provide e-extension to entire population of farmers, since most of the farmers have mobile phones. In addition, Mungai et al. (2018) recommended the development and promotion of mobile based extension platforms to enhance weak farmer extension linkage in Baringo County.

2.4.2 Information communication technology

Information communication technology (ICT), refers to all communication technologies including computer hardware and software, radio and television programmes, video-conferencing, internet, cell phones, social networking, and services enabling users to create, store, manipulate, access, retrieve, and transmit information in a digital form (Ratheeswari, 2018). The use of ICTs has brought dynamic changes in the society by influencing all aspects of peoples' lives, with regard to work places, businesses, education, and entertainment (Ratheeswari, 2018). In agricultural extension, Tata and McNamara (2016) recommended the introduction and use of information communication technologies to complement the services provided by the extension providers in order to expedite the process of transferring agricultural technologies from research institutions to farmers through digital systems; and serve as a channel for farmers to seek agricultural advice (Agwu & Mercy, 2019; Kumar & Singh, 2012). The benefits of using ICT in agricultural extension include: Reduction in physical distance and isolation in agriculture, real time interactions between farmers, researchers and extension specialists, and better retention of the knowledge acquired (Newbury et al., 2014), in addition to enhancing product traceability, disease and pest tracking, and control (Sourcetrace Systems, 2019). Therefore, its usage is becoming a key determinant of organizational competitiveness and productivity (Buhalis & O' Connor, 2005).

There is need to venture into digital systems to provide advisory services to farming communities and other actors involved in agriculture (Sylvester, 2012), since there is high mobile phone penetration rate in Kenya. Currently, there are 34.5 million smartphones and 31.2 million feature phones connected to mobile networks in Kenya, and their penetration rates as at 31st March, 2023 stood at 58.3% and 66.2% respectively (CA, 2023). Due to high smart phone and internet penetration rate in Kenya, intergration of digital systems in agricultural extension service delivery could facilitate effective and efficient transfer and adoption of new agricultural technologies and innovations by farmers.

To boost agricultural development in Kenya through the integration of ICT, the government established the National Agricultural Information System (NAIS) to provide farmers with access to timely and relevant agricultural information through ICTs (Biradar et al., 2023). The system entails SMS alerts, voice-based services and web-based services. Authors like Kiptot and Franzel (2015) have acknowledged the role played by ICTs in agriculture in providing farmers with approved agricultural information and reference materials during farm productions. In this study, to facilitate effective and efficient delivery of Cape Gooseberry technologies to farming families in a systematically structured and standardized manner during the introduction and domestication of Cape Gooseberry crop, the study deployed the following digital systems: Documentary audio-visual aids to create awareness and interest about Cape Gooseberry production, online training to disseminate the crop approved technologies to the farming families, and Cape Gooseberry mobile app to provide approved reference materials on the crop husbandry practices to the farming families.

Documentary audio-visual aids refer to captured items, events and activities by cameras and presented through smart phones, televisions, computers, websites and projectors (Bentley et al., 2015). The use of audio-visuals as visual aids are effective in creating awareness and interest among farmers in agricultural technologies or innovations, and have a long lasting impression about it (Zossou et al., 2009). To enhance its use by the farmers, the following guiding principles must be observed: Purpose of the video, local context, relevance, proper definition of the targeted group, accuracy of content, combination with other methods of extension, and quality of visuals and audio (Gandhi et al., 2009). Audio-visual aids with experiential learning principles play a significant role when addressing problems of participatory methodologies for scaling up local innovation capacity beyond the pilot range (Chowdhury et al., 2012).

The use of documentary audio-visual aids in sharing knowledge has been demonstrated, for example by a group of women in Dedza District, Malawi, who use their own recorded audio-visuals to explain and demonstrate to other women new ways of cooking nutritious food to improve family nutrition, while reducing food waste (Olson & Steinfiel, 2017). In Kenya, farmers in Machakos and Makueni counties used audio-visual aids to explain and demonstrate in the field to other farmers the procedure they followed in adopting drought resilient maize variety in order to improve the crop productivity (Olson & Steinfiel, 2017). Access Agriculture is, also, another notable non-governmental organization supporting organic farming and agroecology through preparation of quality training videos in local languages (Access Agriculture, 2024).

Other uses of documentary audio-visual aids in dissemination of agricultural technologies to farmers in Kenya include Shamba Shape Up TV programme which uses agricultural experts to provide practical demonstrations at featured farm families carefully selected. The experts use communication approaches understood by farmers with varied literacy levels (Clarkson et al., 2018: Thiga, 2018). Mkulima Young is another digital platform which has drawn youth into farming, by helping them to learn among themselves through radio programme, short messages and social media by posting relevant audio-visuals and asking questions on the platform (Irungu et al., 2015). In addition, Seeds of Gold TV programme offered practical information on improved agricultural technologies and practices using real farms, as well as disseminating information on marketing and value additions (Langat et al., 2018). In this study, Cape Gooseberry documentary audio-visual aids was used to create awareness and interest among the farming families towards Cape Gooseberry production.

Online training involves digital transmission of data, information, knowledge and illustrations for the purpose of learning and sharing information through the internet from anywhere in the globe to targeted audience (Andres & Woodard, 2013). Online platforms allow farmers to have real time interactions with other farmers, researchers and extension specialists (Newbury et al., 2014). The benefits associated with online training include: Flexibility, mobility, meeting different people, online support and information retention (Jasmin, 2018).

Internationally, due to the benefits to be achieved in using online agricultural extension services based on experiences from other sectors of the economy such as tourism, education and entertainment, Pandav et al. (2020), and Purwanto and Tannady (2020), recommended training of farmers on changing agricultural methods and using appropriate technologies to disseminate agricultural information to improve production, while minimizing the spread of Coronavirus. In line with this, online technical assistance has been used by agricultural extension agents in Mississippi University to minimize the spread of Coronavirus (Chatterjee, 2020).

In Africa, during the outbreak of Ebola in Western Africa, Digital Farmer Field School was developed to enable learning and knowledge exchange about cocoa production where farmers were receiving either offline or online training from the extension agents through tablets connected to internet (Witteveen et al., 2017). However, in Kenya, there is limited evidence regarding the use of online training in agricultural extension. In this study, online training was used in awareness creation among the farming families about Cape Gooseberry production and its associated value-added products by linking the farming families in the study with established Cape gooseberry farmer from the neighboring county of Uasin Gishu through Zoom meeting. Also, online training was used in dissemination of the crop technologies to the farming families.

Mobile app is a software application that runs on smart phones, tablets and computers, in order to facilitate dissemination of data, information, knowledge and illustrations in an interactive manner (Serrano et al., 2013). Agricultural mobile apps can provide farmers with valuable context specific data and information that can help them improve their agricultural production (Mobindustry, 2020; Thar et al., 2021).

In developed countries, Internet of Things (IOT) mobile app is being used to connect drones and sensors on agricultural machinery to facilitate precision farming, which is an agricultural technique that focuses on observing and measuring specific data on crops and then responding to the data (Mobindustry, 2020). Reuters Market Light SMS service app, provides localized data and information on crop cultivation, weather, and on real-time commodity pricing information, which helps farmers in deciding whether to sell or hold farm produce until when the prices are favorable, in addition to enabling them to identify the best crop to grow (Sourcetrace Systems, 2019).

In South Africa, Vodacom has partnered with Manstrat Agricultural Intelligence Solutions to launch a mobile technology solution which links smallholder farmers to agriculture value chain, enabling them access to information, services and markets (Chetty, 2017). While in Egypt, the Smart Farmer Guide mobile app provides advice on the best agricultural practices regarding various crops and connecting farmers to wholesale markets to enable them receive daily prices of different crops (IFPRI, 2022).

There are several mobile applications providing agricultural information to farmers in Kenya, operated by both public institutions and private organizations. With regard to public institutions, in 2018, KALRO launched several mobile applications for various crops including Cape Gooseberry, maize, millet, potatoes, sorghum, wheat, tomatoes, pineapples and avocado. The applications enable farmers receive approved technologies about the crop production and associated value additions (FAO, 2018). Furthermore, to enable farmers access weather forecasts and advisories that could help them make better decisions with regard to farming, KALRO in partnership with the World Bank, Kenya Climate Smart Agriculture, Kenya Meteorological Department and the Ministry of Agriculture developed Kenya Agricultural Observatory Platform (KOAP, 2019).

Private organizations are responsible for a greater percentage of agricultural mobile applications which are commodity based and motivated by profits, rather, than public interest (Muyanga & Jayne, 2006). Some of the mobile apps operated by private organizations include Mshamba, Mbeguchoice, Mfarm, Vet Africa and icow (Bizna, 2018). All these apps have been developed to enable farmers receive approved agricultural technologies and adopt them to enhance their agricultural productivity.

With regard to the use of mobile applications in agricultural extension, USAID (2018) noted that, use of mobile apps such as WhatsApp for dissemination of extension information in

Baringo County, could help increase farmer's adaptive capacity to climate change leading to improved agricultural production. This is in concurrence with recommendations by Mungai et al. (2017), about the use of mobile based agricultural extension platforms in Baringo County to improve agricultural production. Based on the literature regarding the benefits of using agricultural mobile apps to facilitate effective adoption of agricultural technologies by farmers, the study deployed Cape Gooseberry mobile app to enable farming families receive reference materials during Cape Gooseberry production in Baringo County.

2.5 Stages in agricultural technology adoption

Technology adoption refers to acceptance, integration, and use of new technology to improve efficiency in service delivery, besides, increasing productivity (Altadonna, 2022; Moustapha, 2019). There are five (5) stages through which farmers pass during the adoption of new agricultural technologies and innovations which include: Awareness, interest, evaluation, trial and adoption/disadoption (Simtowe et al., 2016; Rogers, 2003). At every stage, agricultural extension service provider is required to facilitate the farmers with the essential data, information and knowledge required for decision making (Jaideep, 2015).

Technology awareness is an important pre-condition for any adoption to occur (Simtowe et al., 2016), since lack of its awareness is an absolute constraint to its adoption (Phillips, 2008). Also, the benefits of a technology or an innovation increases its demand among users (Lawrence, 2003), which helps in stimulating interest towards its adoption (Adejo et al., 2017). At this stage, information about the new technology is provided to the farmers to make them aware of its existence, which leads to interest, and searching for more information about the technology (IEduNote, 2020; Rogers, 2003). Awareness creation can be conducted through regular extension services, besides, ICTs which include TV and radio programmes, social media sites, mobile apps, online training materials and documentary audio-visual aids, (Asenso & Mekonnen, 2012).

According to Zossou et al. (2009), the use of documentary audio-visual aids in demonstrating the use of new agricultural technologies is more effective in creating awareness and stimulating interest in the technology. In this study, Cape Gooseberry documentary audio-visual aids were used during the awareness creation stage to enable the farmers to be aware about the crop, besides its nutritional, medicinal and economic benefits. Online training and Cape Gooseberry mobile app were used to provide necessary data, information and knowledge, regarding Cape Gooseberry production.

The interest stage is more about persuasion and forming of favorable attitudes and beliefs regarding the new technology based on the knowledge gained through awareness creation stage (Rogers, 2003; Simtowe et al., 2016; Sulyaningsih, 2010). Farmers inquire for more data and information concerning the technology which they will use to evaluate the relevance of the technology in relation to their agricultural needs, before making any decision (Simtowe et al., 2016). Provision of necessary information on the technology features promotes its interest and adoption among the farmers at this stage (Jaideep, 2015; OECD, 2001; Simtowe et al., 2016).

At the evaluation stage, the farmers analyze the benefits of the new technology based on the information available to them, with regard to its features which comprise ease of use, technical support, portability, costs involved, and likely challenges to be encountered during its usage (Simtowe et al., 2016), which helps in development of behavioral intentions to try the technology (Rogers, 2003). After evaluating the potential benefits associated with the new technology to their satisfaction, the farmers will try it in their farms on a small scale to determine its usefulness based on their set criteria (Simtowe et al., 2016; Sulyaningsih, 2010). In this stage, trial involves evident behavior change, as the new technology is actually put into practice, and if the technology has a certain degree of relative advantage to the farmers, then they will adopt it **(**Sulyaningsih, 2010). In this study, the farming families incorporated climate smart agricultural practices when growing Cape Gooseberry, and received approved crop technologies through online training, Cape Gooseberry mobile app and regular extension services. During the course of the study, documentation of data and information regarding the crop production, productivity and the adoption in number of farmers growing the crop, and new farmers who joined in the domestication process was done.

Adoption means replicating how the technology has been used previously in other different settings (Sulyaningsih, 2010), and is only successful when it becomes institutionalized or regularized of the farmer’s ongoing operations (Simtowe et al., 2016; Sulyaningsih, 2010), besides, recognition of the economic benefits of the technology (Rogers, 2003).

2.6 Climate Smart Agriculture

Climate Smart Agriculture (CSA) is an agricultural approach that can help farmers improve agricultural productivity and incomes in a sustainable way by improving soil fertility, reducing the cost of production, and control of pest and disease infestation (FAO, 2021; FAO, 2010). Implementation of climate smart agricultural practices and technologies helps in minimization of adverse effects associated with climate change and variability (Saguye, 2017; Khatri et al., 2016). However, scholars have pointed that adoption of climate smart agricultural practices by farmers largely depends on the economic benefits associated with the practices. Some of the agricultural practices under climate smart agriculture include use of improved crop varieties, residue management, crop rotation, minimum tillage, sub-soiling, mulching, water conservation, integration of organic manures and incorporation of legumes (Moswetsi et al., 2017; Sullivan et al., 2013). Application of organic manure during crop production provides nutrients, besides, improving biological activities necessary for microorganism (Jangir et al., 2021). In addition, intercropping with legumes promotes soil conservation, improve soil fertility and reduce pest and disease incidence (Muna et al., 2010).

2.6.1 Application of organic manure

Organic manure refers to decomposed mixture of urine and dung from livestock along with litter and left-over fodder fed to the livestock (TNAU, 2014). Traditionally, farmers have been using organic manures to provide nutrients to crops (Ibrahim et al., 2008). Hsich and Hsu (1993) found that, farmyard manures have a positive effect on soil acidity, buffering the soil pH and improving water infiltration. Hence, management of soil nutrients through the use of organic manures and bio-fertilizers can improve physical condition and general health of the soil (Shreekant & Ram, 2018).

Organic manure improves biological activities necessary for microorganism, which have been considered important for their nitrogen fixing efficiency and production of antibacterial, antifungal compound and crop growth regulators (Jangir et al., 2021). Thus, organic fertilizers increase the yield and quality of agricultural crops (Heeb et al., 2006; Jangir et al., 2021; Tonfack et al., 2009), by playing a significant role as the nutrient cycling in the soil-plant ecosystem which has immense importance in sustainable crop production (Ali & Singh, 2015). In Cape Gooseberry farming, Kamal and Ghanem (2011) found that, it is possible to produce high quality Cape Gooseberry plants with improved yield by applying sheep manure as an organic amendment in combination with foliar application.

In addition, with regard to biofertilizers, Shreekant and Ram (2018) found that it improves bioactivities of desirable microorganisms in the soil, thus, improving the crop yield and quality of produce. The authors, also, noted that microorganisms like Azotobacter are considered important for their nitrogen fixing efficiency and their ability to produce antifungal compound, antibacterial compound, and growth regulators.

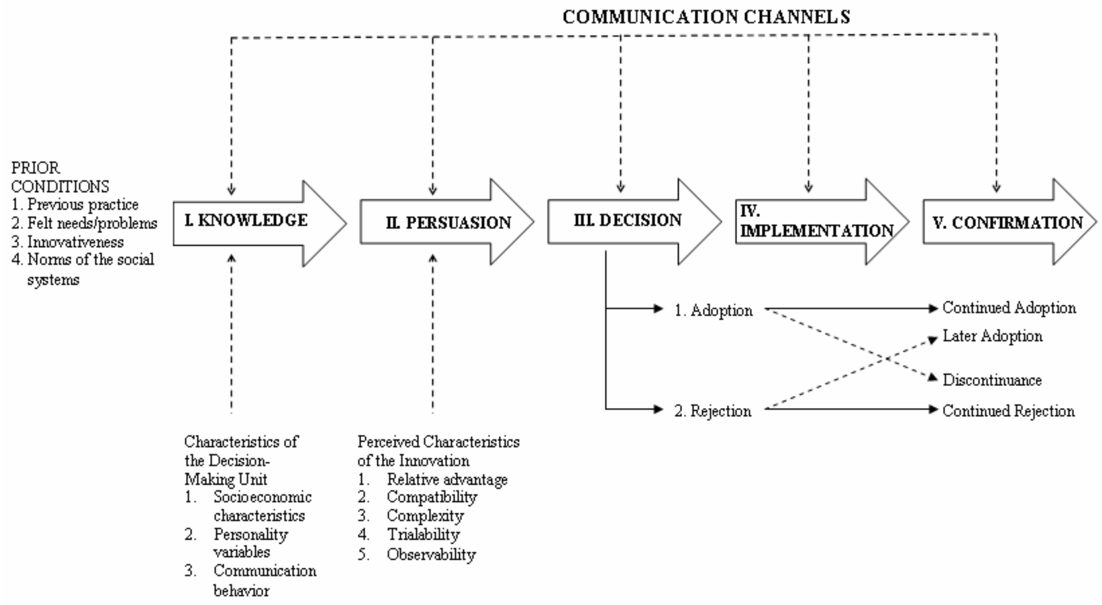
2.6.2 Legume crops

According to Marel et al. (2012), legumes are flowering plants that produce seedpods, and they are usually utilized as cover since they provide many benefits to the soil. Legumes play an important role in low-input farming systems improving soil quality through atmospheric nitrogen fixation, production of substantial amounts of organic nitrogen and increases soil organic matter, as well as improving soil porosity and structure (Kumar et al., 2012; Pandey et al., 2016).

Planting legume crops as intercrops promotes soil conservation; improvement of soil fertility through nitrogen fixation; reduction of pest and disease incidence, as well as, promotion of biodiversity (lithourgidis et al., 2011; Muna et al., 2010; Trenbath, 1993). According to Ghanbari et al. (2010), using legumes as intercrops reduces water evaporation, and improves conservation of the soil moisture. In addition, intercrop help in reducing soil erosion and sustaining crop production (El-Swaify et al., 1988). Legume crops include; beans, peas, lentils, soybeans and peanuts (Kumar et al., 2012).

2.7 Theoretical Framework

The theoretical foundations of this study is based on diffusion of innovation theory by Rogers (2003). The theory describes how new ideas, technologies, behaviors, or goods are transferred through a population from introduction to widespread adoption as shown on Figure 1. According to Miller (2015), the theory conceptualizes the process of innovation diffusion, and can be used in adoption of educational technologies (Jwaifell & Gasaymeh, 2013). In agricultural production, Rogers (2003) noted that the theory remains used today in agricultural extension services especially once an extension is focused on the adoption of a specific practice or technology. In addition, authors have, also, noted that the theory is one of the most needed in agribusiness farming to enable farmers improve their income (Mardiana & Kembauw, 2021).



Adapted from Rogers (2003)

Figure 1: Technology Adoption Framework

The decision process for innovation adoption involves five stages which include: Knowledge, persuasion, decision, implementation and confirmation stage. All these stages played a crucial role in participatory learning and action research processes utilized in this study. The overall aim of participatory learning and action research is to improve knowledge and the livelihoods of the participants in a sustainable approach by giving them a chance to learn, practice and reflect on their actions, before making a decision whether to adopt, modify or drop a certain practice. Therefore, the theory guided in understanding the effects of using digital systems in dissemination of Cape Gooseberry technologies, and incorporation of climate smart agricultural practices on domestication and productivity of Cape Gooseberry crop in Baringo County through participatory learning and action research.

The knowledge stage is where an individual learns about the existence of an idea and seeks information about the innovation. During this phase, the individual seeks information to determine "what the innovation is, how and why it works", and how to use it efficiently (Sahin, 2006; Rogers, 2003). According to the authors, making available adequate information, which answers the questions raised at the knowledge stage increases the likelihood that individuals will adopt the innovation. Rogers and Shoemaker (1971) pointed out that the use of mass media channels can play a critical role in uptake of agricultural innovations at the knowledge function. According to Rogers (1983) mass media include radio and television programmes, and newspapers. In the recent times, the concept of mass media has been expanded to include digital newspapers, websites, e-conferences, podcasts and internet-based social media (Shabir et al., 2015; Turow, 2010).

At the persuasion stage, attitudes about the innovation are formed as individuals become interested in the innovation and actively seeks more information about it in order to reduce uncertainty about the innovation's expected consequences (Rogers, 2003). The author, also, posits that interpersonal communication and mass media communication channels are more important at the persuasion stage of the innovation-decision process. Here, an individual wants to know the advantages and disadvantages of the innovation, which aids in the formation of favourable or unfavourable attitude towards an innovation.

The decision stage occurs when an individual engages in activities that lead to a choice to try out the innovation. At this stage, the higher the number of prior opportunities to try it out, the higher the likelihood of choosing to adopt an innovation increases (Sahin, 2006; Rogers, 1983). Peshin et al. (2009) noted that most individuals prefer to try an innovation on small-scale prior to adoption.

The implementation stage is when the individual puts the innovation into practice and examines the outcomes (Rogers, 1995). Consequently, at this stage, it is essential that users receive support, assistance and feedback from experts, to help decrease uncertainty (Frei-Landau et al., 2022). Sometimes, individuals attempt to modify innovations based on the context or to accommodate their needs (Rogers, 2003).

According to Frei-Landau et al. (2022), users reflectively examine the innovation adoption process and its outcomes in the confirmation stage, in addition to seeking confirmation for their decision as they consolidate their final attitudes towards the innovation.

The study was, also, guided by sustainable Livelihood Framework (SLF) developed by Chambers and Conway (1992). The framework is guided by the following principles: Promotion of linkages between different stakeholders, dynamism to enable integration of new ideas and adaptation to diverse local contexts, building on existing strengths, and finally aiming at sustainability (DFID, 2000; Kollmair & Gamper, 2002). All these principles played a crucial role in participatory action research processes which were utilized in this study. The overall aim of participatory action research is to improve knowledge and the livelihoods of the participants in a sustainable approach by giving them a chance to learn, practice and reflect on their actions, before making a decision whether to adopt, modify or drop a certain practice. Therefore, the framework guided in understanding the effects of using digital systems in dissemination of Cape gooseberry technologies, and incorporation of climate smart agriculture on domestication of Cape gooseberry crop in Baringo County through participatory action research.

The framework describes stakeholders as operating in a vulnerability context. Within that context, they have access to certain livelihood assets or capitals. The weight and value of the assets is influenced by the prevailing social, institutional and organizational environment. This context decisively influences the livelihood strategies that are available to individuals in pursuit of their livelihood outcomes (Kollmair & Gamper, 2002).

Vulnerability context refers to unpredictable events which include trends, shocks and seasonality that undermine livelihoods and causes families to fall into poverty (Carloni & Crowley, 2005). The main aspect of these events is that they are not susceptible to control by the people (DFID, 2000). However, not all trends and seasonality can be considered negative. Hence, there is need to identify means of minimizing the negative effects of vulnerability context by building greater resilience and overall livelihood security (DFID, 2000). In order to realize resilience and livelihood security, this framework is concerned with the livelihood asset status of different categories of households and attempts to build on these assets (DFID, 2000). The framework identifies five types of assets which can be used to build livelihoods, namely, social capital, human capital, physical capital, natural capital and financial capital (Serrat, 2017).

Policies, institutions and processes are man-made factors which influence livelihood assets options accessible by different people and terms of exchanging those assets (Carloni & Crowley, 2005). Enabling policies and institutional environments allows the poor access to assets necessary for their livelihoods (DFID, 2000). Furthermore, policies, institutions and processes influence choice of livelihood strategies which enables people to achieve livelihood outcomes (Alinovi et al., 2010). Livelihood strategies are combination of activities which individuals choose to undertake in order to achieve their livelihood outcomes (Alinovi et al., 2010). It is a dynamic process in which people combine activities at different times. The choice of these activities is driven by the people’s preferences and priorities, in order for them to achieve their desired outcome.

Livelihood outcomes are what people are seeking to achieve through their preferred livelihood strategies (DFID, 2000). The outcomes vary according to place, time, context and individuals. However, understanding the goals of the people to be supported, and what they are actually achieving is crucial in developing a meaningful understanding of livelihoods as a whole (DFID, 2000).

The main strength of SLA is that, the design and openness to changes make the approach adaptable to diverse local contexts (Kollmair & Gamper, 2002). However, there are some limitations which include; a differentiated livelihood analysis needs time, financial and human resources. Due to its holistic principle, inevitably generates and delivers an overflow of information which may not be fully utilized (DFID, 2000).

2.8 Conceptual Framework

The conceptual framework of this study was based on the study objectives. In addition to the objectives, the study was guided by the five stages of diffusion of innovation theory. The stages were knowledge, perception, decision, implementation and confirmation. The study attempted to introduce Cape Gooseberry crop for cultivation through participatory learning and action research, and documented the levels of adoption and yields. The study had three independent variables namely; Digital system, climate smart agricultural practices and regular extension services. The digital system comprise use of documentary audio-visuals, online training and mobile app. With regard to the climate smart agricultural practices, the farming families incorporated organic manure and intercropped Cape Gooseberry with beans. In addition, agricultural extension staff from respective Wards provided technical advice on Cape Gooseberry production to some farmers in the study.

The introduction of Cape Gooseberry production involved awareness creation about the crop, its benefits and the associated husbandry practices among the farming families. At this stage the farming families have got to learn about the idea of Cape Gooseberry domestication, which aligns with, stage one of Rogers's diffusion of innovation theory. In order to aid in promoting effective and efficient awareness creation about the idea of Cape Gooseberry domestication, audio-visual aids were used at this stage in creating awareness and interest about the crop among the farming families participating in the study.

After awareness creation, online training was used to disseminate approved Cape Gooseberry technologies to two groups of farming families by an agronomist. Also, the purpose of using online training was to allow real time interactions among the farmers with their colleagues and the agronomist. In addition, the two groups were, also, provided with Cape Gooseberry mobile app to enable them access approved reference materials about the crop husbandry practices during its production. The mobile app was already developed by KALRO. Furthermore, two other groups of farming families relied on regular extension services from their respective Wards for information on Cape Gooseberry husbandry practices during the crop domestication process. The extension staff visited the Cape gooseberry fields atleast once in a month. Since the regular extension services were involved in the domestication process, they are likely to promote sustainability of the crop production after the project has ended.

Upon receiving adequate information and knowledge regarding the benefits of Cape Gooseberry domestication, the farming families made a decision to participate in the crop production by setting aside part of their land for growing it. They were issued with Cape Gooseberry seedlings to try in their farms. At this stage two groups of farming families incorporated climate smart agricultural practices when growing the crop. The practices were use of organic manure and intercropping with beans. One group accessed information on Cape Gooseberry husbandry practices through digital system and integrated climate smart agricultural practices, while the other group relied on regular extension services for information on the crop technologies and incorporated climate smart agricultural practices.

The farming families grew and managed the crop to maturity. At this stage, the groups of farming families who received the crop technologies through digital systems were encouraged to continually access the crop production reference materials from the mobile app installed in their smart phones. The groups of farming families who were relying on extension staff for information on Cape Gooseberry production were, also, encouraged to seek information on the crop production from agrovets within their accessibility and the Kenya climate smart agriculture staff within their respective Wards, as well as, researchers from research institutions conducting research projects within their Wards. The overall aim was to enable the farmers to learn, practice, reflect and make modification where necessary on selected Cape Gooseberry farming practices, leading to ownership of the practices.

The independent variables have an impact on the dependent variables. Figure 2 shows the interaction between the independent and dependent variables conceived for this study. The independent variables were digital system, climate smart agriculture and regular extension systems. The dependent variables were Cape Gooseberry adoption indicated by number of farming families who grew and managed the crop to maturity, in addition to the new farmers who joined in the domestication process, and the crop productivity in kilograms per acre.

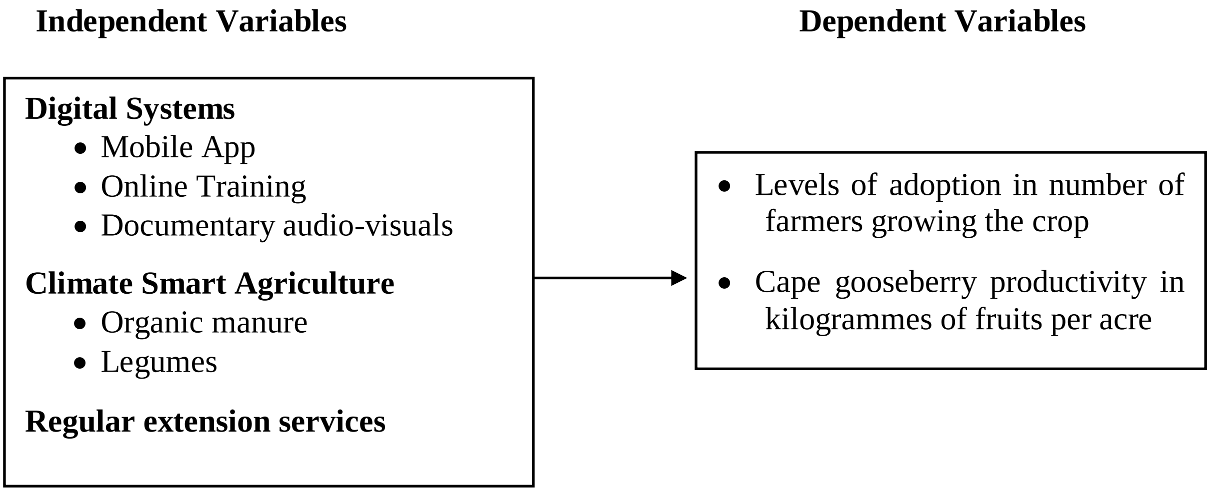


Figure 2: Conceptual Framework Showing the Relationships between Independent and Dependent Variables in the Domestication of Cape gooseberry Crop

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter presents the research design, description of the study area, study population, sampling procedures and sample size, procedures for data collection, validity and reliability of the data and information collection instruments, data collection procedures, and procedures for data and information analysis. The chapter, also, presents a summary of the statistical tests and ethical considerations.

3.2 Research Design

The study used participatory learning and action research, and quasi-experimental research design. Participatory Learning and Action Research (PLAR) is qualitative research used to gain an in-depth understanding of a situation, and engender learning and then the knowledge acquired is translated into action. It is a sustainable learning process involving different stakeholders where individuals under study are fully involved in the research activities, and its success depends on active participation of concerned individuals.

In this study, participatory learning and action research was used since farming families were to be given a chance to learn, practice and reflect on Cape Gooseberry production practices. The farming families were to modify or drop selected Cape Gooseberry farming practices. Finally, the farming families were expected to assume ownership of Cape Gooseberry production practices.

In participatory learning and action research, the farming families were grouped by interventions. The farming families were then engaged in the whole Cape Gooseberry production process. The content of Cape Gooseberry production was delivered in local languages. The farming families were involved in focus group discussions after presentation of every agronomic practices. During the discussions, there was documentation on challenges, experiences and opportunities, as well as, feedback and reflections.

The study used quasi-experimental research design since it involves human beings who have different characteristics. The design is useful in determining cause-and-effect relationships in which an experimental group (or groups) receives a specific treatment(s) while the control group receives no treatment. In this study, quasi-experimental research design was selected since there was need to document and analyse the effects of the interventions on Cape

Gooseberry productivity and levels of adoption. The interventions comprised digital systems, climate smart agriculture, and regular extension services.

The effects of the interventions were determined through the use of quasi-experimental research design. The farming families were grouped by interventions. The first group received information on approved Cape Gooseberry technologies through digital systems and incorporated climate smart agricultural practices. The second group received approved Cape Gooseberry technologies through digital systems. The third group received information on Cape Gooseberry husbandry practices from the regular extension staff and incorporated climate smart agricultural practices. The last group relied on regular extension services without climate smart agricultural practices. All groups were issued with Cape Gooseberry seedlings.

The data collection instruments included farmer register list, potential farmer register list templates, observation schedule, focus group discussion templates and Cape Gooseberry productivity records. Each individual farming families kept records of Cape Gooseberry production processes, register of new farmers and the crop yields.

Farmer register list was used to collect discrete data on the number of farming families who grew and managed the crop to maturity and, also, the number of farming families who dropped during the crop domestication process. Potential farmer register list templates were used to collect discrete data on the number of new farmers who joined during Cape Gooseberry domestication process. In addition, Cape Gooseberry productivity records were used to collect continuous data regarding the crop productivity in kilograms per acre, while focus group discussion protocols were used to collect qualitative data.

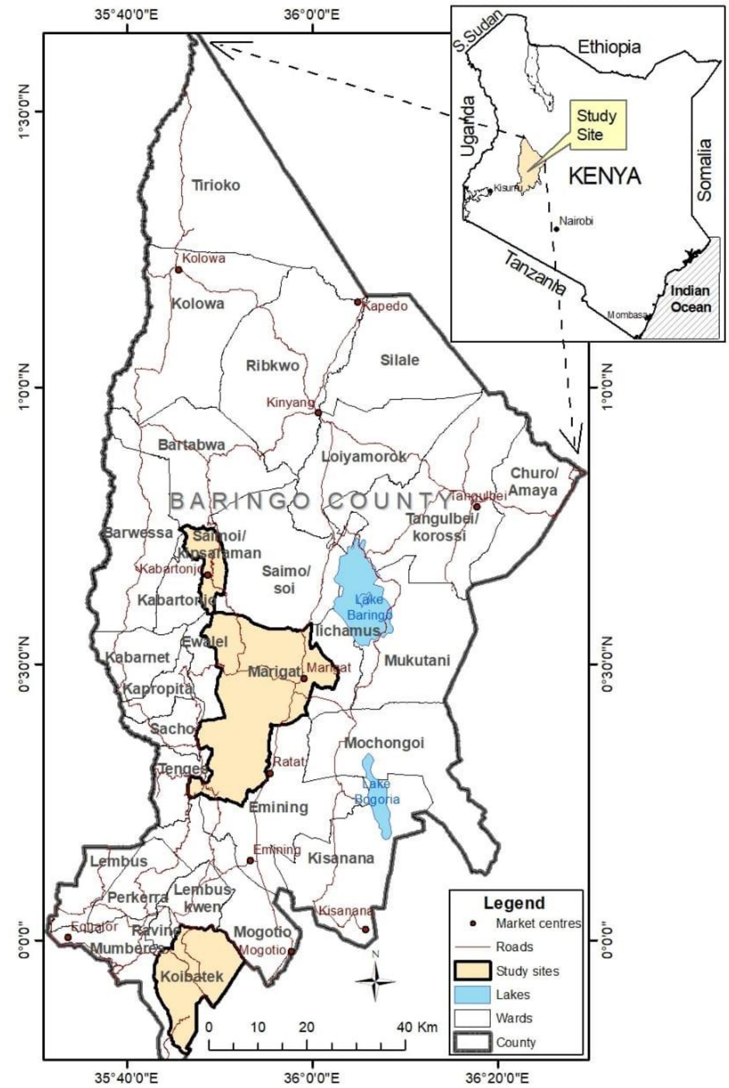
With regard to eco-physiological characteristics of Cape Gooseberry, the study collected and analysed data on the soil characteristics where the crop grows naturally, the plant condition and the vegetation around the crop up to three meters to determine its ecological suitability.

3.3 Location of the Study

This study was conducted in Baringo County. This is because it is one of the counties where available literature indicates that Cape Gooseberry plants are found growing in the wild in Koibatek forest and fallow lands. In addition, Baringo County is one of the Kenya Climate Smart Agriculture Project (KCSAP) implementing counties in Kenya, which is the funding organization for the study. The county covers an area of 11,015.3 sq km and has population of 666,763 people according to 2019 census (KNBS, 2019). Its geographical location is between longitudes 35 30’ and 36 30’ East and latitudes 0 10’ South and 1 40’ North.

The County has three ecological zones: The Highlands, the Midlands and the Lowlands (Koskei et al., 2018). The Highlands have high potential for agricultural development. The soils are fertile and well drained, which was suitable for cereals, fruit, horticultural and industrial crops. The Lowland zones are semi-arid and relies mainly on irrigation for farming. It has complex soils and essentially a rangeland with scattered and isolated grass-like plants or shrubs suitable for grazing. Some of the crops being grown under irrigation in lowland ecological zones of Baringo County are onions, tomatoes, watermelon and vegetables. The Midland ecological zones are areas in between the highland and the lowland ecological zones. The main farm enterprises in this ecological zone are livestock keeping and growing of cereal crops such as maize, beans, millet and sorghum (Koskei et al., 2018).

Baringo County has six sub-counties, namely: Baringo Central, Baringo North, Baringo South, Mogotio, Eldama Ravine and Tiaty. The farming families who took part in this study were from three Sub-Counties, namely: Baringo South, Baringo North and Eldama Ravine. From each Sub-county, one Ward was purposively selected. The selected Wards were Saimo/Kipsaraman in Baringo North, Marigat ward in Baringo South and Koibatek ward in Eldama Ravine. The Sub-counties and Wards were selected because Cape Gooseberry plants were found growing naturally. Details about the study areas in Baringo County are presented in Figure 3.



Source: Kenya Ministry of Lands and Physical Planing Survey (2015).

Figure 3: Map of Baringo County

3.4 Population of the Study

The target population of the study was 167,000 farming families in Baringo County and 59,337 farming families from the three sampled Wards. The accessible population comprise 14,834 farming families drawn from the three purposively selected wards of Baringo County, namely: Saimo/Kipsaraman Ward in Baringo North Sub-County, Koibatek Ward in Eldama Ravine sub-county and Marigat Ward in Baringo South Sub-County. The study focused on farming families who were above 18 years of age from either gender, and owning land, as well as practicing either crop farming, livestock keeping or mixed farming.

3.5 Sampling Procedure and Sample Size

This study used purposive sampling technique in selecting three Sub-counties in Baringo County where Cape Gooseberry plants were found growing naturally. The study sample was drawn from the three Sub-counties. From each Sub-County, one Ward was, also, purposively selected. The sample size per Ward was determined using the formula;

$$n = \frac{NC^2}{C^2 + (N-1)\,e^2}$$ (Nassiuma, 2000).

Where: n = Sample size,

N = Population,

C = Coefficient of variation,

e = Standard error

Nassiuma (2000) indicates that, a coefficient of variation in the range of 21% - 30% and standard error in the range 2% - 5% are usually acceptable in surveys and experimental designs. This study used a coefficient of variation of 21% and a standard error of 2%.

Based on the formula, the sample was calculated as follows:

$$n = \frac{14834\ x\ 0.21^2}{0.21^2 + (14834 - 1)\ 0.02^2}$$

= 109.44

The sample size was adjusted by 10%, resulting in an increase of 10.944. The final sample, therefore, was 109.44 + 10.944 = 120.384. This was rounded off to 120.

The accessible population sizes from the three wards were close, and, therefore, the sample of 120 farming families were allocated equally among the three wards. The distribution is as shown in Table 1.

Table 1: Farming Families Sample Size Distribution by Wards

Ward	Target Population	Accessible Population	Sample
Saimo/Kipsaraman	21,300	5,325	40
Marigat	18,555	4,639	40
Koibatek	19,482	4,870	40
Total	**59,337**	**14,834**	**120**

The sample of 120 farming families were distributed based on the study interventions as shown in Table 2.

Table 2: Sample Distribution per Intervention

Interventions	**Sample size**
Digital systems and Climate Smart Agriculture	30
Digital Systems	30
Regular extension service and Climate Smart Agriculture	30
Regular extension Services	30
Total	**120**

The Sub-County agricultural officers from Baringo North, Baringo South and Eldama Ravine Sub-counties in liaison with the agricultural extension officers from the purposively selected Wards were requested to provide list of farmers from the three Wards. The lists of farmers provided by the Sub-County agricultural officers from the wards were prepared. From the lists, sampling frames were developed and samples were randomly drawn for the study. Based on the proximity of the farming families to each other, and the desired distance of not less than five (5) kilometers between the groups within a Ward to minimize interactions and possible data contamination, the sampled farming families were assigned into four groups per Ward as shown in Table 3.

Also, due to the difference in soil and climatic factors in the three Wards, one group of farming families per Ward applied similar intervention as follows: The first group of ten (10) farming families received approved Cape Gooseberry technologies through digital systems and incorporated climate smart agricultural practices; the second group of ten (10) farming families received approved Cape Gooseberry technologies through digital systems; the third group of ten (10) farming families received information on Cape Gooseberry husbandry practices from the regular extension staff and incorporated climate smart agricultural practices; and the last group of ten (10) farming families was allowed to rely on regular extension services. All the four groups were issued with Cape gooseberry seedlings.

Table 3: Distribution of Farming Families per Intevention per Ward

Wards	Digital Systems and CSA	Digital Systems	Regular extension staff and CSA	Regular extension services	Total
Saimo/Kipsaraman	10	10	10	10	40
Marigat	10	10	10	10	40
Koibatek	10	10	10	10	40
Total	**30**	**30**	**30**	**30**	**120**

In addition, there were four Focus Group Discussion (FGD) groups in the study. The following formula was used to determine the number of farming families who participated in the focus group discussions (Nassiuma, 2000).

$$n = \frac{NC^2}{C^2 + (N-1)\,e^2}$$

Where: n = Sample size,
N = Population,
C = Coefficient of variation,
e = Standard error

$$n = \frac{120 \; x \; 0.26^2}{0.26^2 + (120-1)\,0.05^2}$$

$$= 22.21$$

The sample size was adjusted by 10%, resulting in an increase of 2.221 samples. The final sample size was 22.21 + 2.221 = 24.43, rounded off to 24.

The sampled 24 farming families were distributed equally among the four study groups. The groups were use of digital system and climate smart agricultural practices, digital system, regular extension service and climate smart agricultural practices, and regular extension services. Within each group, random sampling was used to identify six (6) farmers who participated in the focus group discussions. Consensus on in-depth information on Cape Gooseberry domestication levels, challenges, experiences and opportunities was documented during the focus group discussions. After every focus group discussion, the moderator shared the resolutions with the farmers who were represented through phone calls and farm visits. The farmers' representatives, also, played a role in relaying the discussion resolutions to farmers in the group they represent. The represented farmers were encouraged to forward their comments to their representatives at least one day before the focus group discussion date. All discussions were recorded.

3.6 Instrumentation

This study utilized seven instruments for data collection, namely: Interview schedule for farmers (Appendix A); First focus group discussion guide for farmers (Appendix B); Second focus group discussion guide for farmers (Appendix C); Cape Gooseberry agronomic record for farmers (Appendix D); Cape Gooseberry productivity records for farmers (Appendix E); potential farmer register lists (Appendix G) and observation guide (Appendix H).

Interview schedule was used during the baseline survey to collect data from the farming families. The schedule had five sections. Section A covered farmer and farm characteristics. Section B covered awareness of Cape Gooseberry. Section C was about Cape Gooseberry production. Section D focused on climate smart agricultural practices. Section E was about sources of agricultural information. Section F covered the use of digital systems.

Observation guides were used to collect data for establishing the ecological and botanical characteristics of Cape Gooseberry in terms of edaphic factors, climatic conditions and persistently associating plants which are important for its physiological growth, besides, observable pests and diseases.

Farmer register list was used to record data on the number of farming families who grew and managed Cape Gooseberry to maturity, as well as the number of farming families who dropped during the crop domestication process. The researcher kept the records of participating farming families and those who dropped during the process. Potential farmer register lists kept by the farming families were used to record the details of new farmers who joined in Cape Gooseberry domestication process. The recorded data of participating farming families, those who dropped and the new farmers who joined were used in determination of the crop adoption levels.

Focus group discussion protocols were used to collect indepth information on the challenges, experiences and opportunities experienced by the farming families during the crop production. The focus group discussions were held after every Cape Gooseberry agronomic practices. The main purpose of using the FGDs was to help in understanding the crop agronomic practices which the farming families needed more support in order to facilitate the adoption of the crop, as well as improving the crop productivity.

The farming families harvested ripe Cape Gooseberry fruits for a period of three months from the date of first harvest at an interval of two weeks, and recorded the weights on Cape Gooseberry productivity templates. The Cape Gooseberry production records kept by the farming families were used to calculate the crop productivity in kilograms per acre.

3.6.1 Validity

The data collection instruments were presented to four experts from the field of agricultural extension and education to improve the face and content validity of the instruments. For the face validity, the experts were to consider the presentation of the instruments to the respondents with regard to language, instructions and structure. The content validity was checked to ensure that the instrument items will seek responses required by the research objectives. Three experts were drawn from the Department of Agricultural Education and Extension, Egerton University, and one independent expert from Laikipia University. In addition, there was validation of the data collection instruments during the proposal defences at the Departmental and Faculty levels. The comments from the experts and the boards of examiners were incorporated in the development of the final instruments.

3.6.2 Reliability

A pilot study was done using a sample of 18 farmers from Ewalel Chapchap Ward in Baringo Central Sub-County of Baringo County. The sample size was based on Baker (1994) who proposes an equivalent of 10-20 percent of the sample size for a pilot study. Ewalel Chapchap Ward was chosen since it has similar characteristics to those of the sampled Wards. Piloting the interview schedule instrument addressed deficiencies and ambiguities in the instrument which the researcher corrected before producing the final instrument for data collection.

To ensure reliability of the soil sampling and analysis process, internationally approved procedures of soil sampling and analysis were applied. For objective three (3), split-half correlation was used to assess the data collection instrument reliability, which yielded a reliability coefficient of 0.717 which was above the threshold.

Two data collection instruments were used to collect data required for the determination of the reliability of Cape Gooseberry production data generated by objective four, five, six and seven. The instruments were: Farmers' Cape Gooseberry productivity template; and Observers' Cape Gooseberry productivity template. The purpose of using the two instruments was for triangulation of the data collected by farmers, and the data collected by an independent team of observers. The team comprised four members namely; Crop scientist from the County Government of Baringo, Department of Agriculture; one staff from Kenya Climate Smart Agriculture Baringo County office, and two agrovet operators from each Sub-County. The observers were selected because they were knowledgeable on crop production, climate smart agricultural practices and they understand the parameters in consideration in the study.

As part of Cape Gooseberry agronomic practices, each farming family harvested the ripe fruits, weighed and recorded the weights in kilogrammes, in the Farmers' Cape Gooseberry productivity template. The fruits were harvested for a period of three months from the date of first harvest at an interval of two weeks. The team of independent observers visited selected farming families's farms when harvesting and weighing the fruits. They observed the harvesting and weighing of the fruits, then recorded the harvests on the Observers' Cape Gooseberry productivity templates. In addition, the observers, also, observed the farming families' Cape Gooseberry fields for conformity to the recommended approved crop husbandry practices.

Since Cape Gooseberry fruit production data were in ratios, Kuder-Richardson 21 (KR21), was used in the determination of the data reliability. The reliability coefficients for each intervention are as shown in Table 4. Based on Kuder-Richardson 21 formula, all the reliability co-efficiencies for the productivities were above 0.94. For survey and experimental studies, a reliability coefficient of .70 is acceptable (Fraenkel & Wallen, 2012). Therefore, in this study, the coefficients were acceptable because they were above the threshold.

Table 4: Kuder-Richardson 21 Reliability Coefficients by Interventions

Interventions	**Coefficients**
Digital systems and climate smart agriculture	0.966
Digital systems	0.946
Regular extension services and climate smart agriculture	0.941
Regular extension services	0.943
Overall reliability	**0.966**

3.7 Data Collection Procedure

A letter from Egerton University Board of Post-Graduate Studies was used to seek a research permit from the National Commission for Science, Technology and Innovation (Appendix

N). After receipt of the research permit, approval was sought from the County Government of Baringo for permission to conduct research in the county.

There were three data collection phases. The first phase was the baseline survey. Under baseline survey, information on farmer characteristics, farm data, and the details of potential farming families who could participate in Cape Gooseberry production were recorded. Data from the farming families were collected through interviews. The interviews with the respondents were at designated venues, time and date. Confidentiality was guaranteed. Also, under the first phase of data collection, an observation schedule was used to collect and document information on eco-physiological characteristics associated with Cape Gooseberry crop in terms of climatic conditions, persistently associated plants, and observable crop pests and diseases. KALRO through its National Agricultural Research Labaratory was requested to carry out soil analysis. The laboratory conducted soil sampling and analysis of the soil pH, soil texture, soil nutrient, soil electron conductivity and cation exchange capacity.

The soil sampling was a case study in Saimo/Kipsaraman Ward in Baringo North Sub-County which is in Baringo County. The study area is flanked by two forests: Katimok and Saimo. Soil was sampled where Cape Gooseberry plant was located to be growing naturally. Samples were taken at approximate distances of 500 meters apart, and 30 centimeters deep. A total of 15 samples were collected from 15 spots. In addition, the altitude and the geographical locations of the sample spots were, also, recorded. Photographs of plants persistently associated with Cape Gooseberry in the wild, pests and diseases observed on Cape Gooseberry plants in the wild were documented and analysed.

The soil samples were air dried under shade for one week before packaging into paper bags for delivery to the Kenya National Agricultural Laboratories for analysis. Total organic carbon was determined by calorimetric method (Anderson & Ingram, 1993) where all organic carbon in the oven-dry at 40^0 C soil sample (< 0.5 mm) was oxidized by acidified dichromate at 150^0 Cfor 30 minutes to ensure complete oxidation. Thereafter, Barium chloride was added to the cool digests. After mixing thoroughly, the digests were allowed to stand overnight. The carbon concentration was then determined on the spectrophotometer at 600 nm.

Soil pH and Electrical Conductivity (EC) were determined in a 1:2.5 (w/v) soil – water suspension with pH – meter and conductivity meter respectively. The soil-water suspension was homogenized by short but vigorous manual shaking and left overnight. The next day the suspension homogenized by short but vigorous manual shaking again, and the pH and conductivity of the suspension measured with a pH – meter and conductivity meter respectively (Hesse, 1971). To establish the Cation Exchange Capacity (CEC) pH 7.0 and Exchangeable Ca, Mg, K, Na; Methods of soil analysis by Jones et al. (2017) was used. The soil sample was leached with 1N ammonium acetate buffered at pH 7. The leachate was analyzed for exchangeable Ca, Mg, K and Na. The sample was further leached with 1N KCl, and the leachate used for the determination of the CEC. Elements such as Na and K were determined with a flame photometer; Ca and Mg with AAS (atomic absorption spectrophotometer) and CEC was determined by distillation followed by titration with 0.01 *N* HCl.

Establishment of the climatic factors comprised the average annual rainfall and temperature of the study area. Also, established was the altitude of the points where Cape Gooseberry was found growing naturally. The data were obtained from public databases. Plants observed to be persistently growing, at least three meters around Cape Gooseberry plants, and observable crop pests and diseases on the Cape Gooseberry were, also, documented.

The second phase involved collection of data during the introduction and production of the crop. The first task was creation of awareness and interest among the farmers through the use of Cape Gooseberry documentary audio-visual aids guided by the Cape Gooseberry domestication script (Appendix I) and Cape Gooseberry domestication manual (Appendix L); translated in Tugen languages (Appendix M). This was followed by introduction of the crop for cultivation. At this stage the farmers received information on the crop husbandry practices through online training, mobile app and the regular extension services.

The use of Cape Gooseberry mobile app was preceded by guiding of the farming families on how to use the mobile app, then assisted in downloading the mobile app on their smart phones. For those farming families where the household head had no smartphone, they installed the app on any of their family member's smart phone. The farmers were instructed to use the mobile app during the various Cape Gooseberry agronomic practices. With regard to the use of regular extension services, there was one (1) extension staff per ward in the study area. Therefore, two groups of farming families per ward received information on Cape Gooseberry husbandry practices from the extension staff in their respective wards. The extension staff were requested to offer technical advice on Cape Gooseberry production to the farming families at least once in a month from planting to maturity.

The farmers were issued with Cape Gooseberry seedlings to grow on their farms. During the crop production, the farm activities were documented continually. Focus group discussions were used to collect data and information on issues of concern raised by the farming families. Cape Gooseberry production records kept by the farming families during the introduction and production of the crop were used to collect data on the crop production.

The Cape Gooseberry crop took between 5 – 6 months to mature, and be ready for harvesting. Therefore, the third phase of data collection was conducted during three months of harvesting the ripe Cape Gooseberry fruits from the first date of harvest, at an interval of two weeks. The farming families harvested and weighted the ripe fruits using weighing scale. They recorded the harvests in kilogrammes in the designated crop productivity record templates (Appendix E). Only Cape Gooseberry productivity records for the farming families who grew and managed the crop from the beginning of the study to maturity were used to determine the crop productivity per acre.

In addition, under phase three of the data collection, the farming families recorded details of farmers who joined in the crop domestication process from the beginning to the end of the study in the potential farmer register lists. The potential farmer register lists were used in determination of Cape Gooseberry adoption levels.

3.8 Data Analysis

This study used descriptive and inferential statistics. The descriptive statistics used include frequency, percentages and means. Inferential statistics used were t-tests and analysis of variance to compare means of interventions.

The levels of awareness of Cape Gooseberry among the farming families in Baringo County was presented in a frequency distribution table which captures the percentages of farming families who were aware of the crop. The survey and fact-finding inquiries data describe the eco-physiological characteristics of Cape Gooseberry plant that make it grow and produce naturally in Baringo County. Line graph was used to show the number of farming families who joined in the crop domestication as a result of the study interventions.

Before undertaking the inferential statistical tests, the data on Cape Gooseberry productivities were checked if they met the required assumptions for conducting T-tests and Analysis of Variance (ANOVA). Shapiro-Wilk test was used to assess the normality of the data from all the four groups, which each yielded a Sig. Value greater than 0.05 which is an indicator of data normality. In addition, Lavene's test was used to test the homogeneity of variances in

Cape Gooseberry productivities for the four groups of farming families. The tests yielded values greater than 0.05, both for T-tests and ANOVA, which was an indicator that the homogeneity assumption of the variance is met.

The test statistic for the difference of two independent means, when the variances are unknown is t-test. Therefore, t-test was used to test differences in productivity levels between those farming families who received approved technologies through digital systems in the growing of Cape Gooseberry and those who relied on the regular extension services. This occurred between those who received information on the crop husbandry practices from the regular extension and incorporated climate smart agricultural practices in the growing of Cape Gooseberry and those who relied on regular extension services. The test was further administered between those who received approved crop technologies through digital systems and incorporated climate smart agricultural practices in the growing of Cape Gooseberry and those who relied on regular extension services during the crop production.

Since the fourth hypothesis ($H0_4$) had more than two interventions, analysis of variance (ANOVA) was used to determine whether or not there was statistically significant difference among the interventions. The inteventions were: Farming families who received approved Cape Gooseberry technologies through digital systems; farming families who relied on regular extension services and incorporated climate smart agricultural practices; farming families who received approved Cape gooseberry technologies through digital systems and incorporated climate smart agricultural practices; and those farming families who relied on regular extension services in growing Cape Gooseberry. To isolate where the differences in means occur, Least Significant Difference (LSD) Post Hoc test was used.

Thematic analysis was used in analyzing qualitative data generated through observations, focus group discussions and interviews. Nvivo software was used to organize the data per themes prior to their analysis

3.9 Ethical and Biosafety Considerations

Clearance from the University Ethics Committee was sought first (Appendix O), then research permit obtained from the National Commission for Science, Technology and Innovation (NACOSTI) before the commencement of the data and information collection processes (Appendix P). Ethical standards which were observed during the research period include: Informed consent, plagiarism, academic freedom, financial integrity, confidentiality and dissemination of research findings. Informed consent was obtained from the landowners whose farms were surveyed as well as farmers involved in the study. All sources of information were acknowledged.

Financial aid was used strictly for the intended purpose and accounted for. Confidentiality of sources of data and information was guaranteed. The research findings were disseminated appropriately, including publications in refereed journals. Cape Gooseberry has no known negative effects on both human health and the environment.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents results, analyses, discussions and the findings of the study on the "Effects of Digital Systems and Climate Smart Agriculture on Domestication and Productivity of Cape Gooseberry (*Physalis peruviana l.*) by Farming Families in Baringo County, Kenya". The presentations are organized starting with demographic characteristics and farming activities practiced by the farming families followed by the study objectives.

4.2 Demographic Characteristics and Agricultural Activities of the Farming Families

The demographic characteristics which covers the gender representation of the farming families are as discussed in section 4.2.1, while the agricultural activities practiced by the farming families are as presented in section 4.2.2.

4.2.1 Demographic characteristics of the farming families

Table 5 presents the gender representation of the farmers who took part in the baseline survey, and the distribution of farming families per Ward in frequencies. The results show that among the 107 farming families who participated in the baseline survey, 60(56.1%) were male while 47(43.9%) were female. The results further show that Koibatek Ward had the lowest number of male farmers who participated in the survey compared to Saimo/Kipsaraman and Marigat Wards as shown on Table 5.

Table 5: Gender Distribution of Farming Families

	Gender		
Wards	Male	Female	Total
Saimo/Kipsaraman	25	15	40
Marigat	24	15	39
Koibatek	11	17	28
Total	**60**	**47**	**107**

The highest number of male respondents who participated in the baseline survey could be attributed to local gender relations which involves power distribution in the farming families in which men are the family's spokesperson. Kilic et al. (2015) observed that in agricultural production, there exists a gender gap in access to and use of land, land tenure security and investment. According to Osanya et al. (2020), most of the decisions concerning agricultural activities in Kenya are made by men, which is in agreement with DFID et al. (2002) that in every society there are gender gaps which are manifested in different ways, and mostly, women have less power and influence than men. However, the households headed by female are not homogenous, as classified by Gebre et al. (2019) into two categories: Households headed by women who are not married, divorced or widowed, and the category of women whose spouses could be away from home for other reasons.

4.2.2 Types of agricultural activities practiced by the farming families

The results in Table 6 indicate that among the types of agricultural activities practiced by the farming families in the three Wards of Baringo County, majority of the farming families practiced mixed farming (89/107). Crop farming was ranked second (12/107), followed by livestock farming (6/107).

Table 6: Types of farming practiced by the farmers

	Type of Farming			
Wards	Livestock	Crop	Mixed Farming	Total
Saimo	0	5	35	40
Marigat	5	3	31	39
Koibatek	1	4	23	28
Total	**6**	**12**	**89**	**107**

Majority of the farming families were engaged in mixed farming of growing crops and keeping livestock, which is in agreement with Ntale and Litondo (2013) who found that small scale farmers in Muranga and Kiambu counties were practicing mixed farming. According to the farming families who participated in the focus group discussions, their main purpose behind mixed farming was to promote diversification of sources of livelihoods, assurance against crop failure due to unpredictable rainfall patterns, and the livestock is, also, a good source of organic manure which improves the soil healthy and quality. In addition, other farmers in the focus group discussions, also, noted that due to land sub-division, the available land cannot support large scale production of certain crops or livestock keeping. Therefore, they preferred mixed farming to produce products for home consumption and the surplus can be sold.

According to Devendra and Thomas (2002), there is noticeable relationship in resource use in mixed farming, with inputs from one sector being supplied to others; thus, helping in solving problems associated with low external input through more intensive use of natural resources at farming (Funes-Monzote, 2008). This is achieved through the following ways: The crops are used to feed the livestock, and the livestock wastes can be used in preparation of organic manure to improve the soil healthy and quality for sustainable agricultural production. This in turn, immensely reduces the cost of agricultural production leading to attainment of food self-sufficiency and at the same time yielding marketable farm produce that contribute to household income without degrading the natural resource base (Funes-Monzote, 2008).

The results, also, show that crop farming was the second type of farming practiced by the farming families. According to some of the farming families, the available size of land is not economically viable for livestock farming, but can support growing of crops for home consumption. In addition, other farmers noted that lack of land dermacation in parts of Marigat Ward significally limits the type of farm investments one would venture into. During the focus group discussions, one farmer from Marigat Ward said, *"I preferred crop farming to avoid conflicts with my neighbours due to free range livestock keeping since i cannot fence my farm because it has not been adjudicated"* Similarly another farmer from the same Ward, also, said, *"scarcity of water for livestock watering has forced some farmers to grow crops only, since the rivers are far away".*

The study finding confirms what Angassa and Oba (2008), and Coppock (1994) indicated that, crop cultivation continues to expand due to subdivision of family lands and grazing lands into smaller pieces which cannot support economical large scale farming. Land demarcation is, also, the foundation of land ownership and individual land use according personal interests as noted by Libecap and Lueck (2011). Initially, as a community member, there were limited options regarding the agricultural activity one would venture into, since the lands were open grazing fields without individual boundaries. Therefore, most of them would prefer crop farming to avoid conflicts with their neighbors occasioned by livestock feeding on their crops as noted by (Ofem & Inyang, 2014). However, with the land demarcation, despite the lands becoming smaller to accommodate livestock farming, farmers have the freedom to venture into any agricultural activity of their choice. Lack of water for watering the livestock as a factor discouraging livestock farming as indicated by the farming families has been supported by Beede (2005) who indicated water is an essential nutrient for livestock and referred to as, *"the second in importance only to oxygen to sustain life and performance of dairy cattle".*

Lastly, the results from the study indicates that livestock farming was the least practiced across the three wards, and Marigat Ward had the highest number of farming families keeping livestock only. This could be attributed the fact that Marigat Ward falls under the lowland ecological zone where livestock keeping is the major economic activity. According to the farming families, unpredictable rainfall patterns, pest and disease infestation, wild animals feeding on the crops, as well as degrading soil fertility due to soil erosion are some of the factors affecting crop production in the area. Communal land ownership in Marigat Ward is another factor which could be forcing farmers in the ward to practice free range livestock keeping since land demarcation is yet to be established in some areas. Furthermore, inadequate access to agricultural extension services could be a factor which may have limited the number of livelihoods strategies accessible to the farmers. In addition, during the focus group discussion some farmers noted that apart from keeping livestock for food and income generation, it is, also, a mark of self-esteem and wealth in the community.

According to Sansoucy (1995), livestock are closely linked to the social and cultural lives of various communities who are resource-poor for whom livestock keeping guarantees varying degrees of sustainable farming and economic stability; they are not only a means of subsistence, but, also, signified wealth and food security. In support of this, Mutta (2020) noted that in traditional settings, livestock signified the wealth of a man, and the larger the herd were, the greater the respect he commands from the community. In addition, Makamure (1970) found that livestock had and still has social, economic, political, spiritual, as well as ecological significance

4.3 Levels of Awareness of Cape Gooseberry Crop in Baringo County

The first objective of the study was:

To establish the levels of awareness of Cape Gooseberry crop among farming families in Baringo County.

The research question which guided this section of the first objective was:

What are the levels of awareness of Cape Gooseberry crop among farming families in Baringo County?

Baseline survey was conducted at the beginning of the study to determine the degree to which the farming families were familiar with the crop in Baringo County. In addition, the farming families' perceptions regarding the support which would be required to successfully grow Cape Gooseberry were documented and analysed. Five areas to aid in determining the level of awareness of Cape Gooseberry crop by the farming families in Baringo County, Kenya were examined:

i. Levels of Awareness of Cape Gooseberry crop;
ii. Existence of Cape Gooseberry around Homesteads;
iii. Awareness of Farmers growing Cape Gooseberry;
iv. Willingness among the Farmers to Grow the crop;
v. Reasons for not willing to grow Cape Gooseberry; and
vi. Support required by the Farming Families to grow Cape Gooseberry Crop.

4.3.1 Awareness of Cape Gooseberry crop

The study focused on domestication of Cape Gooseberry crop in Baringo County. It was, therefore, essential to determine the current status of farmers' level of awareness about the crop. Table 7 presents the results on the degree of awareness of Cape Gooseberry among the farming families, for the County and the Wards. From the results, over 85% of the farming families from the three Wards of Baringo County were aware of Cape Gooseberry crop. When the levels of awareness were examined by Wards, 100% of the farming families in Saimo/Kipsaraman Ward were aware of the crop, 86% of the farming families in Koibatek Ward were aware of Cape gooseberry and 74% of the farming families in Marigat Ward were aware of the crop. This implies that Cape Gooseberry plants are widely available in the County, therefore, production of the crop can be supported by the local soil and climatic conditions in the study areas.

Some of the farming families who participated in focus group discussions indicated that they normally notice Cape Gooseberry plants while clearing their farms before and after cropping, and harvest ripe fruits. One farmer from Saimo/Kipsaraman Ward said, "*I frequently gather ripe Cape Gooseberies while harvesting millet or maize and take them to my children. They like them.*" Another farmer from Marigat Ward said, "*I mostly see Cape Gooseberry plants during farm preparations; we eat some of its fruits to quench our dirsty at the farm and take the remaining to our children at home. I share the ripe berries with them the way I share sweets.*" In addition, there were other participants in group discussions who had noticed prevalence of Cape Gooseberry plants in forested areas of the County, "*there are a lot of*

Cape Gooseberries in neighboring forests or forested areas within our farms where we normally fetch firewoods". A farmer from Koibatek Ward said, "*those fruits are in plenty in Koibatek forest and some youths harvest ripe ones and sell them along the Eldama Ravine – Eldoret highway, and Nakuru – Eldoret highway at Salgaa.*" Other farmers from Saimo/Kipsaraman and Marigat Wards mentioned the presence of Cape Gooseberry plants at Saimo forest and Katimok forests respectively. The study findings corroborates those of Wasilwa et al. (2021) which found that Cape Gooseberry plants grows in the wild in Baringo County. This may be the reason why majority of the farming families were aware of the crop.

Table 7: Awareness of Cape Gooseberry among Farming Families (n=107)

	Number of Farming Families Aware of Cape Gooseberry					
Wards	YES		NO		Total	
	F	%	F	%	F	%
Saimo/Kipsaraman	40	100	0	0	40	100
Marigat	29	74	10	26	39	100
Koibatek	24	86	4	14	28	100
Total	**93**	**87**	**14**	**13**	**107**	**100**

4.3.2 Existence of Cape Gooseberry plants around homesteads

In addition to determining awareness about the crop, the farming families were requested to indicate if they had observed the crop near their homesteads. The results show that over 75% of the farming families had seen Cape Gooseberry plants around their homesteads as shown in Table 6. This suggests that farmers could have been eating Cape Gooseberry fruits harvested from the wild, and in the process some of the seeds could have dropped, thus, germinating. In addition, apart from the possibility human dispersion of the plant seeds around their homesteads, and since there were no farmers growing the crop in the study areas, the results implies that the crop seeds could have, also, been dropped by birds. According to Wasilwa et al. (2021), birds feed on ripe Cape Gooseberry fruits, which according to Parker (2022), though birds damage the crop fruits, they, also, play an important role of dispersing the crop seeds.

Table 8: Existence of Cape Gooseberry around Homesteads (n=107)

Number of Farming Families Interviewed					
Wards	YES		NO		TOTAL
	F	%	F	%	
Saimo/Kipsaraman	40	100	0	0	100
Marigat	18	46	21	54	100
Koibatek	24	86	4	14	100
Total	**82**	**77**	**25**	**23**	**100**

The prevalence of Cape Gooseberry in Saimo/Kipsaraman and Koibatek Wards as compared with Marigat Ward may be due to lower temperatures. The temperatures in Saimo/ Kipsaraman and Koibatek Wards are lower than that of Marigat Ward and this favours the growth of the crop that does well under low temperatures.

4.3.3 Awareness of farmers growing Cape Gooseberry

The study attempted to determine how many of the farming families under study were aware of any farmer who was growing the crop. From the data in Table 9, the farmers who indicated they were aware of farmers growing the crop comprised 5% of the study sample. When the data were disaggregated by Wards, 5% of the farmers from Saimo/Kipsaraman Ward were aware of farmers who were growing Cape gooseberry, 0% of the farmers from Marigat Ward indicated they were aware of farmers who were growing the crop. Finally, 11% of the farmers from Koibatek Ward were aware of farmers who were growing the crop.

Table 9: Awareness of Farmers Growing Cape Gooseberry (n=107)

Number of Farming Families					
	YES		NO		
Wards	F	%	F	%	Total
Saimo/Kipsaraman	2	5	38	95	100
Marigat	0	0	39	0	100
Koibatek	3	11	25	89	100
Total	**5**	**5**	**102**	**95**	**100**

The percentage of farming families who were aware of farms where the crop is being grown is relatively low, 5%. This may be due to the rural nature of the areas where the farming families live, thus, limiting their exposure to farming activities in other counties. During the focus group discussions, however, some of the farmers indicated they were aware of farmers in the neighbouring Counties of Nakuru and Uasin Gushu who were growing the crop. A farmer from Koibatek Ward said, *"I once visited a farmer in Elburgon, Nakuru County who grows Cape Gooseberry and supplies the fruits to Nairobi, I requested him for the crop seeds or seedlings but he said there were no seeds at that moment and those in the farm were not mature for harvesting. If I can be provided with the seeds or seedlings, I will grow because I have seen the benefits."* Another farmer from Saimo/Kipsaraman Ward said, *"After attending the graduation ceremony of my son who works in Eldoret in Uasin Gishu County, I spent some days at his place of residence at Kiplombe - Uasin Gishu County; where I noticed one of his neighbor was growing Cape Gooseberry crop."* The differences by Wards could be due to proximity of Saimo/Kipsaraman Ward to Uasin Gishu County and Koibatek Ward to Nakuru County.

4.3.4 Willingness among the farming families to grow Cape Gooseberry

Since the study was focused on domestication of Cape Gooseberry crop by farming families in Baringo County, the study determined the willingness among the farming families under the study to participate in the crop domestication process. The data in Table 10, showed that 90% of the farming families were willing to participate in Cape Gooseberry domestication process.

Table 10: Willing to Grow Cape Gooseberry

	Number of Farming Families				
Wards	YES		NO		Total
	F	%	F	%	
Saimo/Kipsaraman	39	100	0	0	39
Marigat	31	82	7	18	38
Koibatek	25	89	3	11	28
Total	**95**	**90**	**10**	**10**	**105**

4.3.5 Reasons for not willing to grow Cape Gooseberry among the farming families

The study sought to find out the reasons why the farming families were not willing to grow Cape Gooseberry crop. The results from the study show that lack of awareness about the benefits and husbandry practices of Cape gooseberry was cited 10 times by the farming families as their main reason for not growing the crop as shown on Table 11. Lack of ready market for Cape Gooseberry fruits was noted 7 times by the respondents as reason for not growing the crop. The ease of collecting Cape Gooseberry fruits either from the wild or fallow lands has been quoted 6 times by the respondents as the reason for not growing it. This shows the extent to which Cape Gooseberry is abundantly available in Baringo County. The size of land owned by the farming families plays a significant role regarding the choice of agricultural activities they undertake. In this study, the results show that the farming families cited 5 times the size of their lands as their reason for not growing the crop. Pest and disease infestation, and engagement in other activities were cited 4 times each by the respondents as their reasons hindering cultivation of crop. Lastly, fear of theft of Cape gooseberry fruits by children was indicated 3 times by the farming families.

Table 11: Reasons for not willing to grow Cape gooseberry

No.	Reasons for not willing to growing the crop	Frequencies
1	Lack of awareness about its benefits and husbandry practices	14
2	There is no ready market for the fruits	7
3	Wild fruits and easily available	6
4	The land is small	5
5	The fruits can be stolen by children	3

The study findings regarding lack of awareness about the crop benefits and its associated husbandry practices are in agreement with the recommendations presented by Barirega (2014) that there is need for training farmers to enhance awareness creation on the nutritional, medicinal and the economic potentials of Cape Gooseberry fruits in order to catalyze commercialization of the crop. According to Lawrence (2003), awareness about a crop and its benefits increases its demand; since awareness is an important pre-condition for any adoption to take place as noted by Simtowe et al. (2016). Farmers awareness of a crop has been found to help in stimulating interest towards its cultivation and commercialization (Zossou et al., 2009). In addition, with regard to the crop agronomic practices, Mushobozi (2010) highlighted that awareness about the benefits of a crop and its associated husbandry practices are essential to help producers ensure the safety of their farm produce; which according to Collazos et al. (2019) enables farmers produce quality fruits which meets both the local and international market standards.

The study findings regarding lack of markets as a factor hindering Cape Gooseberry commercialization are in agreement with what Gomez et al. (2022) noted that Cape

Gooseberry fruits are highly perishable, therefore, there should be ready markets to minimize post-harvest losses. In spite of local markets picking up slowly, there is a huge international export market which demands a high degree of quality and proper postharvest management with an optimal conservation during the storage and transportation in order to maintain competitiveness in the market (Galvis et al., 2005). Therefore, there is need to train Cape Gooseberry farmers on the market requirements to minimize postharvest loses. Furthermore, to promote continuous fruit supply to the markets, it is recommended that the farmers should schedule the crop planting calendar.

The results further show that ease of accessing wild Cape Gooseberry fruits could be one of the reasons why the farmers were not willing to grow the crop; which is in agreement with Wasilwa et al. (2021) who noted that Cape Gooseberries are found growing in forested areas and fallow lands in Kenya. According to Chacón et al. (2016), Cape Gooseberry plants are found growing in the wild in other countries including Columbia. Authors like Enciso-Rodríguez et al. (2013) have found that the wild accessions of Cape Gooseberry are superior in terms of tolerance to pest and disease infestation, number of fruits per plant, lack of fruit cracking and high concentration of total soluble solids. However, Herrera et al. (2011) and Herrera et al. (2012) found that cultivated accessions are superior in terms of fruit yield, weight and color. Therefore, there is need for farmer training to promote awareness about the potential benefits of Cape Gooseberry production.

The results, also, show that the size of farm owned by a farmer influences the type of agricultural activities to engage in. Some farmers noted that their farms were too small which can only support subsistence farming. During the focus group discussions, one farmer from Marigat Ward said, *"though I have a large farm, only a small portion of it is arable which we normally grow maize and beans, or millet and sorghum. The harvests from the farm cannot support the family food requirements for the whole year. The remaining part of the land is hilly with shrubs, which we use as a free range for our livestock"*

4.3.6 Support required by the farming families to grow Cape Gooseberry

The design of the study was participatory learning and action research, which necessitated continual observation of Cape Gooseberry farming practices, and adjustments of farmer support systems with time and the nature of farming activities. In addition, as the crop was being introduced in the area for adoption by the farmers, there was need to determine what the farmers required to successfully participate in the domestication of the crop. The study, therefore, during the baseline survey, sought to determine the support requirements by the farmers using open ended items. The results are presented in Table 12.

The results from the study show that 44.9% of the farming families required training on the crop husbandry practices; 37.4% of the farming families indicated they needed to be supplied with Cape gooseberry seedlings; and 34.6% of the farming families needed more information to improve their awareness of the benefits of the crop. Another 30.8% of the farming families indicated that they needed farm credit for them to undertake the enterprise, while 26.2% of the farming families emphasized the need for Cape gooseberry market outlets. Finally, 23.4% of the farming families indicated that in growing the crop they needed assistance in the control of pests and diseases.

Table 12: Support required by the Farmers to Grow Cape gooseberry (n=107)

Support Required	Frequencies (n=107)	Percentages
Training on Cape Gooseberry husbandry practices	48	44.9
Provision of Cape Gooseberry seedlings	40	37.4
Creation of awareness on benefits of the crop	37	34.6
Credit	33	30.8
Market for Cape gooseberries	28	26.2
Control of crop pests and diseases	25	23.4

The results in Table 12 indicate that training on Cape Gooseberry husbandry practices was the most needed form of support required by the farming families to participate in Cape Gooseberry domestication. This implies that there is need for farmers who plan to undertake domestication of Cape Gooseberry to be provided with knowledge and skills in critical areas of the crop management which comprise land preparation, planting, fertilizer application, weed control, harvesting and fruit storage. These education undertakings can be provided through demonstrations, visits by agricultural extension officers, field trips, farmer field schools, farmer to farmer learning and use of media (Abdullah et al., 2014; Naika et al., 2021).

The farming families indicated that the second most important requirement is the provision of Cape Gooseberry seedlings. This is necessary because Cape Gooseberry farming is a new crop enterprise among the farmers in the area and availability of seeds or seedlings could be a challenge to them during the initial phases of the acceptance of the crop. This implies that there is need for local agricultural extension officers to identify sources of quality Cape

Gooseberry seeds and seedlings for the farmers. In addition, the study finding, also, suggests that it is possible to contract farmers whose primary function is raising seedlings.

Third in rank among farmer requirements was awareness creation about the benefits of Cape Gooseberry crop. Since Cape Gooseberry production is a new enterprise in the area, majority of the farmers may not be conversant with the benefits of the crop and the required husbandry practices. This implies that despite harvesting and eating wild Cape Gooseberry fruits for many years, the farmers were not aware of the industrial, nutritional and medicinal benefits the crop. The finding, also, suggests that awareness creation about the benefits of Cape Gooseberry would improve its adoption levels among farmers.

The benefits of Cape Gooseberry crop have been noted by Hassanien (2011) as industrial, nutritional and medicinal. The emphasis on creation of awareness was, also, evident during the focus group discussion session, when some of the participants raised concerns that they needed to be provided with more information about the economic benefits of the crop since they were setting aside part of their land for Cape Gooseberry in place of other crops, *" If we grow this crop, what will we get from it in return because we have to displace some of the crops we have been growing"*. The need for awareness creation, when new technologies and innovations are being introduced, has, also, been emphasized by agricultural extension specialists, like Rogers (2003), and Oakley and Garforth (1985). Extension specialists have proposed a number of extension methods which could be used in creating awareness, which include: Field visits; use of media, display of realia and demonstrations (Hassan, 1995; Marchand et al., 2021).

The data in Table 12 indicates that the fourth requirement for adoption of Cape Gooseberry crop in Baringo County is farm credit. Access to farm credit is one of the necessities required by farmers when adopting new agricultural technologies and innovations. The finding implies that in Baringo County, where Cape Gooseberry has not been cultivated, it would be essential to develop a framework for providing credit to farmers, to enable them access capital that may be required during the crop production process.

The results from the study indicate that the fifth ranked support required by the farming families was knowledge on the availability of markets for the Cape Gooseberries. The low ranking of market information inquiry could be attributed to the fact that Cape Gooseberry production in the study areas was a new farm enterprise. Therefore, the farmers could not be aware of the benefits of the crop, as well as the management of Cape Gooseberry fruits to prevent post-harvest loses since they are very perishable. Despite the low rating of market information, the findings are corroborated by Gomez et al. (2021) who found that crop berries are highly perishable, and requires a ready market to minimize post-harvest losses.

The control of pests and diseases is one of the Cape Gooseberry husbandry practices, and it is possible that some of the farmers indicated as a need without considering that it is a critical component of crop husbandry practices.

4.3.7 Sources of agricultural information used by the farming families

The results in Table 13 illustrates that majority of the farming families (37.6%) were relying on their fellow farmers for agricultural information. Accessing agricultural information through television programmes was ranked second (22.8%), while sourcing agricultural information through radio programmes was the third ranked source (15.2%). Farmer meetings as a source of agricultural information was cited by 13.5% of the farming families. The use of mobile applications was ranked second last (5.9%). To the contrary of normal expectations, accessing agricultural information through regular extension services was ranked last (5.0%).

Table 13: Sources of Agricultural Information used by the Farming Families

Sources of Agricultural Information	Eldama Ravine	Baringo North	Baringo South		
	Frequency N=29	Frequency N=39	Frequency N=40	Frequencies	Percentage
Fellow farmers	26	28	35	89	37.6
Television	3	23	28	54	22.8
Radio	3	21	12	36	15.2
Farmer Meetings	9	13	10	32	13.5
Mobile Phones	5	5	4	14	5.9
Extension staff	5	5	2	12	5.0

Highest percentage of the farming families reported relying frequently on their fellow farmers for agricultural information needs. According to the farmers who participated in the focus group discussions, they consulted their immediate neighboring farmers, family members and friends either through visits or phone calls. When the researcher requested to know about accessing the farm information from the regular extension services, most of the farming families cited unavailability of the extension staff when needed. One farmer from Saimo/Kipsaraman Ward said, "*there are no extension officers around, and if they are, we have not seen them for many years*." The results implies that either there are limited number of extension staff in the study area, or the extension staff are not visiting the farmers.

The finding of this study is supported by those of Amudavi et al. (2009), Asiabaka et al. (2001), Irfan et al. (2006), Olajide (2011) and Onemolease (2013) which found that farmers ranked their fellow farmers as their main source of agricultural information. In a study conducted in Tanzania, Mwakaje (2010) found that sourcing market information from fellow farmers was ranked first among other sources. In support of this, Robert (2007) noted that farmers rely on interpersonal communication for detailed, local, and farm-specific information; which according to Mntambo (2007) farmer to farmer interactions promotes knowledge exchange and adoption of new agricultural technologies, especially from experienced fellow farmers. Sabo et al. (2020) attributed the reliance on fellow farmers to more exposure to informal sources of agricultural information compared to formal sources such as extension workers and mass media; due to ineffective public extension services (Ajayi et al., 2011; Antholt, 1994).

The wide spread use of various information communication technology (ICT) facilities in agricultural sectors globally, have generally been acknowledged (Arokoyo, 2007). These ICTs include television, radio, computers, tablets and mobile phones. In this study the results show that there was higher frequency of farming families accessing agricultural information through television in Baringo South followed by Baringo North. According to the farmers from Baringo North and Baringo South Sub-Counties, despite the generalization of agricultural information broadcasted through the televisions, they had to be contented with it since there were no other reliable source of agricultural extension services. Koibatek ward recorded the least number of farming families relying on television programmes for agricultural information which could be attributed to a number of factors: The presence of various research projects conducted by public universities, government agricultural departments such as KALRO, Kenya Climate Agriculture Smart Project and County government projects; presence of several agro-vets within the Ward; and Non-governmental organizations. The presence of these entities in Koibatek Ward could have aided in filling in the gap left by the extension staff.

The results are supported by Farooq et al. (2007) who found that television programme was ranked second source of agricultural information after print media in Pakistan. Effective use of television programmes has the potential to bring about rural transformation through agriculture as it works well with farmers with lower literacy levels (Munene & Mberia, 2016). According to Ovwigho et al. (2009), television was the major ICT used in extension delivery in Nigeria; and it has played an important role in dissemination of agricultural information to the farming communities (Ekoja, 2003). In addition, Kiplang'at and Ocholla (2005), noted that television programmes are widely used by agricultural researchers and extension workers to disseminate agricultural information to the farming community.

Radio was ranked third source of agricultural information. According to the farming families, they sometimes listen to agricultural programmes broadcasted by local radio stations in Kalenjin languages and other national stations. According to the farmers, Alpha radio which is broadcasting from Kabarnet town is one of their preferred station broadcasting agricultural updates originating from either the County government of Baringo or the agro-vets within the county. The results are in agreement with those of a study on the benefits and limitations of using radio programmes in dissemination of agricultural information to peasant farmers in Zimbabwe, which found that delivering relevant content in local languages and accents were useful when incorporating radio service in agricultural extension, since radio is highly cost-effective technology in dissemination of agricultural knowledge in rural areas (Nyareza & Dick, 2012). The shift to local radio production facilitated by establishment of various vernacular FM radio stations offers a great opportunity to reach a wider audience of rural farmers since it removes barriers of language and dialect (Nyareza & Dick, 2012).

In contrary to the popular opinion, accessing agricultural information through regular extension services was ranked last. According to the farming families, agricultural extension services seems to have never existed for the last two decades. Some farmers who participated in the focus group discussions indicated that the last time they were visited by the extension personnel was in the late 1990s. They added that free public extension services which were previously offered are now hardly offered, safe for only during the times of pests and disease outbreaks. In a rejoinder, during the interviews with the agricultural extension officers, the officers cited poor road infrastructure in their respective as the major factor which has limited their movements when conducting farm visits; similarly due to poor ratio of extension officers: farmers, visiting the agricultural extension offices is not guarantee that you will find the extension officer because they could be in field work or attending to other office duties which could be away from the office.

The results of this study is supported by those of Mungai et al. (2018) and Wagacha et al. (2017) which found that there was weak farmer extension linkage in Baringo County which affects extension service delivery in the County. The weakness was occasioned by poor ratio of extension staff to farmers as noted by Gichamba et al. (2017). According to Feder et al. (2001), agricultural extension faces two challenges: Information and organization; and Extension funding and delivery. In such scenarios, it is difficult to employ the services of skilled agricultural extensionists with improved skills, information and ideas that will meet complex demand patterns to develop agriculture. Therefore, in such circumstances the technologies promoted by the inadequate number of extension services may not customized to specific farmer's needs, particularly those touching on women farmers, illiterate and special categories of farmers, due to aging, reduced staffing, funding for operations, lack of participatory technology development, and poor packaging and information dissemination (Evans, 2014).

4.3.8 Challenges experienced by farming families in accessing agricultural information

The results from the study indicate that majority of the farming families had challenges in accessing agricultural extension staff when they needed their services at (36.9%) as shown on Table 14. Limited access to ICT devices has been cited by (19.4%) of the sampled farming families as a challenge affecting their access in to the extension services. Also, the results show that (18.8%) of the farming families noted that limited network connection is affecting their access to agricultural information or contacting the extension personnel. Furthermore, (16.9%) of the farming families indicated that limited power connection is another factor affecting the use of ICT technologies to facilitate access to agricultural information. According (8.1%) of the farming families, their major challenge in accessing agricultural information is the relevance of the content received. They could have preferred customized information specific to certain farm enterprises instead of generalizations.

Table 14: Challenges Experienced by Farming Families in seeking agricultural Information

Challenges	Frequency	Percentage
Unavailability of extension staff when needed	59	36.9
Limited access to ICT devices	31	19.4
Limited phone connection	30	18.8
Limited power connection	27	16.9
Relevance of information	13	8.1

The farming families indicated they were rarely accessing agricultural extension services or being visited by the extension staff, while other farming families queried if the extension services were ever existing, since they had never come across them for more than two decades. According to the farming families, visiting the extension staff in their offices is very expensive and time consuming since one has to cover long distances being driven on a motor cycle; and in some situations, you cannot find them in their offices due to other extension commitments. The results of this study, thus, confirms the findings of Mungai et al. (2018), which found that there exist weak linkages between farmers and extension staff in Baringo County; and, also, in agreement with earlier suggestions by NALEP (2006), that agricultural extension was facing challenges in enhancing its access to farmers, improving its efficiency and maintaining relevancy to different end-users. This has been attributed to poor ratio of extension staff to farmers in Kenya of 1:1500 (Gichamba et al., 2017), which is against the Food and Agricultural Organization (FAO) recommendation of 1:400 (Akuku et al., 2014). As a result, the wider the geographical distances to be covered by the extensionists in delivering extension services to a widely dispersed farming families, the harder to meet each individuals farmers' information needs since they vary considerably (Ferroni & Zhou, 2012). Thus affecting the quality of agricultural extension service delivery in the country (GoK, 2010). However, to overcome some of these challenges affecting agricultural extension in Kenya, there is need to integrate ICT in agricultural extension to enable farmers, extension providers and other stakeholders to access approved information and improve farm productivity (Gichamba et al., 2017; Mungai et al., 2018; Nyaga, 2012).

According to the results, a section of the farming families cited lack of access to ICT devices as a challenge which has hindered their access to agricultural information through alternative channels, which include mobile phones, radio and television. Apart from the cost attached to its acquisition, this study, also, identified that since most of the online agricultural contents were mostly developed based on web 2 technologies, some farming families with ordinary phones were disadvantaged, because they could not access the online agricultural contents. Additionally, according to the farmers, lack of technical skills to operate smart phones was another barrier hindering its acquisition and usage. Access to information and communication technologies (ICT) by rural farming communities in developing countries can improve networking between farmers and extension agents; which will enable households to receive supply-driven agricultural extension services (NALEP, 2006; Nyaga, 2012).

Limited phone network coverage was the third challenge cited as a factor affecting access to agricultural information by the farming families. According to the farming families, despite having mobile phones either smart phone or ordinary phones, poor network coverage is hindering the phone usage. Some farmers who participated in the focus group discussions indicated they had to travel to certain identified locations to enable them communicate or access online services. In addition, limited phone network coverage hinders the use of web 2. mobile app agricultural services used by the farmers. The results of this study are in agreement with those of Nyaplue et al. (2021), who found that the quality of mobile phone network in an area determine the frequency at which farmers use mobile phones to exchange agricultural information; and in their recommendations for "ICTs for the future", Agwu and Mercy (2019) suggested the improvement of network infrastructure to reduce network fluctuations to better serve rural farmers.

Limited electricity connection has been cited as a factor affecting access to agricultural information by the farming families. According to the farming families, lack of electricity connection in most of the households has made it difficult for them to access supply-driven agricultural information disseminated through various ICT devices, which includes mobile phones, computers, radio and televisions. Existence of stable power connection stimulates the urge to purchase and use ICT related devices, while erratic power supply is one of the major challenges hindering the use of ICT technologies in agricultural extension (Agwu & Mercy, 2019; Akpabio et al., 2007; Deichmann et al., 2016). Lack of power connection and erratic power supply has, also, been found to be the main cause for limited television viewing and development in rural areas (Kerr et al., 2007; Syiem & Raj, 2015).

Lastly, the results show that the relevance of information being disseminated to the farmers could be a factor promoting or limiting access to agricultural information. Some famers who participated in the focus group discussions noted that supply-driven extension services were largely based on generalization of agricultural information being shared by the extension staff. According to the farming families, they could have preferred demand driven extension services in line with their farm activities. According to Siyao (2012), for agricultural information to contribute positively to agricultural development, one of the quality pillars is the relevance of the information; which should specifically answer the farmer's questions (Ofuoku et al., 2008). Nakasone and Torero (2016) found the relevance of information provided to farmers improves the use of ICTs in agricultural development.

4.3.9 Agricultural extension channels used by the extension Staff

The results show that Chiefs Barazaas was the main channel utilized by the agricultural extension services as a platform for dissemination of agricultural information to farmers. According to the interviewed extension officers, the Chiefs Barazaas are coordinated by the local area Chiefs through their social networks which helps in mobilizing farmers to attend scheduled training or meetings. Owing to the limited number of extension staff and wider geographical distances to cover in visiting sparsely populated farmers, in most cases, the Chiefs assumes the role of relaying the agricultural information or announcements on behalf of the extension staff during public gatherings. Such communications reach all corners of the locations within a Ward due to its amplification by the clan elders supported by the heads of *"Nyumba kumi"*.

The results point out to an array of challenges experienced by the extension service ranging from inadequate funding to employ more extensionists, facilitate farm visits in form of provision of means of transport, provision of communication devices coupled with wider geographical distances to be covered in visiting sparsely populated farmers. All these composite challenges have hindered the frequency of delivery of agricultural extension services to the rural communities in the study area.

The study finding is in agreement with Kadesa (2017) who found that the use of public Barazaas as a platform for communication plays a key role in inviting the public to participate in key governance and agricultural development issues in a country. Barazaas have been widely used to mobilize farmers, particularly when there is information to pass regarding new agricultural knowledge being introduced in an area (Murage et al., 2012; Njuguna et al., 2007) which has positively impacted agricultural service delivery (Kabunga, 2020), leading to improved farm productivity.

The results from study show that dissemination of agricultural information through the radio was the second utilized channel by the extension services in Baringo County. The information is shared through local radio stations broadcasting in Kalenjin dialects. The stations were Chamgei FM, Kass FM and Emoo FM. However, there are other local stations broadcasting in National languages such as Alpha radio broadcasting from Kabarnet town in Baringo County. According to the extension officers, they prefer broadcasting through the Alpha radio because it is the most popular station in the county, and the farmers associate with it since they feel ownership and attachment to it. According to the extension staff, they normally use the radio when disseminating general agricultural information regarding the availability of subsidized farm inputs such as fertilizers, seeds and seedlings; new policies and regulations, and control of pests and disease outbreaks.

The findings of the study are in agreement with those of Nyareza and Dick (2012), who found that a community radio service was the most preferred medium of communication for rural peasant farmers, as it uses their language and accents, thus, appealing to the listeners when discussing local issues affecting the community, in addition to its cost effectiveness (Sharma, 2011; Girard, 2003). In support of this, Okwu et al. (2007) and Khanal (2011) noted that in several jurisdictions, radio has been recognized and approved as the most appropriate medium for enhancement of agricultural development in the rural areas since it does not require literacy: In addition to disseminating agricultural information to remote rural farming communities (Chapman et al., 2003; Parvizian et al., 2011). The strength of using radio in agricultural extension is based on its wider coverage reaching many people (Sharma, 2011). However, in order to achieve optimum benefits of using radio in sharing agricultural information, the programs ought to be broadcasted in the evenings when farmers would have returned from the field (Okwu et al., 2007).

The use of agricultural posters by the extension staff to disseminate agricultural information was ranked third. These are agricultural posters mounted on the walls of agricultural offices, Chiefs and Sub-Chiefs offices, public spaces and along the roadsides. The content of the posters ranges from announcement of upcoming farmer training, availability of subsidized farm inputs, new County or National Government regulations, and management of pests and disease outbreaks. According to the extension officers, this was the cheapest and efficient channel for reaching both the literate and illiterate farmers. The influence of social media platforms such as WhatsApp, Facebook, Instagram and Twitter have elevated the use of posters in communicating certain information to the wider audience. Members of the public take a photo of a poster and share it in their social media accounts, thus reaching a wider audience of farmers within a shorter period of time.

In a study to assess the role of print media in agricultural technology transfer, Farooq et al. (2007) found that the use of posters was ranked second after pamphlets. Similarly, the use of posters in agricultural extension was ranked third by Abubakar et al. (2009); which according to Surudhi et al. (2017) use of agricultural posters plays an important role in creating awareness among the farmers, and it has been widely accepted by the extension functionaries. Posters usually contain a combination of text and graphics produced in a way that appeals to the target audience and portrays key information in a very immediate way (CABI, 2022; Haneef et al., 2014; Sumang, 2017). According to Tadesse (2008) lower proportion of farmers accessing agricultural information through posters could be attributed to scarcity of the posters.

According to the extension officers, the use of common interest groups was the most efficient and effective channel of disseminating new knowledge to the targeted group of farmers. The attendance has always been excellent since it is demand driven. In Baringo County, the approach was being applied with groups of farmers dealing with bee keeping, coffee farming, dairy farming, poultry farming and crop irrigation. Based on the results, this channel was applied mostly in Koibatek and Marigat Wards, which could be attributed to the presence of various research projects targeting specific farming activities conducted either by universities or government agencies.

Githaiga (2007) and Akal (2014) found that there was significant impact on farmers' access to extension services, new technologies and agricultural productivity among the common interest group members. The authors, also, posit that common interest group approach has the potential to ensure a socially equitable rural development through empowerment of farmers to take up agri-business enterprises that are market oriented and income driven. The approach gives equal chances to males and females participating in common interest group of their choice (Machuki, 2013); enabling smallholder farmers to move from subsistence to business farming associated with increased knowledge, increased productivity and increased demand for produce and reaching more farmers (Kiara, 2011).

Field demonstration is one of the approaches being used by the extension staff to share agricultural knowledge with the farmers. According to the interviewed extension staff, they normally conduct field demonstrations in collaboration with other stakeholders which include input suppliers, research institutions, non-governmental organizations and financial institutions. Studies conducted by Khan et al. (2009) and Sseguya et al. (2020) revealed that field demonstration was not only effective model for enhancing improved agricultural technology adoption among farmers, but, also, it has been used by the extension agents to effect desirable changes in the behavior of rural farmers by providing conducive environment for learning; by enabling the farmers to learn first-hand about improved technologies (Mbure & Sullivan, 2017). Thus, realization of the phrase *"seeing is believing"*, through the establishment of demonstration plots on farmers' lands (Annual Report of AKRSP, 2003). According to Richardson (2003), demonstrations established on private farms gained great acceptance by the nearby farmers, who consequently adopted the knowledge they acquired through the demonstrations (Schaub, 1953). This has significantly improved farm productivity among the participating farmers leading to increase in household's income and investment (Egziabher, 2013; Wordofa & Sassi, 2014). Obahayujie and Hilson (1988) reported that, in a Virginia study, part-time farmers preferred demonstrations as their means for receiving agricultural extension information compared to the full-time farmers. In contrast Cafer and Rikoon (2018) indicated that even though the use of demonstrations were linked to agricultural technology adoption decisions, the impact was limited by capital constraints.

4.3.10 Familiarity with climate smart agriculture among the farming families

During the baseline survey, the study sought to determine the levels of awareness of climate smart agriculture among the farming families. The results show that over 50% (59/107) of the farming families were aware of climate smart agriculture as shown on Table 15.

Table 15: Familiarity with Climate Smart Agriculture

	Familiarity with CSA		Total
	YES	NO	
Saimo	18	22	40
Marigat	18	21	39
Koibatek	23	5	28
Total	**59**	**48**	**107**

The results further show that Koibatek Ward had the highest number of farming families who were farmiliar with climate smart agriculture (23/28). The results, also, show that Saimo/Kipsaraman and Marigat Wards had the highest number of farming families who were not familiar with climate smart agriculture. According to the farming families, they have been incorporating some of the climate smart agricultural practices which were convenient to them during crop production. The higher familiarity with climate smart agriculture among the farming families from Koibatek Ward could be attributed to the presence of climate smart agricultural projects funded by the World Bank through the Ministry of Agriculture, Livestock and Fisheries. In addition, it could, also, be attributed to the presence of various research projects conducted by research institutions and seed companies. Saimo/Kipsaraman and Marigat Wards have certain characterictics which could be attributed to the low levels of familiarity with climate smart agriculture. First, unlike Koibatek Ward, there were no climate smart agricultural projects in Saimo/Kipsaraman and Marigat Wards. Secondlty the low ratio of extension staff: farmers in the two Wards could have contributed to the lower levels of familiarity with climate smart agriculture. According to the farming families who participated in focus group discussions, there were no agricultural extension officers to train them on climate smart agriculture. Furthermore, lack of alternative source of agricultural information for farmers from the two Wards could be another contributing factor.

The study further probed to understand the climate smart agricultural practices which the farming families were incorporating during crop production. The results from the probe show that intercropping was the major climate smart agricultural practice incorporated by the farming families as shown on Table 16. The results indicate that 102 out of 107 farming families reported applying the practice annually. Incorporation of organic manure during crop production was ranked second with 95 farming families practicing. Third in the rank of the climate smart agricultural practices integrated was the use of boundary trees as cited by 74 farming families. Crop rotation was the fourth ranked practice applied by the farming families as noted by 67 farming families. Other practices incorporated by the farmers include mulching, traditional control of pests and diseases, fallowing, minimum tillage, use of irrigation and sub-soiling.

Table 16: Climate smart agricultural practices incorporated by the farming families

	Frequencies			
Climate Smart Practices	**All Wards (107)**	**Saimo (40)**	**Marigat (39)**	**Koibatek (28)**
Intercropping	102	39	36	27
Organic manure	95	38	32	25
Boundary trees	74	37	17	20
Crop rotation	67	16	28	23
Mulching	11	4	4	3
Traditional control pests and diseases	11	6	3	2
Fallowing	2	0	2	0
Minimum tillage	2	0	1	1
Use of irrigation	2	1	0	1
Sub-soiling	2	1	0	1

The results in Table 16 show that intercropping was practiced by majority of the farming families in the study area. According to the farming families, they have been intercropping for many years, and some of the crops being intercropped were maize and beans, coffee trees and beans, maize and millet, sorghum and millet, cowpeas and cassava, and peas and maize. During the focus group discussions, the farmers attributed their use of intercropping to maximization of the available small land and to prevent total loss in case of poor returns of the main crop due to adverse weather patterns or pest and disease infestation. Though, these are some of the benefits of intercropping, the finding implies that the farming families may not be aware of the wider benefits to be achieved through the use of intercropping; which include improvement of the soil fertility through atmospheric nitrogen fixation, control of pests and diseases, soil and water conservation, and suppression of weed infestation when legumes are used as intercrops.

The use of intercropping to maximize farm benefits has been supported by Blanco-Canqui and Lal (2008) who noted that intercropping is a more profitable farming system than growing one crop per year; which according to Brooker et al. (2015), the practice is predominant in subsistence farming or farming systems that are resource-limited. According to Khuran et al. (2016), growing more one crop is considered as a safety net on farmers' income. This is because if one crop is severely affected by adverse weather or pests and diseases, the farmer may not suffer a total loss. This is in agreement with the reasons provided by the farming families in this study on why they practiced intercropping. Intercropping variety of crops by the farming families in Baringo County using different configurations is supported by Toker et al. (2023) who noted intercropping systems incorporate an extensive array of crops and configurations to capitalize on agricultural efficiency and sustainability.

The use of organic manure by farmers dates back to the origins of agriculture, since before the advent of modern agriculture, there was no fertilizers, pesticides or herbicides used to produce crops. In the study, the use of organic manure was second ranked climate smart agricultural practice applied by the farmers. According to the farmers, they applied organic manure to address the low soil fertility levels attributed to soil degradation due to continuous and intensive cultivation and soil erosion. The farming families indicated they have been using organic manure from their livestock since they are available in plenty, especially from cattle. The manure were generated from dung and urine along with litter and left over fodder fed to the livestock. During the focus group discussion, one farmer from koibatek Ward said, *"Due to the high cost of chemical fertilizers, we have resorted to our traditional organic manure to fertilize our farms. They are available in adequate quantities since each and every family has cows."* In addition, another farmer from Saimo/Kipsaraman Ward said, *"Though organic manure from cattle is easily available, there is need for training of farmers on its preparation prior to its usage."* In support of the sentiments by the farmer from Saimo/Kipsaraman Ward, another farmer from Koibatek Ward noted that adequate accumulation of organic manure from cattle could be achieved through zero gracing mode of livestock production.

The study finding has been supported by Song et al. (2017), who noted that farmers tend to use organic manure to restore soil fertility in response to the rising prices of chemical fertilizers and the concerns about soil quality and sustainable agricultural production. According to Wamalwa (2013), extensive application of organic manure from livestock during crop production is limited by its insufficient supply due to free range mode of livestock production and few animals kept by farmers.

The third ranked climate smart agricultural practices applied by the farming families was the use of boundary trees. Observation of the farms shows the presence of trees along the boundary fences. The most common trees observed along the boundaries were cypress, eucalyptus and crivelia. Saimo/Kipsaraman Ward had the highest number of farming families with established boundary trees followed by Koibatek Ward. In Marigat Ward, the boundary trees which was a combination of exotic and indigenous trees were scarcely planted around the farms. According to the farming families, they planted the trees to mark their land boundaries and, also, to provide raw materials for constructions. During the focus group discussions, one farmer from Koibatek Ward said, *"We use the trees for three purposes, to mark boundary, provide building materials and to control wind strength."* This implies that the farming families were knowledgeable about the benefits of planting boundary trees. In addition, some farmers from Saimo/Kipsaraman and Koibatek Wards who participated in the focus group discussions noted that they, also, sell the trees.

The results further showed that crop rotation was ranked fourth by the farming families. In spite of the lower ranking of crop rotation practice, comparatively the practice was one of the climate smart agricultural practices that was widely known among the farmers. The lower ranking of crop rotation could be attributed to reducing land sizes, forcing farmers to utilize what is available to them.

There were, also, other climate smart agricultural practices applied by the farming families in the study area which were ranked lowly. The practices were ranked in the following order mulching, traditional methods of controlling pests and diseases, fallowing, minimum tillage, use of irrigation and sub-soiling.

The study finding for objective one, which is "*To establish the levels of awareness of Cape Gooseberry crop in Baringo County"* is that there is high level of awareness about Cape Gooseberry among farming families in Baringo County. From the objective, the research question was generated, and is "*What are the levels of awareness of Cape Gooseberry crop in Baringo County?"* The level of awareness, based on the results, is 87%. Awareness of an innovation and technology, which is intended to be adopted by farmers, could assist in their uptake. From the data, there was a high level of awareness among the farming families about Cape Gooseberry crop in Baringo County. To examine the awareness further, a number of items were included as constructs to assist in recommendations regarding the domestication of the crop. The constructs are: *Existence of Cape Gooseberry around homesteads; awareness of farmers growing Cape Gooseberry; willingness among the farming families to participate in Cape Gooseberry domestication; and support required by the farming families to grow Cape Gooseberry crop.*

The data from Table 8 indicate that there is high prevalence of Cape Gooseberry around homesteads. This shows the crop can be grown in the area, since it is already growing in the area without the farmers taking care of it. However, the data from Table 7 show that most of the farming families have not come across farmers who are growing the crop. This is an indication that the crop is either not being grown in the County, and if there are, then they are very few, since from data in the Table only 5% of the farming families have noticed farmers growing the crop. When the farming families were asked if they were willing to grow the crop, 90% of the farmers indicated their willingness to grow the crop. From the results, there is an opportunity for introducing the crop in Baringo County. Finally, the farmers were requested to indicate the support they would need to grow Cape Gooseberry crop. The support which some of the farming families indicated that they would need are: Training on Cape Gooseberry husbandry practices as well as on the associated benefits of the crop; access to improved Cape Gooseberry seedlings; provision of farm credit; markets for the fruits; and control of pests and diseases.

4.4 Eco-physiological Characteristics of Cape Gooseberry Crop

The second objective of the study was:

To determine the eco-physiological characteristics of Cape Gooseberry that make it thrive naturally in Baringo County;

The research question which guided this section of the second objective was:

What are the eco-physiological characteristics of Cape Gooseberry?

The study focused on soil testing, establishment of average annual rainfall and temperature of the study area where Cape Gooseberry is growing naturally; the altitude of the points where Cape Gooseberry was found growing naturally, plants persistently associated with Cape Gooseberry plants; and observable crop pests and diseases on the Cape Gooseberry.

Soil testing is the rapid chemical analyses to assess the plant-available nutrient status, salinity and elemental toxicity of a soil, and broadened to represent a program that includes interpretations, evaluations, fertilizer, and amendment recommendations based on results of chemical analyses. In this study, however, soil testing was carried out to ascertain the soil characteristics that favour the growth and development of Cape Gooseberry in the wild in Baringo County. The soil characteristics were soil pH, Total Organic Carbon and Cation Exchange Capacity.

The results from the analyses of the soil characteristics show that the soil pH of the sampled spots where Cape Gooseberry plants were found growing in the wild had a pH range of between 4.97 and 7.53, with an average pH of 6.42, as presented in Table 17.

Table 17: Average Soil Characteristics in the Study Area

Sample Designation	Average
Soil pH-H_2O (1:2.5)	6.42
Total Organic Carbon %	3.16
Cation Exchange Capacity meq%	27.91

According to Fischer and Melgarejo (2020), *Physalis peruviana* grows in a wide range of agro-ecological conditions. The crop performs better in fertile soils with a pH range of between 5.5 and 7.0. This, confirmed the findings of Singh et al. (2019), who in their findings, reported that Cape Gooseberry plants could tolerate a pH range of between 4.5 and 8.2.

The soil texture in the study area was found to be: Clay loam, clay, silty clay loam and silty clay soils. Though Cape Gooseberry grows and does well in varied soil textures (Fischer & Melgarejo, 2020), over 60% of the sampled spots in the study area had clay loam soil, indicating that Cape Gooseberry does well in clay loam soils. This corroborates the study findings of Wasilwa et al. (2021) and Singh et al. (2019), where they recommended fertile well drained loam soils for the production of Cape Gooseberry.

Mineral nutrition is one of the main factors of consideration in agricultural production systems. It has the potential of limiting optimum development of plants (Fageria et al., 2010). Martínez et al. (2008) reported that absence of phosphorous decreased the yields of Cape Gooseberry by 50%. The study established that though some Cape Gooseberry plants were able to grow but not able to fruit in primary and even secondary nutrient deficient soils, they exhibited mineral deficiency symptoms for the same elements. This, also, points out that the crop is tolerant to mineral deficient soils.

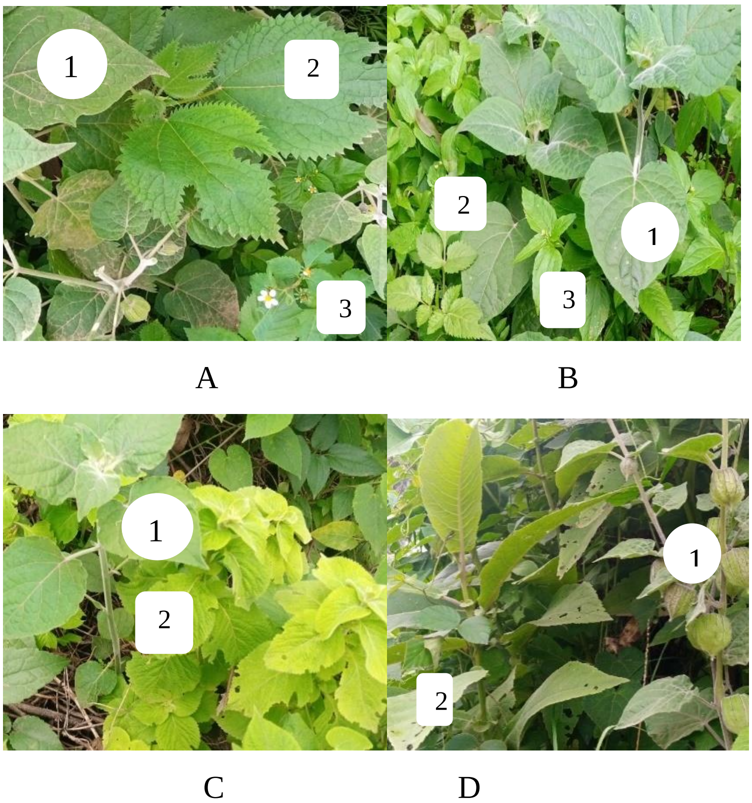
The study established that Cape Gooseberry is capable of growing within a percentage organic carbon of between 1.68 - 5.70 with a mean of 3.16, and the cation exchange capacity (C.E.C) ranging from 18.7 to 37.4 with an average of 27.9, an indication of fertile soils. In a related study on the effect of organic manure on growth, yields and leaf nutrient uptake, and soil properties of kiwi fruit, Sharma et al. (2022) established that different organic manure treatments modify the cation exchange capacity of soil to between 11.78 to 14.01 mg/100 g. The established levels in this study validates the preference of the crop to fertile clay loam soils, which on average have a C.E.C of 25 to 50 meq/100 g soil (Culman et al., 2019).

Fischer and Melgarejo (2020) reported that Cape Gooseberry requires an altitude of between 1800 to 2800m above the sea level and annual rainfall of between 1000mm to 2000mm. This was confirmed in this study since the crop was found to be naturally growing in the altitude between 2020 to 2315m above sea level (Appendix K). The data on the annual rainfall of the study area, however, shows that the crop can tolerate very low annual precipitation of 232.32mm (Appendix J). The average annual temperature of the study area is 18.63^0C (Appendix J), which is within the established range of temperatures of 13^0 C to 21^0 C by Duarte and Paull (2015), and Aguilar et al. (2018).

In terms of where the crop grows and associated plants, Cape Gooseberry is mostly found growing along the roadsides and fences together with broad leaved shrubs as shown in Figure 4.

Figure 4: Cape Gooseberry Plants Growing Naturally and Associated Weeds

With regard to associated plants, Cape Gooseberry plants were found to be growing persistently together with broad leaved shrubs and weeds like blackjack, MacDonald's eye, devils horse whip, brambles and bitter leave plant (Figure 5). Blackjack was the most persistent weed found on spots where Cape Gooseberry was growing naturally.



Key

A1. Cape Gooseberry (*Physalis peruviana*)
A2. Stinging nettle ("*thafai*")
A3. Brambles*(Rubus)*

B1. Cape Gooseberry (*Physalis Peruviana*)
B2. Blackjack *(Bidens pilosa)*
B3. Mcdonold's eye plant (*Gallinsoga parviflora*)

C1. Cape Gooseberry (*Physalis peruviana*)
C2. Devils whip *(Achyranthes aspera)*

D1. Cape Gooseberry
D2. Vernonia auriculifera

Figure 5: Plants Associated with Cape gooseberry in the Wild

During observation of the crop, the following pests were observed: Tomato borer, green stink bug and speckled mouse bird (Figure 6). The survey of Cape Gooseberry pests confirmed the findings of Afsah et al. (2015) and Wasilwa et al. (2021). The study finding, also, corroborates those of Afsa (2015), who observed similar pests affecting Cape Goosberry in plants and fruits in Egypt. According to Parker (2022) though birds damage Cape Gooseberry fruits, they, also, play an important role in the process by dispersing the crop seeds, since they do not necessarily digest fruit seeds they eat, but they ingest the flavourful pulp surrounding the seeds (Kueny, 2021). Kumar et al. (2024) indicated that the most important of the many insect pests that affect Cape Gooseberry (*Physalis peruvian)* in South Africa are cutworms, in seedbeds, while in India mites cause defoliation The author, also, posits that young Cape Gooseberry plants are damaged by hares and birds. This study established that speckled mouse bird affects Cape Goosberry fruits in Baringo County, while in South Africa, Kumar et al. (2024) found that francolin bird devours Cape Gooseberry fruits if not repelled.

Tomato borer　　Green stink bug　　Speckled mouse bird

Figure 6: Observed Cape Gooseberry Pests

With regard to Cape Gooseberry diseases, powdery mildew was the only disease observed affecting wild Cape Gooseberry fruits during the observation period (Figure 7). The study finding is supported by Kumar et al. (2024), who listed powdery mildew and leaf spot as some of the diseases affecting Cape Goosebeery. In other studies, vascular wilt disease caused by *Fusarium oxysporum* was found to attack Cape Gooseberry resulting in reduced crop productivity per acre (Chaves-Gómez et al., 2021).

Figure 7: Cape Gooseberry Fruit affected by Powdery Mildew

4.5 Levels of Cape Gooseberry Adoption by Farming Families in Baringo County

The third objective of the study was:

To determine the levels of Cape Gooseberry adoption in Baringo County.

In order to aid in determination of the levels of adoption of Cape Gooseberry crop by farmers; the study documented and examined data relating to the number of farming families who grew and managed the crop to maturity; the number of farming families who dropped from the domestication process; and the number of new farming families who joined in Cape Gooseberry domestication process.

The research question which guided this section of the third objective was:

What are the levels of Cape Gooseberry adoption in Baringo County?

The results in Table 18 show that from the four modes of Cape Gooseberry production, a total of 86 farming families grew and managed the crop to maturity. Out of the 34 farming families who dropped from the crop domestication process, the highest percentage (10 farming families) were from the group of farming families who were receiving the Cape Gooseberry technologies through digital systems.

Table 18: Cape Gooseberry Adoption Levels among the Farming Families

Mode of Production	Number of Farming Families			
	At Beginning	At end	Dropped	New
Digital systems and CSA	30	22	8	115
Digital systems	30	20	10	92
Regular extension services and CSA	30	21	9	77
Regular extension services	30	23	7	86
Total	**120**	**86**	**34**	**370**

Based on the large number of farming families who dropped out of the crop domestication process, farm visits were conducted on the affected farms to try to understand and document the reasons why the farming families were dropping out. Analysis of qualitative data collected during the farm visits show that majority of the farming families from the four modes of Cape Gooseberry production dropped out of the domestication process since all their Cape Gooseberry crops dried up due to poor rainfall at various stages of the crop production. According to the farming families, most of the crops withered dry after planting since they had no water for irrigating them. In addition, some farming families from Koibatek Ward and Marigat Ward reported the outbreak of armyworms (Figure 8) which infested on their food crops during Cape Gooseberry production process, forcing them to spend most of their time spraying their field crops to control the armyworms. This, according to the farming families, negatively affected their daily routine activities including the time spent on management of Cape Gooseberry plants after planting.

Pictures taken on June, 2022 courtesy of Moikutwo Location Chief, Marigat Ward.

Figure 8: Observed Armyworms Infesting on Millet Crop in Marigat and Koibatek Wards.

In the study, majority of the farming families who dropped out of Cape Gooseberry domestication process cited withering of Cape Gooseberry plants and interference of their daily routine farm activities by the outbreak of armyworms as the major causes. This corroborates the works of crop scientists like Boukar et al. (2016) who have posited that droughts (or reduced rainfall) and crop pests are the major challenges experienced by farmers in mid and high altitude agro-ecological zones. According to agricultural extensionists like Kahan (2008), when farmers are faced with droughts, pests and diseases outbreaks, they tend opt for more drought and pest tolerant crops. In the study, majority of the farming families who dropped indicated that they planted other crops like maize, millet and sorghum.

The study, also, documented and analysed the number of new farming families who joined in Cape Gooseberry domestication process from the four modes of the crop production at various stages. The results in Table 18, further show that by the end of the study period, a total of 370 new farming families had joined in the crop domestication process. From the results, majority of the new farmers who joined in the crop domestication process were recorded by the group of farming families who were integrating digital systems and climate agricultural practices during the crop production.

Figure 9 illustrates the distribution of the new farming families who joined in the crop domestication process per month from the four modes of Cape Gooseberry production since the beginning of the study on April, 2022 to the end of the study on the first week of January, 2023 when the final Cape Gooseberry fruits were harvested. Notably in the figure, is the sharp decline in the number of new farmers who joined in the crop domestication in the month of January, 2023. The participating farming families recorded the details of new farmers who joined in Cape Gooseberry domestication process from the beginning of the study to the crop maturity. At crop maturity, the farming families harvested the fruits for a period of three months from the date of first harvest. Since the crop maturity rates were varying from field to field, the three months harvests for majority of the farming families ended in the month of December, 2022. The three months harvesting period for the few remaining farming families ended on the first week of January, 2023. Therefore, the dropping in the graph was due to the fact that the data on new farmers who joined were only from the few farming families who completed the three months harvests in the first week of January, 2023, which marked the end of the study period. The results implies that there was a continuous increase in the number of new farmers joining in Cape Gooseberry production.

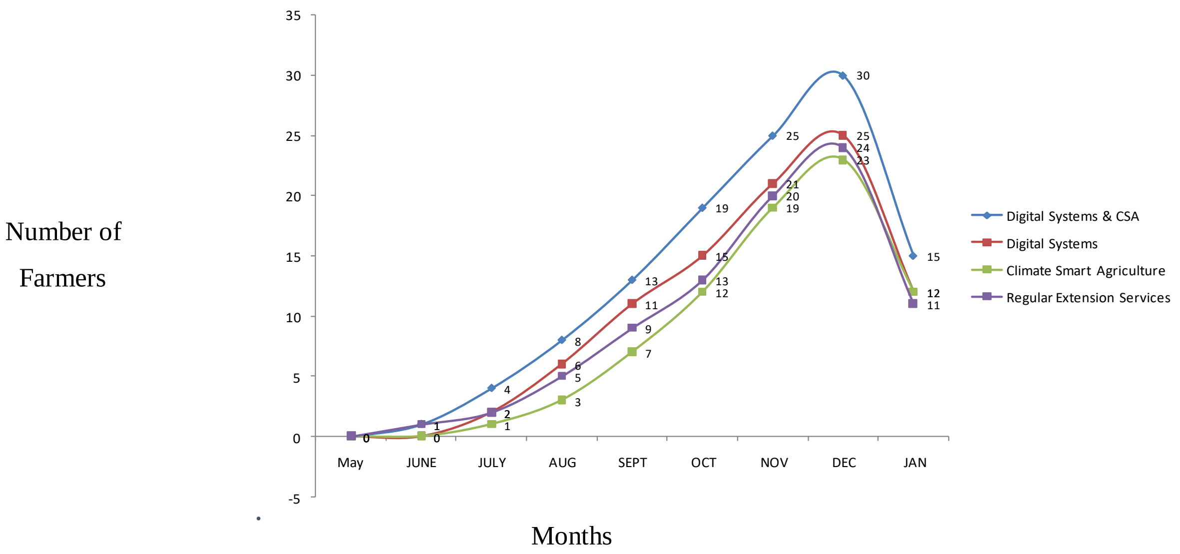


Figure 9: Number of Farmers who joined in Cape Gooseberry Domestication per Month

Figure 9 indicates that from the heights of the line graph, the group of farming families who integrated digital system and incorporated climate smart agricultural practices continually registered higher number of new farmers per month who joined in Cape Gooseberry domestication process compared with the other groups. This could be attributed to a number of factors. First, the structured nature of dissemination of Cape Gooseberry technologies through digital system to the farming families, starting with the creation of awareness and interest stimulation, through visual exposure of the farming families on the benefits of Cape Gooseberry products and the appearance of the crop in the field which was followed by oral explanation of the challenges, opportunities and possible income streams using online training; and third, with use of Cape Gooseberry mobile app, approved Cape Gooseberry technologies were disseminated to the farming families in a systematic manner ranging from land preparation to harvesting.

In this study, a farm in the neighboring County of Uasin Gishu was used to provide the visual aspects of Cape Gooseberry production through Zoom meeting. The farmer, with the use of real Cape Gooseberry farm products and farming activities, exposed the farmers in the study to the potential Cape Gooseberry products, income streams, challenges and opportunities in Cape Gooseberry farming and Cape Gooseberry husbandry practices through audio-visuals. The purpose of engaging the farmer was to create awareness and interest in Cape Gooseberry farming among the farmers in the study. To disseminate the crop technologies to the farming families, an agronomist used online training through Zoom meetings to describe to the farmers the process of Cape Gooseberry production, with emphasis on nursery management, land preparation, planting, weed control, disease and pest control, harvesting and record keeping. In addition, the farming families were provided with Cape Gooseberry production mobile app for use as a reference resource during the management of the crop.

Providing agricultural information from different sources to farmers to facilitate technology and innovation adoption has been supported by Isaac (2012), and Spielman et al. (2008), who pointed that multiple source of information play a significant role in informing adoption decisions. The use of audio-visual aids in creation of awareness and interest on agricultural technologies and innovations has been supported by two maxims: *"One picture is worth a thousand words"* (Reinert, 1976)*;* and *"if we hear we forget, if we see we remember, and if we do something we know it"* by a Chinese philosopher (Vaillancourt, 2009). Education specialists like Shabiralyani et al. (2015) further stated that people remember 50% of what they hear and see, and 90% what they say and practice. The authors, also, pointed out that use of audio-visual aids in imparting knowledge to adult learners arouses their interest and attention. In the study, exposure of the farming families to Cape Gooseberry products, farms and Cape Gooseberry factory from the neighboring County of Uasin Gishu through audio-visual aids, could have provided the farming families with realistic experience and knowledge on Cape Gooseberry farming, making it easier for them to transfer the knowledge to their fellow potential Cape Gooseberry farmers.

In the study, online training programmes were held at designated locations which were convenient to the farming families. The purpose of using online training was to allow simultaneous dissemination of standardized information on Cape Gooseberry husbandry practices to the farming families regardless of their geographical locations. According to communication specialists, use of online training in agricultural extension allows dissemination of standardized agricultural information to farmers on real time regardless of their locations (Hemmati & Sefidian, 2006; Newbury et al., 2014; Raj & Syiem, 2015). The specialists, also, posit that the use of online training promotes better retention of the knowledge acquired since it involves the senses of sight and hearing. Thus, in this study, the use of online training could have enhanced retention of information and knowledge regarding Cape Gooseberry production among the farming families which may have aided in influencing the new farming families in joining the crop domestication process.

The farming families were, also, provided with Cape Gooseberry mobile app containing structured information regarding the crop husbandry practices for reference during the crop production process. The use of agricultural mobile app reference materials to facilitate transfer of agricultural information to farmers can be seen through the works of Kiptot and Franzel (2015) who noted that lack of reference materials was a limiting factor to the transfer of improved agricultural technologies to farmers. Authors like Costopoulou et al. (2016) have, also, posited that use of mobile apps in agricultural extension provides farmers with reference resources during agricultural production processes. The use of the apps in delivery of customized, structured, standardized and timely agricultural extension services to a targeted group of farmers, has been supported by Aguilar et al. (2015), and Selvi and Balasubramaniam (2009) who have noted that agricultural extension strategies should be customized and packaged in accessible form to meet specific farmer needs. Therefore, the provision of Cape Gooseberry mobile app downloadable from Google Play Store to the farming families for reference during the crop production could have aided in refering other farmers to download the app and learn more about Cape Gooseberry production. Thus, influencing their decisions to participate in the crop domestication.

Apart from receiving the crop technologies through digital systems, the farming families, also, incorporated climate smart agricultural practices. The practices comprised use of organic manure during the crop production and intercropping Cape Gooseberry with beans. The benefits of applying organic manure during crop production has been supported by FAO (2010); and Lipper et al. (2014), who argue that organic manure improve soil health and quality, resulting in increased agricultural productivity, reduction in production costs and promotes sustainability of production. Leguminous crops provide additional nitrogen to the soils through atmospheric nitrogen fixation, thus, improve the soil fertility (Mukhala et al., 1999; Perrone et al., 2020; Tobert et al., 1996). Other benefits associated with intercropping with legumes include better use of available resources and reduction of damages caused by pests and diseases (Fernández-Aparicio et al., 2010). In the study, intercropping Cape Gooseberry with beans could have improved the soil fertility through atmospheric nitrogen fixation, as well as, reducing pests and diseases attacks on Cape Gooseberry plants resulting in higher productivity.

The combined benefits to be achieved through the application of organic manure and intercropping with beans are some of the factors which are considered by farmers before crop production. Therefore, since Cape Gooseberry domestication does not necessarily require external farm inputs, there is a high possibility that the use of locally sourced farm inputs during Cape Gooseberry production could be a factor which prompted new farming families to join in the crop production process.

The findings from the data were:

i. The group of farming families who received the crop technologies through digital systems and incorporated climate smart agricultural practices continually registered the highest number of new farmers who joined in the crop domestication. The results show that the group recorded 115 new farmers.

ii. There was an increase in the number of farming families who participated in the crop domestication from the initial sample of 120. The results show that, from the 120 farming families who participated in the study, 86 farming families grew and managed the crop until maturity, while 34 farming families dropped out. In addition, 370 new farmers joined. At the end of the study, there were 456 farming families participating in the crop production.

4.6 Effects on Productivity in Cape Gooseberry Production when Digital Systems are used in the Dissemination of the Crop Technologies in Baringo County

The fourth objective of the study was:

To determine the effects of disseminating approved Cape Gooseberry technologies to farming families through digital systems on productivity levels of Cape Gooseberry in Baringo County.

The examination of the effects of the use of digital system in disseminating Cape Gooseberry technologies to farming families, and reliance on regular extension services by farming families in receiving the crop technologies involved organizing farming families, who grew the crop from planting to harvesting. The harvested fruits were weighed to assist in determination of productivity in kilogrammes per acre.

At the beginning of the examination, the farming families were placed into two groups. Each farming family in the groups grew Cape Gooseberry crop on 1/8 acre. One group received information on the husbandry practices needed to grow the crop through digital systems. At the beginning of the study, there were 30 farming families in the group, but only 20 farming families grew and managed the crop to the end. During the course of the study, 92 more farming families joined the group in the crop production process. The second group were provided with information on the crop husbandry practices through the regular extension services. At the start of the study, there were 30 farming families in this group, but only 23 farming families grew and managed the crop to the end. The group registered 86 new farming families during the crop production process. The farming families in the two groups raised the crop, and at maturity harvested and weighed the fruits in kilogrammes, and then kept records of the weights. From the records of the production, productivity in kilogrammes per acre was calculated for each farming family. From the data on productivity for each farming family, the mean productivity was calculated for each group. Based on the data on productivity, effects of the two modes of disseminating agricultural information were documented and analysed.

The results by the modes of technology dissemination and means in kilogrammes per acre are shown in Table 19. The mean productivity by the farming families who received Cape Gooseberry husbandry practices through digital system was 1249.71 kilogrammes per acre. Those farming families who were relying on the regular extension services realized mean productivity of 535.38 kilogrammes per acre.

Table 19: Comparison of Crop Productivity Means by Modes of Production

Mode of Production	n	Mean	SD
Digital Systems	20	1249.71	711.60
Regular Extension Services	23	535.38	341.75

As the Table indicates, the use of digital systems in the dissemination of Cape Gooseberry technologies to the farming families resulted in higher productivity mean, which could be attributed to a number of factors. First, the structured nature of the dissemination of Cape Gooseberry technologies, starting with the creation of awareness and interest, through visual exposure of the farming families on the benefits of Cape Gooseberry products and the appearance of the crop in the field; followed by oral explanation of the challenges, opportunities and possible income streams using online training; and third, with use of online training and Cape Gooseberry mobile app, approved Cape Gooseberry technologies were disseminated in systematic manner, from land preparation to harvesting, weighing and record keeping.

In this study, the use of Cape Gooseberry farm in the neighboring County of Uasin Gishu for demonstration was intended to provide the farming families with the visual aspects of Cape Gooseberry production through Zoom meeting. The farm owner through the use of audio-visual aids demonstrated to the farming families the potential Cape Gooseberry products, income streams, challenges and opportunities in the crop farming. In addition, the farmer explained to the farming families the basic Cape Gooseberry husbandry practices. The main aim of engaging the farmer was to help in creating awareness and interest in Cape Gooseberry farming among the farmers in the study. The farming families received the crop technologies from an agronomist who used online training through Zoom meeting. The agronomist described to the farming families the process of Cape Gooseberry production, with emphasis on nursery management, land preparation, planting, weed control, disease and pest control, harvesting and record keeping. In addition, the farming families were provided with Cape Gooseberry production mobile app for use as a reference resource during the management of the crop. The function of audio-visual aids at the beginning of the study was to create awareness regarding potential benefits of growing Cape Gooseberry.

The essence of using audio-visual aids for creation of awareness and interest is based on theory and practices proposed by extension and communication specialists, like Rogers (2003), and Oakley and Garforth (1985). The specialists emphasized that when audio-visual aids are carefully selected and properly used, they engender interest of farmers and maintain their attention, as a number of senses are engaged. The aids, also, make it easy to explain processes and concepts which are difficult to explain with the use of words alone. Similar ideas have been expressed by Sani et al. (2021), and Santucci (2005).

After awareness creation about Cape Gooseberry crop, the farming families were trained by an agronomist on the crop husbandry practices through online Zoom meeting. The choice of online Zoom meeting was based on the need for standardization of the information and knowledge disseminated to the farming families. The Wards where the farming families are located are far apart, and, therefore, online training made it possible to reach them simultaneously. Extension specialists emphasize that information and knowledge disseminated to farmers should, ideally, be gathered from varied sources, including books, journals and reports. Berge and Leary (2006), Dahiya et al. (2016), Hemmati and Sefidian (2006), and Syiem and Raj (2015) similarly indicate that the use of online training enables extension officers to assemble, organise and disseminate improved agricultural technologies and innovations from various sources. The same authors, posit that farmers from different geographical locations can receive the technologies and innovations simultaneously and within a limited period.

Another digital system used in this study was Cape Gooseberry production mobile app. The app was used as a reference resource for the farmers, which they could consult during the crop farming operations. The mobile app contents were structured systematically, with the contents on nursery management, land preparation, planting, weed control, disease and pest management, harvesting, storage and value addition.

The results in Table 19, also, indicate that the standard deviation of the crop productivity for the group of farming families who were receiving the crop technologies through digital systems was 711.60 kilogrammes per acre. Further observation of the data show that the farmer who realized the highest productivity was from Marigat Ward, with 3040.7 kilogrammes per acre, while the farmer who achieved the lowest was from Saimo/Kipsaraman Ward, with 366.6 kilogrammes per acre as shown in Table 20. With regard to the group of farming families who were receiving the crop technologies from the regular extension services, the standard deviation was 341.75 kilogrammes per acre. The farmer who realized the highest crop productivity in this group was from Saimo/Kipsaraman Ward. Similarly, in this group, the farmer who achieved the lowest productivity was from Saimo/Kipsaraman. The data indicate that the highest productivity realized was 1465.07 kilogrammes per acre, while the lowest productivity achieved was 102.7 kilogrammes per acre.

Table 20: Highest and Lowest Cape Gooseberry Productivitity in Kilogrammes per Ward and Mode of Production

Mode of Production	Wards					
	Saimo/Kipsaraman		Koibatek		Marigat	
	Highest	Lowest	Highest	Lowest	Highest	Lowest
Digital Systems	2458.26	366.70	2251.49	840.0	3040.7	550.0
Regular Extension Services	1465.07	102.70	916.70	183.3	1067.9	220.0

The researcher probed to establish the variation in fields among the farming families. The farming family from Marigat Ward who was receiving the crop technologies through digital system, and attained the highest Cape Gooseberry productivity has certain characteristics which can explain the results. First, the farming family used irrigation during periods of low rainfall. Secondly, the family operates a mixed farming, leading to a possibility of high soil quality of the farm. Finally, the farming family was familiar with the use of mobile apps, since it has been using them with other crops.

Similarly, probing of the farming family from Saimo/Kipsaraman Ward who received the crop technologies through digital systems, and attained the lowest Cape Gooseberry productivity was done. The farming family has certain characteristics which can explain the results. According to the farming family, some seedlings withered during transplanting period due to low rainfall which led to loss of some seedlings, as well as, affecting negatively the growth and healthy of the remaining Cape Goosberry plants in the field, thus, resulted in poor crop productivity.

The farming family from Saimo/Kipsaraman Ward who received information on Cape Gooseberry husbandry practices from the regular extension systems and achieved higher crop productivity under regular extension mode of production had certain attributes which can explain the high level of productivity. The family incorporated organic manure when growing the crop. The farming family, also, applied ammonia fertilizers, in addition to irrigating the crops during periods of low rainfall. However, the farming family from Saimo/Kipsaraman Ward who received the crop technologies from regular extension services and achieved the lowest Cape Gooseberry productivity indicated that there were low seedling survival rates after transplanting due to low rainfall.

The study further examined Cape Gooseberry productivities by Wards, the results, of which, are presented in Table 21. Examination of the data indicates that the productivity by Wards for those farming families who received the crop technologies through digital system were close, with Saimo/Kipsaraman realizing the highest Cape Gooseberry productivity mean of 1264.94 kilogrammes per acre, and Marigat Ward attaining the lowest, at 1228.22 kilogrammes per acre. The range is low at 36.72 kilogrammes. The low range confirms the explanation of specialists that online training results in standardization during dissemination of agricultural information and knowledge.

With regard to those farming families who were receiving the crop technologies from regular extension services, the Ward which attained the highest productivity was Saimo/Kipsaraman, at 658.26 kilogrammes, and the Ward which realized the lowest productivity was Koibatek, at 383.13 kilogrammes. The range between the Ward which realized the highest productivity and the one which attained the lowest productivity was relatively high, at 432.12 kilogrammes. The possible explanation could be differential extension services management and delivery.

Table 21: Cape Gooseberry Productivity Means in Kilograms per Acre by Wards and Modes of Technology Dissemination

Wards	Digital Systems (n=20)	Regular Extension (n=23)
Saimo/Kipsaraman Ward	1264.94	658.26
Koibatek Ward	1257.01	383.13
Marigat Ward	1228.22	568.95

The findings from the data:

i. The farming families who received Cape Gooseberry technologies through digital system realized higher crop productivity in terms of kilogrammes per acre than those who received the crop technologies from regular extension services. The mean productivity for those farming families who received the crop technologies through digital system was, at 1249.71 kilogrammes per acre and those who received the technologies from regular extension services was, at 535.38 kilogrammes per acre.

ii. The productivity means for the farming families who received Cape Gooseberry technologies through digital system tended to be standard, with little difference in yields per acre between the Wards. The productivity means by Wards were: Saimo/Kipsaraman, 1264.94 kilogrammes per acre; Koibatek Ward, 1257.01 kilogrammes per acre; and Marigat Ward, 1228.22 kilogrammes per acre. On the other hand, the productivity means for the farming families who received information on Cape Gooseberry husbandry practices from regular extension services were varied, there were wide differences in means depending on the locations of the farmers. The productivity means by Wards were: Saimo/Kipsaraman Ward, 658.26 kilogrammes per acre; Koibatek Ward, 383.13 kilogrammes per acre; and Marigat Ward, 568.95 kilogrammes per acre.

The study, also, sought to determine if there was statistically significant difference in Cape Gooseberry productivity means between the farms whose owners received the crop technologies through digital systems and those farms whose owners received the technologies from regular extension services.

The hypothesis to guide the test was:

There is no statistically significant difference in Cape Gooseberry productivity levels when the crop technologies are disseminated to farming families through digital systems, and when farming families receive the technologies from regular extension services during the crop production.

An independent-samples t-test was conducted to determine whether there was a difference in the Cape Gooseberry productivity means between those farming families who received the crop technologies through digital systems and those farming families who received the crop technologies from the regular extension services. The results are as shown in Table 22.

Table 22: T-test of Means of Cape Gooseberry Productivity in Kilogrammes when the Crop Technologies are disseminated through Digital Systems and Regular Extension Services

Mode of Production	n	Mean	SD	df	t-value	p-value
Digital Systems	20	1249.71	711.60	41	2.842	0.000
Regular Extension Services	23	535.38	341.72			

Finding from the T-test, indicate that there was statistically significant difference in Cape Gooseberry productivity means in terms of kilogrammes per acre between those farming families who integrated digital systems and those who relied on regular extension services at $p = .000 > .05$. level of significance based on whether the technology was disseminated through digital systems or regular extension services. The null hypothesis was, therefore, rejected

4.7 Use of Regular Extension Services and Climate Smart Agricultural Practices on Cape Gooseberry Productivity

The fift objective of the study was:

To determine the effects of receiving information on Cape Gooseberry husbandry practices through regular extension services and incorporating climate smart agricultural practices in Baringo County on Cape Gooseberry productivity levels among farming families.

The examination of combined effects of receiving information on Cape Gooseberry husbandry practices through regular extension services and incorporating climate smart agricultural practices during the growing of the crop by the farming families on the crop productivity, and receiving the crop technologies through regular extension services entailed organizing the farming families into two groups, who grew and managed the crop from planting to harvesting. The harvested Cape Gooseberry fruits were weighed to determine productivity in kilogrammes per acre.

The fifth objective of the study involved, like objective four, organizing farming families into two groups. Each of the farming family grew Cape Gooseberry crop on 1/8-acre piece of land. One group that initially comprised of 30 farming families and due to attrition ended up comprising of 21 farming families incorporated climate smart agricultural practices during the production of the crop and relied on the regular extension services for information on the crop husbandry practices. By the end of the study period, 77 new farming families had joined the group in the crop production process. In this study, climate smart agriculture entailed incorporation of organic manure during the growing of Cape Gooseberry and intercropping the plant with beans.

The second group comprising 23 farming families received information on Cape Gooseberry technologies from the regular extension services. The farming families in the two groups grew the crop, and at maturity harvested and weighed the fruits and recorded the weights in kilogrammes. From the Cape Gooseberry production records, the crop productivity in kilogrammes per acre was calculated for each farming family. Based on the data on Cape Gooseberry productivity for each farming family, the mean productivity for each group was calculated. From the data on Cape Gooseberry productivity, the effects of combined incorporation of climate smart agricultural practices and reliance on regular extension services, and the effects of dissemination of Cape Gooseberry technologies through regular extension services on the crop productivity were documented and analysed.

The mean Cape Gooseberry productivities for the farming families who incorporated climate smart agricultural practices in growing the crop and relied on regular extension services, and those farming families who relied on the regular extension services without climate smart agriculture when growing the crop are presented in Table 23. The data in the Table show that the mean Cape Gooseberry productivity for the farming families who incorporated climate smart agriculture during the growing of Cape Gooseberry was 1128.50 kilogrammes per acre, and mean productivity for those farming families who relied on regular extension services during the crop production was 535.38 kilogrammes per acre.

Table 23: Cape Gooseberry Productivity means in kilograms per Acre when combined CSA and Extension Services applied, and when Extension Services only are applied

Mode of Production	n	Mean	SD
Regular extension services and CSA practices	21	1128.50	511.95
Regular extension services	23	535.38	341.75

The results in Table 16 indicate that receiving information on Cape Gooseberry husbandry practices through the regular extension services and incorporation of climate smart agricultural practices by the farming families resulted in higher Cape Gooseberry productivity mean as compared with the mean productivity of the farming families who relied on regular extension services only. In this study, the two climate smart agricultural practices were use of organic manure and intercropping Cape Gooseberry with beans. The use of organic manure in growing Cape Gooseberry was intended to improve the soil quality and add nutrients. The purpose of intercropping with beans was to improve soil fertility through atmospheric nitrogen fixation and suppression of weeds.

Organic manure and intercropping with beans were selected for the study since the farming families have livestock from which organic manure can be generated and beans are easily available. Climate smart agriculture, however, is an approach which incorporates many practices which are geared towards the achievement of long-term development objectives. The critical long-term objectives are sustainable development, resilience to limitations imposed to communities by environmental factors and preservation of natural resources (FAO, 2010; Lipper et al., 2014). To achieve these long-term development objectives, climate smart agriculture has isolated and developed practices that are essential to the achievement of the objectives. The practices include: Agroforestry; rotational grazing; sub-soiling; minimum tillage; cultivation of drought-tolerant crops; water harvesting for irrigation and livestock; crop rotation; mulching; use of organic manure; and intercropping (Kaptymer et al., 2019).

In this study, the combined use of organic manure and intercropping with beans resulted in higher Cape Gooseberry productivity mean. Authors like Eghball et al. (2002), Smith et al. (1998) and Zhang et al. (2020) have indicated in their works that the use of organic manure results in higher crop yields due to its effects in improving soil fertility since it has macro and micronutrients. In addition, Karami et al. (2012), also, posited that organic manure plays a significant role in improving soil structure, which results in improved water infiltration and holding capacity.

In addition to the use of organic manure, the farming families, also, intercropped Cape Gooseberry with beans. It is this combination that could have resulted in improved Cape Gooseberry productivity, which reflects the position of Atera et al. (2013), and Mukhala et al. (1999) who have stated that the use of leguminous intercrops helps in suppressing weed infestation and population, resulting in improved farm productivity. In addition, Fageria et al. (2005), Perrone et al. (2020) have argued that legume crops play a significant role in improving soil quality and nitrogen availability through biological nitrogen fixation.

The study, also, noted that there were high levels of standard deviations, as shown in Table 16. The results indicate that the standard deviation of the crop productivity for the group of farming families who incorporated climate smart agriculture was, at 511.95 kilogrammes per acre. Further observation of the data indicates that the farmer who achieved the highest Cape Gooseberry productivity was from Marigat Ward, with 2171.8 kilogrammes per acre, while the farmer who realized the lowest productivity was from Koibatek Ward, with 301.1 kilogrammes per acre as shown in Table 24. In addition, based on the data from the Table, the standard deviation of the crop productivity for the group of farming families who relied on the regular extension services was, at 341.75 kilogrammes per acre. However, for the same group of farming families, the farmer who realized the highest Cape Gooseberry productivity was from Saimo/Kipsaraman Ward with 1465.07 kilogrammes per acre, while the farming family who achieved the lowest Cape Gooseberry productivity was from Saimo/Kipsaraman Ward, with 102.7 kilogrammes per acre.

Table 24: Highest and Lowest Cape Gooseberry Productivitity in Kilogrammes per Ward and Intervention

Mode of Production	Wards					
	Saimo/Kipsaraman		Koibatek		Marigat	
	Highest	Lowest	Highest	Lowest	Highest	Lowest
Regular Extension Services + CSA	1957.80	795.2	1723.3	301.1	2171.8	460.47
Regular Extension Services	1465.07	102.7	916.7	183.3	1067.9	220.00

Based on the observed ranges in productivity, organized visits were undertaken to farms, which realized the highest and the lowest yields. The farming family which attained the highest Cape Gooseberry yields from the group that received the crop technolgoies through the regular extension service and incorporated climate smart agriculture grew the crop on virgin land, which could have led to high productivity. In contrast, the farming family that realized the least Cape Gooseberry productivity reported fruit losses due to bird infestation and unauthorized harvests before harvest, which could be the possible cause for the low productivity.

The study further documented and analysed the crop productivities by Wards. The results are presented in Table 25. Close examination of the data show that the productivities of those farming families who incorporated climate smart agriculture realized higher productivities compared with those farming families who relied on the regular extension services, with Saimo/Kipsaraman Ward realizing 1319.66 kilogrammes per acre, Koibatek, attaining 1025.53 kilogrammes per acre and Marigat Ward, achieving 1000.3 kilogrammes per acre. With regard to those farming families who relied on regular extension services, Saimo/Kipsaraman realized 658.26 kilogrammes per acre, Koibatek, achieved 383.13 kilogrammes per acre and Marigat Ward, attained 568.95 kilogrammes per acre.

Table 25: Cape Gooseberry Productivity Means in Kilogrammes by Wards and Modes of Technology Dissemination

Wards	Regular Extension and CSA (n=21)	Regular Extension (n=23)
Saimo/Kipsaraman Ward	1319.66	658.26
Koibatek Ward	1025.53	383.13
Marigat Ward	1000.03	568.95

The findings from the data:

The farming families who received information on Cape Gooseberry husbandry practices through regular extension services and incorporated climate smart agriculture realized higher crop productivity in terms of kilogrammes per acre. The mean productivity for those farming families who incorporated climate smart agriculture was, at 1128.50 kilogrammes per acre as compared with those who relied on the regular extension services only which was, at 535.38 kilogrammes per acre.

The study, also, sought to determine if there was statistically significant difference in Cape Gooseberry productivity means between the farms whose owners received information on the crop husbandry practices from the regular extension services and incorporated climate smart agriculture during the crop production, and those farms whose owners relied on regular extension services during the crop production. The hypothesis which guided the test was:

There is no statistically significant difference in Cape Gooseberry productivity levels when farming families receive information on the crop husbandry practices through the regular extension service and incorporate climate smart agricultural practices during Cape Gooseberry production, and when farming families rely on regular extension services during the crop production.

An independent-samples t-test was conducted to determine whether there was a statistically significant difference in Cape Gooseberry productivity means between those farming families who received the crop technologies through the regular extension services and incorporated climate smart agriculture, and those farming families who relied on regular extension services. The results in Table 26 indicate there was statistically significant difference in Cape Gooseberry productivity means per acre between those farming families who incorporated climate smart agriculture and relied on regular extension services (Regular and CSA Mean=1128.50, SD=511.95) and those who relied on regular extension services only (Regular Mean=535.38, SD=341.75), t (42) = 4.557, p = .0000> .05.

Table 26: T-test Results Comparing Crop Productivity means between Combined Use of Regular Extension Service and CSA, and Reliance on Regular Extension Services

Mode of Production	n	Mean	SD	df	t-value	p-value
Regular extension service and CSA	21	1128.50	511.95	42	4.557	0.000
Regular extension services	23	535.38	341.75			

Finding from the T-test, indicate that there was statistically significant difference in Cape Gooseberry productivity means in terms of kilogrammes per acre between those farming families who received information on Cape Gooseberry technologies through the regular extension services and incorporated climate smart agriculture, and those who relied on regular extension services at p = .000> .05. level of significance based on whether the technologies were received through the regular extension services with incorporation of climate smart agriculture or reliance on regular extension services. The null hypothesis was, therefore, rejected.

4.8 Use of Digital Systems and Climate Smart Agricultural Practices on Cape Gooseberry Productivity

The sixth objective of the study was:
To determine the effects of disseminating approved Cape Gooseberry technologies through digital systems and incorporating climate smart agricultural practices in Baringo County on Cape Gooseberry productivity levels among farming families.

This objective involved farming families receiving Cape Gooseberry technologies through digital systems and incorporating climate smart agricultural practices during the production of the crop. Another group of farming families received agricultural information on the crop husbandry practices from regular extension system during the crop production. At maturity, the fruits were harvested, weighed and the productivity in kilogrammes per acre of the crop determined. The productivities under the two modes of production were compared to determine their differential effects.

At the beginning of the study, the farming families were organized into two groups. Each farming family in the groups grew Cape Gooseberry crop on 1/8 acre. One group consisting of 30 farming families received information on the crop husbandry practices through digital systems and incorporated climate smart agricultural practices. In the group, only 22 farming families grew and managed the crop to maturity. During the domestication period, 115 new farming families joined the crop production in this group. Another group comprising 30 farming families received information on the crop husbandry practices from the regular extension services. In the group, only 23 farming families grew and managed the crop to maturity. In this group, 86 new farming families joined during the crop production.

The farming families in the two groups raised the crop, and at maturity harvested and weighed the fruits in kilogrammes, and then kept records of the weights. From the records of the production, productivity in kilogrammes per acre was calculated for each farming family. From the data on productivity for each farming family, the mean productivity was calculated for each group. Based on the data on Cape Gooseberry productivity, the effects of dissemination of the crop technologies to farming families through digital systems and incorporation of climate smart agricultural practices during the crop production were documented and analysed. Data on Cape Gooseberry productivity for farming families who received agricultural information on the crop husbandry practices from regular extension services were, also, documented and analysed.

Table 27 presents the results of Cape Gooseberry productivity in kilogrammes per acre when the crop technologies were communicated to the farming families through digital systems and incorporation of climate smart agricultural practices, and Cape Gooseberry productivity in kilogrammes per acre when the farming families relied on regular extension services during the crop production. The mean productivity by the farming families who received information on Cape Gooseberry husbandry practices using digital systems and incorporated climate smart agricultural practices was 1764.70 kilogrammes per acre, while those farming families who relied on the regular extension services for agricultural information regarding Cape Gooseberry husbandry practices achieved a mean productivity of 535.38 kilogrammes per acre.

Table 27: Productivity Means in Kilogrammes due to Combined Integration of Digital Systems and CSA, and Reliance on Regular Extension Services

Mode of Production	n	Mean	SD
Digital systems + Climate smart agriculture	22	1764.70	722.60
Regular extension services	23	535.38	341.75

Data in the Table indicate that the use of digital systems in dissemination of Cape Gooseberry technologies and incorporation of climate smart agriculture resulted in higher Cape Gooseberry productivity. The higher productivity could be due to the combined effects of use of digital systems in dissemination of the crop technologies and incorporation of climate smart agricultural practices during the crop production.

In this study, the digital systems comprised use of audio-visuals, online training and Cape Gooseberry mobile app. The climate smart agricultural practices involved application of organic manure and intercropping Cape Gooseberry with beans. The purpose of using audio-visual aids was to create awareness regarding the potential benefits of Cape Gooseberry farming among the farming families, since it makes it easier to explain processes and concepts to farmers which may be difficult to explain using words. Further, an agronomist used online training through Zoom meetings during farmers training to promote standardization of information and knowledge disseminated to the farmers regarding Cape Gooseberry husbandry practices. The choice of online training was, also, prompted by the need to reach all the farmers located far apart simultaneously. In addition, the use of Cape

Gooseberry mobile app in this study was to provide the farmers with systematically structured reference resources, which they could consult during the crop production process.

The application of organic manure during Cape Gooseberry production by the farmers was intended to improve the soil structure resulting in improved water infiltration and greater water holding capacity, as well as adding soil nutrients. In addition, the purpose of intercropping with beans was to improve soil fertility through atmospheric nitrogen fixation and suppression of weeds.

The results in Table 27, also, indicate that the standard deviation of the crop productivity for the group of farming families who were receiving the crop technologies through digital systems and incorporated climate smart agriculture was, at 722.60 kilogrammes per acre. Due to the high standard deviation, further examination of the data was conducted. The examination results show that the farmer who achieved the highest Cape Gooseberry productivity was from Koibatek Ward, with 2989.13 kilogrammes per acre as shown in Table 28. Similarly, the farming family who achieved the lowest crop productivity was from Koibatek Ward, with 793.60 kilogrammes per acre. With regard to the farming families who were receiving the crop technologies from regular extension services, the standard deviation was, at 341.75 kilogrammes per acre. In this group, the farmer who realized the highest Cape Gooseberry productivity was from Saimo/Kipsaraman Ward, with 1465.07 kilogrammes per acre, and similarly, the farmer who achieved the lowest productivity was from Saimo/Kipsaraman Ward, at 102.7 kilogrammes per acre.

Table 28: Highest and Lowest Crop Productivity per Ward and Mode of Production

Mode of Production	Wards					
	Saimo/Kipsaraman		Koibatek		Marigat	
	Highest	Lowest	Highest	Lowest	Highest	Lowest
Digital Systems + CSA	2636.24	188.6	2989.13	793.6	2945.6	806.7
Regular Extension Services	1465.07	102.7	916.70	183.3	1067.9	220.0

The farming family from Koibatek Ward who was receiving Cape Gooseberry technologies through digital systems and incorporated climate smart agriculture, and attained the highest productivity has certain characteristics which can explain the results. First, according to the family, they used irrigation when there was low rainfall. Secondly, the family engages in mixed farming, leading to a possibility of high soil quality of the farm. Finally, the farming family was familiar with the use of mobile apps, since it has been using it with other crops.

The farming family from Saimo/Kipsaraman Ward who received the crop technologies through digital systems and incorporated climate smart agriculture, and attained the lowest Cape Gooseberry productivity experienced a challenge during the crop production, since the primary farmer was transferred from the work station in the Ward to a different Sub-County.

The study further examined the Cape Gooseberry productivities by Wards. The results, of which, are presented in Table 29.

Table 29: Productivity Means by Wards and Modes of Production

Wards	Digital Systems and CSA (n=21)	Regular Extension (n=23)
Saimo/Kipsaraman	1821.40	658.26
Koibatek	1743.38	383.13
Marigat	1723.83	568.95

Examination of the data indicate that the crop productivity by Wards for the group of farming families who received the crop technologies through digital systems and incorporated climate smart agriculture were close, with Saimo/Kipsaraman achieving the highest productivity of 1821.40 kilogrammes per acre, and Marigat Ward attaining the lowest at 1723.83 kilogrammes per acre. The range is low at 97.57 kilogrammes. The low range confirms the explanation by extension and communication specialists that online training results in standardization during dissemination of agricultural information and knowledge.

With regard to those farming families who were receiving the crop technologies from regular extension services, the range between the Ward, which achieved the highest productivity, and the one, which attained the lowest productivity, was relatively high, at 275.13 kilogrammes. From the Table, the Ward, which attained the highest productivity, was Saimo/Kipsaraman, at 658.26 kilogrammes, and the Ward, which realized the lowest productivity, was Koibatek Ward, at 383.13 kilogrammes. The possible explanation could be differential extension services management and delivery.

The findings from the data:

i. The farming families who received Cape Gooseberry technologies through digital systems and incorporated climate smart agriculture realized higher crop productivity in terms of kilogrammes per acre than those who received the crop technologies from regular extension services. The mean productivity for those farming families who received the technologies through digital systems and incorporated climate smart agriculture was 1764.70 kilogrammes per acre and those who received the technologies from regular extension services was, 535.38 kilogrammes per acre.

ii. The crop productivity means for the farming families who received Cape Gooseberry technologies through digital systems and incorporated climate smart agriculture tended to be standard, with little difference in yields per acre between the Wards. The productivity means by Wards were: Saimo/Kipsaraman, 1821.40 kilogrammes per acre; Koibatek Ward, 1743.38 kilogrammes per acre and Marigat Ward, 1723.83 kilogrammes per acre. On the other hand, the Cape Gooseberry productivity means for farming families who received the crop technologies from regular extension services were varied, there were wide differences in means depending on the locations of the farmers. The productivity means by Wards were: Saimo/Kipsaraman Ward, 658.26 kilogrammes per acre; Koibatek Ward, 383.13 kilogrammes per acre and Marigat Ward, 568.95 kilogrammes per acre.

The study, also, sought to determine if there was statistically significant difference in Cape Gooseberry productivity means between the farms whose owners received the crop technologies through digital systems and incorporated climate agriculture and those farms whose owners received the technologies from regular extension services. The hypothesis which guided the test was:

There is no statistically significant difference in Cape Gooseberry productivity levels when farming families receive the crop technologies through digital systems in combination with incorporation of climate smart agricultural practices during the crop production, and when the farming families receive the crop technologies from regular extension services during the crop production.

An independent-samples t-test was conducted to determine whether there was a difference in Cape Gooseberry productivity means between those farming families who received the crop technologies through digital systems and incorporated climate agriculture, and those farming families who received the crop technologies from the regular extension services. The results in Table 30 indicate that there was statistically significant difference in Cape Gooseberry productivity means in terms of kilogrammes per acre between those farming families who integrated digital systems and climate smart agriculture (Digital + CSA Mean=1764.70, SD=722.60) and those who relied on regular extension services (Regular Mean=535.38, SD=341.75), $t\ (41) = 7.348$, $p = .000 > .05$.

Table 30: T-test of Means on Productivity due to combined Use of Digital Systems and Climate Smart Agriculture, and Use of Regular Extension Services

Mode of Production	n	Mean	SD	df	t-value	p-value
Digital systems + CSA	21	1764.70	722.60	43	7.348	0.000
Regular extension services	23	535.38	535.38			

The finding from the T-test, which examined if there was statistically significant difference between the productivity levels of the farming families who received Cape Gooseberry technologies through digital systems and incorporated climate smart agriculture, and those who received Cape Gooseberry technologies from regular extension services is that:

There is statistically significant difference between Cape Gooseberry productivity means at 0.05 level of significance based on whether the technology was disseminated through digital systems with incorporation of climate smart agriculture or through regular extension services. The null hypothesis was, therefore, rejected.

4.9 Comparison of use of Digital Systems; Regular Extension services and Climate Smart Agriculture; Digital Systems and Climate Smart Agriculture; and Regular Extension Services on Cape Gooseberry Productivity

The seventh objective of the study was:
To determine the difference in Cape Gooseberry productivity levels when the crop technologies are disseminated through the use of digital systems, combined use of regular extension services and climate smart agricultural practices, combined digital systems and climate smart agricultural practices, and use of regular extension services only.

At the beginning of the study, the sample comprised 120 farming families distributed in three Wards of Baringo County, namely; Saimo/Kipsaraman in Baringo North Sub-County; Marigat Ward in Baringo South Sub-County; and Koibatek Ward in Eldama Ravine Sub-County. From the sample, 107 farming families took part in a baseline survey which was conducted to determine the levels of Cape Gooseberry awareness in Baringo County. After the baseline survey, all the 120 sampled farming families were placed equally into four groups per Ward. The grouping was based on the mode of Cape Gooseberry production by the farming families. The modes were: Use of digital systems in dissemination of Cape Gooseberry technologies to the farming families and integration of climate smart agricultural practices during the crop production; use of digital systems in dissemination of the crop technologies to the farming families during the crop production; incorporation of climate smart agricultural practices during the production of the crop by the farming families and reliance on regular extension services for information on the crop husbandry practices; and reliance on regular extension services by the farming families during the crop production.

The farming families were requested to allocate 1/8 acre of their farm for growing Cape Gooseberry crop. During the crop production process, the number of farming families who dropped from each group and the new farmers who joined in the group during various stages of the crop domestication were documented. At the crop maturity, out of the 120 farming families who started the crop domestication at the beginning of the study, 34 farming families had dropped from the crop production process, and remained 86 farming families who managed the crop from the beginning of the study to maturity. Documentation and analysis of Cape Gooseberry productivities was based on the data from the remaining 86 farming families that formed the four groups. In addition, during the same period, there were 370 new farmers who joined in the crop domestication process at various stages.

The first group comprising 22 farming families received Cape Gooseberry technologies through digital systems and incorporated climate smart agriculture during the production of the crop. The second group consisting of 20 farming families received Cape Gooseberry technologies through digital systems during the crop production. The third group involving 21 farming families received information on Cape Gooseberry husbandry practices through the regular extension services and integrated climate smart agricultural practices during the production of the crop. The fourth group comprising 23 farming families relied on the regular extension services during the production of the crop.

The farming families in the four groups were issued with Cape Gooseberry seedlings for growing at the start of the study which they grew. At maturity, the farmers harvested and weighed the fruits and recorded the weights in kilogrammes. The farmers kept records of the weights. From Cape Gooseberry production records, productivity in kilogrammes per acre was calculated for each farming family. From the data on productivity for each farming family, the mean productivity was calculated for each group, documented and analysed. The productivities under the four modes of production were compared to determine their differential effects on productivity of Cape Gooseberry.

Table 31 presents the results of Cape Gooseberry mean productivities in kilogrammes per acre under the four modes of production. In the first mode where the farmers received the crop technologies through digital systems and incorporated climate smart agricultural practices during the crop production, the mean productivity was, at 1764.74 kilogrammes per acre. In the second mode where the farmers received the crop technologies through digital systems during the crop production, the mean productivity was, at 1249.71 kilogrammes per acre. In the third mode where the farmers integrated climate smart agricultural practices during the crop production and relied on regular extension services for information on the crop husbandry practices, the mean productivity was, at 1128.50 kilogrammes per acre. In the last mode where the farmers received information on the crop husbandry practices from regular extension services, the mean productivity was, at 535.38 kilogrammes per acre.

Table 31: Cape Gooseberry Mean Productivities in Kilogrammes per Mode of Production

Mode of Production	n (86)	Mean	SD
Digital systems	20	1249.71	711.57
Regular extension services and climate smart agriculture	21	1128.50	511.95
Digital systems and climate smart agriculture	22	1764.70	722.60
Regular extension services	23	535.38	341.75

The results in the Table indicate that the group of farming families who received Cape Gooseberry technologies through digital systems and incorporated climate smart agriculture during the production of the crop realized the highest productivity mean of 1764.70 kilogrammes per acre. In this group, an agronomist used online training to describe to the farming families Cape Gooseberry husbandry practices, which covered, crop production, farm management, crop protection from pests and diseases, harvesting and prevention of post-harvest loses. Therefore, the use of online training could have promoted standardization of information and knowledge disseminated to the farmers, thus, reducing inconsistencies and errors in application of the approved Cape Gooseberry technologies. Apart from the use of online training, the farming families were provided with Cape Gooseberry mobile containing reference materials covering the various crop husbandry practices. The combined use of the two digital platforms could have synergized information and knowledge regarding Cape Gooseberry production from the two sources resulting in improved management of the crop by the farming families. In addition, the farming families incorporated climate smart agricultural practices when growing the crop which could have, also, improved the soil fertility, resulting in healthy growth of Cape Gooseberry crop. The higher Cape Gooseberry productivity mean recorded in this group could be attributed to the combined effects of use of online training, Cape Gooseberry mobile app and climate smart agricultural practices during the crop production.

The study finding is supported by Wasilwa et al. (2021) who indicated that the average Cape Gooseberry productivity in kilogrammes per acre in Kenya is 1666.67. According to Naik (1994), the performance of Cape Gooseberry in terms of productivity depends on management of the crop by farmers. Therefore, for successful management, the farmers need to be provided with adequate information and knowledge on the crop approved husbandry practices through various sources such as the regular extension system and digital platforms.

According to Rogers (2003), and Oakley and Garforth (1985), use of audio-visual aids during creation of awareness and interest in new agricultural technologies and innovations are very effective, since they stimulate interest and attentiveness among farmers. With regard to the use of online training, Hemmati and Sefidian (2006), Ruishi et al. (2023), and Syiem and Raj (2015) have argued that integration of online training in agricultural extension services allows for standardization of information and knowledge disseminated to farmers on timely basis regardless of farmers geographic locations. In addition, the use of mobile apps in agricultural extension has been supported by Costopoulou et al. (2016) who argued that agricultural mobile apps provide farmers with reference resources during agricultural production processes.

The climate smart agricultural practices incorporated by the farming families in this study during the production of Cape Gooseberry consisted of application of farmyard manure and intercropping Cape Gooseberry with beans. Studies have shown that application of organic manure improves soil structure and quality (Eghball et al., 2002; Karami et al., 2012; Smith et al., 1998, and Zhang et al., 2020). In addition, El-Nadi et al. (1995) and Mc-Grath et al. (1988) posit that organic manure increases organic materials in the soil, which in turn increases the soil nutrients required for health plant growth, as well as improving soil water holding capacity. Intercropping with leguminous crops improves the soil fertility through fixation of atmospheric nitrogen. The practice is supported by Mukhala et al. (1999), Perrone et al. (2020), and Tobert et al. (1996) who noted that intercropping with leguminous crops helps in providing additional nitrogen to the soils.

Findings from the data:

i. The group of farming families who received Cape Gooseberry technologies through digital systems and incorporated climate smart agriculture during the production of the crop realized the highest productivity mean in terms of kilogrammes per acre, at 1764.74.
ii. The range between Cape Gooseberry productivity means for the group of farming families who received the crop technologies through digital systems, and the group of farming families who received the crop technologies through the regular extension services and incorporated climate smart agriculture is lower compared with the others, at 121.21 kilogrammes.

The study, also, sought to determine if there was statistically significant difference in Cape Gooseberry productivity means among the four groups of farmers who were using different modes of Cape Gooseberry production. The hypothesis that guided the test was:

There is no statistically significant difference in Cape Gooseberry productivity levels when the crop technologies are disseminated through the use of digital systems, combined use of regular extension services and climate smart agricultural practices, combined digital systems and climate smart agricultural practices, and use of regular extension services.

One Way-Analysis of Variance (ANOVA) was conducted to determine whether there was a statistically significant difference in Cape Gooseberry productivity means among the four study groups. The results in Table 32 indicate that there is statistically significant difference in Cape Gooseberry productivity means in terms of kilogrammes per acre among the four groups of farmers, F, (3.82) =16.556, P = .000 > .05.

Table 32: ANOVA Results on Effects of the Interventions on Cape Gooseberry Productivity

Yields	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	17199743.45	3	5733247.82	16.556	.000
Within Groups	28396962.56	82	346304.42		

The results indicate that there is statistically significant difference in Cape Gooseberry productivity means in terms of kilogrammes per acre among the four groups of farming families.

The results from ANOVA showed that the four Cape Gooseberry productivity means were not equal (p < .05), but it does not indicate which means are different from others. Therefore, Post hoc test was conducted using Least Significant Difference (LSD) to identify the groups of farmers whose Cape Gooseberry productivity means are statistically different. Table 33 presents the post hoc test results.

Table 33: Cape Gooseberry Productivity Means Post Hoc Test Results Using LSD

(I) Group_No	(J) Group_No	Mean Difference (I-J)	Sig.
Digital + CSA	Digital	514.98895*	.006
Digital + CSA	Regular + CSA	636.19569*	.001
Digital + CSA	Regular	1229.31958*	.000
Digital	Regular + CSA	121.20674	.512
Digital	Regular	714.33063*	.000
Regular	Regular + CSA	-593.12389*	.001

*. The mean differences at 0.05 level of significance.

The findings from the data:

i. There is statistically significant difference in Cape Gooseberry productivity means between the group of farming families who received the crop technologies through digital systems and incorporated climate smart agriculture during the crop production and the other three groups of farming families, at 0.05 level of significance.

ii. There is no statistically significant difference in Cape Gooseberry productivity means between the group of farming families who received the crop technologies through digital systems during the crop production, and the group of farming families who relied on regular extension services and incorporated climate smart agriculture during the crop production, at 0.05 level of significance.

iii. There is statistically significant difference in Cape Gooseberry productivity means between the group of farming families who received the crop technologies through digital systems during the crop production, and the group of farming families who received information on the crop husbandry practices from the regular extension services, at 0.05 level of significance.

iv. There is statistically significant difference in Cape Gooseberry productivity means between the group of farming families who received information on the crop husbandry practices from the regular extension services and incorporated climate smart agriculture during the crop production, and the group of farming families who relied on the regular extension services during the crop production, at 0.05 level of significance.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter presents the summary, the conclusions and recommendations of the study. The summary of the study includes the background, literature review, methodology and the key research findings. The conclusions present the major findings from chapter four. The recommendations outline policy suggestions as well as areas for further research.

5.2 Summary of the Study

Cape Gooseberry is one of the underutilized indigenous fruit crops in Kenya. The crop is known to have nutritional, medicinal and industrial benefits, and it grows in the wild mostly in forested areas. The purpose of this study was to introduce Cape Gooseberry for domestication to farming families in Baringo County. Baringo County was chosen because available literature indicated that Cape Gooseberry was naturally growing in the County (Wasilwa et al., 2021). Since Cape Gooseberry farming was a new farm enterprise, and authors, also, posited that there is a poor ratio of extension officers: farmers in Baringo County (Gichamba et al., 2007; Mungai et al., 2017), there was need to integrate digital systems in the delivery of farming technologies of the crop to the farming families. The digital systems used were: Audio-visual aids, online training and Cape Gooseberry mobile app.

The audio-visual aids were used in creating awareness and interest on Cape Gooseberry farming among the farming families. Online training was used to allow simultaneous dissemination of structured and standardized information on Cape Gooseberry husbandry practices to farming families who were in different locations. Cape Gooseberry mobile app was used to provide reference resources to the farming families during the crop production. The use of the three forms of digital systems in creation of awareness and delivery of agricultural extension services has been supported by Oakley and Garforth (1985), Rogers (2003), and Zossou et al. (2009).

In addition, literature shows that low soil fertility, pests and high cost of inputs are some of the factors hindering sustainable crop production in Baringo County. Therefore, in this study, two groups of farming families incorporated climate smart agricultural practices during Cape Gooseberry crop production. The climate smart practices included the use of organic manure and intercropping Cape Gooseberry with beans. The main purpose of incorporating the climate smart agricultural practices was to improve the soil fertility for maximum production as noted by Kaptymer et al. (2019).

Before the introduction of the crop, baseline survey was conducted to determine the levels of awareness of Cape Gooseberry, followed by another study on the eco-physiological characteristics of the crop to aid in the understanding of the crop's eco-physiology as well as the associated plants, pests and diseases in the study area.

The study was guided by the following objectives:

i. To establish the levels of awareness of Cape Gooseberry crop in Baringo County,
ii. To determine the eco-physiological characteristics of Cape gooseberry that make it thrive naturally in Baringo County,
iii. To determine the levels of Cape Gooseberry adoption in Baringo County.
iv. To determine the effects of disseminating approved Cape Gooseberry technologies to farming families through digital systems on productivity levels of Cape Gooseberry in Baringo County,
v. To determine the effects of receiving information on Cape Gooseberry husbandry practices through regular extension services and incorporating climate smart agricultural practices in Baringo County on Cape Gooseberry productivity levels among farming families,
vi. To determine the effects of disseminating approved Cape Gooseberry technologies through digital systems and incorporating climate smart agricultural practices in Baringo County on Cape Gooseberry productivity levels among farming families, and
vii. To determine the difference in Cape Gooseberry productivity levels when the crop technologies are disseminated through the use of digital systems, combined use of regular extension services and climate smart agricultural practices, combined digital systems and climate smart agricultural practices, and use of regular extension services only.

The study adopted participatory learning and action research, and quasi-experimental research designs. The farming families who took part in the study were drawn from three Sub-counties of Baringo County. From each of the three Sub-Counties, one Ward was selected purposively for the study. A sample of 120 farming families were drawn from the accessible population of 14,834 from the three Wards of Baringo County, namely; Saimo/Kipsaraman Ward, Koibatek Ward and Marigat Ward. In participatory learning and action research, baseline survey was conducted on the 120 farming families. After the survey, the farming families were zoned into four groups per Ward. The zoning was based on the interventions and the desired distance between the groups. The first group of farming families received the crop technologies through digital systems and incorporated climate smart agriculture; the second group received the crop technologies through digital systems only; the third group received information on the crop husbandry practices from the regular extension services and incorporated climate smart agriculture; and the fourth group relied on regular extension services. The farming families grew and managed the crop until maturity. During the study period, some farming families dropped out of the crop domestication process, while some farming families joined in the crop domestication process.

Data on the levels of Cape Gooseberry awareness in Baringo County were collected through the use of interview schedules. Observation protocols were used to collect information and knowledge on the eco-physiological characteristics of the crop. Potential farmer register lists were used to collect data about Cape Gooseberry adoption levels. The effects of the study interventions on Cape Gooseberry productivity were determined through the use of quasi-experimental research design. Data on the crop productivity for the farming families who grew and managed the crop to maturity were recorded in Cape Gooseberry productivity templates. Both descriptive and inferential statistics were used in analysing the data.

From the analyses of data presented in chapter four, the summary of the study findings has been organized according to the study objectives as follows:

i. Majority of the farming families in Baringo County were aware of Cape Gooseberry plants. The results indicated that 87% of the farming families were aware of the plant. The results, also, show that 82% of the farming families reported existence of Cape Gooseberry plants around their homesteads. In addition, majority of the farming families were willing to participate in Cape gooseberry domestication. The survey data indicated that 90% of the farming families from the three Wards of Baringo County were willing to grow the crop.

ii. Cape Gooseberry crop performs well under fertile clay loam soil. Over 60% of the sampled spots where Cape Gooseberry was growing naturally had clay loam soil. Also, Cape Gooseberry plants grow under a wide pH range, from acidic to basic. In addition, Cape Gooseberry experienced some disease and pest attacks. The disease observed was powdery mildew, and the pests were tomato borer, green stink bug and speckled mouse bird.

iii. There was an increase in the number of farmers who participated in the crop domestication from the initial sample of 120. Data from the study show that, out of 120 farming families who took part in the study, 86 farming families grew and managed the crop until maturity. At the end of the study, there were 456 farmers participating in the crop production. From the original sample of 120 farming families, 34 farming families dropped out. In addition, 370 new farming families joined.

iv. Dissemination of Cape Gooseberry technologies through the use of digital systems results in higher Cape Gooseberry productivity. The level of Cape Gooseberry productivity when digital systems were used in the dissemination of the crop technologies was 1249.71, while the crop productivity when the farming families relied on regular extension services was 535.38 kilogrammes per acre.

v. Dissemination of Cape Gooseberry technologies through the regular extension services and incorporation of climate smart agriculture results in higher Cape Gooseberry productivity. The levels of the crop productivity when the crop husbandry practices were disseminated through the regular extension services and climate smart agricultural practices incorporated was 1128.50 kilogrammes per acre, while the crop productivity when the farming families relied on regular extension services only was 535.38 kilogrammes per acre.

vi. Dissemination of Cape Gooseberry technologies through the use of digital systems and incorporation of climate smart agriculture results in higher Cape Gooseberry productivity. The level of Cape Gooseberry productivity under digital systems and climate smart agriculture was 1764.70 kilogrammes per acre, while the level of the crop productivity when the farming families relied on regular extension services was 535.38 kilogrammes per acre.

vii. Use of digital systems in dissemination of Cape Gooseberry technologies and incorporation of climate smart agriculture results in higher Cape Gooseberry productivity compared with the use of digital systems; use of regular extension services and climate smart agriculture; and regular extension services. The level of Cape Gooseberry productivity under digital systems and climate smart agriculture was 1764.70 kilogrammes per acre. The levels of productivity when digital systems were used in the dissemination of the crop technologies was 1249.71 kilogrammes per acre. The levels of the crop productivity when climate smart agricultural practices were incorporated was 1128.50 kilogrammes per acre, while the crop productivity when the farming families relied on regular extension services was 535.38 kilogrammes per acre.

5.3 Conclusions of the Study

Based on the study findings the following conclusions were made:

i. Farming families in Baringo County were aware of Cape Gooseberry plant.
ii. Cape Gooseberry crop performs well under fertile loam soils, with a wide range of pH ranging from acidic to basic.
iii. Farmers in Baringo County were willing to grow Cape Gooseberry. There was an increase in the number of farmers from an initial number of 120 to 456 by end of the study.
iv. Use of digital systems in dissemination of agricultural technologies results in improved crop productivity compared with the use of regular extension services.
v. Use of regular extension services in dissemination of agricultural technologies with incorporation of climate smart agricultural practices results in improved crop productivity compared with the use of regular extension services only.
vi. Use of digital systems in dissemination of agricultural technologies and integration of climate smart agricultural practices results in improved crop productivity compared with the use of regular extension services.
vii. Use of digital systems and climate smart agriculture results in improved crop productivity compared with the use of digital systems; use of regular extension services and climate smart agriculture; and reliance on regular extension services.

5.4 Recommendations from the Study

Based on the conclusions drawn from the study, the following recommendations for practice and research are made:

5.4.1 Recommendations for practice

i. The County Government of Baringo needs to introduce Cape Gooseberry production by supporting and encouraging the extension staff in the County to promote the crop.

ii. The County Government of Baringo needs to promote the integration of digital systems in their regular extension services, for improved delivery of agricultural extension services.

iii. The County Government of Baringo needs to support and promote integration of climate smart agricultural practices in their regular extension services.

5.4.2 Recommendations for research

i. Similar longitudinal studies on Cape Gooseberry adoption and productivity levels to concretize the results. The study was conducted in one year, and it is essential that researchers need to have the same group of farmers grow the crop over several years so that they can document and examine the results over longer periods.

ii. Study on integration of other information communication and technology tools and configurations in dissemination of Cape Gooseberry technologies. The study incorporated only three ICT tools; audio-visual aids, online training and mobile app. There are other tools which could have been included. Therefore, it is essential that research be conducted further on the other tools and their configurations in delivery of Cape Gooseberry technologies to see how it would improve performance of the crop production.

iii. Study on integration of other climate smart agricultural practices in Cape Gooseberry production. The study incorporated only two climate smart agricultural practices which were use of organic manure and intercropping Cape Gooseberry with beans. It is, therefore, essential that research be conducted on the other climate smart agricultural practices to see how it would improve the crop productivity.

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APPENDICES

Appendix A: Interview Schedule For Farming Families

Introduction: Hello, my name is Jonathan Chebor Kandagor; I am a PhD student at Egerton University undertaking research on *"Effects of Digital Systems and Climate Smart Agriculture on Domestication and Productivity of Cape Gooseberry (Physalis Peruviana L.) by farming families in Baringo County, Kenya".* The information you give by filling in the questionnaire will strictly be confidential.

Section A: Socio-Economic Background of the Respondents

Date of interview…………………………………………………………………………………

Respondent Number……………………………………………………………….………..

Gender of the Respondent: Male ☐ Female ☐

Sub-County: Baringo North ☐ Baringo South ☐ Eldama Ravine ☐

Ward: Saimo/Kipsaraman ☐ Marigat ☐ Koibatek ☐

Size of the farm in acres?..

What type of Farming do you practice? livestock ☐ Crop ☐ Mixed farming ☐

Section B: Awareness about Cape gooseberry Fruit Crop

Instruction: Tick or provide response as appropriate

Have you heard of Cape gooseberry fruit? Yes ☐ No ☐

Have you noticed them around your homestead? Yes ☐ No ☐

Section C: Willingness to grow Cape gooseberry

Instruction: Tick or providerelevant information

i) Have you noticed any farmer growing Cape gooseberry? Yes ☐ No ☐

a. If Yes, are you willing to grow the crop if supported? Yes ☐ No ☐

b. IfNo, are you willing to grow the crop? Yes ☐ No ☐

c. If your response for (i) a or b is No, what are the reasons?.......................……........……

……………………………………………………………………………..…………......

......……………………………………………………………………………..…………

ii) What kind of support would you need to grow the crop?

………………………………………………………………………………………………..

………………………………………………………………………………………………..

Section D: Climate Smart Agriculture Interventions

Instruction: Tick or provide response as appropriate

i) Are you familiar with climate smart agriculture? Yes ☐ No ☐

ii) Have you been incorporating climate smart agriculture in your farming?

Yes ☐ No ☐

iii) Indicate which of the following farming practices you have been incorporating in your farm?

Use of organic manure	☐	Fallowing	☐	Mulching	☐
Intercropping	☐	Crop rotation	☐	Establishment of boundary trees	☐
Minimum or no tillage	☐	Sub-soiling	☐	Use of irrigation	☐

Traditional means of controlling pests and disease ☐

iv) Are you willing to incorporate climate smart agriculture in growing Cape gooseberry fruit crop? Yes ☐ No ☐

v) Do you keep livestock in your farm? Yes ☐ No ☐

vi) Does your livestock produce adequate manure for use in your farming activities?

Yes ☐ No ☐

vii) If you have adequate manure, are you willing to use part of the manure in growing Cape gooseberry fruit crops? Yes ☐ No ☐

viii) Do you incorporate legumes in your farming? Yes ☐ No ☐

ix) Do have sufficient legumes seeds for use in your farming activities? Yes ☐ No. ☐

x) Are you willing to use some of the seeds in growing Cape gooseberry fruit crops?

Yes ☐ No ☐

Section E: Sources of Extension Services

Instruction: Tick or provide response as appropriate

i) Which are your main sources of agricultural information? (Please tick them)

Extension staff	☐	Internet	☐	Shows and exhibitions	☐
Radio	☐	Mobile phones	☐	Research stations	☐
Television	☐	Fellow farmers	☐	Farmer training centers	☐
Demonstrations	☐	Farmer meeting (Barazas)	☐	Education institutions	☐

Agricultural information resources centers ☐

ii) Which agricultural information do you access through these sources?

Crop husbandry practices ☐ Pests and diseases ☐

Market information ☐ Value additions ☐

iii) Which challenges do you experience when seeking agricultural information?

Availability of extension staff when needed ☐

Relevance of the agricultural information provided ☐

Limited phone connection ☐

Limited power connection ☐

Limited access to the devices ☐

Appendix B

First Focus Group Discussion Protocol Template

Sub-county:		Date:	
Ward:		Day:	
Group:		Start time:	
Venue:		Stop time:	

No. of Participants: Males:____________________ Females: ________________________

Facilitator: ____

Note taker:____________________ ____

WELCOME Thank you for agreeing to be part of this focus group discussion. We appreciate your willingness to participate. Your point of view during the discussion is important. I know you are busy with your daily activities.

Introduction: This forum is intended to discuss the domestication of Cape gooseberry fruit crop. The discussion will take less than two hours.

Participant Consent: Kindly we are requesting you to sign the consent form voluntarily to participate in the discussion. Also, we are seeking your consent to record the discussion using electronic devices.

Anonymity: The discussion will be anonymous.

Ground rules	
For quality discussions only one person should speak at a time.	You do not have to agree with the views of other people in the group
There are no right or wrong answers	If you have any question please ask?
You do not have to speak in any particular order	OK, let’s begin

Warm up

Before we start the discussion, I would like to request everyone to introduce themselves. Please can you tell us your name?

Introductory question

I am just going to give you a couple of minutes to think about Cape gooseberry fruit crop and its cultivation. Is anyone happy to share his or her experience?

Guiding questions

- Are you aware of Cape gooseberry fruit crop?
- Have you noticed them around your homesteads?
- Who normally collects the fruits? And for what purpose?
- Why have you not grown Cape gooseberry in your farm?
- Can you grow them in your farm? What are the reasons?
- What are some of the challenges preventing farmers from growing this crop?
- What needs to be done to promote its cultivation by the farmers?

Concluding question:	Of all the issues we have discussed today, do you have any question regarding our discussion?
Brief Summery	Common Response
Comments/Observation	

Conclusion

Thank you for participating. This has been a very successful discussion

We hope you have found the discussion interesting. If there is any reservations, please contact the researcher. Thank you.

Appendix C

Second Focus Group Discussion Protocoltemplate

Sub-county:		Date:	
Ward:		Day:	
Group:		Start time:	
Venue:		Stop time:	

No. of Participants: Males:____________________ Females: ________________________

Facilitator: ____

Note taker: ____________________ ____

WELCOMEThank you for agreeing to be part of this focus group discussion. We appreciate your willingness to participate. Your point of view during the discussion is important. I know you are busy with your daily activities.

Introduction: This forum is intended to discuss the progress of Cape gooseberry production. The discussion will take less than two hours.

Participant Consent: Kindly we are requesting you to sign the consent form voluntarily to participate in the discussion. Also, we are seeking your consent to record the discussion using electronic devices.

Anonymity: The discussion will be anonymous.

Ground rules

For quality discussions only one person should speak at a time.

There are no right or wrong answers

You do not have to speak in any particular order

You do not have to agree with the views of other farmers in the group

If you have any question please ask?

OK, let's begin

Warm up

Before we start the discussion, I would like to request everyone to introduce themselves. Please can you tell us your name?

Introductory question

I am just going to give you a couple of minutes to think about your Cape gooseberry farming since the date you planted the young Cape gooseberry plants to this date. Is anyone happy to share his or her experience?

Guiding questions

- *Tell us about the progress of your Cape gooseberry production*
- *Are there any challenges you encountered since you planted the Cape gooseberry seedlings?*
- *If there were challenges, how did you manage them?*
- *For those challenges you were not able to manage, what kind of support would you require*

Concluding question:	Based on what we have discussed today, is there any one of you who have any question regarding our discussion, or any issue you have not understood?
Brief Summery	**Common Response**
Comments/Observation	

Conclusion

Thank you for participating. This has been a very successful discussion

We hope you have found the discussion interesting

If there is any reservations, please contact the researcher. Thank you.

Appendix D

Cape Gooseberry Domestication Activities Templates

<table>
<tr><td colspan="3">Group:</td><td colspan="4"></td></tr>
<tr><td colspan="3">Farm ID:</td><td colspan="4"></td></tr>
<tr><td colspan="3">Name of the Farmer:</td><td colspan="4"></td></tr>
<tr><td colspan="3">Acreage:</td><td colspan="4"></td></tr>
<tr><td colspan="3">Crop:</td><td colspan="4">Cape gooseberry</td></tr>
<tr><td colspan="3">Number of Seedlings:</td><td colspan="2"></td><td>Size of land (acres):</td><td></td></tr>
<tr><td colspan="7"></td></tr>
<tr><td>No</td><td>Date</td><td>Activity</td><td>Challenges</td><td>Interventions</td><td colspan="2">Lessons learnt</td></tr>
<tr><td>1.</td><td></td><td></td><td></td><td></td><td colspan="2"></td></tr>
<tr><td>2.</td><td></td><td></td><td></td><td></td><td colspan="2"></td></tr>
<tr><td>3.</td><td></td><td></td><td></td><td></td><td colspan="2"></td></tr>
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<tr><td>5.</td><td></td><td></td><td></td><td></td><td colspan="2"></td></tr>
<tr><td>6.</td><td></td><td></td><td></td><td></td><td colspan="2"></td></tr>
</table>

Instruction: Kindly fill in the register after every activity

Appendix E

Cape Gooseberry Productivity Records

Instruction: Kindly fill in the details after every harvest.

Production Record: Harvesting				
Group:				
Field ID:				
Name of the Farmer:				
Crop:	**Cape Gooseberry**			
Harvesting Notes for the Farmer: i). Only ripe fruits to be harvested ii) Maintain hygienic standards iii) Store harvested fruits in dry cool environment iv) Spoiled fruits are to be measured (Comment on the cause)				
Harvesting Date	**Unit of Measure (Kgs)**	**Harvested Quantity**	**Quantity Spoiled**	**Comments**
Total Kgs:				
Total Acreage:				
Yield:				
Total Spoiled (Kgs):				

Appendix F

Cape gooseberry Productivity Observation Template for Independent Observer

Instruction: Kindly fill in the details after every harvest.

Production Record: Harvesting				
Group:				
Field ID:				
Crop:	**Cape Gooseberry**			
Name of the Independent Observer:				
Organization				
Harvesting Notes for the Farmer: i). Only ripe fruits to be harvested ii) Hygienic standards should be maintained iii) Quantity of spoiled fruits iv) Spoiled fruits are to be measured (Comment on the cause)				
Harvesting Date	**Unit of Measure (Kgs)**	**Harvested Quantity**	**Quantity Spoiled**	**Comments**
Total Kgs:				
Total Acreage:				
Yield:				
Total Spoiled (Kgs):				
Date……………………….			**Signature …............……………**	

Appendix G

Potential Farmer Register List Template

Instruction: Please kindly register any farmer who has visited or contacted you about Cape gooseberry crop by filling in the following form.

No.	Date	Name of Farmer	Gender	Contacts	Ward	Information sought	Wants to join or not

Appendix H

Observation Protocol

Instruction: Observation schedule foreco-physiological factors that seem to favour the growth of Cape gooseberry crop in the wild in Baringo County.

Sub-county		
Ward		
Location/sub-location		
Date		
Subject of observation		**Comments**
Soil properties		
Associated plants		
Climatic conditions		
Pests		
Diseases		
Observer Name		

Appendix I

Cape Gooseberry Domestication Script

- Introduction to Cape gooseberry
- Cape gooseberry propagation
  - Seed propagation
  - Stem cutting (vegetative) propagation
- **Ecological requirements**
  - Rainfall
  - Relative humidity
  - Temperature
  - Weather - warm and wet weather condition
- Soil requirements
- Nursery bed establishment and management
  - Orientation-North to South
  - Spacing – 5cm between rows
  - Sheds
  - Mulching
  - Watering – morning and evening
- Seed bed establishment
- Bush clearing
- Ploughing and harrowing
- Agronomic practices
- Transplanting - 6 feet between rows 3 feet within rows
- Use of organic manures during transplanting at 3200kg per acre
- Weed control
- Weeding twice in season
- Mulching
- Intercropping – Legumes at a spacing of 30cm by 15 cm within Capegooseberry rows
- Pests and diseases
- Pests and diseases control for the legumes
- Use of cultural methods
- Harvesting
- Maturity indices
- Harvesting and storage methods

Appendix J

Climatic Conditions of Saimo/Kipsaraman Ward where Cape Gooseberry Grows in the Wild

Climatic Factors	
Annual high temperature	25.11ºC (77.2ºF)
Annual low temperature	12.15ºC (53.87ºF)
Average annual precipitation	232.32mm
Warmest month	February (28.22ºC / 82.8ºF)
Coldest Month	June (11.17ºC / 52.11ºF)

Appendix K

GPS Locations of Data Collection Points where Cape gooseberry Plants were Growing in Wild

Point	N	E	Altitude
1	N00.64941	E035.82202	2030
2	N0064783	E035.82090	2030
3	N0064683	E035.81969	2020
4	N00.64513	E035.82030	2028
5	N00.64704	E035.82524	2082
6	N00.64645	E035.82706	2127
7	N0064605	E035.82733	2179
8	N00.64579	E035.82872	2139
9	N00.63451	E035.82534	2136
10	N00.63484	E035.82131	2086
11	N00.63659	E035.83122	2150
12	N00.64047	E035.83225	2213
13	N00.64141	E035.83569	2292
14	N00.64275	E035.83769	2298
15	N00.64272	E035.83687	2315

Appendix L

Domestication Manual in English Language

CAPE GOOSEBERRY DOMESTICATION MANUAL

By Jonathan Chebor Kandagor

Egerton University

Kenya Climate Smart Agriculture Project

Introduction to Cape gooseberry *("Toliong" / "Chelolo")*

- It is a perennial fruit crop found growing naturally around our homesteads
- Grows to a height of 0.9 – 1.8 meters and spreads up to 4 meters wide
- Its flowers are yellow in color
- The fruit is covered by a husk which is bitter and inedible
- When ripe, the husk turns brown in colour
- The husk is peeled off to reveal the fruit
- The fruit is spherical, approximately 2cm wide and is golden yellow when ripe
- Similar in size and appearance to a small cherry tomato.
- Immature fruits are poisonous to humans when consumed
- The fruits have nutritional, medicinal and economic benefits
- It takes 6 months for the plant to reach maturity and harvesting
- They are ready for harvesting when the papery husk dries
- Ripe berries drop on the ground

Ecological Requirements

Rainfall requirements

- A of 800 mm of rainfall during the growing season.
- Higher rainfall, up to 4300 mm, increases growth and yield if the soil is well drained.
- The plants become dormant during drought periods.
- For proper production, 1000 - 2000 mm of well-distributed rainfall is needed, otherwise irrigation is required (Duarte and Paull, 2015)

Temperature

- Grows well with an annual average temperature from 13°C to 18°C.
- Day temperatures of 27^{0}C -30^{0}C apparently do not affect fruit set

Weather

- Planting is done during rainy season/winter (April – June) and (October - December)
- Winter season is conducive for flowering and fruit set
- The summer temperatures are unfavorable for fruit development (December-March)
- Harvesting the fruits is conducive during summer weather

Soil Requirements

- Grows well in well-drained loam soil enriched with organic manure
- It can, a lso, grow in sandy loam soil
- Highly fertile soils trigger excessive vegetative growth with poor fruit color formation.

AGRONOMIC PRACTICES:

- The crop should be planted on a gentle slope in areas where drainage is a p
- Intercropping with legume crops is recommended to improve soil health

Cape gooseberry propagation

Seed Propagation (Preparation) Procedure:

- Select ripe and healthy fruits from the farm
- Remove the dry husks
- Put the fruits in a plastic bag squeeze the fruits in the plastic bag to separate the contents including the seeds
- Repeat the process until all the fruits are completely pulped
- Add water and pour into a large bowel and shake gently
- Upon settling, the seeds will sink to the bottom of the bowel
- Pour off the fruit debris
- Wash the seeds 3 times and gently pour the debris

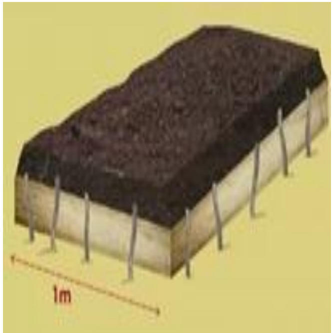
Place the well-drained seeds on a tray and let it dry under shade for 3-5 days

- Store them in a paper bag in a dry cool place (Wasilwa et al. 2018)

Nursery Bed Establishment and Management

Factors to consider in selecting the nursery bed location

- Nearness to the seed bed
- Availability of water
- Topography – it should be flat area, for accessibility
- Facing North to South for maximum sunshine
- Near road for easy transportation



Nursery bed preparation

- The nursery bed should be 1 meter - wide and 10 inches deep
- The edges can be supported with woods or bricks
- Mix loam soil, sand and farm yard manure at ratio of 3:2:1 the soil should be very soft

Seed Planting

- Sparsely place the seeds on the nursery bed in rows of 2 inches apart
- Plant seeds 1/4" deep in the soil.
- Cover with thin layer of soil
- Cover the nursery bedwith dry grass
- Water carefully every morning and evening hours
- Over watering can cause fungal growth leading to seed rot
- Excess water can bury the seed, making it difficult to break the
    - surface
- Water only when the soil surfaces begins to dry
- The plants should be thinned once seedlings appear crowded

Germination

- Keep the soils consistently warm by covering the nursery bed with mulching materials
- Cool soils will significantly delay the germination
- Seeds germinate 7 -15 days after planting
- Seedlings are ready for transplanting in 4 - 6 weeks under ideal conditions day temperatures range from 22°c – 28°c and night temperatures between 7° to 13° c

Nursery Bed Management

- Once few leaves have developed, the nursery bed should be uncovered
- There should be minimization of direct scorching sun; to harden the plants slowly, uncover the nursery for exposure to sun
- Hardening off time take 5 -10 days
- Water the seedlings in the morning and evening hours gently
- Monitor the seedlings for pests and diseases

Stem cutting (Vegetative) propagation

- Use of stem cuttings can, also, be a viable means of propagation
- Select health branches that are at least one year old
- Ideal period is when the leaves have dropped, right before the buds open
- Don't take cuttings during cold weather
- Trim the soft part, off the tip of the branch
- Cut the branch in six inch sections
- Make your top cut at an angle, just above a bud
- Make your bottom cuts just below a bud, and cut in a straight line.

- Use a container for rooting cuttings, filled with a mixture of compost.
- Treat the bottom end of each cutting with hormone rooting powder
- Bury to half its height in the soil mixture in your container
- Keep the containers in a shade
- Manage them until the time it grows roots, transplant when fully sprouted

Seed bed selection and establishment

- Away from forested areas
- Sunny location required, sheltered from strong winds
- A wind break using trees and hedges can be used to shelter the plants
- The seed bed should not be in the same vicinity with potato crops

Land preparation

- Clear bushes if exists in the selected seed bed and surrounding, to minimize occurrence of pests and rodents
- Plough the field and harrow to fine tilth, avoid big clumps of soil Wasilwa et al,. 2018

Agronomic Practices

Planting

- Use spacing of 3 feet within rows and 5 feet between the rows
- Select seedlings that are 10 - 20 cm
  - tall for transplanting
- Transplant to a hole previously preloaded with farm yard manure and wetted with water at the rate of 3200kg per acre
- Fasten the young seedlings on a stake for support and water gently after transplanting
- Watering the plants should done regularly to avoid water stress, if it is not raining
- The stakes will, also, help in marking the plants to avoid loses during weeding time

Weed Control

- Weed lightly with a jembe or a panga
- Weeding should be done twice in a season
- Handle gently the fragile stems

Mulching

- Mulch the fruit trees with dry matter to minimize water evaporation

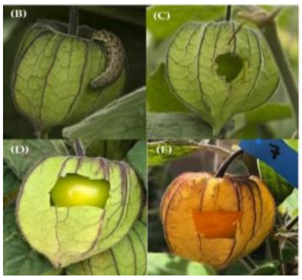
Intercropping

- Intercrop with legume crops such as beans and peas
- Avoid intercropping with climbing legume crops
- Intercrop with legumes at a spacing of 30cm by 15 cm within the gooseberry rows

Pests and diseases affecting Cape gooseberry

Pests

Fruit borer



White flies

Aphids

Birds

Diseases

Leaf spot

Fruit Rots

Powdery mildew

Dumping off and bacterial wilt

Prevention of pests and diseases

- Proper seedbed location
- Monitoring the weather patterns and the crop calendar
- Well drained soils to prevent water logging
- Using appropriate plant spacing
- Proper crop maintenance (watering, pruning, spraying, weeding, and cleanup)
- Use of dry mulching materials
- Uprooting infected or dead plants
- Reducing leaf wetness by removing weeds around the plants
- Crop rotation
- Intercropping
- Application of environmental-friendly chemicals as the last resort to control pests and diseases

Preventing Pests and diseases from affecting the legume crops

- Applying appropriate plant spacing
- Growing disease resistant varieties
- Using drought tolerant varieties
- Uprooting infected or dead plants
- Proper maintenance (weeding and cleanup)
- Practicing crop rotation
- Application of environmental-friendly chemicals as the last resort to control pests and diseases

Cultural Methods of controlling pests and diseases

- Crop rotation
- Intercropping
- Burying crop residues
- Timing the crop calendar to avoid certain insects
- Controlling weeds and natural vegetation that harbor insects

Harvesting

- Ready for harvesting when the calyx has a dry-grass colour
- For markets, mature fruits are harvested while still green in color
- Harvest the fruits using clean and dry plastic crates
- Fruits are picked by hand, while observing hygienic conditions
- If it is raining, don’t pick the fruits until when the plants are dry
- Wet berries should be dried in the sun for a short time
- Fruits can be harvested in traditional baskets and plastic bags

- **Storage of fruits**
  - Observe hygienic conditions
  - Store the fruits in a clean and dry plastic crates
  - Keep the fruits in a fully aerated room
  - Don't remove the calyx until when the fruits are ready for use or
  - consumption
  - The calyx preserves the fruit shelf-life for 4 to six weeks at room
  - Temperatures
  - For prolonged storage, fruits can be refrigerated at 2-4 C for 4 to 5 months

Uses of Cape Gooseberry Fruits

Health Benefits of Cape gooseberry fruits

i. Store house of Vitamin C and antioxidants

- Very rich in Vitamin C, which is good for your skin, and boosting immunity

ii. Good for your eyesight

- The fruits are rich in Vitamin A and iron, which improves eyesight, and immunity.
- Prevents cataracts and age-related macular degeneration.

iii. Controls high blood pressure

- The fruits can regulate high blood pressure levels, by keeping the bad cholesterol levels in check and promote heart health.

iv. Born strength

- Being high in calcium and phosphorous, the fruits help in making

your bones stronger.

v. Can control diabetes

- Cape gooseberries contain immense soluble fibre like fructose
- which can prove beneficial for diabetic patients.
- The fruits can help lower the blood sugar levels (If you are a
  - diabetic, consult a diabetologist first).

vi. Promotes weight loss

- Low in fat and calories, a handful of cape gooseberries make for a great snack or a meal filler to support your weight loss goals.

vii. Eases Digestion

- Cape gooseberries are very rich in fibre which plays an important role in managing your digestive processes, preventing constipation

viii. Anti-Inflammatory properties

- Prevents inflammation caused by pain, swelling, and redness.
- May, also, help in treating disorders like asthma which is basically the inflammation of tracheal passage.

ix. Fights cold and flu

- Cape gooseberries can protect against common cold and flu attacks.
- Consume them with tea or hot water at least twice a day.

x. It will soothe your clogged nasal passage and you will begin to feel much more relaxed.

Economic benefits of Cape gooseberry fruits

1) R aw fruits can be sold

2) Cape gooseberry Jam

3) Cape gooseberry Yoghurt (By Delight Limited, Uasin Gishu, Kenya)

4) Cape gooseberry juice

5) Cape gooseberry queen cakes

6) Cosmetics industry –

Cape gooseberry Cream

REFERENCE

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Appendix M

Domestication Manual Translated in Tugen Language

KABORUNETAB KOLSE KAB TOLIONGEK

By Jonathan Chebor Kandagor

Egerton University

Kenya Climate Smart Agriculture Project

KABORUNETAB TOLIONGEK

- Ketit nebo loguek ne nyonei makolei chi eng ole lekitien kokwa ole kimenyei, nyonei kityo.
- Nerei eng kointo ne bo mitaisiek 0.9-1.8 ak kokritu kunerei ayo mitaisiek 4
- Taptukche ko bo "yellow"
- Loyoekche kotiyei baralyet ne ngwan ako maamei chi.
- Ye ur kobiririt baralyet (makatet) Loyoikche ko mukule ak seuti mitaelsiek 2 inko "yellow" ye ur.
- Kergei ak nyanyak che mengich
- Sumu logoekche yatomo koyem eng chi ye am.
- Anyine logoekche ako ko kerich ako ku komongut eng mungaret.
- Tarei aroek 6 si. keneryo ak kekes.
- Ye yem kebut koyam makate
- Ye urya loyoek kusuchi ngony.

Tukuk che mako tin (ecological requirements) (rain)

- Ya takekole kamache ropta ne bo ngony ne bo milimitaek 800
- Ropto nebo milimilasler 4300 ka tesei Daretak koi logoek ye kararani kiminte.
- Mu nerei ye mami ropta.
- Si korier komi komachei ropta nebo milimitasiek chebo (1000-2000) si kwi logoek che chang eny ropta ne keikei ne kimachei.

Madi (Temperature)

- Nerei kome eng temperecha kongeten (13^0c-18^0c)
- Temperecha nebo ko nget/ 27^0c-30^0c) ako menyerin logoek
- Kikolei ya roponei kongeten Arawetab angwan akoi arawetab tamanak aeng.
- Kararan ya kaitet amu tapted ak yemachei koi lagoek
- Mayei lagoek ye mamii ropta kongeten arawetab aeng agoi arawetab somok
- Kibutei logoek ya momi ropta.

Kimintet/ngungunyek ne kimachei (soil requirement

- Kiminte ne kimachei/ Ngungunyek ne kararan ne tinyei mboleek che bunu sokek

- Nersot kogeny eng ngasiek
- Ye yakisai kiminte missing komayei logoek

Weli kikolchini (agronomic practices)

- Kikolchini ole maruitos bek amu nyeren.
- Kikolei koboto marakwa amu chamtaak amu kochi kiminte koyakwaet.

Chobet ab kesuwek (seed preparation) sereiya (procedure)

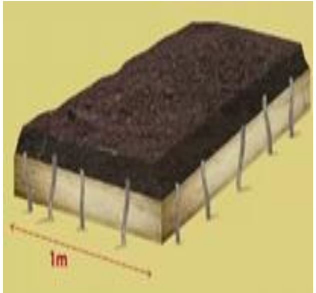
- Kwen kesuwek che kororon eng mbaret
- Icherun makatet (Baralyet)
- Intenen kesuwek eng tekelkel akibirji
- Teschi koutai agoi kobekchi
- Rong in bei bakulit ak isach komie
- Meten ye kaitet.
- Till komosto he nyalolat eng barak
- Til tamwe ye mi inchisiek lo (6)
- Yei weli kitep eng barakutab ole namei logoek.
- Nebo ngony ile kowo street.
- Boisien ki ya rongini ole kitel, changanyan mboleik
- Rongin ole kitel kerchick ak (hormone rooting powaler)
- Tuch agoi nusu nebo kointo nebo kimente ne kichanganyan eng kibabet.

- Nde kibabet eng urwo
- Kany kotesi agoi kokwa sekarek, ak iwe iko.

Tuguk che makotin ya ileweni nasari

- Lekit ak weli kibiten
- Weli mi bek
- Weli momi mareny
- Weli mangunen asista ak weli rektoen asista
- Weli negiten barabaret

Kitokitab kesuwek kelewen (seed bed selection & establishment)



- Ngar kerti nemi eng ole imache inte kitokitab kesuwek, si maibu chongik che inyeren koboto (morek ak torit).
- Bir kiminte si kotalkesiet amat ibiste che kinton

Chobetab nasari

- Kimachi kitokitab nasari kock mitaek (I) eng kointen ak inchisiak yaman (10) kowo gony.
- Kerker ko kerongi ketek and korek

- Mikisen kimente na biriri ngaisiek ak sikiek chebo kiyakek (3:2:1) kimente ko na talks.

Koletab kesuwek

- Rongi kesuwek eng kitokitab nasare eng laiwi chibo incheisiuk eng 22 kongeten ailiani age agoi age.
- Tup eng kiminte ne terter
- Tich kitokitab nasare eng sokek che kiyomo.

Kolsiet (planting)

- Bosien futisiek 3 eng lainisitk ak futisiek 5 kongete laini age agoi age.
- Lewen kisuwek che escntimita 10-20 che koen ye ikole.
- Kolchin ole kaichop ne kaituye kimente ak mboleyek ak ironchi bek
- chebo 3200 kg eng ekait ogenye.
- Rongin bek sait age tagul si mame ketit ye momi ropta.
- soch komic si mayakito ya kisembarei

Sate kenout (weed control)

- Boisein jembe and pronge mutyo mutyo
- Kisemborei konyel aeng
- Rip komie tamonaek amu ngarngar

Keronch sok (mulching)

- Tich Ketikab logoek eng sokek che kiyomo simaib bek barak

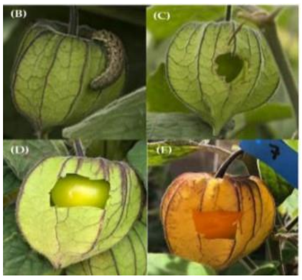
Ketuya ak kesuwek (intercropping)

- Ketuya nu marakwa ak pinsi
- Metuye au kesuweu che setei
- Kole kesuwek alak eng borointo nebo sentimitasiek 30-15 eng yo miten lainisiekab tolyongek.

Chongik ak Korotwek ab Toliongek

Pests

Fruit borer



White flies

Aphids

Birds

Diseases

Leaf spot

Fruit Rots

Powdery mildew

Dumping off and bacterial wilt

Kerengtaet ab chongik ak korotwek (preventing of pests & diseases)

- Weli kararan eng kitokitab kesuwek
- Kerop ole u betu ak ketutab koletab kesuwek
- Ole matononei bei au kimente ne kararan
- Chop kolee ne kiyem
- Ripest ne mie (kerongibek ketor, kebit, kesember ok kechop tililinto).
- Bosiek sokek che yomotin
- Icherun che kayakitu ak che yomotin
- Icherun sate ne mi
- Me koichin ota agenge, naktaen
- Kole ak tuguk alak
- Boisien kerchiek che manyerin koek nebo let si kobar chongik and korotwek.

Kerentab chongik ak korotwek eng kisunek arak (preventing pests and diseases affectingthe legume crops)

- Kole eng nafasit ne yamei
- Kole chema nyunyum kinam korotwek
- Kole che yamekei ak tirelet
- Chutun che kakonam korotwek ak komeiyo
- Ripset ne mie (semboret, kerongi bek, ketor, kebit, ak kechop tililinto)
- Boishen sokek che yomotin
- Icherun che kiyakituu ak che yomotin
- Icherun satee ne mi
- Mekolchi ota agange
- Kol ak tuguk alak
- Boisen karchiek che menyeren koiek ne bo.

Oret nebo kipkaa ne barei chongik ak korotwek (cultural methods of controlling pests and diseases)

- Naktaten
- Kole ak taguk alak
- Tup kesuwek che yach
- Ibere batut ne kikolen asi koisto tutuk

Kesisiet ab lokoek (harvesting)

- Kichesei ye kakoyam talotei
- Ye kakokito kekes ye kotakonyalil logoiku
- Kekese logock keboisen tekelked ne kararan ne b krates.
- Kebute keboisiene ennt ne tilil
- Ya roboni mebut logock agoi koyam
- Logock che mayomo kama any asis
- Kibutini logoek kikabut nebo kipkaa ak nebo plastil
- Konoretab logoek (storage of fruits)
- Ker tililiroto we kararan
- Aiten logoek eny ole tilil eng plastic krets
- Rongin logoek ole mi koristo orit
- Me cheru kit ne name logoek agoi koyam keam
- Kit ne name logoiyanted kotebiye wikisieu 4-6 eng rumit ne mi mat.
- Ye tebi betusiek che chang keutonoi weli mi koititet ne bo 2^{0c} - 4^{oc} eng araek 4-5.
- Bestan agoi kotebi -eng bakulit orit komie.
- Tarten bek chemi logoek
- Tun logoek konyed somok agoi kotebi eng ngony ak itante bek mutyo.
- Ma eng sanit agoi koyomo ak ima eng oi nemi orwo betusiek (3-5)
- Aiten eng tekelkel eng oi ne yamat ako kitet.

Koneretab lokoek (storage of fruits)

- Ker tillinto ne kararan
- Aiten lokoek eng ole tilil kou plastic bags krets
- Rongin lokoech olimii koristo orit
- Me chero kit ne namei logoek akoi koyam keam
- Kit ne namei logoyanted kotebeyei wekisiek 4-6 eng rumit nemi mat
- Ye tebi eng betusiek che chang kentonoi weli mi koitityet nebo 2°C - 4°C

eng oraek 4-5

Tuguk Che Kechoben Toliongek

1) R aw fruits can be sold

2) Cape gooseberry Jam

3) Cape gooseberry Yoghurt (By Delight Limited, Uasin Gishu, Kenya)

4) Cape gooseberry juice

5) Cape gooseberry queen cakes

6) Cosmetics industry –

Cape gooseberry Cream

REFERENCE:

Source: https://hort.purdue.edu/newcrop/morton/cape_gooseberry.html

Source: https://www.cabi.org/isc/datasheet/40713

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Source: https://www.canr.msu.edu/nativeplants/gettingstarted/howtoplant/sixstep stoasuccessfulseeding

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Source: Miyake, N., Nagai, H., Kato, S., Matsusaki, M., Ishikawa, H.,&Kageyama, K. (2015). Detection of damping-off of Cape gooseberry caused by Pythium aphanidermatum and its suppression with phosphonate. Journal of General Plant Pathology, 81(3), 192-200.

Source: https://www. cabi.org/isc/datasheet/40713

Source: https://cgspace. cgiar.org/handle/10568/34814

Appendix N

Board of Post-Graduate Studies Letter of the Study Approval

7.7.23

EGERTON UNIVERSITY

Tel: Pilot: 254-51-2217620
254-51-2217877
254-51-2217631
Dir.line/Fax: 254-51-2217847
Cell Phone

P.O. Box 536 - 20115
Egerton, Njoro, Kenya
Email: bpgs@egerton.ac.ke
www.egerton.ac.ke

OFFICE OF THE DIRECTOR GRADUATE SCHOOL

Ref: **ED23/15543/19**

Date: **5th July, 2023**

Mr. Jonathan C. Kandagor
Dept. of AGED
Egerton University,
P. O. Box 536,
EGERTON.

Dear Mr. Kandagor

RE: CORRECTED PROPOSAL

This is to acknowledge receipt of soft copies of your corrected proposal entitled **"Effects of Digital Systems and Climate Smart Agriculture on Domestication of Cape Gooseberry (Physalis Peruviana L.) by Farming Families in Baringo County, Kenya"**

You are now at liberty to commence your fieldwork. However note the following: -

1. You must register each semester.
2. Pay your fees every semester.
3. Submit progress reports every four (4) months (Masters) or six (6) months (PhDs). Without this, your thesis/project will not be accepted. Forms are available at the Board.
4. You are expected to publish one (1) paper (Masters) or two (2) papers (PhD) in peer-reviewed journal and present them before issuance of "Intent to Submit Thesis/Project" form by the Board.

NB: Please provide a **HARD COPY** of the proposal duly signed by the supervisors for the file.

Thank you.

Yours sincerely,

DIRECTOR, BOARD OF POST GRADUATE STUDIES EGERTON UNIVERSITY 06 JUL 2023

Prof. George M. Ogendi, Ph.D
DIRECTOR, BOARD OF POSTGRADUATE STUDIES

c.c. Dean, FEDCOS
COD, AGED
Supervisors

"Transforming Lives Through Quality Education"

Appendix O

Ethical Clearance Letter

EGERTON UNIVERSITY

TEL: (051) 2217808
FAX: 051-2217942

P.O. BOX 536
EGERTON

EGERTON UNIVERSITY INSTITUTIONAL SCIENTIFIC AND ETHICS REVIEW COMMITTEE

EU/RE/DVC/009
Approval No. EUISERC/APP/200/2022 ***3rd October*, 2022**

Jonathan Chebor Kandagor
Telephone: 0710683978
E-mail: kandagor@egerton.ac.ke

Dear Jonathan,

RE: ETHICAL APPROVAL: EFFECTS OF DIGITAL SYSTEMS AND CLIMATE SMART AGRICULTURE ON DOMESTICATION OF CAPE GOOSEBERRY (PHYSALIS PERUVIANA L.) BY FARMING FAMILIES IN BARINGO COUNTY, KENYA

This is to inform you that ***Egerton University Institutional Scientific and Ethics Review Committee*** has reviewed and approved your above research proposal. Your application approval number is ***EUISERC/APP/200/2022.*** The approval period is ***3rd October, 2022 – 4th October, 2023.***

- This approval is subject to compliance with the following requirements;

i. Only approved documents including (informed consents, study instruments, MTA) will be used.

ii. All changes including (amendments, deviations, and violations) are submitted for review and approval by ***Egerton University Institutional Scientific and Ethics Review Committee***.

iii. Death and life-threatening problems and serious adverse events or unexpected adverse events whether related or unrelated to the study must be reported to ***Egerton University Institutional Scientific and Ethics Review Committee*** within 72 hours of notification

iv. Any changes, anticipated or otherwise that may increase the risks or affected safety or welfare of study participants and others or affect the integrity of the research must be reported to ***Egerton University Institutional Scientific and Ethics Review Committee*** within 72 hours.

v. Clearance for Material Transfer of biological specimens must be obtained from relevant institutions.

"Transforming Lives through Quality Education"

vi. Submission of a request for renewal of approval at least 60 days prior to expiry of the approval period. Attach a comprehensive progress report to support the renewal.

vii. Submission of an executive summary report within 90 days upon completion of the study to ***Egerton University Institutional Scientific and Ethics Review Committee***.

- Prior to commencing your study, you will be expected to obtain a research license from National Commission for Science, Technology and Innovation (NACOSTI) https://oris.nacosti.go.ke and also obtain other clearances needed.

EGERTON UNIVERSITY
Date. 03/10/2022
RESEARCH ETHICS

- Yours sincerely.
- Prof. R. Ngure

CHAIRMAN, EGERTON UNIVERSITY INSTITUTIONAL SCIENTIFIC AND ETHICS REVIEW CTTEE

RMN/BK/

Appendix P

NACOSTI Research Permit

REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY & INNOVATION

Ref No: **197137**

Date of Issue: **25/July/2023**

RESEARCH LICENSE

This is to Certify that Mr.. Jonathan Chebor Kandagor of Egerton University, has been licensed to conduct research as per the provision of the Science, Technology and Innovation Act, 2013 (Rev.2014) in Baringo on the topic: Effects of Digital Systems and Climate Smart Agriculture on Domestication of Cape Gooseberry (Physalis Peruviana L.) by Farming Families in Baringo County, Kenya for the period ending : 25/July/2024.

License No: **NACOSTI/P/23/27895**

197137

Applicant Identification Number

Director General
NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY & INNOVATION

Verification QR Code

NOTE: This is a computer generated License. To verify the authenticity of this document, Scan the QR Code using QR scanner application.

See overleaf for conditions

THE SCIENCE, TECHNOLOGY AND INNOVATION ACT, 2013 (Rev. 2014)

- Legal Notice No. 108: The Science, Technology and Innovation (Research Licensing) Regulations, 2014

- **The National Commission for Science, Technology and Innovation**, hereafter referred to as the Commission, was the established under the Science, Technology and Innovation Act 2013 (Revised 2014) herein after referred to as the Act. The objective of the Commission shall be to regulate and assure quality in the science, technology and innovation sector and advise the Government in matters related thereto.

CONDITIONS OF THE RESEARCH LICENSE

1. The License is granted subject to provisions of the Constitution of Kenya, the Science, Technology and Innovation Act, and other relevant laws, policies and regulations. Accordingly, the licensee shall adhere to such procedures, standards, code of ethics and guidelines as may be prescribed by regulations made under the Act, or prescribed by provisions of International treaties of which Kenya is a signatory to
2. The research and its related activities as well as outcomes shall be beneficial to the country and shall not in any way;
    i. Endanger national security
    ii. Adversely affect the lives of Kenyans
    iii. Be in contravention of Kenya's international obligations including Biological Weapons Convention (BWC), Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO), Chemical, Biological, Radiological and Nuclear (CBRN).
    iv. Result in exploitation of intellectual property rights of communities in Kenya
    v. Adversely affect the environment
    vi. Adversely affect the rights of communities
    vii. Endanger public safety and national cohesion
    viii. Plagiarize someone else's work
3. The License is valid for the proposed research, location and specified period.
4. The license any rights thereunder are non-transferable
5. The Commission reserves the right to cancel the research at any time during the research period if in the opinion of the Commission the research is not implemented in conformity with the provisions of the Act or any other written law.
6. The Licensee shall inform the relevant County Director of Education, County Commissioner and County Governor before commencement of the research.
7. Excavation, filming, movement, and collection of specimens are subject to further necessary clearance from relevant Government Agencies.
8. The License does not give authority to transfer research materials.
9. The Commission may monitor and evaluate the licensed research project for the purpose of assessing and evaluating compliance with the conditions of the License.
10. The Licensee shall submit one hard copy, and upload a soft copy of their final report (thesis) onto a platform designated by the Commission within one year of completion of the research.
11. The Commission reserves the right to modify the conditions of the License including cancellation without prior notice.
12. Research, findings and information regarding research systems shall be stored or disseminated, utilized or applied in such a manner as may be prescribed by the Commission from time to time.
13. The Licensee shall disclose to the Commission, the relevant Institutional Scientific and Ethical Review Committee, and the relevant national agencies any inventions and discoveries that are of National strategic importance.
14. The Commission shall have powers to acquire from any person the right in, or to, any scientific innovation, invention or patent of strategic importance to the country.
15. Relevant Institutional Scientific and Ethical Review Committee shall monitor and evaluate the research periodically, and make a report of its findings to the Commission for necessary action.
16.

National Commission for Science, Technology and Innovation(NACOSTI),
Off Waiyaki Way, Upper Kabete,
P. O. Box 30623 - 00100 Nairobi, KENYA
Telephone: 020 4007000, 0713788787, 0735404245
E-mail: dg@nacosti.go.ke
Website: www.nacosti.go.ke

Appendix Q

Publications

E. Afri. Agri. For. J (2022,Volume 86 (3), Pg 252-259)

LEVELS OF AWARENESS FOR DOMESTICATION OF CAPE GOOSEBERRY AMONG FARMING FAMILIES IN BARINGO COUNTY, KENYA

J. C. Kandagor[1#], F. U. Ngesa[1], M. O. Udoto[1] and D. O. Pande[2]
[1]Department of Agricultural Education and Extension, Egerton University
[2]Department of Biological and Biomedical Science & Technology, Laikipia University

ABSTRACT

Cape gooseberry *(Physalis peruviana L.)* is a fruit crop with nutritional, medicinal and industrial values. The crop grows naturally in the wild and around homesteads in Baringo County. Farmers in the County, however, have not grown the crop. Because of the benefits associated with the crop, there is need for further attempts to introduce the crop in the County. The purpose of this paper was to evaluate the level of awareness of domestication of Cape gooseberry among farmers in Baringo County. The results are based on a baseline survey data collected from farmers randomly selected from three Wards namely; Saimo/Kipsaraman in Baringo North sub-County, Marigat in Baringo South sub-County and Koibatek in Eldama Ravine sub-County. The survey sample comprised 107 households, distributed equally among the three Wards. Data were analysed using descriptive statistics and inferential statistics involving Chi-square tests. The results from the survey showed that 87% of the farming families were aware of Cape gooseberry. With regards to presence of Cape gooseberry around homesteads, 77% of the farming families reported its existence. The results, also, indicated that 95% of the farming families were not aware of Cape gooseberry farming. Out of those not aware of Cape gooseberry farming, 90% were willing to grow the crop. Additionally, there was no significant relationship between gender and Cape gooseberry awareness. Based on the findings, the study concludes that majority of the farming families were aware of Cape gooseberry crop and expressed their willingness to grow it. Therefore, the study recommends the domestication of the crop in Baringo County, and that the County and National Governments should put in place appropriate policies and frameworks for its promotion, production and marketing.

Keywords: Willingness, nutritious fruits, health, medicinal value

[#]Corresponding author: kandagor@egerton.a.ke

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Journal Brief

FARMING FAMILIES RATING ON THE SOURCES OF AGRICULTURAL INFORMATION IN BARINGO COUNTY, KENYA

J. C. Kandagor1, F. U. Ngesa1, M. O. Udoto1 and D. O. Pande2
[1] Egerton University, Department of Agricultural Education and Extension, P.O Box 536-20115,Njoro, Kenya,[2] Laikipia University, Department of Biological and Biomedical Science and Technology, P.O Box 1100-20300, Nyahururu, Kenya

ABSTRACT

Quality agricultural extension services are critical in agricultural development, since it provides linkages between agricultural research, development systems and producers. In Kenya, researchers have reported weaknesses in the services, positing which is due to limited extension personnel and the failure of the new Kenya constitution to assign the services to any of the two levels of governments. The county and national have contributed to challenges in dissemination and adoption of improved agricultural technologies. Before proposing frameworks for improvements, however, it is critical that studies be conducted to determine the efficiency of the current models of disseminating agricultural technologies. The purpose of this article is to present the rating of sources of agricultural information and knowledge which farming families in Baringo County, Kenya, indicated were accessible to them. Additionally, the article presents the challenges which the farming families experienced when seeking agricultural information and knowledge. The data were collected during baseline survey on the "Effects of digital systems and climate smart agriculture on the domestication of Cape gooseberry in Baringo County, Kenya". In the study, a sample of 120 farming families were randomly selected from three wards in the County. Data were collected using interview schedule, and analysed using descriptive statistics. Majority of the farming families indicated they receive agricultural information from fellow farmers and television programmes, at the ratings of 83.2% and 50.5%, respectively. The farming families rated exhibitions, demonstrations and extension staff lowly at the ratings of 6.5%, 9.3% and 15.0%, respectively. Additionally, farming families were requested to indicate the challenges they encounter when seeking agricultural information. Most of the farming families rated unavailability of extension staff as the main challenge when seeking agricultural information. They rated it at 55.1%. Based on the findings of the baseline survey, the article proposes that farmer groups and digital systems form the nuclei through which the extension systems disseminate improved agricultural technologies.

Keywords: Extension, digital system, ICT, innovations, dissemination, adoption

[#]Corresponding author: kandagor@egerton.ac.ke